# STUDY GUIDE

## Master of Science Degree Programme in Geo-information Science and Earth Observation

## Academic year 2022-2023

University of Twente, Faculty ITC
Bureau Education and Research Support

UNIVERSITY OF TWENTE.

ITC

# COLOFON

UNIVERSITY OF TWENTE
FACULTY OF GEO-INFORMATION SCIENCE AND EARTH OBSERVATION
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DATE PRINTED
04/07/2022

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PUBLISHED BY
University of Twente
Faculty of Geo-Information Science and Earth Observation
Bureau Education and Research Support

# PREFACE

This study guide provides an overview of the Master's programme Geo-information Science and Earth Observation and the study units of the programme for this academic year. In this study guide, you find an overview of the learning outcomes and the structure of the programme as well as an overview of the various roles within the programme.

Each study unit of the study programme is described in terms of its study load, learning outcomes, contents, teaching and learning approach, test plan and entry requirements.

Through this study guide, we hope to provide you insight in what you can expect from the education we offer. The programme manager can be contacted for further general information about the programme. For further information about a specific study unit, the coordinator of that study unit can be contacted.

Success with your studies!

# CONTENTS

# INTRODUCTION

# WELCOME TO THE MASTER'S PROGRAMME GEO-INFORMATION SCIENCE AND EARTH OBSERVATION

The Master's Programme Geo-Information Science and Earth Observation (M-GEO) is a two-year academic curriculum at MSc level, taught fully in English, dedicated to understanding the earth's systems from a geographic and spatial perspective. The field of Geo-information Science and Earth Observation has, in recent years, witnessed fast scientific and technological developments. As a result, geographic information has become a vital asset to society and part of our daily life. The ubiquitous production and availability of spatial data require cloud computing and new technology to turn the increasing volume of 'big data' to good use.

The growing range of global challenges, from climate change and resource depletion to environmental pollution and pandemic diseases, that our society and in particular the more vulnerable populations on our planet are facing, increases the demand for academic professionals who have the ability, attitudes and skills to design solutions that are sustainable, transdisciplinary and innovative with positive societal impacts. Our education focuses on addressing these global problems by means of advanced geo-information and earth observation applications.

### It's an international programme

Throughout our programme, it is our ambition that students become increasingly able to critically evaluate the use of geo-information and create new insights for analysing, modelling and visualising the spatial and temporal dimensions of contemporary and imminent problems facing our society. Examples include designing sustainable management solutions for water and natural resources; assessing ecosystem services for agricultural, industrial and urban use; identifying and responding to natural hazards in drafting development strategies; and characterising settlement dynamics and urban demand. It is our ambition that this transformation and integration of knowledge is carried out in a multicultural and international environment, through group work, discussion groups and individual assignments. Internationalisation is an important aspect of the students' learning experience: throughout the programme, they are stimulated to imagine new ways to solve problems and create value beyond subjective opinions, conflicts, language, and cultural differences.

M-GEO is, therefore, an international programme, which has been awarded "Top Programme" (Keuzegids Masters) six times and is one of the very few Dutch academic Master's programmes to have earned the ECA special feature for internationalization in education. Furthermore, ITC is one of the worlds top-ranking research institutes in the field of Earth Observation, allowing the programme to build on the input of high-class research.

The programme is not only international in its education, but its faculty puts much effort into creating an inclusive academic and social environment in which students feel comfortable, allowing them to grow to their full potential. We nurture an international community of graduates, students and teachers who remain in life-long contact in an active global alumni network of over 20,000 Geo-professionals. This global network allows us, as a faculty, to generate and exchange knowledge that inspires global developments. It empowers students with the knowledge and skills to address challenges that are central to (inter)national communities.

### Who are our students?

Students of the M-GEO Programme are young graduates and mid-career professionals with BSc-level education or above, who aspire to perform in research that is mostly problem-driven, or who require academic knowledge and skills to enhance their professional practice. The M-GEO programme enables them as graduates to address worldwide challenges in a local context, using the core knowledge areas of Geo-Information Science and Earth Observation, and applying scientifically sound spatio-temporal analysis and model development, while taking into account both environmental and socio-economic drivers of change. Our students choose to develop these skills in an international classroom and are therefore also interested to also addressing global challenges beyond the borders of the EU. The students joining the programme come to learn from science, practice and experience developed in Europe and the Netherlands, but are particularly keen to learn about the application of new insights in other parts of the World, where the challenges faced are often greater.

## What's the content of the programme?

In today's world, spatial information is everywhere, providing ever more detailed impressions of reality. M-GEO uses spatial information as the key to solving complex issues that may involve, for example:

- helping to achieve **food security** by advancing the livelihoods of smallholder farmers in poor countries
- evaluating and planning health infrastructure, risk mapping and analysis as well as responding to **disease outbreaks and epidemics**
- making **land rights mapping** faster, cheaper, easier, and more responsible
- helping emerging economies by improving **water safety** and security
- using UAVs for assessing **disaster resilience**
- promoting **energy transition** through exploration of geothermal energy sources and multi-stakeholder planning of renewable energy sources
- designing frameworks for **big data and cloud computing** use in spatial analysis
- helping to achieve sustainable social housing and **inclusive urban communities**

M-GEO graduates are provided with the knowledge and tools required for working with spatial information in any of these fields − and more. To achieve this, the programme is accessible to a wide range of BSc education backgrounds. If students have a relevant background to one of the following programme specializations, they can enter the programme:

**M-GEO specializations:**

- ***Applied Remote Sensing for Earth Sciences***; for those who wish to explore for earth and geothermal resources to secure future demands for energy and minerals
- ***Geoinformatics***; for those who wish to develop technologies required for analysing, distributing and visualizing geospatial data.
- ***Geo-information Management for Land Administration***; for those who wish to use cadastral intelligence for designing and applying responsible land administration solutions.
- ***Natural Hazards and Disaster Risk Reduction***; for those who wish to predict and monitor multi-hazard risk and help increase our resilience to disasters;
- ***Natural Resources Management***; for those who wish to utilize geo-spatial data to help achieve more sustainable use of natural resources;
- ***Urban Planning and Management****;* for those who wish to understand dynamic urban processes and create interventions to help make cities competitive, compact, sustainable, inclusive and resilient;
- ***Water Resources and Environmental Management***; for those who wish to use earth observation and geo-information techniques to create safe and sustainable water management solutions;

## How is the programme offered?

The programme structure is visualized in the interactive interface of this study guide. The first part of the programme is dedicated to bringing the participants with their different BSc backgrounds together into a common understanding of the core knowledge of Geo-information Science and Earth Observation. The remainder of the first year is then dedicated to courses in a chosen field of specialization, supplemented with preparation for academic research.

The second year of the programme leaves ample freedom for students to make choices. The majority of the second year is devoted to an individual MSc research project under the guidance of experienced research staff, which can be partly executed abroad. Students can further complement their academic programme with a wide selection of elective courses. These courses are offered to allow students to either specialize further or broaden their knowledge of M-GEO related subject areas. As part of the second-year elective space, you can also choose to do an (international) internship. The programme furthermore includes common elements of multidisciplinary work, in which the internationalisation of the programme is highlighted in a challenge-based environment.

## Graduating with competencies demanded by the job market

M-GEO is the ideal programme for someone who wishes to enhance their competency in dealing with global problems, such as climate change, disaster resilience, global health and food security, from a geospatial perspective. Offering solutions from a geospatial perspective, ensures that the cause-effect relations of a solution can be measured, modelled and quantified according to the full extent of their geographical impact. Whether you like to offer in-depth knowledge or provide oversight with a ‘helicopter view’ to those challenges, the M-GEO programme offers the opportunity to set your own direction. Through research and internship support, we offer you the opportunity to build an international professional network. This is because M-GEO is an international programme with participants from the entire world. The programme’s focus is on challenges faced by the majority of the world and not just those affecting us in Europe. Joining M-GEO means you will study together with participants from at least 20 different nationalities, mostly from outside Europe.

A graduate of M-GEO is capable of unravelling geospatial processes and developing (creating) small scale solutions for global problems as an applied scientist or a geo-information consultant. M-GEO graduates have the competency to work at the nexus between technical specialists and decision-makers. They are equipped to translate policy decisions into technical requirements and can, vice versa, translate technical and scientific results into policy advice or scenarios.

Furthermore, graduates can communicate both orally and in writing on findings of research work to specialists and non-specialists. They have learned to explain and contrast cultural and contextual differences that influence the collection, classification and visualization of spatial information. Communication and internationalisation skills allow them to operate professionally and ethically in a multi-cultural environment.

# PROGRAMME STRUCTURE

This study guide offers you the opportunity to construct your own programme. Although there is a lot of flexibility in the programme, there are a few boundary conditions. The programme offers common courses, specialization courses and elective courses. The common courses are mandatory as you can see in the overview. These cannot be changed. You have to choose 4 specialization courses. Usually, students choose a predefined track of 4 courses within one specialization, but it is possible to construct your own specialization out of the available specialization courses. Approval of a free specialization has to receive approval from the programme manager. In the first and second year, there are a number of electives you can choose from to complete your 120 EC programme.

Please explore the interactive study guide, and if you have questions you are welcome to contact the study adviser.

— Common
— Thesis

| Q1 | Q2 | Q3 | Q4 |
|---|---|---|---|
| Academic Skills | Academic Skills | Academic Skills | Academic Skills |
| GIS & RS for Geospatial Solutions | | Global Challenges, Local Action | |
| Geospatial data: concepts, acquisition and management | | | |
| Geospatial analysis and interpretation | | | |

25 EC / 60

| Q5 | Q6 | Q7 | Q8 |
|---|---|---|---|
| MSc Research Proposal and Thesis Writing | MSc Research Proposal and Thesis Writing | MSc Research Proposal and Thesis Writing | MSc Research Proposal and Thesis Writing |

45 EC / 60

# TEACHING PERIOD

The two-year programme (120 EC), is built up out of 4 quartiles per year of each 10 weeks (15 EC). The programme starts around the 1st of September and the 4th quartile ends in July.

| **Period** | **Time** |
|---|---|
| 1st period | 08:45 - 10:30 |
| | Coffee/tea break |
| 2nd period | 10:45 - 12:30 |
| | Lunch break |
| 3rd period | 13:45 - 15:30 |
| | Coffee/tea break |
| 4th period | 15:45 - 17:30 |

# EVENTS, HOLIDAYS AND BREAKS

**Events**

| | |
|---|---|
| Introduction week | 28 August 2022 through 02 September 2022 |
| Opening Academic Year UT | Monday, 5 September 2022 |
| Dies Natalis UT | |
| Research Themes Introduction | |
| Christmas drinks | |
| New Year's coffee | |
| MSc topic market | |
| Career Event | |
| International Food Festival | |

**Holidays and Breaks**

| | |
|---|---|
| Winter break | 27 December 2022 through 08 January 2023 |
| Spring break | 27 February 2023 through 05 March 2023 |
| Good Friday | Friday, 07 April 2023 |
| Easter Monday | Monday, 10 April 2023 |
| King’s Day | Thursday, 27 April 2023 |
| Liberation Day | Friday, 5 May 2023 |
| Ascension break | Thursday, 18 May 2023 and Friday 19 May 2023 |
| Whit Monday | Monday, 29 May 2023 |
| Summer break | 24 July 2023 through 03 September 2023 |

# ROLES WITHIN THE CURRICULUM

**Examination Board**
The Examination Board is the body that determines autonomously and objectively whether a student satisfies the conditions that the Education and Examination Regulations set on the knowledge, understanding and skills needed to obtain an MSc degree or Certificate.

**Examiner**
The individual who has been appointed by the Examination Board to adminster exams and tests and determine their results.

**Mentor**
The faculty member who is the first point of contact for a student for academic guidance within a specialisation.

**Programme Committee**
The Programme Committee is composed of both teacher and student members. they monitor the quality of education and approve the EER on specific topics and can offer advice on all matters related to education in the Master's programme.

**Programme Director**
The person appointed by the Dean to be the governing head of a Master's programme as defined in the Law on Higher Education. The Programme Director is responsible for the development and quality of the programme.

**Programme Manager**
The person who is responsible for the planning, organization, implementation of the Master's programme and its derived courses.

**Study Unit Coordinator**
Each study unit is coordinated by a scientific staff member. The Study Unit Coordinator is responsible for the organization and execution of the entire study unit, and is first point of contact for staff and students when questions arise regarding the study unit.

**Study Adviser**
Faculty member appointed by the Dean of the Faculty to act as a contact between the student and the programme and in this role represents the interests of the students, as well as fulfilling an advisory role.

**Student Affairs Officers**
ITC Student Affairs Officers provide ITC students with information, advice, and assistance on social, cultural, and medical issues. Occasionally, a student may have a serious problem. Student Affairs Officers can help by listening and can advise and guide you on where best to seek assistance. Everything you tell them is treated with strict confidentiality.

**Supervisor**
All Master's programme students will be assigned a Supervisor for the development of their MSc Research proposal and the execution of their MSc Research.

# PROGRAMME LEARNING OUTCOMES

**Programme learning outcomes of the Master’s Programme Geo-information Science and Earth Observation (MSc), as defined in the EER.**

At the successful completion of the Master’s programme, the student is able to:

| **Domain/academic field** | |
|---|---|
| 1. | Identify and explain principles, concepts, methods and techniques relevant for geo-information processing and earth observation. |
| 2. | Analyse problems and cases from a (geo-)spatial perspective. |
| 3. | Use and design models to simulate (or: study) processes in the system earth with a spatial component. |
| 4. | Apply principles, concepts, methods and techniques in the context of system earth, the user and an application domain to solve scientific and practical problems. |
| 5. | Independently design and carry out research in the domain according to scientific quality standards. |
| **Scientific** | |
| 6. | Analyse issues in an academic manner and formulate judgments based on this. |
| 7. | Analyse scientific and practical domain problems in a systematic manner and develop scientifically valid solutions for these problems in a societal context. |
| 8. | Communicate both orally and in writing on findings of research work to specialists and non-specialists. |
| 9. | Explore the temporal and social context of geo-information science and technology and be able to integrate these insights into scientific work. |
| **Internationalization** | |
| 10. | Explain and contrast cultural and contextual differences that influence the collection, classification and visualization of spatial information. |
| 11. | Operate professionally and ethically in a multi-cultural environment. |
| **General** | |
| 12. | Critically reflect on own and other's work. |
| 13. | Study in a manner that is largely self-directed and autonomous. |

These learning outcomes at programme level are worked out into specific learning outcomes at course level.

# SOURCES OF INFORMATION

**STUDY GUIDE IN DIGITAL FORMAT**
www.itc.nl/studyguide

**EDUCATION AND EXAMINATION REGULATIONS AND RULES AND REGULATIONS OF THE EXAMINATION BOARD**
www.itc.nl/regulations

**FACULTY ITC**
www.itc.nl

**UNIVERSITY OF TWENTE**
www.utwente.nl/en

# COMMON

## ACADEMIC SKILLS

| **Course** | **201800271** |
| --- | --- |
| Period | 05 September 2022 - 07 July 2023 |
| EC | 4 |
| Course coordinator | |

#### INTRODUCTION

This course provides students with the foundational knowledge and skills required to undertake scientific research in their chosen domain within Geo-information Science and Earth Observation. The course combines an understanding of important conceptual issues in scientific research with skills for designing and executing an individual research project. A critical, scientific attitude and the ability to reflect upon their own work and that of others will be developed.

#### CONTENT

- Handling scientific information
  - Find relevant, reputable and up-to-date scientific literature to support your research
  - Store, manage and use bibliographic data with a reference manager
  - Avoid plagiarism
- Critical reading
  - Abstract and summarize information from scientific publications
  - Evaluate the scientific quality of an article based on a set of criteria
- Open Science
  - Introduction to Open Science
  - Support reuse of research data with good Research Data Management and Data Management plans
- Scientific communication
  - Design and produce graphic illustrations (maps, charts, diagrams, etc.) and tables to communicate scientific concepts, data and information
  - Prepare and deliver an oral presentation to communicate aspects of their research to an audience
  - Write a well-structured and logically-argued justification for their research topic according to scientific writing principles
- Critical attitude
  - Give and receive peer feedback in order to stimulate learning and elevate skill levels
  - Critically reflect on suitable research topic and actively drive the development of a possible MSc research topic with supervisor

#### TEACHING AND LEARNING APPROACH

Teaching and learning involves a mix of different types of activities, including plenary lectures, tutorials, peer-review sessions and self-study. Active participation and critical reflection are stimulated.

#### TESTS

Students will be evaluated on the basis of one written assignment per quartile. The Assignments of Q1 and Q3 are on a Pass/Fail basis, while assignment of Q2 (40%) and Q4 (60%) are combined for the final grade. The assignment of Q2 has a full second test opportunity (range 1-10). The second test opportunities of assignments Q1, Q3 and Q4 are all repair opportunities. This entails that the repair of assignment Q4 results in a maximum grade of 6.0

Note: Completing the Academic Skills course with a pass mark is a prerequisite to be admitted to the MSc research phase in year 2. This requires passing the Q1 and Q3 assignment with “Pass” and having a weighted average of the other 2 assignments at or above the pass grade.

## ENTRY REQUIREMENTS
As for entry to the programme.

## LEARNING OUTCOMES
Upon completion of this course, the student is able to:

LO 1 Apply basic academic skills for handling scientific information.
LO 2 Critically read and evaluate technical and scientific literature.
LO 3 Develop an appropriate research design to address a scientific problem.
LO 4 Effectively communicate research process and outcomes to peers and scientific community.
LO 5 Critically reflect on the work of peers and on feedback received on their own performance in the design and execution of research tasks.

## ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 16 |
| Tutorial | 30 |
| Individual assignment | 30 |
| Self-study | 36 |
| | 0 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Learning Outcomes that are addressed in the test Q1 | Q2 | Q3 | Q4 |
|---|---|---|---|---|---|
| LO 1 | Apply basic academic skills for handling scientific information. | ● | ● | | ● |
| LO 2 | Critically read and evaluate technical and scientific literature. | | ● | | ● |
| LO 3 | Develop an appropriate research design to address a scientific problem. | | | | ● |
| LO 4 | Effectively communicate research process and outcomes to peers and scientific community. | | | ● | ● |
| LO 5 | Critically reflect on the work of peers and on feedback received on their own performance in the design and execution of research tasks. | | | ● | |
| | Test type | Assignment | Assignment | Assignment | Assignment |
| | Weight of the test | 0 | 40 | 0 | 60 |
| | Individual or group test | Individual | Individual | Individual | Individual |
| | Type of marking | Pass/Fail | 1-10 | Pass/Fail | 1-10 |
| | Required minimum mark per test | | | | |
| | Number of test opportunities per academic year | 1 | 2 | 1 | 1 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| **Learning outcomes (LO) of the course: The student will be able to...** | | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Apply basic academic skills for handling scientific information. | | | | | ● | | | | | | | | |
| LO 2 | Critically read and evaluate technical and scientific literature. | | | | | | ● | | | | | | | |
| LO 3 | Develop an appropriate research design to address a scientific problem. | | | | | ● | | ● | | | | | | |
| LO 4 | Effectively communicate research process and outcomes to peers and scientific community. | | | | | | | | ● | | | | | |

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 5 | Critically reflect on the work of peers and on feedback received on their own performance in the design and execution of research tasks. | | | | | | | | | | | | ● | |

# GLOBAL CHALLENGES, LOCAL ACTION

| **Course** | **201800317** |
|---|---|
| Period | 06 February 2023 - 21 April 2023 |
| EC | 7 |
| Course coordinator | |

## INTRODUCTION

Global challenges of the 21st century, as caused by or related to climate change, rapid urbanization and increased resource use cannot be simply addressed at the global level within disciplinary boundaries but require careful consideration and detailed analysis at the regional and local level and an interdisciplinary lens. In this course, we aim to increase your awareness of the urgency to address global challenges of the 21st century at multiple scales and the added value of engaging with other disciplines. Besides learning about internationally recognized key global challenges, you will further strengthen the geo-spatial and domain knowledge and skills acquired in preceding courses. You will become aware of both the added value and challenges of crossing disciplinary boundaries and recognize the contribution of your own discipline in analysing global problems and designing actions at the local level.

The course consists of two elements, moving from a multi-disciplinary to an interdisciplinary approach. The **first element** introduces you to a set of key global challenges which have been recognized internationally and relate to selected research themes of ITC and the educational tracks of the Master Geo-Information Science and Earth Observation. This is done by means of keynote lectures and associated working groups. The **second element** is an interdisciplinary and project-based investigation in multi-disciplinary groups (i.e. a region-specific case study that reflects a mix of challenges and impacts). With the group, you will analyse a global issue more in-depth and collaboratively design a response (plan, strategy, policy recommendation, etc.) at the local level. For further details see the content section.

## CONTENT

For each selected **global challenge** (climate change, rapid urbanization, increased resource use) and related **problems** (e.g. natural and man-made hazards, degradation of fragile ecosystems, resource scarcity), the lectures and associated working groups of the course provide an overview of:

- processes and trends;
- examples of local impacts;
- the role of Geo-information and Earth Observation to analyse and monitor global changes and policy goals as well as local and/or regional effects; and
- institutional frameworks and agreements and relevant actors (e.g. Climate Change Agreement (COP21), the Sendai Framework for Disaster Risk Reduction (SFDRR), Sustainable Development Goals; UN Habitat for addressing pressing urban issues or the Food and Agriculture Organization of the United Nations (FAO) with regard to food security);
- basic principles of an interdisciplinary approach and how to collaborate within a diverse group.

With regard to the interdisciplinary and **project-based** group work, students will choose 1 project from a set of projects (4-5) offered. The projects are region-specific/thematic case studies that reflect a mix of challenges and impacts (i.e. Challenges of Urbanisation; Challenges in the Coastal Zone; Geo-Health; Energy transition; Food Security) for which students will do the following in a multi-disciplinary and an international group setting (4-6 students; the lecturers will form these sub-groups):

- Analyse the local and/or regional effects of global challenges and current ways of addressing these utilizing the skills and knowledge acquired in preceding courses
- Integrate different disciplinary contributions and local experiences in the design of a context- specific strategy, plan, indicator framework or policy recommendation to address the global challenge at the local level.
- Reflect on differences in perceptions encountered due to their different disciplinary and international backgrounds.

The course ends with a plenary event where all groups will present their results.

### TEACHING AND LEARNING APPROACH

**Lectures** about global challenges (processes and trends, policy frameworks, use of geo- information and earth observation, examples of local impacts)
**Working groups** to further process the information provided by the lectures/reading material through the perspective of your own discipline/project group
**Supervised project group-work** to work on a specific case study (4-6 students)
**Tutorials**, to acquire some specific methods that students aim to use in the elaboration of the projects
**Self-study**
**Excursion or discussion** with invited experts (1 per case study project)

### TESTS

- Individual essay (50%)
- Group project (40%)
- Individual reflection report (10%)

Please note: the 2nd opportunity of the Individual reflection report, is a **repair**

### ENTRY REQUIREMENTS

Successful completion of the ITC course 'GIS and RS for Geospatial Problem Solving' or equivalent.

### LEARNING OUTCOMES

Upon completion of this course, the student is able to:

LO 1 Explain global challenges and trends and how their impacts differ across geographic areas, critically reflect on institutional frameworks/global agreements related to the global challenges addressed in the keynote lectures.
LO 2 Critically reflect on the capacity of geo-spatial data, methods and tools in addressing specific global challenges.
LO 3 Apply knowledge and skills acquired in preceding courses to analyse global challenges and trends and their effects at the local/regional level.
LO 4 Jointly analyse, synthesize and communicate on the local and/or regional effects of a selected global challenge.
LO 5 Apply professional skills (oral communication, formulating an argument, scientific debate) and (ethical) values needed (justice, responsibility, reasonableness, respect, honesty) for working in international and interdisciplinary teams and environments.
LO 6 Reflect on international and interdisciplinary differences when co-developing local actions (context-specific strategy, plan, indicators, policy recommendation) to address global challenges.

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 20 |
| Supervised practical | 20 |
| Tutorial | 12 |
| Study trip | 8 |
| Written/oral test | 24 |
| Group assignment | 80 |
| Self-study | 32 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Individual essay | Group project | Individual reflection report |
|---|---|---|---|---|
| | | Learning Outcomes that are addressed in the test | | |
| LO 1 | Explain global challenges and trends and how their impacts differ across geographic areas, critically reflect on institutional frameworks/global agreements related to the global challenges addressed in the keynote lectures. | ● | | |
| LO 2 | Critically reflect on the capacity of geo-spatial data, methods and tools in addressing specific global challenges. | ● | | |
| LO 3 | Apply knowledge and skills acquired in preceding courses to analyse global challenges and trends and their effects at the local/regional level. | | ● | |
| LO 4 | Jointly analyse, synthesize and communicate on the local and/or regional effects of a selected global challenge. | | ● | |
| LO 5 | Apply professional skills (oral communication, formulating an argument, scientific debate) and (ethical) values needed (justice, responsibility, reasonableness, respect, honesty) for working in international and interdisciplinary teams and environments. | | ● | |
| LO 6 | Reflect on international and interdisciplinary differences when co-developing local actions (context-specific strategy, plan, indicators, policy recommendation) to address global challenges. | | | ● |
| | Test type | Assignment | Group project | Report |
| | Weight of the test | 50 | 40 | 10 |
| | Individual or group test | Individual | Group | Individual |
| | Type of marking | 1-10 | 1-10 | 1-10 |
| | Required minimum mark per test | 5 | | |
| | Number of test opportunities per academic year | 2 | 1 | 2 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Explain global challenges and trends and how their impacts differ across geographic areas, critically reflect on institutional frameworks/global agreements related to the global challenges addressed in the keynote lectures. | ● | | | | | ● | | ● | | | | ● | ● |
| LO 2 | Critically reflect on the capacity of geo-spatial data, methods and tools in addressing specific global challenges. | | ● | | | | ● | | | | | | | |
| LO 3 | Apply knowledge and skills acquired in preceding courses to analyse global challenges and trends and their effects at the local/regional level. | ● | ● | ● | ● | ● | | | ● | | | | | ● |

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 4 | Jointly analyse, synthesize and communicate on the local and/or regional effects of a selected global challenge. | | ● | ● | ● | | ● | ● | ● | | | | | ● |
| LO 5 | Apply professional skills (oral communication, formulating an argument, scientific debate) and (ethical) values needed (justice, responsibility, reasonableness, respect, honesty) for working in international and interdisciplinary teams and environments. | | | | | | | | | | ● | ● | ● | |

| | Learning outcomes (LO) of the course: The student will be able to... | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 6 | Reflect on international and interdisciplinary differences when co-developing local actions (context-specific strategy, plan, indicators, policy recommendation) to address global challenges. | | | | | | | | | | ● | ● | ● | |

# GIS & RS FOR GEOSPATIAL SOLUTIONS

| **Course** | **202001419** |
| --- | --- |
| Period | 05 September 2022 - 11 November 2022 |
| EC | 4 |
| Course coordinator | |

## INTRODUCTION

Geo-Information Systems and Science (GIS) and Earth Observation by Remote Sensing (RS) are among the main focus areas of the Faculty ITC. We concentrate on the underlying geospatial concepts that contribute to the development of technological innovations. With the help of GIS and RS we also increase our understanding of aspects of system Earth. GIS and RS help us in making contributions to solutions for global challenges, such as the dealing with effects of climate change and rapid urbanisation, and the need for a more sustainable use of our resources.

This first quartile (entitled 'GIS and RS for Geospatial Problem Solving') of your study programme at ITC consists of three interrelated courses. In these courses we aim to provide you with a general understanding about GIS and RS principles, and with hands-on experience in using software tools for handling and processing geospatial data. Apart from the geo-technological focus, the courses also challenge you in developing an attitude of using GIS and RS in dealing with geospatial problems and answering geospatial questions related to real world problems and challenges. The three courses will take you through the main stages of a geospatial problem solving cycle: from the identification of a geospatial problem and associated questions, via the acquisition, management and exploration of maps, images and other geospatial data, to the analysis and processing of images and spatial data, and eventually to the generation and communication of geospatial information needed for answering the geospatial questions.

## CONTENT

The three courses in this quartile share a common structure that follows the stages of the geospatial problem solving cycle. GIS- and RS-topics are not dealt with in isolation, but are integrated throughout the courses. The 1st course focuses on the use of GIS and RS in producing geo-information to help find solutions for geospatial problems.

**Course 1: GIS and RS for geospatial solutions (4 EC)**

In the first week of this course we introduce the geospatial problem solving approach. For this we consider the differences between uses and users of geo-information for problem solving, and the needs for answering geospatial questions. Furthermore, we discuss the influence of societal differences in selecting approaches and priorities when managing natural resources. We will also discuss the role of geo-information in the context of the Sustainable Development Goals and other global challenges. In the last two weeks of the course you will carry out a project assignment, in which you apply elements of the geospatial problem solving approach to produce geo-information relevant for a specific geospatial problem issue.

## TEACHING AND LEARNING APPROACH

The first week of the course (i.e. the first week of quartile 1) consists of a series of introductory presentations, group assignments and plenary discussions. In the last two weeks of the course (i.e. weeks 9 and 10 of quartile 1) you will carry out an individual project assignment.

### TESTS

A **project report**, as deliverable of the written project assignment, is used to assess the learning outcomes of the course. Per academic year an opportunity exists of improving on (i.e. 'repairing') the project assignment deliverable; this repair option will be assigned a maximum mark of 6.0.

### ENTRY REQUIREMENTS

Open for students in the Master of Science degree programme in Geo-Information Science and Earth Observation. The suitability of other candidates will be assessed on an individual basis.

### LEARNING OUTCOMES

Upon completion of this course, the student is able to:

LO 1 Apply the geospatial problem solving approach to address a specific geospatial problem.

LO 2 Build a geospatial data processing workflow and apply appropriate methods for data acquisition, management and analysis, including the integration of data and analysis functions.

LO 3 Explain how contextual and cultural differences can influence the collection and analysis of geospatial data, and the presentation of geo-information to a target audience.

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
| --- | --- |
| Lecture | 16 |
| Group assignment | 10 |
| Individual assignment | 70 |
| Self-study | 16 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Learning Outcomes that are addressed in the test<br>Project assignment course 1 |
|---|---|---|
| LO 1 | Apply the geospatial problem solving approach to address a specific geospatial problem. | ● |
| LO 2 | Build a geospatial data processing workflow and apply appropriate methods for data acquisition, management and analysis, including the integration of data and analysis functions. | ● |
| LO 3 | Explain how contextual and cultural differences can influence the collection and analysis of geospatial data, and the presentation of geo-information to a target audience. | ● |
| | Test type | Report |
| | Weight of the test | 100 |
| | Individual or group test | Individual |
| | Type of marking | 1-10 |
| | Required minimum mark per test | 5.5 |
| | Number of test opportunities per academic year | 1 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Apply the geospatial problem solving approach to address a specific geospatial problem. | | ● | ● | | | | | | | | | | ● |
| LO 2 | Build a geospatial data processing workflow and apply appropriate methods for data acquisition, management and analysis, including the integration of data and analysis functions. | | ● | ● | | | | | | | | | | ● |

| **Learning outcomes (LO) of the course: The student will be able to...** | | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 3 | Explain how contextual and cultural differences can influence the collection and analysis of geospatial data, and the presentation of geo-information to a target audience. | | ● | ● | | | | | | | ● | ● | | |

# GEOSPATIAL DATA: CONCEPTS, ACQUISITION AND MANAGEMENT

| **Course** | **202001457** |
|---|---|
| Period | 05 September 2022 - 11 November 2022 |
| EC | 5 |
| Course coordinator | |

## INTRODUCTION

Geo-Information Systems and Science (GIS) and Earth Observation by Remote Sensing (RS) are among the main focus areas of the Faculty ITC. We concentrate on the underlying geospatial concepts that contribute to the development of technological innovations. With the help of GIS and RS we also increase our understanding of aspects of system Earth. GIS and RS help us in making contributions to solutions for global challenges, such as the dealing with effects of climate change and rapid urbanisation, and the need for a more sustainable use of our resources.

This first quartile (entitled 'GIS and RS for Geospatial Problem Solving') of your study programme at ITC consists of three interrelated courses. In these courses we aim to provide you with a general understanding about GIS and RS principles, and with hands-on experience in using software tools for handling and processing geospatial data. Apart from the geo-technological focus, the courses also challenge you in developing an attitude of using GIS and RS in dealing with geospatial problems and answering geospatial questions related to real world  problems and challenges. The three courses will take you through the main stages of a geospatial problem solving cycle: from the identification of a geospatial problem and associated questions, via the acquisition, management and exploration of maps, images and other geospatial data, to the analysis and processing of images and spatial data, and eventually to the generation and communication of geospatial information needed for answering the geospatial questions.

## CONTENT

The three courses in this quartile share a common structure that follows the stages of the geospatial problem solving cycle. GIS- and RS-topics are not dealt with in isolation, but are integrated throughout the courses. The 2nd course focusses on concepts and aspects of acquisition, management and preprocessing of geospatial data. We assume that most participants have considerable knowledge about GIS and vector related data and models but require increased understanding of remote sensing and image data concepts.

**Course 2: Geospatial data: concepts, acquisition and management (5 EC)**

In this course we will introduce the main GIS and RS concepts relevant for the acquisition, management and exploration of geospatial data. We will consider both the use of map data, and remote sensing images. Main topics include:

- Spatial data models;
- Principles of Electro-Magnetic radiation;
- Data acquisition;
- Analyzing reflected and emitted radiation;
- Introduction to Atmospheric correction;
- Geospatial data management and retrieval;
- Spatial reference systems;
- Image reprojection and resampling;
- Visualisation principles and map creation;
- Image visualisation and colour composites.

This course is concluded with a written test.

### TEACHING AND LEARNING APPROACH

The course mainly consists of a mix of lectures, practicals and self-study time. Main topics' concepts and theory are briefly introduced through lectures which are usually scheduled in the morning. The subsequent practicals provide an illustration of the introduced concepts to increase understanding and also allow participants to develop practical skills. They consist of a supervised part, to help participants to start up practical activities and to discuss the intermediate results, and an unsupervised part for self-directed learning and skills development. Topics are usually finalised with plenary wrap-up sessions in the afternoon in which conceptual and practical issues that emerged from the lecture and practical are dealt with. Questions which arise at other later moments can be issued to the online discussion fora. Fellow students are encouraged to help solving the issues with moderation of the responsible lecturer.

Over time the practical instructions become less instructive and more task oriented, thus requiring a more active and self-supporting attitude from participants. This also helps to prepare for the planning and execution of the project assignments that you will carry out later on in the programme at ITC. Most pratical exercises will have a generic nature with specific instructions for QGIS. Alternatives can be available for ArcGIS and ERDAS.

### TESTS

A **written test** (in course week 5 of quartile 1) assesses the learning outcomes of this course. Two test opportunities are offered per academic year.

### ENTRY REQUIREMENTS

Compulsory course for students in the Master of Science degree programme in Geo-Information Science and Earth Observation. The suitability of other candidates will be assessed on an individual basis.

### LEARNING OUTCOMES

Upon completion of this course, the student is able to:

LO 1 Explain the relevant concepts in geo-information science for the acquisition, management and retrieval of geospatial data using geo-databases.

LO 2 Define spatial reference systems, coordinate systems and projections for geospatial data and apply relevant transformations for data integration with an emphasis on images.

LO 3 Explain electromagnetic radiation and the main processes of its interaction with the Earth surface and atmosphere.

LO 4 Apply atmospheric correction and image enhancement techniques to a remote sensing dataset to prepare for information extraction.

LO 5 Explain visualization principles and apply them for the interpretation and communication of geospatial data products (maps, graphs and remote sensing images).

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 32 |
| Supervised practical | 33 |
| Written/oral test | 2 |
| Self-study | 73 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Learning Outcomes that are addressed in the test<br>Written test course 2 |
|---|---|---|
| LO 1 | Explain the relevant concepts in geo-information science for the acquisition, management and retrieval of geospatial data using geo-databases. | ● |
| LO 2 | Define spatial reference systems, coordinate systems and projections for geospatial data and apply relevant transformations for data integration with an emphasis on images. | ● |
| LO 3 | Explain electromagnetic radiation and the main processes of its interaction with the Earth surface and atmosphere. | ● |
| LO 4 | Apply atmospheric correction and image enhancement techniques to a remote sensing dataset to prepare for information extraction. | ● |
| LO 5 | Explain visualization principles and apply them for the interpretation and communication of geospatial data products (maps, graphs and remote sensing images). | ● |
| | Test type | Written test |
| | Weight of the test | 100 |
| | Individual or group test | Individual |
| | Type of marking | 1-10 |
| | Required minimum mark per test | |
| | Number of test opportunities per academic year | 2 |

RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Explain the relevant concepts in geo-information science for the acquisition, management and retrieval of geospatial data using geo-databases. | ● | | | | | | | | | | | | |
| LO 2 | Define spatial reference systems, coordinate systems and projections for geospatial data and apply relevant transformations for data integration with an emphasis on images. | ● | | | | | | | | | | | | |
| LO 3 | Explain electromagnetic radiation and the main processes of its interaction with the Earth surface and atmosphere. | ● | | | | | | | | | | | | |

| | Learning outcomes (LO) of the course: The student will be able to... | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 4 | Apply atmospheric correction and image enhancement techniques to a remote sensing dataset to prepare for information extraction. | ● | | | | | | | | | | | | |
| LO 5 | Explain visualization principles and apply them for the interpretation and communication of geospatial data products (maps, graphs and remote sensing images). | ● | | | | | | | | | | | | |

# GEOSPATIAL ANALYSIS AND INTERPRETATION

| Course | 202001458 |
|---|---|
| Period | 05 September 2022 - 11 November 2022 |
| EC | 5 |
| Course coordinator | |

## INTRODUCTION

Geo-Information Systems and Science (GIS) and Earth Observation by Remote Sensing (RS) are among the main focus areas of the Faculty ITC. We concentrate on the underlying geospatial concepts that contribute to the development of technological innovations. With the help of GIS and RS we also increase our understanding of aspects of system Earth. GIS and RS help us in making contributions to solutions for global challenges, such as the dealing with effects of climate change and rapid urbanisation, and the need for a more sustainable use of our resources.

This first quartile (entitled 'GIS and RS for Geospatial Problem Solving') of your study programme at ITC consists of three interrelated courses. In these courses we aim to provide you with a general understanding about GIS and RS principles, and with hands-on experience in using software tools for handling and processing geospatial data. Apart from the geo-technological focus, the courses also challenge you in developing an attitude of using GIS and RS in dealing with geospatial problems and answering geospatial questions related to real world  problems and challenges. The three courses will take you through the main stages of a geospatial problem solving cycle: from the identification of a geospatial problem and associated questions, via the acquisition, management and exploration of maps, images and other geospatial data, to the analysis and processing of images and spatial data, and eventually to the generation and communication of geospatial information needed for answering the geospatial questions.

## CONTENT

The three courses in this quartile share a common structure that follows the stages of the geospatial problem solving cycle. GIS- and RS-topics are not dealt with in isolation, but are integrated throughout the courses. The 3rd course focuses on the analysis and interpretation of geospatial data.

**Course 3: Geospatial analysis and interpretation (5 EC)**

In this course we mainly concentrate on the analysis of geo-data, including remote sensing images, to produce geo-information. We also give attention to the quality aspects of the geo-data and their effect on the quality of the result of data analysis.

Main topics include:

- Overview of spatial analysis functions;
- Vector analysis;
- Raster analysis;
- Network analysis;
- Spatial filtering;
- Image ratios and indices;
- Digital image classification;
- Analyzing spatial and temporal patterns;
- Data quality;
- Geo-portals.

This course concludes with a written test.

### TEACHING AND LEARNING APPROACH

The course mainly consists of a mix of lectures, practicals and self-study time. Lectures are used to introduce concepts and theory. The practicals provide an illustration of the introduced concepts and also allow you the develop practical skills. They consist of a supervised part, to help you start up practical activities and to discuss the results, and an unsupervised part for self-directed learning and skills development. Topics are usually finalised with plenary wrap-up sessions in which conceptual and practical issues are dealt with.

Exercise instructions used in the practicals are task oriented, thus requiring a more active and self-supporting attitude from you. This also helps you to prepare for the planning and execution of project assignments that you will carry out later on in the course programme at ITC. In the year 2021 we will consider QGIS as the software of choice for majority of the practicals and assignments.

### TESTS

A **written test** (in course week 8 of quartile 1) assesses the learning outcomes of this course. Two test opportunities are offered per academic year.

### ENTRY REQUIREMENTS

Open for students in the Master of Science degree programme in Geo-Information Science and Earth Observation. The suitability of other candidates will be assessed on an individual basis.

### LEARNING OUTCOMES

Upon completion of this course, the student is able to:

LO 1 Classify spatial analysis functions and apply appropriate analysis operations on a geospatial dataset.

LO 2 Apply standard image analysis and change detection techniques to extract spatial and temporal information from a geospatial dataset.

LO 3 Identify the impact of geospatial data handling on data quality and implement standard quality assessment procedures.

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 24 |
| Supervised practical | 40 |
| Written/oral test | 2 |
| Self-study | 74 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Learning Outcomes that are addressed in the test<br>Written test course 3 |
|---|---|---|
| LO 1 | Classify spatial analysis functions and apply appropriate analysis operations on a geospatial dataset. | ● |
| LO 2 | Apply standard image analysis and change detection techniques to extract spatial and temporal information from a geospatial dataset. | ● |
| LO 3 | Identify the impact of geospatial data handling on data quality and implement standard quality assessment procedures. | ● |
| | Test type | Written test |
| | Weight of the test | 100 |
| | Individual or group test | Individual |
| | Type of marking | 1-10 |
| | Required minimum mark per test | 5.5 |
| | Number of test opportunities per academic year | 2 |

RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Classify spatial analysis functions and apply appropriate analysis operations on a geospatial dataset. | ● | | | | | | | | | | | | |
| LO 2 | Apply standard image analysis and change detection techniques to extract spatial and temporal information from a geospatial dataset. | ● | | | | | | | | | | | | |

| | Learning outcomes (LO) of the course: The student will be able to... | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 3 | Identify the impact of geospatial data handling on data quality and implement standard quality assessment procedures. | ● | | | | | | | | | | | | |

# SPECIALIZATIONS

## SPECTRAL DATA PROCESSING

| **Course** | **201800273** |
|---|---|
| Period | 14 November 2022 - 03 February 2023 |
| EC | 7 |
| Course coordinator | |

### INTRODUCTION

Earth observation (EO) satellites generate large amounts of geospatial data that are freely available for society and researchers. Technologies such as cloud computing and distributed systems are modern solutions to access and process big Earth observation data. Examples of online platforms for big Earth observation data management and analysis are, just to name a few popular ones, the *Google Earth Engine*, the *Sentinel Hub* and the *Open Data Cube*.

This course is on processing remote sensing data from operational and historic missions in an online platform, with specific emphasis on earth science applications. The course first gives an introduction to scripting with a higher-level programming language, such as *Python* or *JavaScript*. Writing own scripts allows to create custom processing solutions, automate such processing chains, apply them to various remote sensing data and provide scalable solutions for handling small or large data sets. The application to Earth sciences will help you to recognize landforms in images, determine earth surface composition and derive various physical parameters from the Earth surface.

### CONTENT

Platforms for big Earth observation data management and analysis; Computer programming; Scripting; Pre-processing and processing levels; Multi-spectral remote sensing; Hyperspectral remote sensing; Multi-temporal analysis; Spectral math; Spectral indices; Band ratios; Visualization; Visual image interpretation; Impact of weather and illumination; Earth science applications (such as surface compositional mapping, landslides, flooding, vegetation change).

### TEACHING AND LEARNING APPROACH

The course is designed for self-directed learning in an online (e-learning) setting. Independent of the COVID-19 situation, the majority of the course can be done online or at home. The course uses short lectures to introduce course components; interactive sessions for plenary question-and-answer moments as well as personalized feedback; and individual practical assignments. During the course is ample time for self-study and experimenting with scripting and data processing.

### TESTS

The assessment is composed of multiple tests:

1. A digital test based on computer tutorials (graded; 50%);
2. An oral test based on an individual project (graded; 50%).

A second test opportunity for the "individual project" will consist of improving (i.e. 'repairing') the project deliverable(s) and will be assigned a maximum mark of 6.0.

Formative assessment (self-reflection) is used for feedback and personalized development. This is not graded but completing the formative assessment is required to be able to participate in the oral test.

### ENTRY REQUIREMENTS

Participants should have introductory-level experience with GIS and Remote Sensing and possess an affinity with earth sciences, physical geography or spatial sciences. Participants will need an account with Google and Google Earth Engine to follow the practicals.

### LEARNING OUTCOMES

Upon completion of this course, the student is able to:

LO 1 understand the principles of a higher level programming language and apply these to scripting.

LO 2 adapt basic programming skills to construct scripts in an (online) processing platform.

LO 3 operate an online processing platform to compute useful Earth surface parameters.

LO 4 evaluate the quality of processing results and judge their suitability for further interpretation.

LO 5 criticize remote sensing approaches in terms of suitability for a specific application.

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 8 |
| Tutorial | 40 |
| Individual assignment | 40 |
| Self-study | 100 |
| Written/oral test | 8 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Test 1 | Test 2 |
|---|---|---|---|
| | | **Learning Outcomes that are addressed in the test** | |
| LO 1 | understand the principles of a higher level programming language and apply these to scripting. | ● | |
| LO 2 | adapt basic programming skills to construct scripts in an (online) processing platform. | ● | |
| LO 3 | operate an online processing platform to compute useful Earth surface parameters. | ● | ● |
| LO 4 | evaluate the quality of processing results and judge their suitability for further interpretation. | | ● |
| LO 5 | criticize remote sensing approaches in terms of suitability for a specific application. | | ● |
| | Test type | Report | Oral test |
| | Weight of the test | 50 | 50 |
| | Individual or group test | Individual | Individual |
| | Type of marking | 1-10 | 1-10 |
| | Required minimum mark per test | | |
| | Number of test opportunities per academic year | 2 | 1 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | understand the principles of a higher level programming language and apply these to scripting. | ● | | | | | | | | | | | | ● |
| LO 2 | adapt basic programming skills to construct scripts in an (online) processing platform. | ● | | | | ● | | | | | | | | ● |
| LO 3 | operate an online processing platform to compute useful Earth surface parameters. | ● | ● | | ● | ● | ● | ● | ● | | | | ● | ● |
| LO 4 | evaluate the quality of processing results and judge their suitability for further interpretation. | ● | ● | | ● | ● | ● | ● | ● | | | ● | ● | ● |

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 5 | criticize remote sensing approaches in terms of suitability for a specific application. | ● | ● | | ● | ● | ● | ● | ● | | | ● | ● | ● |

# FIELD MEASUREMENTS AND VALIDATION

| **Course** | **201800318** |
|---|---|
| Period | 24 April 2023 - 07 July 2023 |
| EC | 7 |
| Course coordinator | |

### INTRODUCTION
Field methods play an important role in geological remote sensing studies for validation of remote sensing interpretations and characterization of rocks and geological environments.

This course introduces students to state-of-the-art methods for field validation and characterization of rock and outcrop. Methods include the acquisition of measurements of mineralogical and chemical rock composition and physical rock properties. Acquisition of field data is practiced with a variety of field instruments, including reflectance and gamma-ray spectrometers and portable XRF.

The preparation and execution of a field campaign is also practiced in this course. A remote sensing study is performed prior to field work and forms the basis for the preparation of detailed field data acquisition plans. Data collection using various sampling strategies and different instruments will be exercised in the field and includes assessment of data quality. Results of the field campaign are analysed, interpreted and integrated with the results of desk studies. Additional measurements may be performed in the ITC geoscience laboratory.

### CONTENT
The course covers both theoretical subjects and practical work, including a 5-days field visit in the middle of the course. During the field visit to a geological interesting area, students will practice the acquisition of field measurements with a variety of field instruments and will gain experience with many aspects of data acquisition in the field.

Prior to the field visit, data acquisition plans will be prepared from desk studies of remote sensing and other data sets and specific objectives related to the geology of the area. After the field visit the acquired data sets will be analysed, interpreted and integrated with the desk study. Additional sample analysis can be performed in the ITC geoscience lab.

Theoretical subjects support the practical work and deepen the knowledge on field methods in Earth Sciences. These topics will be conveyed in self-study assignments and lectures and include theory about the field instruments, sampling strategy and campaign planning, data quality assessment, and integration and validation techniques.

Practical aspects of the course include the operation of field instruments, testing and packing of equipment, acquisition of measurements and sampling, outcrop description and interpretation, logistics in the field, field data management and presentation of results.

The field work is organized as a group assignment where each student contributes to the group effort and where all group members also have individual tasks. It is necessary that the students work as a group in order to meet the field work objectives. The results will be communicated in a project report.

### TEACHING AND LEARNING APPROACH
Combination of self-directed learning in individual assignments, learning by joint work with colleagues in a group assignment during field data collection, and theory lectures in support of the practical work and operation of field equipment.

#### TESTS
Individual assignment resulting in a report (50%).
Group assignment resulting in a peer-evaluation of group work (25%) and a data product (25%).

Second test opportunities for the ‘individual assignment report (test 1)’ and the ‘data product assessment (test 3)’ will consist of improving on (i.e. 'repairing') the test deliverable(s), and will be assigned a maximum mark of 6.0.

#### ENTRY REQUIREMENTS
Compulsory for the ‘Applied Remote Sensing for Earth Sciences’ (ARS) specialization of the ‘Geo-information Science and Earth Observation (M-GEO) programme.
Students from other specializations and programmes should have a background in earth sciences, knowledge of GIS and Remote Sensing techniques for geological applications, and a basic understanding of chemical analytical methods

#### LEARNING OUTCOMES
Upon completion of this course, the student is able to:

LO 1 Create a data acquisition plan for field measurements based on a GIS remote sensing desk study and objectives specific to the geology of an area.
LO 2 Acquire field measurements that cover the lithological variability at outcrop scale using a variety of different field instruments and manage the measurements adequately.
LO 3 Perform quality assessment of the field measurements and derive meaningful information about rock composition and rock formation from the measurements.
LO 4 Evaluate the results of the desk study, the field campaign and laboratory analyses and explain the observed relationships between the remote sensing and field data, considering sensor type, scale, physiography and other factors.
LO 5 Perform a specific task in a manner that is largely self-directed but that requires cooperation with other colleagues during a field campaign.

#### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 12 |
| Supervised practical | 14 |
| Tutorial | 7 |
| Study trip | 40 |
| Individual assignment | 80 |
| Group assignment | 24 |
| Self-study | 19 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Test 1 | Test 2 | Test 3 |
|---|---|---|---|---|
| | | Learning Outcomes that are addressed in the test | | |
| LO 1 | Create a data acquisition plan for field measurements based on a GIS remote sensing desk study and objectives specific to the geology of an area. | ● | | |
| LO 2 | Acquire field measurements that cover the lithological variability at outcrop scale using a variety of different field instruments and manage the measurements adequately. | | | ● |
| LO 3 | Perform quality assessment of the field measurements and derive meaningful information about rock composition and rock formation from the measurements. | | | ● |
| LO 4 | Evaluate the results of the desk study, the field campaign and laboratory analyses and explain the observed relationships between the remote sensing and field data, considering sensor type, scale, physiography and other factors. | ● | | |
| LO 5 | Perform a specific task in a manner that is largely self-directed but that requires cooperation with other colleagues during a field campaign. | ● | ● | |
| | Test type | Report | Peer-evaluation | Assessment of data product |
| | Weight of the test | 50 | 25 | 25 |
| | Individual or group test | Individual | Individual | Group |
| | Type of marking | 1-10 | 1-10 | 1-10 |
| | Required minimum mark per test | | | |
| | Number of test opportunities per academic year | 2 | 1 | 2 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Create a data acquisition plan for field measurements based on a GIS remote sensing desk study and objectives specific to the geology of an area. | | ● | | | | | | | | | | | |
| LO 2 | Acquire field measurements that cover the lithological variability at outcrop scale using a variety of different field instruments and manage the measurements adequately. | | | | ● | | | | | | | | | |

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 3 | Perform quality assessment of the field measurements and derive meaningful information about rock composition and rock formation from the measurements. | | | | | | ● | | | | | | | |
| LO 4 | Evaluate the results of the desk study, the field campaign and laboratory analyses and explain the observed relationships between the remote sensing and field data, considering sensor type, scale, physiography and other factors. | | | | | | | | | ● | | | | |

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 5 | Perform a specific task in a manner that is largely self-directed but that requires cooperation with other colleagues during a field campaign. | | | | | | | | | | | | | ● |

# GEOLOGICAL REMOTE SENSING

| **Course** | **201800291** |
|---|---|
| Period | 06 February 2023 - 21 April 2023 |
| EC | 7 |
| Course coordinator | |

### INTRODUCTION

This course gives an introduction to geological remote sensing in the application of earth resources mapping. It includes the integration of regional geophysics and remote sensing imagery for geoscience interpretation and map generation. The course is designed for students with a background in earth sciences and an ability to operate remote sensing and GIS software.

The course covers descriptions and applications of regional geophysics, radar, and their integration with multi-spectral sensors for geological remote sensing. Background theory of regional geophysical techniques and radar are outlined, including their processing and filtering techniques. The integration of theses datasets with multi-spectral sensors is also outlined. Pre-processing and information extraction algorithms are covered for students to understand the steps involved in converting raw data and images' digital numbers into structural and compositional mapped products. The evaluation of the mapped products and their uncertainties will be also outlined.

The course includes the practical application and map generation by students of interpreted geological information from relevant geophysical, remote sensing, and geoscience datasets.

### CONTENT

The course covers the following topics:

- Issues and caveats, including spatial and spectral resolution, of regional geophysics and remote sensing techniques for geological mapping;
- Background theory of regional geophysics (aeromagnetics, radiometrics, and gravity) involved with pre-processing techniques and data interpretation for geoscientific case studies;
- An outline of radar remote sensing techniques for geological applications;
- Application of high-resolution digital elevation models (derived from radar, spectral, or LiDAR sensors) for structural geological mapping;
- Application of PC based and cloud-based data processing techniques for geophysics, remote sensing, and geospatial datasets;
- Information extraction strategies and geological case study examples using regional geophysics, multi-, hyper-spectral, and radar datasets;
- Integration strategies of surface and subsurface information using geophysical and remote sensing datasets.
- Integrated case studies incorporating geophysical, remote sensing, and geoscience datasets;
- Geoscience map generation using geophysical, multi-spectral, and radar sensors and relevant integrated datasets;
- Evaluation of the derived structural and compositional map products using field ground-truthing and quantification validation techniques.

### TEACHING AND LEARNING APPROACH

The course has lectures to introduce background knowledge, concepts and case studies that include question-and-answer moments. Supervised practicals related to lectures are scheduled throughout the course. Assessed assignments will include submitting exercises, written test, and individual project work about geoscience map generation and interpretation case study, and a final individual examination. Significant time is reserved for self-study and unsupervised practical activity.

### TESTS

- Submission of exercises results (20%);
- One closed book individual written test (40%);
- One individual geoscience map generation and interpretation written assignment with individual oral presentations (40%).

### ENTRY REQUIREMENTS

Compulsory for the ‘Applied Remote Sensing for Earth Sciences’ (ARS) specialization of the ‘Geo-information Science and Earth Observation (M-GEO) programme.
Students from other specializations and programmes should have experience with GIS and Remote Sensing, and a background in infrared spectroscopy, imaging spectroscopy, and spectral modelling applied to earth resource exploration (spectral geology and spectral data processing courses or equivalent).

### LEARNING OUTCOMES

Upon completion of this course, the student is able to:

LO 1 Understand sensor specifications and their processed image products, in order to assess their application for a particular geological/mineralogical setting and targeted mapping activity.

LO 2 Explain the pre-processing chain applied to sensor output from raw data to interpretable geological and geophysical data products, including pre-processing, calibration, corrections, geolocation, and filtering.

LO 3 Choose and apply appropriate algorithms to processed geophysical and remote sensing products for the extraction of compositional and structural earth science information.

LO 4 Compose and generate earth science map products using the integration of various earth science information to construct a surface and sub-surface geological interpretation.

LO 5 Evaluate the uncertainties of data processing and mapping products.

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 30 |
| Supervised practical | 40 |
| Written/oral test | 2 |
| Individual assignment | 72 |
| Self-study | 52 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | written test | project assignment | Excercises submission |
|---|---|---|---|---|
| | | Learning Outcomes that are addressed in the test | | |
| LO 1 | Understand sensor specifications and their processed image products, in order to assess their application for a particular geological/mineralogical setting and targeted mapping activity. | ● | | ● |
| LO 2 | Explain the pre-processing chain applied to sensor output from raw data to interpretable geological and geophysical data products, including pre-processing, calibration, corrections, geolocation, and filtering. | ● | ● | |
| LO 3 | Choose and apply appropriate algorithms to processed geophysical and remote sensing products for the extraction of compositional and structural earth science information. | ● | ● | |
| LO 4 | Compose and generate earth science map products using the integration of various earth science information to construct a surface and sub-surface geological interpretation. | | ● | |
| LO 5 | Evaluate the uncertainties of data processing and mapping products. | ● | ● | |
| | Test type | Written test | Oral presentation and written report | Sheet |
| | Weight of the test | 40 | 50 | 10 |
| | Individual or group test | Individual | Individual | Individual |
| | Type of marking | 1-10 | 1-10 | 1-10 |
| | Required minimum mark per test | | | |
| | Number of test opportunities per academic year | 2 | 2 | 1 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Understand sensor specifications and their processed image products, in order to assess their application for a particular geological/mineralogical setting and targeted mapping activity. | ● | ● | ● | | | | | | | | | | |
| LO 2 | Explain the pre-processing chain applied to sensor output from raw data to interpretable geological and geophysical data products, including pre-processing, calibration, corrections, geolocation, and filtering. | ● | | | | | | | | | | | | |
| LO 3 | Choose and apply appropriate algorithms to processed geophysical and remote sensing products for the extraction of compositional and structural earth science information. | | | | ● | | ● | | | | | | | |

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 4 | Compose and generate earth science map products using the integration of various earth science information to construct a surface and sub-surface geological interpretation. | | | | ● | ● | | ● | ● | | | ● | ● | ● |
| LO 5 | Evaluate the uncertainties of data processing and mapping products. | | | | | | ● | | | | | | ● | ● |

# SPECTRAL GEOLOGY

| **Course** | **201800287** |
|---|---|
| Period | 14 November 2022 - 03 February 2023 |
| EC | 7 |
| Course coordinator | |

## INTRODUCTION

This course focuses on the use of spectroscopic methods to obtain geological information related to, for example, minerals and rocks, mineralised and geothermal systems, soils and other natural materials. It is designed for students with a solid understanding of Earth Sciences who wish to use state-of-the-art spectroscopic methods to analyse the mineral content and texture of samples.

The course will cover the interaction of matter with electromagnetic radiation of different wavelength ranges (e.g. visible, near- & short-wave infrared, as well as long-wave infrared). The students will be involved in laboratory measurements with various imaging and non-imaging spectroscopic instruments, and compare and contrast the results with those from other mineralogical and geochemical analytical methods.

The course further contains a component on statistical data processing and (semi-) quantitative spectral modelling techniques derived from current research. These analytical techniques will lead to information on the mineralogy and mineral chemistry of samples, as well as Earth surface parameters. The students will experiment with, validate and compare multiple approaches, investigate their assumptions and limitations, and critically evaluate their suitability to solve Earth science problems.

## CONTENT

This course covers the following topics:

- Interaction between electromagnetic radiation and matter;
- Laboratory spectral measurements with imaging and non-imaging infrared spectrometers;
- Instrument calibration and storage of data in spectral data cubes and libraries;
- Pre-processing of image data and assessment of data quality;
- Spectral interpretation strategy: linking the spectra to mineral/rock composition;
- Spectral absorption feature analysis;
- Spectral end-member extraction from images and spectral libraries;
- (Semi-) quantitative spectral matching and classification methods;
- Mineral mapping in rock samples or drill cores of a particular mineralised or geothermal system.

Throughout the course, these topics will be covered in a logical order from instrument data acquisition and data (pre-) processing, to extracting (semi-) quantitative results, and ending with putting the results into the context of the geologic system. The topics will be introduced in lectures and familiarised using computer tutorials. The second part of the course contains a project in which a deeper knowledge of these techniques and application possibilities will be developed.

## TEACHING AND LEARNING APPROACH

This research-informed course contains lectures to introduce new theory, reading assignments and other self-study exercises with associated feedback sessions to deepen the theory, and supervised and unsupervised practicals to put the theory into practice. The course furthermore contains hands-on introductions to some key GeoScience Laboratory instruments. Overall, the course has a very strong experiential learning component.

The course will be completed by a group assignment in which skills from the course will be applied to an authentic sample set to produce a useful dataset and relevant scientific results in, as much as possible, a real-world context.

### TESTS

The course assessment is composed of several elements:

- A closed book written test on the theory of the course (30%)
- An individual assignment to identify and describe a mineral using spectral and geochemical techniques (25%)
- A group assignment resulting in a group presentation with time for questioning (45%)
- Note that the second test opportunity for the ‘group assignment’ as well as for the 'individual assignment' will consist of improving on (i.e., 'repairing') the deliverable(s), and will be assigned a maximum mark of 6.0.

### ENTRY REQUIREMENTS

Compulsory for the Applied Remote Sensing for Earth Sciences (ARS) specialization of the Geo-Information Science and Earth Observation (M-GEO) programme.

Students from other specializations and programmes should have introductory level experience with GIS and Remote Sensing, have an affinity with Earth sciences, and have a good background knowledge of rocks and minerals.

### LEARNING OUTCOMES

Upon completion of this course, the student is able to:

LO 1 Explain the physical principles that guide infrared spectroscopy.

LO 2 Describe the spectral and spatial characteristics of various spectrometers.

LO 3 Operate various imaging and non-imaging spectrometers in the lab and acquire meaningful data.

LO 4 Assess and evaluate the quality of measurements and execute possible corrective measures.

LO 5 Design and execute a spectral interpretation strategy, turning a spectral dataset into a mineralogical and geological interpretation.

LO 6 Test different processing algorithms on spectral datasets and critically evaluate their effect on the geological outcome of the interpretation.

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 20 |
| Supervised practical | 50 |
| Tutorial | 5 |
| Written/oral test | 3 |
| Group assignment | 30 |
| Self-study | 80 |
| Individual assignment | 8 |

## TESTPLAN

| | | Learning Outcomes that are addressed in the test | | |
|---|---|---|---|---|
| | **Learning outcomes (LO) of the course: The student will be able to...** | **Test 1** | **Test 2** | **Test 3** |
| LO 1 | Explain the physical principles that guide infrared spectroscopy. | ● | ● | |
| LO 2 | Describe the spectral and spatial characteristics of various spectrometers. | ● | | |
| LO 3 | Operate various imaging and non-imaging spectrometers in the lab and acquire meaningful data. | | ● | ● |
| LO 4 | Assess and evaluate the quality of measurements and execute possible corrective measures. | | | ● |
| LO 5 | Design and execute a spectral interpretation strategy, turning a spectral dataset into a mineralogical and geological interpretation. | | ● | ● |
| LO 6 | Test different processing algorithms on spectral datasets and critically evaluate their effect on the geological outcome of the interpretation. | | | ● |
| | Test type | Written test | Report | Presentation |
| | Weight of the test | 30 | 25 | 45 |
| | Individual or group test | Individual | Individual | Group |
| | Type of marking | 1-10 | 1-10 | 1-10 |
| | Required minimum mark per test | | | |
| | Number of test opportunities per academic year | 2 | 2 | 2 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Explain the physical principles that guide infrared spectroscopy. | ● | | | | | | | | | | | | |
| LO 2 | Describe the spectral and spatial characteristics of various spectrometers. | ● | | | | | | | | | | | | |
| LO 3 | Operate various imaging and non-imaging spectrometers in the lab and acquire meaningful data. | | | | ● | | | | | | | | | |
| LO 4 | Assess and evaluate the quality of measurements and execute possible corrective measures. | | | | | | | ● | | | | | ● | |

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 5 | Design and execute a spectral interpretation strategy, turning a spectral dataset into a mineralogical and geological interpretation. | | | | | | | ● | | | | | | |
| LO 6 | Test different processing algorithms on spectral datasets and critically evaluate their effect on the geological outcome of the interpretation. | | | | | | ● | | | | | | ● | ● |

# ACQUISITION AND EXPLORATION OF GEOSPATIAL DATA

| **Course** | **201800281** |
|---|---|
| Period | 14 November 2022 - 03 February 2023 |
| EC | 7 |
| Course coordinator | |

## INTRODUCTION

The aim of this course is to equip students with theoretical and practical knowledge on methods for spatial data acquisition and exploration, while helping them to develop critical thinking for method selection. In this course, you will use algorithmic thinking and programming skills to find, retrieve, store, and explore various geospatial datasets. In scientific research, significant time and effort goes into acquiring, understanding, and cleaning the data before the actual analysis begins. Maps and diagrams are not only used to present the final results, but also to verify and explore the data during the whole data processing process phase. After this course, you will have a good overview of acquisition and exploration of geospatial data principles and methods and be able to select the most appropriate data acquisition and exploration methods as well as working environment (among R, Python, C++ etc).

## CONTENT

1. Model-driven architecture for transformational design of geospatial information systems
   - UML for data store design
   - Simple spatial features
2. Data acquisition
   - From space, airborne, terrestrial and in situ sensor systems
   - Through human sensors and from existing repositories
   - Strategies (field survey planning, sampling, collaborative mapping, use of mobile applications)
3. Basics of calculus, probability and statistics for data exploration
   - Calculus
   - Basic rules of probability
   - Distributions of random variables
   - Graphical tools for descriptive statistics
4. Inferential statistics
   - Confidence intervals
   - Hypothesis testing
5. Regression
   - Least squares and linear regression
6. Linear algebra
7. Spatial data quality
   - Elements of spatial data quality in relation to sensors and other data sources.
   - Error propagation and Taylor series.
8. Cartographic data exploration

## TEACHING AND LEARNING APPROACH

This course aims to bring both scientific background and practical skills with respect to the acquisition and exploration of geospatial data. Lectures bring the theoretical background and a series of tutorials prepare students for practical work and the course's individual assignment. Extensive practicals hold a big weight to this course and are intended to facilitate individual and peer learning. Students will be asked to share the findings of their practicals and solutions to problems. Finally, students will have to work on an assignment that will cover different steps of the process from data acquisition to its final visual exploration.

### TESTS
The course mark is based on (1) a written test (weight 60%) and (2) an individual project assignment (40%).

### ENTRY REQUIREMENTS
Basic knowledge and skills on Geo-Information Science and Modelling, Earth Observation and Data Integration: Principles, Approaches and User perspectives.

Students entering the course should have basic programming and GIS skills and be able to select, modify and apply solution strategies implemented in some programming language (e.g., Python, C++, Matlab, R and SpatialSQL).

### LEARNING OUTCOMES
Upon completion of this course, the student is able to:

- LO 1 Design basic database structures for the storage of geospatial data using model-driven architecture principles.
- LO 2 Make informed decisions on: the appropriate sensor or source, and methods for data acquisition, including field surveys, Web Services available through Spatial Data Infrastructures, crowdsourcing and Web-scraping.
- LO 3 Analyse geospatial data resources and describe their usefulness in terms of spatial, temporal, and attribute quality using statistics and calculus concepts.
- LO 4 Apply cartographic design principles in either exploration or presentation of geospatial data.
- LO 5 Use or modify algorithms written in Python, C++, Matlab, R or Spatial SQL as part of acquisition and exploration of geospatial data tasks.

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 38 |
| Supervised practical | 40 |
| Written/oral test | 3 |
| Individual assignment | 40 |
| Self-study | 75 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Learning Outcomes that are addressed in the test<br>Test 1 | Test 2 |
|---|---|---|---|
| LO 1 | Design basic database structures for the storage of geospatial data using model-driven architecture principles. | ● | ● |
| LO 2 | Make informed decisions on: the appropriate sensor or source, and methods for data acquisition, including field surveys, Web Services available through Spatial Data Infrastructures, crowdsourcing and Web-scraping. | ● | ● |
| LO 3 | Analyse geospatial data resources and describe their usefulness in terms of spatial, temporal, and attribute quality using statistics and calculus concepts. | ● | ● |
| LO 4 | Apply cartographic design principles in either exploration or presentation of geospatial data. | ● | ● |
| LO 5 | Use or modify algorithms written in Python, C++, Matlab, R or Spatial SQL as part of acquisition and exploration of geospatial data tasks. | | |
| | Test type | Written test | Report |
| | Weight of the test | 60 | 40 |
| | Individual or group test | Individual | Individual |
| | Type of marking | 1-10 | 1-10 |
| | Required minimum mark per test | | |
| | Number of test opportunities per academic year | 2 | 1 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Design basic database structures for the storage of geospatial data using model-driven architecture principles. | ● | ● | ● | | | | ● | | | | | ● | ● |
| LO 2 | Make informed decisions on: the appropriate sensor or source, and methods for data acquisition, including field surveys, Web Services available through Spatial Data Infrastructures, crowdsourcing and Web-scraping. | ● | ● | | | | ● | ● | | | | | ● | ● |

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 3 | Analyse geospatial data resources and describe their usefulness in terms of spatial, temporal, and attribute quality using statistics and calculus concepts. | | ● | | ● | | | | | | | | | ● |
| LO 4 | Apply cartographic design principles in either exploration or presentation of geospatial data. | | ● | | ● | | ● | ● | | | | | ● | ● |
| LO 5 | Use or modify algorithms written in Python, C++, Matlab, R or Spatial SQL as part of acquisition and exploration of geospatial data tasks. | | | | | | | | | | | | | |

# EXTRACTION, ANALYSIS AND DISSEMINATION OF GEOSPATIAL INFORMATION

| **Course** | **201800290** |
| --- | --- |
| Period | 06 February 2023 - 21 April 2023 |
| EC | 7 |
| Course coordinator | |

## INTRODUCTION

This course teaches the extraction, analysis, and dissemination of information from geospatial data in an iterative approach using concrete applications. Exemplary course topics are the creation of Digital Terrain Models using photogrammetric techniques, and the visualization of the results in a 3D environment using Virtual Reality. Furthermore, you will use different map representations to visualize time series results taking uncertainty of measurements and models into account. Lastly, the design and creation of geoservices and web mapping technology will be discussed.

## CONTENT

1. Photogrammetry
   - Flight planning
   - Image orientation
   - DTM generation
   - 2D and 3D feature extraction

2. GeoWebservices and mapping clients
   - Client-server technology
   - Open Standards and GeoWebservices
   - Web clients for data and map dissemination

3. Geovisualization
   - 3D visualization (depth cues, VR)
   - Time series (animation)
   - Geovisualization environments

4. Uncertainty
   - Uncertainty in image classification (sensitivity)
   - Validation and accuracy assessment
   - Uncertainty visualization

## TEACHING AND LEARNING APPROACH

This course deepens the theoretical knowledge and practical skills regarding the extraction, analysis, and dissemination of geospatial information. Theoretical lectures and flipped-classrooms will provide students with in-depth scientific knowledge of the methods and (ungraded) supervised practical sessions will let students practice these skills. An individual assignment will test the student’s practical knowledge on Geovisualization. Key to this course is a group assignment which integrates the various concepts taught in the lectures and promotes peer-learning. Teams will work together to combine the different processes of extraction, analysis and dissemination into a single practical project. Question hours and example exams will help students prepare for the final individual exam which tests the theoretical knowledge acquired during the course.

## TESTS

Group Assignment “Photogrammetry – Visualization/Webmapping”
Individual Assignment “Geovisualization”
Written test

## ENTRY REQUIREMENTS

Knowledge and skills as covered in the Core courses Geo-information Science and Modelling, Earth Observation and Data Integration: Principles, Approaches and User perspectives.

Being able to develop solution strategies, high-level solution descriptions in pseudo-code, and translations of these into an implementation in some programming language as covered in the course Scientific Geocomputing.

Knowledge and skills with respect to geodata curation, manipulation and transformation, transformational design, mathematics, spatial data quality and cartographic design principles as covered in course Acquisition and Exploration of Geospatial data.

## LEARNING OUTCOMES

Upon completion of this course, the student is able to:

LO 1 Plan a photogrammetric mission with a focus on quality aspects of the results.
LO 2 Utilize image orientation procedures for the generation of topographic products such as maps and Digital Terrain Models.
LO 3 Assess requirements from an application perspective to select appropriate graphic representations to map changes.
LO 4 Determine the requirements of 3d viewing environments, and explain the application of depth cues.
LO 5 Explain the principles of web architectures and web services requirements for web/cloud applications.
LO 6 Explain the role of Open Standards and use them for the creation and consumption of GeoWebservices.
LO 7 Create GeoWebservices and associated web mapping clients for information dissemination
LO 8 Evaluate and analyse the uncertainty of spatial datasets and model outputs, and choose the appropriate option to design an effective uncertainty visualization.

## ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 35 |
| Supervised practical | 20 |
| Written/oral test | 4 |
| Individual assignment | 16 |
| Group assignment | 24 |
| Self-study | 97 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Test 1 Group Assignment | Test 2 Individual Assignment | Test 3 Written test |
|---|---|---|---|---|
| | | Learning Outcomes that are addressed in the test | | |
| LO 1 | Plan a photogrammetric mission with a focus on quality aspects of the results. | ● | | ● |
| LO 2 | Utilize image orientation procedures for the generation of topographic products such as maps and Digital Terrain Models. | ● | | ● |
| LO 3 | Assess requirements from an application perspective to select appropriate graphic representations to map changes. | | ● | ● |
| LO 4 | Determine the requirements of 3d viewing environments, and explain the application of depth cues. | ● | ● | ● |
| LO 5 | Explain the principles of web architectures and web services requirements for web/cloud applications. | ● | | |
| LO 6 | Explain the role of Open Standards and use them for the creation and consumption of GeoWebservices. | ● | | |
| LO 7 | Create GeoWebservices and associated web mapping clients for information dissemination | ● | | |
| LO 8 | Evaluate and analyse the uncertainty of spatial datasets and model outputs, and choose the appropriate option to design an effective uncertainty visualization. | ● | | ● |
| | Test type | Assignment "Photogrammetry - Visualization/Webmapping" | Assignment "Geovisualization" | Written test |
| | Weight of the test | 40 | 20 | 40 |
| | Individual or group test | Group | Individual | Individual |
| | Type of marking | 1-10 | 1-10 | 1-10 |
| | Required minimum mark per test | | | 4 |
| | Number of test opportunities per academic year | 1 | 2 | 2 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Plan a photogrammetric mission with a focus on quality aspects of the results. | ● | | ● | | | | | | | | | | |
| LO 2 | Utilize image orientation procedures for the generation of topographic products such as maps and Digital Terrain Models. | ● | | ● | ● | | ● | | ● | | ● | ● | ● | ● |
| LO 3 | Assess requirements from an application perspective to select appropriate graphic representations to map changes. | | ● | | ● | | | ● | | | | | | |
| LO 4 | Determine the requirements of 3d viewing environments, and explain the application of depth cues. | | ● | | ● | | ● | | ● | | ● | ● | ● | |

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 5 | Explain the principles of web architectures and web services requirements for web/cloud applications. | ● | | ● | ● | | ● | | ● | | ● | ● | ● | ● |
| LO 6 | Explain the role of Open Standards and use them for the creation and consumption of GeoWebservices. | | | ● | ● | | | ● | | | | | | |
| LO 7 | Create GeoWebservices and associated web mapping clients for information dissemination | ● | | ● | | | | | ● | | | | ● | ● |
| LO 8 | Evaluate and analyse the uncertainty of spatial datasets and model outputs, and choose the appropriate option to design an effective uncertainty visualization. | ● | | | ● | | ● | | ● | | ● | | | |

# IMAGE ANALYSIS

| **Course** | **201800302** |
|---|---|
| Period | 24 April 2023 - 07 July 2023 |
| EC | 7 |
| Course coordinator | |

## INTRODUCTION

In this course, you will be introduced to more advanced image analysis methods enabling to enrich your geo-information problem solving abilities. Image processing methods treated in previous courses, such as linear filters, feature based DTM production and conventional hard pixel based classification, face limitations making them insufficient for reliable geo-information extraction in automatic settings. Non-linear filters will be introduced for reduction of noise while preserving the boundaries. In addition, interest operators will be introduced to detect stable structures in images that are invariant to scale and rotation transformation. Various methods for dealing with objects in images will be studied: mathematical morphology and segmentation. Fuzzy and sub-pixel classification will be introduced to deal with uncertainty and to increase the information content extracted from the imagery. For multisource classification decision trees will be introduced. To automatically detect corresponding image positions, the image matching techniques will be introduced. In particular, area-based matching and feature-based matching will be investigated in this course.

## CONTENT

1. Image processing: non-linear filters, Förstner operator, mathematical morphology
2. Image segmentation (split-and-merge, mean shift)
3. Image orthorectification, orthophoto
4. Image matching including area based and feature based methods
5. Dense image matching
6. Image classification methods for spatial and temporal geo-information extraction (fuzzy classification, sub-pixel classification, decision trees, segment based, vague objects)
7. Scale and attribute uncertainty
8. Error propagation

## TEACHING AND LEARNING APPROACH

Image analysis requires a mixture of theoretical concepts and practical skills. The subjects will be introduced in lectures and applied in practical classes. As a preparation for lectures, reading textbook material will be recommended on some subjects. In addition, on some other subjects reading research articles will be recommended after the lecture to go deeper into the subject.
Practical classes will consist of a mixture of a demo by an instructor, individual work following written instructions and summarizing the outcome of the exercise in a class. In practical class students are supposed to work with existing programming codes and modify these (to a limited degree). In this way the students can get insight in the intermediate stages of the image analysis algorithms and make decisions on the outcomes. In these summaries reflection on theoretical concepts will be done. In this way a solid integration of theory and practice will be achieved.

## TESTS

A written test with questions on several subjects taught in the course
An individual assignment on mainly image matching, possibly including also other subjects.
An individual assignment on mainly image classification, possibly including also other subjects.

## ENTRY REQUIREMENTS

Knowledge and skills in programming, linear filters, basic image classification, basic photogrammetry.

Preferably subjects as covered in the courses Scientific Geocomputing, Acquisition and Exploration of Geospatial Data and the course Extraction, Analysis and Dissemination of Geospatial Information.

## LEARNING OUTCOMES

Upon completion of this course, the student is able to:

- LO 1 Develop an image processing chain using non-linear filters and mathematical morphology operations for automatic information extraction from images in context of a given problem.
- LO 2 Choose and apply a segmentation method to a given image and describe the uncertainty of the obtained result.
- LO 3 Make informed decisions on the best classification method for a given set of images and a specific problem.
- LO 4 Apply orthorectification to derive orthophoto.
- LO 5 Make informed decisions on appropriate image matching method for a given type of data and problem.
- LO 6 Evaluate attribute and scale uncertainty and relate it to the quality of derived orthophotos, accuracy of resulting image classification and matching.

## ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 40 |
| Supervised practical | 32 |
| Written/oral test | 3 |
| Individual assignment | 40 |
| Self-study | 81 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Written test | Ind assignment Image Classification | Ind assignment Image Matching |
|---|---|---|---|---|
| | | Learning Outcomes that are addressed in the test | | |
| LO 1 | Develop an image processing chain using non-linear filters and mathematical morphology operations for automatic information extraction from images in context of a given problem. | ● | ● | |
| LO 2 | Choose and apply a segmentation method to a given image and describe the uncertainty of the obtained result. | ● | | |
| LO 3 | Make informed decisions on the best classification method for a given set of images and a specific problem. | ● | ● | |
| LO 4 | Apply orthorectification to derive orthophoto. | | | ● |
| LO 5 | Make informed decisions on appropriate image matching method for a given type of data and problem. | ● | | ● |
| LO 6 | Evaluate attribute and scale uncertainty and relate it to the quality of derived orthophotos, accuracy of resulting image classification and matching. | ● | | |
| | Test type | Written test | Report | Report |
| | Weight of the test | 50 | 25 | 25 |
| | Individual or group test | Individual | Individual | Individual |
| | Type of marking | 1-10 | 1-10 | 1-10 |
| | Required minimum mark per test | | | |
| | Number of test opportunities per academic year | 2 | 2 | 2 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Develop an image processing chain using non-linear filters and mathematical morphology operations for automatic information extraction from images in context of a given problem. | ● | ● | | ● | | ● | | | | | | | |
| LO 2 | Choose and apply a segmentation method to a given image and describe the uncertainty of the obtained result. | ● | ● | | ● | | ● | | | | | | | |
| LO 3 | Make informed decisions on the best classification method for a given set of images and a specific problem. | ● | ● | | ● | | ● | | | | | | | |

| | Learning outcomes (LO) of the course: The student will be able to... | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 4 | Apply orthorectification to derive orthophoto. | ● | ● | | ● | | ● | | | | | | | |
| LO 5 | Make informed decisions on appropriate image matching method for a given type of data and problem. | ● | ● | | ● | | ● | | | | | | | |
| LO 6 | Evaluate attribute and scale uncertainty and relate it to the quality of derived orthophotos, accuracy of resulting image classification and matching. | ● | ● | | ● | | ● | | | | | | | |

# INTEGRATED GEOSPATIAL WORKFLOWS

| **Course** | **201800301** |
|---|---|
| Period | 24 April 2023 - 07 July 2023 |
| EC | 7 |
| Course coordinator | |

## INTRODUCTION

A crucial practical demand lies in converting geodata into usable and actionable geo-information that supports decision-making at various scales and that can be further processed to generate knowledge. As a consequence, scientific workflows, semantic models and effective infrastructures become more important for knowledge sharing and ensuring reproducibility.
This course covers the emerging methods for meaningfully integrating geospatial data through workflows in different application contexts and connect different types of data into a spatial data infrastucture (SDI) on the Web.

## CONTENT

1. **Characteristics and curation of structured and semi-structured data sources**
   - Data source differentiation (Authoritative data, Sensor data, Crowdsourced data, Geosocial media)
   - Data quality
   - Data pro-processing
2. **Semantic information integration**
   - Introduction to knowledge formalization (Semantic web, Ontologies, Linked data)
   - Semantic enrichment
   - Exploratory querying
3. **Scientific workflow & process modelling**
   - Process logic
   - Reproducibility, versioning, performance
   - Workflow languages and systems
4. **Web service exploitation**
   - Web frameworks
   - Client-side visualisation techniques
   - Model-View-Controller (MVC)
5. **Infrastructural system design**
   - Spatial Data Infrastructures
   - User-centric design
   - Interoperability
   - Data discovery

## TEACHING AND LEARNING APPROACH

Students will be confronted with problems from reality in which the integration of heterogeneous data sources is key to derive meaningful information.
The conceptual understanding will be built by the students by creating a concept map within the Living Textbook, based on selected literature.
After learning the principles (through lectures and reading papers) and applying existing tools, they will use their coding experience to create a mini SDI as a proof of concept.
Students will need to critically reflect in a report and in a presentation on the tools which they used and identify their potential, limitations and scalability.

## TESTS

The conceptual knowledge of the student will be evaluated by means of contributions to the Living Textbook and a written exam.
The practical skills will be judged based on the results of assignments, a mini-research and an end-project through presentations and reports. See test plan for balance of weights.

### ENTRY REQUIREMENTS

Knowledge and skills as covered in the courses Scientific Geocomputing, Acquisition and Exploration of Geospatial Data and the course Extraction, Analysis and Dissemination of Geospatial Information.

### LEARNING OUTCOMES

Upon completion of this course, the student is able to:

LO 1 Analyse the quality of structured and semi-structured data sources and apply coding solutions for the storage, querying and curation of this data, appropriate for specific application contexts.
LO 2 Apply semantic information integration through knowledge formalisation, semantic enrichment, exploratory querying and data mining.
LO 3 Construct interoperable and reproducible geospatial workflows based on process modelling methods and workflow languages.
LO 4 Create webservices and visualise their content systematically.
LO 5 Make informed decisions on the infrastructural system design for enabling meaningful data integration on the web.

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 24 |
| Supervised practical | 40 |
| Tutorial | 16 |
| Written/oral test | 3 |
| Individual assignment | 16 |
| Group assignment | 17 |
| Self-study | 80 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Test 1 | Test 2 | Test 3 | Test 4 | Test 5 | Test 6 |
|---|---|---|---|---|---|---|---|
| | | Learning Outcomes that are addressed in the test | | | | | |
| LO 1 | Analyse the quality of structured and semi-structured data sources and apply coding solutions for the storage, querying and curation of this data, appropriate for specific application contexts. | ● | ● | ● | ● | | ● |
| LO 2 | Apply semantic information integration through knowledge formalisation, semantic enrichment, exploratory querying and data mining. | ● | | ● | | | ● |
| LO 3 | Construct interoperable and reproducible geospatial workflows based on process modelling methods and workflow languages. | ● | | | ● | ● | ● |
| LO 4 | Create webservices and visualise their content systematically. | | | | | | |
| LO 5 | Make informed decisions on the infrastructural system design for enabling meaningful data integration on the web. | ● | ● | | | ● | ● |
| | Test type | Oral exam on all content | Living Textbook conceptualization | Assignment Semantic integration | Assignment Workflow modeling | Mini-Research | End Project |
| | Weight of the test | 20 | 20 | 10 | 10 | 15 | 25 |
| | Individual or group test | Individual | Individual | Individual | Individual | Group | Group |
| | Type of marking | 1-10 | 1-10 | 1-10 | 1-10 | 1-10 | 1-10 |
| | Required minimum mark per test | | | | | | |
| | Number of test opportunities per academic year | 2 | 1 | 1 | 1 | 1 | 1 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Analyse the quality of structured and semi-structured data sources and apply coding solutions for the storage, querying and curation of this data, appropriate for specific application contexts. | ● | ● | | | ● | ● | | | ● | ● | ● | ● | |
| LO 2 | Apply semantic information integration through knowledge formalisation, semantic enrichment, exploratory querying and data mining. | ● | ● | ● | ● | | ● | ● | | | | | | ● |

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 3 | Construct interoperable and reproducible geospatial workflows based on process modelling methods and workflow languages. | ● | ● | ● | ● | | ● | ● | | ● | | | | ● |
| LO 4 | Create webservices and visualise their content systematically. | | ● | | ● | | | ● | ● | | | | | |
| LO 5 | Make informed decisions on the infrastructural system design for enabling meaningful data integration on the web. | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |

# SCIENTIFIC GEOCOMPUTING

| Course | 201800280 |
|---|---|
| Period | 14 November 2022 - 03 February 2023 |
| EC | 7 |
| Course coordinator | |

## INTRODUCTION

In this course, the student learns to develop algorithmic solutions to geospatial problems. Turn-key software systems for Geo-information Science and Earth Observation are functionally powerful but have no instant solution to each geospatial problem that may arise. The ability to construct custom solutions is an essential capability of the Geoinformatics specialist, who should have competence in addressing geospatial problems by algorithmic solutions.

You specifically learn about solution strategies, high-level solution descriptions and translations of these into an implementation in some programming language. The course's programming language will be Python, but throughout the Geoinformatics specialization, you will learn to implement your algorithms using also other programming/scripting languages/environments.

Dissemination of code output is important and so we will make an excursion into the visualization of scientific outputs such as charts and maps, and web programming also.

We will discuss the scientific side of programming by an introduction into literate programming, which emphasizes documentation of code and the FAIR principles of scientific data management, which apply to data and code. We emphasize the role of data in geospatial algorithms, as these are often data-intensive. By reviewing and developing (high-level) code, you will increase your understanding of basic concepts in Geo-information Science and Earth Observation.

## CONTENT

1. Mathematics for computing: predicate logic, set theory, regular expressions (LO 1)
2. Algorithmics: computational abstractions, problem classes, time and data complexity, algorithm design and analysis (LO 1, 2, 3, 8)
3. Data, data types, variables, expressions, functions and data manipulation (LO 2, 4, 5)
4. Spatial data types (simple vector features, image types) (LO 2, 4, 5)
5. Control flow and set-based operations (LO 3, 4)
6. Literate programming: recording train of thought, interwoven documentation and code, Jupyter notebook principles (LO 1, 2, 3, 4, 6, 8)
7. Principles of scientific data visualization (charts and maps) (LO 6)
8. Principles of web programming (LO 7)
9. Libraries for spatial data handling (LO 3, 5)
10. Spatial database operation (LO 4, 5)

## TEACHING AND LEARNING APPROACH

The student should expect a course that aims to bring professional and scientific skills in computational work with geospatial data. Short but intensive lectures bring the theoretical background, which is separately examined. Extensive practicals aim for the student to learn alone but also together and to share with peers in what is learned; students will be asked to explain their problems and solutions in the practical sessions. These practicals prepare for a batch of skills tests that each student executes individually during the course. A final skills test is executed at course end.

In the post-covid19 era, we may continue to see specific requirements and conditions for education. These may impact opportunities for face-to-face exchange, which appears especially relevant for practicals supervision. We will try find ways that allow optimal exchange and discussion between supervisors and students.

### TESTS
Written test: one on theory, open book (40%)
Written test: one on coding skills, open book (30%)
Individual assignments: two (or more) on separate topics (30%)*

*: No resit opportunity offered.

### ENTRY REQUIREMENTS
Sufficient understanding of the spatial data models (simple vector features, raster images) and their elements and spatial data operations as covered in the Core courses Geo-information Science and Modelling, Earth Observation and Data Integration.

The course is likely to see entrants with different levels of understanding and skills in the computational (scripting/coding) domain. Its design assumes no previous scripting/coding experience, but having such will generally help.

### LEARNING OUTCOMES
Upon completion of this course, the student is able to:

- LO 1 Explain mathematical notions in algorithmics and literate programming, and apply in code development.
- LO 2 Understand and apply the fundamentals of programming, and express programs in properly documented code. Use of geospatial data in algorithms, amongst others, through dedicated libraries.
- LO 3 Critically evaluate program logic and correctness through read, test and debug cycles.
- LO 4 Programmatically manipulate data containers such as plain text files, vector data sets and raster images, and program-internal containers such as arrays.
- LO 5 Use spatial databases to load, curate and otherwise manipulate data in a vector database.
- LO 6 Explain and use in code the fundamental notions of scientific data visualization.
- LO 7 Explain and use principles of web programming.
- LO 8 Develop independent learning, critical thinking through portfolio building.

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 54 |
| Supervised practical | 30 |
| Written/oral test | 10 |
| Individual assignment | 24 |
| Self-study | 78 |

## TESTPLAN

| | **Learning outcomes (LO) of the course: The student will be able to...** | **Test 1 (theory)** | **Test 2 (skills)** | **Test 3 (portfolio 1)** | **Test 4 (portfolio 2)** |
|---|---|---|---|---|---|
| | | **Learning Outcomes that are addressed in the test** | | | |
| LO 1 | Explain mathematical notions in algorithmics and literate programming, and apply in code development. | ● | | | |
| LO 2 | Understand and apply the fundamentals of programming, and express programs in properly documented code. Use of geospatial data in algorithms, amongst others, through dedicated libraries. | | ● | ● | |
| LO 3 | Critically evaluate program logic and correctness through read, test and debug cycles. | ● | ● | ● | ● |
| LO 4 | Programmatically manipulate data containers such as plain text files, vector data sets and raster images, and program-internal containers such as arrays. | | ● | ● | ● |
| LO 5 | Use spatial databases to load, curate and otherwise manipulate data in a vector database. | ● | | | ● |
| LO 6 | Explain and use in code the fundamental notions of scientific data visualization. | | ● | ● | |
| LO 7 | Explain and use principles of web programming. | ● | | | |
| LO 8 | Develop independent learning, critical thinking through portfolio building. | | | ● | ● |
| | Test type | Digital test | Digital test | Portfolio | Portfolio |
| | Weight of the test | 40 | 30 | 15 | 15 |
| | Individual or group test | Individual | Individual | Individual | Individual |
| | Type of marking | 1-10 | 1-10 | 1-10 | 1-10 |
| | Required minimum mark per test | | | | |
| | Number of test opportunities per academic year | 2 | 2 | 1 | 1 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Explain mathematical notions in algorithmics and literate programming, and apply in code development. | ● | ● | ● | ● | | ● | | | | | ● | ● | |
| LO 2 | Understand and apply the fundamentals of programming, and express programs in properly documented code. Use of geospatial data in algorithms, amongst others, through dedicated libraries. | ● | ● | ● | ● | ● | ● | ● | ● | | ● | ● | ● | ● |
| LO 3 | Critically evaluate program logic and correctness through read, test and debug cycles. | | ● | ● | ● | ● | | ● | | | | | ● | |

| | **Learning outcomes (LO) of the course: The student will be able to…** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 4 | Programmatically manipulate data containers such as plain text files, vector data sets and raster images, and program-internal containers such as arrays. | | ● | ● | | ● | | ● | ● | | | ● | ● | |
| LO 5 | Use spatial databases to load, curate and otherwise manipulate data in a vector database. | ● | | | ● | | | | | | | | ● | |
| LO 6 | Explain and use in code the fundamental notions of scientific data visualization. | ● | | | ● | | | | | | | | ● | |
| LO 7 | Explain and use principles of web programming. | | | | ● | | | | | ● | | | ● | ● |
| LO 8 | Develop independent learning, critical thinking through portfolio building. | | ● | | | ● | ● | | | ● | | ● | ● | ● |

# CADASTRAL DATA ACQUISITION TECHNOLOGIES AND DISSEMINATION METHODS

| **Course** | **201800294** |
|---|---|
| Period | 06 February 2023 - 21 April 2023 |
| EC | 7 |
| Course coordinator | |

## INTRODUCTION

Land Informatics is the science and technology that deals with the creation, maintenance, and dissemination of land information. It uses the existing structures of geoinformatics to design fit-for-purpose land administration systems. 3D Cadastres are land administration concepts, technologies, and systems that deal with the height dimension. Moreover, the use of ICT, open source, proprietary and web-based services, have seen an emergence of innovative cadastres. They can efficiently support unconventional land administration through documentation and management of land rights.
This course aims to provide contemporary knowledge, hands-on experience, and implementation know-how in land informatics and 3D Cadastre using innovative tools. Through practical sessions, students obtain experience and a better understanding of the possible innovations and their applications. Their relevance for different country contexts and scenarios are evaluated.

## CONTENT

- Technical aspects of societal challenges relating to 'land grabbing', food security, climate change, and rapid urbanization;
- Geodetic science for land administration, including models of earth, dates, coordinate systems, projects, conversion, transformation, and control networks;
- Cadastral surveying and demarcation theories, including fit-for-purpose approaches, boundary options, monuments and identifiers, whole-to-part / part-to-whole, 3D options, establishment, maintenance, and renewal;
- Global navigation satellite systems (GNSS) for land administration, including GPS signals, segments, satellites, ranging techniques (inc. DGPS), mobile mapping, receiver types, quality, errors, and positioning infrastructure;
- Hands-on on Free and Open Source software/tools for land tenure documentation;
- Imagery for land administration including aerial imagery, orthophotos, satellite imagery, terrestrial imagery, UAV imagery, LiDAR and Laser Scanning and oblique imagery;
- Cadastral data rejuvenation including scanning, digitizing, and georeferencing of maps, sketches, and legal documents;
- Integrated technology designs for land adjudication, surveying, demarcation, and recording.
- 3D modelling, BIM for 3D Cadastre and smart cities
- Web platforms that facilitate open and transparent land administration - Crowd Sourced Cadastres;
- Web architectures, web services; open systems; static and dynamic geo-services; client/server components for web service implementation;
- Case studies from the professional experiences of students.

## TEACHING AND LEARNING APPROACH

- Active learning approach will be applied to the lectures with more theory
- Lectures are supported by PPT and references to reading material
- The students are asked to write a project proposal for a tender applying the theoretical knowledge obtained from the lectures in a group assignment

### TESTS

Test: 40%

Group assignment: 40%

Individual assignment: 20%

### ENTRY REQUIREMENTS

Basic land surveying skills and knowledge, and operational knowledge of ESRI ArcGIS, ERDAS, and Microsoft Office. Intermediate knowledge of cadastres, land registration, land information systems. Basic notions of conceptual modelling.

### LEARNING OUTCOMES

Upon completion of this course, the student is able to:

LO 1 Explain current demands, challenges and opportunities in the domains of land informatics and 3D Cadastres.

LO 2 Compare modern geospatial, photogrammetric and 3D modelling technologies and their application in land informatics and 3D Cadastre.

LO 3 Formulate and assess integrated technological solutions for adjudication, surveying, demarcation, and recording in various contexts.

LO 4 Justify and defend the importance of alternative techniques for capturing cadastral/tenure information

LO 5 Explain the principles and provide examples of web architectures, web services and open systems in real life geo-information value chains.

LO 6 Create static and dynamic geo-services using web frameworks for the creation of web applications that consume geo-services.

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 52 |
| Supervised practical | 40 |
| Study trip | 4 |
| Written/oral test | 3 |
| Group assignment | 30 |
| Individual assignment | 16 |
| Self-study | 51 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Test 1 | Test 2 | Test 3 |
|---|---|---|---|---|
| | | Learning Outcomes that are addressed in the test | | |
| LO 1 | Explain current demands, challenges and opportunities in the domains of land informatics and 3D Cadastres. | ● | ● | |
| LO 2 | Compare modern geospatial, photogrammetric and 3D modelling technologies and their application in land informatics and 3D Cadastre. | ● | | |
| LO 3 | Formulate and assess integrated technological solutions for adjudication, surveying, demarcation, and recording in various contexts. | ● | ● | |
| LO 4 | Justify and defend the importance of alternative techniques for capturing cadastral/tenure information | | ● | ● |
| LO 5 | Explain the principles and provide examples of web architectures, web services and open systems in real life geo-information value chains. | ● | | ● |
| LO 6 | Create static and dynamic geo-services using web frameworks for the creation of web applications that consume geo-services. | ● | | ● |
| | Test type | Digital test | Group assignment | Individual assignment |
| | Weight of the test | 40 | 40 | 20 |
| | Individual or group test | Individual | Group | Individual |
| | Type of marking | 1-10 | 1-10 | 1-10 |
| | Required minimum mark per test | | | |
| | Number of test opportunities per academic year | 2 | 1 | 2 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Explain current demands, challenges and opportunities in the domains of land informatics and 3D Cadastres. | ● | ● | | | | | | | | | ● | | |
| LO 2 | Compare modern geospatial, photogrammetric and 3D modelling technologies and their application in land informatics and 3D Cadastre. | | | ● | ● | ● | | | ● | | ● | ● | ● | |
| LO 3 | Formulate and assess integrated technological solutions for adjudication, surveying, demarcation, and recording in various contexts. | | | | ● | | | | ● | | ● | ● | | |

| **Learning outcomes (LO) of the course: The student will be able to...** | | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 4 | Justify and defend the importance of alternative techniques for capturing cadastral/tenure information | | | | ● | ● | | | ● | | ● | ● | | ● |
| LO 5 | Explain the principles and provide examples of web architectures, web services and open systems in real life geo-information value chains. | ● | ● | | ● | | | | | | | | | |
| LO 6 | Create static and dynamic geo-services using web frameworks for the creation of web applications that consume geo-services. | | ● | | ● | | | | ● | | | | | |

# LAND INFORMATION SYSTEMS AND MODELS

| **Course** | **201800286** |
|---|---|
| Period | 14 November 2022 - 03 February 2023 |
| EC | 7 |
| Course coordinator | |

## INTRODUCTION

Land information systems are systems for acquiring, processing, storing, and distributing information about land. They may contribute to secure land tenure or support land valuation, land use planning and land development. Despite contextual differences between countries, there are fundamental concepts that apply to all land information systems. The main objective of this course is to discover, apply, and assess these concepts and technologies – and inspire students to deploy them in the creation and maintenance of scalable real-world land information systems.

The course focuses on the modeling of data and processes for the implementation of Information Systems for Land Administration. It therefore has two integrated series of lectures: one focusing on data modeling and implementation in a spatially enabled database management systems; the other focusing on the identification and modeling/design of software functionalities that support land administration processes. These two parts are linked together by a practical LIS prototyping workshop.

## CONTENT

- Overview of Information Systems and Land Information Systems
- Information Systems development and the software process (incl. tools and specific methodologies)
- Introduction to requirements engineering
- Fundamental concepts for land information systems (modelling; design and architectures; transactions and processes; users and contexts)
- Business and information process modelling with the Unified Modelling Language (UML):
    - Use case diagrams
    - Information flow diagrams
    - Activity diagrams
- Principles of spatial database design:
    - Fundamentals of the relational data model
    - Object-relational modelling
- Domain modeling with the Unified Modelling Language (UML):
    - Class diagrams
    - Object/Instance diagrams
- Model driven architecture
- Spatial data manipulation and access using SQL (implementing transaction concepts; database management)
- Land Administration Domain Model (ISO LADM)
- Prototype Land Information System Development (incl. transaction designs using database and geo-ICT)
- Advanced concepts (key registers; webservices; front office; back office; one stop shop)
- Future developments for LIS.

## TEACHING AND LEARNING APPROACH

This course is taught through lectures and hands-on activities presented as exercises. An individual assignment and a group assignment evaluate learning of practical skills and an exam assesses the students' understanding of concepts introduced in the course. Exercises and assignments are performed using software introduced during lectures or supervised practical sessions and, where possible, real-world data-sets are used.

The group assignment is completed as part of the LIS Workshop during which student groups develop a software prototype that implements one or more land administration processes using the Scrum method. The Scrum approach, used in most modern software development projects, is introduced at the beginning of the course. Students have the opportunity to practice using the Scrum method in exercises.

### TESTS

Written test: 50%

Individual assignment: 25%

Group assignment: 25%

### ENTRY REQUIREMENTS

Experience in Land Administration or motivated to work in this domain. It is an advantage to have:

- followed the course Responsible Land Administration, or
- a basic understanding of Geographic information models, or
- experience/background/knowledge in an ICT or IS field

### LEARNING OUTCOMES

Upon completion of this course, the student is able to:

LO 1 Explain in detail the role of information systems for land administration.

LO 2 Identify, describe, and apply the phases of the system development life cycle.

LO 3 Apply principles, concepts, methods, tools and standards for the design and application of data models.

LO 4 Apply principles, concepts, methods, tools and standards for the design and implementation of functionalities and processes in an information system.

LO 5 Design, develop and perform operations in a prototype LIS.

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 36 |
| Supervised practical | 42 |
| Individual assignment | 24 |
| Group assignment | 48 |
| Self-study | 42 |
| Written/oral test | 4 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Test 1 | Test 2 | Test 3 |
|---|---|---|---|---|
| | | Learning Outcomes that are addressed in the test | | |
| LO 1 | Explain in detail the role of information systems for land administration. | ● | | |
| LO 2 | Identify, describe, and apply the phases of the system development life cycle. | ● | | ● |
| LO 3 | Apply principles, concepts, methods, tools and standards for the design and application of data models. | ● | ● | ● |
| LO 4 | Apply principles, concepts, methods, tools and standards for the design and implementation of functionalities and processes in an information system. | ● | ● | ● |
| LO 5 | Design, develop and perform operations in a prototype LIS. | | | ● |
| | Test type | Written test | Exercise | Assignment |
| | Weight of the test | 40 | 30 | 30 |
| | Individual or group test | Individual | Individual | Group |
| | Type of marking | 1-10 | 1-10 | 1-10 |
| | Required minimum mark per test | | | |
| | Number of test opportunities per academic year | 2 | 2 | 2 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Explain in detail the role of information systems for land administration. | ● | | | | | | | | | | | | |
| LO 2 | Identify, describe, and apply the phases of the system development life cycle. | | | ● | ● | | | ● | | | | | | |
| LO 3 | Apply principles, concepts, methods, tools and standards for the design and application of data models. | ● | ● | ● | ● | | | | | | | | | |

| | Learning outcomes (LO) of the course: The student will be able to... | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 4 | Apply principles, concepts, methods, tools and standards for the design and implementation of functionalities and processes in an information system. | | ● | ● | ● | | | ● | | | | | | |
| LO 5 | Design, develop and perform operations in a prototype LIS. | | | ● | ● | | | ● | ● | ● | | ● | ● | |

# ORGANIZING LAND INFORMATION

| **Course** | **201800305** |
| --- | --- |
| Period | 24 April 2023 - 07 July 2023 |
| EC | 7 |
| Course coordinator | |

**INTRODUCTION**

Land administration has long been executed through state-based agencies such as cadastral departments, land registry offices, ministries of land, or local governments with their own analogue or digital data repositories. These organizations do not act in a vacuum, but within larger institutional fields and forces. The broader environment of land governance, in which public organizations operate, is characterized by the interactions of multiple state and non-state actors, formal and informal practices, a multitude of regulatory frameworks and increasing global interconnectivity. This environment has been witnessing public sector reforms and increased adoption of (geo)Information and Communication Technologies (ICT), including automatization techniques, mobile device generated data, crowdsourcing and advanced remote sensing technologies. In many places more established forms of organizing meet latest technological developments. While some organizations are beginning to digitize paper-based workflows, others may function through highly automated and digitized processes. At the same time information technologies and digital data are not merely neutral tools, but they reflect, transport and transform the practices and values of organizations and institutional fields.

It is important therefore to understand and learn how to describe, explain, and assess organizational change in response to changing environments, (geo-)ICT implementation, and related forms of data sharing, uses and dissemination. In this course, these socio-technical processes are addressed from social science and from applied technology angles

## CONTENT

**1) Organizational change**

Topics:

- Metaphors of organizations
- Describing organizational structure and process

Related activities (including formative/summative assessment moments):

- SWOT analysis workshop
- Literature analysis

**2) Organizational change and ICT**

Topics:

- Re-engineering the organization
- Responsible data management as a driver of organizational change
- Co-shaping between organizational change and ICT implementation

Related activities (including formative/summative assessment moments):

- Literature analysis
- Engineering workflows: workflow modelling assignment

**3) Organizing in open data environments**

Topics:

- Access to, integration and dissemination of geo-information
- Responsible data management
- Open data and data protection

Related activities (including formative/summative assessment moments):

- Focus group about the balance between open data/data protection
- Individual paper assignment on organizing in (open) data environments

## TEACHING AND LEARNING APPROACH

In this course the socio-technical processes involved in organizational change are addressed from social science and from applied technology angles as stated in the introduction. Social science focuses on insights from organization and management studies critical data studies and geodata ethics . To grasp these insights and their relevance to practice lectures are complemented by student-led activities, including the analysis of relevant literature and discussions, and application of organizational assessment and strategy building frameworks. The applied technology angle of the course is addressed through two extensive practical periods with assignments (ca. 1/2 of the allocated time of the course), during which students will acquire and apply technological skills to manage organizational workflows and to analyse web services for spatial data provision. Through the incorporation of literature analysis activities, focus group and interview methods into activities and assignments the course also provides opportunity to learn and practice these research skills that are applicable beyond the specific course content.

## TESTS

- Literature analysis group assignment: 20%
- Individual SWOT assignment: 20%
- Individual WFMS assignment: 30%
- Individual paper assignment: 30%

### ENTRY REQUIREMENTS

- Understanding and knowledge of basic land administration concepts and principles
- Basic critical reading/writing ability and analytical skills
- Fluency in using computers and online data searches
- Affinity with and/or openness towards learning the techniques of workflow digitalization
- Desire to understand both institutional and technical dimensions of the organizational processes

### LEARNING OUTCOMES

Upon completion of this course, the student is able to:

LO 1 know about and be able to critically assess organizational implications of ICT implementation and responsible data management.

LO 2 systematically assess an organization and its environment in order to develop a change strategy.

LO 3 critically discuss and evaluate opportunities and risks of open data environments form social and technical perspectives.

LO 4 create a model to manage an organization's workflows to improve spatial data sharing.

LO 5 apply basic qualitative social science research methods, which are useful in organizational assessment, innovation management, and academic research: e.g. semi-structured interviews, focus groups, and qualitative content analysis.

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 20 |
| Supervised practical | 38 |
| Tutorial | 22 |
| Written/oral test | 6 |
| Individual assignment | 34 |
| Group assignment | 16 |
| Self-study | 60 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Literature Analysis | SWOT Analysis | Workflow Management Modelling | Scientific Paper |
|---|---|---|---|---|---|
| | | Learning Outcomes that are addressed in the test | | | |
| LO 1 | know about and be able to critically assess organizational implications of ICT implementation and responsible data management. | ● | | | ● |
| LO 2 | systematically assess an organization and its environment in order to develop a change strategy. | | ● | | |
| LO 3 | critically discuss and evaluate opportunities and risks of open data environments form social and technical perspectives. | | | ● | ● |
| LO 4 | create a model to manage an organization's workflows to improve spatial data sharing. | | | ● | |
| LO 5 | apply basic qualitative social science research methods, which are useful in organizational assessment, innovation management, and academic research: e.g. semi-structured interviews, focus groups, and qualitative content analysis. | | | | ● |
| | Test type | Oral group presentation with student led discussion | Oral presentation of results | Modelling and implementing a workflow to improve data sharing in organization | Conduct and write up mini-research project |
| | Weight of the test | 20 | 20 | 30 | 30 |
| | Individual or group test | Group | Individual | Individual | Individual |
| | Type of marking | 1-10 | 1-10 | 1-10 | 1-10 |
| | Required minimum mark per test | | | | |
| | Number of test opportunities per academic year | 2 | 2 | 1 | 2 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | Learning outcomes (LO) of the course: The student will be able to... | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | know about and be able to critically assess organizational implications of ICT implementation and responsible data management. | ● | | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| LO 2 | systematically assess an organization and its environment in order to develop a change strategy. | ● | | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| LO 3 | critically discuss and evaluate opportunities and risks of open data environments form social and technical perspectives. | ● | ● | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |

| Learning outcomes (LO) of the course: The student will be able to... | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 4 | create a model to manage an organization's workflows to improve spatial data sharing. | ● | ● | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| LO 5 | apply basic qualitative social science research methods, which are useful in organizational assessment, innovation management, and academic research: e.g. semi-structured interviews, focus groups, and qualitative content analysis. | ● | ● | | ● | ● | ● | ● | | ● | ● | ● | ● | ● |

# RESPONSIBLE LAND ADMINISTRATION

| **Course** | **201800279** |
|---|---|
| Period | 14 November 2022 - 03 February 2023 |
| EC | 7 |
| Course coordinator | |

## INTRODUCTION

This course introduces land administration in the context of land policy and sustainable development using the land management paradigm as an initial guiding framework.

The land management paradigm stresses the relationship between land policy and land administration functions – land tenure, land value, land use and land development – and the wider societal goals.

The economic, environmental, and social drivers underpinning land policy development are examined, with an emphasis on the need for securing land rights for all.

Based on the core notion of the people-to-land relationship, land tenure, land rights, land law, security of tenure, and systems of land registration and cadastre are addressed.

New insights in acknowledging and securing land rights, new societal drivers and innovative technical solutions challenges conventional forms of land administration. The course therefore addresses both conventional and innovative ways of securing land rights, promoting a paradigm shift towards responsible land administration.

The course relates state-of-the-art scientific knowledge to students' experiences, perceptions and country context.

## CONTENT
### Units

Concepts and context

- Land and Land administration defined
- Societal aims
- Institutional functions and aims
- Major challenges in Land Administration
- Land Management Paradigm
- Towards Responsible Land Administration
- Evaluating land administration projects

Land Policy Framework

- Land Policy
- Land Law

Land Tenure

- People-to-land relationship
- Land tenure security
- Land tenure systems
- Land rights
- Women's Land Rights and vulnerable groups/slums & informal settlements

Land Management and Development

- Land use
- Land value
- Land taxation
- Land markets
- Land consolidation
- Land readjustment
- Land expropriation and compensation
- Land reform

Land Registration

- Adjudication
- Regularization
- Registration and Cadastre
- Up-dating/maintaining
- Towards Fit-for-Purpose land registration

## TEACHING AND LEARNING APPROACH
The educational approach applied in the course is based on the principles of experience-based learning. Students' experiences and tacit knowledge are an important source of learning. Systematic analysis of these experiences will be combined with scientific knowledge and critical reflection.
The course is characterized by a blend of lectures, guest lectures, videos, games and individual and group exercises (reading assignments, poster development, presentations and discussions).

## TESTS
- Written test (closed book, with an opportunity for resit in case of fail): 55%
- Land Administration Country Case (assignment): 35% Since the portfolio of completed practical assignments is very time-consuming, there is only one full test opportunity per academic year. However, students can repair the first attempt, leading to a max of 6 points for this assignment.
- Post reading discussions: 10%

### ENTRY REQUIREMENTS
Experience in land administration or motivation to work in land administration.

### LEARNING OUTCOMES
Upon completion of this course, the student is able to:

LO 1 Explain and discuss the concept land administration and examine the impact of land administration projects on land tenure.
LO 2 Justify and defend the importance of responsible land administration.
LO 3 Compare and contrast different approaches in securing land tenure and related systems of land registration in different countries
LO 4 Evaluate the role of land administration in land management and land development.
LO 5 Propose and integrate responsible land administration measures in support of the conventional land management paradigm.

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 39 |
| Supervised practical | 5 |
| Tutorial | 32 |
| Study trip | 7 |
| Written/oral test | 9 |
| Individual assignment | 30 |
| Group assignment | 11 |
| Self-study | 65 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Test 1 | Test 2 | Test 3 |
|---|---|---|---|---|
| | | Learning Outcomes that are addressed in the test | | |
| LO 1 | Explain and discuss the concept land administration and examine the impact of land administration projects on land tenure. | ● | | |
| LO 2 | Justify and defend the importance of responsible land administration. | ● | | ● |
| LO 3 | Compare and contrast different approaches in securing land tenure and related systems of land registration in different countries | | ● | |
| LO 4 | Evaluate the role of land administration in land management and land development. | ● | | ● |
| LO 5 | Propose and integrate responsible land administration measures in support of the conventional land management paradigm. | ● | ● | |
| | Test type | Written test | Land registration assignment | Post reading discussions |
| | Weight of the test | 55 | 35 | 10 |
| | Individual or group test | Individual | Individual | Individual |
| | Type of marking | 1-10 | 1-10 | 1-10 |
| | Required minimum mark per test | | | |
| | Number of test opportunities per academic year | 2 | 1 | 1 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Explain and discuss the concept land administration and examine the impact of land administration projects on land tenure. | ● | ● | ● | ● | | ● | ● | ● | | ● | ● | ● | |
| LO 2 | Justify and defend the importance of responsible land administration. | ● | ● | | ● | ● | | | ● | ● | ● | ● | | |
| LO 3 | Compare and contrast different approaches in securing land tenure and related systems of land registration in different countries | ● | ● | ● | | ● | | | ● | | ● | ● | ● | ● |

| | Learning outcomes (LO) of the course: The student will be able to... | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 4 | Evaluate the role of land administration in land management and land development. | ● | | ● | | ● | ● | | ● | ● | ● | ● | ● | ● |
| LO 5 | Propose and integrate responsible land administration measures in support of the conventional land management paradigm. | ● | ● | ● | ● | | ● | ● | ● | ● | ● | ● | ● | |

# DISASTER RISK MANAGEMENT

| **Course** | **201800304** |
|---|---|
| Period | 24 April 2023 - 07 July 2023 |
| EC | 7 |
| Course coordinator | |

## INTRODUCTION

The knowledge of hazardous processes and the ability to predict their occurrence in terms of intensity and frequency and their interaction are important requirements to quantify their impact on society. This module focuses on the analysis of the risk, its evaluation, and its use in decision making for different disaster management phases.

The assessment of risk is a very multi-disciplinary field, that requires knowledge on hazards (types, frequency, intensity, modeling methods), elements-at-risk (types, classification, data collection, quantification), vulnerabilities (physical, social, environmental, institutional), capacities (to predict, cope, and recover) and resilience. Risk could be expressed as qualitative classes, risk matrices, or quantified as expected losses (e.g. monetary values, population).

Qualitative and/or quantitative risk assessment is used as a basis for different types of decision-making by various stakeholders, with different objectives: evaluating different risk reduction planning alternatives; link meteorological forecasts with loss estimation in impact-based forecasting; analyze post-disaster reconstruction alternatives in order to “build-back-better”, and increase the resilience. From the perspective of a continuously changing world, driving forces such as climate change, socio-economic development, population growth, and land-use change will put pressure on society, and require that risk is analyzed for future scenarios in order to plan wisely.

## CONTENT

The course is organized in two main blocks: one block that leads towards the quantitative analysis of risk, and the other block that uses risk information for decision making in different disaster management phases.

The first block gives an overview of the methods to generate elements-at-risk databases, with a focus on buildings and population. Several methods for evaluating physical vulnerability are introduced, with a focus on building vulnerability for flooding and earthquakes. Also, social vulnerability assessment with the use of multi-criteria evaluation is treated. Different approaches for analyzing risk are presented, depending on the availability of input data, the scale of analysis, and objectives.

The second block starts with a discussion on the evaluation of risk, and risk acceptability. The requirements of different stakeholders for risk information are discussed. Risk information can be used for risk reduction planning, and cost-benefit analysis is applied to compare various alternatives. The use of risk information is also presented for early warning applications, as impact-based forecasting. Damage assessment methods are treated to validate loss estimation, and the use of risk information in disaster reconstruction planning is presented. Finally, also changes in risk due to climate change, population change, and land-use change are treated.

### TEACHING AND LEARNING APPROACH

Students will be encouraged to find creative solutions in the use of models, data, and concepts taught as well as state-of-the-art literature and consultation of in-house experts. Introductory lectures are given by teachers that give an overview of the particular topic and guide students with respect to main methods and techniques. For most of the topics treated, an accompanying GIS exercise is offered, in which students can apply what was taught. The exercises contain also advanced sections, where students are further challenged to come up with new solutions. Answer sheets are provided for each of the exercises. Most of the exercises relate to RiskCity, a (partly) hypothetical case study city in a developing country that is exposed to multiple hazards (earthquakes, floods, landslides, technological hazards). Several larger case studies are included where students work in small groups on a particular problem in a real case study related to risk assessment. Students build up a portfolio of assignments.

The teaching approach contains:

1 - Keynote lectures to introduce key concepts and principles

2 - Supervised practicals to bring the knowledge into practice using a range of tools

3 - Tutorials for personalized and plenary feedback and to explore more independently the use of knowledge and tools

4 - Project work, either individual or group projects

### TESTS

- Group project on multi-hazard risk assessment (30 %)
- Group presentation on risk mitigation options in the Netherlands (15%)
- Individual Final project (report) (30 %)
- Small tests (quiz) and assignments on individual topics (25 %)

### ENTRY REQUIREMENTS

Compulsory for the ‘Natural Hazards and Disaster Risk Reduction’ (NHR) specialization of the ‘Geo-information Science and Earth Observation (M-GEO) programme.
Students from other specializations and programmes should have introductory level experience with GIS and Remote Sensing, and a background in earth sciences, geography, environmental science or civil engineering.

### LEARNING OUTCOMES

Upon completion of this course, the student is able to:

LO 1 Develop a deeper understanding of the risk components (hazard, exposure, vulnerability, capacity, and resilience), and the way these are combined for different types of risk.

LO 2 Generate and select relevant spatial and temporal data for risk assessment at specific scales of analysis and for specific objectives.

LO 3 Utilize and evaluate appropriate methods for integrated qualitative and quantitative risk assessment.

LO 4 Apply risk information for different disaster management phases to make society more resilient.

LO 5 Communicate effectively on risk and hazard information to a professional and non-professional audience.

## ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 24 |
| Supervised practical | 35 |
| Tutorial | 4 |
| Study trip | 16 |
| Written/oral test | 0 |
| Individual assignment | 28 |
| Group assignment | 20 |
| Self-study | 69 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | written test | group project assignment | poster assignment | individual project assignment |
|---|---|---|---|---|---|
| | | Learning Outcomes that are addressed in the test | | | |
| LO 1 | Develop a deeper understanding of the risk components (hazard, exposure, vulnerability, capacity, and resilience), and the way these are combined for different types of risk. | ● | | | ● |
| LO 2 | Generate and select relevant spatial and temporal data for risk assessment at specific scales of analysis and for specific objectives. | ● | ● | | ● |
| LO 3 | Utilize and evaluate appropriate methods for integrated qualitative and quantitative risk assessment. | ● | ● | ● | ● |
| LO 4 | Apply risk information for different disaster management phases to make society more resilient. | ● | | ● | ● |
| LO 5 | Communicate effectively on risk and hazard information to a professional and non-professional audience. | | ● | | ● |
| | Test type | Quiz | Presentation | Poster | Report |
| | Weight of the test | 25 | 30 | 15 | 30 |
| | Individual or group test | Individual | Group | Group | Individual |
| | Type of marking | 1-10 | 1-10 | 1-10 | 1-10 |
| | Required minimum mark per test | | | | |
| | Number of test opportunities per academic year | 2 | 1 | 1 | 2 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Develop a deeper understanding of the risk components (hazard, exposure, vulnerability, capacity, and resilience), and the way these are combined for different types of risk. | ● | | | | | | | | | | | | |
| LO 2 | Generate and select relevant spatial and temporal data for risk assessment at specific scales of analysis and for specific objectives. | | ● | | | ● | | ● | | ● | | | ● | |

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 3 | Utilize and evaluate appropriate methods for integrated qualitative and quantitative risk assessment. | | | ● | ● | ● | | | | | | | | |
| LO 4 | Apply risk information for different disaster management phases to make society more resilient. | | | ● | | ● | | | | | | ● | | |
| LO 5 | Communicate effectively on risk and hazard information to a professional and non-professional audience. | | | | | | | | ● | | ● | ● | ● | |

# INTRODUCTION TO HAZARD AND RISK

| **Course** | **201800276** |
|---|---|
| Period | 14 November 2022 - 03 February 2023 |
| EC | 7 |
| Course coordinator | |

## INTRODUCTION

This course will provide a fundamental introduction to natural hazards and the disaster risk concept, as well as the role of geomatics, in particular remote sensing (RS). It builds on the knowledge students gained in the core courses on basic RS and GIS principles, and expands it. The course aims at creating a knowledge base for the other hazard modelling and risk management courses and electives in the NHR specialization, by enabling the students to develop a solid understanding of the main geohazard types, and all relevant conceptual aspects of disaster risk. Students will learn how geo-information and geomatics tools are uniquely suited to study, monitor and quantify each aspect of risk and disasters. Following an introduction to the main hazard types and their core properties, students will dissect past disaster events to discover the nature and properties of the underlying hazards and vulnerabilities, and learn how in particular RS provides comprehensive and specifically tailored means to gain insights into the risk components for different hazards and environmental settings. The course runs in parallel to the Statistically-based Hazard Modelling course (Q2.2), and both are closely coupled. Particular attention will be given to the generation of input data for hazard modelling, including image-based indices and topographic derivatives. Relevant background information on soils, geology and landforms as drivers of hazards will also be provided. Academic skills will be taught together with this course in an integrated manner.

## CONTENT

The course will start with background information about disasters worldwide, their frequencies, consequences and significance, as well as trends, also in the context of climate change. The principal hydrometeorological and geohazards will be introduced in terms of their characteristics, origins and dynamics, in particular in relation to landforms, geology and geomorphology (terrain information), as well as land cover and land use, and the use of remote sensing. The basic origins and drivers of geohazards will be introduced in a plenary setting, together with the other NHR lecturers, providing both hazard modelling and risk management perspectives. The learning will then continue in parallel with Q2.2, and will be partly project–based, whereby students in groups start with past disaster events of different types and work backwards to unravel the constituent elements, as well as how RS has already been operationally employed in the specific disaster type context, and what additional potential it has. As different forms of hazard modelling are introduced in Q2.2, the sources of the needed input data, derived from different geospatial data types, as well as their properties related to scale and quality are introduced. Terrain will be treated as a fundamental environmental information layer with immediate explanatory significance for all risk components. For that reason the creation and use of elevation models, including through the use of UAVs, will be treated in detail. Relevant advanced image analysis techniques will be introduced and practiced. Group-based reporting and discussions will play a prominent role. In addition an excursion is foreseen to a nearby quarry in Germany, where data acquisition with different instruments will be demonstrated and practiced, though this will depend on Covid-related restrictions that prevented a field visit in the last 2 years.

#### TEACHING AND LEARNING APPROACH

The course is based on student-centered learning principles, whereby students will be enabled to cut though the complexity of natural systems, risk situations and disaster scenarios in this case, and learn to identify relevant questions to understand complex systems. In a project-based setting students will work backwards from a disaster event to discover the genesis of the event through understanding of the conceptual elements. The aim is for students not only to learn about theoretical aspects of different hazard and disaster types, but to understand the conceptual links, and to gain the ability to apply the risk concepts to different contexts and scales. A further aim is to enable the students to identify relevant questions before sourcing answers, including from other ESA staff members. There will further be emphasis on presentations (including groups to each other) and critical discussion. At critical points students will receive lectures, but the course is more strongly aimed at self-discovery of relevant facts, concepts and methods. Select RS analysis methods will be taught in a practical setting, while others will be discovered as part of the group work. In addition, skills related to the use of different data acquisition techniques will be gained during a field excursion. With courses Q2.1 and 2.2 running in parallel, the teaching of different modelling techniques will be aligned with the introduction relevant key input data, and some classes will be done in a plenary setting, involving different NHR teachers. Research skills will also be incorporated into the course where appropriate, rather than taught in parallel.

#### TESTS

Individual assessment will be based on: Final test (70%, closed book), group-based reporting, including written report and presentations/ discussions (30%). For the exam a second test opportunity will be provided (up to full marks), while for the group project a repair option will be offered (maximum score of 6).

#### ENTRY REQUIREMENTS

Compulsory for the ‘Natural Hazards and Disaster Risk Reduction’ (NHR) specialization of the ‘Geo-information Science and Earth Observation (M-GEO) programme. Students from other specializations and programmes should have introductory level experience with GIS and Remote Sensing, and a background in earth sciences, geography, environmental science, physics, data science, or civil engineering.

#### LEARNING OUTCOMES

Upon completion of this course, the student is able to:

LO 1 Explain the risk concept and all constituent elements.
LO 2 Demonstrate the ability to transfer the risk concept to different scales and settings.
LO 3 Describe key geohazards in terms of their origin, dynamics and consequences.
LO 4 Create and critically analyse terrain information.
LO 5 Describe different landforms and demonstrate ability to recognize them in imagery.
LO 6 Explain fundamental photogrammetric principles, and link them with topographic data quality.
LO 7 Describe key data sources and techniques to characterize and quantify geohazards, and as input to hazard modelling.
LO 8 Apply research skills in the specific disaster risk context.

#### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 22 |
| Supervised practical | 20 |
| Tutorial | 32 |
| Study trip | 8 |
| Written/oral test | 12 |
| Individual assignment | 16 |
| Group assignment | 22 |
| Self-study | 64 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Group project | Written test |
|---|---|---|---|
| | | **Learning Outcomes that are addressed in the test** | |
| LO 1 | Explain the risk concept and all constituent elements. | ● | ● |
| LO 2 | Demonstrate the ability to transfer the risk concept to different scales and settings. | ● | ● |
| LO 3 | Describe key geohazards in terms of their origin, dynamics and consequences. | ● | ● |
| LO 4 | Create and critically analyse terrain information. | | ● |
| LO 5 | Describe different landforms and demonstrate ability to recognize them in imagery. | | ● |
| LO 6 | Explain fundamental photogrammetric principles, and link them with topographic data quality. | | ● |
| LO 7 | Describe key data sources and techniques to characterize and quantify geohazards, and as input to hazard modelling. | ● | ● |
| LO 8 | Apply research skills in the specific disaster risk context. | ● | |
| | Test type | Group project | Written test |
| | Weight of the test | 30 | 70 |
| | Individual or group test | Group | Individual |
| | Type of marking | 1-10 | 1-10 |
| | Required minimum mark per test | | |
| | Number of test opportunities per academic year | 1 | 2 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Explain the risk concept and all constituent elements. | ● | | | | | ● | | ● | | ● | | ● | |
| LO 2 | Demonstrate the ability to transfer the risk concept to different scales and settings. | ● | | | | | | | ● | ● | | | ● | |
| LO 3 | Describe key geohazards in terms of their origin, dynamics and consequences. | | | | ● | | ● | ● | ● | ● | ● | ● | ● | ● |
| LO 4 | Create and critically analyse terrain information. | | ● | | | | ● | | | | | | ● | ● |
| LO 5 | Describe different landforms and demonstrate ability to recognize them in imagery. | ● | | | | | | | ● | | | | ● | |
| LO 6 | Explain fundamental photogrammetric principles, and link them with topographic data quality. | ● | | | | | | | ● | | | | ● | |

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 7 | Describe key data sources and techniques to characterize and quantify geohazards, and as input to hazard modelling. | ● | | | | | | | ● | | ● | | ● | |
| LO 8 | Apply research skills in the specific disaster risk context. | | ● | | | | | | ● | | | ● | ● | ● |

# DATA-DRIVEN HAZARD MODELLING

| **Course** | **201800282** |
|---|---|
| Period | 14 November 2022 - 03 February 2023 |
| EC | 7 |
| Course coordinator | |

## INTRODUCTION

The identification and assessment of natural hazards is a crucial component of disaster risk management. This course will focus on the modelling of natural hazards, with an emphasis on hydro-meteorological hazards (floods, landslides and erosion). Starting from the relevant natural phenomena and their causes, the generation of historical inventories of hazardous phenomena will be discussed. From the cloud-based generation of the hazard inventories and their interpretation, the course will expand on the main methods and tools to assess the susceptibility and hazard at different scales. The course will provide the foundation for predictive approaches with a particular focus given to statistical models of multivariate nature. The latter will combine the spatial and temporal dimensions. The use of empirical models will further investigate runout patterns to estimate areas under threat.

The course runs in parallel to the "Introduction to Hazard and Risk" course (Q2.1) where data input for hazard modelling are explained. The two course are closely coupled and part of the necessary knowledge for the "Data-Driven Hazard modeling" course will be gained in parallel through lessons and concepts explained in Q2.1.

## CONTENT

In this course we will explore how to exploit current state-of-the-art cloud-based solution in Google Earth Engine to map and monitor natural hazard occurrences in space and time. Landslides will be considered as an example of various natural hazards behaving with similar spatio-temporal characteristics. The inventoried landslides will then be used to investigate landslide-size statistics and estimate the associated event-magnitude. This introductory steps will be completed by using statistical modelling as a tool to better understand, define, visualize and predict hazardous phenomena spatially and temporally. A background introduction will be provided to contextualize the currently available predictive tools. And, a particular emphasis will be given to multivariate statistical models (e.g., generalized linear models and generalized additive mixed models of the binomial family) methods. These methods will be used to make prediction over space and time of locations likely to undergo hydro-meteorological hazards, hence providing information on the susceptibility distribution in a given area. To complete the scenario, the resulting size and potential impact of the considered hazard will be also considered via runout empirical models, hence providing information on the hazard distribution in a given area. In this context, scripting skills (with a focus on the R “language”) will also be developed during practical sessions.

## TEACHING AND LEARNING APPROACH

This course focuses on building the required understanding of natural hazards and the available approaches to map them and further predict their occurrence in space and time. This knowledge will be systematically acquired through short theoretical lectures followed by supervised practicals and tutorials that will expose students to the whole conceptual and modeling pipeline, from cloud-based inventory-making to data acquisition and ultimately to susceptibility and hazard assessment. To promote and make a constructive use of the diversity in the background of the students, each step of the course will also feature a peer-learning process where students with different training will share their knowledge to mutually benefit from each respective understanding of the lessons. At the end of each day, interactive quiz will be provided to monitor the growth of each student and provide support where needed. The learning process will be further supported by a group project assignment that will link together the content of the course. In fact, the automated mapping and the modelling techniques will be implemented and critically assessed in terms of their specific limitations and with respect to the final goal (inventory generation and susceptibility/hazard mapping).

### TESTS
Assessment will be based on: written test (60%) and project (40%). For each of the examination components, a minimum score of 5.5 must be reached.

A second test opportunity for the ‘project’ will consist of improving on (i.e. 'repairing') the project deliverable(s), and will be assigned a maximum mark of 6.0.

### ENTRY REQUIREMENTS
Compulsory for the “Natural Hazards and Disaster Risk Reduction” (NHR) specialization of the “Geoinformation Science and Earth Observation” (M-GEO) programme. Students from other specializations and programmes should have introductory level experience with GIS and Remote Sensing, and a background in earth sciences, geography, environmental science or civil engineering.

### LEARNING OUTCOMES
Upon completion of this course, the student is able to:

LO 1 In the context of landslide hazard, formulate the data requirements to automatically map inventories through Google Earth Engine.

LO 2 In the context of landslide hazard, formulate the data requirements for the statistical modelling approaches (including aspects of scale and data quality).

LO 3 Classify, explain and analyse the factors underlying the hazards and evaluate their relative importance.

LO 4 Understand the appropriate use, the limitations and the issues one can tackle through statistical modelling for predictive mapping of hazards. Implement this knowledge through scripting data-driven methods for hazard prediction.

LO 5 Critically asses susceptibility maps and the approaches to convert them into hazard maps.

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| **Teaching / learning method** | **Hours** |
|---|---|
| Lecture | 32 |
| Supervised practical | 42 |
| Tutorial | 10 |
| Written/oral test | 3 |
| Individual assignment | 20 |
| Group assignment | 44 |
| Self-study | 45 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Written test | Project report |
|---|---|---|---|
| LO 1 | In the context of landslide hazard, formulate the data requirements to automatically map inventories through Google Earth Engine. | ● | ● |
| LO 2 | In the context of landslide hazard, formulate the data requirements for the statistical modelling approaches (including aspects of scale and data quality). | ● | ● |
| LO 3 | Classify, explain and analyse the factors underlying the hazards and evaluate their relative importance. | ● | ● |
| LO 4 | Understand the appropriate use, the limitations and the issues one can tackle through statistical modelling for predictive mapping of hazards. Implement this knowledge through scripting data-driven methods for hazard prediction. | ● | ● |
| LO 5 | Critically asses susceptibility maps and the approaches to convert them into hazard maps. | ● | ● |
| | Test type | Written test | Report |
| | Weight of the test | 60 | 40 |
| | Individual or group test | Individual | Group |
| | Type of marking | 1-10 | 1-10 |
| | Required minimum mark per test | 5.5 | 5.5 |
| | Number of test opportunities per academic year | 2 | 2 |

### RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | In the context of landslide hazard, formulate the data requirements to automatically map inventories through Google Earth Engine. | ● | ● | ● | ● | ● | ● | ● | ● | | | | ● | ● |
| LO 2 | In the context of landslide hazard, formulate the data requirements for the statistical modelling approaches (including aspects of scale and data quality). | ● | ● | ● | ● | | ● | ● | ● | ● | | | ● | ● |

| | **Learning outcomes (LO) of the course: The student will be able to...** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 3 | Classify, explain and analyse the factors underlying the hazards and evaluate their relative importance. | ● | ● | ● | ● | ● | ● | ● | | | | | ● | ● |
| LO 4 | Understand the appropriate use, the limitations and the issues one can tackle through statistical modelling for predictive mapping of hazards. Implement this knowledge through scripting data-driven methods for hazard prediction. | ● | ● | ● | ● | ● | ● | ● | ● | ● | | | ● | ● |

| | Learning outcomes (LO) of the course: The student will be able to... | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 5 | Critically asses susceptibility maps and the approaches to convert them into hazard maps. | ● | | ● | | | ● | | ● | | | | ● | |

# PHYSICALLY-BASED HAZARD MODELLING

| **Course** | **201800289** |
|---|---|
| Period | 06 February 2023 - 21 April 2023 |
| EC | 7 |
| Course coordinator | |

## INTRODUCTION

The aim of this course is to enhance the student's understanding of the physical processes that cause natural hazards, the methods and the physically-based modelling approaches for hazard analysis, to the point at which students are able to use them with their own data. As the processes of selected natural hazards, including flooding, landslides and earthquakes, are explained, the students will be introduced to fundamentals of the underpinning science and engineering. Model data requirements and data collection will be treated, as well as the evaluation of uncertainty of input data on simulation outputs. Modelling principles and assumptions, possibilities and limitations will be discussed with the aim that students can make a proper selection of models for a given situation and critically reflect on the results, in order to support hazard analysis as input to risk management and mitigation.

## CONTENT

In this course, we focus on the physical processes that lead to and determine the dynamics of natural hazards. Using the hydrological cycle and rock cycle as a foundation, a variety of modelling approaches are addressed. Amongst others, some topics to be covered are: precipitation and generation of rainfall maps, ground water fluctuation, infiltration, overland flow and (flash) floods;  soil and rock slope instability types, initiation, propagation and intensity; seismic wave propagation, macro and/or micro hazard analysis. In the second part of the course, students are able to select a specific natural hazard. For the selected hazard, a full hazard assessment is developed to address the challenges posed by potential disaster.  Students learn how relevant physical parameters can be acquired or derived using a range of data collection methods (including remote sensing, laboratory analysis, field tests and empirical analysis). Practical issues of modelling and scripting are addressed. Through assignments on selected hazards, students critically assess how process based modelling results can be translated into hazard maps, addressing sources of uncertainty and their effects, model limitations and reliability.

## TEACHING AND LEARNING APPROACH

The students will focus on the principles and modelling of selected natural hazards through a combination of theory, practicals, and hazard assessment project. Interactive lectures and tutorials in the form of group discussions are planned to facilitate the introduction and comprehension of critical scientific and engineering concepts. The flipped classroom technique will be used as a self-paced educational method to promote the personal involvement of the student in the learning process and to enhance independent thinking. The educational aim of this course is twofold: on one hand, to provide the students with a range of modelling tools in order to develop their practical and technical skills; and on the other, to promote their ability to reason well and to encourage their disposition to do so, at the moment of discussing modelling assumptions, suitability and limitations. These aims are planned to be achieved through supervised practicals and short individual or group assignments, in an initially guided and, later on, more independent environment. Sensitivity analysis of the models and comparison and interpretation of their results, (e.g. using different datasets, modelling techniques and parameters) are intended to trigger active exploration of and reasoning on the physical processes and simulations. Students are further encouraged to deepen into theory and practice with supplementary material to independently explore during the group projects.

## TESTS

Assessment will be based on: written test (40%, closed book), project (60%).

## ENTRY REQUIREMENTS

Compulsory for the 'Natural Hazards and Disaster Risk Reduction' (NHR) specialization of the 'Geo-information Science and Earth Observation (M-GEO) programme.
Students from other specializations and programmes should have experience with GIS and Remote Sensing, and a background in earth sciences, geography, environmental science or civil engineering.

## LEARNING OUTCOMES

Upon completion of this course, the student is able to:

LO 1 Describe the scientific and engineering principles that underlie natural hazards, including the factors affecting the initiation, the spatio-temporal evolution, and hazard interactions.
LO 2 Select a model for the simulation of a specific process, summarize the modelling principles and assumptions, and recognize limitations.
LO 3 Use process-based models for assessing the spatio-temporal distribution and evolution of hazardous events in order to construct hazard scenarios and maps that are important for risk analysis.
LO 4 Understand and describe sources of model uncertainty. Calibrate and validate process-based models for natural hazards.
LO 5 Detect sources of uncertainty and assess their effect on modelling results. Interpret model outcomes to define hazard posed by process.

## ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 32 |
| Supervised practical | 20 |
| Tutorial | 2 |
| Written/oral test | 4 |
| Individual assignment | 58 |
| Group assignment | 20 |
| Self-study | 60 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Test 1 | Test 2 |
|---|---|---|---|
| | | **Learning Outcomes that are addressed in the test** | |
| LO 1 | Describe the scientific and engineering principles that underlie natural hazards, including the factors affecting the initiation, the spatio-temporal evolution, and hazard interactions. | ● | ● |
| LO 2 | Select a model for the simulation of a specific process, summarize the modelling principles and assumptions, and recognize limitations. | | ● |
| LO 3 | Use process-based models for assessing the spatio-temporal distribution and evolution of hazardous events in order to construct hazard scenarios and maps that are important for risk analysis. | | ● |
| LO 4 | Understand and describe sources of model uncertainty. Calibrate and validate process-based models for natural hazards. | ● | ● |
| LO 5 | Detect sources of uncertainty and assess their effect on modelling results. Interpret model outcomes to define hazard posed by process. | ● | ● |
| | Test type | Written test | Project |
| | Weight of the test | 40 | 60 |
| | Individual or group test | Individual | Group |
| | Type of marking | 1-10 | 1-10 |
| | Required minimum mark per test | 5 | |
| | Number of test opportunities per academic year | 2 | 2 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Describe the scientific and engineering principles that underlie natural hazards, including the factors affecting the initiation, the spatio-temporal evolution, and hazard interactions. | ● | ● | | ● | | ● | | | | | ● | | |
| LO 2 | Select a model for the simulation of a specific process, summarize the modelling principles and assumptions, and recognize limitations. | ● | ● | ● | ● | | ● | | | | | | | |

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 3 | Use process-based models for assessing the spatio-temporal distribution and evolution of hazardous events in order to construct hazard scenarios and maps that are important for risk analysis. | ● | ● | ● | ● | ● | ● | ● | ● | | | | ● | ● |
| LO 4 | Understand and describe sources of model uncertainty. Calibrate and validate process-based models for natural hazards. | ● | ● | ● | ● | | ● | | | | | | ● | |

| | Learning outcomes (LO) of the course: The student will be able to... | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 5 | Detect sources of uncertainty and assess their effect on modelling results. Interpret model outcomes to define hazard posed by process. | ● | ● | ● | ● | | ● | | | | | | ● | ● |

# ENVIRONMENTAL MODELLING: CAUSES AND IMPACTS OF CHANGING RESOURCES

| **Course** | **201800299** |
| --- | --- |
| Period | 24 April 2023 - 07 July 2023 |
| EC | 7 |
| Course coordinator | |

## INTRODUCTION

The previous Natural Resource Management (NRM) courses have focused on the inventory natural resources and to detect and assess changes in the environment such as loss of ecosystems and biodiversity, deforestation and forest degradation and threats to food security due to decreased crop yields. Different methods and techniques are available to guide NRM in its efforts to reverse resource degradation or alleviate its consequences. Proper understanding of cause and effect of changes in natural resources is crucial to achieve this. As these changes occur in the real-world, and not in a laboratory set-up, making statements about causal relations is a challenge.

In this course, students will study generic techniques and apply and evaluate environmental models that aim to estimate change in natural resources in response to environmental changes.

## CONTENT

This course emphasizes the role of environmental modelling as a tool for examining the causes and impacts of changes in natural resources. During the course, students study a range of generic statistical techniques and specific environmental models to assess the possible impacts of environmental changes on natural resources. Throughout the course students will be exposed to discipline-specific examples.

- **Statistical techniques**

  Here the focus will be on the use of statistical regression techniques, knowledge of their underlying assumptions, and proper interpretation of the results. During the course, we use the R software environment to apply generic techniques which could be applied in any other statistical software tool.

- **Environmental modelling**

  A number of different environmental models will be presented, as well as specific issues related to working with these models in the context of different NRM goals related to forests, agriculture, and mixed landscapes. These models take different remote sensing and GIS-based approaches to the description of the natural world, depending on the objectives of the model. They range from simple static models to dynamic process models.

## TEACHING AND LEARNING APPROACH

With lectures, we will introduce you to background knowledge, concepts and theory behind environmental models. Supervised and unsupervised practicals on the environmental models are scheduled throughout the course for hands-on experience. A day is typically closed with a plenary question and answer session. Knowledge is tested with one graded individual assignment and one written test.

## TESTS

1 graded individual assignment for statistics and 1 written test on environmental modelling.

## ENTRY REQUIREMENTS

Basic knowledge on and skills in remote sensing and GIS.

## LEARNING OUTCOMES

Upon completion of this course, the student is able to:

LO 1 Apply regression techniques for environmental modelling and describe opportunities and limitations of correlative statistics.

LO 2 Describe the main elements and processes of different types of environmental models and approaches.

LO 3 Apply various models to estimate impacts and consequences of environmental change.

LO 4 Appraise an environmental model based on its purpose and geographic context.

LO 5 Critically assess the quality and uncertainty of model results.

LO 6 Compare and contrast environmental models.

## ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 28 |
| Supervised practical | 7 |
| Tutorial | 28 |
| Written/oral test | 2 |
| Individual assignment | 0 |
| Group assignment | 0 |
| Self-study | 131 |

## TESTPLAN

| | Learning Outcomes that are addressed in the test | | |
|---|---|---|---|
| | **Learning outcomes (LO) of the course: The student will be able to...** | **Test 1** | **Test 2** |
| LO 1 | Apply regression techniques for environmental modelling and describe opportunities and limitations of correlative statistics. | ● | |
| LO 2 | Describe the main elements and processes of different types of environmental models and approaches. | | ● |
| LO 3 | Apply various models to estimate impacts and consequences of environmental change. | | ● |
| LO 4 | Appraise an environmental model based on its purpose and geographic context. | | ● |
| LO 5 | Critically assess the quality and uncertainty of model results. | | ● |
| LO 6 | Compare and contrast environmental models. | | ● |
| | Test type | Report | Written test |
| | Weight of the test | 30 | 70 |
| | Individual or group test | Individual | Individual |
| | Type of marking | 1-10 | 1-10 |
| | Required minimum mark per test | | |
| | Number of test opportunities per academic year | 2 | 2 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Apply regression techniques for environmental modelling and describe opportunities and limitations of correlative statistics. | ● | | ● | ● | | ● | | ● | | | | ● | |
| LO 2 | Describe the main elements and processes of different types of environmental models and approaches. | ● | ● | | | | | | | | | | | |
| LO 3 | Apply various models to estimate impacts and consequences of environmental change. | | ● | ● | ● | | | ● | | | | | | |
| LO 4 | Appraise an environmental model based on its purpose and geographic context. | | | | | | | | | ● | ● | ● | ● | |

| | Learning outcomes (LO) of the course: The student will be able to... | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 5 | Critically assess the quality and uncertainty of model results. | | | | | | ● | | | | ● | ● | ● | |
| LO 6 | Compare and contrast environmental models. | | | | | | ● | | ● | | | | ● | ● |

# FROM DATA TO GEO-INFORMATION FOR NATURAL RESOURCES MANAGEMENT

| **Course** | **201800284** |
|---|---|
| Period | 14 November 2022 - 03 February 2023 |
| EC | 7 |
| Course coordinator | |

## INTRODUCTION

Sound natural resource management requires adequate geoinformation describing the spatial and temporal dimensions of ecosystems. This involves - in most cases - large datasets from multiple sources and stakeholders from different disciplines and institutions. The collection of these data and the definition of ad-hoc automatic data processing chains are nowadays necessary to support planning or management activities of a forest, agricultural or ecological systems.

During this course, the student will learn the basic concepts for the conceptual design and development of a prototype data processing chain based on Earth Observation (EO) and Geographic Information Systems (GIS) to support planning and decision-making in Natural Resource Management (NRM) situations. Upon completion, students will acquire the knowledge and skills necessary for the collection, preparation, processing and interpretation of spatial information provided by EO and GIS data to address a specific NRM problem.

At the end of the course, the student should be able to execute simple scripts, make minor modifications and search online for existing scripts to design a basic processing chain. The developed prototype must be presented, explained and justified in the final report.

## CONTENT

The entire course is developed around a real case study: each student will choose 1 case study from a set of different NRM problems. The course is organised as follows:

- The student will carry out the conceptual design of the case study to formulate the objectives, research questions and anticipated challenges for the NRM problem under consideration.
- The EO and GIS database will be prepared. An overview of the main publicly available global archives will be provided to support the student in identifying and preparing the most suitable datasets for the case study.
- The characteristics and distribution of the collected data will be quantitatively described or summarized through descriptive statistics. Furthermore, inferential statistics will be used to make conclusions, or inferences and predictions, based on the available data from a smaller sample population.
- The prototype of the data processing chain will be developed on the online platform Google Earth Engine (GEE).

Main content topics:

- Assessment of information requirements, development of use cases and data needs for a specific NRM situation.
- Preparation of the EO and GIS database required for the NRM use case under consideration. Assessment of the suitability for use of these data in terms of, for example, spatial and temporal resolution, quality and standards.
- Application of descriptive and inferential statistics for data exploration and analysis.
- Implementation of a prototype processing chain on GEE.
- Evaluation of the usefulness and limitations of the developed prototype.
- Presentation, explanation and justification of the developed prototype.

### TEACHING AND LEARNING APPROACH
The main component of the course is an NRM case study, which requires the definition of a prototype data processing chain adapted to the specific characteristics of the NRM problem under consideration.

During the course, students will be guided in the development of this prototype data processing chain through lectures, tutorials and supervised practical. At the end of each week, students have to submit an individual assignment related to the definition of one component of the prototype (e.g., conceptual design, EO and GIS database, etc.). During the process, students can interact with their peers and course staff to define the processing chain and implement the prototype version in GEE.

### TESTS
Graded Assignments (weight: 25%)

Conceptual design and prototype development (weight: 25% of the final mark)

Reflection document on conceptual design and prototype (weight: 50% of the final mark)

### ENTRY REQUIREMENTS
RS, GIS, concepts of NRM, and systems-based thinking.

### LEARNING OUTCOMES
Upon completion of this course, the student is able to:

LO 1 Develop a prototype processing chain to address environmental analysis that can answer the research questions related to a specific case study.

LO 2 Search and acquire geospatial data from existing global archives (including satellite data).

LO 3 Assess the main challenges expected for the considered environmental analysis.

LO 4 Apply descriptive and inferential statistics to explore and analyse the spatial and non-spatial data.

LO 5 Implement a demo version of the processing chain and justify its fitness for use with a demonstration product.

LO 6 Demonstrate clear scientific reasoning and capability of making justified choices for the development of the system architecture.

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 42 |
| Supervised practical | 50 |
| Tutorial | 16 |
| Individual assignment | 58 |
| Self-study | 30 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Prototype Development | Conceptual Design Report | Skills assignment |
|---|---|---|---|---|
| | | Learning Outcomes that are addressed in the test | | |
| LO 1 | Develop a prototype processing chain to address environmental analysis that can answer the research questions related to a specific case study. | ● | ● | ● |
| LO 2 | Search and acquire geospatial data from existing global archives (including satellite data). | ● | ● | ● |
| LO 3 | Assess the main challenges expected for the considered environmental analysis. | ● | ● | ● |
| LO 4 | Apply descriptive and inferential statistics to explore and analyse the spatial and non-spatial data. | ● | ● | ● |
| LO 5 | Implement a demo version of the processing chain and justify its fitness for use with a demonstration product. | ● | ● | ● |
| LO 6 | Demonstrate clear scientific reasoning and capability of making justified choices for the development of the system architecture. | ● | ● | ● |
| | Test type | Prototype Development | Report | Assignment |
| | Weight of the test | 25 | 50 | 25 |
| | Individual or group test | Individual | Individual | Individual |
| | Type of marking | 1-10 | 1-10 | 1-10 |
| | Required minimum mark per test | | | |
| | Number of test opportunities per academic year | 2 | 1 | 2 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | Learning outcomes (LO) of the course: The student will be able to... | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Develop a prototype processing chain to address environmental analysis that can answer the research questions related to a specific case study. | ● | ● | | ● | | ● | ● | | ● | | | | ● |
| LO 2 | Search and acquire geospatial data from existing global archives (including satellite data). | ● | ● | | ● | | | | | | | | | ● |
| LO 3 | Assess the main challenges expected for the considered environmental analysis. | ● | | | ● | | ● | | | | | | | ● |

| | Learning outcomes (LO) of the course: The student will be able to... | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 4 | Apply descriptive and inferential statistics to explore and analyse the spatial and non-spatial data. | ● | ● | | ● | | ● | | | | | | | ● |
| LO 5 | Implement a demo version of the processing chain and justify its fitness for use with a demonstration product. | ● | ● | | ● | | | ● | | ● | | | | ● |
| LO 6 | Demonstrate clear scientific reasoning and capability of making justified choices for the development of the system architecture. | ● | ● | | | | ● | ● | ● | | | | ● | ● |

# EARTH OBSERVATION FOR NATURAL RESOURCES MANAGEMENT

| **Course** | **201800292** |
|---|---|
| Period | 06 February 2023 - 21 April 2023 |
| EC | 7 |
| Course coordinator | |

## INTRODUCTION

The 21$^{st}$ century has witnessed an increase in the availability of Earth observation (EO) data and their use in addressing critical problems in natural resources management (NRM). The myriad of datasets and stakeholder needs can make the selection of a specific sensor and analytical technique to address a problem a daunting task. At the heart of this dilemma is the scale of observation at which we can effectively address the problem. Biophysical processes, flows or interactions can occur at the plant, canopy or regional scale. Similarly, image-based map products have a specific purpose. For example, food security analysts may want to know the location of crop field boundaries in an agroecosystem, while foresters may want to assess forest stand biomass.

The guiding principle of this course, therefore, is to *use the scale observation together with stakeholder needs to select and apply an appropriate EO dataset and analytical technique to solve problems within the three NRS Forest, Agriculture and Environment in the Spatial Sciences (FORAGES) themes (biodiversity conservation, forest management and food security analysis)*. In the end, students will be able to design a workflow to address these problems that includes the appropriate selection of EO data and analytical techniques.

## CONTENT

The course consists of teaching units that address problems from the FORAGES themes. Each problem includes a lecture, demonstration and practical. The lecture introduces the problem in the context of the scale of observation and stakeholder needs. A demonstration follows the lecture and exposes students to a remote sensing instrument that can be used to address the problem. Students then review relevant literature to enrich their understanding. Finally, students use an analytical technique to create an image-based map from the selected EO dataset. The bullets below show how remote sensing data and analytical techniques are linked to a FORAGES problem:

- Optical properties of plants and soil + multispectral vegetation indices
- Ecosystem resilience + hyperspectral RS + narrowband indices
- Carbon sequestration + RADAR/LIDAR + polarization
- Forest degradation + UAS + OBIA
- Food abundance + hypertemporal + stratification
- Crop water productivity + thermal + thermal indices

In the last third of the course, students generate a vegetation type map for Lemele. The map addresses an important problem in biodiversity conservation. The case study includes teaching units on sampling theory and design + accuracy assessment; the available vegetation type field data; and the available remote sensing (aerial photos, LIDAR and Sentinel-2 multispectral broadband).

## TEACHING AND LEARNING APPROACH

The course takes a student-centered (inquiry-based) approach to teaching and learning. Students assume an active/participatory role in their education, while teachers are facilitators who encourage interaction with new material presented and reflective thinking. The teacher uses class discussions, hands-on practicals and other experiential learning tools to track student comprehension, learning needs and academic progress over a teaching unit. Three summative assessments (written exam + individual assignment + final group project) measure how well the students achieve higher order thinking and learning outcomes.

### TESTS

Written in-class exam, two individual writing assignments and a final group project to be delivered orally. For the final group project, groups will be evaluated by relevant teaching staff privately to avoid bias. Peer-to-peer evaluations will also be conducted, so that individuals within groups receive marks proportional to their contribution.

### ENTRY REQUIREMENTS

Geo-Information Science and Earth Observation: A Systems-Based Approach

Systems Approach for Management of Natural Resources (NRM specialization 2.1)

From Data to Geo-Information for Natural Resources Management (NRM specialization 2.2)

### LEARNING OUTCOMES

Upon completion of this course, the student is able to:

LO 1 Examine problems in biodiversity conservation, forest management and food security analysis considering the scale of observation and information requirements

LO 2 Justify the application of an Earth observation dataset based on its spatial, temporal, radiometric and spectral resolution to generate an image-based map

LO 3 Select a specific analytical method based on its effectiveness, reliability, validity, efficiency and usability to generate an image-based map

LO 4 Design a sampling strategy and use it for the accuracy assessment of an image-based map

LO 5 Defend a work flow using hierarchy theory that generates a vegetation type map for the Lemele study area

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| **Teaching / learning method** | **Hours** |
|---|---|
| Lecture | 19 |
| Tutorial | 16 |
| Supervised practical | 32 |
| Study trip | 7 |
| Written/oral test | 7 |
| Individual assignment | 7 |
| Self-study | 108 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Learning Outcomes that are addressed in the test<br>Test 1 | Test 2 | Test 3 |
|---|---|---|---|---|
| LO 1 | Examine problems in biodiversity conservation, forest management and food security analysis considering the scale of observation and information requirements | ● | | |
| LO 2 | Justify the application of an Earth observation dataset based on its spatial, temporal, radiometric and spectral resolution to generate an image-based map | ● | | |
| LO 3 | Select a specific analytical method based on its effectiveness, reliability, validity, efficiency and usability to generate an image-based map | ● | | |
| LO 4 | Design a sampling strategy and use it for the accuracy assessment of an image-based map | | ● | |
| LO 5 | Defend a work flow using hierarchy theory that generates a vegetation type map for the Lemele study area | | | ● |
| | Test type | Written test | Report | Presentation |
| | Weight of the test | 40 | 20 | 40 |
| | Individual or group test | Individual | Individual | Group |
| | Type of marking | 1-10 | 1-10 | 1-10 |
| | Required minimum mark per test | | | |
| | Number of test opportunities per academic year | 2 | 2 | 2 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | Learning outcomes (LO) of the course: The student will be able to... | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Examine problems in biodiversity conservation, forest management and food security analysis considering the scale of observation and information requirements | ● | | | | | | | | | | | ● | ● |
| LO 2 | Justify the application of an Earth observation dataset based on its spatial, temporal, radiometric and spectral resolution to generate an image-based map | ● | ● | | ● | | ● | | | | | | ● | ● |

| **Learning outcomes (LO) of the course: The student will be able to...** | | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 3 | Select a specific analytical method based on its effectiveness, reliability, validity, efficiency and usability to generate an image-based map | ● | ● | | ● | | ● | | | | | | ● | ● |
| LO 4 | Design a sampling strategy and use it for the accuracy assessment of an image-based map | ● | ● | | | | | | ● | | | | ● | ● |
| LO 5 | Defend a work flow using hierarchy theory that generates a vegetation type map for the Lemele study area | ● | ● | | ● | ● | ● | ● | ● | | | ● | ● | ● |

# SYSTEMS APPROACH FOR MANAGEMENT OF NATURAL RESOURCES

| **Course** | **201800278** |
|---|---|
| Period | 14 November 2022 - 03 February 2023 |
| EC | 7 |
| Course coordinator | |

## INTRODUCTION

Natural resources management has a multi-disciplinary character. So does this course. Students will learn to unravel complex systems and to deal with different stakeholders and conflicting interests in Natural Resources Management. It will set a common basis for all sorts of research and other activities in the field of NRM. Particular attention is given to the spatial and temporal dynamics of natural systems and data needs for the management of these.

Concepts of NRM are reviewed and discussed. Students are introduced to apply systems thinking and learn to apply analytical reasoning when translating complex real-world situations into conceptual diagrams. This enables them to describe and develop knowledge about how ecosystems work and how humans make an impact on natural systems. Students discover how essential this step is in identifying meaningful biophysical and socio-economic variables for scientifically sound decision making and management of natural resources. They also put themselves in the shoes of a stakeholder in an NRM conflict and apply remote sensing and GIS to help making claims or illustrate possible solutions. Conceptualising real-world situations helps students in identifying knowledge gaps and formulating research hypotheses.

Natural Resources Management is a multiple-stakeholder effort per default. Therefore, part of the assignments will involve working in multi-disciplinary teams.

## CONTENT

1. NRM concepts and definitions
2. Stakeholders analysis and reporting
3. Systems thinking
4. Design conceptual diagrams to describe:
    - the link between actors and their NRM problems, objectives and conflicts
    - relations between elements and processes in ecosystems involved in NRM problems
5. Hypothesis formulation
6. Systems dynamics in NRM context
7. Apply and communicate geo-information in an NRM context

## TEACHING AND LEARNING APPROACH

We apply a mix of different activating teaching and learning approaches which includes interactive teaching, reflective teaching (learning by doing), e-learning, individual and group exercises and problem-based project work.

## TESTS

The exam has three components.

The theory test assesses to what extent the student is able to explain and apply the theoretical concepts of the course. (40% of the final grade)

The practical skills test assesses to what extent the student is able to apply systems analysis and translate a set of descriptions of an NRM context into a conceptual diagram that shows how the system works. (25% of the final grade)

The final project assesses to what extent the student is able to use geo-information to help a stakeholder making a claim within the context of an NRM conflict. (35% of the final grade)

## ENTRY REQUIREMENTS

A prerequisite is to have finished the core modules at ITC or to have a basic level in GIS and remote sensing.

## LEARNING OUTCOMES

Upon completion of this course, the student is able to:

- LO 1 Define NRM and describe the role of sustainable development.
- LO 2 Identify and describe stakeholders and perform basic stakeholder analysis in NRM context.
- LO 3 Apply systems thinking in an NRM context.
- LO 4 Design conceptual system models illustrating how natural systems work and how humans influence them.
- LO 5 Identify researchable topics based on initial description and understanding of a system within an NRM context.
- LO 6 Interpret and discuss the spatio-temporal dynamics of system variables in the context of NRM.
- LO 7 Apply and communicate geo-spatial and temporal information for stakeholders to address NRM issues.

## ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 10 |
| Supervised practical | 24 |
| Tutorial | 34 |
| Study trip | 8 |
| Written/oral test | 6 |
| Individual assignment | 34 |
| Group assignment | 44 |
| Self-study | 40 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Test 1 | Test 2 | Test 3 |
|---|---|---|---|---|
| | | Learning Outcomes that are addressed in the test | | |
| LO 1 | Define NRM and describe the role of sustainable development. | ● | | |
| LO 2 | Identify and describe stakeholders and perform basic stakeholder analysis in NRM context. | ● | | |
| LO 3 | Apply systems thinking in an NRM context. | ● | | |
| LO 4 | Design conceptual system models illustrating how natural systems work and how humans influence them. | | ● | |
| LO 5 | Identify researchable topics based on initial description and understanding of a system within an NRM context. | ● | | |
| LO 6 | Interpret and discuss the spatio-temporal dynamics of system variables in the context of NRM. | ● | | |
| LO 7 | Apply and communicate geo-spatial and temporal information for stakeholders to address NRM issues. | | | ● |
| | Test type | Written test | Digital test | Report or poster |
| | Weight of the test | 40 | 25 | 35 |
| | Individual or group test | Individual | Individual | Group |
| | Type of marking | 1-10 | 1-10 | 1-10 |
| | Required minimum mark per test | 4 | 4 | 4 |
| | Number of test opportunities per academic year | 2 | 2 | 2 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Define NRM and describe the role of sustainable development. | | | | ● | | | | ● | | ● | ● | | |
| LO 2 | Identify and describe stakeholders and perform basic stakeholder analysis in NRM context. | | | | ● | | ● | ● | ● | | ● | ● | ● | |
| LO 3 | Apply systems thinking in an NRM context. | | | ● | ● | | ● | ● | ● | | | | ● | ● |
| LO 4 | Design conceptual system models illustrating how natural systems work and how humans influence them. | ● | ● | | ● | ● | ● | ● | | ● | | ● | ● | ● |

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 5 | Identify researchable topics based on initial description and understanding of a system within an NRM context. | | | | | ● | | | | | | | | ● |
| LO 6 | Interpret and discuss the spatio-temporal dynamics of system variables in the context of NRM. | ● | ● | ● | ● | | ● | | ● | ● | | | ● | |
| LO 7 | Apply and communicate geo-spatial and temporal information for stakeholders to address NRM issues. | ● | ● | | ● | ● | ● | ● | | ● | | ● | ● | ● |

# BUILDING INCLUSIVE AND COMPETITIVE CITIES

| Course | 201800283 |
|---|---|
| Period | 14 November 2022 - 03 February 2023 |
| EC | 7 |
| Course coordinator | |

#### INTRODUCTION
Cities are unequal. Considerable parts of the urban population, especially in the Global South, are poor, whereas others are affluent. In part, poverty is associated with the influx of poor rural immigrants in need of jobs, shelter and basic services such as water, electricity, education and health care. Levels of access to these basic services can differ a lot between socio-economic groups and will also vary across urban spaces. To address such inequalities, contemporary urban development strategies and policies are directed toward the inclusion of socially and economically weaker groups. These groups need to benefit most from sustainable planning interventions. Here, inclusiveness and competitiveness need to be linked, as only inclusive cities can be truly competitive. Successful cities offer competitive locations and are centres of innovation, where liveability and inclusiveness are important factors. When analysing the economic performance of an urban region, the role of geography needs explicit consideration as urban competitiveness requires an understanding of spatial relationships inside cities (e.g., variations of locational factors and clustering of economic activities). Furthermore, the role of land use (planning) and land markets is essential for understanding competitiveness in all its dimensions for building competitive and inclusive cities.

#### CONTENT
- Policies of inclusion (lecture and discussion session)
- Inequality, deprivation, and quality of life (lectures and group assignment)
- Network analysis (lecture and guided practical)
- Accessibility concept and operationalisation (lectures and group assignment
- Inclusive (water) infrastructure provision (lectures)
- Urban competitiveness / economics (lectures)
- Land value modelling (lectures and individual assignment)
- 3D city modelling (lectures and practical)
- Excursion or site visit in the province of Overijssel
- Literature seminars (3x, guided discussion sessions on literature used for course)

#### TEACHING AND LEARNING APPROACH
Lectures, supervised practicals, discussion sessions (literature seminars), individual assignment, group assignment.

Participation and attendance:

- Since many of the educational activities require active involvement attendance of supervised practicals, literature seminars & group presentations is highly advisable

#### TESTS
- Individual theory test (50%)
- Assignment 1 (group): Inequality and Deprivation Mapping (10%),
- Assignment 2 (group): Accessibility to Health Care (20%)
- Assignment 3 (individual): Urban Development and Slum Relocation (20%)

Please note: the 2nd opportunity of the Group and Individual assignment, is a **repair**

### ENTRY REQUIREMENTS
Completion of ITC course GIS and RS for Geospatial Problem Solving, or equivalent.

### LEARNING OUTCOMES
Upon completion of this course, the student is able to:

LO 1 Describe and compare different perspectives on the inclusive city concept and associated theoretical notions of equity, fairness and social justice.

LO 2 Define and operationalize spatial and non-spatial indicators to measure intra-urban socio-spatial variation.

LO 3 Apply appropriate spatial and statistical methods to describe socio-spatial patterns within cities.

LO 4 Analyse and assess intra-urban socio-spatial patterns for selected thematic sectors (e.g. quality of life, health care).

LO 5 Describe the main factors of competitiveness (human, physical, institutional, and economic) of an urban region.

LO 6 Analyse the case of slum relocation in the context of land markets, land use (planning) and competitiveness of cities.

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 30 |
| Group assignment | 44 |
| Individual assignment | 15 |
| Tutorial | 10 |
| Written/oral test | 4 |
| Self-study | 55 |
| Study trip | 8 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Individual Theory Test | Assignment 1 | Assignment 2 | Assignment 3 |
|---|---|---|---|---|---|
| | | Learning Outcomes that are addressed in the test | | | |
| LO 1 | Describe and compare different perspectives on the inclusive city concept and associated theoretical notions of equity, fairness and social justice. | ● | | | |
| LO 2 | Define and operationalize spatial and non-spatial indicators to measure intra-urban socio-spatial variation. | | ● | ● | |
| LO 3 | Apply appropriate spatial and statistical methods to describe socio-spatial patterns within cities. | | ● | ● | |
| LO 4 | Analyse and assess intra-urban socio-spatial patterns for selected thematic sectors (e.g. quality of life, health care). | | ● | ● | |
| LO 5 | Describe the main factors of competitiveness (human, physical, institutional, and economic) of an urban region. | ● | | | ● |
| LO 6 | Analyse the case of slum relocation in the context of land markets, land use (planning) and competitiveness of cities. | | | | ● |
| | Test type | Written test | Practical & report | Practical & report | Practical, report & poster |
| | Weight of the test | 50 | 10 | 20 | 20 |
| | Individual or group test | Individual | Group | Group | Individual |
| | Type of marking | 1-10 | 1-10 | 1-10 | 1-10 |
| | Required minimum mark per test | | | | |
| | Number of test opportunities per academic year | 2 | 2 | 2 | 2 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| Learning outcomes (LO) of the course: The student will be able to... | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Describe and compare different perspectives on the inclusive city concept and associated theoretical notions of equity, fairness and social justice. | ● | | | ● | | | | | | | ● | ● | |
| LO 2 | Define and operationalize spatial and non-spatial indicators to measure intra-urban socio-spatial variation. | | ● | | ● | | ● | | | | | | | |
| LO 3 | Apply appropriate spatial and statistical methods to describe socio-spatial patterns within cities. | | ● | | ● | | | | ● | | | | | |
| LO 4 | Analyse and assess intra-urban socio-spatial patterns for selected thematic sectors (e.g. quality of life, health care). | | ● | | ● | | ● | | ● | | | | | |
| LO 5 | Describe the main factors of competitiveness (human, physical, institutional, and economic) of an urban region. | ● | | | ● | | | | | | | ● | ● | |

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 6 | Analyse the case of slum relocation in the context of land markets, land use (planning) and competitiveness of cities. | | ● | | ● | | | | ● | | | | | |

# PLANNING SUSTAINABLE CITIES

| **Course** | **201800277** |
|---|---|
| Period | 14 November 2022 - 03 February 2023 |
| EC | 7 |
| Course coordinator | |

## INTRODUCTION

This course aims to develop a critical understanding of spatial planning based on academic discourses, the international development agenda and students' own experiences. Throughout the course the role of spatial data and information systems in urban planning and management will be highlighted and illustrated. Students will develop a spatial understanding of specific urban issues in the students' home country by applying knowledge and skills in spatial information handling. Students are introduced to a set of both spatial and non-spatial methods relevant for the practice of urban planning and management. The concepts of Sustainability, Gentrification and Informality will be introduced and discussed. Available databases and data catalogues are explored to discuss different approaches to sustainability frameworks and assessments, and to understand the urban processes of gentrification and informality.

## CONTENT

**Concepts/ theories and frameworks**

1. What is urban planning
2. Planning instruments/ types of plans
3. Planning traditions
4. Contemporary planning issues in the global south
5. Theories and concepts in urban planning and management
6. Urban processes (gentrification, informality) and concepts (sustainability, land tenure)
7. Planning processes, Role of GI in planning

**Methods and tool**

1. Primary and secondary data collection
2. SWOT analysis
3. Basic programming
4. Sustainability assessment
5. indicators selection
6. Geographical patterns
7. Data visualization and reporting

## TEACHING AND LEARNING APPROACH

A variety of approaches will be mixed. Introductory lectures (primarily dealing with theory and concepts), discussion sessions (in which particulars such as literature, videos or other materials are being discussed) practicals (in which concepts and methods that have been studied will be practiced by the students), tutorials (cook book style assignments to learn to apply methods and tools) and a local fieldwork to gather data in the field and integrate these in the assignment.

Participation and attendance:

- Mandatory attendance for supervised practicals, fieldwork activities and seminars is required;
- Due to educational activities that require active involvement (e.g. group presentations), the lecturer may demand mandatory attendance during lectures or parts thereof.

The course coordinator will communicate this at the start of the course.

### TESTS

Test 1 - Individual assignment - Planning theory and theories in planning (20%)

Test 2 – Group assignment "Sustainability in Enschede" – (15%)

Test 3 – Group assignment Tenure from space (10%)

Test 4 - Mapping changes in the Roombeek area (15%)

Test 5 - Final test (40%)

### ENTRY REQUIREMENTS

M-Geo Core courses

### LEARNING OUTCOMES

Upon completion of this course, the student is able to:

LO 1 Describe different definitions and approaches to urban planning and management (contexts; regions; levels).

LO 2 Discuss contemporary urban planning theories and concepts.

LO 3 Identify critical issues in the practice of urban planning and management (a.o. based on students' experiences and international development agenda).

LO 4 Collect, process and analyse different sets of data to describe urban processes.

LO 5 Discuss the sustainability of urban regions by means of the chosen set of data and relevant methods of analysis

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 38 |
| Supervised practical | 34 |
| Study trip | 2 |
| Written/oral test | 4 |
| Individual assignment | 24 |
| Group assignment | 58 |
| Self-study | 36 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Test 1 | Test 2 | Test 3 | Test 4 | Test 5 |
|---|---|---|---|---|---|---|
| | | Learning Outcomes that are addressed in the test | | | | |
| LO 1 | Describe different definitions and approaches to urban planning and management (contexts; regions; levels). | | | | | ● |
| LO 2 | Discuss contemporary urban planning theories and concepts. | ● | | | | ● |
| LO 3 | Identify critical issues in the practice of urban planning and management (a.o. based on students' experiences and international development agenda). | ● | | | | ● |
| LO 4 | Collect, process and analyse different sets of data to describe urban processes. | | | ● | ● | ● |
| LO 5 | Discuss the sustainability of urban regions by means of the chosen set of data and relevant methods of analysis | | ● | | | ● |
| | Test type | Report | Group work | Group work | Group work | Written test |
| | Weight of the test | 20 | 15 | 10 | 15 | 40 |
| | Individual or group test | Individual | Group | Group | Group | Individual |
| | Type of marking | 1-10 | 1-10 | 1-10 | 1-10 | 1-10 |
| | Required minimum mark per test | | | | | |
| | Number of test opportunities per academic year | 2 | 1 | 1 | 1 | 2 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Describe different definitions and approaches to urban planning and management (contexts; regions; levels). | | | | ● | | | | | | ● | ● | | |
| LO 2 | Discuss contemporary urban planning theories and concepts. | ● | | | ● | | | | | | | | ● | |
| LO 3 | Identify critical issues in the practice of urban planning and management (a.o. based on students' experiences and international development agenda). | | | | ● | | | | | | ● | ● | | |

| Learning outcomes (LO) of the course: The student will be able to... | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 4 | Collect, process and analyse different sets of data to describe urban processes. | ● | ● | | | ● | | ● | | | | | | |
| LO 5 | Discuss the sustainability of urban regions by means of the chosen set of data and relevant methods of analysis | | ● | | | | | | | | | | | |

# RISK-SENSITIVE URBAN PLANNING STUDIO

| **Course** | **201800312** |
|---|---|
| Period | 24 April 2023 - 07 July 2023 |
| EC | 7 |
| Course coordinator | |

### INTRODUCTION

Urban areas and their populations are often seriously affected by hazards (e.g. natural, biological, technological hazards or combinations of these). They also have to adapt to the impacts of climate change. Accordingly, city authorities, planners and other stakeholders are searching for ways to be more risk-sensitive in their plans and actions. Becoming resilient includes developing the capacities to meet such challenges.

This course addresses concepts of urban risk management and approaches to integrate risks associated with hazards and climate change into urban planning and management strategies and actions. GIS-based methods to conduct urban risk and vulnerability assessments and evaluate potential planning interventions will be learned and applied.

### CONTENT

- Relevant scientific concepts that will be addressed in the course: natural and technological hazards, risk, physical and social vulnerability, climate change mitigation and adaption, resilience
- Hazard assessment
- Vulnerability and risk assessment
- Urban growth and climate change scenarios affecting levels of risk and vulnerability
- Risk-sensitive planning interventions
- Evaluation of planning interventions
- strategy and policy making

### TEACHING AND LEARNING APPROACH

The students will work in a studio setting, i.e. they will work in teams pro-actively on a given case study project throughout the entire course. Project teams will need to develop a work plan that they then follow. Inputs in terms of lectures on certain topics, issues and methods as well as feedback and supervision by the team of lecturer will be provided as needed.

Important concepts, methods and techniques that have been addressed earlier in the curriculum can also be applied. Students need to demonstrate that they are able to describe, analyse and discuss a planning problem and come up with well-motivated plans that are risk sensitive. The emphasis will be on their ability to critically discuss and explain choices and to critically reflect on the proposed course of action.

A link will be made with ESA course Q4. Lectures will be given partly to both student populations and some group assignments will be interdisciplinary in group composition and tasks.

Participation and attendance:

- Compulsory attendance for supervised practicals, fieldwork activities and seminars is required;
- Due to educational activities that require active involvement (e.g. group presentations), the lecturer may demand mandatory attendance during lectures or parts thereof.

The course coordinator will communicate this at the start of the course.

### TESTS

Test 1: Vulnerability mapping: Development and interpretation of case study specific vulnerability maps (individual)

Test 2: Development of an urban adaptation plan (group report)

Test 3: Group presentation and discussion of results

### ENTRY REQUIREMENTS

All students in the UPM specialization are accepted. Students following other specializations or programmes should have a background in urban planning.

### LEARNING OUTCOMES

Upon completion of this course, the student is able to:

LO 1 Describe the roles of urban planning and management in addressing risks from natural hazards

LO 2 Identify urban risks resulting from natural or industrial hazards and climate change

LO 3 Apply spatial modelling and analytical techniques and methods for assessing urban risks and levels of vulnerability

LO 4 Analyze risk-related urban development policies

LO 5 Develop alternative risk-related urban adaptation plans and interventions

LO 6 Evaluate risk-related urban adaptation plans and interventions addressing urban risks

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 18 |
| Supervised practical | 2 |
| Tutorial | 32 |
| Written/oral test | 2 |
| Individual assignment | 6 |
| Group assignment | 104 |
| Self-study | 32 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Test 1 | Test 2 | Test 3 |
|---|---|---|---|---|
| | | **Learning Outcomes that are addressed in the test** | | |
| LO 1 | Describe the roles of urban planning and management in addressing risks from natural hazards | | ● | ● |
| LO 2 | Identify urban risks resulting from natural or industrial hazards and climate change | ● | | ● |
| LO 3 | Apply spatial modelling and analytical techniques and methods for assessing urban risks and levels of vulnerability | ● | | |
| LO 4 | Analyze risk-related urban development policies | | ● | |
| LO 5 | Develop alternative risk-related urban adaptation plans and interventions | | ● | ● |
| LO 6 | Evaluate risk-related urban adaptation plans and interventions addressing urban risks | | ● | ● |
| | Test type | Map and short report | Report | Presentation |
| | Weight of the test | 30 | 40 | 30 |
| | Individual or group test | Individual | Group | Group |
| | Type of marking | 1-10 | 1-10 | 1-10 |
| | Required minimum mark per test | | | |
| | Number of test opportunities per academic year | 2 | 1 | 1 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Describe the roles of urban planning and management in addressing risks from natural hazards | | | | | | ● | | | | | | | ● |
| LO 2 | Identify urban risks resulting from natural or industrial hazards and climate change | | ● | | | | | | | ● | ● | ● | | ● |
| LO 3 | Apply spatial modelling and analytical techniques and methods for assessing urban risks and levels of vulnerability | ● | ● | ● | ● | ● | | | | | | | | ● |

| **Learning outcomes (LO) of the course: The student will be able to...** | | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 4 | Analyze risk-related urban development policies | | | | | | ● | | ● | ● | ● | ● | ● | ● |
| LO 5 | Develop alternative risk-related urban adaptation plans and interventions | | | ● | ● | ● | ● | ● | ● | | ● | ● | | ● |
| LO 6 | Evaluate risk-related urban adaptation plans and interventions addressing urban risks | | | | | | ● | ● | | | ● | ● | ● | ● |

# THE COMPACT CITY

| **Course** | **201800293** |
|---|---|
| Period | 06 February 2023 - 21 April 2023 |
| EC | 7 |
| Course coordinator | |

## INTRODUCTION

Cities are centres in which a variety of functions and activities are organised in a relatively compact space. People engage in these activities through spatial interaction. The way in which these activities are arranged spatially has a huge bearing on the amount of spatial interaction (and thus travel demand) generated and the infrastructure required to facilitate this interaction. The physical manifestation of this spatial arrangement is referred to as urban form, a concept which can help us understand the way cities function in terms of their spatial structure and pattern, at different scales. The processes of land use and infrastructure development that determine urban form are closely linked and are mutually influencing. In this course, we investigate urban form and are addressing urban spatial development concepts in terms of their spatial interaction. We look at the most important theoretical concepts that describe the relation between land use and transportation. We make use of a variety of modelling tools and techniques to help analyse and understand this mutual relation and come up with better spatial planning policies.

## CONTENT

- Urban form and compactness
- Morphological models
- Spatial metrics to quantify urban form
- Urban growth modelling
- Urban transport, land use and urban form
- Sustainable transport
- Transit oriented Development
- Spatial interaction
- Travel behaviour
- Travel demand

## TEACHING AND LEARNING APPROACH

A variety of approaches will be used. Introductory lectures (primarily dealing with theory and concepts), discussion sessions (in which particulars such as specific literature, videos or other materials are being discussed), practicals (in which concepts and methods that have been studied will be practiced by the students), tutorials (cook book style assignments to learn to apply methods and tools), a local fieldwork to gather data in the field and integrate these in the assignment, guest lectures (of practitioners in transport and land use planning) and an excursion.

Participation and attendance:

- Compulsory attendance for supervised practicals, fieldwork activities and seminars is required;
- Due to educational activities that require active involvement (e.g. group presentations), the lecturer may demand mandatory attendance during lectures or parts thereof.

The course coordinator will communicate this at the start of the course.

## TESTS

The following tests will be organised:

Test 1 - individual written test Urban Form and Urban Growth
Test 2 - individual written test Urban Form and Transport
Test 3 - Individual assignment Urban Growth and Spatial Metrics
Test 4 - Group assignment Transit Oriented Development
Test 5 – Individual assignment Travel Demand/Travel Behaviour

### ENTRY REQUIREMENTS

Basics in GIS equivalent to M-Geo core courses. Background in urban planning, geography, engineering or related is an advantage.

### LEARNING OUTCOMES

Upon completion of this course, the student is able to:

LO 1 Define and explain important urban form concepts (e.g. compactness, density, intensity).

LO 2 Critically review concepts of urban form and transport interaction and ways to relate characteristics of the built environment to measures of travel.

LO 3 Discuss the application of various models related to urban development and transport studies (logistic regression models of urban growth, multi-criteria evaluation, trip generation, distribution and trip assignment models, choice models).

LO 4 Quantify a set of urban form indicators using spatial metrics

LO 5 Interpret and reflect on quantified urban form indicators to understand the changing spatial structures of an urban region.

LO 6 Apply spatial and non spatial multi-criteria analysis for Transit Oriented Development

LO 7 Develop a conceptual understanding and implement a 4-step Travel Demand Model

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 32 |
| Supervised practical | 22 |
| Tutorial | 20 |
| Study trip | 4 |
| Written/oral test | 4 |
| Individual assignment | 22 |
| Group assignment | 24 |
| Self-study | 68 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Test 1 | Test 2 | Assignment 1 | Assignment 2 | Assignment 3 |
|---|---|---|---|---|---|---|
| | | **Learning Outcomes that are addressed in the test** | | | | |
| LO 1 | Define and explain important urban form concepts (e.g. compactness, density, intensity). | ● | | | | |
| LO 2 | Critically review concepts of urban form and transport interaction and ways to relate characteristics of the built environment to measures of travel. | | ● | | | |
| LO 3 | Discuss the application of various models related to urban development and transport studies (logistic regression models of urban growth, multi-criteria evaluation, trip generation, distribution and trip assignment models, choice models). | ● | ● | | | |
| LO 4 | Quantify a set of urban form indicators using spatial metrics | | | ● | | |
| LO 5 | Interpret and reflect on quantified urban form indicators to understand the changing spatial structures of an urban region. | | | ● | | |
| LO 6 | Apply spatial and non spatial multi-criteria analysis for Transit Oriented Development | | | | ● | |
| LO 7 | Develop a conceptual understanding and implement a 4-step Travel Demand Model | | | | | ● |
| | Test type | Written test | Written test | Assignment | Assignment | Assignment |
| | Weight of the test | 25 | 25 | 20 | 15 | 15 |
| | Individual or group test | Individual | Individual | Individual | Group | Individual |
| | Type of marking | 1-10 | 1-10 | 1-10 | 1-10 | 1-10 |
| | Required minimum mark per test | | | | | |
| | Number of test opportunities per academic year | 2 | 2 | 2 | 2 | 2 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Define and explain important urban form concepts (e.g. compactness, density, intensity). | ● | | | | | | | | | | | | |
| LO 2 | Critically review concepts of urban form and transport interaction and ways to relate characteristics of the built environment to measures of travel. | | | ● | | | | | | | | | | |

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 3 | Discuss the application of various models related to urban development and transport studies (logistic regression models of urban growth, multi-criteria evaluation, trip generation, distribution and trip assignment models, choice models). | | | | ● | | | | | | | | | |
| LO 4 | Quantify a set of urban form indicators using spatial metrics | ● | | | | | | | | | | | | |

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 5 | Interpret and reflect on quantified urban form indicators to understand the changing spatial structures of an urban region. | | | | ● | | | | | | | | | |
| LO 6 | Apply spatial and non spatial multi-criteria analysis for Transit Oriented Development | | | | ● | | | | | | | | | |
| LO 7 | Develop a conceptual understanding and implement a 4-step Travel Demand Model | | | | ● | | | | | | | | | |

# EARTH OBSERVATION OF WATER RESOURCES

| **Course** | **201800285** |
|---|---|
| Period | 14 November 2022 - 03 February 2023 |
| EC | 7 |
| Course coordinator | |

## INTRODUCTION

Water and energy are fundamental for life on Earth, their variations, trends, and extremes are sources for drought extremes, heat waves, heavy rains, floods, and intensive storms that are increasingly threatening our society to cause havoc as the climate changes. Better observations and analysis of these phenomena will help improve our ability to understand their physical processes (as introduced in Q2.1) and to model and predict them. Earth Observation technology is a unique tool to provide a global understanding of essential water and energy variables and monitor their evolution from global to basin scales. In this course, you will learn the physical principles of how electromagnetic signals were applied to monitor these essential variables by spaceborne sensors, and learn tools and methods to collect, process, and visualize Earth observation data of surface solar radiation, evapotranspiration, precipitation, soil moisture, and terrestrial water storage. Furthermore, students will learn how to retrieve the essential water/climate variable – soil moisture from Earth observation data, applying the radiative transfer theory.

## CONTENT

This course is closely linked and complementary to Q2.1, in a way that Q2.1 focuses on the physical processes of Water and Energy Cycles, while Q2.2 on Earth observation technology. For each thematic topic (i.e., energy balance, evapotranspiration, precipitation, soil moisture, and groundwater storage), the physical processes will be first presented in Q2.1, and the Earth observation part will follow correspondingly. The course content is as follows:

Week 1-2 Earth observations for radiation and energy balance

Week 3-4 Earth observations for evapotranspiration

Week 4-5 Earth observations for precipitation

Week 6-8 Earth observation for terrestrial water storage (physical processes + integrated assessment)

Week 8-9 Earth observation for soil moisture

## TEACHING AND LEARNING APPROACH

The course lasts for 10 weeks with 2 days a week, and the Q2.1 (Physical Processes) and Q2.2 (Earth Observations) of water and energy cycles in the Earth system are designed as such to be closely complementary to each other. The course is designed for a continuous flow and the student is mostly unaware of this partition, adding to the robustness of the teaching.

In this way, the 10 weeks are divided in topics covering Water and Energy Balance components, each of which could last between 1 to 2 weeks depending on the complexity. Each topic ends up with a Question Hour direct to the involved staff. A number of quizzes are designed along the way as formative assessments, able to correct misalignments in the studies.

Some topics have field trips to the novel LILA site at the campus in the University of Twente, where students practice on equipment and measuring devices.

## TESTS

Test 1. Written test (weight 50 %, individual) on radiative transfer theory, accuracy assessment, and sources of uncertainty.
Test 2. Individual assignment (weight 20 %, individual) aimed at assessing the student's competence in collecting, processing and visualizing Earth observation data.
Test 3. Group assignment (weight 30 %, group) focus on the creation of the hydrological state variables.

If the assignments do result in a mark below 6 a possibility to repair/improve the assignments will be given. The maximum mark after this repair is a 6.

The number of test attempts is 2 per academic year.

## ENTRY REQUIREMENTS

- knowledge of geometry, integration, differentiation

## LEARNING OUTCOMES

Upon completion of this course, the student is able to:

LO 1 Derive essential water and energy variables from Earth Observation data.
LO 2 Apply the concepts of radiative transfer theory in the optical, thermal and microwave parts of the electromagnetic spectrum for water and energy cycles.
LO 3 Collect, process, and visualize essential water and energy variables from Earth observation data supplied via the world wide web and through satellite broadcasts.
LO 4 Apply a calibration/validation protocol and calculate statistical error metrics for quantitative accuracy assessment of derived water and energy variables.

## ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 40 |
| Supervised practical | 24 |
| Written/oral test | 3 |
| Individual assignment | 16 |
| Group assignment | 44 |
| Self-study | 69 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Written test | Individual assignment | Group assignment |
|---|---|---|---|---|
| | | Learning Outcomes that are addressed in the test | | |
| LO 1 | Derive essential water and energy variables from Earth Observation data. | | | ● |
| LO 2 | Apply the concepts of radiative transfer theory in the optical, thermal and microwave parts of the electromagnetic spectrum for water and energy cycles. | ● | | |
| LO 3 | Collect, process, and visualize essential water and energy variables from Earth observation data supplied via the world wide web and through satellite broadcasts. | | ● | |
| LO 4 | Apply a calibration/validation protocol and calculate statistical error metrics for quantitative accuracy assessment of derived water and energy variables. | ● | | ● |
| | Test type | Written test | Individual assignment | Group assignment |
| | Weight of the test | 50 | 20 | 30 |
| | Individual or group test | Individual | Individual | Group |
| | Type of marking | 1-10 | 1-10 | 1-10 |
| | Required minimum mark per test | | | |
| | Number of test opportunities per academic year | 2 | 1 | 1 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Derive essential water and energy variables from Earth Observation data. | ● | | ● | ● | | | | | | | | | |
| LO 2 | Apply the concepts of radiative transfer theory in the optical, thermal and microwave parts of the electromagnetic spectrum for water and energy cycles. | | | | ● | | | | | | | | | |
| LO 3 | Collect, process, and visualize essential water and energy variables from Earth observation data supplied via the world wide web and through satellite broadcasts. | | | | ● | | | | | | | | | |
| LO 4 | Apply a calibration/validation protocol and calculate statistical error metrics for quantitative accuracy assessment of derived water and energy variables. | | | | ● | ● | | ● | | | | | | |

# HYDROLOGICAL AND ENVIRONMENTAL CYCLES

| **Course** | **201800275** |
|---|---|
| Period | 14 November 2022 - 03 February 2023 |
| EC | 7 |
| Course coordinator | |

## INTRODUCTION

The interrelated Water and Energy cycle ultimate control all water presence and climatic processes on Earth, and consequently, the life of all beings and its quality. To understand those cycles is foundational to any conservative and sustainable action we, as professionals, may attempt in our environment. This course digs into the most critical and delicate balance of nature.

To explain the importance of the components of the water and energy cycle, the course envisages two end practical examples: the calculation of **Water Productivity** (Crop per Drop) and the evaluation of **droughts**. *Water Productivity* estimates is obtained after the studies of the radiation balance and evapotranspiration and *droughts* is the end product of the previous learnings and the addition of the precipitation, soil moisture and groundwater concepts. Along the course physical processes and their Remote Sensing retrievals are fully integrated.

It is to note that this Q2.1 is designed being supplementary to the Q2.2, in a dual treatment manner, wherein Q2.1 focuses on the understanding of Physical Processes and Q2.2 on Earth Observation of the Water and Energy Cycles of Earth System.

## CONTENT

The content of the course follows a thematic partition imposed by the treatment of Water and Energy Balance of Earth System that is widely accepted in most educational programs. The logical sequence is described as: First, the Radiation Balance Equation (RBE), is used to evaluate “net” radiation on the ground to be used by the Earth System. The availability of water in the ground widely determines how this radiation excess is used between heat and evapotranspiration by the use of Energy Balance Equation (EBE).
The EBE ultimately solves the evapotranspiration, that is the transfer of water between the surface and the atmosphere, triggering the water cycle. The rest of the course digs in the understanding of the vertical components, fluxes and storages of the water cycle: evapotranspiration, precipitation, water in soils (vadose and groundwater zones).

To integrate the components of the water and energy cycle, the estimation of Water Productivity and Droughts is exemplified giving an adequate closure and allowing the division of the course in two periods as well.
The practical is linked to study cases for the processes and to Q2.2 for the from Remote Sensing.
The course has wrap up sessions where the EBE and the water cycle are used to analyze water excess or deficits and crop water requirements.

- Week 1: Water and Energy Cycles on Earth Systems: Physics and Earth observation (SW&TIR).
- Week 2: Water and Energy Cycles on Earth Systems: Evapotranspiration processes.
- Week 3: Earth system atmosphere - Water Cycle: Evapotranspiration (continuation), portal sources and data acquisition.
- Week 4: Application on Water productivity. Earth system atmosphere - Water Cycle: Precipitation and its Earth Observation.
- Week 5: Earth system atmosphere - Water Cycle: Precipitation (continuation) and its Earth Observation.
- Week 6: Earth system soil: Soil Moisture processes in unsaturated zone.
- Week 7: Earth system soil - Ground water processes.
- Week 8: Earth system soil - EO for gravimetry and Microwaves in soil water.
- Week 9: Earth system soil - Microwaves in soil water (continuation) and EO calibration and validation. Application on Droughts.
- Week 10: Deliveries and Exams.

### TEACHING AND LEARNING APPROACH

The course lasts for 10 weeks, with a balance time between Q2.1 (Physical Processes, this course) and Q2.2 (Earth Observations, sibling course).
Lectures, usually during mornings, explain the physical process in the radiation, energy and water balance, its components and the application examples to Water Productivity and Droughts. Lectures are both in class and recorded.
The practice is both supervised and unsupervised, although the responsible staff is always available for consultation. Practical style are chosen to best suit the process under study: exercises using standard tools (Excel sheets, calculations) to grasp the main (1D) “vertical” processes. The extension to 2-3D is done in Q2.2 in a natural conjunction along the course.
The blending between the theory and the practical is done through the use of Jupyter NoteBooks (JNB) where complementary explanations and exercising are together. Python is slowly introduced in this routinely work that is part of the Centre of Expertise in Big Geodata Science (CRIB) at ITC.
The course counts on Question Hour, practice quizzes and exploration in Field measurement and devices from the new LILA experimental site of the UT.

### TESTS

Despite the integration between Q2.1 (processes) and Q2.2 (EO), for the assessments, there is a clear thematic partition between Q2.1 and Q2.2.

The Q2.1 will assess the processes of Radiaton, energy and water balance, evapotranspiration, precipitation, soil moisture and ground water. That will be done with a combination of the following tests:

Exam test: Overall weight: 45%.
Selected quizzes, exercises and minor assignments (when not practice). Overall weight is 5%.
Assignments: single area, multiple aspects. with facilitated rubrics. Overall weights: 50%

If the assignments do result in a mark below 6 a possibility to repair/improve the assignments will be given. The maximum mark after this repair is a 6. The number of test attempts is 2 per academic year.

Note: the tests are designed to evaluate the Learning objectives of this course. In general, one type of test is selected to evaluate a learning objective, however in some cases this is not possible and then a combination of these tests will be indicated.

### ENTRY REQUIREMENTS

To have completed the Core Course of ITC (Quartile 1).
The strongly advised conditions are good skills in physics and math, high marks in the Remote Sensing related topics of the Core (Q1), have previous exposure to hydrology and activities in the Water Sector.

### LEARNING OUTCOMES

Upon completion of this course, the student is able to:

LO 1 Understand the concepts of Radiation & Energy Balance and the synergy in the water cycle.
LO 2 Understand the water storage of nature and the forces and resistances acting over the water fluxes in the Earth-Atmosphere.
LO 3 Operate conceptual & 1-D models of flux exchange of precipitation and evapotranspiration.
LO 4 Operate conceptual & 1-D models of flux exchange of soil moisture and conceptual models of groundwater.
LO 5 Find and collect hydro related information from EO data supplied via the world wide web.
LO 6 Analyze time series of weather and EO data for applications in Water Productivity and droughts.

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 70 |
| Written/oral test | 6 |
| Individual assignment | 28 |
| Self-study | 92 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Test 1 | Test 2 | Test 3 |
|---|---|---|---|---|
| | | Learning Outcomes that are addressed in the test | | |
| LO 1 | Understand the concepts of Radiation & Energy Balance and the synergy in the water cycle. | ● | | ● |
| LO 2 | Understand the water storage of nature and the forces and resistances acting over the water fluxes in the Earth-Atmosphere. | ● | | ● |
| LO 3 | Operate conceptual & 1-D models of flux exchange of precipitation and evapotranspiration. | ● | ● | |
| LO 4 | Operate conceptual & 1-D models of flux exchange of soil moisture and conceptual models of groundwater. | ● | ● | |
| LO 5 | Find and collect hydro related information from EO data supplied via the world wide web. | | ● | |
| LO 6 | Analyze time series of weather and EO data for applications in Water Productivity and droughts. | | ● | |
| | Test type | Written test | Assignment | Digital test |
| | Weight of the test | 45 | 50 | 5 |
| | Individual or group test | Individual | Individual | Individual |
| | Type of marking | 1-10 | 1-10 | Pass/Fail |
| | Required minimum mark per test | 6 | 6 | |
| | Number of test opportunities per academic year | 2 | 2 | 2 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | Learning outcomes (LO) of the course: The student will be able to... | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Understand the concepts of Radiation & Energy Balance and the synergy in the water cycle. | ● | | | ● | | | | | ● | | | ● | ● |
| LO 2 | Understand the water storage of nature and the forces and resistances acting over the water fluxes in the Earth-Atmosphere. | ● | | | ● | | ● | | ● | | | | ● | ● |
| LO 3 | Operate conceptual & 1-D models of flux exchange of precipitation and evapotranspiration. | ● | | ● | ● | | ● | | ● | | | | ● | ● |
| LO 4 | Operate conceptual & 1-D models of flux exchange of soil moisture and conceptual models of groundwater. | ● | | ● | ● | | | | ● | | | | ● | ● |
| LO 5 | Find and collect hydro related information from EO data supplied via the world wide web. | | | | | | | | | | ● | ● | | ● |

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 6 | Analyze time series of weather and EO data for applications in Water Productivity and droughts. | | ● | | ● | ● | ● | ● | ● | ● | | ● | ● | ● |

# SHADES-OF-BLUE: EARTH OBSERVATION OF COASTAL AND INLAND WATERS

| **Course** | **201800303** |
|---|---|
| Period | 24 April 2023 - 07 July 2023 |
| EC | 7 |
| Course coordinator | |

## INTRODUCTION

This teaching course SHADES-OF-BLUE aims at providing the students with the competence to use Earth Observation (EO) data and products to leverage the management of coastal and inland aquatic resources and policymaking.

The main objective is to deepen and broaden the knowledge and practical skills of students in using EO products and applications for the integrated management of aquatic resources in deltas. The course includes technical skills and know-how about EO data, products, and applications and, more importantly, global phenomena related to ocean-land-atmosphere interactions. EO products and applications are fundamental components of the planned course and form the backbone of the teaching from the start to the end. Therefore, the course will not only focus on the more generic building stones of remote sensing of aquatic resources but also on the wider scope of applications that addresses the water-atmosphere-land nexus with a deeper analysis and evaluation phase. During this course, the students will acquire competencies needed to address the national (Dutch Research Agenda, routes nr. 1, 4, 9, 13, 23, and 25) and the international research agenda (UN’s Sustainable Development Goals nr. 6, 13, 14, 15).

## CONTENT

The course SHADES-OF-BLUE builds upon the M-GEO- core and the WREM 2.0 courses and covers four thematic fields (sub-courses) related to Earth Observation of coastal and inland waters. The first sub-course addresses the **ocean-climate nexus** and the role of satellite-based essential climate variables in describing these interactions. The second sub-course focuses on the **vulnerability and resilience of coastal areas**. The third sub-course handles **water quality and land-based pollution**. The fourth sub-course addresses the **productivity of aquatic systems** (aquatic vegetation, primary production) and their role in the global carbon cycle. In addition to these themes, the course closes with a group assignment for the students to apply the gained knowledge and for the teacher to assess the learning process.

In total, the course contains five scaffolded learning units (sub-courses) that will be taught during one quartile (~10 weeks) with 7 EC of study load. The first four learning units, although interconnected, are designed to be offered as independent distance education courses. The last learning unit “Challenge” is an assignment that will serve the students to investigate new ways to address relevant challenges, and the teachers to assess the learning of the students. The sub courses are:

- **Ocean-climate nexus**: in this course, the students will learn about the importance of oceanic-climate global phenomena, such as ENSO and other oscillations, and how satellite-based products of essential climate variables are used to describe these interactions;
- **Coastal systems and sea-level rise**: in this course, the students will learn about hydrological, morphological, sedimentological and biological processes that shape coastal (eco)systems at various spatiotemporal scales, about aspects related to sea-level change (e.g., sea level, vertical land motion), and how satellite data can help to evaluate the vulnerability and adaptive capacity of coastal areas to sea-level change, erosion and subsidence;
- **Water pollution**: in this course, the students will learn how to derive water quality indicators from optical and thermal Earth Observation sensors and integrate different satellite products to evaluate the vulnerability of coastal and inland waters to pollution and turbidity;
- **Blue productivity**: in this course, the students will learn how the dynamics (e.g. upwelling) and biology (primary production of water and aquatic vegetation) play a vital role in the Earth’s carbon cycle and control the productivity (fishing ground aquaculture) of aquatic systems. During the exercises and the assignment, different satellite products will be integrated to estimate the primary production of coastal and oceanic waters;
- **Challenge**: this unit spans three weeks and provides four course-related challenges that the students can choose from them. The assignment is part of the learning process as it provides an opportunity for the students to apply the newly gained knowledge (from units 1 to 4) and integrate different EO data in challenging applications.

## TEACHING AND LEARNING APPROACH

The course SHADES-OF-BLUE will be offered as part of the M-GEO programme and will therefore be delivered in a hybrid setup (face-to-face and online) in the teaching rooms of the University of Twente. The lectures will be recorded and shared with the students. During the lectures, students are exposed to new concepts followed by hands-on practical exercises. A field excursion is organized to provide the students with practical skills to collect in-situ data for calibration and validation purposes. The students are requested to be physically present during the field excursion to improve their learning gain.

During the assignment, the students will be coached while they are working on developing the specific application of the assignment. The students are requested to work in groups and prepare a case study from the selected challenge and provide the details of the application developed as well as the results obtained in a report supported by a poster presentation.

The main sub-courses forming this course (namely, **Ocean-climate nexus**, **Coastal systems and sea-level rise**, **Water pollution** and **Blue productivity**) with their corresponding challenges will also be offered as distance education courses.

**TESTS**

The test consists of three parts, one written test, a group assignment and a poster presentation. The following assessment matrix shows the guidelines that will be employed to evaluate the learning outcomes of students:

Table 1: assessment matrix of the course SHADES-OF-BLUE and the alignment with the learning objectives and Bloom's taxonomy, different shades indicate the type of used assessment.

| ***Assessment type*** | **Written exam** | | **Assignment** | | **Poster presentation** |
|---|---|---|---|---|---|
| ***Questions' type*** | MC, OC questions | Case study | The students can choose one of the four assignments | | Assignment |
| ***Weight*** | 0.2 | 0.2 | 0.4 | | 0.2 |
| ***Learning outcomes*** | LO1 | LO2 | LO3 | LO4 | LO5 |
| ***Bloom taxonomy*** | Understand | Apply | Analyse | Evaluate | Communicate |
| ***Level Factual*** | Summarize the basic principles of remote sensing as applied to the aquatic system | Apply the principles of remote sensing to aquatic systems | Check the consistency of EO data and assemble different EO-derived variables for a selected application | Generate EO-based descriptors of the nexus under study | Professionally present the scientific results |
| ***Level Conceptual*** | Classify EO data and procedures suited for the selected applications | Choose the best method/procedure to carry out the selected applications using EO data | Analyse trends and differentiate changes in an area of interest using EO data with error metrics and the confidence | Determine the cause-effect relationships between various interactions | Present the scientific results in an easy to follow manner suited for non-specialists |
| ***Level Procedural*** | Clarify the pre-processing steps to work with EO data | Carry out the selected applications using EO data | Integrate EO applications in your area's coast/delta/aquatic system | Judge the validity of EO results | Communicate the results in an engaging manner |

### ENTRY REQUIREMENTS

- Basic knowledge in remote sensing and spatial data analysis
- Background in physics, biology, earth sciences and/or applied mathematics
- Affinity of working with EO data and natural resources

### LEARNING OUTCOMES

Upon completion of this course, the student is able to:

LO 1 Summarize and classify the types of EO data available and how it can be accessed and used (including data handling & limitations of EO) to address a specific application;

LO 2 Apply procedures to proceed EO data and to assemble multi variables and indices in a way that can characterise the system under study

LO 3 Analyse change trends, error metrics and the confidence of the trend and changes;

LO 4 Evaluate the cause-effect relationships between various interaction mechanisms at the water interfaces with the atmosphere and land;

LO 5 Communicate the scientific results professionally and be able to engage with non-specialised stakeholders.

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 32 |
| Supervised practical | 32 |
| Study trip | 20 |
| Written/oral test | 4 |
| Group assignment | 28 |
| Self-study | 64 |
| Individual assignment | 16 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Test 1 | Test 2 | Test 3 |
|---|---|---|---|---|
| | | Learning Outcomes that are addressed in the test | | |
| LO 1 | Summarize and classify the types of EO data available and how it can be accessed and used (including data handling & limitations of EO) to address a specific application; | ● | | |
| LO 2 | Apply procedures to proceed EO data and to assemble multi variables and indices in a way that can characterise the system under study | ● | | |
| LO 3 | Analyse change trends, error metrics and the confidence of the trend and changes; | | ● | |
| LO 4 | Evaluate the cause-effect relationships between various interaction mechanisms at the water interfaces with the atmosphere and land; | | ● | |
| LO 5 | Communicate the scientific results professionally and be able to engage with non-specialised stakeholders. | | | ● |
| | Test type | Written test | Report | Presentation |
| | Weight of the test | 40 | 40 | 20 |
| | Individual or group test | Individual | Group | Individual |
| | Type of marking | 1-10 | 1-10 | 1-10 |
| | Required minimum mark per test | | | |
| | Number of test opportunities per academic year | 2 | 2 | 2 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Summarize and classify the types of EO data available and how it can be accessed and used (including data handling & limitations of EO) to address a specific application; | ● | ● | ● | | | | | | | | | | |
| LO 2 | Apply procedures to proceed EO data and to assemble multi variables and indices in a way that can characterise the system under study | | | ● | ● | ● | | | | | | | | |

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 3 | Analyse change trends, error metrics and the confidence of the trend and changes; | | | | | ● | ● | ● | | | | | | ● |
| LO 4 | Evaluate the cause-effect relationships between various interaction mechanisms at the water interfaces with the atmosphere and land; | | | | | | | ● | | ● | | ● | ● | ● |
| LO 5 | Communicate the scientific results professionally and be able to engage with non-specialised stakeholders. | | | | | | | | ● | | ● | ● | | ● |

# OBSERVING AND MODELLING SURFACE WATER IN A CHANGING WORLD

| **Course** | **201800295** |
| --- | --- |
| Period | 06 February 2023 - 21 April 2023 |
| EC | 7 |
| Course coordinator | |

## INTRODUCTION

### Significance

Surface waters such as lakes and rivers play a key role in water management and ecosystems in many countries. On the one hand, they offer direct access to water needed for agriculture, domestic uses, and industry. On the other hand, surface waters act as the interface between groundwater and the atmosphere, through processes such as evapotranspiration, runoff, and aquifer recharge.

At a geopolitical level, unsustainable anthropogenic use of surface water have a serious potential for conflicts. Many rivers cross international boundaries and upstream usage therefore can create shortages and pollution downstream.

Furthermore, in light of climate change, it is expected that the water cycle will intensify at a global scale (“dry gets drier and wet gets wetter”) but there is still uncertainty on how this will manifests itself at a local and regional level. It is imaginable that some areas see little change in their climatic regime, while others will experience longer droughts more intense floodings and/or changes in the rain seasons.

### Aims

This course aims to provide students with a foundation to (1) understand the geophysical processes which affect surface water changes in lakes and rivers, (2) explore various observation methods from space and in situ, and (3) explore ways of adding value to existing datasets. As such, the course will provide students with a skill-set allowing them to tackle surface water problems in various regions of the world, and make them aware of climatic and human factors which are modulating the water cycle with a dedicated focus on lakes and rivers.

The course offers content which is relevant to the United Nations sustainable development goals (SDG) 6 (Clean water and Sanitation). It furthermore has relevance to SDG 2 (Zero Hunger) through the water use issues of crops, and SDG 11 (Sustainable cities and communities) through water availability for urban areas.

**CONTENT**

The course builds upon the M-GEO in Q1 and WREM Q2 courses, and will cover the topics below. The overall course accounts for 7ECTS and will be taught over a period of ~10 weeks, starting the first week of February.

W1 The relevance of surface waters in a changing world

- Basic hydrological concepts used in this course will be introduced
- A set of (recent) scientific papers will be reviewed and discussed during lectures.
- The students will perform a classroom exercise as a Jupyter notebook to visualize and interpret scientific results from a scientific paper.

W2 Interaction of surface water with the water cycle

- An introduction to the processes and fundamentals of surface runoff models will be explained during the lectures
- An example case using a numerical surface water runoff model will be executed and interpreted by the students

W3 River stage and discharge

- The concept of the Manning equation and stage-discharge relationships will be explained in the lectures
- A Jupyter exercise will be performed were a rating curve will be derived from an example dataset.

W4 Remote sensing of lake and river heights

- The principles of inland radar altimetry and re-tracking will be explained in the lectures.
- A radar altimetry re-tracking exercise will be performed in Jupyter

W5 Lake extent and hypsometry

- The principles of detecting water bodies extents will be explained in the lectures
- A Jupyter exercise will be performed to extract the water body extent from remote sensing data.W6 Field excursion
- During a visit to the River Dinkel, students will perform flow experiments on the river.
- Evaluate the findings and learnings from the field visit

W7 Data analysis Jupyter exercise (graded)

- Students will perform an individual Jupyter notebook exercise using a surface water related dataset/model. Interactive classroom sessions are available for help

W8-9 Group (2-3p) assignment “Shark tank”

- Identify a surface water related problem and create a business concept which leverages (remote sensing) datasets and or models.
- Present a (graded) pitch for a simulated set of enterpreneurs and try to convince them to invest in the business concept

W10 Written exam

### TEACHING AND LEARNING APPROACH

The course starts with a set of showcases from current research to illustrate the significance of the topic, and to highlight the role of climate change and human interactions and interventions. The course will provide a more in-depth understanding of the processes affecting surface waters, where it is interleaved with (Jupyter notebook) exercises, allowing students to link theory to more practical applications.

In week 7, student will perform a graded notebook exercise. Students will adapt a template Jupyter notebook exercise to process a dataset or modelling result related to surface water, and perform several experiments to answer questions related to the dataset and scientific problem.

The field excursion to the river Dinkel serves to illustrate how theory on discharge links to practical experiments, and to show the students the contrast between natural river courses versus man-made waterways.

Weeks 8 and 9 are dedicated to a challenge, where groups of students will develop a small business case where they develop a case on how remote sensing data and/or modelling can be used to serve a customer need. The development of the business case and its pitching in front of a simulated set of entrepreneurs aims to make students learn about different stakeholder perspectives (users, scientist, inverstor), and link the material from the course to a non-academic setting. The contact hours will serve to explain the structure and steps to come to a business case.

### TESTS

The grade will be built up from 3 parts, which consists of grades in the 1-10 range:

1. A written exam (weight 50%, individual)
    1. The written exam questions will cover the materials presented over the course and include the topics covered by the fieldwork.
2. A grade for the Jupyter exercise (weight 20%, individual).
    1. The submission will consist of a Jupter notebook which contains beside the code snippets: visualizations, a flow chart explaining how the notebook works, and a motivation/reflection for the found results/answered questions.
3. The Sharktank pitch (weight 30%, group).
    1. The pitch will be judged on (1) (scientific) feasibility of the proposed concept, (2) identification of the most important stakeholders and their needs and demands, (3) effectiveness of the presentation.

### ENTRY REQUIREMENTS

A necessary condition is to have attended the WREM courses Q2.1 & Q2.2.

### LEARNING OUTCOMES

Upon completion of this course, the student is able to:

| | |
|---|---|
| LO 1 | Explain the role of surface water in the water cycle and changing climate |
| LO 2 | Understand the concept of river rating curves, surface runoff models, radar altimetry and lake hypsometry |
| LO 3 | Analyse earth observation data for a surface water application |
| LO 4 | Carry out a field experiment and understand the scientific concepts applied |
| LO 5 | Develop a (scientifically) feasible business case plan in the field of surface water applications targeting a use in a non-governmental organization (NGO) or commercial setting |
| LO 6 | Apply different stakeholder perspectives to a surface water related business case, and use these to create an effective presentation |

## ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 20 |
| Tutorial | 20 |
| Supervised practical | 20 |
| Individual assignment | 30 |
| Group assignment | 40 |
| Self-study | 64 |
| Written/oral test | 2 |

### TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Individual assignment | Sharktank Pitch | Written exam |
|---|---|---|---|---|
| | | Learning Outcomes that are addressed in the test | | |
| LO 1 | Explain the role of surface water in the water cycle and changing climate | | | ● |
| LO 2 | Understand the concept of river rating curves, surface runoff models, radar altimetry and lake hypsometry | | | ● |
| LO 3 | Analyse earth observation data for a surface water application | ● | | |
| LO 4 | Carry out a field experiment and understand the scientific concepts applied | | | ● |
| LO 5 | Develop a (scientifically) feasible business case plan in the field of surface water applications targeting a use in a non-governmental organization (NGO) or commercial setting | | ● | |
| LO 6 | Apply different stakeholder perspectives to a surface water related business case, and use these to create an effective presentation | | ● | |
| | Test type | Documented Jupyter notebook | Presentation | Written test |
| | Weight of the test | 20 | 30 | 50 |
| | Individual or group test | Individual | Group | Individual |
| | Type of marking | 1-10 | 1-10 | 1-10 |
| | Required minimum mark per test | | | 6 |
| | Number of test opportunities per academic year | 2 | 1 | 2 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Explain the role of surface water in the water cycle and changing climate | ● | | | | | | ● | | | | | | |
| LO 2 | Understand the concept of river rating curves, surface runoff models, radar altimetry and lake hypsometry | ● | | | | | | | | | | | | |
| LO 3 | Analyse earth observation data for a surface water application | | ● | | ● | ● | ● | | ● | | | | | ● |
| LO 4 | Carry out a field experiment and understand the scientific concepts applied | | | | | | | | | | | | ● | ● |

| | Learning outcomes (LO) of the course: The student will be able to... | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 5 | Develop a (scientifically) feasible business case plan in the field of surface water applications targeting a use in a non-governmental organization (NGO) or commercial setting | | ● | | | | ● | | ● | | ● | ● | | ● |
| LO 6 | Apply different stakeholder perspectives to a surface water related business case, and use these to create an effective presentation | | | | | | | | ● | ● | | | ● | ● |

# ELECTIVES

## 3D MODELLING FOR CITY DIGITAL TWINS BASED ON GEOSPATIAL INFORMATION

| Course | 201900060 |
| --- | --- |
| Period | 14 November 2022 - 03 February 2023 |
| EC | 5 |
| Course coordinator | |

### INTRODUCTION

This course is suitable for all specializations of ITC and students from UT (e.g., Civil Engineering, Computer Science, or Creative Technology). It aims to provide the student with knowledge of different 3D city/building modelling methods (as a base for Digital Twins), based on geospatial information. The students will be given the opportunity to practice with a variety of applications (e.g., GIS, BIM, image-based, gaming, or Virtual reality and Augmented reality) to develop and interpret their own 3D city/building model.

To achieve this, theoretical and practical activities where the student can learn different 3D city/building modelling techniques and methods, used in a variety of applications, based on geospatial data are used.

The student will have the opportunity to work on a 3D modelling/Digital Twin assignment.

### CONTENT

**3D city modelling as a base for Digital Twin creation:**

- 3D modelling (geometry, topology, semantics)
- 3D city modelling (categories, standards, methods, formats)
- 3D reconstruction from images
- 3D visualization (Virtual reality/Augmented reality)
- 3D city modelling/Digital Twin applications
- 3D spatial databases
- 3D data integration BIM/GIS (e.g. for infrastructure/utilities, using FME)
- Principles of parametric and generative design (using Dynamo/Refinery)
- CityGML (using FME)

### TEACHING AND LEARNING APPROACH

- An active learning approach will be applied to the lectures
- Lectures are supported by PPT, videos, and references to reading material
- The students will have practical sessions and an individual assignment to practice what they learned from the theory
- The students will have the unique opportunity to select and practice the usage of a variety of open and closed-source geospatial and gaming solutions for 3D city/building model creation (e.g. FME, VR/AR apps, Blender, SketchUp, CityEngyne, Unity3D, Unreal Engine 5 and Twinmotion among other)

### TESTS

- Written test (30%)
- Individual assignment (70%)

## ENTRY REQUIREMENTS

Recommended knowledge on how to use ArcGIS/QGIS

Preferable experience with the usage of geoformation data and simple modelling techniques

## LEARNING OUTCOMES

Upon completion of this course, the student is able to:

LO 1 Distinguish the geometric, topologic and semantic 3D modelling.

LO 2 Classify and explain the variety of 3D modelling techniques and methods, and how the results can be visualized and stored in a 3D Database.

LO 3 Distinguish and explain the principles and differences between GIS, BIM and CityGML modelling and their applications

LO 4 Select the most suitable 3D modelling technique to develop a 3D model for a concrete scenario.

LO 5 Interpret the model outcomes.

## ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| **Teaching / learning method** | **Hours** |
|---|---|
| Lecture | 34 |
| Supervised practical | 30 |
| Written/oral test | 3 |
| Individual assignment | 35 |
| Self-study | 38 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Written test | Individual assignment |
|---|---|---|---|
| | | **Learning Outcomes that are addressed in the test** | |
| LO 1 | Distinguish the geometric, topologic and semantic 3D modelling. | ● | |
| LO 2 | Classify and explain the variety of 3D modelling techniques and methods, and how the results can be visualized and stored in a 3D Database. | ● | |
| LO 3 | Distinguish and explain the principles and differences between GIS, BIM and CityGML modelling and their applications | ● | |
| LO 4 | Select the most suitable 3D modelling technique to develop a 3D model for a concrete scenario. | | ● |
| LO 5 | Interpret the model outcomes. | | ● |
| | Test type | Written test | Individual assignment |
| | Weight of the test | 30 | 70 |
| | Individual or group test | Individual | Individual |
| | Type of marking | 1-10 | 1-10 |
| | Required minimum mark per test | | |
| | Number of test opportunities per academic year | 2 | 2 |

RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Distinguish the geometric, topologic and semantic 3D modelling. | ● | ● | ● | ● | ● | | | ● | | | | | |
| LO 2 | Classify and explain the variety of 3D modelling techniques and methods, and how the results can be visualized and stored in a 3D Database. | ● | ● | ● | ● | ● | | | ● | | | | | |

| **Learning outcomes (LO) of the course: The student will be able to...** | | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 3 | Distinguish and explain the principles and differences between GIS, BIM and CityGML modelling and their applications | ● | ● | | ● | ● | | ● | ● | | | | | |
| LO 4 | Select the most suitable 3D modelling technique to develop a 3D model for a concrete scenario. | ● | ● | ● | ● | | ● | ● | | | | | ● | ● |
| LO 5 | Interpret the model outcomes. | ● | ● | ● | ● | | ● | ● | ● | ● | | | ● | |

# ADVANCED IMAGE ANALYSIS

| Course | 201900065 |
|---|---|
| Period | 05 September 2022 - 11 November 2022 |
| EC | 5 |
| Course coordinator | |

## INTRODUCTION

In this course, the students will be introduced to advanced image analysis methods dedicated to enriching their geo-information problem-solving abilities. Image processing and analysis methods treated in previous courses, such as conventional hard pixel-based classification, do not take into account spatial correlations in images and, therefore, do not completely exploit the information contained in images. In this course, we aim to introduce more specialized image analysis methods. In particular, Support Vector Machine and Random Forest will be taught for multisource classification at the pixel level. Convolutional Neural Networks (CNNs) and Fully Convolutional Neural Networks (FCN) will be introduced for contextual classification. Advantages and challenges related to multi-temporal image analysis will also be discussed. The methods introduced in this course will be applied to real case studies.

## CONTENT

1. Support Vector Machines for classification
2. Random Forest for classification
3. Deep Learning with Convolutional Neural Networks (CNNs) and Fully Convolutional Neural Networks (FCN) applied for classification
4. Multi-temporal image analysis for classification and change detection

## TEACHING AND LEARNING APPROACH

Image analysis requires theoretical concepts and practical skills. Lectures will be used to introduce the topics, followed by reading textbook material. Research articles will also be recommended for those students who are interested in learning more about a specific concept, method, algorithm etc. Practical classes will consist of a mixture of demos, individual work following written instructions, and presentations of the outcomes during feedback sessions. In the practical classes, students will work with existing program codes and modify them (to a limited degree). In this way, the students can get insight into the intermediate stages of the image analysis algorithms and make decisions on the outcomes. Furthermore, a reflection on theoretical concepts will be made. In this way, a solid integration of theory and practice will be achieved.

## TESTS

- A written test on image analysis methods
- Group assignment; students apply selected image analysis method(s) on selected datasets; the results of the analysis are summarized and compared to the peers in the group using either different methods or different datasets;

## ENTRY REQUIREMENTS

All students in Geoinformatics specialization are accepted. Students following other specializations should have background in programming and image analysis.

### LEARNING OUTCOMES

Upon completion of this course, the student is able to:

LO 1 Explain the advantages and disadvantages of the advanced image analysis methods introduced in this course

LO 2 Apply advanced image analysis methods to classify both single-date and multi-temporal images in support of addressing environmental and societal problems

LO 3 Critically interpret the classification results obtained using advanced image analysis methods

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| **Teaching / learning method** | **Hours** |
|---|---|
| Lecture | 24 |
| Supervised practical | 38 |
| Written/oral test | 3 |
| Group assignment | 37 |
| Self-study | 38 |

TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Written test | Group assignment |
|---|---|---|---|
| | | Learning Outcomes that are addressed in the test | |
| LO 1 | Explain the advantages and disadvantages of the advanced image analysis methods introduced in this course | ● | ● |
| LO 2 | Apply advanced image analysis methods to classify both single-date and multi-temporal images in support of addressing environmental and societal problems | | ● |
| LO 3 | Critically interpret the classification results obtained using advanced image analysis methods | | ● |
| | Test type | Written test | Group assignment |
| | Weight of the test | 30 | 70 |
| | Individual or group test | Individual | Group |
| | Type of marking | 1-10 | 1-10 |
| | Required minimum mark per test | | |
| | Number of test opportunities per academic year | 2 | 2 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | Learning outcomes (LO) of the course: The student will be able to... | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Explain the advantages and disadvantages of the advanced image analysis methods introduced in this course | ● | ● | | ● | | ● | | | | ● | | ● | ● |
| LO 2 | Apply advanced image analysis methods to classify both single-date and multi-temporal images in support of addressing environmental and societal problems | ● | ● | | ● | | ● | | | | ● | | ● | ● |
| LO 3 | Critically interpret the classification results obtained using advanced image analysis methods | ● | ● | | ● | | ● | | | | ● | | ● | ● |

| | Learning outcomes (LO) of the course: The student will be able to... | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | methods | | | | | | | | | | | | | |

# BIG GEODATA PROCESSING

| **Course** | **201900064** |
|---|---|
| Period | 05 September 2022 - 11 November 2022 |
| EC | 5 |
| Course coordinator | |

## INTRODUCTION

Thanks to the digital, mobile and sensor revolutions, massive amounts of data are becoming available at unprecedented spatial, temporal, and thematic scales. This leads to the practical problem of transforming big geodatasets into actionable information that can support a variety of decision-making processes. In this respect, geodata science workflows are not only key to processing big geospatial datasets but also to sharing the extracted information and knowledge and to ensuring the reproducibility of the results.

To handle and analyse massive and potentially heterogeneous amounts of spatio-temporal data, scientists need to 1) understand the particular characteristics of big geodata, 2) learn to work with scalable data management and processing systems, and 3) develop scalable and robust data mining and machine learning workflows. Hence, this course presents theories, methods, and techniques to build scalable solutions for handling and analysing big geodata.

## CONTENT

1. Introduction to big geodata (including the seven Vs: Volume, Velocity, Variety, Variability, Veracity, Value and Visualization.)
2. Principles of big geodata management
3. Principles of big geodata modelling and analysis (clustering, classification and regression tasks).
4. Setting up a computational solution to store and process big geodatasets
5. Off-the-shelf vs. do-it-yourself big geodata solutions (e.g. Google Earth Engine vs. HADOOP/SPARK or DASK-based solutions).
6. Big data solutions to process raster, vector and crowdsourced data
7. Building scalable workflows
8. Code versioning
9. Open Science (including reproducibility and triangulation)

## TEACHING AND LEARNING APPROACH

In this course, students will learn the fundamentals of big geodata processing. Then, they will be introduced (via lectures, demos and exercises) to various distributed big data solutions as well as the role of cloud computing. After that, they will work on a real-life problem involving a big geo-dataset. They will work in groups and create the necessary workflows to process the data. This requires programming skills and critical thinking to select the "best" algorithm and computational solution.

In this course, there will also be a strong emphasis on Open Science principles, with a focus on scientific reproducibility and triangulation. Lectures on archiving data and code will be provided too.

## TESTS

- Project work (50% - Including project conceptualization and mid-term and final presentations, as well as the necessary narrative and code to understand the project results)
- Technical report (25%)
- Peer review report (25%)

## ENTRY REQUIREMENTS

The knowledge gained during the Scientific Geocomputing course is advantageous but not strictly necessary to follow this course. Some self-study material will be provided through Canvas for students that do not follow the Geoinformatics specialisation. You are advised to contact the course coordinator to discuss the materials' relevance for you.

## LEARNING OUTCOMES

Upon completion of this course, the student is able to:

LO 1 Explain to peers the fundamentals of big geodata processing.

LO 2 Compare various big geodata solutions.

LO 3 Create the required data management and analytical workflows to execute a big geo-data project.

LO 4 Design scalable workflows that run in the cloud, and consider options for efficient computing.

LO 5 Prepare and maintain a code repository.

LO 6 Interpret the analytical results and demonstrate their reproducibility.

## ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 30 |
| Supervised practical | 32 |
| Individual assignment | 8 |
| Group assignment | 46 |
| Self-study | 24 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Project | Peer review | Technical Report |
|---|---|---|---|---|
| | | Learning Outcomes that are addressed in the test | | |
| LO 1 | Explain to peers the fundamentals of big geodata processing. | ● | | |
| LO 2 | Compare various big geodata solutions. | ● | | ● |
| LO 3 | Create the required data management and analytical workflows to execute a big geo-data project. | ● | | |
| LO 4 | Design scalable workflows that run in the cloud, and consider options for efficient computing. | ● | ● | ● |
| LO 5 | Prepare and maintain a code repository. | ● | ● | |
| LO 6 | Interpret the analytical results and demonstrate their reproducibility. | ● | ● | |
| | Test type | Project | Report | Report |
| | Weight of the test | 50 | 25 | 25 |
| | Individual or group test | Group | Individual | Individual |
| | Type of marking | 1-10 | 1-10 | 1-10 |
| | Required minimum mark per test | | | |
| | Number of test opportunities per academic year | 1 | 2 | 2 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Explain to peers the fundamentals of big geodata processing. | ● | ● | | | | | | | | ● | ● | | |
| LO 2 | Compare various big geodata solutions. | ● | ● | | | | ● | ● | | ● | | | | ● |
| LO 3 | Create the required data management and analytical workflows to execute a big geo-data project. | ● | ● | ● | ● | ● | ● | ● | | ● | | | | ● |
| LO 4 | Design scalable workflows that run in the cloud, and consider options for efficient computing. | ● | ● | ● | ● | ● | ● | ● | | ● | | | | |
| LO 5 | Prepare and maintain a code repository. | | | | | ● | ● | ● | | | | | ● | |

| | Learning outcomes (LO) of the course: The student will be able to... | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 6 | Interpret the analytical results and demonstrate their reproducibility. | ● | | | | ● | ● | ● | ● | ● | ● | ● | ● | ● |

# CATCHMENT HYDROLOGY AND SURFACE WATER

| **Course** | **201800298** |
|---|---|
| Period | 24 April 2023 - 07 July 2023 |
| EC | 7 |
| Course coordinator | |

## INTRODUCTION

The course aims at various aspects of integrated water resource modelling for surface water assessments. Aspects of catchment system representation for integrated surface water – groundwater, rainfall-runoff, floods, Lakes and water allocation for food production will be addressed. Mechanisms on runoff production, model parameterization, model integration and coupling; multi-objective model calibration, effects of time-space scales, model error propagation and uncertainties will be addressed. An introduction to numerical 1d2d flood-modelling will be provided. A number of case studies with employing satellite data (DEM/Rain/ET/Floods/Moisture) will be discussed with emphasis on rainfall-runoff and flood modelling including stream flow modelling and water balance closure analysis. Use of earth observation data of DEMs, flood-events and water cycle variables such as rainfall and evapotranspiration will be shown, as well as use of data from climatic models for water resources impact assessments. Knowledge transfer is by lecturing and student participatory teaching. A number of assignments are available. Digital terrain modelling by flying drones and processing of collected terrain data will be practiced as well.

## CONTENT

This course aims at a principle understanding on the various aspects of integrated water resource modelling. Generic aspects (e.g. time-space representation, model initialization) and specific aspects of modelling (e.g. use of numerical boundary conditions and calibration) will be discussed with emphasis on model design and building, and a broad understanding on model performance assessments. Aspects of catchment system and process representation, model parameterization, time-space scales, model error propagation and uncertainties will be addressed. A range of model applications including modelling in data scarce areas and crop growth modelling will be addressed. A number of case studies are discussed with emphasis on catchment hydrology, stream flow modelling, water balance closure, rainfall-runoff modeling, flood modelling and modelling of crop growth. Use of earth observation data of water variables such as rainfall, evapotranspiration and floods is shown and, were possible, practiced in this course. In-situ data and satellite data analysis are part of the course. Knowledge also is to be gained by student participatory teaching and self-study. A number of assignments on catchment scale runoff and flood modelling are prepared. Assessment is done via an examination and assignments.

## TEACHING AND LEARNING APPROACH

Combination of frontal and participatory teaching; Self-study, and Practical’s that serve submission of assignments.

## TESTS

Exam and Assignments. For the exam and mean grade of the assignments minimum grades of 5 should be obtained.

## ENTRY REQUIREMENTS

Proven knowledge on hydrology, EO and hydrological modelling concepts.

### LEARNING OUTCOMES

Upon completion of this course, the student is able to:

LO 1 Conceptualize hydrological catchment system behaviour to construct a water balance.
LO 2 Select, set-up and run hydrological models.
LO 3 Assess functioning of model parameters as well as selected boundary condition.
LO 4 Demonstrate and describe the approach to optimize model parameters by use of objective functions.
LO 5 Identify and argue for key factors that affect model performance so to reason for plausibility of obtained model performance.
LO 6 Interpret and explain the sources of error and uncertainty in modelling.
LO 7 Understand basic concepts of satellite data-model integration.
LO 8 Process selected satellite data to support catchment and surface water modelling.
LO 9 Assess water balance closure for integrated models.

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 52 |
| Supervised practical | 15 |
| Written/oral test | 3 |
| Individual assignment | 64 |
| Self-study | 62 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Individual assignments | Written or oral test |
|---|---|---|---|
| | | **Learning Outcomes that are addressed in the test** | |
| LO 1 | Conceptualize hydrological catchment system behaviour to construct a water balance. | ● | ● |
| LO 2 | Select, set-up and run hydrological models. | ● | |
| LO 3 | Assess functioning of model parameters as well as selected boundary condition. | ● | ● |
| LO 4 | Demonstrate and describe the approach to optimize model parameters by use of objective functions. | ● | ● |
| LO 5 | Identify and argue for key factors that affect model performance so to reason for plausibility of obtained model performance. | ● | ● |
| LO 6 | Interpret and explain the sources of error and uncertainty in modelling. | ● | ● |
| LO 7 | Understand basic concepts of satellite data-model integration. | ● | |
| LO 8 | Process selected satellite data to support catchment and surface water modelling. | ● | |
| LO 9 | Assess water balance closure for integrated models. | ● | ● |
| | Test type | Report | Written or oral test |
| | Weight of the test | 50 | 50 |
| | Individual or group test | Individual | Individual |
| | Type of marking | 1-10 | 1-10 |
| | Required minimum mark per test | 5 | 5 |
| | Number of test opportunities per academic year | 1 | 2 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Conceptualize hydrological catchment system behaviour to construct a water balance. | ● | ● | ● | ● | | | ● | | | | | | |
| LO 2 | Select, set-up and run hydrological models. | | | ● | ● | | | | | | | | | |
| LO 3 | Assess functioning of model parameters as well as selected boundary condition. | | | ● | ● | | ● | | | | | | | |
| LO 4 | Demonstrate and describe the approach to optimize model parameters by use of objective functions. | ● | | ● | ● | | | ● | | | | | | |

| | Learning outcomes (LO) of the course: The student will be able to... | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 5 | Identify and argue for key factors that affect model performance so to reason for plausibility of obtained model performance. | | | ● | ● | | ● | | ● | | | | | ● |
| LO 6 | Interpret and explain the sources of error and uncertainty in modelling. | | ● | ● | | | | ● | | | | | ● | |
| LO 7 | Understand basic concepts of satellite data-model integration. | | | ● | ● | | | | | | | | ● | |
| LO 8 | Process selected satellite data to support catchment and surface water modelling. | | ● | ● | | | | | | | | ● | | |
| LO 9 | Assess water balance closure for integrated models. | | | ● | ● | | ● | | ● | | ● | | | ● |

# DATA ASSIMILATION

| **Course** | **201900071** |
| --- | --- |
| Period | 14 November 2022 - 03 February 2023 |
| EC | 5 |
| Course coordinator | |

### INTRODUCTION

Data assimilation is a standard practice in numerical weather prediction (e.g., as implemented in the European Centre for Medium-Range Weather Forecasts, ECMWF), and is increasingly used in many other areas of climate, atmosphere, ocean, land and environment modeling.

Data Assimilation is a process in which observations are assimilated into a dynamical numerical model in order to determine as accurately as possible the state of the physical system. This course will introduce the theoretical background, the state-of-the-art methods and practical systems, and examples of data assimilation.

### CONTENT

The course will introduce:

- Bayesian theory (Bayesian statistics, prior distribution and likelihood function, posterior distribution, importance sampling, Markov Chain Monte Carlo methods).
- Data assimilation schemes used in hydrometeorological modelling and predictions (common language and terminologies, Cressman analysis, optimal least squares estimator, optimal interpolation, variational methods, particle filters, Kalman filters).
- Practicals (workshops) of data assimilations (Particle filter & Open-DA).

### TEACHING AND LEARNING APPROACH

Lectures, practicals (workshops), tutorials, individual assignment and group work and written tests.

### TESTS

- Written tests (open book, 40%)
- Individual assignment (workshop) (30%)
- Group assignment, weight each (30%) (this will depend on number of students and their interests)

### ENTRY REQUIREMENTS

Successful completion of year 1 M-GEO WREM specialization courses, or equivalent.

### LEARNING OUTCOMES

Upon completion of this course, the student is able to:

LO 1 Learn the Bayesian theory.

LO 2 Acquire the language, terminology and methods of data assimilation.

LO 3 Learn the techniques for parameter estimation.

LO 4 Apply practical data assimilation techniques to improve hydrometeorological modelling and predictions.

LO 5 Use reanalysis data and know the limitations

## ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 48 |
| Supervised practical | 48 |
| Tutorial | 8 |
| Written/oral test | 2 |
| Individual assignment | 8 |
| Group assignment | 10 |
| Self-study | 16 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Written test | Individual assignment | Group assignment |
|---|---|---|---|---|
| | | Learning Outcomes that are addressed in the test | | |
| LO 1 | Learn the Bayesian theory. | ● | | |
| LO 2 | Acquire the language, terminology and methods of data assimilation. | ● | | |
| LO 3 | Learn the techniques for parameter estimation. | ● | | |
| LO 4 | Apply practical data assimilation techniques to improve hydrometeorological modelling and predictions. | | ● | ● |
| LO 5 | Use reanalysis data and know the limitations | | | ● |
| | Test type | Written test | Individual assignment | Group assignment |
| | Weight of the test | 40 | 30 | 30 |
| | Individual or group test | Individual | Individual | Individual |
| | Type of marking | 1-10 | 1-10 | 1-10 |
| | Required minimum mark per test | | | |
| | Number of test opportunities per academic year | 2 | 2 | 2 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| Learning outcomes (LO) of the course: The student will be able to... | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Learn the Bayesian theory. | ● | | | | | | | | | | | | |
| LO 2 | Acquire the language, terminology and methods of data assimilation. | ● | ● | | | | | | | | | | | |
| LO 3 | Learn the techniques for parameter estimation. | ● | ● | | | | | | | | | | | |
| LO 4 | Apply practical data assimilation techniques to improve hydrometeorological modelling and predictions. | ● | ● | ● | ● | | ● | ● | ● | | ● | ● | ● | |
| LO 5 | Use reanalysis data and know the limitations | | | | ● | | | | ● | | | | | |

# EARTH OBSERVATION FOR WETLAND MONITORING AND MANAGEMENT

| **Course** | **201900072** |
|---|---|
| Period | 05 September 2022 - 11 November 2022 |
| EC | 5 |
| Course coordinator | |

## INTRODUCTION

Wetlands are very dynamic and very vulnerable environmental resources, providing a wide scale of ecosystem services but being threatened by various human activities.
The following EO challenges will be addressed in the course:

- Synergic use of optical and SAR image time series for monitoring
- Different aspects of wetland mapping (inventory, habitat mapping, hydrological cycles, conflicting land uses in and around wetlands, image time series processing in the Google Earth Engine environment, etc.)
- Linkage to socio-economic processes: ecosystem services

## CONTENT

Lectures on:

- EO of wetlands (special problems in the optical and radar wavelength ranges)

- Advanced classification methods

- Time series processing in GEE environment

- Socioeconomic aspects of wetlands.

Related exercises.

Case study of a region selected by the student.

## TEACHING AND LEARNING APPROACH

Lectures, case studies, cloud processing, group project.

## TESTS

Individual assignment with a report and a presentation.

## ENTRY REQUIREMENTS

Basic EO techniques (optical and SAR) and related software, statistics.

## LEARNING OUTCOMES

Upon completion of this course, the student is able to:

| | |
|---|---|
| LO 1 | Understand EO techniques and their accuracies used for wetland monitoring. |
| LO 2 | Get experience in practical use of time series analysis and big data processing. |
| LO 3 | Understand the linkage between geophysical variables (EO measurements), hydro-ecological variables (wetland state and rate variables) and socio-economic variables (ecosystem service values). |

## ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 16 |
| Tutorial | 6 |
| Supervised practical | 32 |
| Individual assignment | 54 |
| Self-study | 24 |
| Study trip | 8 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Individual assignment (portfolio) | Presentation |
|---|---|---|---|
| | | **Learning Outcomes that are addressed in the test** | |
| LO 1 | Understand EO techniques and their accuracies used for wetland monitoring. | ● | |
| LO 2 | Get experience in practical use of time series analysis and big data processing. | ● | |
| LO 3 | Understand the linkage between geophysical variables (EO measurements), hydro-ecological variables (wetland state and rate variables) and socio-economic variables (ecosystem service values). | | ● |
| | Test type | Report | Presentation |
| | Weight of the test | 60 | 40 |
| | Individual or group test | Individual | Group |
| | Type of marking | 1-10 | 1-10 |
| | Required minimum mark per test | | |
| | Number of test opportunities per academic year | 2 | 2 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Understand EO techniques and their accuracies used for wetland monitoring. | | | | | | | | | | | | | |
| LO 2 | Get experience in practical use of time series analysis and big data processing. | | | | | | | | | | | | | |
| LO 3 | Understand the linkage between geophysical variables (EO measurements), hydro-ecological variables (wetland state and rate variables) and socio-economic variables (ecosystem service values). | | | | | | | | | | | | | |

# EARTH OBSERVATION WITH UNMANNED AERIAL VEHICLES

| **Course** | **201900053** |
|---|---|
| Period | 05 September 2022 - 11 November 2022 |
| EC | 5 |
| Course coordinator | |

## INTRODUCTION

Image-based modelling (IBM) refers to the techniques of acquiring 3D object information from two or more images. This includes three traditional photogrammetric algorithms (feature extraction and matching, Bundle Block Adjustment and orthophoto generation) and new techniques from the Computer Vision community (such as structure from Motion, Visual Odometry and Semi-Global Matching) to derive 3D point information from an image sequence. These techniques can be used to process both terrestrial and airborne images.
Among the innovative platforms for data capture, Unmanned Aerial Vehicles (UAV, better known as drones) are becoming a valid alternative to traditional Geomatics acquisition systems, as they close the gap between higher resolution terrestrial images and the lower resolution airborne and satellite data. UAV can be remotely controlled helicopters, fixed wind airplanes or kites. Different sensors can be installed on-board to acquire data. Many applications ranging from 3D building modelling to crop and forest monitoring can profit from these data acquisition platforms.

In this course the advanced IBM techniques and, in general, the 3D geo-information processing will be explained, with focus on the use of data acquired by UAVs. The course is composed of two main parts. In the first part, the four main steps of the modern IBM process (image orientation, point cloud generation, orthophoto generation and quality assessment) to retrieve 3D information from images will be defined. The peculiarities of IBM process using UAV images will be discussed in detail, showing the differences with the traditional acquisition of airborne images. During the second part the participants will gain hands-on experience on the use of UAVs. In this period, the students will learn how to process images acquired with different sensors and for different applications.

Specifically, participants will learn the principle of IBM methods and they will design three simple solutions (feature extraction, feature matching and relative orientation) by adopting these methods in simple Matlab codes. Lectures will be always coupled with demonstrations and practical sessions on the theory delivered.

The second part of the course will allow the participants to experience the UAV data acquisition and processing workflow. They will understand how a UAV related project is planned and executed with their involvement to a real UAV acquisition project. Then, they will apply the learned IBM techniques using a commercial software (Pix4D – www.pix4d.com) to process the acquired data and extract 3D information. They will finally analyse and compare the data using the available ground truth and dedicated tools and software (Matlab scripts and CloudCompare) to evaluate their results. Multi-spectral and thermal image acquisitions from UAVs will be also part of the course topics. Participants will learn how to process these images and how to better use them for different applications. Additional presentations will be finally provided to describe the use of UAVs in six different domains covering different perspectives of ITC Departments: land administration, disaster mapping and management, natural resources and crop monitoring, water management and flood monitoring, maintenance of UAVs and real-time processing.

Participants do not need prior knowledge on the topics of the course.

### CONTENT

Topics of the course are:

- The IBM algorithms: feature extraction and matching, Structure from Motion, Visual Odometry, Bundle Block Adjustment, dense image matching techniques and orthophoto generation. These algorithms will be described considering the specific problems related to the use of UAVs;
- Use of existing simple libraries as well as commercial software to manage IBM techniques;
- Analysis and evaluation of results generated by IBM techniques using simple tools and the available ground truth;
- UAV image acquisition and processing for different geo-information purposes, using different camera sensors and for different applications;
- The use and understanding of UAVs in different domains: land administration, disaster mapping and management, natural resources and crop monitoring, water management and flood monitoring, maintenance of UAVs and real-time processing.

### TEACHING AND LEARNING APPROACH

The course will be composed of lectures (with the use of flipped classrooms when necessary), practicals, supervised and unsupervised assignments and fieldwork for UAV image acquisitions. The student will learn how to correctly process the acquired images receiving both the theoretical and practical knowledge and gaining in self-confidence and independence during the course.

### TESTS

- Written test (70%)
- Group assignment (30%)

### ENTRY REQUIREMENTS

All M-GEO and M-SE students are accepted.

Note that we offer two UAV courses in Q5. GFM students should choose "Scene understanding with UAVs", while all the other M-GEO and M-SE students should join this course. In general, all students should have basic knowledge of remote sensing.

### LEARNING OUTCOMES

Upon completion of this course, the student is able to:

| | |
|---|---|
| LO 1 | Understand and describe the four main steps of the modern IBM process for UAV imagery. |
| LO 2 | Design three state-of-the-art IBM algorithms (in MATLAB) for processing given terrestrial and/or UAV imagery. |
| LO 3 | Apply the learned IBM techniques using the proposed commercial software (pix4D) for UAV data. |
| LO 4 | Analyse and evaluate the geometric quality of the previously generated data using the two available tools (MATLAB and CloudCompare). |
| LO 5 | Describe the typical UAV data acquisition procedure and data processing for geo-information purposes, understanding the technical decisions usually adopted in real practical cases. |
| LO 6 | Identify the major pros and cons of the use of UAVs upon the gained experience and relate them with the six different domains. |
| LO 7 | Design at least one different possible application for UAVs beyond the experienced/learned ones |
| LO 8 | Report and critically 'discuss' the scientific outcomes by providing relevant referencing. |

## ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 24 |
| Supervised practical | 18 |
| Tutorial | 6 |
| Written/oral test | 3 |
| Group assignment | 48 |
| Self-study | 100 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Written exam | Group assignment |
|---|---|---|---|
| | | **Learning Outcomes that are addressed in the test** | |
| LO 1 | Understand and describe the four main steps of the modern IBM process for UAV imagery. | ● | ● |
| LO 2 | Design three state-of-the-art IBM algorithms (in MATLAB) for processing given terrestrial and/or UAV imagery. | | ● |
| LO 3 | Apply the learned IBM techniques using the proposed commercial software (pix4D) for UAV data. | | ● |
| LO 4 | Analyse and evaluate the geometric quality of the previously generated data using the two available tools (MATLAB and CloudCompare). | ● | ● |
| LO 5 | Describe the typical UAV data acquisition procedure and data processing for geo-information purposes, understanding the technical decisions usually adopted in real practical cases. | ● | |
| LO 6 | Identify the major pros and cons of the use of UAVs upon the gained experience and relate them with the six different domains. | ● | |
| LO 7 | Design at least one different possible application for UAVs beyond the experienced/learned ones | | ● |
| LO 8 | Report and critically 'discuss' the scientific outcomes by providing relevant referencing. | ● | ● |
| | Test type | Written test | Group assignment |
| | Weight of the test | 70 | 30 |
| | Individual or group test | Individual | Group |
| | Type of marking | 1-10 | 1-10 |
| | Required minimum mark per test | | |
| | Number of test opportunities per academic year | 2 | 2 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | Learning outcomes (LO) of the course: The student will be able to... | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Understand and describe the four main steps of the modern IBM process for UAV imagery. | ● | | | | | | | | | | | | |
| LO 2 | Design three state-of-the-art IBM algorithms (in MATLAB) for processing given terrestrial and/or UAV imagery. | | | ● | | ● | | | | | | | | |
| LO 3 | Apply the learned IBM techniques using the proposed commercial software (pix4D) for UAV data. | | ● | | ● | | | | | | | | | |
| LO 4 | Analyse and evaluate the geometric quality of the previously generated data using the two available tools (MATLAB and CloudCompare). | | ● | | | | ● | | | | | | | |

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 5 | Describe the typical UAV data acquisition procedure and data processing for geo-information purposes, understanding the technical decisions usually adopted in real practical cases. | ● | | | | | | | ● | | | | | |
| LO 6 | Identify the major pros and cons of the use of UAVs upon the gained experience and relate them with the six different domains. | | ● | | | | | | | ● | | ● | | ● |
| LO 7 | Design at least one different possible application for UAVs beyond the experienced/learned ones | | | ● | | ● | | ● | | ● | ● | | | ● |
| LO 8 | Report and critically 'discuss' the scientific outcomes by providing relevant referencing. | | | | | ● | ● | | ● | | | | ● | |

# ENTREPRENEURSHIP: A BRIDGE TOWARDS GEOSPATIAL INNOVATION

| **Course** | **201900066** |
|---|---|
| Period | 14 November 2022 - 03 February 2023 |
| EC | 5 |
| Course coordinator | |

## INTRODUCTION

The objective of this course is to equip the students with entrepreneurial skills.

Entrepreneurship is defined as the capacity and willingness to develop, organize and manage a business venture, along with any of its risks, in order to make a profit. Entrepreneurship can be as an owned company, or internal in a company. This course focuses on Entrepreneurial ‘spirit’ and is characterized by innovation and risk-taking; this is an essential part to succeed in an ever-changing and increasingly competitive global marketplace (from ‘Business dictionary’; 2013). However, entrepreneurship is much broader than the creation of a new business venture. It is also a mind-set – a way of thinking and acting. It is about imagining new ways to solve problems and create value. In the context of changing paradigms in development corporation, giving a mayor role to the private sector in the aid to trade agenda, this entrepreneurial mind-set will help our students to understand and effectively communicate with stakeholders in public-private partnerships and to be active in the private sector as well. Entrepreneurship is, not without a reason, one of the key 21$^{th}$ century skills.

Hence, the focus of this course lies on creating an entrepreneurial mind-set to identify and developed business cases from geo-information science that have economical, societal & environmental values.

**CONTENT**

This course has been designed to facilitate a strong social and learner-centered environment, meaning that learning is active and requires participation from all learners. You will be actively engaged in sharing, reading, reviewing, and commenting on your classmates' work they post to their learnings and through our discussion forums. Teaching is not something that can only be done by an instructor, you will also need to be involved and participate in the process.

**A. Theory: Lean start-up approach**

The content for this course is divided into 9 modules that are grouped into the following units:

- Introduction

- Orientation and expectations

- MOOC content

1. Asses proposition
2. Users and their Job-to-be-Done (JtbD)
3. Tech/Eco opportunities
4. Functionalities and tech. architecture
5. Use and Bizz case
6. Concept validation
7. Tech and Markect PoC, Project Pland
8. Start-up Branding and Pitching
9. Investment Readiness and Raising Capital

**B. Project: design and evaluate a business idea**

In this project you get to improve your professional and academic entrepreneurial and valorisation skills by scoping a real-life entrepreneurial opportunity based on geo-information science, possibly linked to the topic of your MSc research. As with all ideas, they say "the proof of the pudding is in the eating". So, in this phase we will hope to find answers to some key questions potential investors and other collaborators will be seeking an answer to before committing to your business idea:

- What's your customer's perspective of your MVP (minimum-viable product)?
- Do they agree it solves a tangible pain point or creates a noticeable accelerator for them? Is the solution your MVP offers really making their JtbD (Job-to-be-done) easier? In "walking" the customer journey, are they offered a competitive, viable alternative to what they are used to?
- Is you business model transparent and acceptable to them?
- What's their willingness-to-pay in relation to how much time, costs, or frustration your solution helps to reduce?

Step-by-step as you incorporate peer-review and expert feedback, you will gradually reach the final phase of the business ideation process: the validation of your Business idea. As your proof-of-concept gradually becomes more-and-more presentable, why not let your potential users be the judge of your idea? They will be the ones paying for it, ultimately. Therefore, at each stage of the idea validation you will learn how to propose different validation activities cards and methods starting with an easy-to-create mockup to observe the customer's response your solution - either as a hand-sketch or digital mockup of the solutions.

**C. Progress meetings and peer-feedback**

Progress meetings and peer-feedback are foreseen to monitor and stimulate the interaction between staff and students. Student groups will be presenting their progress, identifying the challenges and possible solutions. The students will have the opportunity to comments on each other’s works and ask questions to the scientific consultants.

**D. Pitch**

A pitch (with supporting 60 second movie) will be designed such that the business idea can be presented in a compelling and clear manner to appeal to a broader audience.

**E. Self-reflection report**

A written self-reflection report (max. 400 words) on the learning process within the context of the learning outcomes of the course and the contribution to the case studies supported with evidence (individual and mark).

#### TEACHING AND LEARNING APPROACH
Acknowledging the strength and effectiveness of peer learning, this course has been designed to facilitate a strong social and learner-centered environment, meaning that learning is active and requires participation from all learners. You will be actively engaged in sharing, reading, reviewing, and commenting on your classmates' work they post to their learnings and through our discussion forums. Teaching is not something that can only be done by an instructor, you will also need to be involved and participate in the process.

#### TESTS
The assessment will consist of three tests:

- Test 1: Assignments and participation during sessions, need to finish the training (complete/ fail, 30%)
- Test 2: Project (60%)
  1- Design and execution (40%)
  2- Presentation (20%)
- Test 3: self-reflection report (10%)

#### ENTRY REQUIREMENTS
Affinity with the use of geo-information science and entrepreneurship.

#### LEARNING OUTCOMES
Upon completion of this course, the student is able to:

LO 1 Understand the importance of the basic principles of the lean start-up method.

LO 2 Design start-up business models and experiment with relevant tools (e.g. business model canvas).

LO 3 Perform idea validation using tools (e.g. questionnaires, interviews, etc.)

LO 4 Analyse the competition and pivot their original idea accordingly

LO 5 Understand the importance of team, raising capital and pitching

LO 6 Appraise inclusive innovation business (model) ideas, e.g. along agricultural value-chains, that are likely work in “Bottom-of-Pyramid” (BoP) markets.

#### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 38 |
| Supervised practical | 14 |
| Tutorial | 10 |
| Individual assignment | 26 |
| Group assignment | 26 |
| Self-study | 26 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Test 1 | Test 2 | Test 3 |
|---|---|---|---|---|
| | | Learning Outcomes that are addressed in the test | | |
| LO 1 | Understand the importance of the basic principles of the lean start-up method. | ● | ● | ● |
| LO 2 | Design start-up business models and experiment with relevant tools (e.g. business model canvas). | ● | ● | |
| LO 3 | Perform idea validation using tools (e.g. questionnaires, interviews, etc.) | ● | ● | |
| LO 4 | Analyse the competition and pivot their original idea accordingly | | ● | ● |
| LO 5 | Understand the importance of team, raising capital and pitching | | ● | ● |
| LO 6 | Appraise inclusive innovation business (model) ideas, e.g. along agricultural value-chains, that are likely work in “Bottom-of-Pyramid” (BoP) markets. | ● | ● | |
| | Test type | Digital test | Report | Report |
| | Weight of the test | 30 | 60 | 10 |
| | Individual or group test | | | |
| | Type of marking | Pass/Fail | 1-10 | 1-10 |
| | Required minimum mark per test | | | |
| | Number of test opportunities per academic year | 2 | 1 | 2 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Understand the importance of the basic principles of the lean start-up method. | ● | | | | | | | | | | | | |
| LO 2 | Design start-up business models and experiment with relevant tools (e.g. business model canvas). | | ● | | | | | | | | | | | |
| LO 3 | Perform idea validation using tools (e.g. questionnaires, interviews, etc.) | | | ● | ● | ● | | | | | | | | |
| LO 4 | Analyse the competition and pivot their original idea accordingly | | | | | | ● | ● | | ● | | | | |
| LO 5 | Understand the importance of team, raising capital and pitching | | | | | | | | ● | | ● | | ● | |

| | Learning outcomes (LO) of the course: The student will be able to... | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 6 | Appraise inclusive innovation business (model) ideas, e.g. along agricultural value-chains, that are likely work in "Bottom-of-Pyramid" (BoP) markets. | | | | | | | | | | | | | ● |

# ENVIRONMENTAL ASSESSMENT USING SDSS AND ADVANCED EO TOOLS

| **Course** | **201900045** |
|---|---|
| Period | 14 November 2022 - 03 February 2023 |
| EC | 5 |
| Course coordinator | |

## INTRODUCTION

*How can spatial decision support (SDS) and advanced earth observation tools enhance the environmental assessment process in order to ensure sustainable planning and decision-making?*

Ad hoc and often uncontrolled development initiatives can have undesired social, economic and ecological consequences. Rapid population growth, pollution, climate change, exposure to hazards and disasters, and the loss of biodiversity and ecosystem services require effective assessment tools to assist sustainable planning and decision-making.

Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA) are the basic procedures to support this process. The key principles of EIA and SEA are the involvement of relevant stakeholders, a transparent and adaptive planning process, consideration of alternatives, and using the best possible information for decision and policymaking. They, therefore, improve both the (spatial) planning process and the information used in this process. In addition, earth observation (EO) tools can provide the biophysical baseline in a given geographical area and monitor the proposed activity, making the environmental assessment process more efficient.

In this course, you will not only explore how to integrate SEA into the planning process to enhance sustainable decision-making but also will address how GIS, spatial decision support and advanced EO tools such as an unmanned aerial vehicle (UAV) and high-resolution space-borne imagery, can be used to help identify and structure the problem(s), as well as generate and compare possible solutions, and monitor and evaluate the proposed activities.

Hands-on experience with real EIA and SEA projects will be a major part of the course.

## CONTENT

The course is spread over ten weeks and is based on task-based learning, which integrates theory and practice. The course exists of eight modules and includes the following topics:

- Introduction and EIA
- SEA: concepts, principles, stages and interaction with the planning process
- Advanced EO tools: a review of UAV and high-resolution space-borne imagery principles, applications in environmental assessments and their advantages
- Screening & Scoping: key elements & plan objectives, key issues, SEA objectives and identification of alternatives & options
- Assessment: baseline information, impact prediction & significance, mitigation, comparison of alternatives and justification for selected one(s), taking hazard, vulnerability, and potential risk into account; SEA report
- Spatial Decision Support tools in EA: spatial multi-criteria evaluation for site selection and vulnerability analysis using GIS application
- Review and decision-making
- Monitoring

A final project dealing with a typical application within the field of environmental assessment for spatial planning

### TEACHING AND LEARNING APPROACH
The course will be 'problem-driven', based on learning by doing. Several real-life based case studies from different disciplines will be offered to gain hands-on experience in the environmental assessment for sustainable planning and decision-making. Teaching will be based on presentations, supervised and un-supervised practical, self-study, plenary discussions, self-tests, project work.

### TESTS
four individual assignments and a summary group report.

### ENTRY REQUIREMENTS
- GIS and Remote Sensing skills
- Basic understanding of the environmental issues

### LEARNING OUTCOMES
Upon completion of this course, the student is able to:

LO 1 Explain the basic principles, procedures and steps in EIA & SEA and their integration in the planning process.
LO 2 Analyze the potential application of GIS and advanced EO tools in the environmental assessment process
LO 3 Incorporate hazard, vulnerability and risk in EA for (spatial) planning
LO 4 Apply SDS tools to define, analyse and assess alternatives
LO 5 Carry out an EA project dealing with a typical application within the field of SEA & EIA for spatial planning
LO 6 Evaluate the use of GIS, EO and SDS tools in EA

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 26 |
| Supervised practical | 26 |
| Individual assignment | 32 |
| Self-study | 30 |
| Tutorial | 6 |
| Group assignment | 20 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Group Assessment | Individual Assessment 1 | Individual Assessment 2 | Individual Assessment 3 | Individual Assessment 4 |
|---|---|---|---|---|---|---|
| | | Learning Outcomes that are addressed in the test | | | | |
| LO 1 | Explain the basic principles, procedures and steps in EIA & SEA and their integration in the planning process. | ● | ● | | | ● |
| LO 2 | Analyze the potential application of GIS and advanced EO tools in the environmental assessment process | ● | | ● | ● | ● |
| LO 3 | Incorporate hazard, vulnerability and risk in EA for (spatial) planning | ● | | ● | | ● |
| LO 4 | Apply SDS tools to define, analyse and assess alternatives | ● | | | | |
| LO 5 | Carry out an EA project dealing with a typical application within the field of SEA & EIA for spatial planning | ● | | | | |
| LO 6 | Evaluate the use of GIS, EO and SDS tools in EA | ● | | | ● | |
| | Test type | Report | Assignment | | | |
| | Weight of the test | 60 | 10 | 10 | 10 | 10 |
| | Individual or group test | Group | Individual | Individual | Individual | Individual |
| | Type of marking | 1-10 | 1-10 | 1-10 | 1-10 | 1-10 |
| | Required minimum mark per test | | | | | |
| | Number of test opportunities per academic year | 2 | 2 | 2 | 2 | 2 |

RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | Learning outcomes (LO) of the course: The student will be able to... | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Explain the basic principles, procedures and steps in EIA & SEA and their integration in the planning process. | ● | | | | | | | | | ● | ● | | |
| LO 2 | Analyze the potential application of GIS and advanced EO tools in the environmental assessment process | | ● | ● | ● | | ● | ● | | | ● | ● | | |
| LO 3 | Incorporate hazard, vulnerability and risk in EA for (spatial) planning | ● | | | | | ● | ● | | | | | | |
| LO 4 | Apply SDS tools to define, analyse and assess alternatives | | ● | ● | | | ● | ● | | | | | | |

| Learning outcomes (LO) of the course: The student will be able to... | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 5 | Carry out an EA project dealing with a typical application within the field of SEA & EIA for spatial planning | | ● | ● | ● | | ● | ● | | | | | | |
| LO 6 | Evaluate the use of GIS, EO and SDS tools in EA | ● | ● | ● | ● | | | | ● | ● | | | | |

# ENVIRONMENTAL MONITORING WITH SATELLITE IMAGE TIME SERIES

| **Course** | **202200017** |
| --- | --- |
| Period | 14 November 2022 - 03 February 2023 |
| EC | 5 |
| Course coordinator | |

## INTRODUCTION

The 21$^{st}$ century has witnessed an increase in the availability and use of satellite images to capture changes in landscape patterns through time. You may have already been exposed to classical change detection analysis, which is a type of monitoring in which changes in landscape patterns are quantified from satellite imagery between few snapshots in time. Change detection analysis in this way is insufficient however when the processes under investigation are highly dynamic, e.g., crop rotation and ecosystem disturbances/recovery. Such cases require continuous monitoring of satellite images at frequent intervals with time series analysis (TSA). Continuous satellite image data, referred to as Satellite Image Time Series (SITS) in this course, are used to monitor dynamic processes. Ecological indicators derived from SITS capture landscape patterns consistently at frequent intervals, which enable researchers and practioners alike to detect both abrupt or seasonal changes and gradual trends over time. In addition, SITS spanning long periods of time, provide insights into the “drivers of change” and underlying mechanisms governing change. Several satellite image archives are now publicly available with the emergence of relatively inexpensive high-performance cloud computing platforms. Each archive presents unique challenges in terms of acquisition and processing. At the same time, TSA encompasses an array of quantitative approaches to monitor and forecast ecological indicators derived from SITS. These include among others, autoregressive (AR), moving average (MA) and autoregressive moving average (ARMA) models.

The number of SITS and methods for TSA can make environmental monitoring with Earth observation data a daunting task. The overall goal of this course therefore is to provide participants with sufficient knowledge and tools to acquire and process SITS, perform TSA on ecological indicators derived from SITS and design a successful environmental monitoring solution.

We begin the course with a review of key terms and concepts in environmental monitoring with Earth observation. These include: landscape patterns, pattern-generating processes and process interactions. The course continues with the exploitation of SITS to identify eco-physiological traits (ecological indicators) that can be used to monitor landscape patterns through time. With this foundation, we enter the nuts and bolts of the course: how to acquire, process, analyze and evaluate SITS for environmental monitoring. We use the Google Earth Engine cloud computing platform, Breaks For Additive Season and Trend (BFAST) algorithm and Box–Jenkins method for TSA at these stages. Google Earth Engine is a freely-available, convenient and widely used platform to acquire and process SITS. BFAST is an intuitive and widely used algorithm to decompose ecological indicators derived from SITS based on trend, seasonality, cyclical irregularity and structural changes. Box–Jenkins is a classical and systematic method for constructing ARMA models for retrospective time series analysis and forecasting. The ARMA process consists of five stages: (i) model identification; (ii) model estimation; (iii) model validation; (iv) forecasting; and (v) forecasting evaluation. You will then apply your new knowledge and skills to two case studies. The first case study deals with ecosystem detecting tipping points with the time series segmentation tool Landtrendr. The second case study involves modelling and forecasting crop rotations with AR models. Each case study links a problem to an ecological indicator, SITS and method for TSA. For the remainder of the course, participants will form groups to design and execute their own small environmental monitoring solution. Each group will present their findings to the entire class at the end of the course.

### CONTENT

- Key terms and concepts in remote sensing and environmental monitoring
- Ecological indicators derived from SITS
- SITS: data acquisition and processing
- Time series decomposition with BFAST
- Box–Jenkins method for TSA
- Detecting ecosystem tipping points with time series segmentation (Landtrendr)
- Modeling and forecasting crop rotation with AR models
- Environmental monitoring group project

### TEACHING AND LEARNING APPROACH

- The course takes a student-centered (inquiry-based) approach to teaching and learning. Students assume an active/participatory role in their education, while teachers are facilitators who encourage interaction with new material presented and reflective thinking. The teacher uses class discussions, hands-on practicals and other experiential learning tools to track student comprehension, learning needs and academic progress over a teaching unit. Four summative assessments (writing assignment×2 + written test + final group project) measure how well the students achieve higher order thinking and learning outcomes.

### TESTS

- Two individual written assignments, one individual written test and one group oral assignment

### ENTRY REQUIREMENTS

- Geo-Information Science and Earth Observation: A Systems-Based Approach
- Earth Observation for Natural Resources Management (or equivalent)

### LEARNING OUTCOMES

Upon completion of this course, the student is able to:

LO 1 Explain key concepts in environmental monitoring (landscape patterns, pattern-generating processes and process interactions)

LO 2 Assess environmental problems through an Earth observation lens (ecological indicators, SITS acquisition and processing, TSA, accuracy assessment)

LO 3 Simulate ecosystem tipping points and crop rotations with SITS and TSA

LO 4 Design and implement an environmental monitoring solution in which SITS are acquired, processed, analyzed and evaluated

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 16 |
| Supervised practical | 31 |
| Written/oral test | 6 |
| Individual assignment | 14 |
| Self-study | 30 |
| Group assignment | 36 |
| Tutorial | 7 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Written Assignment | Written Assignment | Written Test | Oral Assignment |
|---|---|---|---|---|---|
| | **Learning Outcomes that are addressed in the test** | | | | |
| LO 1 | Explain key concepts in environmental monitoring (landscape patterns, pattern-generating processes and process interactions) | | | ● | |
| LO 2 | Assess environmental problems through an Earth observation lens (ecological indicators, SITS acquisition and processing, TSA, accuracy assessment) | | | ● | |
| LO 3 | Simulate ecosystem tipping points and crop rotations with SITS and TSA | ● | ● | | |
| LO 4 | Design and implement an environmental monitoring solution in which SITS are acquired, processed, analyzed and evaluated | | | | ● |
| | Test type | Written Assignment | Written assignment | Written test | Oral Assignment |
| | Weight of the test | 15 | 15 | 30 | 40 |
| | Individual or group test | Individual | Individual | Individual | Group |
| | Type of marking | Pass/Fail | Pass/Fail | 1-10 | 1-10 |
| | Required minimum mark per test | | | 5.5 | 5.5 |
| | Number of test opportunities per academic year | 2 | 2 | 2 | 2 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Explain key concepts in environmental monitoring (landscape patterns, pattern-generating processes and process interactions) | ● | ● | ● | ● | ● | | | ● | | | | | |
| LO 2 | Assess environmental problems through an Earth observation lens (ecological indicators, SITS acquisition and processing, TSA, accuracy assessment) | ● | ● | ● | ● | ● | | | ● | | | | | |

| | Learning outcomes (LO) of the course: The student will be able to... | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 3 | Simulate ecosystem tipping points and crop rotations with SITS and TSA | ● | ● | ● | ● | ● | | ● | ● | | | | | |
| LO 4 | Design and implement an environmental monitoring solution in which SITS are acquired, processed, analyzed and evaluated | ● | ● | ● | ● | ● | ● | ● | | | | | ● | ● |

# GEO-HEALTH_5EC

| **Course** | **202100001** |
| --- | --- |
| Period | 14 November 2022 - 03 February 2023 |
| EC | 5 |
| Course coordinator | |

## INTRODUCTION

Geohealth integrates epidemiology with spatial data science.  During the course students will be introduced to different spatial analysis methods, spatial data science methods and spatial concepts useful for the analysis of health and disease. These include the collection and use of geographic information, mapping of disease incidence and understanding where, when, why and how disease incidences may be occurring.

## CONTENT

Each week students will be provided with lecture notes and readings, be required to participate in a range of weekly activities that may include taking a quiz, discussions and weekly projects. Each week students will focus on a single topic so that they can develop a thorough understanding of how the spatial data method(s) can be used for tackling specific health or disease problem. Problem scenarios range across data surveillance and infrastructure planning, spatial and temporal analysis of health or disease, modeling vector-borne diseases, evaluating and planning health infrastructure, risk mapping and analysis as well as responding to disease outbreaks and epidemics.

## TEACHING AND LEARNING APPROACH

Readings: lecture notes and readings,

Weekly quizzes, discussions and projects.

Interactive peer-review

Individual term project where the student selects a topic and use what they learn during the course to the topic.

## TESTS

weekly quizzes

## ENTRY REQUIREMENTS

All students in Geoinformatics specialization are accepted. Students following other specializations should have a background in one or more of the following: data science, epidemiology, statistics, health sciences or public health.

### LEARNING OUTCOMES

Upon completion of this course, the student is able to:

- LO 1 Describe how geospatial information, technologies and spatial analysis methods can be used in health and disease studies
- LO 2 Identify data sources useful for exploring health and disease outcomes and distinguish and critique between authoritative vs. non-authoritiative data sources;
- LO 3 List factors important in understanding the ecology of vector-borne diseases; Apply map algebra, spatial statistics and raster analysis to model risk of vector-borne disease - malaria
- LO 4 Describe the research process used to investigate patterns associated with health and disease ; Calculate summary statistics (central tendency, variability);Calculate the three centers of spatial data distributions; Describe the concepts of basic biostatistics and how these can be applied to summarize and analyze health and disease data
- LO 5 Explain what cluster analysis is; Explain how cluster analysis can be used in health studies;List different clustering methods that can be used for clustering analysis; Perform spatial clustering analysis and assess map and examine spatial patterns in the data.
- LO 6 List factors important in determining accessibility to health care; Review different approaches used to model accessibility to healthcare; Describe approaches useful for examining access to healthcare based on distance, time and cost;Explain the map algebra concepts; Evaluate disparities of accessibility to health care; Propose solutions to improving access to health care
- LO 8 Develop and execute an independent geohealth project.
- LO 9 Complete analysis and write-up of individual term-project.
- LO 10 Present individual term-project and peer-evaluate term project

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 20 |
| Supervised practical | 20 |
| Written/oral test | 10 |
| Individual assignment | 40 |
| Group assignment | 10 |
| Self-study | 40 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Written test | Individual assignment | Group assignment |
|---|---|---|---|---|
| | | Learning Outcomes that are addressed in the test | | |
| LO 1 | Describe how geospatial information, technologies and spatial analysis methods can be used in health and disease studies | ● | ● | |
| LO 2 | Identify data sources useful for exploring health and disease outcomes and distinguish and critique between authoritative vs. non-authoritiative data sources; | ● | ● | ● |
| LO 3 | List factors important in understanding the ecology of vector-borne diseases; Apply map algebra, spatial statistics and raster analysis to model risk of vector-borne disease - malaria | ● | ● | |
| LO 4 | Describe the research process used to investigate patterns associated with health and disease ; Calculate summary statistics (central tendency, variability);Calculate the three centers of spatial data distributions; Describe the concepts of basic biostatistics and how these can be applied to summarize and analyze health and disease data | ● | ● | ● |
| LO 5 | Explain what cluster analysis is; Explain how cluster analysis can be used in health studies;List different clustering methods that can be used for clustering analysis; Perform spatial clustering analysis and assess map and examine spatial patterns in the data. | ● | ● | ● |
| LO 6 | List factors important in determining accessibility to health care; Review different approaches used to model accessibility to healthcare; Describe approaches useful for examining access to healthcare based on distance, time and cost;Explain the map algebra concepts; Evaluate disparities of accessibility to health care; Propose solutions to improving access to health care | ● | ● | |
| LO 7 | | ● | ● | |
| LO 8 | Develop and execute an independent geohealth project. | ● | ● | |
| LO 9 | Complete analysis and write-up of individual term-project. | ● | ● | |
| LO 10 | Present individual term-project and peer-evaluate term project | ● | ● | ● |
| | Test type | Written test | Individual assignment | Group assignment |
| | Weight of the test | 20 | 70 | 10 |
| | Individual or group test | Individual | Individual | Group |

| | Learning outcomes (LO) of the course: The student will be able to... | Learning Outcomes that are addressed in the test<br>Written test | Individual assignment | Group assignment |
|---|---|---|---|---|
| | Type of marking | 1-10 | 1-10 | 1-10 |
| | Required minimum mark per test | | | |
| | Number of test opportunities per academic year | 2 | 1 | 1 |

RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Describe how geospatial information, technologies and spatial analysis methods can be used in health and disease studies | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| LO 2 | Identify data sources useful for exploring health and disease outcomes and distinguish and critique between authoritative vs. non-authoritiative data sources; | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| LO 3 | List factors important in understanding the ecology of vector-borne diseases; Apply map algebra, spatial statistics and raster analysis to model risk of vector-borne disease - malaria | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| LO 4 | Describe the research process used to investigate patterns associated with health and disease ; Calculate summary statistics (central tendency, variability);Calculate the three centers of spatial data distributions; Describe the concepts of basic biostatistics and how these can be applied to summarize and analyze health and disease data | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |

| | Learning outcomes (LO) of the course: The student will be able to... | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 5 | Explain what cluster analysis is; Explain how cluster analysis can be used in health studies;List different clustering methods that can be used for clustering analysis; Perform spatial clustering analysis and assess map and examine spatial patterns in the data. | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| LO 6 | List factors important in determining accessibility to health care; Review different approaches used to model accessibility to healthcare; Describe approaches useful for examining access to healthcare based on distance, time and cost;Explain the map algebra concepts; Evaluate disparities of accessibility to health care; Propose solutions to improving access to health care | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| LO 7 | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| LO 8 | Develop and execute an independent geohealth project. | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| LO 9 | Complete analysis and write-up of individual term-project. | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |

| | Learning outcomes (LO) of the course: The student will be able to... | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 10 | Present individual term-project and peer-evaluate term project | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |

# GEO-HEALTH_7EC

| **Course** | **202100310** |
|---|---|
| Period | 24 April 2023 - 07 July 2023 |
| EC | 7 |
| Course coordinator | |

## INTRODUCTION

Geohealth integrates epidemiology with spatial data science.  During the course students will be introduced to different spatial analysis methods, spatial data science methods and spatial concepts useful for the analysis of health and disease. These include the collection and use of geographic information, mapping of disease incidence and understanding where, when, why and how disease incidences may be occurring.

## CONTENT

Each week students will be provided with lecture notes and readings, be required to participate in a range of weekly activities that may include taking a quiz, discussions and weekly projects. Each week students will focus on a single topic so that they can develop a thorough understanding of how the spatial data method(s) can be used for tackling specific health or disease problem. Problem scenarios range across data surveillance and infrastructure planning, spatial and temporal analysis of health or disease, modeling vector-borne diseases, evaluating and planning health infrastructure, risk mapping and analysis as well as responding to disease outbreaks and epidemics.

## TEACHING AND LEARNING APPROACH

Readings: lecture notes and readings,

Weekly quizzes, discussions and projects.

Interactive peer-review

Individual term project where the student selects a topic and use what they learn during the course to the topic.

## TESTS

weekly quizzes

## ENTRY REQUIREMENTS

All students in Geoinformatics specialization are accepted. Students following other specializations should have a background in one or more of the following: data science, epidemiology, statistics, health sciences or public health.

## LEARNING OUTCOMES

Upon completion of this course, the student is able to:

| | |
|---|---|
| LO 1 | Describe how geospatial information, technologies and spatial analysis methods can be used in health and disease studies; apply spatial analysis methods to describe health risks |
| LO 2 | Identify data sources useful for exploring health and disease outcomes; Explain why spatial data is special and limitations associated with spatial data ;Distinguish and critique between authoritative vs. non-authoritiative data sources; Explain privacy and ethical concerns associated with mapping and using health and disease data; Explore technologies and assess how these can be used for collecting health and disease data |
| LO 3 | List factors important in understanding the ecology of vector-borne diseases; Examine the epidemiologic triad for different vector-borne diseases;Examine different methods of complexity used to map and model vector-borne diseases; Explain theoretical approaches and how overlay methods and raster-based modeling approaches can be used; Describe the epidemiologic triad for malaria;Apply complex map algebra operations to model risk of vector-borne disease - malaria; Describe how these outputs are useful for public health response. |
| LO 4 | Describe the research process used to investigate patterns associated with health and disease ; Calculate summary statistics (central tendency, variability);Calculate the three centers of spatial data distributions; Describe the concepts of basic biostatistics and how these can be applied to summarize and analyze health and disease data; Assess how (geo)visualizations can be useful for examining disease. |
| LO 5 | Explain what cluster analysis is; Explain how cluster analysis can be used in health studies;List different clustering methods that can be used for clustering analysis; Perform spatial clustering analysis and assess map and examine spatial patterns in the data. Peer-review term project |
| LO 6 | List factors important in determining accessibility to health care; Review different approaches used to model accessibility to healthcare; Describe approaches useful for examining access to healthcare based on distance, time and cost;Explain the map algebra concepts; Evaluate disparities of accessibility to health care; Propose solutions to improving access to health care |
| LO 7 | Same as LO6 |
| LO 8 | Explain Epidemic theory; Identify what surveillance data are important; List the steps important in an outbreak investigation; Describe the spatial tools that are useful at each of these steps; Identify data limitations during a crisis (pandemic)-response situation; Analyze and describe the spread of an outbreak/pandemic and distribution of human cases; Critique analytical outputs and data visualizations and evaluate their usefulness in assessing and communicating risk; Create an interactive outbreak map that would be useful for communicating risk; Evaluate the usefulness of web maps in communicating risk during an on-going outbreak |
| LO 9 | Complete analysis and write-up of individual term-project. |
| LO 10 | Present individual term-project and peer-evaluate term project |

## ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 36 |
| Supervised practical | 20 |
| Written/oral test | 16 |
| Individual assignment | 58 |
| Group assignment | 10 |
| Self-study | 56 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Written test | Individual assignment | Group assignment |
|---|---|---|---|---|
| | | Learning Outcomes that are addressed in the test | | |
| LO 1 | Describe how geospatial information, technologies and spatial analysis methods can be used in health and disease studies; apply spatial analysis methods to describe health risks | ● | ● | |
| LO 2 | Identify data sources useful for exploring health and disease outcomes; Explain why spatial data is special and limitations associated with spatial data ;Distinguish and critique between authoritative vs. non-authoritiative data sources; Explain privacy and ethical concerns associated with mapping and using health and disease data; Explore technologies and assess how these can be used for collecting health and disease data | ● | ● | ● |
| LO 3 | List factors important in understanding the ecology of vector-borne diseases; Examine the epidemiologic triad for different vector-borne diseases;Examine different methods of complexity used to map and model vector-borne diseases; Explain theoretical approaches and how overlay methods and raster-based modeling approaches can be used; Describe the epidemiologic triad for malaria;Apply complex map algebra operations to model risk of vector-borne disease - malaria; Describe how these outputs are useful for public health response. | ● | ● | |
| LO 4 | Describe the research process used to investigate patterns associated with health and disease ; Calculate summary statistics (central tendency, variability);Calculate the three centers of spatial data distributions; Describe the concepts of basic biostatistics and how these can be applied to summarize and analyze health and disease data; Assess how (geo)visualizations can be useful for examining disease. | ● | ● | ● |
| LO 5 | Explain what cluster analysis is; Explain how cluster analysis can be used in health studies;List different clustering methods that can be used for clustering analysis; Perform spatial clustering analysis and assess map and examine spatial patterns in the data. Peer-review term project | ● | ● | ● |
| LO 6 | List factors important in determining accessibility to health care; Review different approaches used to model accessibility to healthcare; Describe approaches useful for examining access to healthcare based on distance, time and cost;Explain the map algebra concepts; Evaluate disparities of accessibility to health care; Propose solutions to improving access to health care | ● | ● | |

| | Learning outcomes (LO) of the course: The student will be able to... | Learning Outcomes that are addressed in the test: Written test | Individual assignment | Group assignment |
|---|---|---|---|---|
| LO 7 | Same as LO6 | ● | ● | |
| LO 8 | Explain Epidemic theory; Identify what surveillance data are important; List the steps important in an outbreak investigation; Describe the spatial tools that are useful at each of these steps; Identify data limitations during a crisis (pandemic)-response situation; Analyze and describe the spread of an outbreak/pandemic and distribution of human cases; Critique analytical outputs and data visualizations and evaluate their usefulness in assessing and communicating risk; Create an interactive outbreak map that would be useful for communicating risk; Evaluate the usefulness of web maps in communicating risk during an on-going outbreak | ● | ● | |
| LO 9 | Complete analysis and write-up of individual term-project. | ● | ● | |
| LO 10 | Present individual term-project and peer-evaluate term project | ● | ● | ● |
| | Test type | Written test | Individual assignment | Group assignment |
| | Weight of the test | 20 | 70 | 10 |
| | Individual or group test | Individual | Individual | Group |
| | Type of marking | 1-10 | 1-10 | 1-10 |
| | Required minimum mark per test | | | |
| | Number of test opportunities per academic year | 1 | 1 | 1 |

RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Describe how geospatial information, technologies and spatial analysis methods can be used in health and disease studies; apply spatial analysis methods to describe health risks | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| LO 2 | Identify data sources useful for exploring health and disease outcomes; Explain why spatial data is special and limitations associated with spatial data ;Distinguish and critique between authoritative vs. non- authoritiative data sources; Explain privacy and ethical concerns associated with mapping and using health and disease data; Explore technologies and assess how these can be used for collecting health and disease data | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |

| | Learning outcomes (LO) of the course: The student will be able to... | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 3 | List factors important in understanding the ecology of vector-borne diseases; Examine the epidemiologic triad for different vector-borne diseases;Examine different methods of complexity used to map and model vector-borne diseases; Explain theoretical approaches and how overlay methods and raster-based modeling approaches can be used; Describe the epidemiologic triad for malaria;Apply complex map algebra operations to model risk of vector-borne disease - malaria; Describe how these outputs are useful for public health response. | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |

| | Learning outcomes (LO) of the course: The student will be able to... | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 4 | Describe the research process used to investigate patterns associated with health and disease ; Calculate summary statistics (central tendency, variability);Calculate the three centers of spatial data distributions; Describe the concepts of basic biostatistics and how these can be applied to summarize and analyze health and disease data; Assess how (geo)visualizations can be useful for examining disease. | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| LO 5 | Explain what cluster analysis is; Explain how cluster analysis can be used in health studies;List different clustering methods that can be used for clustering analysis; Perform spatial clustering analysis and assess map and examine spatial patterns in the data. Peer-review term project | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |

| | Learning outcomes (LO) of the course: The student will be able to... | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 6 | List factors important in determining accessibility to health care; Review different approaches used to model accessibility to healthcare; Describe approaches useful for examining access to healthcare based on distance, time and cost;Explain the map algebra concepts; Evaluate disparities of accessibility to health care; Propose solutions to improving access to health care | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| LO 7 | Same as LO6 | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |

| | Learning outcomes (LO) of the course: The student will be able to... | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 8 | Explain Epidemic theory; Identify what surveillance data are important; List the steps important in an outbreak investigation; Describe the spatial tools that are useful at each of these steps; Identify data limitations during a crisis (pandemic)-response situation; Analyze and describe the spread of an outbreak/pandemic and distribution of human cases; Critique analytical outputs and data visualizations and evaluate their usefulness in assessing and communicating risk; Create an interactive outbreak map that would be useful for communicating risk; Evaluate the usefulness of web maps in communicating risk during an on-going outbreak | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| LO 9 | Complete analysis and write-up of individual term-project. | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| LO 10 | Present individual term-project and peer-evaluate term project | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |

# GEO-JOURNALISM

| **Course** | **201900068** |
|---|---|
| Period | 14 November 2022 - 21 April 2023 |
| EC | 5 |
| Course coordinator | |

## INTRODUCTION

The objective of this course is to equip students with an interest in geo-journalism skills to deliver spatial products and thematic information in a condensed, easily understandable format addressing the appropriate level for broad societal uptake.

Stories about our Planet are broad by nature and it is the job of a journalist to help pin down the often interconnected reasons that drive environmental change. The growth of large, publicly accessible datasets presents the media community with new opportunities, but this also comes with the need for new skills to turn this trove of information into easy-to-understand, evidence-based stories. Simultaneously, ITC/UT has been teaching applied geo-information sciences for +60 years, but with increasing emphasis on academic skills in recent years. According to a recent survey, however, more than 80% of our alumni do not pursue an academic career. Therefore, an all-new MSc course on geo-journalism is presented which teaches students to combine geodata, data analytics, and various Bodies of Knowledge (BoK) in creating compelling (cartographic) infographics to support their storytelling. Using this knowledge and skill, students are enabled to create compelling (cartographic) infographics in minutes rather than days. These infographics are fully semantically enriched, allowing others to see and question the data sources and underlying analyses. With each course assignment, students gradually populate their online NEWSroom with blog articles annotated by these (cartographic) infographics. As portfolio of the student's environmental storytelling efforts, this NEWSroom also helps improve their personal branding since their reporting is automatically indexed by Microsoft Bing and Google search because of the Semantic Web.

The skills taught in this course provide important 'spill-overs'; the open-source technology stack used not only facilitates fact-checking of claims made in news and blog articles, but also those in scientific journal articles. Studies show that only 10~30% of published science articles are reproducible. Many argue this is a logical result of the publishing format as in most papers textual reference is made such as "this experiment was conducted as previously reported [insert reference here]" instead of a live reference to the online executable algorithm and workflow to recreate the results. Our hope is that it will enable those with an enthusiasm for storytelling to use these rapid geo-information pipelines to support their valorisation efforts in publishing (reviews) of scientific findings and how to stimulate viral spread across the Internet.

## CONTENT

This course will prepare the students to become vocal individuals who have ability, attitudes, skills and know-how necessary for sound geo-journalism for the valorisation of research results and uptake addressing the appropriate level of understanding for an audience.

The course is structured as follows: (**a**) basic theory (frontal teaching), (**b**) advanced concepts (flipped classroom), (**c**) getting practical;
storytelling, (**d**) editorial meetings, (**e**) NEWSroom of co-authored blogs and infographics by groups of students, and (**f**) Self-reflection report.

**A. Basic theory**
The course starts with frontal lectures consisting of traditional and guest lectures.

<u>A.1 Traditional lectures</u>
Develop knowledge and insights in storytelling about our natural world:

- Discover the story by identifying elements in scientific findings that contradict, agree, or deviate from popular opinion
- How to write a news article in a 'foldable' manner
- Business models for (semi) professional geo-journalism

A.2. Guest lectures
A series of guest lectures will be organized:

- Facts and values in journalistic practice
- Social media strategies
- Cross-media strategies

**B. Advanced concepts: flipped class room**
Online martials are provided to the participants through which they will enhance their competencies in authoring and reviewing blog article with an associated (cartographic) infographic related to a contemporary issue. The aim of this phase is to discover a students' learning path and to prepare them for the role of author, editor, and publisher in a role-play (phase in C).

Master rapid, online executable EO workflows for geo-journalism and online publishing:

- Appraise methods, tools, and data that help summarize these findings using an infographic
- Elaborate data needs for the infographic
- Subset geo-data by time, space, and parameter for the infographic
- Propose rapid geo-data processing functions and reduce the data dimensionality meaningful for the infographic
- Present and augment computer-generated infographics to be visually appealing and easy-to-understand

Master robust, online peer-review workflow to stimulate viral spread across the Internet:

- Understand the basic principles of the Semantic Web 3.0 and the structured data types for "fact-checking"
- Demonstrate an understanding of the full definition of ClaimReview (schema.org/ClaimReview)
- Demonstrate authoring of a (review) claim (schema.org/CreativeWork)
- Understand how truthfulness ratings are assigned using the reviewRating of the ClaimReview-process (schema.org/Rating)
- Understand how the claim being checked by multiple reviewers can be summarized programmatically (based on this crowd of
fact-checkers)

Appraise strategies and reasons to build a personal brand:

- Understand practical ways to build-out your online presence
- Be able to tell a story orally, pitch your perspective on a contemporary environmental issue in less 3 minutes
- Discriminate social media strategies
- Understand (non)monetary business models for (semi) professional geo-journalism (e.g. freelance journalism, personal
branding, or valorisation of research results)

**C. Getting practical; storytelling (oral and written) and roleplaying**
In this phase you get to improve your geo-journalism skills by working on a story covering a real-life, contemporary environmental issue backed by geo-information science. This requires that you use multiple theories and tools from geo-information and journalism in an integrated fashion. Given the technical readiness of geo-journalism, several social-cultural aspects also deserve attention such as what are the (perceived) occupational or cultural barriers to be publicly outspoken.
Four contemporary issues (study cases) are presented to students, whereby groups of students will jointly work on the design cycle of a story, frequently alternating the student's role from author-editor-publisher-reader. Below an example design cycle:

- Read up on promising fact-checking articles and discuss why some spread virally across the Internet
- Compare the findings of three scientific articles (focus on the abstract and conclusions), are there elements that deviate from
popular opinion (contradict, agree)?
- Write an appropriate "lede" for the story you have in mind: hard-news ledes are generally used for breaking news and for
more important, time-sensitive stories. Feature ledes are generally used on stories that are less deadline-oriented and for
those that examine issues in a more in-depth way.

- Write the main body of the blog post in a 'foldable' manner such that the reader can 'skip over' sub-paragraphs while still
  understanding the main point of the story
- By hand, sketch a dummy infographic that would support the main elements of the story.
- Review the handwritten dummy infographic from one of your peers: does it support the main elements of the story?
- Create the online-referenceable, reproducible EO workflow needed to create the infographic (based on the sketch)

The design cycle of a blog or news article is an iterative process. This means that throughout the project you will improve each design step by going back and forth between steps until a satisfactory result is achieved, and checked by a potential reader or paying publisher. This means design iterations and rework are a natural part of this design cycle, all with the sole goal of improving the young geo-journalist.

**D. Editorial meetings**
Editorial meetings are foreseen to monitor and stimulate the progress of the students. The student groups will be presenting their progress in identifying and telling stories, addressing the challenges, and proposing possible solutions. The students will have the opportunity to comments on each other's works and ask questions to the scientific and professional consultants.

**E. NEWSroom**
As part of the students' growing journalistic aspirations, with each course assignment students gradually populate their online NEWSroom with blog articles annotated by (cartographic) infographics as personal portfolio of their environmental storytelling efforts. This NEWSroom also helps to improve their personal branding since their reporting is automatically indexed by Microsoft Bing and Google search because of the ReviewClaim-tag, incl. their work in the various role-playing modes, e.g. as editor and reviewer, where fact-checking and feedback on the scientific rigor of underlying facts, incl. data, method, results and discussion, are presented in a scientific and clear manner.

**F. Self-reflection report**
A written self-reflection report (max 400 words) on the learning process within the context of the learning outcomes of the course and the contribution to the case studies supported with evidence. (individual & mark)

## TEACHING AND LEARNING APPROACH

This course integrates blended learning with storytelling teaching approach. Blended learning combines face-to-face lectures with flipped
classroom via online learning materials. Tutorials are self-learning online materials that stimulates learning by doing with some limited coaching. The students will work, hereafter, in multinational groups (consisting of 3-4 persons) on a article or story, combine and develop their skills in role-playing, and present in a "simulated" public hearing setup.

## TESTS

- Test 1: NEWSroom assignments and tracking, need to finish the training (summative: completed/fail)
- Test 2: Theory: 1 written test (and 1 resit) (30%)
- Test 3: Blog/news article and fact-check assignment (60%)
  1- Blog (40%)
  2- NEWSroom feedback (20%)
- Test 4: self-reflection report (10%)

## ENTRY REQUIREMENTS

Affinity with the use of geo-information science for data journalisms, infographics, and building an online presence.

### LEARNING OUTCOMES

Upon completion of this course, the student is able to:

- LO 1 Discover and tell a story that is appealing.
- LO 2 Gain insights in journalistic best practices by publishing scientific results in the media.
- LO 3 Master tools for geo-journalism and online, rapid executable EO workflows.
- LO 4 Master robust, online peer-review workflow to stimulate viral spread across the Internet.
- LO 5 Valorise on research results by appraising and recommending suitable methods to summarize scientific findings for a broader audience using infographics and social media blog articles.
- LO 6 Understand practical ways to build-out your personal brand.

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 22 |
| Supervised practical | 14 |
| Tutorial | 10 |
| Individual assignment | 26 |
| Group assignment | 26 |
| Self-study | 42 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Discover and tell a story that is appealing. | | | | | | | | | | | | | |
| LO 2 | Gain insights in journalistic best practices by publishing scientific results in the media. | | | | | | | | | | | | | |
| LO 3 | Master tools for geo-journalism and online, rapid executable EO workflows. | | | | | | | | | | | | | |
| LO 4 | Master robust, online peer-review workflow to stimulate viral spread across the Internet. | | | | | | | | | | | | | |

| | Learning outcomes (LO) of the course: The student will be able to... | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 5 | Valorise on research results by appraising and recommending suitable methods to summarize scientific findings for a broader audience using infographics and social media blog articles. | | | | | | | | | | | | | |
| LO 6 | Understand practical ways to build-out your personal brand. | | | | | | | | | | | | | |

# GEODATA VISUALIZATION

| **Course** | **201900059** |
|---|---|
| Period | 05 September 2022 - 11 November 2022 |
| EC | 5 |
| Course coordinator | |

### INTRODUCTION

This course Geodata Visualization covers aspects of geovisual analytics, in particular, with respect to time series of movement data of people, animals, and goods. The objective of this course is to learn how to prepare and integrate, transform, and visually analyse the data to reveal spatio-temporal patterns and trends. Participants will, based on the methods introduced, develop visual environments for answering questions related to a real-world scenario. These visual environments will combine interactive and dynamic map and diagram displays with a focus on user-centred design.

### CONTENT

- Information visualization (0.5 EC): interactive visualization pipeline; visual sense making; visual clutter; design space
- Geovisual analytics (0.5 EC): movement data and time series; flow map and other visual origin–destination representations
- Data preparation (0.5 EC): data structures and scales of measurement; data transformation
- User-centred design (0.5 EC): user requirements; user interaction; functionality
- Case study (3 EC): tool options; implementation of a visualization; qualitative and quantitative evaluation methods

### TEACHING AND LEARNING APPROACH

The lectures provided seek to raise a theoretical and practical understanding of how to analyse, design, implement, and evaluate visualizations. The lectures are complemented by practicals, in which the participants work on group and individual assignments to consolidate what they have learned in practice.

### TESTS

- Essay (for demonstrating the ability to design visualizations for a specific task; 25%)
- Presentation (about the implementation of two visualizations; 40%)
- Report (evaluation of the two visualizations implemented; 35%)

In case a participant fails any of these tests, he/she is granted the possibility to improve it, with the opportunity to achieve a maximum mark of 6.
For further information, please see the test plan.

### ENTRY REQUIREMENTS

No formal ones.

### LEARNING OUTCOMES

Upon completion of this course, the student is able to:

- LO 1 Explain the basics of geovisual analytics, and understand its usefulness in solving real world (movement data related) problems.
- LO 2 Evaluate the different data transformation and visual representation options to display complex movement data.
- LO 3 Design and built a prototype of a visual representation based on real work data (case study).
- LO 4 Follow a user-centred, evaluation-based design approach in choosing and applying appropriate visual representations to analyse a particular spatio-temporal problem.
- LO 5 Explain and justify the selection of components of a geovisual working environment in the context of a selected problem case, considering the usefulness of the application of dashboards.

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 12 |
| Supervised practical | 8 |
| Individual assignment | 42 |
| Group assignment | 42 |
| Self-study | 36 |

## TESTPLAN

| | **Learning outcomes (LO) of the course: The student will be able to...** | **Essay** | **Presentation** | **Report** |
|---|---|---|---|---|
| | | **Learning Outcomes that are addressed in the test** | | |
| LO 1 | Explain the basics of geovisual analytics, and understand its usefulness in solving real world (movement data related) problems. | ● | | |
| LO 2 | Evaluate the different data transformation and visual representation options to display complex movement data. | ● | | |
| LO 3 | Design and built a prototype of a visual representation based on real work data (case study). | | ● | |
| LO 4 | Follow a user-centred, evaluation-based design approach in choosing and applying appropriate visual representations to analyse a particular spatio-temporal problem. | | | ● |
| LO 5 | Explain and justify the selection of components of a geovisual working environment in the context of a selected problem case, considering the usefulness of the application of dashboards. | | | ● |
| | Test type | Essay | Presentation | Report |
| | Weight of the test | 25 | 40 | 35 |
| | Individual or group test | Individual | Group | Individual |
| | Type of marking | 1-10 | 1-10 | 1-10 |
| | Required minimum mark per test | | | |
| | Number of test opportunities per academic year | 2 | 2 | 2 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Explain the basics of geovisual analytics, and understand its usefulness in solving real world (movement data related) problems. | ● | ● | | | | | | | | | | | |
| LO 2 | Evaluate the different data transformation and visual representation options to display complex movement data. | ● | | ● | | | ● | | | | | | | |
| LO 3 | Design and built a prototype of a visual representation based on real work data (case study). | | | | ● | ● | | | | | | | ● | |

| | Learning outcomes (LO) of the course: The student will be able to... | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 4 | Follow a user-centred, evaluation-based design approach in choosing and applying appropriate visual representations to analyse a particular spatio-temporal problem. | | | | | | ● | | | ● | ● | | | ● |
| LO 5 | Explain and justify the selection of components of a geovisual working environment in the context of a selected problem case, considering the usefulness of the application of dashboards. | | | | | ● | | ● | ● | | ● | ● | ● | ● |

# GEOPHYSICS - IMAGING THE UNSEEN

| **Course** | **201800320** |
|---|---|
| Period | 24 April 2023 - 07 July 2023 |
| EC | 7 |
| Course coordinator | |

### INTRODUCTION
This course serves to deliver knowledge on tools for 3D characterization, visualization and modelling of the subsurface. The development of homogeneous 3D subsurface information systems is important for various fields such as for environmental monitoring, soil studies, groundwater, natural hazards, and earth resources.
Many earth processes have a source or a component below the surface. Understanding of the spatial and temporal variation of physical parameters in the subsurface therefore gives additional insight in these processes and their extent. This could be the extent of pollution plumes, distribution of water, nutrients, mineral resources, or e.g. sliding planes of landslides.
The course offers possibility to specialize in two geophysical methods and study these in detail, and final project.

### CONTENT
The course starts with an overview of modern concepts in subsurface characterization and (dynamic) modelling. This will be based on the theoretical basis for the various geophysical tools and techniques. Next, through demos and field work, participants are familiarized with the geophysical method(s) relevant to an application area of their own interest. Finally, through small projects, relevant (sub)surface processes are linked to subsurface properties whereby participants are confronted with natural limitations of the various tools and techniques.

Topics include:

- Physical properties of rocks, minerals and soils
- Theory and practice of geophysical techniques (e.g. geo-electrical, electromagnetic, ground penetrating radar, seismics, gravity, magnetics)
- Analysis of various multi-scale, multi-temporal, and multi-source data sets
- Modelling (2D/3D) of physical properties in the subsurface
- Relation of derived models with physical processes
- Application of the above in various case studies related to specific fields of interest
- Prepare and evaluate geophysical proposals

### TEACHING AND LEARNING APPROACH
Students can choose their own methods (2) to study, which are relevant for their study and/or work and will focus on these methods throughout the course. The teaching is therefore based on self-learning and application of geophysical methods through projects and fieldwork.

### TESTS
Individual bid report and evaluation (40%), individual presentation final project (30%), written exam (30%).

### ENTRY REQUIREMENTS
Open for students with a background in earth sciences, physical geography, water resources, soil science, environmental science, engineering, applied physics/mathematics, with an interest in earth systems.

### LEARNING OUTCOMES

Upon completion of this course, the student is able to:

LO 1 Describe the various geophysical methods and its equipment to study, model and visualize the subsurface in 2D/3D.

LO 2 Determine the applicability of geophysics in 3D subsurface characterization for various applications.

LO 3 Develop a geophysical bid for a study of the subsurface supported by a decision support system to select the right tools and techniques.

LO 4 Evaluate geophysical bid proposals (dynamically) model subsurface parameters and processes.

LO 5 Extract subsurface parameters from analysis, modelling and visualization of geophysical data.

LO 6 Analyse derived subsurface parameters in relation to (sub)surface processes.

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 24 |
| Supervised practical | 16 |
| Individual assignment | 98 |
| Group assignment | 14 |
| Self-study | 44 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Bid proposal | Bid evaluation | Specialisation project | Written exam |
|---|---|---|---|---|---|
| | | Learning Outcomes that are addressed in the test | | | |
| LO 1 | Describe the various geophysical methods and its equipment to study, model and visualize the subsurface in 2D/3D. | ● | | | ● |
| LO 2 | Determine the applicability of geophysics in 3D subsurface characterization for various applications. | ● | ● | | ● |
| LO 3 | Develop a geophysical bid for a study of the subsurface supported by a decision support system to select the right tools and techniques. | ● | | | |
| LO 4 | Evaluate geophysical bid proposals (dynamically) model subsurface parameters and processes. | | ● | | |
| LO 5 | Extract subsurface parameters from analysis, modelling and visualization of geophysical data. | | | ● | ● |
| LO 6 | Analyse derived subsurface parameters in relation to (sub)surface processes. | | | ● | ● |
| | Test type | Proposal | Evaluation | Report | Written test |
| | Weight of the test | 20 | 20 | 30 | 30 |
| | Individual or group test | Individual | Individual | Individual | Individual |
| | Type of marking | 1-10 | 1-10 | 1-10 | 1-10 |
| | Required minimum mark per test | | | | |
| | Number of test opportunities per academic year | 2 | 2 | 2 | 2 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Describe the various geophysical methods and its equipment to study, model and visualize the subsurface in 2D/3D. | ● | | | | | | | | | | | | ● |
| LO 2 | Determine the applicability of geophysics in 3D subsurface characterization for various applications. | ● | | | | | | | | ● | | | | ● |
| LO 3 | Develop a geophysical bid for a study of the subsurface supported by a decision support system to select the right tools and techniques. | ● | ● | | ● | ● | ● | ● | ● | ● | | | ● | ● |
| LO 4 | Evaluate geophysical bid proposals (dynamically) model subsurface parameters and processes. | | ● | | ● | ● | ● | ● | ● | | | | ● | ● |

| | Learning outcomes (LO) of the course: The student will be able to... | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 5 | Extract subsurface parameters from analysis, modelling and visualization of geophysical data. | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | | ● | ● |
| LO 6 | Analyse derived subsurface parameters in relation to (sub)surface processes. | | ● | ● | ● | ● | ● | ● | ● | ● | ● | | ● | ● |

# INTERNSHIP

| **Course** | **201900002** |
|---|---|
| Period | 05 September 2022 - 07 July 2023 |
| EC | 10 |
| Course coordinator | |

## INTRODUCTION

The internship is defined as a credit-bearing experiential activity in a professional work environment. Its main purpose is to integrate knowledge and theory with practical applications and skill development in a host organization.

The internship may be carried out within consultant companies, government agencies, research institutes, NGOs or intergovernmental organisations in the Netherlands or abroad. ITC has a working relation and has made agreements on the possible placement of interns with these organisations. The student will be able to apply for an internship topic based to interests and preferences, and will develop this topic into an internship project plan (IPP) prior to the start of the internship. During the internship, the student will receive guidance from a daily supervisor in the organisation concerned. A member of the ITC scientific staff who is an expert on the area of the internship topic will be assigned as ITC internship supervisor. At the end of the internship, the student will have to hand in several deliverables such as an internship report (IR) and an internship reflection report (IRR) report in which the results experiences will be discussed and highlight the learning that has been achieved during the internship. The supervisor of the host organization will give feedback on the professional skills using the Host Evaluation Form (HEF).

Students choosing to carry out internships will have the opportunity to:

- Develop a working knowledge in the operationalization of geo-information science;
- Learn new practical skills and gain confidence in entrepreneurial and professional settings;
- Practice communication and teamwork skills;
- Establish a network of professionals;
- Boost their career prospects;
- Become a more motivated life-long learner.

## CONTENT

The internship focuses on executing specific tasks of a project or research related to the integration of M-GEO knowledge within the context of a host/client organization. It involves spending part of the second year working at a company/organization as part of a team and can be carried out before or after MSc thesis defence.

### TEACHING AND LEARNING APPROACH

The process of the search for the internship is predominantly the student's own responsibility but it is facilitated by the ITC internship coordinator. Orientation for an internship can be started the moment the student is enrolled in the academic year but should start at least 6 months prior to the desired start date for an internship in The Netherlands and preferably a whole year in advance for an international internship. This extra time is required for arrangements that need to be made.

ITC is providing a database with host organizations and internship assignments from which the student can choose. It is also possible that the student suggests an internship assignment or organization in the field of geo-information science.

The internship coordinator facilitates and supports the student throughout the whole internship process. The UT online tool "mobility online" is used to monitor the internship procedure. An internship can only start after approval and signing of the internship assignment and the Internship Project Plan (IPP) – *to be signed by three parties; host organization, student and ITC internship supervisor (i.e. examiner).* The ITC supervisor is responsible for the quality check of the content of the internship assignment and Internship Project Plan. It is also mandatory to have a signed internship agreement before the internship commences.

During the internship, the student will receive supervision and guidance from an ITC internship supervisor as well as a daily supervisor at the host organization. A minimum of 7 full-time weeks will have to be spent on the internship, with an indicative maximum of 20 weeks (i.e.2 quartiles). Irrespective of the length of the internship within these limits. The number of credits awarded after successful completion of the internship remain 10 EC > (280 hours).

Due to the research orientation of the MSc programme an internship can, in principle, only start after the MSc Research proposal has been approved. The proposed period for internships is, therefore the third and fourth quartiles of the second year.

The internship has to be concluded with an internship report (IR) and preferably with a presentation in the organization and/or at ITC. This internship report provides a content description of the process and results of the internship and includes a discussion of the problem and context, objectives of the assignment, the question addressed, the method used, analyses performed, results and discussion. An internship reflection report (IRR) is mandatory to hand in. This Internship Reflection Report highlights on the learning process of the professional skills during the internship.

### TESTS

Internship shall be assessed as completed/uncompleted using three appraisals:

- Internship Report (IR), received from the student
- Host Evaluation Form received by the host organization (HEF)
- ITC Supervisor Grade and Assessment Form

**Host Evaluation Form - (HEF)**

The Host Evaluation Form is shall include evaluations of the followings:

- Did the intern apply the M-GEO's knowledge-field as specified in IPP.1.a in an adequate and correct manner?
- Did the intern learn new skills as specified in IPP 1.d? What is the degree of the intern's level before and after the internship? Use the following grading: *novice, advanced, expert*;
- How the intern did manage the realization of the internship? Specify the followings:
    1. The planned tasks and deliverables were accomplished and supplied;
    2. The communication plan was aligned with milestones and properly implemented;
    3. The planned time schedule was realized and if changed, was properly communicated and did not affect achieving the goals of the internship.
- Communicate the internship results effectively to the host organization

**Internship Report (IR)**

Each intern shall submit a report that contains the IPP and reflection section highlighting the followings:

1. **The learning process**: s/he gained professional skills in the workplace, with focus on application of theoretical knowledge, problem solving, communication, time management and teamwork skills.
2. **The realization process**: how the tasks and deliverables were realized and supplied?
3. **The communication process**: how the internship results were communicated to professionals, ITC and the host?
4. **Self-assessment**: reflection on your strength (your best skills), values (what matters most to you) and interests (what you like to do) in professional work environment.
5. **Recommendation** for improved experience on internship.

### ENTRY REQUIREMENTS

- Approved study plan for the second academic year
- MSc Research proposal has been approved
- Approved Internship Project Plan
- IPP & Internship Agreement signed by the student, the host organization and the faculty ITC

IMPORTANT:

Whether an internship is possible in a certain country could depend on scholarship conditions. As these are different for each scholarship provider, the internship coordinator should be consulted to provide clarity on this issue.

### LEARNING OUTCOMES

Upon completion of this course, the student is able to:

| | |
|---|---|
| LO 1 | Develop a deliverable that integrate M-GEO knowledge with the practical applications of a host/client organization. |
| LO 2 | Operate practically and confidentially in entrepreneurial and professional settings. |
| LO 3 | Reflect/evaluate the content and process of the learning experience of the internship. |
| LO 4 | Communicate the internship results effectively to the client/industry and academics. |

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Written/oral test | 24 |
| Individual assignment | 256 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Test 1 | Test 2 |
|---|---|---|---|
| | | Learning Outcomes that are addressed in the test | |
| LO 1 | Develop a deliverable that integrate M-GEO knowledge with the practical applications of a host/client organization. | ● | |
| LO 2 | Operate practically and confidentially in entrepreneurial and professional settings. | ● | ● |
| LO 3 | Reflect/evaluate the content and process of the learning experience of the internship. | | ● |
| LO 4 | Communicate the internship results effectively to the client/industry and academics. | ● | ● |
| | Test type | Report | Report |
| | Weight of the test | | 100 |
| | Individual or group test | Individual | Individual |
| | Type of marking | Pass/Fail | 1-10 |
| | Required minimum mark per test | | |
| | Number of test opportunities per academic year | 1 | 1 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | Learning outcomes (LO) of the course: The student will be able to... | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Develop a deliverable that integrate M-GEO knowledge with the practical applications of a host/client organization. | ● | ● | ● | ● | | | ● | | | | | | |
| LO 2 | Operate practically and confidentially in entrepreneurial and professional settings. | | | | | ● | | ● | | | ● | | | ● |
| LO 3 | Reflect/evaluate the content and process of the learning experience of the internship. | | | | | | | | | | | ● | ● | |
| LO 4 | Communicate the internship results effectively to the client/industry and academics. | | | | | | | | ● | | | | | |

# INTRA URBAN SPATIAL PATTERNS AND PROCESSES

| Course | 201800306 |
|---|---|
| Period | 24 April 2023 - 07 July 2023 |
| EC | 7 |
| Course coordinator | |

## INTRODUCTION

This elective explores issues of socio-spatial inequality, differentiation and fragmentation that impact the urban environment and the quality-of-life of urban residents. We concentrate on capturing and understanding diverse forms of knowledge regarding intra-urban variations of quality-of-life, including socioeconomic status and health. A better understanding of the resulting socio-spatial patterns is essential for targeting (multiple) deprived areas and implementing area-based and regeneration policies. Particular attention will be paid to different scales of analysis and categorisations.

The course follows a challenge-based learning approach where students Identify a learning path to solve socially relevant challenges related to urban quality of life and well-being. This course presents several methods under a mixed-methods approach. Through a combination of lectures, reading assignments, exercises, and group work, students learn to combine quantitatively derived patterns and measures with urban residents generated data and perceptions and interpret the complementary results acquired. Group collaboration: each student will carry a diary to report their work, observations, challenges, and strategies to methods used.

## CONTENT

**Context and application**

- Intra-Urban Socio-Spatial Patterns in Urban Studies;
- Spatial Justice; Spatial Inequality;
- Quality of Life / Community Well-Being and Deprivation;
- Socio-economic status and health;
- Diverse forms of knowledge;
- Targeting and Regeneration. Area-Based Policies.

**Methods**

- Data reduction, Factor Analysis;
- Geodemographics ["analysis of people by where they live"], neighbourhood analysis and targeting. Cluster analysis. K-means;
- Patterns and scale issues (MAUP);
- Spatial autocorrelation;
- Intra-urban patterns and change;
- Patterns of user generated data and qualitative data. Qualitative GIS. Mixed methods approach. "Objective" and "Subjective" measures;
- Spatial analysis of qualitative data. Geo / place quotation. ATLAS-ti software geocoding.

## TEACHING AND LEARNING APPROACH

Active participation and critical reflection are embedded in a challenge-based learning approach.

**Participation and attendance:**

- Due to educational activities that require active involvement (e.g. group presentations), the lecturer may demand mandatory attendance during lectures or parts thereof.

The course coordinator will communicate this at the start of the course.

## TESTS

Two group assignments and two individual assignments (see test plan for details)

Type of marking: 1-10

## ENTRY REQUIREMENTS

Knowledge of GIS at level of Core Courses or higher;
Ability to independently apply GIS software;
Knowledge of basic statistics.

## LEARNING OUTCOMES

Upon completion of this course, the student is able to:

LO 1 Describe the relevance and validity of selected qualitative and quantitative methods in the context of urban studies and planning.

LO 2 Apply qualitative, statistical, and GIS-based spatial analytical methods to detect and analyse intra-urban socio-spatial patterns.

LO 3 Analyse the intra-urban socio-spatial patterns in relation to current theoretical and empirical debates in urban studies and planning.

LO 4 Interpret results and relate these to policy implications.

LO 5 Identify a learning path to solve socially relevant challenges related to urban quality of life and well-being.

LO 6 Collaborate and communicate with inter and transdisciplinary colleagues to shape societal relevant challenges related to urban quality of life and well-being.

## ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 35 |
| Supervised practical | 19 |
| Tutorial | 16 |
| Written/oral test | 6 |
| Individual assignment | 32 |
| Group assignment | 48 |
| Self-study | 40 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Exercises | CBL presentation | CBL individual diary | Individual paper |
|---|---|---|---|---|---|
| LO 1 | Describe the relevance and validity of selected qualitative and quantitative methods in the context of urban studies and planning. | | | | ● |
| LO 2 | Apply qualitative, statistical, and GIS-based spatial analytical methods to detect and analyse intra-urban socio-spatial patterns. | ● | ● | ● | ● |
| LO 3 | Analyse the intra-urban socio-spatial patterns in relation to current theoretical and empirical debates in urban studies and planning. | | | | ● |
| LO 4 | Interpret results and relate these to policy implications. | | | | ● |
| LO 5 | Identify a learning path to solve socially relevant challenges related to urban quality of life and well-being. | | ● | ● | |
| LO 6 | Collaborate and communicate with inter and transdisciplinary colleagues to shape societal relevant challenges related to urban quality of life and well-being. | | ● | ● | |
| | Test type | Portfolio | Presentation | Report | Report |
| | Weight of the test | 15 | 15 | 25 | 45 |
| | Individual or group test | Group | Group | Individual | Individual |
| | Type of marking | 1-10 | 1-10 | 1-10 | 1-10 |
| | Required minimum mark per test | | | | |
| | Number of test opportunities per academic year | 1 | 1 | 2 | 2 |

Learning Outcomes that are addressed in the test

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Describe the relevance and validity of selected qualitative and quantitative methods in the context of urban studies and planning. | ● | | | | | | | | | | | | |
| LO 2 | Apply qualitative, statistical, and GIS-based spatial analytical methods to detect and analyse intra-urban socio-spatial patterns. | ● | ● | | ● | | ● | | | | | | | |
| LO 3 | Analyse the intra-urban socio-spatial patterns in relation to current theoretical and empirical debates in urban studies and planning. | | | | | ● | ● | | | ● | | | | |
| LO 4 | Interpret results and relate these to policy implications. | | | | | | | | ● | ● | | | | |
| LO 5 | Identify a learning path to solve socially relevant challenges related to urban quality of life and well-being. | | | | | | | | ● | | ● | ● | ● | ● |
| LO 6 | Collaborate and communicate with inter and transdisciplinary colleagues to shape societal relevant challenges related to urban quality of life and well-being. | | | | | | | | ● | | ● | ● | ● | ● |

# LAND CHANGE MODELLING

| **Course** | **201900202** |
|---|---|
| Period | 24 April 2023 - 07 July 2023 |
| EC | 7 |
| Course coordinator | |

## INTRODUCTION

Land use / cover change processes in less developed countries are typically rapid and extensive, and they often include a considerable proportion of unplanned or informal development. Land use / cover change models can help to understand, analyse and simulate the outcomes of such processes, providing information that can inform policy development. This course develops the student's conceptual understanding of three methods for modelling land use / cover change and their ability to select, develop and apply these methods in an appropriate manner. The methods to be examined are: spatial logistic regression for identifying drivers of land use / cover change, Cellular Automata (CA) models and Agent Based Models (ABMs). The course commences with introductory lectures, readings and discussions on the field of land use / cover change modelling. The three methods will be introduced with an urban case study using the modelling platform NetLogo. In the group work phase, students can choose their own application case and apply in depth one of the methods.

## CONTENT

Land use modelling foundations: model purposes and underlying theories and assumptions;

Land use / cover change modelling approaches applied to urban case study:

- Spatial Logistic Regression
- CA model
- ABM

Critical reflection on different modelling approaches;

In-depth application of one modelling approach.

## TEACHING AND LEARNING APPROACH

Lectures and guest lecture, supervised practicals to introduce modelling methods and tools, group assignment using methods and tools introduced in practicals, self study, plenary discussions.

## TESTS

Summative:

- Written test
- Group report on in-depth application of one modelling approach

Since the group report requires a lot of practical work, the resit option is limited to a repair with a maximum mark of 6.

## ENTRY REQUIREMENTS

Knowledge of GIS and remote sensing at level of M-GEO Core, i.e. ability to independently apply GIS software and basic concepts of image classification;

Knowledge of basic statistical methods and tests (e.g. linear and logistic regression analysis).

### LEARNING OUTCOMES

Upon completion of this course, the student is able to:

- LO 1 Explain the theoretic foundations and assumptions of land use / cover change modelling approaches.
- LO 2 Relate the functional requirements for three modelling methods with available data and resources in a case study.
- LO 3 Apply one of three methods for modelling land use / cover change.
- LO 4 Critically reflect on model outcomes.
- LO 5 Propose, with justification, a suitable modelling approach for a given problem situation.

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| **Teaching / learning method** | **Hours** |
|---|---|
| Lecture | 24 |
| Supervised practical | 50 |
| Group assignment | 86 |
| Self-study | 36 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Learning Outcomes that are addressed in the test<br>Written test | <br>Group report |
|---|---|---|---|
| LO 1 | Explain the theoretic foundations and assumptions of land use / cover change modelling approaches. | ● | |
| LO 2 | Relate the functional requirements for three modelling methods with available data and resources in a case study. | ● | |
| LO 3 | Apply one of three methods for modelling land use / cover change. | | ● |
| LO 4 | Critically reflect on model outcomes. | | ● |
| LO 5 | Propose, with justification, a suitable modelling approach for a given problem situation. | ● | ● |
| | Test type | Written test | Report |
| | Weight of the test | 50 | 50 |
| | Individual or group test | Individual | Group |
| | Type of marking | 1-10 | 1-10 |
| | Required minimum mark per test | | |
| | Number of test opportunities per academic year | 2 | 2 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Explain the theoretic foundations and assumptions of land use / cover change modelling approaches. | ● | | ● | | | | | | | | | | |
| LO 2 | Relate the functional requirements for three modelling methods with available data and resources in a case study. | | ● | ● | ● | ● | | ● | ● | | | | | ● |
| LO 3 | Apply one of three methods for modelling land use / cover change. | | | | | ● | ● | | ● | ● | | | ● | |
| LO 4 | Critically reflect on model outcomes. | | | ● | | | ● | | | ● | | | | |

| | Learning outcomes (LO) of the course: The student will be able to... | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 5 | Propose, with justification, a suitable modelling approach for a given problem situation. | | ● | ● | | | ● | ● | | | | | | |

# LAND GOVERNANCE

| **Course** | **201800308** |
|---|---|
| Period | 24 April 2023 - 07 July 2023 |
| EC | 7 |
| Course coordinator | |

## INTRODUCTION

At the beginning of this course, governance in theory is introduced and different initiatives and tools promoting good governance are elaborated. There is a strong relationship between Land, Poverty and Governance. Subsequently, the characteristics of Good Land Governance are going to be introduced and relevant examples are going to be presented and explored. Comparative method is going to distinct effects from Good and Weak Land Governance. Specific attention in this course is put on the principles of good land governance; how were those principles developing through the last decades and their evaluation and assessment. International initiatives from FAO (Voluntary Guidelines on the Responsible Governance of Tenure - VGGT) and World Bank (Land Governance Assessment Framework – LGAF) are addressed from theoretical side and with practice implementation examples. Exercises and assignments with case studies from Africa, Asia and South-East Asia are going to enrich the theoretical framework of Land Governance course.

## CONTENT

- The concept of governance and its principles and reflection on human rights policies;
- Multi-level governance, regulatory governance and new public management;
- International initiatives (such as UN FAO, World Bank, UN-HABITAT, FIG, UT/ITC, etc.), paradigm and vision for land governance;
- Transparency and accountability, urban governance and various governance indicators;
- State land management, World Bank Land Governance Assessment Framework and FAO voluntary guidelines;
- The broader ethical issues to deal with corruption and enhance transparency; exploring and situating ethical dilemmas using real case studies in developing contexts;
- Key substantive issues and tools (i.e. assessment of transparency, access to land information, public participation, professional ethics and integrity, and institutional change to promote good land governance in the management and administration of land;
- Case studies and Scientific papers.

## TEACHING AND LEARNING APPROACH

- Active learning approach will be applied to the lectures with more theory
- Lectures are supported by PPT and references to reading material
- Assignment one and two have supporting reading materials and for this critical reading/writing abilities would be applied
- 1-2 Flip-classroom approach lectures will be applied. Flip-classroom approach is an education method which activates students by changing the roles teacher - student.

## TESTS

Individual assignment (ass.1): 10%
Group assignment (ass.2): 20%
Individual assignment (ass.3): 20%
Individual paper (ass. 3): 50%

## ENTRY REQUIREMENTS

Experience and understanding of basic Land Administration concepts and definitions.
Evaluate and apply basic principles of Good Governance to Good and Weak Land Governance.

### LEARNING OUTCOMES

Upon completion of this course, the student is able to:

LO 1 The student is able to describe various international initiatives and relevant tools for promoting good governance.

LO 2 Discuss and explain the relation between land, human rights, governance and e-governance.

LO 3 Evaluate relevant land governance issues and apply them in land management and land administration in building trust between public agencies and citizens.

LO 4 Apply relevant tools for good governance to reduce corruption in the relevant case study environment of Asian and African continents.

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 32 |
| Supervised practical | 20 |
| Tutorial | 4 |
| Written/oral test | 8 |
| Individual assignment | 48 |
| Group assignment | 28 |
| Self-study | 56 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Assignment 1 | Assignment 2 | Assignment 3 | Scientific Paper |
|---|---|---|---|---|---|
| | | Learning Outcomes that are addressed in the test | | | |
| LO 1 | The student is able to describe various international initiatives and relevant tools for promoting good governance. | ● | | | |
| LO 2 | Discuss and explain the relation between land, human rights, governance and e-governance. | | ● | | |
| LO 3 | Evaluate relevant land governance issues and apply them in land management and land administration in building trust between public agencies and citizens. | | | ● | ● |
| LO 4 | Apply relevant tools for good governance to reduce corruption in the relevant case study environment of Asian and African continents. | | | ● | ● |
| | Test type | Presentation | Presentation | Presentation | Paper |
| | Weight of the test | 10 | 20 | 20 | 50 |
| | Individual or group test | Individual | Group | Individual | Individual |
| | Type of marking | 1-10 | 1-10 | 1-10 | 1-10 |
| | Required minimum mark per test | | | | |
| | Number of test opportunities per academic year | 2 | 2 | 2 | 2 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | The student is able to describe various international initiatives and relevant tools for promoting good governance. | ● | ● | | ● | | ● | ● | ● | ● | | ● | ● | |
| LO 2 | Discuss and explain the relation between land, human rights, governance and e-governance. | | ● | | ● | | ● | ● | ● | | ● | | ● | |
| LO 3 | Evaluate relevant land governance issues and apply them in land management and land administration in building trust between public agencies and citizens. | | ● | | ● | | | ● | ● | | ● | ● | | |

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 4 | Apply relevant tools for good governance to reduce corruption in the relevant case study environment of Asian and African continents. | | ● | | ● | ● | ● | ● | ● | ● | | ● | | |

# LAND USE AND TRANSPORT INTERACTION (LUTI)

| **Course** | **201900138** |
|---|---|
| Period | 24 April 2023 - 07 July 2023 |
| EC | 7 |
| Course coordinator | |

## INTRODUCTION

The interaction between land use and transport is complex, multifaceted, and dynamic. Land use development influences transport-related decisions/behavior and transport decisions influence where, when, and how land development takes place.

In this course, key theories that underlie land use transport interaction are discussed, along with their modeling foundations. Special attention is given to spatial interaction theory, which is of relevance to the study of optimal service locations, accessibility analysis at various levels of detail, simulation, and forecasting, and can also be used to optimize and manage network throughput.

This course covers important modeling foundations of networks and spatial interaction as a basis for accessibility analysis in GIS.

Students will conduct a scenario study and examine the land use, mobility, and accessibility impacts of land use and transport policy strategies, using GIS-based land-use/transport interaction measures for the Netherlands.

The course will be offered to ITC students and CEM students as part of a joint-teaching collaboration between Faculties ITC (UPM) and ET (CEM). Please note that all elective courses at ITC are 7 EC, while the elective courses at ET are 5 EC.

## CONTENT

1. Introduction

- Urban and regional planning foundations, urban form, land use and transport interaction theory, spatial interaction theory
- Challenges of modeling interaction in urban and regional planning

2. Network geography

- Network geography and indicator development
- Multimodal network modeling

3. Transport Equity and accessibility

4. Accessibility modeling

- Various methods and approaches to accessibility modeling
- GIS application in accessibility modeling
- Case study on multimodal accessibility modeling

## TEACHING AND LEARNING APPROACH

Active participation, critical reflection, oral presentation. In addition to lectures and practical assignments, the learning of course concepts is complemented with paper discussion sessions, where students are expected to lead a paper discussion session, position their views about different research articles, and activate their peers with points for discussion. The staff act as observers.

## TESTS

7EC Course (ITC):

Test 1: 30% Critical review of a research article (Individual mark)

Test 2: 50% Written project report (Group mark)

Test 3: 20% Written reflection report linked to Test 2 (Individual mark)

5EC Course (ET):

Test 1: 40% Critical review of a research article (Individual mark)

Test 2: 60% Written project report (Group mark)

Type of marking: 1-10

## ENTRY REQUIREMENTS

Ability to independently apply GIS software. Knowledge of GIS at the level of ITC Core courses or higher is preferred. At Q1 a course on "GIS for transport" is offered to CEM students and exchange students as an introductory course to GIS.

## LEARNING OUTCOMES

Upon completion of this course, the student is able to:

LO 1 Explain the theoretical and modelling foundations of models in urban and regional planning and the role therein of networks and spatial interaction.

LO 2 Apply models for network analysis and accessibility analysis.

LO 3 Analyse and reflect on model outcomes using a real world case study.

LO 4 Describe the strengths and limitations of GIS in modelling networks and land use transport interaction.

## ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 18 |
| Supervised practical | 28 |
| Tutorial | 2 |
| Individual assignment | 22 |
| Group assignment | 98 |
| Self-study | 28 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Test 1 | Test 2 | Test 3 |
|---|---|---|---|---|
| | | Learning Outcomes that are addressed in the test | | |
| LO 1 | Explain the theoretical and modelling foundations of models in urban and regional planning and the role therein of networks and spatial interaction. | ● | | |
| LO 2 | Apply models for network analysis and accessibility analysis. | | ● | |
| LO 3 | Analyse and reflect on model outcomes using a real world case study. | | ● | |
| LO 4 | Describe the strengths and limitations of GIS in modelling networks and land use transport interaction. | | | |
| | Test type | Critical review of a research article | Report | Report |
| | Weight of the test | 30 | 50 | 20 |
| | Individual or group test | Individual | Group | Individual |
| | Type of marking | 1-10 | 1-10 | 1-10 |
| | Required minimum mark per test | 5.5 | 5.5 | |
| | Number of test opportunities per academic year | 2 | 1 | 1 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Explain the theoretical and modelling foundations of models in urban and regional planning and the role therein of networks and spatial interaction. | ● | | | | | | | ● | | ● | | ● | ● |
| LO 2 | Apply models for network analysis and accessibility analysis. | | ● | ● | ● | ● | | | ● | ● | | ● | | |
| LO 3 | Analyse and reflect on model outcomes using a real world case study. | | | | | | ● | ● | ● | | | | ● | |

| | Learning outcomes (LO) of the course: The student will be able to... | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 4 | Describe the strengths and limitations of GIS in modelling networks and land use transport interaction. | ● | ● | | | | | | ● | | | | ● | ● |

# LASER SCANNING

| **Course** | **201800310** |
|---|---|
| Period | 24 April 2023 - 07 July 2023 |
| EC | 7 |
| Course coordinator | |

## INTRODUCTION

Airborne, terrestrial and mobile laser scanning are modern technologies to acquire and monitor the geometry of the Earth's surface and objects above the surface like buildings, trees and road infrastructure. This course provides an overview on the state of the art of these techniques, potential applications, like digital terrain modelling and 3D city modelling, as well as methods to extract geo-information from the recorded point clouds.

## CONTENT

- Principles of airborne, terrestrial and mobile laser scanning
- Sensor and point cloud properties
- Point cloud registration, accuracy potential, error sources and correction methods, quality analysis
- Comparison to other data acquisition techniques
- Overview on various applications
- General point clouds processing: visualisation, segmentation, classification
- Digital terrain models: extraction of terrain points and break lines
- Detection and modelling: 3D building modelling, 3D landscape modelling, extraction of vegetation characteristics, change detection with multi-temporal and single epoch data for map updating

## TEACHING AND LEARNING APPROACH

Lectures, recorded mini-lectures, flipped classroom, supervised exercises, self-study. The lectures will focus on providing a first overview on the various topics as well as on the explanation of the more advanced point cloud processing methods. Not every topic will be addressed in the lectures. The students are expected to study five book chapters and selected articles independently. During the course several lecture hours will be used for discussion of the studied book chapter and articles.

## TESTS

In an individual assignment you will analyse a selected scientific paper related to laser scanning and orally report your findings. The result of this assignment counts for 20% of the course mark. The written test at the end of the course counts for the remaining 80%.

## ENTRY REQUIREMENTS

Completed Bachelor with some mathematics and physics. Basic remote sensing knowledge is an advantage, but not strictly required.

### LEARNING OUTCOMES

Upon completion of this course, the student is able to:

LO 1 Explain how to combine GNSS, IMU, and range finder measurements as well as relative sensor registration parameters to generate a point cloud.

LO 2 Assess the applicability of laser scanning and point cloud processing methods for various tasks, like surface reconstruction and 3D modelling.

LO 3 Design survey plans to acquire point clouds taking into account the accuracy and point density requirements.

LO 4 Evaluate the quality of laser scanning datasets.

LO 5 Determine and apply optimal point cloud processing methods to extract surface descriptions for geometric modelling and point cloud classification.

LO 6 Interpret and analyse point cloud processing results.

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 40 |
| Supervised practical | 12 |
| Written/oral test | 3 |
| Individual assignment | 16 |
| Self-study | 125 |

## TESTPLAN

| | | | |
|---|---|---|---|
| | | **Learning Outcomes that are addressed in the test** | |
| | **Learning outcomes (LO) of the course: The student will be able to...** | **Presentation** | **Written test** |
| LO 1 | Explain how to combine GNSS, IMU, and range finder measurements as well as relative sensor registration parameters to generate a point cloud. | | ● |
| LO 2 | Assess the applicability of laser scanning and point cloud processing methods for various tasks, like surface reconstruction and 3D modelling. | ● | ● |
| LO 3 | Design survey plans to acquire point clouds taking into account the accuracy and point density requirements. | | ● |
| LO 4 | Evaluate the quality of laser scanning datasets. | | ● |
| LO 5 | Determine and apply optimal point cloud processing methods to extract surface descriptions for geometric modelling and point cloud classification. | | ● |
| LO 6 | Interpret and analyse point cloud processing results. | ● | ● |
| | Test type | Presentation | Written test |
| | Weight of the test | 20 | 80 |
| | Individual or group test | Individual | Individual |
| | Type of marking | 1-10 | 1-10 |
| | Required minimum mark per test | | |
| | Number of test opportunities per academic year | 2 | 2 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Explain how to combine GNSS, IMU, and range finder measurements as well as relative sensor registration parameters to generate a point cloud. | ● | | | | | | | | | | | | ● |
| LO 2 | Assess the applicability of laser scanning and point cloud processing methods for various tasks, like surface reconstruction and 3D modelling. | | ● | | | | | ● | | | | | | ● |
| LO 3 | Design survey plans to acquire point clouds taking into account the accuracy and point density requirements. | | | | ● | | | | | | | | | |

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 4 | Evaluate the quality of laser scanning datasets. | | ● | | | | ● | ● | | | | | ● | |
| LO 5 | Determine and apply optimal point cloud processing methods to extract surface descriptions for geometric modelling and point cloud classification. | | ● | | ● | | ● | | | | | | | ● |
| LO 6 | Interpret and analyse point cloud processing results. | | ● | | ● | | ● | | | | | | ● | |

# LOCAL CLIMATE CHANGE PLANNING

| **Course** | **202001426** |
|---|---|
| Period | 14 November 2022 - 03 February 2023 |
| EC | 5 |
| Course coordinator | |

## INTRODUCTION

Climate Change is one of the greatest societal challenges of this century, as recently estimated by the nearly 1,000 experts interviewed for the World Risk Report. Urban areas are pivotal to global adaptation and mitigation efforts as cities are responsible for substantial amounts of greenhouse gases emissions and particularly vulnerable to climate hazards due to their high density of people, assets, and infrastructure. But how do cities currently perform? And, how can cities actually plan for successful climate change mitigation and adaptation?

**In this year we look at how cities across the world can integrate indigenous knowledge, information & land processes into the (more) formal Local Climate Change Planning procedures?**

This course shortly highlights the main processes and agreements of climate policy and governance at the global level (Paris Agreement, etc.) and then introduces in brief the theory and practice of Local Climate Change Planning. Students will study the information on indigenous knowledge in the two recently published IPCC reports and based on that choose 2 case studies as well as a topic within the broader topic of “western and indigenous knowledge integration”.

## CONTENT

Course Content

**Elective sub-topics/ learning chunks:**

1 International climate frameworks and agreements

2 International-national-local linkages

3 Indigenous knowledge in AR6 WGII report & presentation

4 Indigenous knowledge in AR6 WGIII report & presentation

5 Expert presentations

6 Case study work

**Concepts, theories, and frameworks [Literature]**

- International climate change efforts: UNFCCC and IPCC and their products (assessment reports, Special reports, etc.);
- International climate change goals and agreements: Paris Agreement, 2 degree goal, 1.5 degree goal;
- Translation of international goals to the national (as in the agreements) and local level: goals for adaptation;
- Local adaptation and mitigation planning
- Indigenous knowledge frameworks, processes, knowledge, systems, information.

**Methods and tools:**

- Policy evaluation regarding equity considerations of plans/ maladaptation/ malmitigation
- Literature review
- Policy evaluation

### TEACHING AND LEARNING APPROACH

The students will work in a project-oriented style on their topic and in their case studies. This can include literature research, questionnaires, interviews with related case study staff. The findings will be presented in a mid-term presentation and summarized in a final report. The main and broad goal of the course is to develop comparative information on a particular topic within the broader realm of "integrating western and indigenous knowledge systems in climate planning” in order to allow cities to learn from comparative cases and better plan for climate change in areas where western and indigenous knowledge systems and land collide. This can be based on best cases (or worse cases too).

This will include:

- Lectures,
- Written individual exam,
- Written individual assignment,
- Group report,
- Group presentation,
- Self-study.

### TESTS

- Written individual exam (1 time, 25%)
- Written individual assignment (1 times 20%)
- Group report  (40%)
- Group presentation (1 time, 15%)

### ENTRY REQUIREMENTS

No entry requirements.

### LEARNING OUTCOMES

Upon completion of this course, the student is able to:

| | |
|---|---|
| LO 1 | Be able to distinguish between and outline main elements of different international policy agreements related to climate change. |
| LO 2 | Be able to translate the international climate change goals to the national and the local level. |
| LO 3 | Be familiar with and able to discuss about common framework of local mitigation and adaptation planning. |
| LO 4 | Be able to identify elements related to indigenous knowledge in recent IPCC reports |
| LO 5 | Be able to analyse the quality of local climate action plans regarding their inclusion of indigenous knowledge alongside western knowledge |
| LO 6 | Be able to develop and suggest solutions regarding a better inclusion of indigenous knowledge in local climate plans in selected case studies |

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 15 |
| Supervised practical | 7 |
| Written/oral test | 3 |
| Individual assignment | 32 |
| Group assignment | 24 |
| Self-study | 59 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Individual assignment | Group presentation | Individual exam | Group report |
|---|---|---|---|---|---|
| | | Learning Outcomes that are addressed in the test | | | |
| LO 1 | Be able to distinguish between and outline main elements of different international policy agreements related to climate change. | | | ● | |
| LO 2 | Be able to translate the international climate change goals to the national and the local level. | | ● | ● | |
| LO 3 | Be familiar with and able to discuss about common framework of local mitigation and adaptation planning. | | ● | ● | ● |
| LO 4 | Be able to identify elements related to indigenous knowledge in recent IPCC reports | ● | | ● | ● |
| LO 5 | Be able to analyse the quality of local climate action plans regarding their inclusion of indigenous knowledge alongside western knowledge | | | | ● |
| LO 6 | Be able to develop and suggest solutions regarding a better inclusion of indigenous knowledge in local climate plans in selected case studies | | | | ● |
| | Test type | Written assignment | Presentation | Written test | Report |
| | Weight of the test | 20 | 15 | 25 | 40 |
| | Individual or group test | Individual | Group | Individual | Group |
| | Type of marking | 1-10 | 1-10 | 1-10 | 1-10 |
| | Required minimum mark per test | | | | |
| | Number of test opportunities per academic year | 1 | 1 | 1 | 1 |

RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Be able to distinguish between and outline main elements of different international policy agreements related to climate change. | ● | ● | | | | | | | | | | | |
| LO 2 | Be able to translate the international climate change goals to the national and the local level. | | ● | ● | | | | | | | | | | |

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 3 | Be familiar with and able to discuss about common framework of local mitigation and adaptation planning. | ● | ● | ● | | | | | | | | | | |
| LO 4 | Be able to identify elements related to indigenous knowledge in recent IPCC reports | | | | | ● | ● | ● | ● | | | | | ● |

| | Learning outcomes (LO) of the course: The student will be able to... | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 5 | Be able to analyse the quality of local climate action plans regarding their inclusion of indigenous knowledge alongside western knowledge | | | | | | ● | ● | ● | ● | ● | | | ● |
| LO 6 | Be able to develop and suggest solutions regarding a better inclusion of indigenous knowledge in local climate plans in selected case studies | | | | | | | | ● | ● | ● | ● | | ● |

# MODELLING MULTI-HAZARDS & RISK

| **Course** | **202001493** |
|---|---|
| Period | 05 September 2022 - 11 November 2022 |
| EC | 5 |
| Course coordinator | |

## INTRODUCTION

This course provides an advanced understanding in the assessment of dynamic risk for multi-hazards from hydro-meteorological and geological origin (e.g. landslides, floods, debris flows). This course presents approaches to evaluate how multi-hazard risk might change over time. Multi-hazard risk assessment (MHRA) is the quantitative estimation of the spatial distribution of potential losses for an area. These relate to multiple natural hazards with different hazard interactions, with multiple event probabilities, for multiple types of elements-at-risks, and multiple potential loss components. The course first discusses the various types of hazard interactions. An overview is given of the tools available for multi-hazard assessment, stressing the importance of developing integrated physically-based multi-hazard models. One of such models, OpenLISEM Hazard, is treated in detail, and the participants will get hands-on experience in the use of this integrated physically-based multi-hazard model, and the data requirements. After discussing problems involved in analyzing static MHR, the course addressed the analysis of changing multi-hazard risk as a basis for decision-making. These changes may be related to changes in triggering or conditional factors, increasing exposure of elements at risk, and their vulnerability and capacity. Dynamic risk can be evaluated in the long term because of changes in climate, land use, population density, economy, or social conditions. Changes in risk might also be occurring in a short time frame and assessed as a basis for Early Warning and impact based forecasting, and to analyze the consequences of hazard interactions after major events.

## CONTENT

The course teaches how to conduct quantitative multi-hazard modelling, and how this is used in risk assessment, how the risk components (hazards, elements-at-risk and vulnerability) can be obtained, and how risk information can be used in risk reduction planning.

The course will have two major components:

- **Modelling Multi-Hazards**. The first component of the course deals with the use of integrated, physically based models for analyzing multi-hazard interactions, for example, the hazard interaction that occur in mountainous areas during extreme rainfall (flashflood, landslides, debris flows). Users will learn how to work with OpenLISEM Hazard (h https://blog.utwente.nl/lisem/download/) The model includes interactions between rainfall-runoff processes, slope stability, slope failure, sediment and water mixture, entrainment, and deposits. Catchment-scale hydrology directly causes flooding and influences slope stability, failure and runout. Input data related to topography, soils, vegetation, and land use are provided as raster data. Rainfall data is given per time step for specific rainstorm events. The OpenLISEM tool can be used for both forecasting and assessing the hazard and risk of multi-hazards related to hydro-meteorological extremes. The OpenLISEM Hazard model is used in a final project to model multi-hazard in a case studies, and to re-model the hazard for the various risk reduction alternatives.

- **Analyzing Multi-Hazard Risk**. The main focus of the second half is on the quantitative analysis of risk, and how information on changing risk is used in decision making for disaster risk The methods are demonstrated using a tutorial dataset, and the risk assessment is carried out using GIS tools. The participants analyze economic and population risk and evaluate the risk level. Various risk reduction alternatives are defined, and updated hazard maps, assets information and vulnerability information reflecting the consequences of these alternatives are used to re-analyze the risk. Cost-benefit analysis is carried out to define which alternative is best and reviewed in a stakeholder workshop. Several possible future scenarios in terms of climate change, land-use change and population change are taken into account, and risk is calculated for various future years. Students design optimal combinations of alternatives & scenarios. Students will also learn how the methods can be integrated within a Spatial Decision Support System for analyzing risk dynamics

### TEACHING AND LEARNING APPROACH

The course will consist of:

- (Online) Interactive lectures, where an introduction is given to the various topics. The lectures will also be available later as videos. The course is given in hybrid mode, as an online course, as well as face-to-face in ITC.
- Supervised practical. These will be organized in ITC, and a supervisor will be present to give support. Online participants are guided through Canvas.
- Unsupervised practical. The students can work at ITC in the practical room, or decide to work at home.
- Reading assignments.
- Final projects. Both components of the course contain a final project, in which the students analyze a particular problem.
- Group assignments include a stakeholder simulation workshop, where students have to represent certain stakeholder

### TESTS

The learning outcomes will be tested in assignment format. There will be two assessments:

- Report on risk assessment tutorial (individual): 50 %
- Report on Hazard modelling project (individual): 50 %

### ENTRY REQUIREMENTS

This course is open for short-course participants and MSc students with an affinity with disaster risk reduction challenges, combined with experience with GIS and spatial data.

### LEARNING OUTCOMES

Upon completion of this course, the student is able to:

| | |
|---|---|
| LO 1 | Specify the data requirements for hazard and risk assessment, and evaluate how these might change over time. |
| LO 2 | Carry out physically-based hazard modelling, including the generation of the dataset, calibration and validation |
| LO 3 | Analyze changes in hazard interactions using a physically-based model |
| LO 4 | Carry out a spatial quantitative multi-hazard risk assessment |
| LO 5 | Analyze how different planning alternatives alter the hazard, exposure and risk and identify which are optimal from a stakeholder perspective |
| LO 6 | Analyze how hazard and risk may change over time due to climate change, land use change, population changes and other socio-economic changes |

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 24 |
| Supervised practical | 30 |
| Tutorial | 32 |
| Individual assignment | 30 |
| Self-study | 24 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Individual report | Group assignment |
|---|---|---|---|
| | | **Learning Outcomes that are addressed in the test** | |
| LO 1 | Specify the data requirements for hazard and risk assessment, and evaluate how these might change over time. | ● | ● |
| LO 2 | Carry out physically-based hazard modelling, including the generation of the dataset, calibration and validation | ● | |
| LO 3 | Analyze changes in hazard interactions using a physically-based model | ● | |
| LO 4 | Carry out a spatial quantitative multi-hazard risk assessment | | ● |
| LO 5 | Analyze how different planning alternatives alter the hazard, exposure and risk and identify which are optimal from a stakeholder perspective | | ● |
| LO 6 | Analyze how hazard and risk may change over time due to climate change, land use change, population changes and other socio-economic changes | | ● |
| | Test type | Report | Report |
| | Weight of the test | 50 | 50 |
| | Individual or group test | Individual | Individual |
| | Type of marking | 1-10 | 1-10 |
| | Required minimum mark per test | | |
| | Number of test opportunities per academic year | 2 | 2 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Specify the data requirements for hazard and risk assessment, and evaluate how these might change over time. | ● | ● | | | | | | | | | | | |
| LO 2 | Carry out physically-based hazard modelling, including the generation of the dataset, calibration and validation | ● | ● | ● | | | | ● | | | | | | |
| LO 3 | Analyze changes in hazard interactions using a physically-based model | | ● | ● | ● | | ● | | ● | | ● | ● | ● | |

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 4 | Carry out a spatial quantitative multi-hazard risk assessment | | ● | ● | ● | | ● | ● | ● | ● | ● | ● | ● | ● |
| LO 5 | Analyze how different planning alternatives alter the hazard, exposure and risk and identify which are optimal from a stakeholder perspective | | ● | ● | ● | | ● | ● | ● | ● | ● | ● | ● | ● |
| LO 6 | Analyze how hazard and risk may change over time due to climate change, land use change, population changes and other socio-economic changes | | ● | ● | ● | | ● | ● | ● | ● | ● | ● | ● | ● |

# PARTICIPATORY PLANNING 1: THEORY AND DEVELOPMENT OF PSS FOR DECISION ROOMS, WEB APPLICATIONS AND SERIOUS GAMES

| **Course** | **201900055** |
|---|---|
| Period | 05 September 2022 - 11 November 2022 |
| EC | 5 |
| Course coordinator | |

## INTRODUCTION

Spatial planning and decision-making processes occur in any domain, be it urban or rural areas, management of natural and water resources, distribution of welfare, wellbeing and risk, adaptation to climate change, or energy transition. They involve stakeholders in civil society, private sector, public administration and government, which hold different interests, norms, values, and knowledge as well as different practices and strategies of dealing with planning, decision-making and conflicts. Information and information systems do not capture the normative and collaborative/participative aspects of these processes whereas Planning Support Systems (PSS) and Spatial Decision Support Systems (SDSS) do.

You can either study theory and methods about (participatory) development of geo-technologies for participatory planning or theory and methods about the use of these technologies in planning and decision-making processes. This course is the first of two courses and addresses the former study. It focuses on theory, methods and technologies that participatory development of PSS and SDSS to support spatial planning and decision-making. The second course focuses on theory and methods of processes of participation and learning while using spatial information and moderation of PSS and SDSS in spatial planning and decision-making.

## CONTENT

- Theories and methods of PGIS, PSS and DSS, and serious gaming for same vs. different place and time planning and decision-making
- Participatory (co)design and development of PSS/SDSS for a decision room, web application, or a serious game
- Usability and usefulness of PSS and SDSS

## TEACHING AND LEARNING APPROACH

The approach is:

- Independently review resources offered and discuss them in groups or in class.
- Guidance by either introduction lectures to resources or discussion lectures.
- A project of designing and developing a PSS for decision rooms, a web application, or a serious game, considering resources offered as well as other resources relevant to students.
- A participatory game design
- Students can work on their research projects or work on a project offered by staff involved in the course
- The course provides technical facilities such as the ITC group decision room and server capacity for web application development.
- Example projects will illustrate the use of PGIS, decision rooms, (web-based) PSS, and serious games
- We avail of contacts with projects in which we partner, where MSc thesis projects and internships can be done, for instance in
    - The Ingenuity project Settlement Synergies in which a co-design takes place of a web application for spatial evaluation.
    - the Go Blue project on environmentally sustainable urban planning and development of the coastal region of Kenya.

### TESTS

- Conceptual design and prototype development (60%)
- Reflection document on conceptual design and prototype demonstrating mastery of concepts learned in this course (40%)

### ENTRY REQUIREMENTS

This course requires students from any university to have successfully completed the first year of their MSc degree including the GIS, geo-databases, and possibly Remote Sensing courses.

NOTE: The minimum number of participants is 8 students and the maximum number of students is 18 due to a co-design group assignment.

### LEARNING OUTCOMES

Upon completion of this course, the student is able to:

LO 1 Position their research in the theoretical context of PSS and DSS, technological environments for collaborative work, web-based geo-ICT for planning, and serious gaming.

LO 2 Conceptualize and (co-)design a PSS for decision rooms, a web application or serious game

LO 3 Technically implement a PSS for decision rooms, a web application or serious game to a prototype (up to Technology Readiness Level 4)

LO 4 Evaluate a PSS for decision rooms, a web application, or a serious game for applicability and usability.

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| **Teaching / learning method** | **Hours** |
|---|---|
| Lecture | 40 |
| Group assignment | 24 |
| Individual assignment | 60 |
| Written/oral test | 16 |
| | 0 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Conceptual design and prototype devt | Reflection document |
|---|---|---|---|
| | | **Learning Outcomes that are addressed in the test** | |
| LO 1 | Position their research in the theoretical context of PSS and DSS, technological environments for collaborative work, web-based geo-ICT for planning, and serious gaming. | | ● |
| LO 2 | Conceptualize and (co-)design a PSS for decision rooms, a web application or serious game | ● | |
| LO 3 | Technically implement a PSS for decision rooms, a web application or serious game to a prototype (up to Technology Readiness Level 4) | ● | |
| LO 4 | Evaluate a PSS for decision rooms, a web application, or a serious game for applicability and usability. | | ● |
| | Test type | Conceptual design and prototype development | Reflection document on conceptual design and prototype |
| | Weight of the test | 60 | 40 |
| | Individual or group test | Individual | Individual |
| | Type of marking | 1-10 | 1-10 |
| | Required minimum mark per test | | |
| | Number of test opportunities per academic year | 1 | 1 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Position their research in the theoretical context of PSS and DSS, technological environments for collaborative work, web-based geo-ICT for planning, and serious gaming. | ● | | | | | | ● | | ● | | | | |
| LO 2 | Conceptualize and (co-)design a PSS for decision rooms, a web application or serious game | | ● | ● | | | ● | ● | | ● | ● | | | |

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 3 | Technically implement a PSS for decision rooms, a web application or serious game to a prototype (up to Technology Readiness Level 4) | | | | ● | ● | | ● | | | ● | | | ● |
| LO 4 | Evaluate a PSS for decision rooms, a web application, or a serious game for applicability and usability. | | | | ● | | | ● | | | ● | | ● | ● |

# PARTICIPATORY PLANNING 2: THEORY AND APPLICATION OF, AND LEARNING FROM, PSS AND SERIOUS GAMES IN PLANNING AND DECISION PROCESSES

| **Course** | **201900056** |
|---|---|
| Period | 05 September 2022 - 11 November 2022 |
| EC | 5 |
| Course coordinator | |

## INTRODUCTION

Spatial planning and decision-making processes occur in any domain, be it urban or rural areas, management of natural and water resources, distribution of welfare, wellbeing and risk, adaptation to climate change, or energy transition. They involve stakeholders in civil society, private sector, public administration and government which hold different interests, norms, values and knowledge as well as different practices and strategies of dealing with planning, decision-making and conflicts. Information and information systems do not capture the normative and collaborative/participative aspects of these processes whereas Planning Support Systems (PSS) and Spatial Decision Support Systems (SDSS) do.

You can either study theory and methods about participatory development of geo-technologies for participatory planning or theory and methods about the use of these technologies in planning and decision-making processes. This course is the second of two courses and addresses the latter study. It focuses on theory and methods of processes of participation and learning in the generation of spatial information and moderation of PSS and SDSS in planning and decision-making. The first course focuses on the theory, methods and technologies fo the participatory development of PSS and SDSS that support spatial planning and decision-making.

## CONTENT

- Theories and methods of the practice of participatory GIS, planning and decision processes, conflict analysis and resolution, and learning.
- Use of geo-ICT technologies for same vs. different place and time planning and decision-making.
- Design and implementation of planning and decision processes
- Methods to study use of PSS and DSS in planning and decision-making processes.
- Social learning and knowledge co-production using geo-tools in participatory planning activities
- Task technology fit of PSS, task facilitation, Thinklets.
- Interpretive methods for researching institutionalization of participatory planning and decision methods and tools in existing processes.

## TEACHING AND LEARNING APPROACH

- Students will independently review the resources offered and discuss them in groups or in class.
- Guidance by either introduction lectures to resources or discussion lectures.
- A project of designing and developing a participatory planning process considering resources offered as well as other resources relevant to students.
- Students will take part in a spatial decision-making game to gain experience with the theory and methods learned.
- Students can work on their own research projects or work on a project offered by staff involved in the course.
- The course provides technical facilities such as the ITC group decision room and server capacity for web application development.
- Example projects will illustrate the use of PGIS, decision rooms, (web-based) PSS, and serious games.
- We avail of contacts with projects in which we partner, where MSc thesis projects and internships can be done, for instance in
    - The Ingenuity project Settlement Synergies in which collaborative planning support takes place with a web application for spatial evaluation.
    - the Go Blue project on environmentally sustainable urban planning and development of the coastal region of Kenya.

### TESTS

- Conceptual design and implementation of planning and decision process (60%)
- Reflection document on conceptual design and implementation of planning and decision process (40%)

### ENTRY REQUIREMENTS

This course requires students from any university to have successfully completed the first year of their MSc degree including the GIS, geo-databases, and possibly Remote Sensing courses.

NOTE: The minimum number of participants is 8 students and the maximum number of students is 18 due to a game of spatial decision-making.

### LEARNING OUTCOMES

Upon completion of this course, the student is able to:

LO 1 Position their research in the theoretical context of process design of Participatory GIS, conflict resolution, collaborative work and learning.

LO 2 Co-design participatory planning and decision processes for planning and research purposes.

LO 3 Moderate participatory planning and decision processes using spatial information tools.

LO 4 Learn to extract data from participatory planning and decision processes for planning and research purposes.

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 40 |
| Group assignment | 32 |
| Individual assignment | 52 |
| Written/oral test | 16 |
| | 0 |

## TESTPLAN

| | Learning Outcomes that are addressed in the test<br>Learning outcomes (LO) of the course: The student will be able to... | Conceptual design and implementation of planning and decision process | Reflection document on conceptual design and implementation of planning and decision process |
|---|---|---|---|
| LO 1 | Position their research in the theoretical context of process design of Participatory GIS, conflict resolution, collaborative work and learning. | | ● |
| LO 2 | Co-design participatory planning and decision processes for planning and research purposes. | ● | |
| LO 3 | Moderate participatory planning and decision processes using spatial information tools. | ● | |
| LO 4 | Learn to extract data from participatory planning and decision processes for planning and research purposes. | | ● |
| | Test type | Conceptual design and prototype development of process | Reflection on conceptual design and prototype of process |
| | Weight of the test | 60 | 40 |
| | Individual or group test | Individual | Individual |

| | Learning outcomes (LO) of the course: The student will be able to... | Learning Outcomes that are addressed in the test<br>Conceptual design and implementation of planning and decision process | Reflection document on conceptual design and implementation of planning and decision process |
|---|---|---|---|
| | Type of marking | 1-10 | 1-10 |
| | Required minimum mark per test | | |
| | Number of test opportunities per academic year | 1 | 1 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | Learning outcomes (LO) of the course: The student will be able to... | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Position their research in the theoretical context of process design of Participatory GIS, conflict resolution, collaborative work and learning. | ● | | | | | | ● | | ● | | | | |
| LO 2 | Co-design participatory planning and decision processes for planning and research purposes. | | ● | ● | | | ● | ● | | ● | ● | | | |
| LO 3 | Moderate participatory planning and decision processes using spatial information tools. | | | | ● | ● | | ● | ● | ● | | ● | ● | |

| | Learning outcomes (LO) of the course: The student will be able to... | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 4 | Learn to extract data from participatory planning and decision processes for planning and research purposes. | | ● | ● | ● | ● | ● | ● | ● | | ● | | | ● |

# PYTHON SOLUTIONS

| **Course** | **201900069** |
|---|---|
| Period | 14 November 2022 - 03 February 2023 |
| EC | 5 |
| Course coordinator | |

## INTRODUCTION

Standard geo-data processing can be done using standard functionality offered by standard software tools. But for the solving of complex spatial-temporal problems in earth and environmental research often the handling of (very) large and complex data sets is required. This typically asks for special geoprocessing solutions.

This course teaches students how to plan and carry out their own programming or scripting project, to support the processing, visualization and analysis of large and complex data sets in their MSc research phase. During the course, students will work on their own geoprocessing challenge, in their own application field and using their own research data

Emphasis is on scientific computing using the programming (and scripting) language Python. Depending on student interest, other modern programming languages may be considered as well. In a similar manner, tools for the design of Graphical User-Interfaces (GUI) will be considered, which will allow building interactive windows containing buttons, text boxes, graphs, maps etc.

Special attention will be given to available statistical and scientific packages for mathematics, science and engineering, such as array processing, linear algebra, regression, optimization, classification, clustering and machine learning.

The course intends to support individual students in programming solutions that they need during their MSc research. Therefore, certain flexibility is offered to students when to start the course.

## CONTENT

- Object-oriented programming using the Python programming language
- Scientific Computing and cloud computing
- Building graphical user-interfaces
- Add-on mathematical, scientific and engineering packages
- Case Study on a topic related to geoinformatics

## TEACHING AND LEARNING APPROACH

The course has an overall distance learning setup, supported by regular tutorial- and 'Question&Answer'-sessions. Students will spend most of the course on self-study of course materials and on individual project work. This project work will involve the planning, running and documenting of a scripting/programming assignment.

## TESTS

Course assessment is done on the basis of the results of the project assignment.

## ENTRY REQUIREMENTS

Open for students with basic programming skills and affinity with handling large spatial-temporal data sets.

GFM students are excluded from this course as GFM has its own courses in programming!

### LEARNING OUTCOMES

Upon completion of this course, the student is able to:

LO 1 Understand the principles of high-level programming.
LO 2 Plan a software project.
LO 3 Solve problems related to geo-information processing using programming.
LO 4 Break down a problem into engineering solutions.
LO 5 Create (interactive) solutions for real-world problems.
LO 6 Compare alternative approaches to programming solutions.

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Tutorial | 36 |
| Individual assignment | 40 |
| Self-study | 64 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Learning Outcomes that are addressed in the test: Project assignment |
|---|---|---|
| LO 1 | Understand the principles of high-level programming. | ● |
| LO 2 | Plan a software project. | ● |
| LO 3 | Solve problems related to geo-information processing using programming. | ● |
| LO 4 | Break down a problem into engineering solutions. | ● |
| LO 5 | Create (interactive) solutions for real-world problems. | ● |
| LO 6 | Compare alternative approaches to programming solutions. | ● |
| | Test type | Project |
| | Weight of the test | 100 |
| | Individual or group test | Individual |
| | Type of marking | 1-10 |
| | Required minimum mark per test | |
| | Number of test opportunities per academic year | 2 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Understand the principles of high-level programming. | ● | | | | ● | | | | | | | | ● |
| LO 2 | Plan a software project. | | ● | | | ● | | | | | | | | ● |
| LO 3 | Solve problems related to geo-information processing using programming. | | ● | | | | ● | | | | | | | ● |
| LO 4 | Break down a problem into engineering solutions. | | | ● | | | | ● | | | | | | ● |
| LO 5 | Create (interactive) solutions for real-world problems. | | | | ● | | | ● | ● | ● | | | ● | ● |
| LO 6 | Compare alternative approaches to programming solutions. | | | | | | | | | | | | ● | ● |

# QUANTITATIVE REMOTE SENSING OF VEGETATION PARAMETERS

| Course | 201900062 |
| --- | --- |
| Period | 05 September 2022 - 11 November 2022 |
| EC | 5 |
| Course coordinator | |

## INTRODUCTION

This course deals with the retrieval of quantitative information about vegetation canopies from remote sensing data. In particular, the focus will be on vegetation physiological parameters, namely leaf area index and phenology and how they can be estimated from remote sensing data.

Definitions and details about these parameters, how they are measured in the field, and how they are estimated using various remote sensing data will be provided during the course.

## CONTENT

The course has a remote sensing focus to model vegetation phenology and biophysical parameters like leaf area index. In addition to interactive lectures, students will be familiarised with lab and field measurements of these parameters and in the practical exercises, they will use multispectral and hyperspectral data to model and estimate these parameters.

In the first part (weeks 1-4), the course deals with the topic of biophysical parameter measurements in the lab/field and their estimations using remote sensing, various statistical approaches and inversion of radiative transfer models. The second part (weeks 5-8) will address the topic of phenology and calculation of phenological metrics by analyzing time-series remote sensing data. During a field visit (at the end of week 8) students will collect data and practice what they have learned earlier in the course. In the last two weeks of the course, students will work on their final assignment and will present it on the last day of the course.

## TEACHING AND LEARNING APPROACH

A series of lectures, tutorials in the forms of discussions and Q&A sessions, field and lab tutoring, supervised practicals, and the use of online and distance learning materials will be implemented.

## TESTS

Two sets of group assignments (each with 20% weight) and one individual final assignment (with 60% weight). The individual final assignment has a second test opportunity through repair with a maximum mark of 6.

## ENTRY REQUIREMENTS

GIS and remote sensing skills.

### LEARNING OUTCOMES

Upon completion of this course, the student is able to:

LO 1 To explain the spectral properties of vegetation and explain the use and role of vegetation physiological parameters in various applications for terrestrial ecosystems.
LO 2 To conduct field and laboratory measurements for several plant physiological parameters;
LO 3 To describe modelling approaches for estimation of plant physiological parameters using remote sensing data, including general statistical approaches (such as calculation of various vegetation indices), and inversion of simple radiative transfer models;
LO 4 To explain existing phenological analysis techniques and its relevance to a range of applications;
LO 5 To estimate phenological parameters, such as start- and end-of-season, from satellite image time series;
LO 6 To apply the learned techniques in an individual assignment related to the student's MSc thesis.

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| **Teaching / learning method** | **Hours** |
|---|---|
| Lecture | 26 |
| Supervised practical | 35 |
| Tutorial | 18 |
| Study trip | 7 |
| Written/oral test | 4 |
| Individual assignment | 24 |
| Self-study | 19 |
| Group assignment | 7 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Measurements biophysical parameters | Phenology | Individual Final Assignment |
|---|---|---|---|---|
| | | Learning Outcomes that are addressed in the test | | |
| LO 1 | To explain the spectral properties of vegetation and explain the use and role of vegetation physiological parameters in various applications for terrestrial ecosystems. | | | ● |
| LO 2 | To conduct field and laboratory measurements for several plant physiological parameters; | ● | | ● |
| LO 3 | To describe modelling approaches for estimation of plant physiological parameters using remote sensing data, including general statistical approaches (such as calculation of various vegetation indices), and inversion of simple radiative transfer models; | ● | | ● |
| LO 4 | To explain existing phenological analysis techniques and its relevance to a range of applications; | | ● | ● |
| LO 5 | To estimate phenological parameters, such as start- and end-of-season, from satellite image time series; | | ● | ● |
| LO 6 | To apply the learned techniques in an individual assignment related to the student's MSc thesis. | | | ● |
| | Test type | Group assignment | Group assignment | Individual assignment |
| | Weight of the test | 20 | 20 | 60 |
| | Individual or group test | Group | Group | Individual |
| | Type of marking | 1-10 | 1-10 | 1-10 |
| | Required minimum mark per test | | | |
| | Number of test opportunities per academic year | 2 | 2 | 1 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | To explain the spectral properties of vegetation and explain the use and role of vegetation physiological parameters in various applications for terrestrial ecosystems. | ● | ● | | | | | ● | | ● | | | ● | ● |
| LO 2 | To conduct field and laboratory measurements for several plant physiological parameters; | | | ● | ● | ● | | ● | | | ● | | ● | |

| | **Learning outcomes (LO) of the course: The student will be able to...** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 3 | To describe modelling approaches for estimation of plant physiological parameters using remote sensing data, including general statistical approaches (such as calculation of various vegetation indices), and inversion of simple radiative transfer models; | | | ● | ● | | | ● | | | | | ● | ● |
| LO 4 | To explain existing phenological analysis techniques and its relevance to a range of applications; | ● | | | | | | | | | | | | |

| | Learning outcomes (LO) of the course: The student will be able to... | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 5 | To estimate phenological parameters, such as start- and end-of-season, from satellite image time series; | | | ● | | | | ● | | | | | | ● |
| LO 6 | To apply the learned techniques in an individual assignment related to the student's MSc thesis. | ● | ● | ● | ● | ● | ● | ● | ● | ● | | ● | ● | ● |

# RADAR REMOTE SENSING

| **Course** | **201900058** |
|---|---|
| Period | 05 September 2022 - 11 November 2022 |
| EC | 5 |
| Course coordinator | |

### INTRODUCTION

Radar Remote Sensing is different from optical Remote Sensing and offers unique opportunities in observing and monitoring the Earth surface. This course provides an overview of technology and applications related to radar remote sensing. Specifically, Synthetic Aperture Radar (SAR) and advanced methods building on SAR are considered: InSAR (Interferometric Synthetic Aperture Radar), DInSAR (Differential InSAR), Time Series InSAR, PolSAR (Polarimetric SAR) and PolInSAR. The students will learn how to choose, handle and pre-process the SAR images and apply advanced methods for information extraction from these images. Various examples of applications will be provided. The quality of obtained results will be discussed in relation to the type of SAR data and choices made during the analysis. The course offers an opportunity to specialise in one of the advanced SAR methods during a practical project.

### CONTENT

1. General radar remote sensing
2. SAR (Synthetic Aperture Radar)
3. InSAR (Interferometric SAR) for elevation and deformation measurements
4. Time series InSAR and quality control
5. PolSAR (Polarimetric SAR) decomposition for characterisation of land cover
6. PolInSAR (Polarmetric InSAR) for forest and crop height and biomass measurements

### TEACHING AND LEARNING APPROACH

Lecture, flipped classroom, self-study, individual assignment, supervised practical and group assignment (oral presentation and individual report).

### TESTS

Individual assignments on:

1. Radar vs optical
2. Complex number analysis
3. Radar equation / radar cross section
4. Coherent/speckle

Group assignment on DEM / DSM / deformation / land cover classification

### ENTRY REQUIREMENTS

All students in the M-GEO GFM specialization are accepted.
Students following other specializations or programmes should have studied programming (Python, Matlab, or R) and basic image analysis knowledge.

### LEARNING OUTCOMES

Upon completion of this course, the student is able to:

LO 1 Explain the differences between microwave and optical remote sensing techniques.

LO 2 Explain main principles of SAR and InSAR techniques: speckle, radar cross section, coherence, phase unwrapping, interferogram and factors affecting the precision of its results, the principle of polarimetric filtering, decomposition, and polarimetric interferometry

LO 3 Make informed decision of radar sensor, image acquisition mode and image processing level for a specific study.

LO 4 Apply InSAR to generate elevation and ground deformation.

LO 5 Apply polarimetric SAR for target identification and land cover classification.

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 24 |
| Supervised practical | 18 |
| Written/oral test | 3 |
| Individual assignment | 15 |
| Group assignment | 27 |
| Self-study | 50 |
| Tutorial | 3 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Learning Outcomes that are addressed in the test: Individual Report | Individual Presentation |
|---|---|---|---|
| LO 1 | Explain the differences between microwave and optical remote sensing techniques. | ● | ● |
| LO 2 | Explain main principles of SAR and InSAR techniques: speckle, radar cross section, coherence, phase unwrapping, interferogram and factors affecting the precision of its results, the principle of polarimetric filtering, decomposition, and polarimetric interferometry | ● | ● |
| LO 3 | Make informed decision of radar sensor, image acquisition mode and image processing level for a specific study. | ● | ● |
| LO 4 | Apply InSAR to generate elevation and ground deformation. | ● | ● |
| LO 5 | Apply polarimetric SAR for target identification and land cover classification. | ● | ● |
| | Test type | Report | Presentation |
| | Weight of the test | 75 | 25 |
| | Individual or group test | Individual | Individual |
| | Type of marking | 1-10 | 1-10 |
| | Required minimum mark per test | | |
| | Number of test opportunities per academic year | 2 | 2 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Explain the differences between microwave and optical remote sensing techniques. | ● | ● | | ● | | ● | | | | ● | | | |
| LO 2 | Explain main principles of SAR and InSAR techniques: speckle, radar cross section, coherence, phase unwrapping, interferogram and factors affecting the precision of its results, the principle of polarimetric filtering, decomposition, and polarimetric interferometry | ● | ● | | ● | | ● | | | | ● | | | |

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 3 | Make informed decision of radar sensor, image acquisition mode and image processing level for a specific study. | ● | ● | | ● | | ● | | | | ● | | | |
| LO 4 | Apply InSAR to generate elevation and ground deformation. | ● | ● | | ● | | ● | | | | ● | | ● | |
| LO 5 | Apply polarimetric SAR for target identification and land cover classification. | ● | ● | | ● | | ● | | | | ● | | ● | |

# REMOTE SENSING AND MODELLING OF PRIMARY PRODUCTIVITY AND PLANT GROWTH

| **Course** | **201900051** |
|---|---|
| Period | 14 November 2022 - 03 February 2023 |
| EC | 5 |
| Course coordinator | |

## INTRODUCTION
Plants play a crucial role in the history of the Earth. They have accelerated the water cycle, and have made soil formation possible, and provide Oxygen through photosynthesis. They are also the primary sink of carbon dioxide, and they are our food.

Ongoing changes in climate affect the functioning of plants, but also vice versa: Land cover changes affect the surface properties of the Earth which in turn affect the climate. For sustainable land cover, ecology and food production, we must be able to quantify the role of plants in the climate on Earth.

This course offers tools to quantify processes in terrestrial vegetation using contemporary remote sensing signals (reflectance, chlorophyll fluorescence, and thermal remote sensing) in combination with in situ data. There is attention for natural ecosystems as well as crops.The following topics will be covered:

- Plant physiological processes and their relation with satellite data
- The use of radiative transfer models for scaling processes from the molecular to the satellite level
- The retrieval of plant functional traits from satellite data, in particular Sentinel 1,2,3, and 5 (Tropomi), and airborne data collected in the frame of the ESA's 8th Earth Explorer mission FLEX.
- The use of these data in dynamic vegetation model

The participants will work on their own mini-project, such as: the effect of companion planting, the water productivity or water footprint, the effect of volcano eruptions, re- or deforestation.

## CONTENT
Week 1 Photosynthesis and the energy balance of plants
Week 2 Scaling from the leaf to the satellite level
Week 3 Retrieval of data from a satellite sensor. Example of Sentinel-3
Week 4 Assimilation of remote sensing data in growth models for seasonal cycles
Week 5 Individual project

## TEACHING AND LEARNING APPROACH
Teaching takes place in an interactive setting. The course starts with a survey on the participants background and focus, followed by the setting of personal goals, which can be more specific than the overall learning objectives. The participants carry out a mini-project to answer a contemporary question related to the remote sensing of plants or crops. The question can be selected from a list on Canvas, or it can be an issue connected to the participant's MSc topic. A weekly lecture guides the participants through the learning objectives, followed by a practical exercise and a quiz (self-test). Other lectures are upon the participants request. A syllabus is provided with a summary of all background information. The content of the syllabus is also presented in Canvas, with links to other resources (web pages, models, data, articles).

## TESTS
- Online test (Canvas) (50%)
- Individual assignment report in Overleaf (50%)

## ENTRY REQUIREMENTS
basic knowledge on remote sensing.

## LEARNING OUTCOMES

Upon completion of this course, the student is able to:

LO 1 Describe the state-of-the-art of satellite models for the primary productivity.

LO 2 Apply plant physiological, radiative transfer and vegetation models for the scaling of processes from leaf to satellite levels.

LO 3 Identify and analyse opportunities for improvement of real time monitoring of vegetation health and functioning.

LO 4 Evaluate the outcome of primary productivity and vegetation growth models.

## ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 9 |
| Supervised practical | 16 |
| Tutorial | 6 |
| Written/oral test | 2 |
| Individual assignment | 45 |
| Self-study | 20 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Online test | Individual assignment |
|---|---|---|---|
| | | Learning Outcomes that are addressed in the test | |
| LO 1 | Describe the state-of-the-art of satellite models for the primary productivity. | ● | |
| LO 2 | Apply plant physiological, radiative transfer and vegetation models for the scaling of processes from leaf to satellite levels. | ● | |
| LO 3 | Identify and analyse opportunities for improvement of real time monitoring of vegetation health and functioning. | | ● |
| LO 4 | Evaluate the outcome of primary productivity and vegetation growth models. | | ● |
| | Test type | Digital test | Individual assignment |
| | Weight of the test | 50 | 50 |
| | Individual or group test | Individual | Individual |
| | Type of marking | 1-10 | 1-10 |
| | Required minimum mark per test | | |
| | Number of test opportunities per academic year | 2 | 1 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Describe the state-of-the-art of satellite models for the primary productivity. | ● | | | | | ● | ● | | | | | | ● |
| LO 2 | Apply plant physiological, radiative transfer and vegetation models for the scaling of processes from leaf to satellite levels. | | | ● | | ● | | | | | | | | ● |
| LO 3 | Identify and analyse opportunities for improvement of real time monitoring of vegetation health and functioning. | ● | ● | | | | ● | | | ● | | | | ● |

| | Learning outcomes (LO) of the course: The student will be able to... | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 4 | Evaluate the outcome of primary productivity and vegetation growth models. | | | ● | ● | | ● | | | | ● | ● | ● | ● |

# SCENE UNDERSTANDING WITH UNMANNED AERIAL VEHICLES

| **Course** | **201900061** |
|---|---|
| Period | 05 September 2022 - 11 November 2022 |
| EC | 5 |
| Course coordinator | |

## INTRODUCTION

Unmanned Aerial Vehicles (UAVs) are becoming a valid alternative to traditional Geomatics acquisition systems, as they close the gap between higher resolution terrestrial images and the lower resolution airborne and satellite data. UAVs can be remotely controlled helicopters, fixed wind airplanes or kites. This course deals with algorithms and techniques for scene information extraction from images. Both geometric (i.e. 3D reconstruction) and semantic (i.e. 2D image understanding) aspects are described in the course.

In this course the 2D and 3D scene analysis will be explained, with focus on the use of data acquired by UAVs. The course is composed of two main parts. In the first part, the participants will focus on 2D scene analysis (semantic segmentation, object detection and tracking, modern deep learning), while during the second part, the participants will gain hands-on experience on the use of UAVs. The second part of the course will be given together with the course on “Earth Observation with UAVs”.

At the end of the course the participants will submit the output of an assignment on the dealt topics, the quality of which will contribute to the course mark.

## CONTENT

1. The scene understanding algorithms: contour detection, semantic segmentation, object detection and tracking
2. State-of-the-art deep learning algorithms
3. Use of the commercial software to manage photogrammetric process
4. Analysis and evaluation of results generated by photogrammetric process using simple tools and the available ground truth
5. UAV image acquisition and processing for geo-information purposes
6. The use of UAVs in different domains: urban monitoring, disaster mapping, land administration, urban monitoring, food security.

## TEACHING AND LEARNING APPROACH

The course will be composed of lectures (with the use of flipped classrooms, or pre-recoreded videos when necessary), practical, assignments and/or fieldwork for UAV image acquisitions. The student will learn how to correctly process the acquired images receiving both the theoretical and practical knowledge and gaining in self-confidence and independence during the course.

## TESTS

- Oral test (60%)
- Group assignment (40%)

## ENTRY REQUIREMENTS

Specialization: Geoinformatics
Stream course: Image Analysis

Note that we offer two UAV courses and that students from other specialisations/outside ITC should choose the Earth Observation with UAVs course in principle.

In case of any doubt, the students can contact course coordinator for clarification.

### LEARNING OUTCOMES

Upon completion of this course, the student is able to:

- LO 1 Apply three semantic segmentation algorithms for UAV imagery.
- LO 2 Apply the learned IBM techniques using the proposed commercial software (pix4D) for UAV data.
- LO 3 Analyse and evaluate the geometric quality of the previously generated data using the two available tools (GNUplot and CloudCompare).
- LO 4 Design two state-of-the-art object detection algorithms for processing given UAV imagery.
- LO 5 Describe the typical UAV data acquisition procedure and data processing for 3D geo-information purposes, understanding the technical decisions usually adopted in real practical cases.
- LO 6 Identify the major pros and cons of the use of UAVs upon the gained experience and relate them with the five different domains.

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 30 |
| Supervised practical | 16 |
| Tutorial | 6 |
| Written/oral test | 3 |
| Individual assignment | 50 |
| Self-study | 35 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Oral test | Group assignment |
|---|---|---|---|
| | | **Learning Outcomes that are addressed in the test** | |
| LO 1 | Apply three semantic segmentation algorithms for UAV imagery. | ● | |
| LO 2 | Apply the learned IBM techniques using the proposed commercial software (pix4D) for UAV data. | | ● |
| LO 3 | Analyse and evaluate the geometric quality of the previously generated data using the two available tools (GNUplot and CloudCompare). | | ● |
| LO 4 | Design two state-of-the-art object detection algorithms for processing given UAV imagery. | ● | |
| LO 5 | Describe the typical UAV data acquisition procedure and data processing for 3D geo-information purposes, understanding the technical decisions usually adopted in real practical cases. | ● | |
| LO 6 | Identify the major pros and cons of the use of UAVs upon the gained experience and relate them with the five different domains. | ● | |
| | Test type | Oral test | group assignment |
| | Weight of the test | 60 | 40 |
| | Individual or group test | Individual | Group |
| | Type of marking | 1-10 | 1-10 |
| | Required minimum mark per test | | |
| | Number of test opportunities per academic year | 2 | 2 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Apply three semantic segmentation algorithms for UAV imagery. | ● | | | | | | | | | | | | |
| LO 2 | Apply the learned IBM techniques using the proposed commercial software (pix4D) for UAV data. | | | ● | | ● | | | | | | | | |
| LO 3 | Analyse and evaluate the geometric quality of the previously generated data using the two available tools (GNUplot and CloudCompare). | | ● | | ● | | | | | | | | | |
| LO 4 | Design two state-of-the-art object detection algorithms for processing given UAV imagery. | | ● | | | | ● | | | | | | | |

| **Learning outcomes (LO) of the course: The student will be able to...** | | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 5 | Describe the typical UAV data acquisition procedure and data processing for 3D geo-information purposes, understanding the technical decisions usually adopted in real practical cases. | ● | | | | | | | ● | | | | | |
| LO 6 | Identify the major pros and cons of the use of UAVs upon the gained experience and relate them with the five different domains. | | ● | | | | | | | ● | | ● | | ● |

# SPACE FOR ETHICS

| **Course** | **201900090** |
|---|---|
| Period | 14 November 2022 - 03 February 2023 |
| EC | 5 |
| Course coordinator | |

### INTRODUCTION
Geodata ethics is becoming an ever more important topic in the field of geo-information science and earth observation. As information and communication technologies advance and everybody can be connected to everybody the volume, velocity, variety veracity and value of available data keeps on increasing. At the same time approaches to getting and linking data are evolving and more detailed models and approaches to studying spatial phenomena become feasible. But does feasibility also mean that we *should* build and implement all new geo-spatial data technologies? How invasive should we allow geo-data technologies to be? What ethical principles and moral considerations should guide how we build and assess technological innovations? What kinds of innovations might we need to counter the risks that an ever more datafied society brings with it? Answering these questions is not easy but more important than ever: It is high time that we secure a *Space for Ethics!*

In this course, we will cover some (but by no means all) current debates surrounding geodata technology ethics. Possible foci will be location privacy and machine learning (or AI) ethics. Information about an individual’s location is substantially different from other kinds of personally or demographically identifiable information which makes privacy a hot topic. We are also witnessing the increasing automation of geospatial processes. This will require astute engagement with Geo-AI ethics as regulation and debates on the topic are bound to increase in the coming decades. Students will engage with and sharpen their critical thinking and transdisciplinary competences in this course.

### CONTENT
- Examples of moral and ethical dilemmas in decision making for wicked geo-data policy problems
- The trajectory of privacy as a concept across time and space
- Basics of applied AI Ethics
- Political and ethical Dimensions of data and maps
- Examples of privacy-safeguarding strategies
- Multi-stakeholder character of geodata technology ethics

### TEACHING AND LEARNING APPROACH
The course is revolving around the moderated discussion of selected literature, key (guest) lectures on geodata and ai ethics. The focus is on debating geoprivacy, cartographic ethics and broader concerns in geodata technology ethics with academic peers.

### TESTS

1. Presentation (50%)
2. Short Essays (50%)

### ENTRY REQUIREMENTS
There are no specific entry requirements for this course, but students should be open to engaging in critical thinking about the development and use of geodata technologies. The course is open to both MSc and PhD students.

### LEARNING OUTCOMES

Upon completion of this course, the student is able to:

LO 1 Recognise issues with the ethical use of geo-spatial data
LO 2 Distinguish between moral and ethical dilemmas in decision-making
LO 3 Explain how the meaning of privacy (and/or other geodata-ethics principles), changes over time and is fiercely contested among different social groups
LO 4 Comment on current debates in the ethics of machine learning and artificial intelligence and how they relate to geospatial innovations
LO 5 Conceptualize information privacy (and/or other geodata-ethics principles) as an aspect of human relations.
LO 6 Distinguish between existing privacy-safeguarding strategies

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 12 |
| Tutorial | 12 |
| Written/oral test | 4 |
| Individual assignment | 36 |
| Group assignment | 36 |
| Self-study | 40 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Presentation | Written test |
|---|---|---|---|
| | | **Learning Outcomes that are addressed in the test** | |
| LO 1 | Recognise issues with the ethical use of geo-spatial data | ● | ● |
| LO 2 | Distinguish between moral and ethical dilemmas in decision-making | ● | |
| LO 3 | Explain how the meaning of privacy (and/or other geodata-ethics principles), changes over time and is fiercely contested among different social groups | ● | |
| LO 4 | Comment on current debates in the ethics of machine learning and artificial intelligence and how they relate to geospatial innovations | ● | |
| LO 5 | Conceptualize information privacy (and/or other geodata-ethics principles) as an aspect of human relations. | ● | ● |
| LO 6 | Distinguish between existing privacy-safeguarding strategies | | ● |
| | Test type | Presentation | Written test |
| | Weight of the test | 50 | 50 |
| | Individual or group test | Individual | Individual |
| | Type of marking | 1-10 | 1-10 |
| | Required minimum mark per test | | |
| | Number of test opportunities per academic year | 2 | 2 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Recognise issues with the ethical use of geo-spatial data | ● | ● | | | ● | | | | | | | | |
| LO 2 | Distinguish between moral and ethical dilemmas in decision-making | | | | | | | | | ● | | | ● | |
| LO 3 | Explain how the meaning of privacy (and/or other geodata-ethics principles), changes over time and is fiercely contested among different social groups | | | | | | | ● | ● | ● | ● | ● | | |

| Learning outcomes (LO) of the course: The student will be able to... | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 4 | Comment on current debates in the ethics of machine learning and artificial intelligence and how they relate to geospatial innovations | | | | | | ● | | | ● | ● | | ● | |
| LO 5 | Conceptualize information privacy (and/or other geodata-ethics principles) as an aspect of human relations. | | | | | ● | | | | ● | ● | ● | ● | |
| LO 6 | Distinguish between existing privacy-safeguarding strategies | | | | | ● | | | | ● | | | | |

# SPATIAL ANALYSES OF ECOSYSTEM SERVICES: NATURE'S BENEFITS TO PEOPLE

| **Course** | **201900057** |
|---|---|
| Period | 05 September 2022 - 11 November 2022 |
| EC | 5 |
| Course coordinator | |

## INTRODUCTION

This elective is given by NRM, UPM and GFM staff.

Ecosystem services i.e., the contributions of nature to human well-being, are increasingly used to describe human-nature interactions in an inclusive way. The ecosystem services concept addresses management objectives that go beyond natural resources or human practices alone, as it focuses on the interactions between nature and society. Geo-information (from earth observation, citizen science, to existing GIS maps) is inherent to ecosystem service assessments since the supply (from ecosystems) and demand (from society) for ecosystem services are spatially explicit. Understanding the ecosystem service concept, selecting and using mapping methods for specific management objectives is therefore essential for incorporating human-nature interactions into environmental management from cities to rural areas and hence the key objective of this course. Managing natural resources in a sustainable way by taking into account human well-being is also at the core of the Sustainable Development Goals as set by the United Nations. After completing this course, the student will have obtained knowledge in the theoretical aspects of the concept of ecosystem services. The student will also be able to select and apply mapping methods and data for ecosystem service assessments on real-life applications in the context of diverse management objectives.

## CONTENT

Knowledge, methods, skills, approaches that the students will learn:

1. Human-nature relation concepts: Scientific concepts over time, terminology of ecosystem services, Natural Capital, Nature-based Solutions, Green/Blue Infrastructure
2. Ecosystem service classifications
3. Concepts of ecosystem service supply, use, demand, and value
4. Decision-making frameworks and (geo-) information needs
5. Decision-making & mapping challenges in urban and rural systems
6. Ecosystem service quantification and valuation approaches: social, economic and ecological measures, interactions, relevance.
7. Ecosystem service mapping methods/tools/software: based on GIS, Remote Sensing, Participatory GIS/social media data and their analysis
8. Ecosystem service data: requirements, sources, challenges
9. Comparing and contrasting ecosystem service mapping methods for decision-making challenges

## TEACHING AND LEARNING APPROACH

Concept, theories, models are introduced to the student with lectures. The lectures followed by (un)supervised practicals to gain hands-one experience. A day is closed with plenary question-and-answer and discussion sessions to share thoughts, insights and doubts. To gain and practice professional implementation of course topic a guest lecture is given by a practitioner, we go outside, and students will solve a real-life challenge. There is a lot of time for self-study to read and do the exercises, informal quizzes, and the assignment.

### TESTS
Summative:

- Digital written test (including questions on hypothetical cases and tool selection) (50%)
- Group assignment report (50%).

Formative: after each teaching activity in the form of quizzes and reporting on exercises.

Students can only do a repair for the group assignment.

### ENTRY REQUIREMENTS
ITC-M-GEO students: Completion of core courses; strong interest in interdisciplinary work
Other students: Able to independently use GIS software; strong interest in interdisciplinary work

### LEARNING OUTCOMES
Upon completion of this course, the student is able to:

LO 1 Summarise the history, explain the definitions and types of classification of ecosystem services.
LO 2 Distinguish ecosystem service supply, use, demand and value.
LO 3 Interpret ecosystem service information for diverse decision-making objectives in different systems (urban and rural).
LO 4 Use data and tools for ecosystem service mapping for one case study application
LO 5 Evaluate and select tools for ecosystem service mapping for selected decision-making objectives.
LO 6 Formulate opportunities and challenges of geo-information on ecosystem services for resource management and planning.

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 20 |
| Supervised practical | 18 |
| Tutorial | 11 |
| Study trip | 4 |
| Written/oral test | 2 |
| Group assignment | 43 |
| Self-study | 42 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Digital test | Written report |
|---|---|---|---|
| | | **Learning Outcomes that are addressed in the test** | |
| LO 1 | Summarise the history, explain the definitions and types of classification of ecosystem services. | ● | |
| LO 2 | Distinguish ecosystem service supply, use, demand and value. | ● | |
| LO 3 | Interpret ecosystem service information for diverse decision-making objectives in different systems (urban and rural). | | ● |
| LO 4 | Use data and tools for ecosystem service mapping for one case study application | | ● |
| LO 5 | Evaluate and select tools for ecosystem service mapping for selected decision-making objectives. | ● | ● |
| LO 6 | Formulate opportunities and challenges of geo-information on ecosystem services for resource management and planning. | ● | ● |
| | Test type | Digital test | Report |
| | Weight of the test | 50 | 50 |
| | Individual or group test | Individual | Group |
| | Type of marking | 1-10 | 1-10 |
| | Required minimum mark per test | | |
| | Number of test opportunities per academic year | 2 | 1 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Summarise the history, explain the definitions and types of classification of ecosystem services. | ● | | | | | | | | | | | | |
| LO 2 | Distinguish ecosystem service supply, use, demand and value. | ● | | | | | | | | | | | | |
| LO 3 | Interpret ecosystem service information for diverse decision-making objectives in different systems (urban and rural). | | ● | | ● | | ● | ● | ● | | | ● | | ● |

| Learning outcomes (LO) of the course: The student will be able to... | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 4 | Use data and tools for ecosystem service mapping for one case study application | | ● | ● | ● | | ● | | | ● | | | ● | |
| LO 5 | Evaluate and select tools for ecosystem service mapping for selected decision-making objectives. | | | | | | ● | | | ● | | ● | ● | |
| LO 6 | Formulate opportunities and challenges of geo-information on ecosystem services for resource management and planning. | ● | | | | | | | | | | | | |

# SPATIO-TEMPORAL ANALYSIS OF REMOTE SENSING DATA FOR FOOD AND WATER SECURITY

| **Course** | **201800311** |
|---|---|
| Period | 24 April 2023 - 07 July 2023 |
| EC | 7 |
| Course coordinator | |

## INTRODUCTION

How will we meet the challenge of producing more food to feed a growing population while sustaining the natural resources that agriculture depends upon? Achieving this requires informed decision making, which will heavily depend upon spatial and temporal information derived through the use of remotely sensed data-streams.

This course provides students with the skills to select, use and interpret state of the art hyper-temporal remote sensing imagery, including both optical and SAR sensors. These skills will be applied to map, monitor, evaluate and explain the performance of the agro-ecosystems. Hyper-temporal remote sensing is also applicable for monitoring urban and natural environments, and to study/assess processes related to e.g. bio-diversity and disasters.

Students will learn when to use and how to process hyper-temporal remote sensing images (SPOT-Vegetation, MODIS, PROBA-V, Sentinel-1, 2, and 3, etc.), data mining and probability techniques to:

- map and monitor different aspects of agro-ecosystems using remote sensing indices such as NDVI, LSWI and LAI, to address e.g. “what food or feed crops are produced where and when?”
- detect anomalies and/or changes in land use and land cover over time, to address e.g. “where are changes in crop production happening and why?”
- feed into early warning systems by detecting anomalies in vegetation, temperature, precipitation and soil moisture, to address e.g. “where and when do droughts, floods, heat/cold waves, fires and pest and diseases affect agriculture?”

After completing this course, the student will have an additional/improved skill-set as required for a wide range of specialized advisory work, like:

- Preparation of inventories for land cover and land use mapping.
- Creation of maps and legends with info on crop calendars and crop management practiced, plus an analysis on production constraints and impacts by perils (yield gaps).
- Providing timely and accurate spatial information that feeds into early warning systems and index based insurance programs.
- Quantified yield gap assessments for land use planning, specifications of advice for extension services, work agenda specifications by research stations, and policy-making considerations.

#### CONTENT

- Introduction to the themes of food and water security, and existing approaches with remote sensing time series to contribute to its analysis.
- Primers on:

1. Contemporary indices in use to monitor agro-ecosystems: their purpose, basics and value.
2. Timescales of indices versus the availability of (hyper-temporal) imagery (SPOT-VGT, MODIS, MeteoSat, Proba-V, Sentinel, etc.)
3. Monitoring Vegetation from Space (eLearning: http://www.eumetrain.org/data/3/36/index.htm)
4. Value of index-based findings versus agro-ecological realities.
5. Practical: Tools to display (also in 3D) time-series data using Ilwis, nVis, etc.
6. EUMETCast and Geonetcast 'primers', with references to 52North manuals and reference materials.
7. Platforms (cloud-based) and tools/algorithms to (pre-) process space-time cube data.

- Skills in obtaining, pre-processing, documenting (metadata), and displaying required time-series of imagery and indices (tool-skills), with advanced individual tasks for experienced users.
- Skills and critical expert decisions needed to optimize spatial-temporal clustering of hyper-temporal data (data-reduction versus info-extraction approaches).
- Agro-ecology versus prepared stratification: map-comparisons, data tabulations, sample schemes, data-mining, etc.
- Anomaly/change detection methods and interpretation issues with discussions on new developments (partly eLearning).

#### TEACHING AND LEARNING APPROACH

The course gradually changes from acquiring a general overview of the use/functionality of RS-imagery (spatial-temporal) to address food/water security aspects, to commonly used indices to monitor and assess that, and to tools and skills developments to obtain-extract-derive-interpret specific spatial-temporal data. It concludes with an individual self-defined task. That task will be assessed. The task must connect to the participant's interests, to a food/water security issue, and to a probable MSc research topic that the participant contemplates pursuing. Ideally, the task consists of prior academic/analytical work as required to underpin an MSc-research proposal.

#### TESTS

The assessment will be based on a submitted written paper (DOCX) describing the approved personal task plus the achieved results. The task will be specified on the basis of the student’s individual academic interests [100% student centered]. The content and result of this individual task must be derived from guidance as provided by lectures, practicals, and individual discussions with staff. Elements of this DOCX that will be critically assessed are:

1. [25 points]. Description of the Food/Water security issue/case selected versus the selection of the required RS-based indicator (plus why?). The issue/case must preferably relate to the MSc topic selected or under consideration by the participant.
2. [25 points]. Select the source to collect the needed RS-based indicator data from; describe/capture/discuss the metadata; download data of the relevant period/area-window, import the data, carry out / describe / discuss required pre-processing steps.
3. [25 points]. Classify/cluster/stratify the data as required. Add the implemented annotated flowchart and discuss decision moments encountered (options chosen). Provide the intermediate results.
4. [25 points]. Describe how the results link to follow-up work / studies, like e.g. sample scheme, data integration plan, hypothesis test, etc. as included/mentioned/suggested in the approved personal task. Include any/all assumptions made.

Upon submitting the DOCX, all students and selected staff will hold a "Present and Defend" session to inform the whole class on specific individual achievements and merits, and to discuss specific analytical outcomes of work carried out (strengths and remaining weaknesses). In case a resit is required, the participant is requested to edit/improve the earlier submitted work, and to verbally defend those edits.

#### ENTRY REQUIREMENTS

All participants must have passed successfully both M-GEO core-modules (RS and GIS), or do possess an equal level RS/GIS skills and knowledge.

### LEARNING OUTCOMES

Upon completion of this course, the student is able to:

LO 1 explain how agro-ecosystems may be mapped and monitored using a selection of hyper-temporal RS-based indices related to vegetation greenness and vigour, evapotranspiration, and rainfall.

LO 2 obtain and pre-process image time series of selected indices, and evaluate how to incorporate their metadata in the pre-processing chain.

LO 3 use the pre-processed imagery to design and implement a flowchart to create an agro-environmental stratification, that is optimized for a specified purpose.

LO 4 identify and evaluate impacts of choices made during the design of the flowchart.

LO 5 create, document, and defend, a “ready-to-go” spatial-temporal stratification and dataset that underpins the individual Agro-Ecosystems related research interests of the participant.

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 25 |
| Supervised practical | 20 |
| Tutorial | 16 |
| Individual assignment | 50 |
| Group assignment | 24 |
| Self-study | 61 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Learning Outcomes that are addressed in the test<br>Test 1 |
|---|---|---|
| LO 1 | explain how agro-ecosystems may be mapped and monitored using a selection of hyper-temporal RS-based indices related to vegetation greenness and vigour, evapotranspiration, and rainfall. | ● |
| LO 2 | obtain and pre-process image time series of selected indices, and evaluate how to incorporate their metadata in the pre-processing chain. | ● |
| LO 3 | use the pre-processed imagery to design and implement a flowchart to create an agro-environmental stratification, that is optimized for a specified purpose. | ● |
| LO 4 | identify and evaluate impacts of choices made during the design of the flowchart. | ● |
| LO 5 | create, document, and defend, a “ready-to-go” spatial-temporal stratification and dataset that underpins the individual Agro-Ecosystems related research interests of the participant. | ● |
| | Test type | Paper |
| | Weight of the test | 100 |
| | Individual or group test | Individual |
| | Type of marking | 1-10 |
| | Required minimum mark per test | |
| | Number of test opportunities per academic year | 1 |

RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | explain how agro-ecosystems may be mapped and monitored using a selection of hyper-temporal RS-based indices related to vegetation greenness and vigour, evapotranspiration, and rainfall. | ● | ● | | | | | | ● | | | | | |
| LO 2 | obtain and pre-process image time series of selected indices, and evaluate how to incorporate their metadata in the pre-processing chain. | | | ● | | | | | | | | | | |
| LO 3 | use the pre-processed imagery to design and implement a flowchart to create an agro-environmental stratification, that is optimized for a specified purpose. | | | | ● | | | | | | | | | |

| | Learning outcomes (LO) of the course: The student will be able to... | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 4 | identify and evaluate impacts of choices made during the design of the flowchart. | | | | | | ● | ● | | | | | | |
| LO 5 | create, document, and defend, a “ready-to-go” spatial-temporal stratification and dataset that underpins the individual Agro-Ecosystems related research interests of the participant. | ● | ● | ● | ● | ● | ● | ● | ● | ● | | | | |

# SPATIO-TEMPORAL ANALYTICS AND MODELLING

| **Course** | **201800314** |
|---|---|
| Period | 25 April 2022 - 07 July 2023 |
| EC | 7 |
| Course coordinator | |

## INTRODUCTION

Processes relevant to system Earth, whether natural or man-affected, commonly display variations in space and over time, yet our understanding of their behavior remains limited. The increase in available monitoring data provides handles for a detailed study of these processes. Unravelling the way these processes function and having a mechanism to test hypotheses as well as the possible impacts of interventions is key to contribute to more sustainable development. At course end, the student will have learnt to make use of the available data in process studies, by a variety of computational techniques.

In this course, we present various geo-computational approaches that help to improve our understanding of geographic processes and/or to extract actionable geo-information. Special attention will be paid to agent-based modelling and to data mining and machine learning analytical methods, and to the integration of different methods.

Agent-based models (ABMs) provide the opportunity to consider both natural and social components when modelling geographic phenomena.
Data mining and machine learning methods allow innovative uses of heterogeneous datasets and have proven their value to solving a variety of social, environmental and scientific problems that were deemed wicked or, even, intractable. Cloud computing is revolutionizing the way we perform spatiotemporal analysis. It allows scaling up our work and designing robust applications for real-life problems.

## CONTENT

- Introduction to spatiotemporal modelling
- Principles of geo-computation, with emphasis on agent-based modelling (ABM), data mining and machine learning methods for spatiotemporal applications
- Use of UML, pattern-oriented modelling (POM) and of the ODD protocol to design an ABM model
- Construction of ABMs and ML models for spatiotemporal applications
- Analysis of spatiotemporal data using data mining and machine learning methods (clustering, classification and regression tasks)
- Integration of ABM, data mining and machine learning methods
- Introduction to cloud computing
- Introduction to critical thinking, with emphasis on the identification of innovation and societal relevance of problems and solutions

## TEACHING AND LEARNING APPROACH

During this course, students create a model in a step-by-step way. This model will be further developed and enhanced with additional functionality (using different geo-computational methods) throughout this course.
There is a strong emphasis on critical reflection (via sensitivity analyses, model verification, validation of models) and comparison of geo-computational techniques. The student is encouraged to identify the innovative parts of analysis and models.

### TESTS
The student will be evaluated based on a project (report and presentation). Students will provide feedback on each other's assignments (peer review). The students will also be evaluated via an open book test.

The weights of each element as are follows:

- Project 45%
- Peer review 5%
- Presentation 5%
- Test 45%

A resit is possible for the examination only.

### ENTRY REQUIREMENTS
Basic understanding of programming (e.g. Python) is recommended. Students that do not have any experience in programming are recommended to contact the course coordinator.

### LEARNING OUTCOMES
Upon completion of this course, the student is able to:

LO 1 Discuss the main modelling paradigms.
LO 2 Design a conceptual model for a spatio-temporal ABM using UML and the ODD protocol.
LO 3 Implement a basic ABM model, and calibrate this model using behavioural space.
LO 4 Explain to peers the main advantages and limitations of using geo-computational methods.
LO 5 Choose and integrate appropriate geocomputational methods to study a simple spatio-temporal problem.
LO 6 Organize and conduct the modelling and analysis phases required by a simple spatio-temporal project.
LO 7 Apply cloud computing approaches to support and/or realize the main modelling and analysis phases.
LO 8 Evaluate the innovation and societal relevance and impact of the project.

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 30 |
| Supervised practical | 30 |
| Tutorial | 20 |
| Written/oral test | 3 |
| Group assignment | 60 |
| Self-study | 53 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Project | Peer review | Open book exam | Presentation |
|---|---|---|---|---|---|
| | | Learning Outcomes that are addressed in the test | | | |
| LO 1 | Discuss the main modelling paradigms. | | | ● | |
| LO 2 | Design a conceptual model for a spatio-temporal ABM using UML and the ODD protocol. | ● | | ● | ● |
| LO 3 | Implement a basic ABM model, and calibrate this model using behavioural space. | | | ● | |
| LO 4 | Explain to peers the main advantages and limitations of using geo-computational methods. | | ● | | ● |
| LO 5 | Choose and integrate appropriate geocomputational methods to study a simple spatio-temporal problem. | ● | | ● | |
| LO 6 | Organize and conduct the modelling and analysis phases required by a simple spatio-temporal project. | ● | | ● | |
| LO 7 | Apply cloud computing approaches to support and/or realize the main modelling and analysis phases. | | | ● | |
| LO 8 | Evaluate the innovation and societal relevance and impact of the project. | ● | | | |
| | Test type | Project | Peer review | Digital test | Presentation |
| | Weight of the test | 45 | 5 | 45 | 5 |
| | Individual or group test | Group | Individual | Individual | Individual |
| | Type of marking | 1-10 | 1-10 | 1-10 | 1-10 |
| | Required minimum mark per test | | | | |
| | Number of test opportunities per academic year | 2 | 2 | 2 | 2 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Discuss the main modelling paradigms. | ● | ● | | | | | | ● | | ● | ● | | |
| LO 2 | Design a conceptual model for a spatio-temporal ABM using UML and the ODD protocol. | ● | ● | ● | | | ● | | | ● | | | ● | |
| LO 3 | Implement a basic ABM model, and calibrate this model using behavioural space. | ● | ● | ● | ● | ● | ● | | | | | | ● | |
| LO 4 | Explain to peers the main advantages and limitations of using geo-computational methods. | ● | ● | ● | ● | | ● | ● | ● | | ● | | ● | |
| LO 5 | Choose and integrate appropriate geocomputational methods to study a simple spatio-temporal problem. | ● | ● | ● | ● | ● | ● | ● | | ● | | | ● | |

| | Learning outcomes (LO) of the course: The student will be able to... | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 6 | Organize and conduct the modelling and analysis phases required by a simple spatio-temporal project. | ● | ● | ● | ● | ● | ● | | | ● | | | ● | ● |
| LO 7 | Apply cloud computing approaches to support and/or realize the main modelling and analysis phases. | ● | ● | ● | ● | ● | ● | | | ● | | | ● | |
| LO 8 | Evaluate the innovation and societal relevance and impact of the project. | ● | ● | ● | ● | | ● | ● | ● | ● | | ● | ● | ● |

# SPECIES DISTRIBUTION AND ENVIRONMENTAL NICHE MODELLING

| Course | 201800300 |
|---|---|
| Period | 24 April 2023 - 07 July 2023 |
| EC | 7 |
| Course coordinator | |

## INTRODUCTION

Species distribution modelling and environmental niche modelling are types of modelling where the occurrence or absence of certain species or crops are linked to environmental conditions that are relevant. The type of organism that is modeled can be variable in nature, ranging from the presence of rare and endangered species, to the outbreak of pest species.

It is used to make interpolations of observations of species over space using relevant explanatory variables. These extrapolations can be used to assess how likely the occurrence of such an species is in unvisited areas. Also, it can provide insight to what extent the spatial distribution of a species will change as a result of changes in conditions, for example due to land cover change, or climate change.

Extrapolations are based on fitting an empirical relation between the presence or absence of a species and the environmental conditions under which it occurs, it's "niche".

In this course students will learn hands on how to design, create and evaluate different kinds of environmental niche models (such as logistic regression, boosted regression trees and maximum entropy) and you will learn how you can use these models to make projections when conditions change.

The course is of interest to people that need statistical interpolation techniques. Also, the course will teach you to apply different types of software packages. Next to geo-information software you will be working with the R-software.

This course mainly aims at applications in the domain of natural resources, but when you have an interest in in other domains where this can be applied (e.g. disease outbreaks or rare events such as landslides) this course can also be very useful for you and there will be room to explore the application to your area of interest.

## CONTENT

1. The course starts with introducing the niche concept and relevant ecological theory that helps in making interpretations of ENMs;
2. Then the R-package as a modelling environment will be introduced and a number of advanced modelling techniques, such as logistic regression models, boosted regression trees, maximum entropy and expert system models;
3. Multi-collinearity diagnostics and spatial auto-correlation and how to deal with this will be discussed;
4. The techniques will be applied to specific thematic application areas such as biodiversity modelling, species distribution probabilities, habitat requirements, Crop Wild relatives (CWR) management and prediction of crop extent under climate change;
5. How to model the impact of Climate Change on the distribution of species will be explained;
6. Model calibration, validation, data quality and model comparison will be discussed and exercised;
7. The above learned theory will be tested in a written test (60% of the mark)
8. After applying all above mentioned techniques on a model species, students will be assigned another data set (or can bring their own) to work in an individual project to apply all learned techniques to this new data set. This will be assessed based on an individual presentation (25% of the mark). In case of a fail a repair can be made (maximum mark then is a 6)
9. In a final group project, you will work on understanding the role of ENMs in Essential Biodiversity Variables (EBVs) for sustainable agricultural, semi-natural and protected area landscapes and information needs for policy (SDGs, Aichi targets). This will also be presented per group (15% of the mark, no chance for a repair here)

## TEACHING AND LEARNING APPROACH

The first part of the course (60%) will be face-to-face teaching and supervised practical's to acquire knowledge on relevant theories and learn how to apply these in a practical way. This will be assessed in a written test, and partly by the individual project making up.

In the second part of the course, two small projects (one individual and one group) will train the student to place the learned techniques and theories into context. This will be student centered learning. The student has a choice of the type of species and or environment that wil be modellend. Also, the student has a choice in a type if (mini) research question that will be addressed in the mini project. The individual project (25%) tests the ability to create and evaluate ENM's for a specific case study of interest for the student. In the group project (15%), the use of ENMs has to be placed in the context of Essential Biodiversity Variables (EBVs), sustainable agricultural, semi-natural and protected area landscapes, or information needs for policy applications (SDGs, Aichi targets). In the group, model outputs created in the individual project will be used as input for the evaluation how these can be used in either of these contexts.

## TESTS

There are three tests

1. A written test on theory and concepts (60%)
2. A presentation on an individual project where an ENM is created and evaluated for a relevant event (can be a species, or anything else when relevant for the student; 25%)
3. A group assignment to place the use of ENM's in the context of policy relating to sustainable landscapes (15%)

There can be a resit for the written test. For the individual and group assignments, a possible repair (max mark a 6) is possible.

## ENTRY REQUIREMENTS

- GIS and Remote sensing skills
- Basic understanding of regression
- Basic understanding of inferential statistics (ANOVA, T test etc)

## LEARNING OUTCOMES

Upon completion of this course, the student is able to:

| | |
|---|---|
| LO 1 | Apply ecological theory related to biogeography and species distributions. |
| LO 2 | Create a relevant database for modelling. |
| LO 3 | Create environmental niche models. |
| LO 4 | Analyse a species relation to environmental parameters. |
| LO 5 | Evaluate the accuracy of models. |
| LO 6 | Synthesize climate model output to use it in environmental niche models. |
| LO 7 | Evaluate how environmental niche models integrate with policy relating to sustainable landscapes. |

## ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 32 |
| Supervised practical | 32 |
| Tutorial | 4 |
| Written/oral test | 10 |
| Individual assignment | 49 |
| Group assignment | 31 |
| Self-study | 38 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Written test | Presentation | Group project |
|---|---|---|---|---|
| | | **Learning Outcomes that are addressed in the test** | | |
| LO 1 | Apply ecological theory related to biogeography and species distributions. | ● | ● | ● |
| LO 2 | Create a relevant database for modelling. | | ● | |
| LO 3 | Create environmental niche models. | | ● | |
| LO 4 | Analyse a species relation to environmental parameters. | ● | ● | |
| LO 5 | Evaluate the accuracy of models. | ● | ● | |
| LO 6 | Synthesize climate model output to use it in environmental niche models. | ● | ● | |
| LO 7 | Evaluate how environmental niche models integrate with policy relating to sustainable landscapes. | ● | | ● |
| | Test type | Written test | Presentation | Group project |
| | Weight of the test | 60 | 25 | 15 |
| | Individual or group test | Individual | Individual | Group |
| | Type of marking | 1-10 | 1-10 | 1-10 |
| | Required minimum mark per test | | | |
| | Number of test opportunities per academic year | 2 | 2 | 2 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | Learning outcomes (LO) of the course: The student will be able to... | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Apply ecological theory related to biogeography and species distributions. | ● | | | | | | | | | | | | |
| LO 2 | Create a relevant database for modelling. | | ● | ● | | | | | | | | | | |
| LO 3 | Create environmental niche models. | | | ● | | | | | | | | | | |
| LO 4 | Analyse a species relation to environmental parameters. | | ● | ● | ● | ● | | | | | | | | |
| LO 5 | Evaluate the accuracy of models. | | ● | | | ● | ● | | | | | | | |
| LO 6 | Synthesize climate model output to use it in environmental niche models. | ● | | | | | | | | | | | | |

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 7 | Evaluate how environmental niche models integrate with policy relating to sustainable landscapes. | ● | | | ● | | | ● | | ● | | | | |

# STATISTICS FOR SPATIAL AND SPATIO-TEMPORAL DATA

| **Course** | **201800315** |
|---|---|
| Period | 25 April 2022 - 07 July 2023 |
| EC | 7 |
| Course coordinator | |

## INTRODUCTION

The premise of the course is motivated by the recent advancements in geoinformation data acquisition and storage and their intended use for evidence-based planning and monitoring. The spatial references of geo-information data may be attributed to the exact locations of measurements or over a fixed set of contiguous regions or lattices. This course seeks to handle the three main classes of spatial data/processes: geostatistical data/spatially continuous process, lattice data/discrete process, and point pattern data/point process. Such data appear common in diverse application fields like environmental science, agriculture, natural resources, environmental epidemiology, and so on. The aim is to present methods that can be used to explore and model such data. Naturally, data vary in space and in time; hence data close to each other (either in space or time) are more similar than those farther. Geostatistical modeling based on the semivariance and/or covariances and interpolation (kriging) in space and time will therefore be introduced. The methods will be extended and applied to data aggregated over contagious regions. The uncertainty is quantified, and attention will be given to making maps showing the probabilities that thresholds are exceeded. Attention is also given to optimal sampling and monitoring. Further, data that arise out of the occurrences of events; thus point pattern data will be considered. The significance of exploring the first and second-order properties of point patterns in diverse application domains like environmental and disaster (like earthquakes) modeling will be explained and applied. The last focus will be on lattice data; in principle, this kind of data consists of observed values over a set of fixed contiguous regions. This kind of data is rather easy to acquire and is mostly applied in health studies where data aggregation is a standard form of protecting locational privacy.

## CONTENT

- Spatial variation and spatio-temporal variation
- Ordinary kriging, co-kriging, external drift kriging
- Probability maps
- Area to point kriging for lattice data
- Spatio-temporal simulation routines
- Statistical sampling and monitoring methods
- Point patterns

## TEACHING AND LEARNING APPROACH

The delivery of this course is partitioned into two: teaching, which embodies lectures, feedback, and Q&A sessions. There are feedback sessions 15 minutes before the start of every days' lecture except day 1. These involve presentations delivered by students (in groups) followed by "questions" from their colleagues. The objective is to ensure students have control over the subject and also develop/encourage the skills to work in multinational groups. The groups are predefined (by myself) to avoid biases to ensure **internationalization**.

The Q&A sessions are ensured after each lecture. Here, the students are encouraged to ask questions or share their experiences pertaining to the topic.

Tutorial sessions are critical to this course as they offer the opportunity to practice the theory in the class. The tutorials for the first three topics are designed to be **supervised**; the remaining are **unsupervised**. The reason being that after the three supervised tutorials students would have gained enough skills and experience to advance **student-centered learning.**

Critical to the design of this course is the mapping exercise and the mini-projects which take 10 and 40 percent of the assessment, respectively. The mapping exercise is to ensure that students can take basic instructions per the materials developed. The mini-project is designed to primarily ensure that students "gain experience and understanding to design and setup a space-time data modelling problem, identity measurable objectives, the modelling ideas in the R statistical software".

### TESTS

There are 3 tests in this course: an individual mapping assignment (weight 10%), assessment of group course work through a report and a presentation (weight 40%) and an individual written test (weight 50%). The group course work (presentation and report) cannot be re-attempted.

### ENTRY REQUIREMENTS

In this course, students are required to have basic knowldge of descriptive and inferential statistics. Basic knowledge of the R statistical software will be an added advantage

### LEARNING OUTCOMES

Upon completion of this course, the student is able to:

LO 1 Describe the conceptualization of spatial data for modelling spatial processes

LO 2 Differentiate between the conceptualization of spatial correlation of the different kinds of spatial processes (geostatistical, lattice, and point pattern processes) and their significance in spatial and space-time prediction

LO 3 Differentiate between the principles of deterministic and stochastic spatial predictions and simulations for the different spatial processes

LO 4 Describe the concepts and assumptions of stationarity (second-order and intrinsic) and its role in stochastic spatial and space-time prediction and simulations

LO 5 Quantify the concept of spatial correlation (second-order and intrinsic) and implement it for variant stochastic spatial and space-time prediction (kriging) methods

LO 6 Apply the concept of spatial and space-time simulations (conditional and unconditional) and evaluate the overriding advantage over kriging predictions.

LO 7 Design and set up a space-time data modeling problem, identity measurable objectives, and implement the modeling ideas in the R statistical software

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 40 |
| Supervised practical | 20 |
| Written/oral test | 2 |
| Group assignment | 40 |
| Self-study | 80 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Mapping assignment | Course work | Exam |
|---|---|---|---|---|
| | | Learning Outcomes that are addressed in the test | | |
| LO 1 | Describe the conceptualization of spatial data for modelling spatial processes | ● | ● | ● |
| LO 2 | Differentiate between the conceptualization of spatial correlation of the different kinds of spatial processes (geostatistical, lattice, and point pattern processes) and their significance in spatial and space-time prediction | ● | ● | ● |
| LO 3 | Differentiate between the principles of deterministic and stochastic spatial predictions and simulations for the different spatial processes | | | ● |
| LO 4 | Describe the concepts and assumptions of stationarity (second-order and intrinsic) and its role in stochastic spatial and space-time prediction and simulations | | | ● |
| LO 5 | Quantify the concept of spatial correlation (second-order and intrinsic) and implement it for variant stochastic spatial and space-time prediction (kriging) methods | ● | ● | ● |
| LO 6 | Apply the concept of spatial and space-time simulations (conditional and unconditional) and evaluate the overriding advantage over kriging predictions. | ● | ● | |
| LO 7 | Design and set up a space-time data modeling problem, identity measurable objectives, and implement the modeling ideas in the R statistical software | ● | ● | |
| | Test type | Presentation | Presentation | Written test |
| | Weight of the test | 10 | 40 | 50 |
| | Individual or group test | Individual | Group | Individual |
| | Type of marking | 1-10 | 1-10 | 1-10 |
| | Required minimum mark per test | | | |
| | Number of test opportunities per academic year | 2 | 2 | 2 |

RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Describe the conceptualization of spatial data for modelling spatial processes | ● | ● | | | | ● | ● | | | | | | |
| LO 2 | Differentiate between the conceptualization of spatial correlation of the different kinds of spatial processes (geostatistical, lattice, and point pattern processes) and their significance in spatial and space-time prediction | ● | ● | | | | ● | ● | | | | | | |
| LO 3 | Differentiate between the principles of deterministic and stochastic spatial predictions and simulations for the different spatial processes | ● | ● | | | | ● | ● | | | | | | |

| | Learning outcomes (LO) of the course: The student will be able to... | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 4 | Describe the concepts and assumptions of stationarity (second-order and intrinsic) and its role in stochastic spatial and space-time prediction and simulations | ● | ● | | | | ● | ● | | | | | | |
| LO 5 | Quantify the concept of spatial correlation (second-order and intrinsic) and implement it for variant stochastic spatial and space-time prediction (kriging) methods | ● | ● | ● | ● | | ● | ● | ● | ● | ● | ● | ● | ● |
| LO 6 | Apply the concept of spatial and space-time simulations (conditional and unconditional) and evaluate the overriding advantage over kriging predictions. | | | | ● | | ● | ● | ● | ● | ● | ● | ● | ● |

| | Learning outcomes (LO) of the course: The student will be able to... | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 7 | Design and set up a space-time data modeling problem, identity measurable objectives, and implement the modeling ideas in the R statistical software | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |

# THE ROLE OF FORESTS IN CLIMATE CHANGE MITIGATION AND THE USE OF MULTI-SENSOR REMOTE SENSING TO ASSESS CARBON

| **Course** | **201800319** |
|---|---|
| Period | 24 April 2023 - 07 July 2023 |
| EC | 7 |
| Course coordinator | |

## INTRODUCTION

The greenhouse effects and the carbon cycle, in particular carbon emissions and carbon sequestration, are at the heart of climate change, one of the most pressing challenges the earth is facing. Global institutions like the UNFCCC, and IPCC all address these challenges, resulting in initiatives to reduce carbon emissions, such as Kyoto protocol.
This establishes an explicit link with the International Environmental Agenda and Sustainable Development Goals.

For identification and development of policy instruments in order to handle the impacts of the foreseeable changes in the carbon cycle, accurate quantification of the various components in the carbon cycle forms a core need. Moreover, for the mitigation of adverse climate effects and, in the end, sustainability of livelihoods in many parts of the earth sound assessment and monitoring tools are required.

Within the carbon cycle, forestry in the broad sense forms the principal scientific area for research including, stocks emissions (sources) and sequestration (sinks). Afforestation, reforestation and deforestation are the current Kyoto focal areas, but sustainable forest management, including certification, and the assessment and prevention of forest degradation are also considered in the so-called post-Kyoto period. Due to size, inaccessibility of the forest resources, and international requirements for a uniform methodology of Monitoring, Reporting and Verification (MRV), quantification of the carbon cycle components in both space and time leans heavily on remote sensing, GIS modelling and related statistical tools.

## CONTENT

1. The course introduces the carbon cycle in general, climate response to changes in emissions and the role of forest on carbon and climate change. It discusses the carbon sequestration strategies e.g., REDD+ accepted by UN countries as a continuation for its policy after Several methods for carbon assessment at different scales (Tiers) and accuracies are introduced.
2. It introduces the relationships between biophysical characteristics (e.g. biomass) of forest and all types of remotely sensed
3. Geo-information applications for biomass and carbon assessment are introduced and elaborated in case studies. This includes the use of Optical very high resolution data, UAV data, Radar, LiDAR. Several mapping and modeling techniques are explored, including pre-processing and processing techniques of radar
4. Then the course looks at impacts on sequestered carbon and carbon A major impact is fire which contributes to about 25% of global emissions. First forest fire behavior is modeled in order to present methods and techniques of modelling carbon emission from forest fire.
5. Tree mortality due to pests and diseases is another impact on sequestered This will also be discussed.
6. Finally the course will look at tools and techniques for monitoring forest density changes in relation to carbon stocks and changes in carbon stocks as an important input in MRV
7. During a day in the field students will learn to navigate, layout sample plots and measure important forest parameters
8. The course will finish with a small group project where students develop a carbon sequestration project and reflect on strengths and weaknesses of different methods

## TEACHING AND LEARNING APPROACH

The course will start with describing climate change and the role of forests to mitigate it. It will show how forest sequester carbon and control global warming. Students work on a small group project where they define a REDD+ project for a specific country. Then in lectures biomass/ carbon stock will be introduced as well as methods to assess that using various remotely sensed data such as optical satellite and airborne images, UAV, Lidar and Radar data. The students will practice on different types of real life case studies using various types of remotely sensed data to assess and map biomass and carbon stock in difference forest ecosystems. The course will also model carbon sequestration by using case studies dealing with multi-temporal remotely sensed data. Theory of fire and fire spreading will be explained in order to understand how fire behavior affects carbon emission and climate change and students practice during a case study

The course will end with a small group project where students evaluate different tools and techniques for the project they specified in the first week.

## TESTS

Written exam (open book), group report.

## ENTRY REQUIREMENTS

N/A

### LEARNING OUTCOMES

Upon completion of this course, the student is able to:

- LO 1 Understand carbon cycle and its effect on climate change.
- LO 2 Understand how deforestation, forest degradation, carbon sequestration and carbon emission affect climate change
- LO 3 Apply methods for modelling biomass/carbon stock of different forest cover types using VHRS images, UAV, Radar and Lidar data.
- LO 4 Apply methods for modelling forest fire behavior and consequently carbon emission.
- LO 5 Apply methods for tree mortality mapping and monitoring
- LO 6 Select an appropriate technique to detect and monitor deforestation and forest degradation.
- LO 7 Carry out a field survey

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 25 |
| Supervised practical | 20 |
| Tutorial | 20 |
| Study trip | 2 |
| Written/oral test | 4 |
| Group assignment | 40 |
| Self-study | 85 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Exam | Case study report |
|---|---|---|---|
| | | Learning Outcomes that are addressed in the test | |
| LO 1 | Understand carbon cycle and its effect on climate change. | ● | |
| LO 2 | Understand how deforestation, forest degradation, carbon sequestration and carbon emission affect climate change | ● | ● |
| LO 3 | Apply methods for modelling biomass/carbon stock of different forest cover types using VHRS images, UAV, Radar and Lidar data. | ● | ● |
| LO 4 | Apply methods for modelling forest fire behavior and consequently carbon emission. | ● | |
| LO 5 | Apply methods for tree mortality mapping and monitoring | ● | |
| LO 6 | Select an appropriate technique to detect and monitor deforestation and forest degradation. | | ● |
| LO 7 | Carry out a field survey | ● | |
| | Test type | Written test | Report |
| | Weight of the test | 65 | 35 |
| | Individual or group test | Individual | Group |
| | Type of marking | 1-10 | 1-10 |
| | Required minimum mark per test | | |
| | Number of test opportunities per academic year | 2 | 1 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Understand carbon cycle and its effect on climate change. | ● | ● | | ● | | ● | ● | | | | | | |
| LO 2 | Understand how deforestation, forest degradation, carbon sequestration and carbon emission affect climate change | | ● | ● | ● | | ● | ● | | | | | | |
| LO 3 | Apply methods for modelling biomass/carbon stock of different forest cover types using VHRS images, UAV, Radar and Lidar data. | | ● | ● | ● | | ● | ● | ● | | | | | |
| LO 4 | Apply methods for modelling forest fire behavior and consequently carbon emission. | | ● | ● | ● | ● | ● | ● | ● | | ● | ● | | ● |

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 5 | Apply methods for tree mortality mapping and monitoring | | ● | ● | ● | | ● | ● | ● | | ● | ● | | ● |
| LO 6 | Select an appropriate technique to detect and monitor deforestation and forest degradation. | ● | | | ● | | | | | ● | | | | |
| LO 7 | Carry out a field survey | ● | | | ● | | | | | | | | | |

# THERMAL INFRARED REMOTE SENSING: FROM THEORY TO APPLICATIONS

| Course | 201900043 |
|---|---|
| Period | 05 September 2022 - 11 November 2022 |
| EC | 5 |
| Course coordinator | |

## INTRODUCTION

Remote sensing in the thermal infrared (TIR) spectral region is highly complementary to other remote sensing techniques, such as reflective remote sensing (VIS-SWIR) or microwave remote sensing (RADAR). TIR remote sensing measures the energy that is emitted by the studied objects themselves. By analysing the TIR data we can gain insight on the objects' temperature as well as composition. These parameters are crucial when studying phenomena such as land and sea surface temperature, (geo-) thermal heat fluxes, crop health, urban heat islands and mineralogic composition of soils, rocks and drill cores.

In this course we will take a multi-application look at thermal remote sensing. The students will learn how TIR remote sensing works in theory and practice. They will get instructed on several state-of-the-art TIR instruments in Faculty ITC's GeoScience Laboratory and will get the chance to experiment and practice with the instruments themselves.

The course contains a component where the students will define a small research question, and design an experiment to answer that question using TIR data or instruments. As this course runs parallel with research proposal writing of the M-GEO programme, a cross-fertilization between the two courses is possible and encouraged.

## CONTENT

This course covers the following topics:

- Fundamentals of the thermal infrared; physical laws that govern the TIR
- Demonstrations and hands-on experience of thermal infrared instruments, including TIR cameras, radiant thermometers, TIR FTIR spectrometers (lab and field)
- Working with TIR datasets from different platforms (ground, airborne, spaceborne) and different spectral resolution (broadband, multi-spectral, hyperspectral)
- Corrections for atmosphere ("split window", MODTRAN, ISAC) and emissivity (ENorm)
- Independent study of relevant TIR articles on a topic or application of choice, and presentation to the peers
- "capita selecta" presentations by Faculty ITC researchers on their work with TIR
- Defining a small research question and working on that question
- Evaluating experiments and analyses with TIR instruments and data of peers and provide constructive criticism

## TEACHING AND LEARNING APPROACH

The course contains lectures to introduce new theory, reading assignments followed by feedback sessions to deepen the theory and supervised and unsupervised practicals to put the theory into practice.

The course has a strong peer component, where the students will learn from each other's experiences. TIR applications in various domains and will be introduced through finding, reading and discussing relevant literature in a peer-discussion context. Students will ask and answer questions based on paper presentations, to get accustomed to scientific scrutiny by their respective peers.

The course will be completed with a mini-project where students define a small research question that fits their background and interests, and they will design an experiment to answer that question using TIR data or instrumentation. It is possible to link this part of the course to the students' own MSc topic if it is related to TIR remote sensing. Alternatively, students can choose from a list of possible topics and datasets to work on for this course based on their interest.

## TESTS

- Open book, written test on the theory aspects of the course. It will cover the material discussed in lectures, exercises, reading assignments and discussions. This test covers learning outcomes 1 and 2 and counts for 50% of the final mark;
- A marked presentation on the mini-project at the end of the course. This short (5-10 min) individual presentation is marked by staff and peers alike (75% vs 25%). This test covers learning outcomes 2,4,5 (and potentially 3) and counts for 50% of the final mark;
- A formative test (not marked) with peer feedback on the review of journal articles. The result does not count towards the final mark of the course.

Type of marking: 1-10

For the written test, there is a second test opportunity for the full possible score. For the mini-project presentation only a repair opportunity is possible, as the assignment spans several weeks.

## ENTRY REQUIREMENTS

Open for students in the programmes 'Geo-information Science and Earth Observation' (M-GEO) and 'Spatial Engineering' (M-SE), with knowledge of earth materials (atmosphere, water, soil, rocks, vegetation). The suitability of other candidates will be assessed on an individual basis.

M-SE students interested in following this course should consult with the course coordinator to resolve possible overlaps with the M-SE "International Module"

## LEARNING OUTCOMES

Upon completion of this course, the student is able to:

| | |
|---|---|
| LO 1 | Explain the theory of TIR, emissivity and the concepts of radiant vs. kinetic temperature. |
| LO 2 | Summarize the usage of TIR data and its limitations in various application fields. |
| LO 3 | Independently operate state-of-the-art instruments under laboratory and field conditions, and to collect good quality data. |
| LO 4 | Retrieve and interpret qualitative and quantitative information from broadband or (hyper-) spectral TIR instrumentation. |
| LO 5 | Define experiments and methods with TIR instrumentation / data to answer relevant research questions. |

## ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 12 |
| Supervised practical | 10 |
| Tutorial | 16 |
| Written/oral test | 10 |
| Individual assignment | 40 |
| Group assignment | 20 |
| Self-study | 32 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Open book test | Project presentation |
|---|---|---|---|
| | | Learning Outcomes that are addressed in the test | |
| LO 1 | Explain the theory of TIR, emissivity and the concepts of radiant vs. kinetic temperature. | ● | |
| LO 2 | Summarize the usage of TIR data and its limitations in various application fields. | ● | ● |
| LO 3 | Independently operate state-of-the-art instruments under laboratory and field conditions, and to collect good quality data. | | ● |
| LO 4 | Retrieve and interpret qualitative and quantitative information from broadband or (hyper-) spectral TIR instrumentation. | | ● |
| LO 5 | Define experiments and methods with TIR instrumentation / data to answer relevant research questions. | | ● |
| | Test type | Written test | Oral test |
| | Weight of the test | 50 | 50 |
| | Individual or group test | Individual | Individual |
| | Type of marking | 1-10 | 1-10 |
| | Required minimum mark per test | | |
| | Number of test opportunities per academic year | 2 | 2 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Explain the theory of TIR, emissivity and the concepts of radiant vs. kinetic temperature. | ● | | | | | | | | | | | | |
| LO 2 | Summarize the usage of TIR data and its limitations in various application fields. | | ● | | | | | | | | | | ● | |
| LO 3 | Independently operate state-of-the-art instruments under laboratory and field conditions, and to collect good quality data. | | | | ● | | | | | | | | | ● |
| LO 4 | Retrieve and interpret qualitative and quantitative information from broadband or (hyper-) spectral TIR instrumentation. | | | | ● | | | | | | | | | |

| | Learning outcomes (LO) of the course: The student will be able to... | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 5 | Define experiments and methods with TIR instrumentation / data to answer relevant research questions. | | | | | ● | ● | ● | ● | | | | ● | ● |

# WATER AND CARBON DYNAMICS IN ECOSYSTEMS

| **Course** | **201800313** |
| --- | --- |
| Period | 24 April 2023 - 07 July 2023 |
| EC | 7 |
| Course coordinator | |

## INTRODUCTION

This course will focus on the combined use of satellite and in-situ observations and models for **environmental monitoring** of terrestrial and aquatic ecosystems. Current satellite and data technology permit observation and quantification of energy and water cycle components. Carbon, primary productivity in ecosystems and greenhouse gas emissions can also be monitored from space. The course will address the challenge of understanding how energy, water and carbon cycles interact and are coupled in ecosystems and at the boundaries between land, water, and atmosphere. Methods for retrieval of radiation, water and biogeochemical variables from satellite data will be reviewed, and an introduction to the use and evaluation of currently available satellite data related to the water, energy and the biogeochemical (BGC) cycles will be given.
Simulation models of soil - vegetation (e.g. agriculture) and aquatic systems (e.g., lakes, wetlands and coastal zones) will be used for analysis, interpretation and systems modelling of water, energy and biogeochemical processes. Field work and visits to one or more of ITC's in-situ monitoring sites (in urban, forest, coastal estuarine, and marine locations) are foreseen.

## CONTENT

Week 1-2: Interactions among water, energy and biogeochemical cycles and processes; quantifying energy & mass transfers; thermodynamic concepts; carbon & nitrogen cycle (land and aquatic ecosystems); water productivity,...

Week 3-4: Programming with a focus on systems model building; Geospatial programming of satellite data of radiation, water, carbon, other biogeochemical data; time series building, analysis using open source software (GDAL, Ilwis, QGIS, Python, R);

Week 5-6: Analysis of In-situ radiation, water, carbon fluxes (EC tower); field and laboratory experiment on water and carbon exports of small catchment; more on carbon equilibria and CO2; assessment of GHG (green house gases) emissions from in-situ and satellite data;

Week 7-9: Field excursion (Dutch estuaries); use case design and execution of a terrestrial or aquatic ecosystem (e.g. agriculture, irrigation, forest, urban or wetlands, coastal zone) using an existing model or by own model building (small group assignment)

Week 10 Study, presentation sessions, self-study and written exam

## TEACHING AND LEARNING APPROACH

Learning outcomes 1, 2, 3: Participatory teaching with targeted individual assignments
Learning outcome 4: Tutorial training and supervised practical
Learning outcome 5: Group work supervision, question & answer sessions

## TESTS

Individual Assignment(s); 3 written (3x10%)

Group Assignment work (field experiment, lab analysis and written report) or
(use case incl. oral presentation and written report (20%)

Written exam (50%)

## ENTRY REQUIREMENTS

N/A

### LEARNING OUTCOMES

Upon completion of this course, the student is able to:

LO 1 Quantify water, energy and carbon budgets and partitioning in- and outflows (e.g. evapotranspiration, streamflow, net primary productivity) in the atmosphere-vegetation-soil zone and/or aquatic systems

LO 2 Perform a coupled water, energy, carbon dynamics analysis on an area of interest, using a blend of satellite, in-situ and global atmospheric and weather forecast model datasets.

LO 3 Analyse greenhouse gas emissions from earth observation sensors and other e.g. in-situ data (and report for an area of interest)

LO 4 Access and use large satellite datasets and retrieve variables for a region of interest using Open Source programming tools.

LO 5 Perform model-based analysis of water and biogeochemical budgets on an ecosystem of choice (e.g. a soil-vegetation or an aquatic e.g. coastal system) - using group work (incl. presentation and reporting)

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 34 |
| Supervised practical | 20 |
| Tutorial | 20 |
| Study trip | 8 |
| Written/oral test | 12 |
| Individual assignment | 28 |
| Group assignment | 34 |
| Self-study | 40 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Learning Outcomes that are addressed in the test<br>Test 1 | Test 2 | Test 3 | Test 4 |
|---|---|---|---|---|---|
| LO 1 | Quantify water, energy and carbon budgets and partitioning in- and outflows (e.g. evapotranspiration, streamflow, net primary productivity) in the atmosphere-vegetation-soil zone and/or aquatic systems | ● | ● | ● | ● |
| LO 2 | Perform a coupled water, energy, carbon dynamics analysis on an area of interest, using a blend of satellite, in-situ and global atmospheric and weather forecast model datasets. | ● | ● | ● | ● |
| LO 3 | Analyse greenhouse gas emissions from earth observation sensors and other e.g. in-situ data (and report for an area of interest) | | ● | ● | ● |
| LO 4 | Access and use large satellite datasets and retrieve variables for a region of interest using Open Source programming tools. | | ● | ● | ● |
| LO 5 | Perform model-based analysis of water and biogeochemical budgets on an ecosystem of choice (e.g. a soil-vegetation or an aquatic e.g. coastal system) - using group work (incl. presentation and reporting) | | | ● | ● |
| | Test type | Elevator pitch presentation | Assignment | Poster/report | Written test |
| | Weight of the test | 10 | 20 | 30 | 40 |
| | Individual or group test | Group | Individual | Group | Individual |
| | Type of marking | 1-10 | 1-10 | 1-10 | 1-10 |
| | Required minimum mark per test | | | | |
| | Number of test opportunities per academic year | 2 | 2 | 2 | 2 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| **Learning outcomes (LO) of the course: The student will be able to...** | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Quantify water, energy and carbon budgets and partitioning in- and outflows (e.g. evapotranspiration, streamflow, net primary productivity) in the atmosphere-vegetation-soil zone and/or aquatic systems | ● | | | | | | | | | | | | ● |
| LO 2 | Perform a coupled water, energy, carbon dynamics analysis on an area of interest, using a blend of satellite, in-situ and global atmospheric and weather forecast model datasets. | ● | ● | | | | ● | ● | | | | | | ● |
| LO 3 | Analyse greenhouse gas emissions from earth observation sensors and other e.g. in-situ data (and report for an area of interest) | | | ● | | ● | | | ● | | | | ● | |

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 4 | Access and use large satellite datasets and retrieve variables for a region of interest using Open Source programming tools. | | ● | | | | | | | | ● | ● | ● | |
| LO 5 | Perform model-based analysis of water and biogeochemical budgets on an ecosystem of choice (e.g. a soil-vegetation or an aquatic e.g. coastal system) - using group work (incl. presentation and reporting) | | | ● | ● | | | | ● | | ● | ● | | |

# WATER, CLIMATE AND CITIES

| **Course** | **202200006** |
|---|---|
| Period | 05 September 2022 - 11 November 2022 |
| EC | 5 |
| Course coordinator | |

## INTRODUCTION

This course will explain the physical principles governing the (urban) climate and climate change, and offer a set of methods and techniques for its analysis and monitoring. This will encompass measuring and modelling approaches, and their applications for understanding water-energy cycles and their extremes (i.e. heatwaves, drought, and floods) with an emphasis on urban environments.

## CONTENT

Water and energy are indispensable for all lifeforms and are needed, in large quantities, in almost all human activities. Climate, water-energy cycles and biophysical systems are interconnected in complex ways, so a change in any one of these induces a change in another. Climate change adds a major pressure to (national, regional and local) authorities that are already confronted with the issue of sustainable water and energy use.

The challenges resulting from climate change related to water are mainly related to having too much water, or having too little water. In turn, the amount of water plays a pivotal role in how the energy cycle and thus the climate and its change manifests themselves, thereby often creating an accelerating feedback effect. As such, water-related issues play a pivotal role among key regional and global vulnerabilities. Therefore the relationship between climate change and water-energy cycles is of primary concern and interest.

This course introduces relevant processes and experimental as well as modelling tools related to climate and climate change for assessing, analysing and evaluating the impact thereof on the spatial and temporal distribution of water and energy fluxes at global, regional local scales. Specific attention is given to urban environments.

## TEACHING AND LEARNING APPROACH

The course starts with a number of lectures setting the general framework and dealing with the governing equations determining the global climate and climate change. Thereafter we will look into the climate at a more local scale, with an emphasis on urban areas. This will take place through lectures which are followed by supervised practical exercises where we deal with the exploration and analysis of typical urban climate datasets. The exercise will be reported by each student and will count as the first individual assignment of this course.

The latter part of the course consists of regional climate modelling. Here the students will work with the Weather Research and Forecasting (WRF) model. The model will be introduced by lectures followed by supervised practical exercises where each student will set up the model, run it and analyze the output. This will be reported by each student and submitted as the second individual assignment of this course.

The course will be rounded off by a written test which will be open book, meaning that the lecture notes will be made available during the test.

## TESTS

- One written test (open book, 33.33%)
- Two individual assignments (each 33.33%)

### ENTRY REQUIREMENTS

All students in the M-GEO WREM specialization are accepted. Students following other specializations or programmes outside ITC faculty should have a BSc level background in meteorology or climatology.

### LEARNING OUTCOMES

Upon completion of this course, the student is able to:

LO 1 Understand the physical processes determining the climate and thus climate change.

LO 2 Understand the climate adaptation and response with respect to water-related issues (“climate change impact”).

LO 3 Understand the implications of climate change for water and energy cycles, at global, regional and urban scales.

LO 4 Apply (regional) climate modelling techniques.

LO 5 Analyse and evaluate (urban) climate observations.

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 36 |
| Supervised practical | 16 |
| Written/oral test | 2 |
| Individual assignment | 16 |
| Self-study | 70 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Written test | Individual assignment | Individual assignment |
|---|---|---|---|---|
| LO 1 | Understand the physical processes determining the climate and thus climate change. | ● | | |
| LO 2 | Understand the climate adaptation and response with respect to water-related issues (“climate change impact”). | ● | | |
| LO 3 | Understand the implications of climate change for water and energy cycles, at global, regional and urban scales. | ● | | |
| LO 4 | Apply (regional) climate modelling techniques. | | | ● |
| LO 5 | Analyse and evaluate (urban) climate observations. | | ● | |
| | Test type | Written test | Individual assignment | Individual assignment |
| | Weight of the test | 33.33 | 33.33 | 33.33 |
| | Individual or group test | Individual | Individual | Individual |
| | Type of marking | 1-10 | 1-10 | 1-10 |
| | Required minimum mark per test | | | |
| | Number of test opportunities per academic year | 2 | 2 | 2 |

RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Understand the physical processes determining the climate and thus climate change. | ● | ● | | | | | | | | | | | |
| LO 2 | Understand the climate adaptation and response with respect to water-related issues (“climate change impact”). | ● | ● | | | | | | | | | | | |
| LO 3 | Understand the implications of climate change for water and energy cycles, at global, regional and urban scales. | ● | ● | | | | | | | | | | | |

| | Learning outcomes (LO) of the course: The student will be able to... | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 4 | Apply (regional) climate modelling techniques. | ● | ● | ● | | | ● | | ● | | | | ● | |
| LO 5 | Analyse and evaluate (urban) climate observations. | ● | ● | ● | | | ● | | ● | | | | ● | |

# WEATHER IMPACT ANALYSIS

| **Course** | **201900168** |
|---|---|
| Period | 24 April 2023 - 07 July 2023 |
| EC | 7 |
| Course coordinator | |

## INTRODUCTION

Weather is everywhere. The weather has an impact on the earth surface, but also on everything that is on that surface: vegetation, soil, water availability, humans, etc. Many natural hazards have extreme weather conditions as a trigger, like droughts, floods, heat-waves, and rainfall-induced landslides. Also, agricultural production is dependent on weather conditions, as extreme weather events might cause damage to crops or land, and lead to less harvest. Similarly, the extent and magnitude of the urban heat island effects are largest under hot, stable weather conditions. When analyzing and visualising this weather information with data on the earth systems under study, one gets insight into the impact of weather and can act accordingly to prevent or mitigate disasters.

Fortunately, the weather is continuously monitored worldwide, by satellites and ground stations at minute, daily or monthly scales. Many meteorological datasets are freely accessible, being an enormously rich source for weather information.

This course provides knowledge on weather data sources and tools to analyze the interaction between the weather and earth surface processes in time and space. The focus will be on analysing meteorological datasets to extract information on extreme weather events. The challenge will be to link this climatic information to non-meteorological data to learn more on the impact weather has on earth systems, such as natural hazards, hydrology, vegetation, urban environments, etc.

## CONTENT

This course introduces students to relevant atmospheric processes together with experimental datasets as well as analytical tools for assessing, analyzing, and evaluating the impact of weather on earth systems. This theoretical basis enlights limitations and benefits of such different datasets for studying various application fields within ITC. Next, students will be introduced in time-series analysis as part of meteorological data processing, to extract information on extreme weather indices, magnitude-frequency distributions, etc., relevant for assessing the impact extreme events have on earth systems.

Finally, through demos, guest lectures and excursion, participants are familiarized with various datasets, analytical tools, observational techniques, relevant to their own interest. Finally, participants will be confronted with the natural limitations of the various tools and techniques through small projects, where relevant weather data is linked to an observed earth surface process.

Staff from various departments (ESA/NHR, ESA/ARS, and NRS) is involved in teaching and supervision to ensure various application fields impacted by weather are covered. An excursion to KNMI (Royal Netherlands Meteorological Institute) is included.

## TEACHING AND LEARNING APPROACH

The course starts with a small set of lectures combined with a number of supervised practicals/tutorials. A number of papers on weather impact analysis will be introduced by staff for self-study. A case-study will be introduced as an individual project; with limited guidance, students will on a self-defined, real-world challenge, where weather data will be collected and analyzed related to an application field of their interest. The project is based on Challenge-based learning approach. Frequently feedback/intervision sessions and formative evaluations will be implemented to ensure students reflect and communicate on their steps in the individual learning process with their peers and experts.

### TESTS
Assignments: individual inception presentation (30%) and individual/group final project report (70%).

After the inception phase of the project students get the option to continue the project on their own, or pair up with another student.

### ENTRY REQUIREMENTS
Open for students with an interest in weather and weather data processing, with a background in earth sciences, physical geography, water resources, natural resources, natural hazards, soil science, engineering.

### LEARNING OUTCOMES
Upon completion of this course, the student is able to:

LO 1 explain physical processes that underly the impact that weather, especially extreme weather events, can have on earth surface processes
LO 2 apply and evaluate basic analytic tools to analyze various weather data sources, focusing on extracting weather extreme events
LO 3 select appropriate observational data sets to analyze the impact of weather
LO 4 design, execute and evaluate extreme weather impact analysis in chosen field of application

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 10 |
| Supervised practical | 16 |
| Study trip | 8 |
| Individual assignment | 64 |
| Tutorial | 16 |
| Self-study | 82 |
| | 0 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Learning Outcomes that are addressed in the test<br>Test 1 | Test 2 |
|---|---|---|---|
| LO 1 | explain physical processes that underly the impact that weather, especially extreme weather events, can have on earth surface processes | ● | ● |
| LO 2 | apply and evaluate basic analytic tools to analyze various weather data sources, focusing on extracting weather extreme events | ● | |
| LO 3 | select appropriate observational data sets to analyze the impact of weather | ● | |
| LO 4 | design, execute and evaluate extreme weather impact analysis in chosen field of application | ● | ● |
| | Test type | Report | Presentation |
| | Weight of the test | 70 | 30 |
| | Individual or group test | Group | Individual |
| | Type of marking | 1-10 | 1-10 |
| | Required minimum mark per test | | |
| | Number of test opportunities per academic year | 1 | 2 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | explain physical processes that underly the impact that weather, especially extreme weather events, can have on earth surface processes | ● | | | ● | | | | | | | | | |
| LO 2 | apply and evaluate basic analytic tools to analyze various weather data sources, focusing on extracting weather extreme events | | ● | | ● | | | | | | | | ● | |
| LO 3 | select appropriate observational data sets to analyze the impact of weather | ● | ● | | | | | ● | | | | | | |
| LO 4 | design, execute and evaluate extreme weather impact analysis in chosen field of application | ● | ● | | ● | ● | | | | ● | | | ● | ● |

# THESIS

## MSC RESEARCH PROPOSAL AND THESIS WRITING

| **Course** | **201900054** |
|---|---|
| Period | 05 September 2022 - 07 July 2023 |
| EC | 45 |
| Course coordinator | |

### INTRODUCTION

The Faculty ITC Research Programme is formulated under the following interlinked research themes:

- 4D-Earth
- Acquisition and quality of geo-spatial information (ACQUAL);
- Forest Agriculture and Environment in the Spatial Sciences (FORAGES);
- People, Land and Urban Systems (PLUS);
- Spatio-temporal analytics, maps and processing (STAMP);
- Water Cycle and Climate (WCC).

These research themes and activities form the subject framework and organizational structure in which Master's students conduct their individual research. Students have to make a choice of the envisaged MSc research topic during the fourth quartile of the first year. For more information about the content and scope of the Faculty ITC Research Programme, please visit: http://www.itc.nl/research-themes

The purpose of the MSc research phase is; i) to deepen the knowledge and skills of the students within the research themes; ii) to help students to define their own MSc Research Proposal, and iii) to facilitate students to individually write a concise, logical and well-structured thesis.

The first stage of this course is spent on developing an MSc Research Proposal with support and feedback from staff and peers. Through the MSc Research Proposal, the students should demonstrate the ability to undertake independent research. The MSc Research Proposal will be assessed by a Proposal Assessment Board based on a written proposal, a presentation and an oral defence. The Proposal Assessment Board decides if the proposal is acceptable, as one of the conditions to continue with the MSc Research phase*.

The second stage of the course is dedicated to the execution of an individual research project. Each student works independently on the basis of an approved research proposal. Where relevant, students can with their supervisors apply for Research Support Activity budget ** to conduct for instance fieldwork for data collection.

In this final part of the course, the students further develop their research skills, interact with their fellow students, PhD researchers and staff members and, finally, demonstrate that they have achieved the learning outcomes of the Master's programme by research, on a satisfactory academic level.

**) If the nature of the research requires a different timeframe for proposal writing and/or data collection, a tailored solution will be considered. Requests for a tailored solution should be addressed to the Programme Director.*

***) RSA budget is limited and only available upon motivated request, supported by the first supervisor and the MSc Research coordinator of the concerned research theme. Covid-19 restrictions might limit the possibilities to execute research support activities.*

## CONTENT

### Guided Proposal Writing

- Introductory lectures on:
  - MSc Research phase process
  - Research ethics
- Tutorials and peer discussion on :
  - Formulating sub-objectives and research questions
  - Methodology
  - Ethical considerations in MSc research
- Optional, theme-specific tutorials
  - Data collection methods
  - Data analysis methods

### Proposal defence

- Oral presentation and defence of the MSc research proposal before the Proposal Assessment Board

### Thesis Writing

Based on the accepted research proposal the student will carry out the planned activities. Regular individual progress meetings with the supervisors will be held to facilitate the progress on the research and thesis writing, and records of the progress will be kept.

The activities include:

- Deepen literature review, including assessment of the usability of literature and previous research;
- Collection of relevant data. If appropriate, preparation and execution of fieldwork to collect primary data required for the research;
- Data processing and analysis
- Active participation in seminars and activities of the research theme under which the MSc research resorts;
- Mid-term presentation; A formative assessment is made on the research progress approximately half-way the thesis development time-frame
- Preparation of the final manuscript of the MSc thesis
- A critical review of the quality, use, and usefulness of the data and results, as well as the learning process;
- Oral presentation and defence of the MSc thesis before the Thesis Assessment Board.

## TEACHING AND LEARNING APPROACH

Academic skills training is offered to students in the first academic year. MSc research classes in the second academic year build on this first-year course. Each research theme can also offer additional research support activities (e.g. specific survey techniques). The research projects or research support activities can be inter-disciplinary.

Students are assigned a supervisor or team of supervisors to guide them during their individual research. Students will make individual arrangements with their supervisor(s) regarding the frequency of supervision meetings and the extent of the guidance they can expect. An elaborate explanation about MSc proposal and thesis writing supervision is available in Canvas.

### TESTS

The research work will be assessed on two occasions:

- Proposal Assessment (Fail/Complete). A Proposal Assessment Board will assess the detailed research proposal and its presentation, leading to admission / non-admission to the actual thesis writing.
- The Thesis assessment (Marked). A Thesis Assessment Board will assess the Thesis document, the presentation of the Thesis and its oral defence.

In addition to these summative assessments, students will receive feedback on the student's performance from the Supervisors throughout the MSc Research period. Approximately halfway through the research period, there is a mid-term evaluation. Students are asked to make a mid-term presentation to update their supervisors and the Research Theme Leader on their progress. The purpose of this formative assessment (no mark is given) for the student is to receive feedback on their research. In case of weak performance, students receive a written warning on behalf of the programme director.

For details see Education and Examination Regulations and Rules and Regulations of the Faculty ITC Examination Board.

### ENTRY REQUIREMENTS

To present an MSc research proposal:

- At least 46 EC worth of courses of year 1 (including 4EC academic skills) must have been successfully completed.

Students not meeting the above-mentioned entry requirements are allowed to attend the MSc research classes in the second academic year. Supervised MSc thesis writing can only start after a successful MSc proposal defence.

### LEARNING OUTCOMES

Upon completion of this course, the student is able to:

LO 1 Address a well-formulated relevant research problem of sufficient scope and depth related to the application of geo-information and earth observation and linked to relevant literature (scientific scope and depth)

LO 2 Undertake research with a clear and transparent methodology with proper use of concepts, methods and techniques (scientific method)

LO 3 Write a well-structured and readable thesis report with a clear layout (reporting)

LO 4 Orally present and defend the research and use proper argumentation in the discussion about the research (presentation and defence)

LO 5 Work in a structured and independent way, while making adequate use of the guidance of the supervisor (process)

LO 6 Reflect and discuss in the thesis, the relevance of the research in different cultural and international contexts, OR, present the research in an international setup, through reflecting on its utility in overarching cultural and societal differences and fostering of stakeholder partnerships.

### ALLOCATED TIME PER TEACHING AND LEARNING METHOD

| Teaching / learning method | Hours |
|---|---|
| Lecture | 4 |
| Tutorial | 12 |
| Supervised practical | 12 |
| Written/oral test | 4 |
| Self-study | 1220 |

## TESTPLAN

| | Learning outcomes (LO) of the course: The student will be able to... | Proposal assessment | Thesis writing and public defence |
|---|---|---|---|
| | | **Learning Outcomes that are addressed in the test** | |
| LO 1 | Address a well-formulated relevant research problem of sufficient scope and depth related to the application of geo-information and earth observation and linked to relevant literature (scientific scope and depth) | ● | ● |
| LO 2 | Undertake research with a clear and transparent methodology with proper use of concepts, methods and techniques (scientific method) | ● | ● |
| LO 3 | Write a well-structured and readable thesis report with a clear layout (reporting) | | ● |
| LO 4 | Orally present and defend the research and use proper argumentation in the discussion about the research (presentation and defence) | | ● |
| LO 5 | Work in a structured and independent way, while making adequate use of the guidance of the supervisor (process) | ● | ● |
| LO 6 | Reflect and discuss in the thesis, the relevance of the research in different cultural and international contexts, OR, present the research in an international setup, through reflecting on its utility in overarching cultural and societal differences and fostering of stakeholder partnerships. | | ● |
| | Test type | Proposal assessment | Thesis defence |
| | Weight of the test | | 100 |
| | Individual or group test | Individual | Individual |
| | Type of marking | Pass/Fail | 1-10 |
| | Required minimum mark per test | | |
| | Number of test opportunities per academic year | 2 | 2 |

## RELATION OF LEARNING OUTCOMES (LO) OF THE COURSE WITH THE PROGRAMME LEARNING OUTCOMES

| | **Learning outcomes (LO) of the course: The student will be able to...** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 1 | Address a well-formulated relevant research problem of sufficient scope and depth related to the application of geo-information and earth observation and linked to relevant literature (scientific scope and depth) | | ● | | ● | | ● | ● | | ● | | | ● | |
| LO 2 | Undertake research with a clear and transparent methodology with proper use of concepts, methods and techniques (scientific method) | | | ● | | ● | ● | ● | | ● | | | ● | |

| | Learning outcomes (LO) of the course: The student will be able to... | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 3 | Write a well-structured and readable thesis report with a clear layout (reporting) | | | | | | | | ● | | | | | |
| LO 4 | Orally present and defend the research and use proper argumentation in the discussion about the research (presentation and defence) | | | | | | | | ● | | | | ● | |
| LO 5 | Work in a structured and independent way, while making adequate use of the guidance of the supervisor (process) | | | | | ● | | | | | | | ● | ● |

| | Learning outcomes (LO) of the course: The student will be able to... | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO 6 | Reflect and discuss in the thesis, the relevance of the research in different cultural and international contexts, OR, present the research in an international setup, through reflecting on its utility in overarching cultural and societal differences and fostering of stakeholder partnerships. | | | | | | | | | | ● | ● | ● | |