

The European Commission's science and knowledge service

Joint Research Centre



Degree of Urbanisation GRID (DUG)

Pre Forum Training Sessions on GHSL Tool Suite

Aneta J Florczyk & GHSL team

Geo HPI Forum 2017, Enschede (Netherlands), 13 Sept. 2017

Overview

- The global harmonized definition of cities and settlements
- “Degree of Urbanisation GRID” main concepts
- GHSL data
- **Hands On**

Global Definition of Cities and Settlements

- During the UN-Habitat III conference in October 2016, the European Union, the OECD and the World Bank launched a voluntary commitment to develop a global, people-based definition of cities and settlements.
- This commitment will support
 - the implementation of the new urban agenda.
 - the monitoring and the comparison of the urban Sustainable Development Goal (SDG). Several of the indicators linked to this goal are highly sensitive to where the boundary is drawn around a city.
- The goal of the commitment is to present a definition to the **UN Statistical Commission in 2019**.
- Two linked definitions are being tested:
 - **The degree of urbanisation**
 - The EU-OECD functional urban area definition.

Global Definition of Cities and Settlements

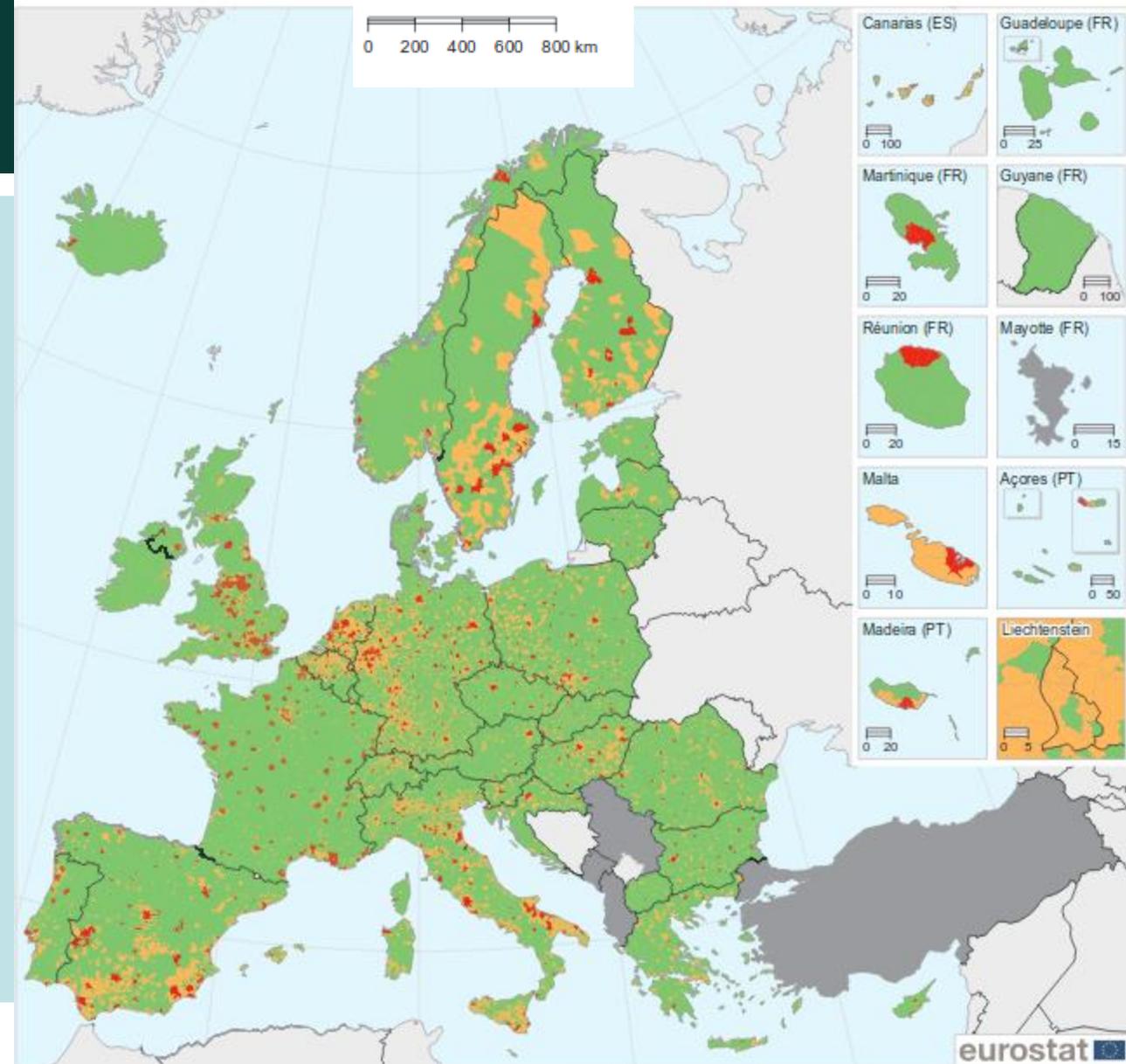
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- Two linked definitions are being tested:
 - **The degree of urbanisation**
 - The EU-OECD functional urban area definition.
- In 2017, the Food and Agricultural Organization (FAO) has joined this commitment linking it with the Global Strategy to improve Agricultural and Rural Statistics.

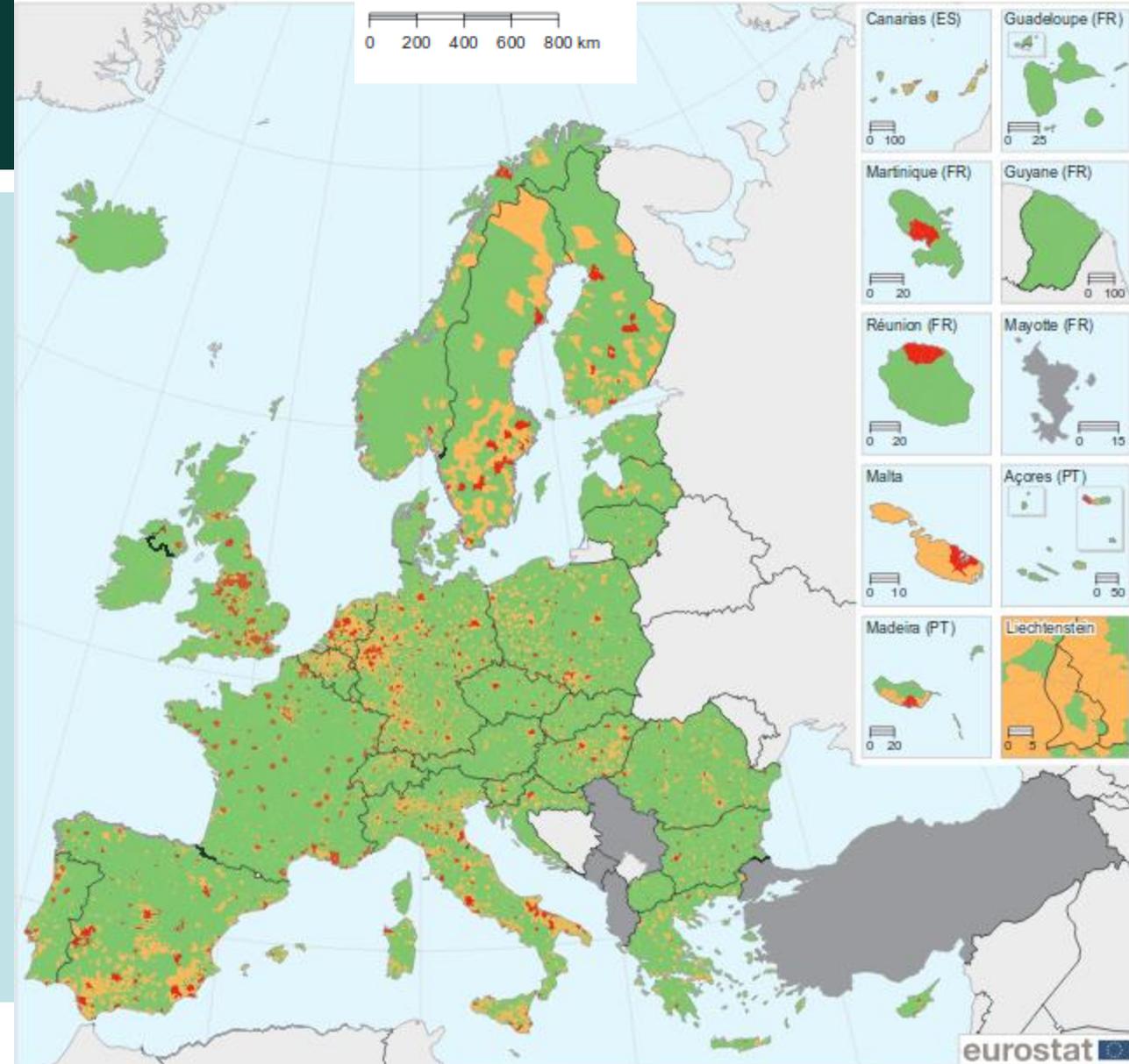
Harmonized Definition of Cities and Rural Areas

- Degree of Urbanization (DEGURBA) - people-base definition
- Classification of municipalities:
 - **Cities** have the majority of their population in an urban centre;
 - **Towns and suburbs** have the majority of their population in an urban cluster, but are not cities;
 - **Rural areas** have the majority of their population in rural grid cells.

Dijkstra, Lewis, and H. Poelmann. "A harmonised definition of cities and rural areas: the new degree of urbanization." European Commission Urban and Regional Policy. Working paper 1 (2014): 2014.

Degree of urbanisation for local administrative units level 2 (LAU2) (*)





9.00-10.30 hrs: Partner showcase session 1:
Global harmonized definition of cities and settlements Lewis Dijkstra, Economic Analysis Unit at European Commission Directorate General for Regional and Urban Policy

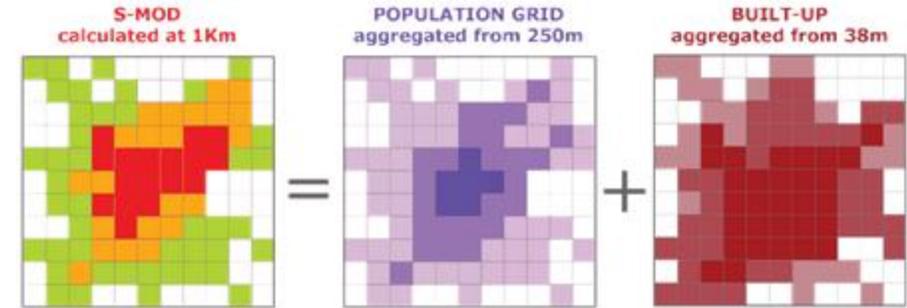
DEGURBA at GRID

DEGURBA at GRID

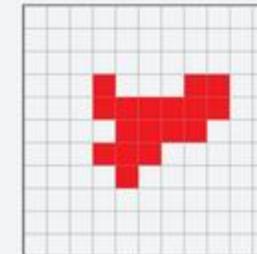
- Urban centre (HDC)
- Urban cluster (LDC)
- Rural cell area

The GHSL Settlement Model

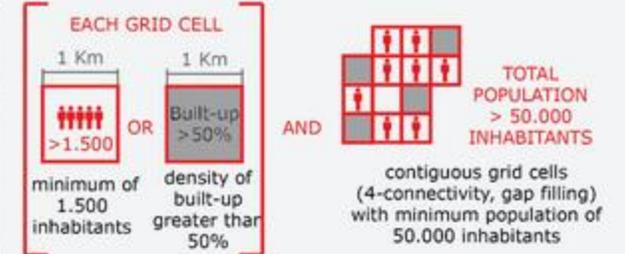
(Porting of the [Degurba model](#) in the GHSL framework)



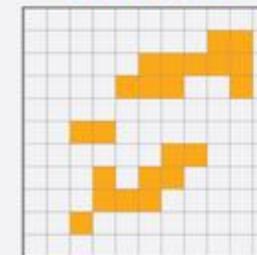
URBAN CENTRE



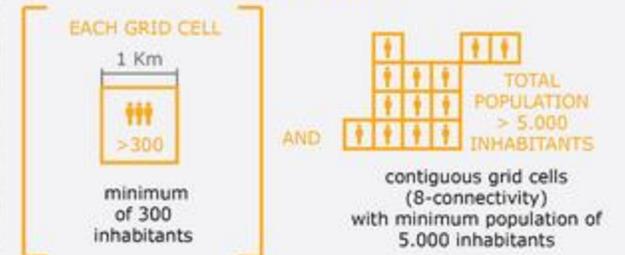
Required conditions



URBAN CLUSTER



Required conditions



DEGURBA at GRID

DEGURBA at GRID

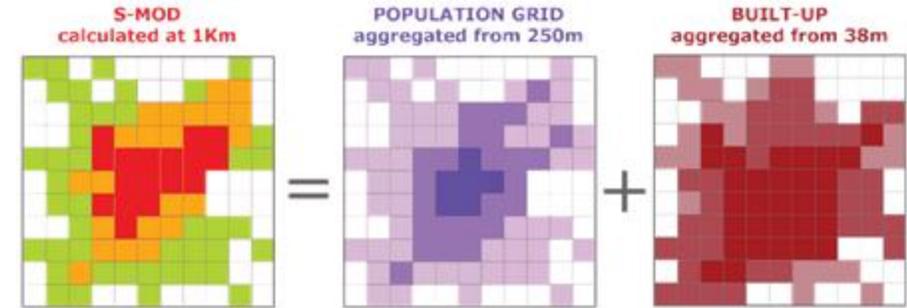
- Urban centre (HDC)
- Urban cluster (LDC)
- Rural cell area

Porting of the *Degree of urbanization (DEGURBA)* in the GHSL framework

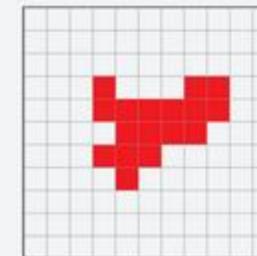
- GHSL Settlement Model – Global harmonized definition of cities and settlements at cell 1km GRID

The GHSL Settlement Model

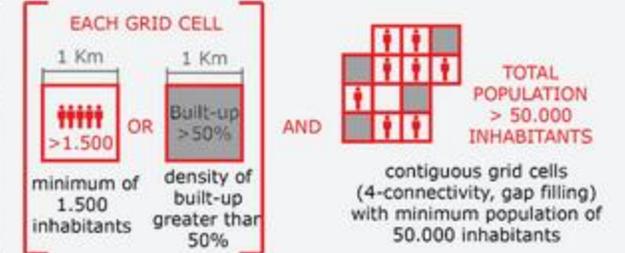
(Porting of the *Degree of urbanization* model in the GHSL framework)



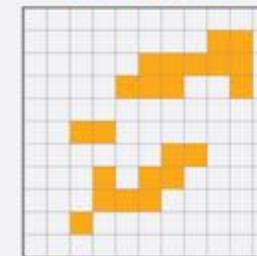
URBAN CENTRE



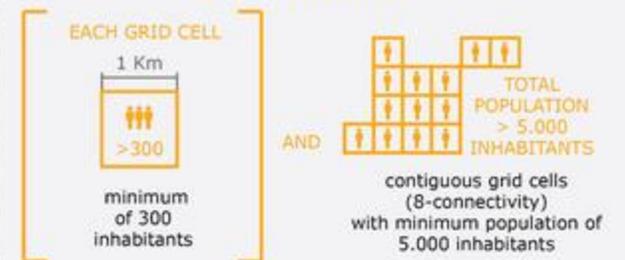
Required conditions



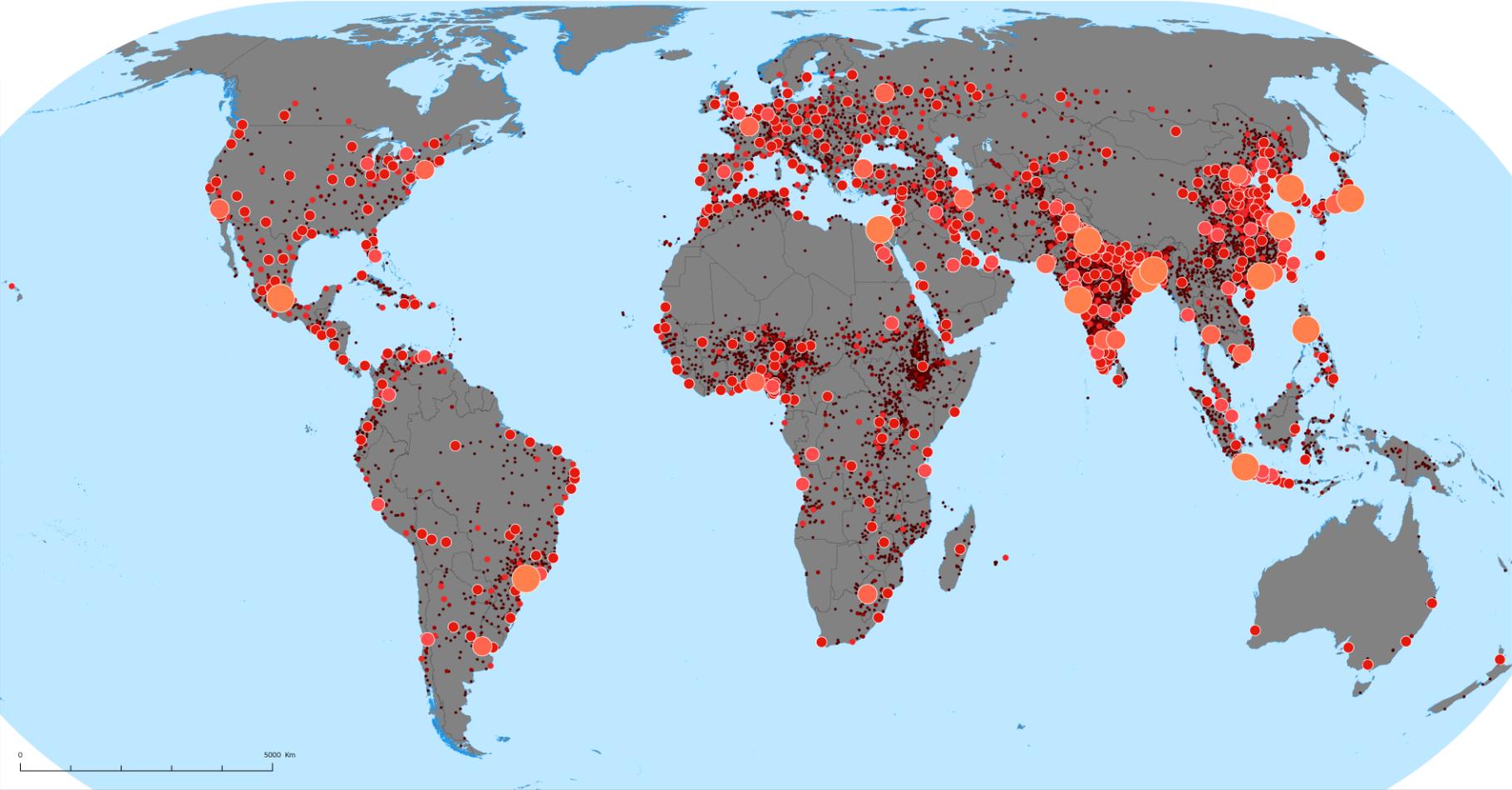
URBAN CLUSTER



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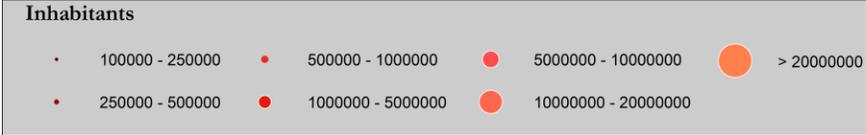


Cities in the world

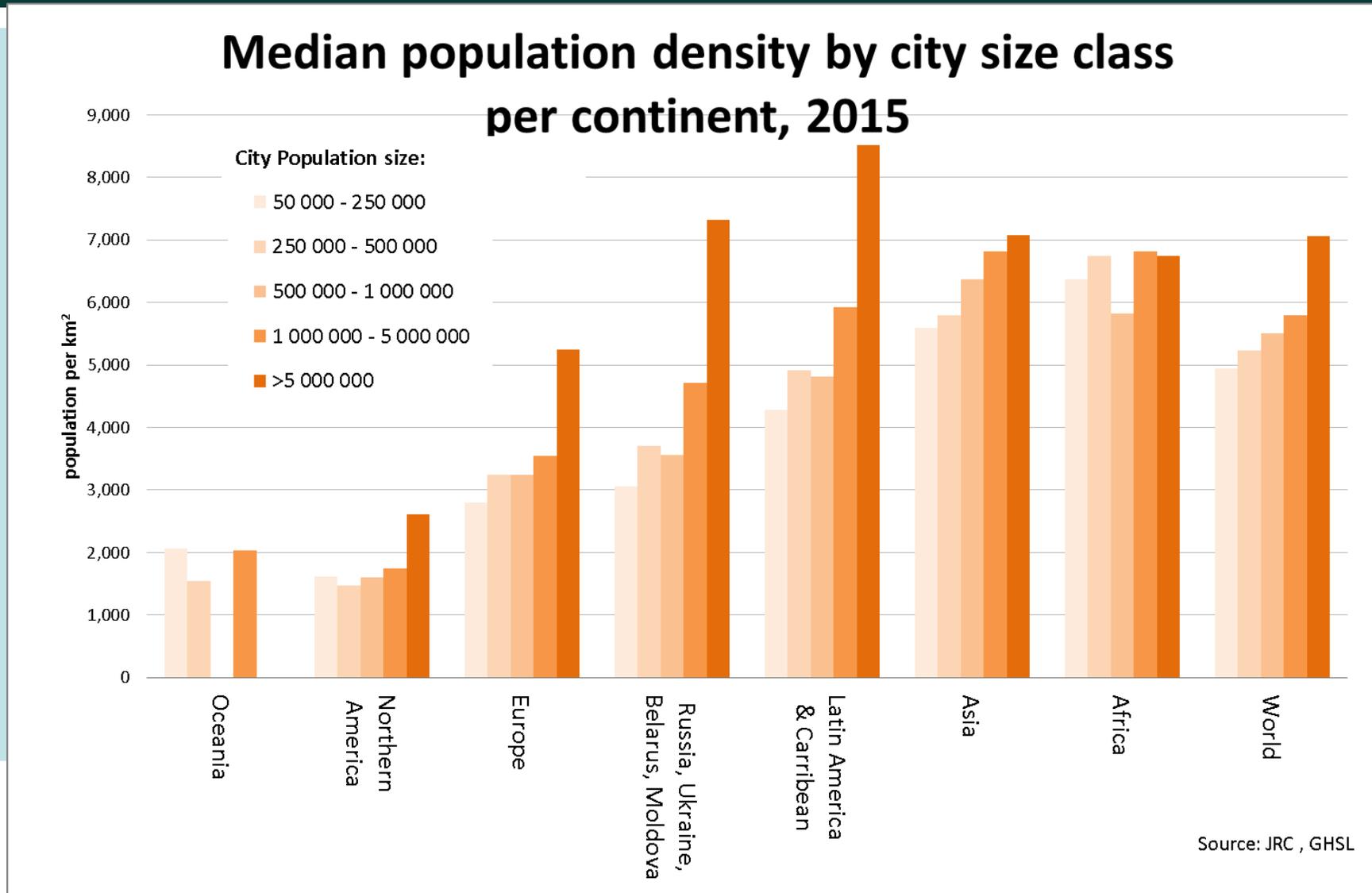


Urban Centres in the world by population size, 2015

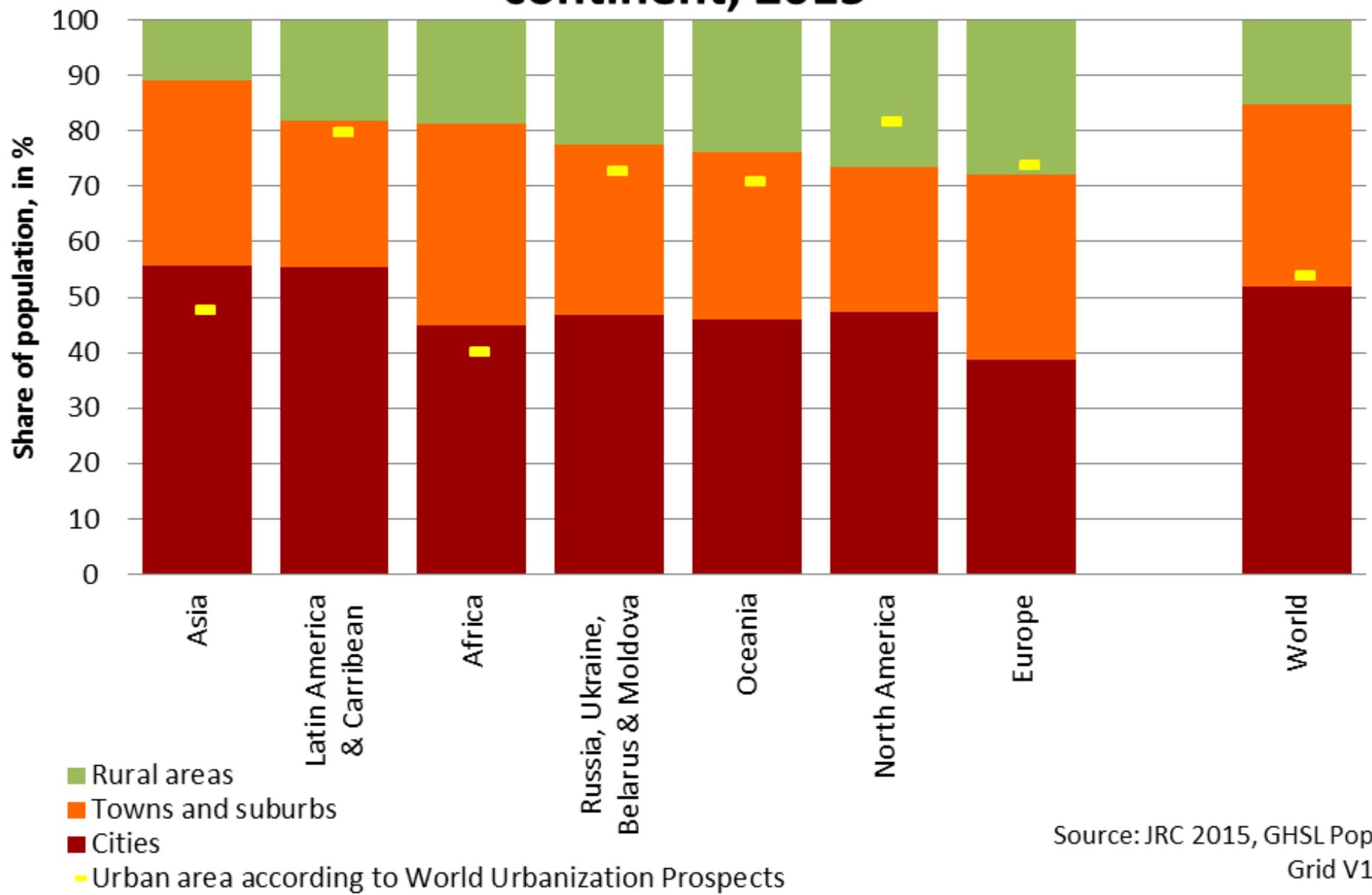
Source : JRC (GHS - POP Global Settlement Model)



Population density by continent



Population by degree of urbanisation per continent, 2015



Source: JRC 2015, GHSL Pop Grid V1

Global Definition of Cities and Settlements

- The country fact sheets in the Degree of urbanisation page are used to inform the discussion on the "global harmonized definition of cities and settlements".

 European Commission | Testing the degree of urbanisation at the Country summary of the Netherlands

Netherlands

Introduction

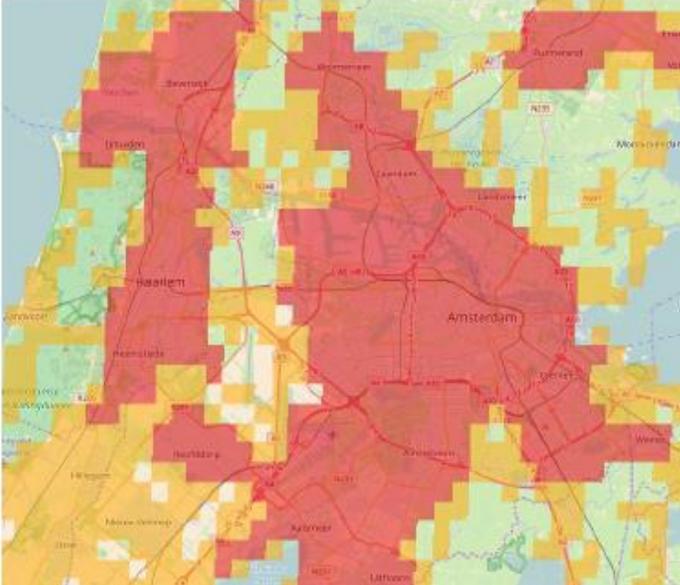
This country summary is provided to support the assessment of the degree of urbanisation by national institutes. The goal of this assessment is to see whether the degree of urbanisation accurately captures cities, smaller settlements and rural areas. Please note that inaccuracies in this country summary may be due to data quality. The results presented are based on a combination of two data sources: population and built-up areas.

The population source data are collected by the [Center for International Earth Science Information](#), mostly from the national statistical offices - more information on the reference years and the geographies found below.

Built-up areas are detected by the European Commission's Joint Research Centre using the Global Human Layer method on satellite imagery from Landsat. The degree of urbanisation can be applied to other data (e.g. census updates, better spatial resolution) to improve the available classification.

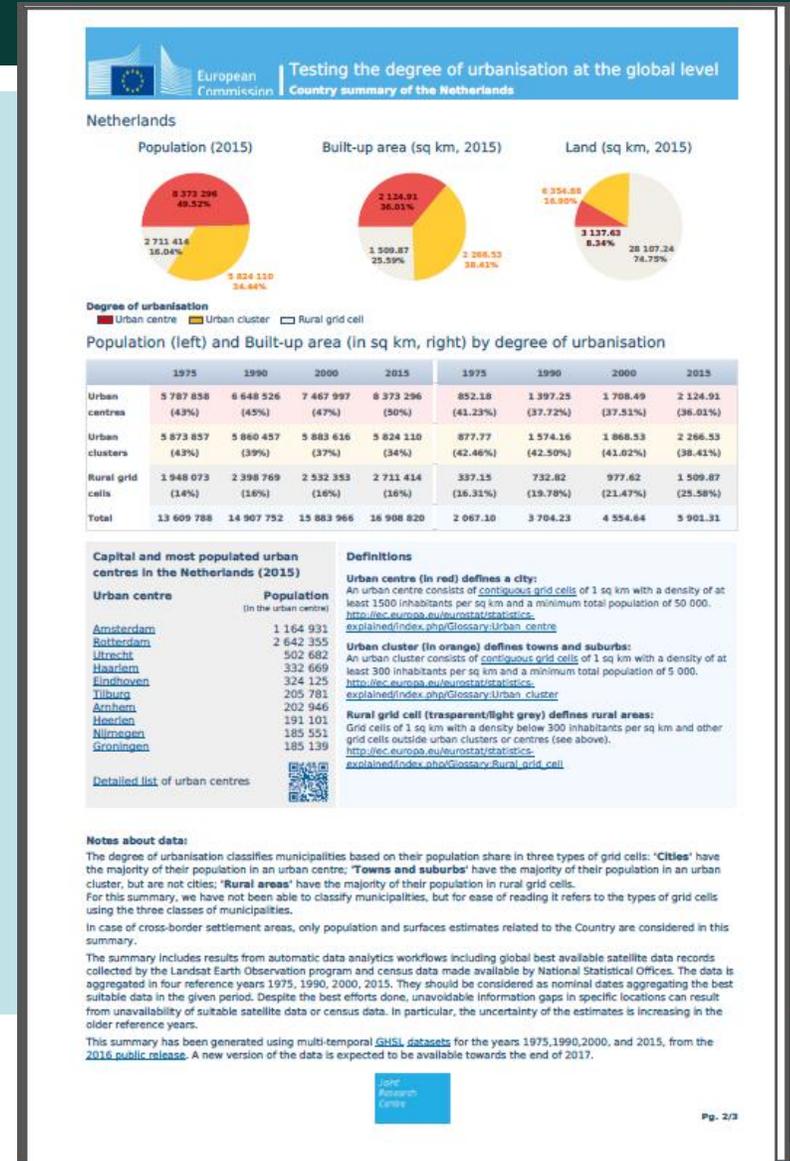
The degree of urbanisation is applied first to a population distribution grid. The results at the grid level are subsequently used to classify municipalities. This second step could not be applied to the globe as it was not consistently available.

Amsterdam, Netherlands



Global Definition of Cities and Settlements

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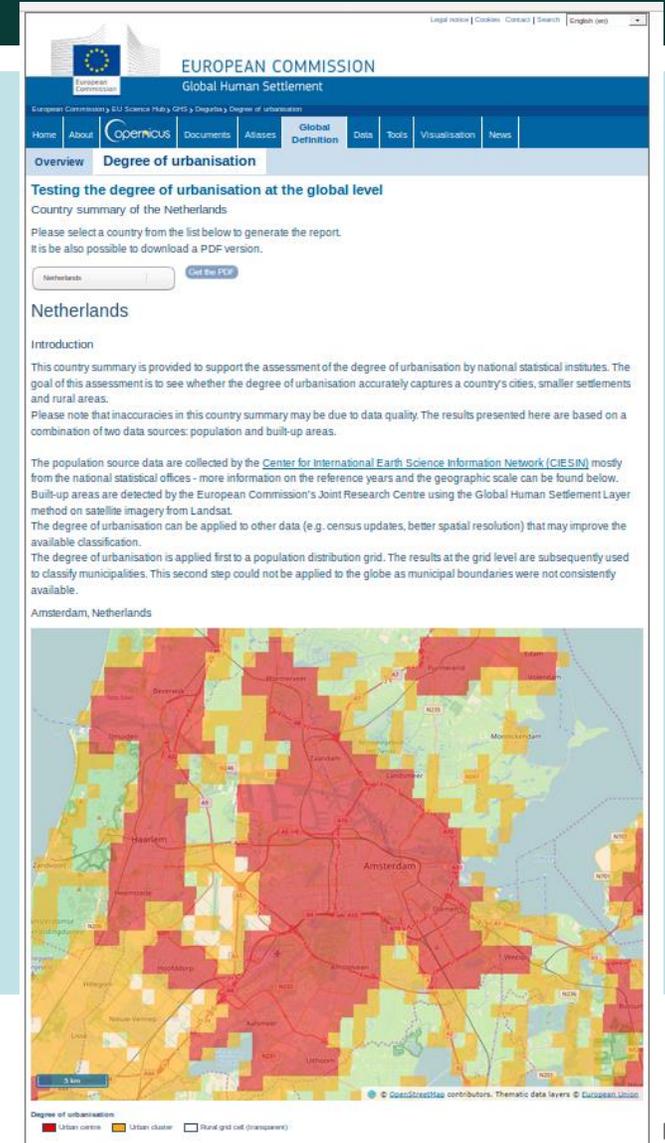
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Global Definition of Cities and Settlements

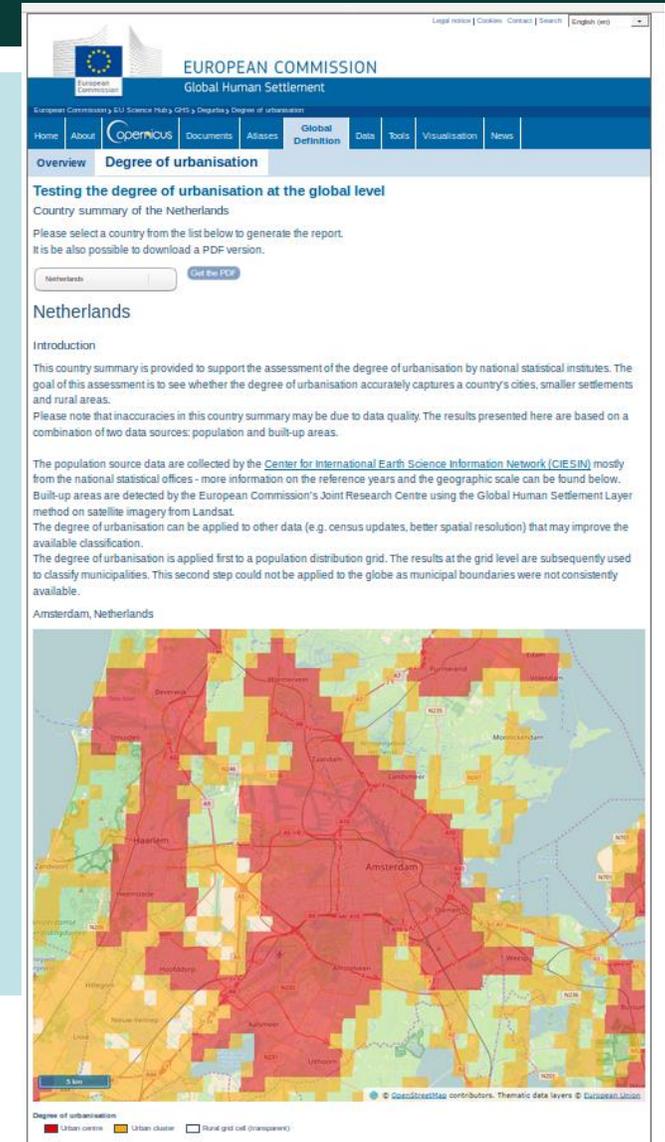
- The country fact sheets in the Degree of urbanisation page are used to inform the discussion on the "global harmonized definition of cities and settlements".
- The data supporting the new global definition of the degree of urbanisation can be visualised on this interactive map



The screenshot displays the European Commission's Global Human Settlement website. The page is titled "Degree of urbanisation" and provides a country summary for the Netherlands. It includes a navigation menu with options like Home, About, COPELICUS, Documents, Atlases, Global Definition, Data, Tools, Visualisation, and News. The main content area features a search bar, a "Get the PDF" button, and an introduction section. Below the text, there is a map of the Netherlands showing the degree of urbanisation, with a legend indicating "Urban centre" (red), "Urban cluster" (orange), and "Rural grid cell (transparent)" (white). The map shows a high concentration of urban centers in the western part of the country, particularly around Amsterdam.

Global Definition of Cities and Settlements

- The country fact sheets in the Degree of urbanisation page are used to inform the Degree discussion on the "global harmonized definition of cities and settlements".
- The data supporting the new global definition of the degree of urbanisation can be visualised on this interactive map
- Degree of Urbanisation GRID (DUG) tool
 - GHSL tool suite

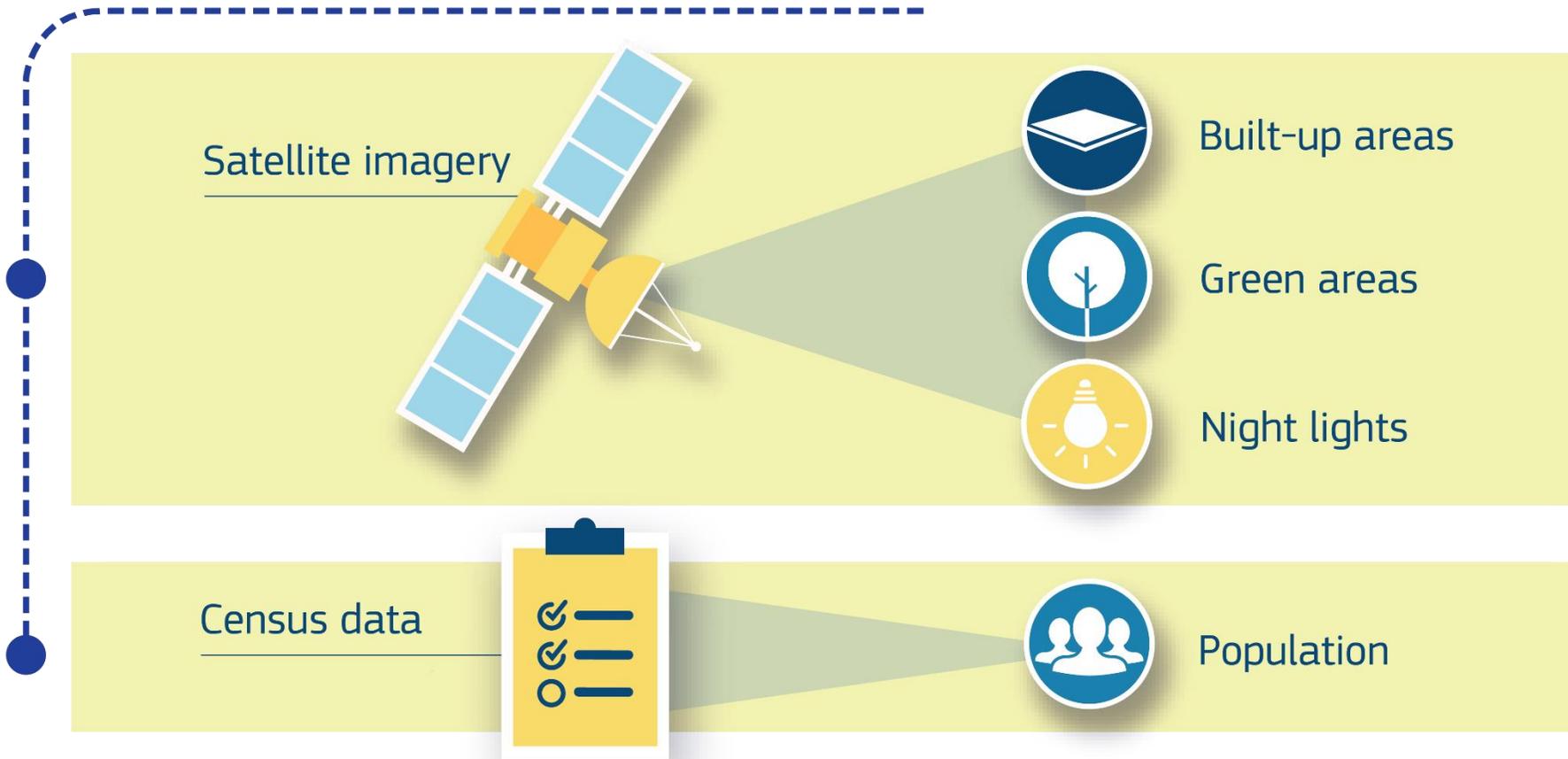




the Global Human Settlement Layer

the most **complete**, **consistent**, **global**, **free** and **open** dataset on human settlements – from the village to the megacity

Spatial info

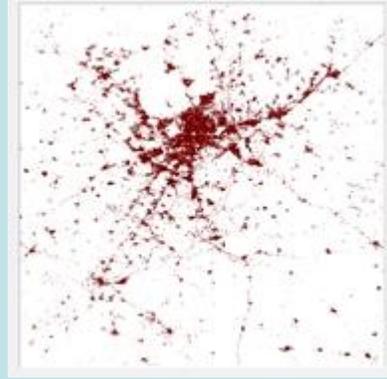


Creating a global built-up grid

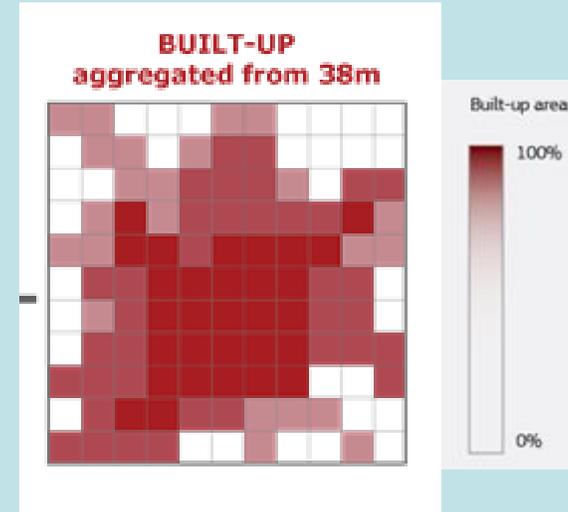
Satellite imagery is processed to extract buildings



Share of area covered by buildings based on satellite imagery

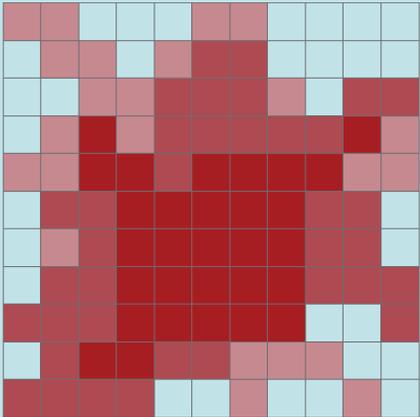


Share of area covered by buildings aggregated to 1 km grid cells



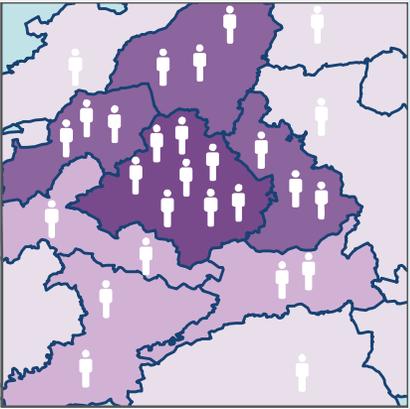
Creating a global population grid

Share of area covered by buildings based on satellite imagery



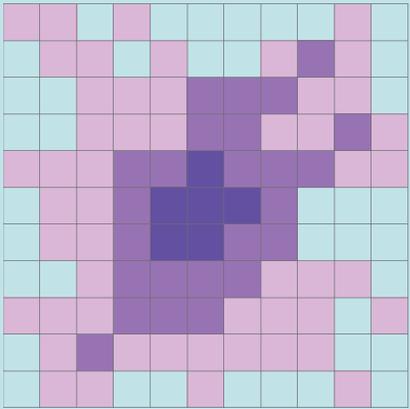
Source: JRC GHSL

Census data on population



Source: CIESIN, Columbia University

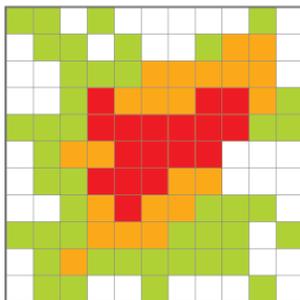
Total population by 1km grid cell



Source: JRC GHS Pop

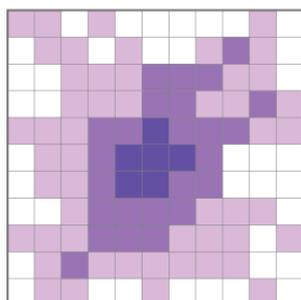
+ =

S-MOD
calculated at 1Km



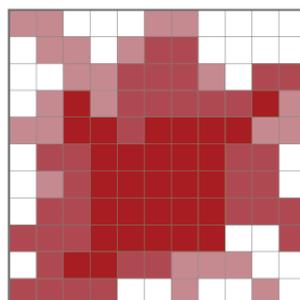
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POPULATION GRID
aggregated from 250m

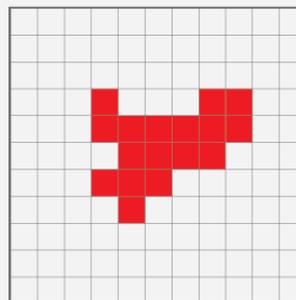


+

BUILT-UP
aggregated from 38m



URBAN CENTRE

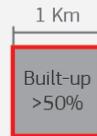


EACH GRID CELL



minimum of
1.500
inhabitants

OR



density of
built-up
greater than
50%

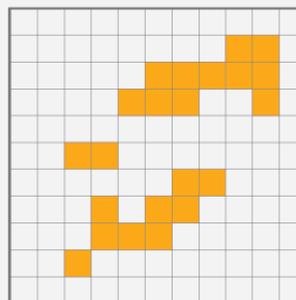
Required conditions



AND

contiguous grid cells
(4-connectivity, gap filling) with
minimum population of 50.000
inhabitants

URBAN CLUSTER



EACH GRID CELL



minimum of
300
inhabitants

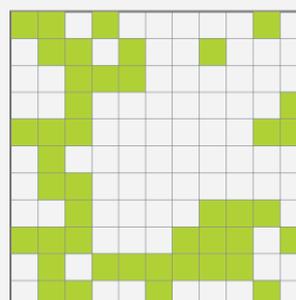
Required conditions



AND

contiguous grid cells
(8-connectivity)
with minimum population of 5.000
inhabitants

RURAL



EACH GRID CELL



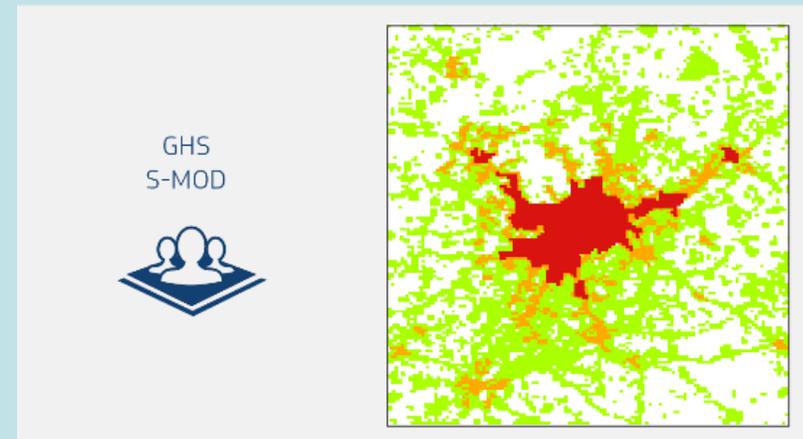
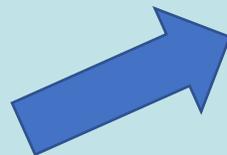
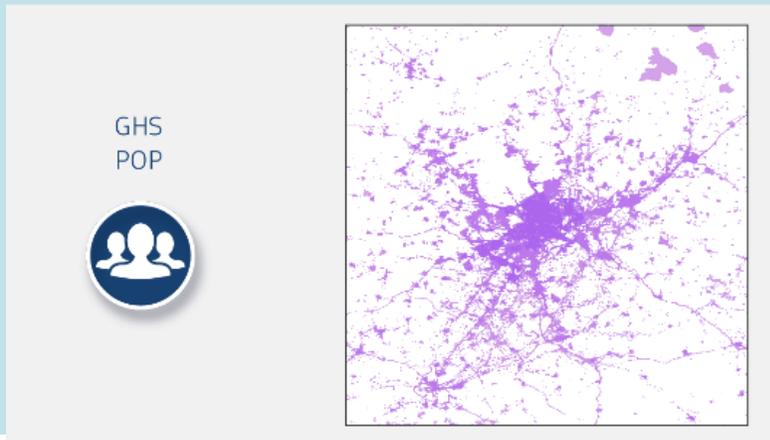
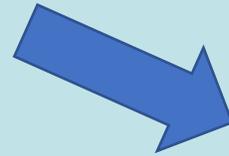
cell with
inhabitants

Required conditions

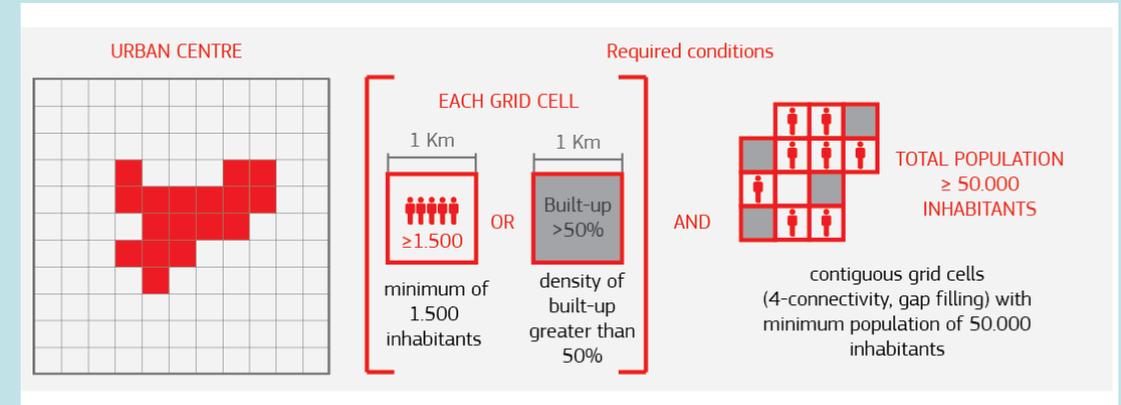
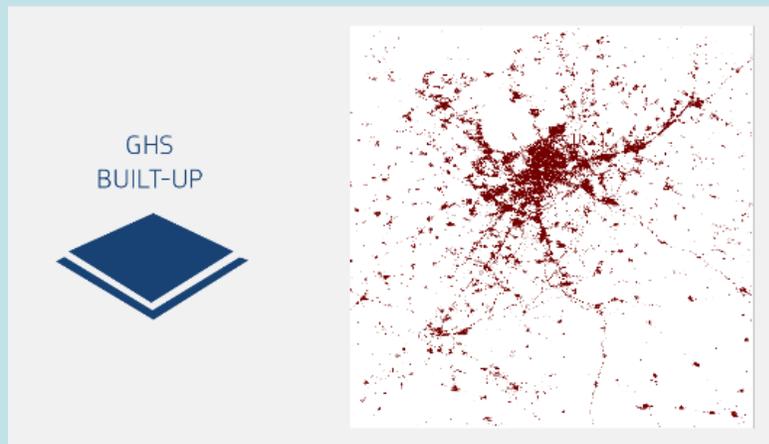
GHSL Data production workflow



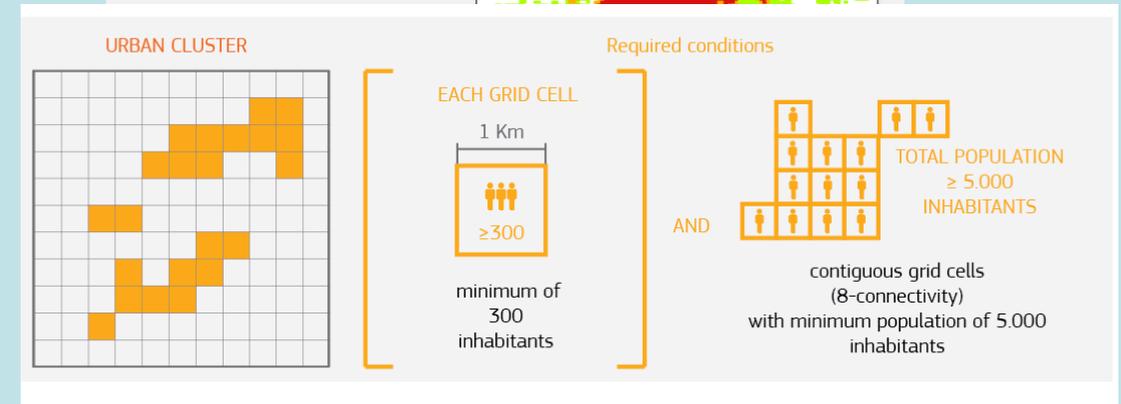
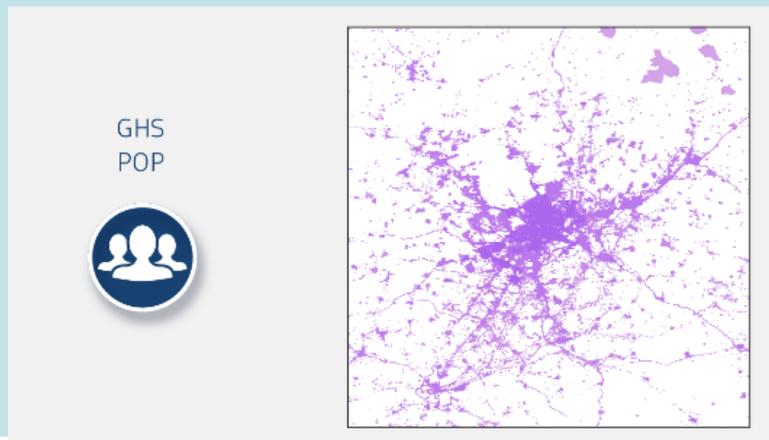
DUG tool



DUG tool



S-MOD



Resources

- GHSL web site
 - <http://ghslsys.jrc.ec.europa.eu/>



The screenshot shows the European Commission website page for 'Global Human Settlement' and 'Degree of urbanisation'. The page features the European Commission logo and navigation menu. The main content area is titled 'Global Definition of Cities and Settlements' and contains several paragraphs of text. A small map is visible in the lower right section of the page.

EUROPEAN COMMISSION
Global Human Settlement

Home About **OPERNICUS** Documents Atlases **Global Definition** Data Tools Visualisation News

Overview **Degree of urbanisation**

Global Definition of Cities and Settlements

During the UN-Habitat III conference in October 2016, the European Union, the OECD and the World Bank [launched a voluntary commitment](#) to develop a global, people-based definition of cities and settlements. This commitment will support the implementation of the new urban agenda. It will also support the monitoring and the comparison of the urban Sustainable Development Goal (SDG). Several of the indicators linked to this goal are highly sensitive to where the boundary is drawn around a city.

The goal of the commitment is to present a definition to the UN Statistical Commission in 2019. Two linked definitions are being tested: The [degree of urbanisation](#) and the [EU-OECD functional urban area](#) definition.

In 2017, the Food and Agricultural Organization (FAO) has joined this commitment linking it with the [Global Strategy to Improve Agricultural and Rural Statistics](#).

This UN-Habitat [Global Urban Lecture](#) explains why such a definition is needed.

The country fact sheets in the [Degree of urbanisation](#) page are used to inform the [discussion on the "global harmonized definition of cities and settlements"](#).

The data supporting the new global definition of the degree of urbanisation can be visualised on this [interactive map](#).

Further reference

[This schema](#), extracted from the [Atlas of the Human Planet 2016 - Mapping Human Presence on Earth](#), shows the methodology used for the application of the model to the GHSL data.

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Resources

- GHSL web site
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The screenshot shows the 'Degree of urbanisation' page on the European Commission's Global Human Settlement website. The page title is 'Global Definition of Cities and Settlements'. The main text describes the commitment to develop a global, people-based definition of cities and settlements, launched during the UN-Habitat III conference in October 2016. It mentions the goal of presenting a definition to the UN Statistical Commission in 2019 and the two linked definitions being tested: the 'degree of urbanisation' and the 'EU-OECD functional urban area' definition. It also notes that in 2017, the Food and Agricultural Organization (FAO) joined the commitment, linking it to the 'Global Strategy to Improve Agricultural and Rural Statistics'. A small satellite image of a city is visible at the bottom right of the page content.

The screenshot shows the 'Overview' page on the European Commission's Global Human Settlement website. The page title is 'Global Human Settlement'. The main text describes the GHSL image analytics framework, which has been tested with a large set of sensors including radar and optical public and commercial missions. It mentions bi-lateral agreements of JRC with European institutions and institutions in China, Brazil and South Africa, which are currently producing continental and country-wide human settlement information layers by application of the GHSL technology to their proprietary image data. The page also mentions the general methodology behind GHSL data, which introduces concepts of GHS BUILT-UP, GHS POP, and the GHS Settlement Model. It states that the main datasets are offered for download as open and free data, and that the GHS P2016 suite consists of multitemporal products, that offers an insight into the human presence in the past 1975, 1990, 2000, and 2014. The European Settlement Maps are pan-European built-up layers derived from higher resolution imagery. The experimental products are available to the members of the GEO Human Planet Initiative, including GHSL analytics extracted from Sentinel 1, the GHSL Label data (an experimental LandCover product from Landsat imagery), and past GHSL Landsat products. The GHSL products, including the experimental GHSL built-up information layer derived from Sentinel 1, can be explored and visually compared in the visualisation page.

The diagram illustrates the GHSL data flow and products. It shows the process starting with 'Spatial info' (Satellite imagery) and 'References' (Census data). The 'Spatial info' is processed into 'GHS Products' (GHS BUILT-UP, GHS POP, GHS S-MOD). The 'References' are used to validate the 'GHS Products'. The 'GHS BUILT-UP' is further processed into 'GHS S-MOD'. The diagram also shows the 'GHS BUILT-UP' and 'GHS POP' products being used to generate 'GHS S-MOD'.

Resources

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EUROPEAN COMMISSION
Global Human Settlement

Overview Degree of urbanisation

Global Definition of Cities and Settlements

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EUROPEAN COMMISSION
Global Human Settlement

Visualisation

Layers selected:

- Built-up - Sentinel-1 (resolution: approx. 20m): none
- Built-up - P2016 (resolution: approx. 38m): none
- Residential population - P2016 (resolution: 250m): none
- Degree of urbanisation* - P2016 (resolution: 1km): SMod 2015

Base: Marker, OSM, Place names

*Porting of the Degurba model in the GHSL framework (SMOD).

Disclaimer:

The designations employed and the presentation of material on this map do not imply the expression of any opinion whatsoever on the part of the European Union concerning the legal status of any territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

Footnote: This designation is without prejudice to positions on status, and is in line with UNSCR 1344/1999 and the ICJ Opinion on the Kosovo declaration of independence.

Footnote: This designation shall not be construed as recognition of a State of Palestine and is without prejudice to the individual positions of the Member States on this issue.

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Global Human Settlement

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Overview Degree of urbanisation

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Tools

The GHSL framework aims to provide new spatial data mining technologies for the automatic processing, analytics and knowledge extraction from large amount of heterogeneous spatial data.

These new tools are used by GHSL to produce new global information that is contributing to new global findings.

The new data mining technologies are openly documented and are freely available for the user and the scientific communities.

This policy aims to improve the reproducibility of the GHSL results, and their scientific and public test by independent parties. The free availability of the analytical tools aims to facilitate the exploitation of the research and development efforts made by the EC JRC, to decrease the information production cost, to facilitate the information sharing, and to democratize the information production also in case of large and complex spatial data analytics scenarios.

AAXY - Associative Analysis between X and Y

AAXY stands for associative analysis between X and Y. The AAXY is a general tool allowing to perform associative analysis between any spatial data instances (continuous, or symbolic) X and abstract (symbolic) spatial data instances Y.

In the AAXY the analytics task is done by Symbolic Machine Learning (SML) operating on the X data instances translated to data sequences and by implementation of an objective data association interestingness measure called Evidence-based Normalized Difference Index (ENDI).

The AAXY tool is the core technology that was used to solve the problem to translate the global remote sensing data records from heterogeneous sensors available since the epoch 1975, to the abstract class of "built-up areas" as required by the GHSL baseline data production.

The SML approach was introduced in [A New Method for Earth Observation Data Analytics Based on Symbolic Machine Learning](#).

The SML was demonstrated superior to the state-of-the-art machine learning approaches in remote sensing data scenarios where larger noise is present in the learning set and abstract classes are ill-defined in the feature space ([Benchmarking of the Symbolic Machine Learning classifier with state of the art image classification methods - application to remote sensing imagery](#)).

The SML is considered a suitable solution for spatial big data analytics tasks [Analyzing big remote sensing data via symbolic machine learning](#).

Downloads

- AAXY Tool (29.2 MB)
- End User License Agreement (181 KB)
- User Guide (1 MB)
- Tutorial (2.46 MB)
- Tutorial files (32.6 MB)

References

- [A New Method for Earth Observation Data Analytics Based on Symbolic Machine Learning](#)
- [Analyzing big remote sensing data via symbolic machine learning](#)
- [Benchmarking of the Symbolic Machine Learning classifier with state of the art image classification methods - application to remote sensing imagery](#)
- [Operating procedure for the production of the Global Human Settlement Layer from Landsat data of the epochs 1975, 1990, 2000, and 2014](#)

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EUROPEAN COMMISSION
Global Human Settlement

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Visualisation

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Layers selected:

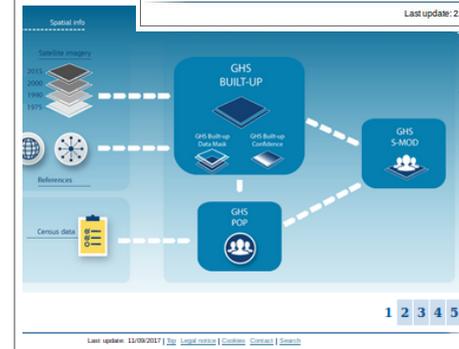
- Built-up - Sentinel-1 (resolution: approx. 20m): none
- Built-up - P2016 (resolution: approx. 38m): none
- Residential population - P2016 (resolution: 250m): none
- Degree of urbanisation* - P2016 (resolution: 1km): SMod 2015

Base: Marker, OSM, Place names

*Porting of the Degurba model in the GHSL framework (SMOD).

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Any questions?

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