



Data and tool training

Built-up Area extraction with the Massive Automatic Spatial Data Analytics (MASADA) tool

Date: 12 September 2017

Trainer: Dr. Christina Corbane, European Commission, Joint Research Centre (JRC)

Venue: University of Twente, Faculty ITC

Program

Morning session

9.00 - 12.30 hrs.

- The Global Human Settlement Layer (GHSL) concept: data analytics, knowledge extraction and global products
- The Symbolic Machine Learning (SML) classifier for mapping human settlements from remote sensing data
- Operationalizing scientific information into indicators in support for post-international frameworks: key findings from Atlas 2016 and Atlas 2017
- How to access to GHSL data

Afternoon session

13.30 - 17.00 hrs.

- Hands-on computer lab on Built-up extraction with the MASADA tool

Participants must bring their own laptop computer (see requirements below)

Basic knowledge of GIS, remote sensing and data analysis

Software: Quantum GIS or ArcGIS, Matlab runtime 2016b

Minimum Hardware requirements for running MASADA: 16 GB of RAM - Any Intel or AMD x86-64 processor, 100 Mb (+700 Mb for Matlab Runtime) disk space for installation and the Matlab Runtime version 2016b. The supported OS are 64-bit Win7-Win10.



Global Human Settlements Layer

<http://ghsl.jrc.ec.europa.eu>

Pesaresi M., Corbane C., Syrris V., Kemper T., Politis P., Soille P., Florczyk A., Sabo F.,
Rodriguez Aseretto R., Maffenini L., Ferri S., Freire S., Ehlich D. Siragusa A.,
Zanchetta L., Airaghi D.

CONCEPTS AND DEFINITIONS



New open and free high resolution information layer

Describing the status of human settlements and their dynamics both in terms of built-up and population.

New technology

For automatic image information extraction from massive volumes of satellite data

A platform

- Integrating different sources contributing to describe the human settlement facts and figures

- Supporting post-2015 international frameworks



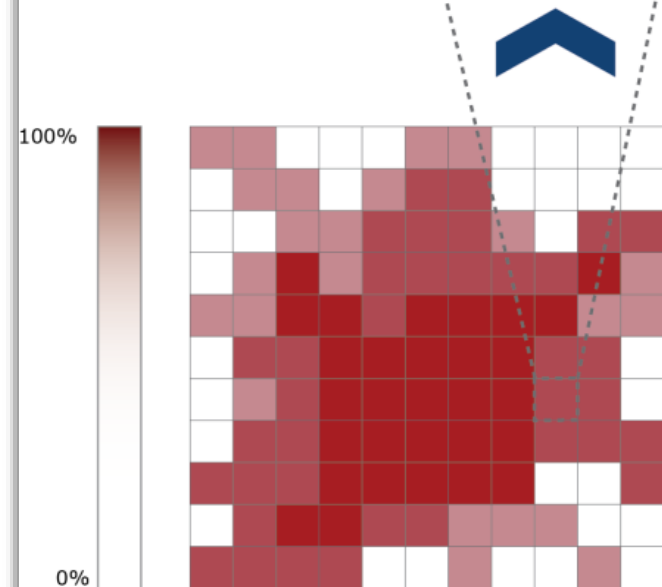
Artificial built-up surface :

- Areas (spatial units) where buildings can be found
- Subset of “artificial surfaces”

Epistemology of settlement:

- Physical description focused on the presence of dwellings
- Made of parts: building/dwelling, roads, open spaces
- Any dwelling included – tents to skyscraper
- Any size included – from hamlet to megacity

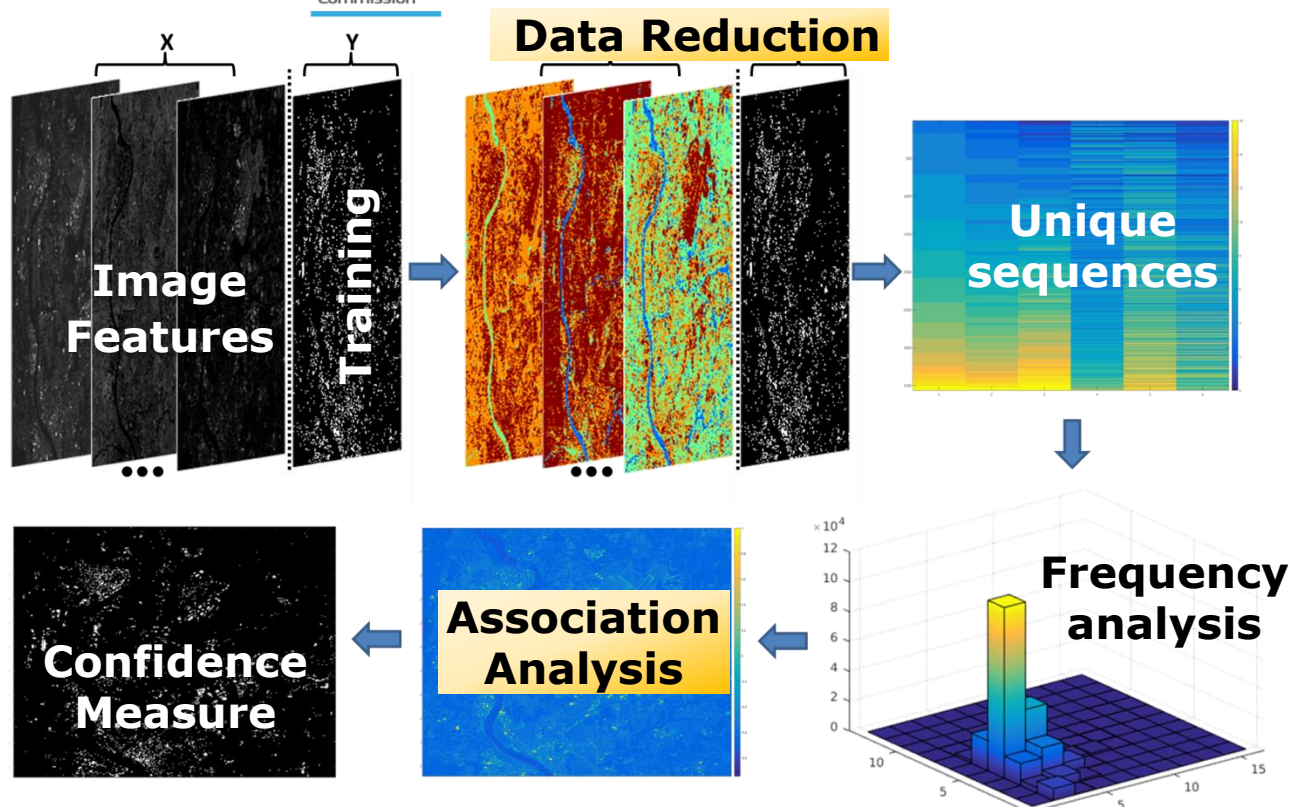
Built up area is typically expressed with a continuous values representing **the proportion of building footprint area within the total size of the cell.**





Built-up area" = all spatial units (e.g. 30x30m /sensor dependent) where a building or part of a building can be recognized

Symbolic Machine Learning (SML)



METHODS AND TOOLS: MULTIPLE CLASS EXTRACTION



Input data in "false color" composite at 2.5 m spatial resolution



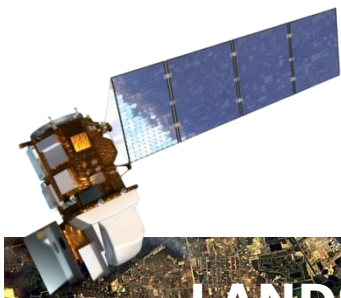
Classes of the reference set extracted from the Land Cover at 100 m resolution



Result of SML classification at 2.5 m spatial resolution.

*Pesaresi M., V. Syrris and Julea A.M. **Benchmarking of the Symbolic Machine Learning classifier with state of the art image classification methods - application to remote sensing imagery.** EUR 27518 EN, 2015. doi:10.2788/638672.*

BUILT-UP INFORMATION FROM MULTIPLE SENSORS



LANDSAT



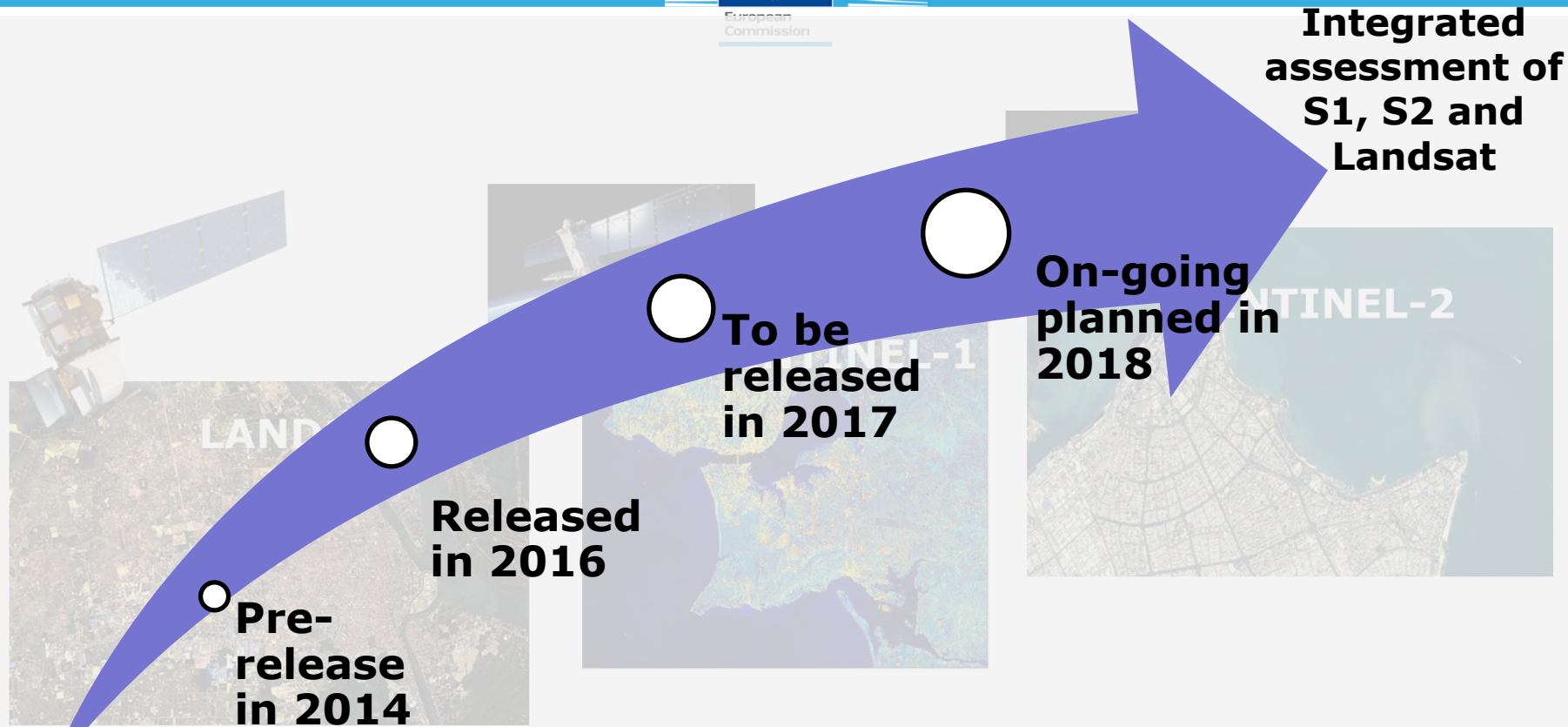
SENTINEL-1



SENTINEL-2



BUILT-UP INFORMATION FROM MULTIPLE SENSORS



A false-color satellite image of a landscape. A winding river, colored blue, flows through a dense forest. The forest is represented by a mix of green and yellow pixels, indicating different vegetation types or health. The background is a dark, textured surface, possibly water or a different type of land cover. The overall image has a high-contrast, digital appearance.

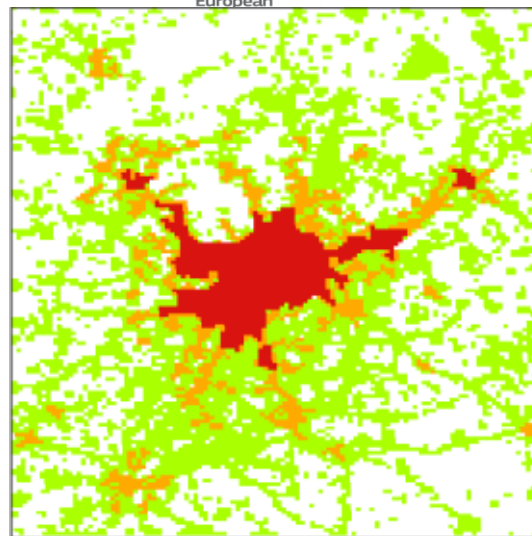
GHSL LANDSAT

1979-1990-2000-2014






First available multi-temporal assessment of human settlements

GHSL LANDSAT-DERIVED GLOBAL PRODUCTS



Settlement classification

-  Rural
-  Urban Cluster
-  Urban Centre

	GHS_BUILT-UP	GHS_POP	GHS_SMOD
Definition	Global built-up grids	Global population grids	Global human settlement model
Epoch	1975, 1990, 2000, 2015	1975, 1990, 2000, 2015	1975, 1990, 2000, 2015
Resolution	38 m, 250 m, 1 km	250 m, 1 km	1km

GHSL – Baseline data anatomy



Fine-scale built-up areas
1975,1990,2000,2014
Landsat 75,30,15m



Population grids
1975,1990,2000,2015
250m

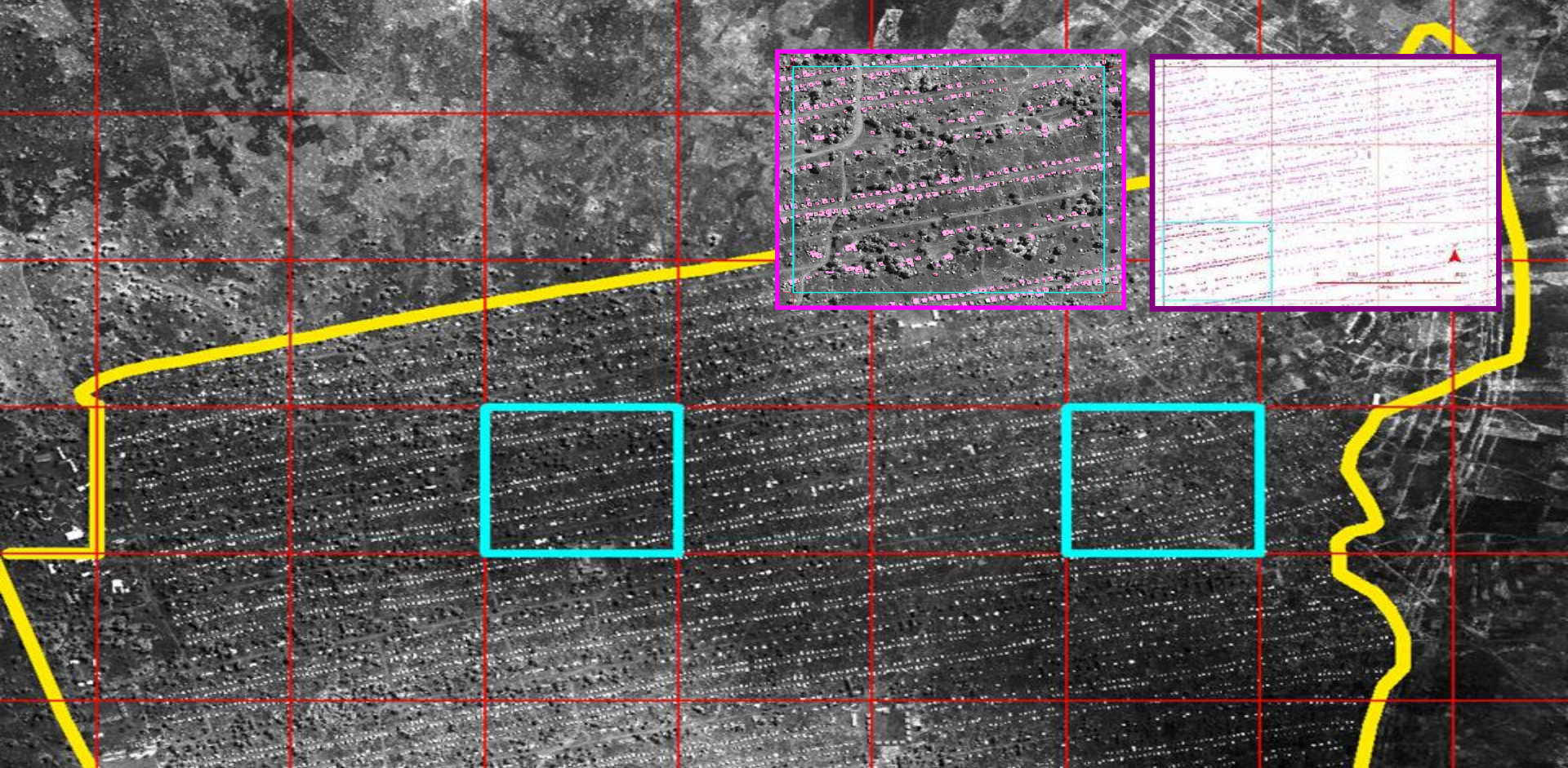


Settlement model
1975,1990,2000,2015
250m , 1000m
Harmonized city spatial footprint
“from the hamlet to the megacity”





GHSL BUILT-UP GRIDS

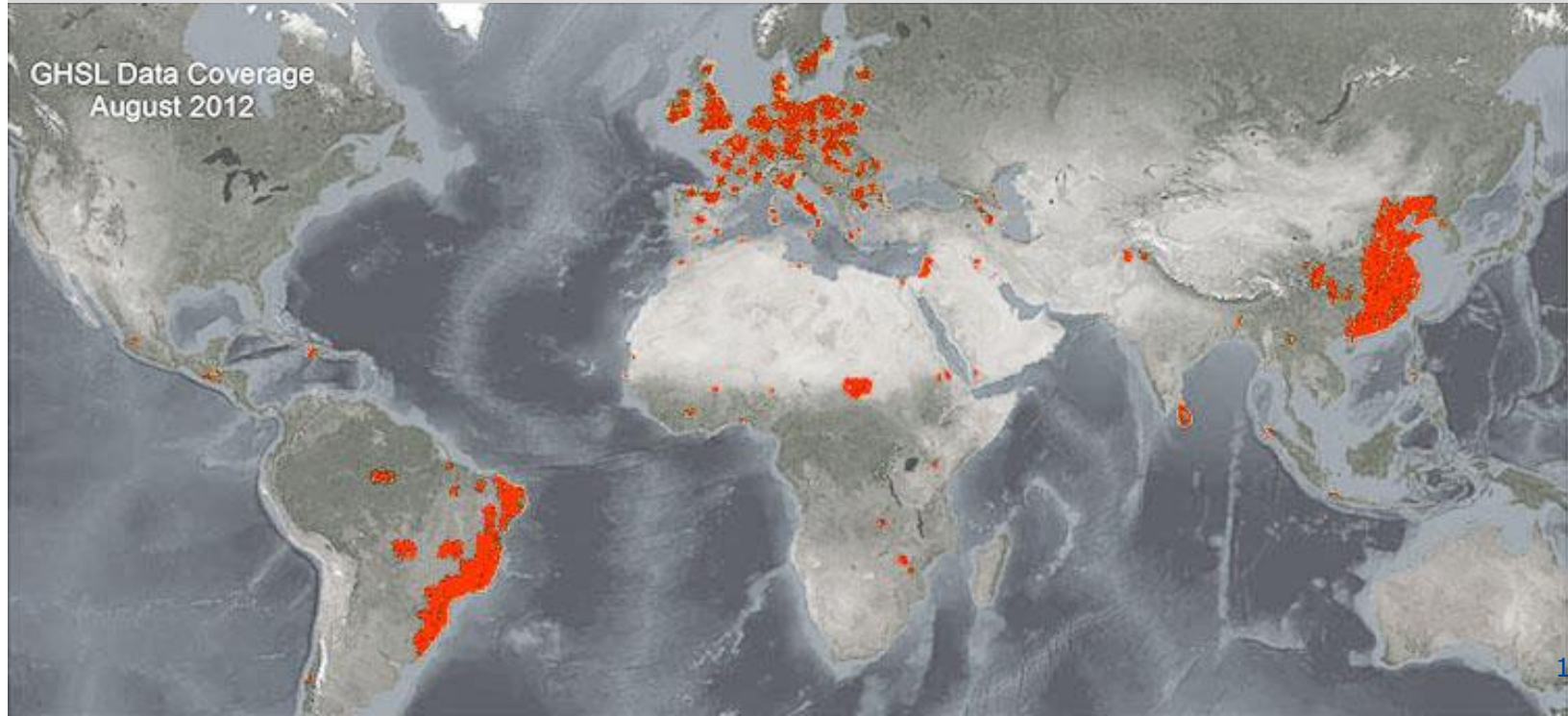


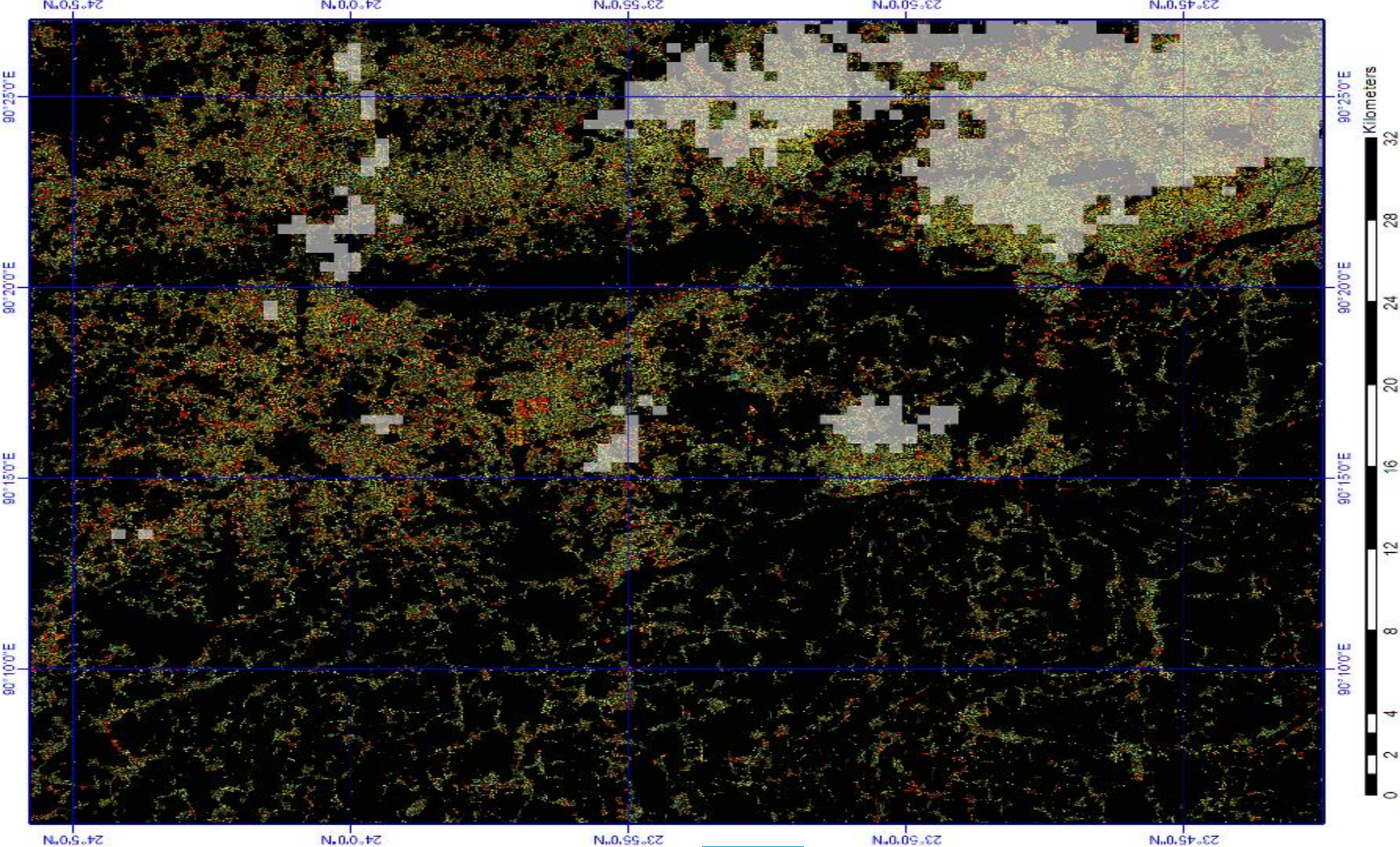
2003 – first tests on automat. enumeration of tents
Lukole refugee camp, Tanzania. Input Ikonos data 1,4-m-res



HR Global Human Settlement Layer

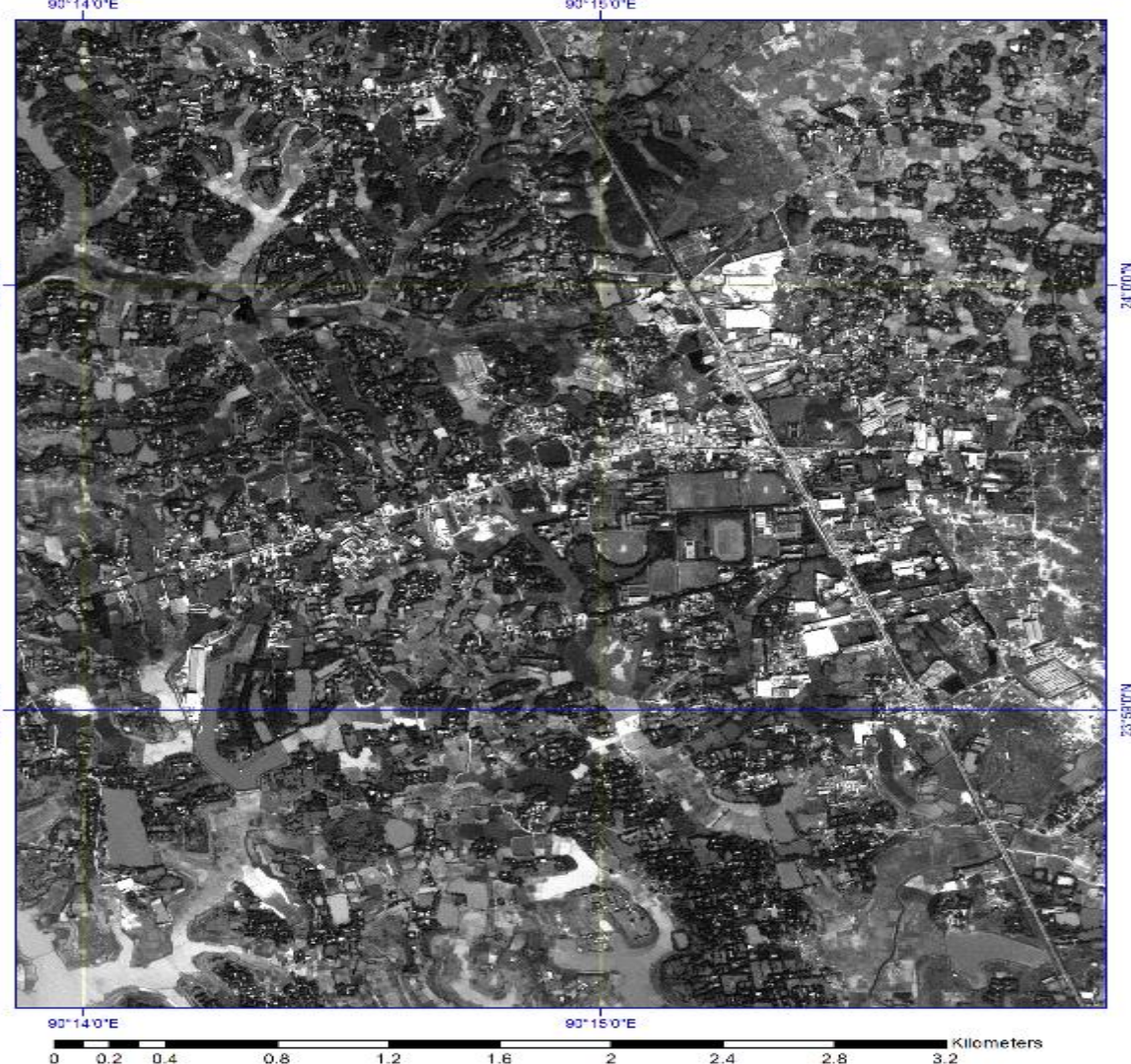
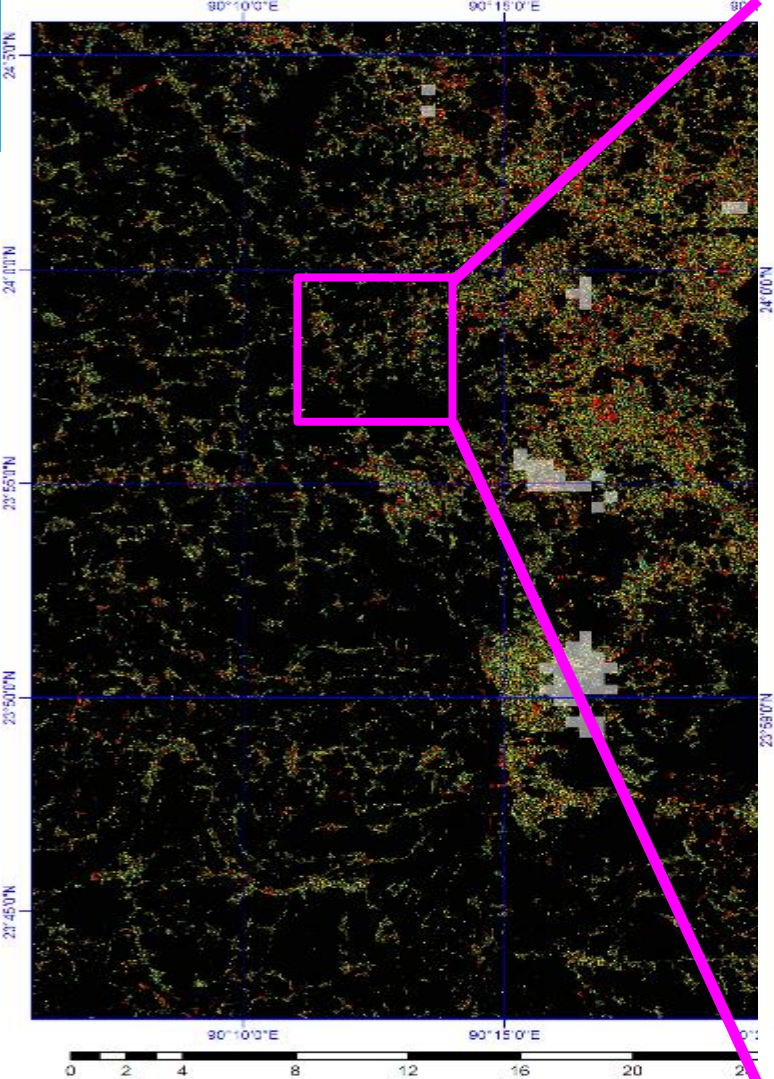
Proof of concept 1st operational test 2012





Dhaka, HR GHSL

(white: LR MODIS Urban layer, color: HR GHSL)





**2012: Fine scale analysis of the whole European settlements using 2.5-m-res input image data
(GMES/Copernicus CORE003 2012)**

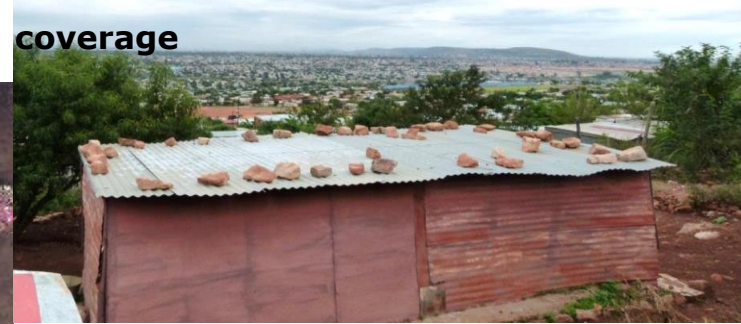
Credits: European Commission, DG Regional Development /Joint Research Centre

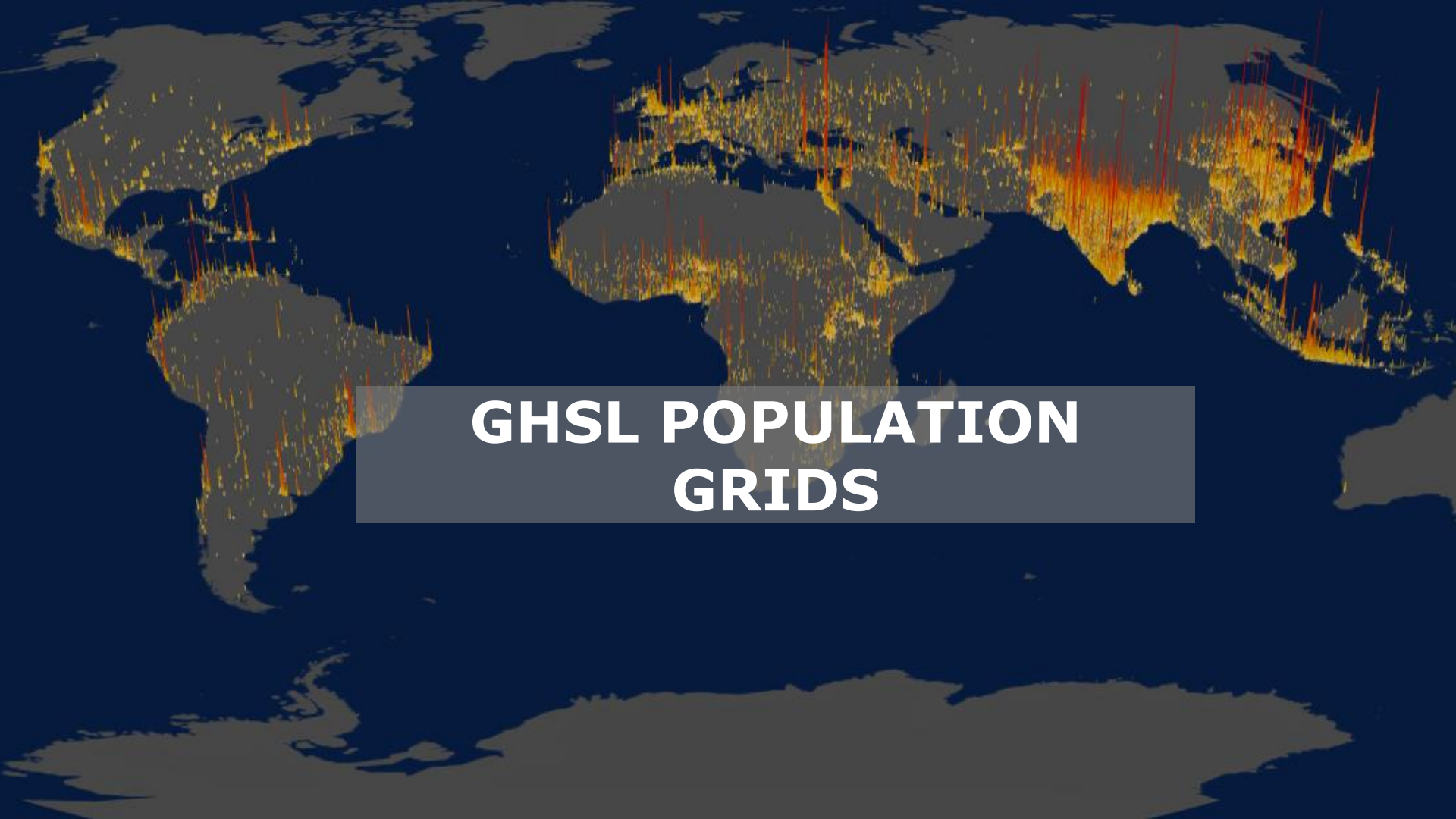
1000

2,000 Meters

**Development of an advanced GHSL
workflow for poor settlement
monitoring and characterization
processing of approx. 500 SPOT-5
scenes national multi-temporal
coverage**

2014: GHSL - South Africa pilot study

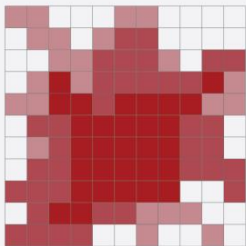


A world map with a dark blue background. The landmasses are outlined in a lighter blue. Overlaid on the map are numerous vertical lines of varying heights, colored in a gradient from yellow to red. These lines represent population density across the globe. A semi-transparent dark blue rectangular box is centered over the map, containing the text 'GHSL POPULATION GRIDS' in white, bold, sans-serif capital letters.

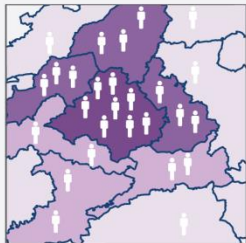
GHSL POPULATION GRIDS

INPUT

GHS
BUILT-UP



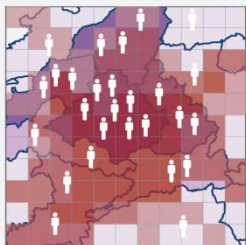
Census data



GSH built-up uses **small grid cells** to measure human settlements **regardless of administrative boundaries**.

Population censuses provide accurate information on the characteristics and **number of residents** for administrative or finer numeration areas (census tracts).

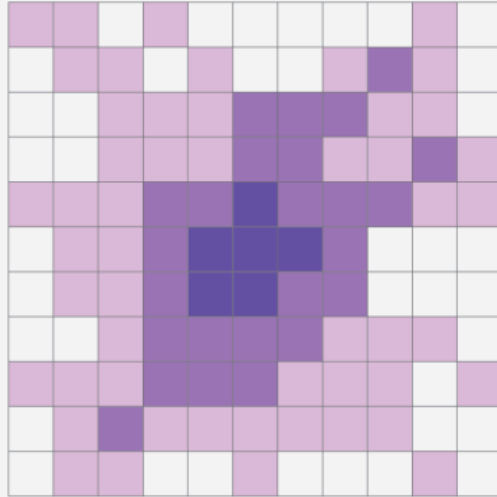
METHOD



The **GHSL method** is design to combine information from population censuses with built-up and to **downscale population** into a **grid of 1Km** of resolution, according to the presence or absence of built-up in the grid cell.

OUTPUT

GHS
POP

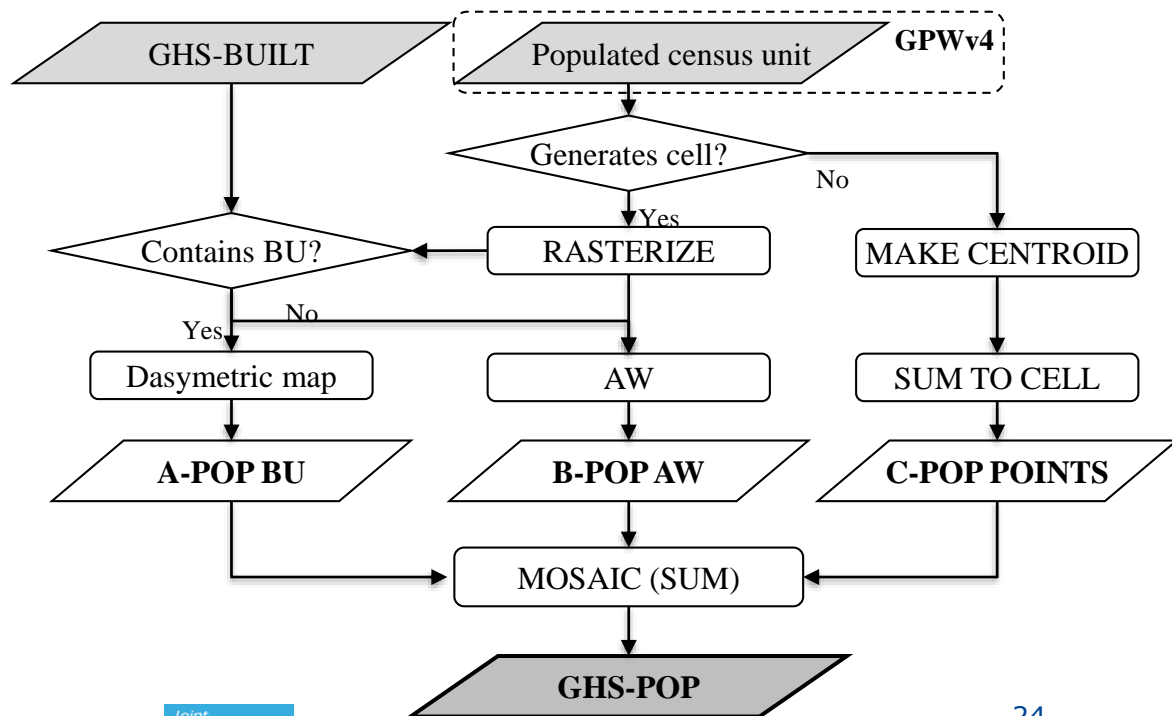


The combined information result into a new layer (resolution 1Km) which disregards administrative boundaries, and represents the **presence and density of population**.

In the GHS pop grid, the grid cell value represents the absolute **number of inhabitants**.

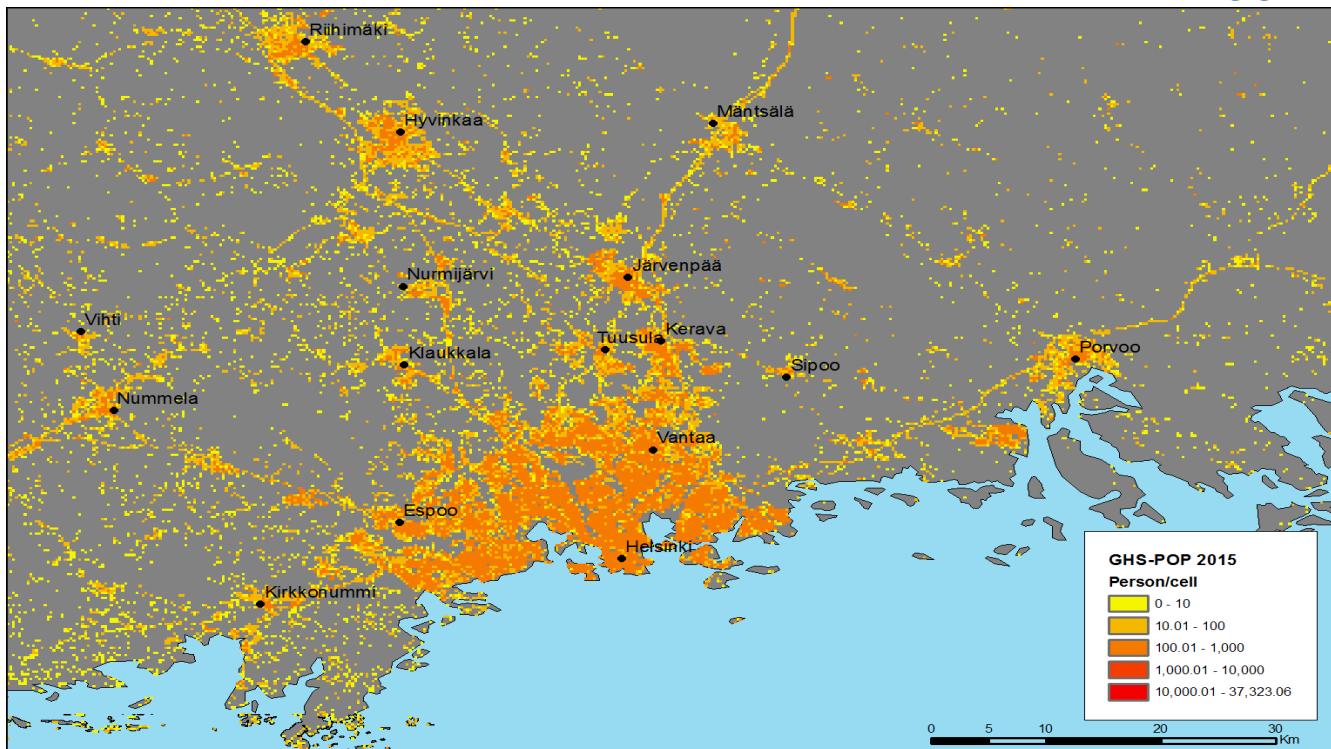
Methodology for Pop. disaggregation

- **Dasymetric mapping:**
- Volume-preserving
- Mollweide projection



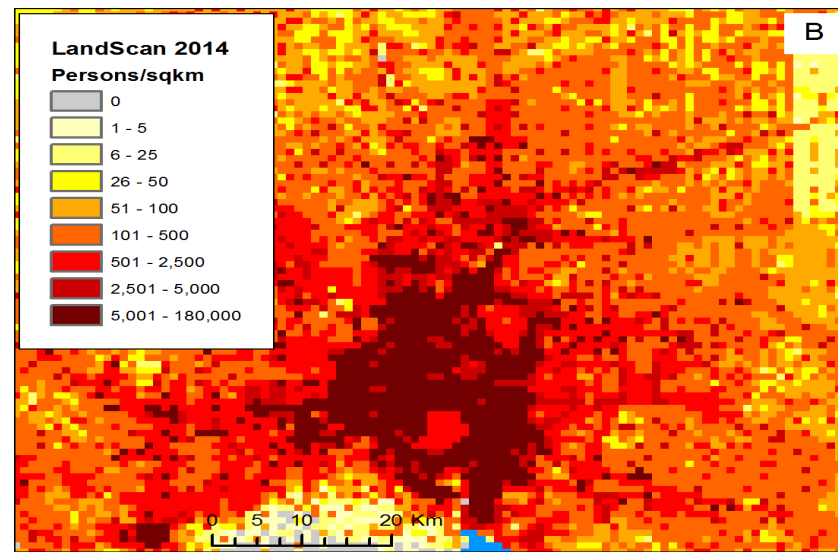
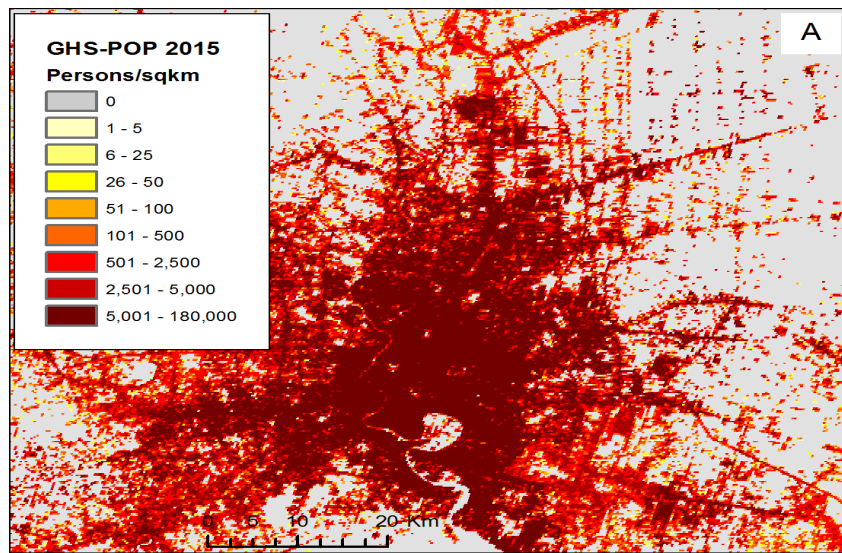
■ Pop. density 1975-1990-2000-2015 @ 250m

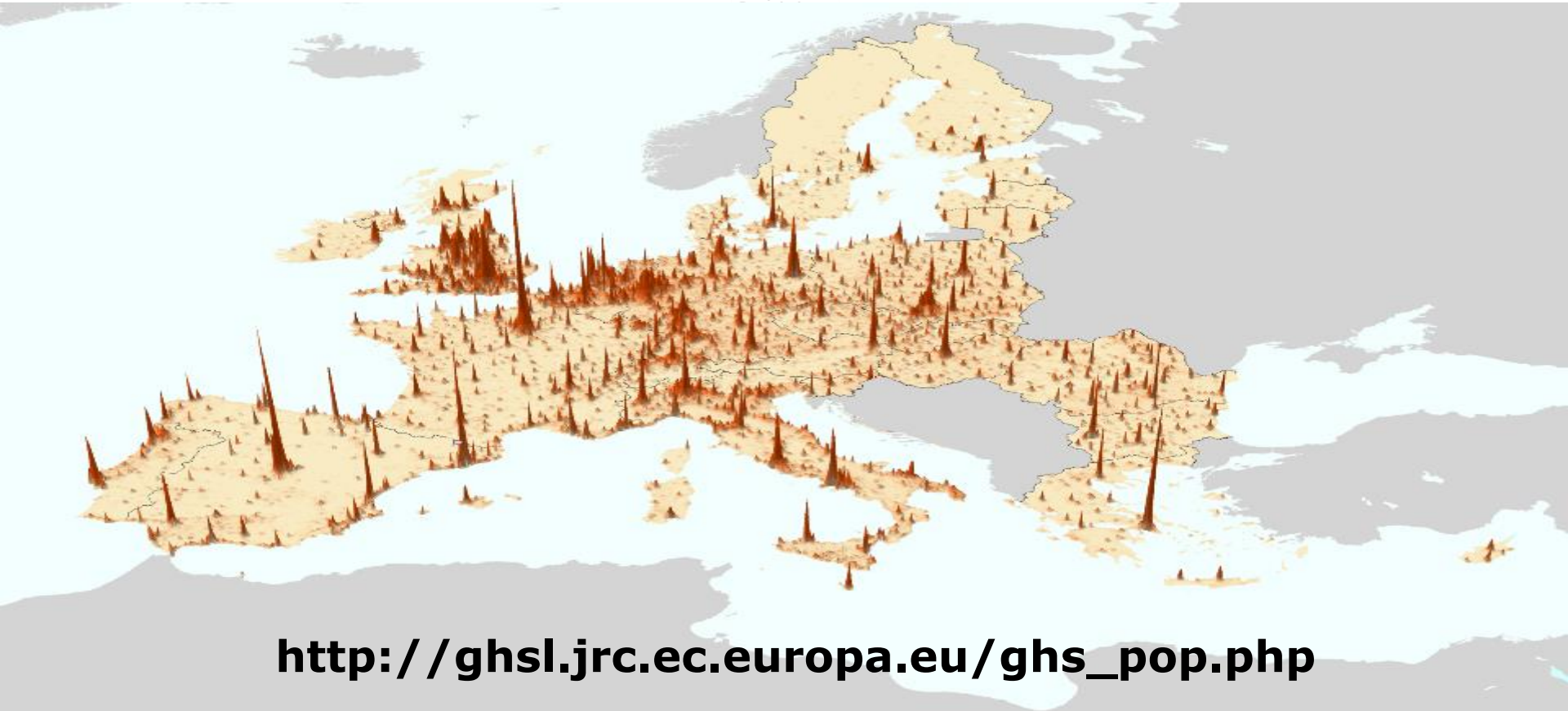
■ Helsinki, FI



■ Comparison with LandScan Global

■ Bangkok, Thailand



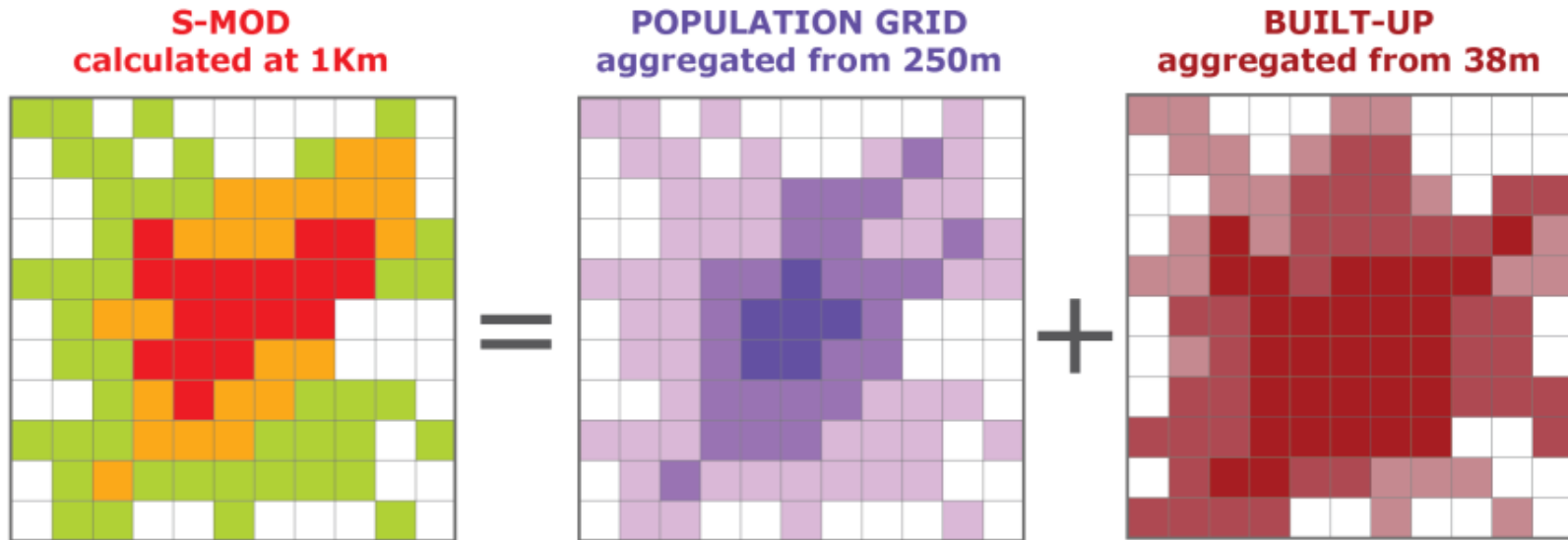


http://ghsl.jrc.ec.europa.eu/ghs_pop.php



GHSL SETTLEMENT MODEL

GHSL-BASED SETTLEMENT MODEL

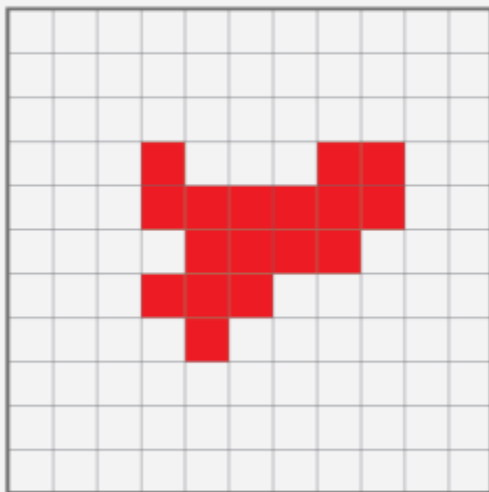


http://ghsl.jrc.ec.europa.eu/ghs_smod.php

GHSL-BASED SETTLEMENT MODEL



URBAN CENTRE



Required conditions

EACH GRID CELL

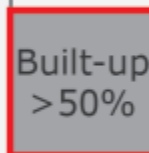
1 Km



minimum of
1.500
inhabitants

OR

1 Km



density of
built-up
greater than
50%

AND



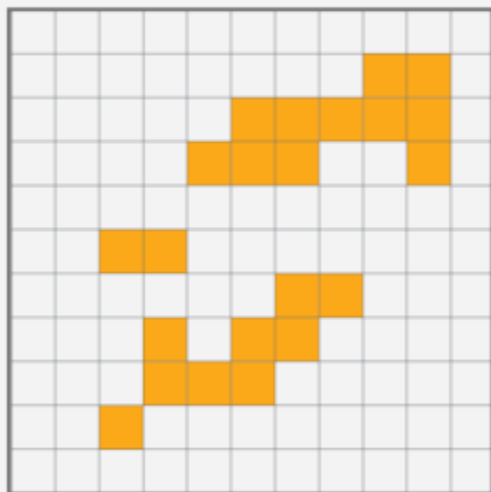
TOTAL
POPULATION
> 50.000
INHABITANTS

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

GHSL-BASED SETTLEMENT MODEL



URBAN CLUSTER



Required conditions

EACH GRID CELL

1 Km



minimum
of 300
inhabitants

AND

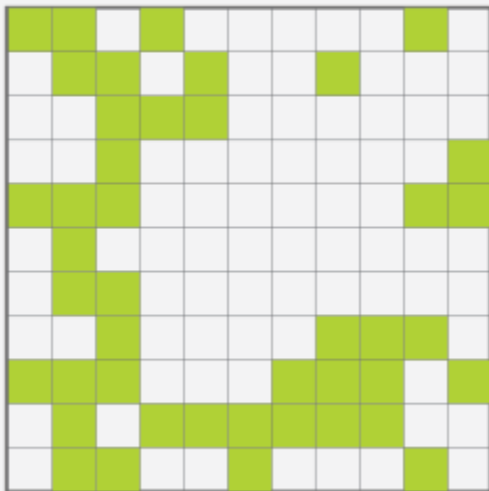


TOTAL
POPULATION
> 5.000
INHABITANTS

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

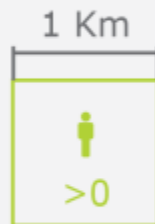
GHSL-BASED SETTLEMENT MODEL

RURAL



Required conditions

EACH GRID CELL



cell with
inhabitants

AND



single or contiguous grid
cells with total population
of less than 5.000
inhabitants

GHSL-BASED SETTLEMENT MODEL: MADRID



Satellite imagery



Legend

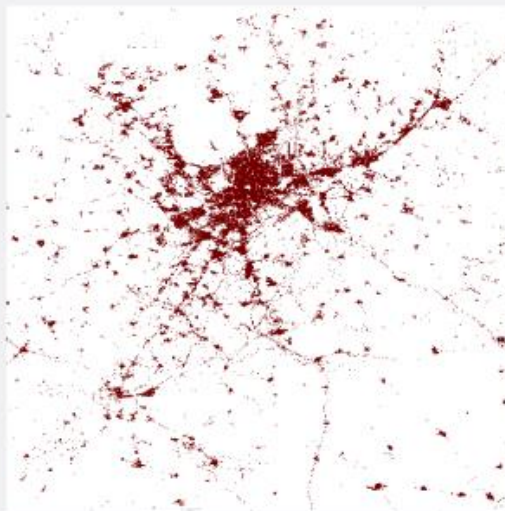


The image on the left is a satellite image of the city of **Madrid, Spain in 2015**. The overlapped administrative boundaries (in blue) show their differences in size and unevenness of borders.

GHSL-BASED SETTLEMENT MODEL: MADRID



GHSL
BUILT-UP



Built-up area



Built-up (resolution 38m)

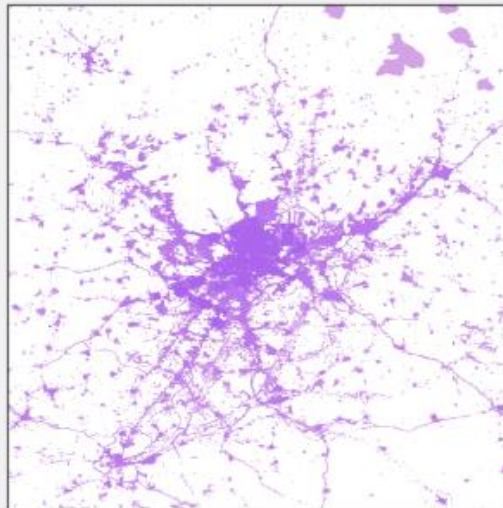
Built up area is typically expressed with a continuous values representing **the proportion of building footprint area within the total size of the cell.**

The value of the cells in this area are significantly different, from 0 to 98.

GHSL-BASED SETTLEMENT MODEL: MADRID



GHS
POP



Number of inhabitants

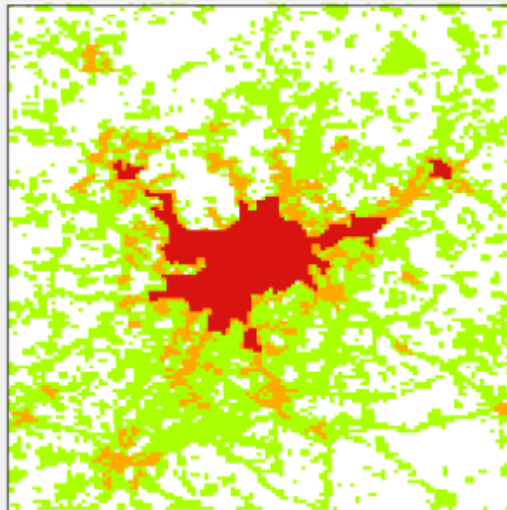


Population grids (resolution 250m)





In the population grid, grid cell value represents the number of inhabitants.

In this specific area, the number of inhabitants varies from 3 to about 12.000 per sqKm.

GHSL-BASED SETTLEMENT MODEL: MADRID



Settlement classification

-  No data
-  Rural
-  Urban Cluster
-  Urban Centre

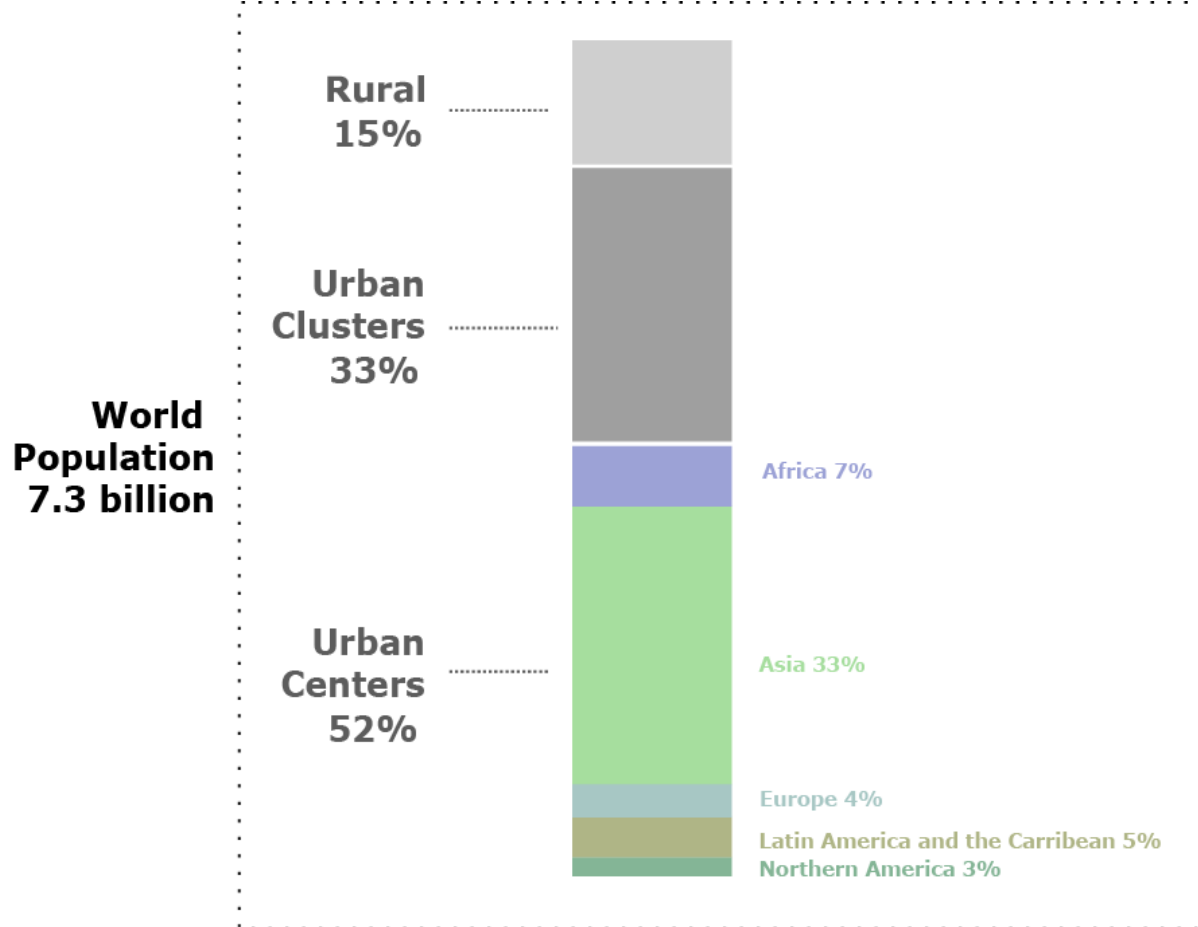
Settlement Model (resolution 1Km)

The GHS S-MOD aims at classifying human settlements according to certain rules of population and built-up density and contiguity of grid cells.

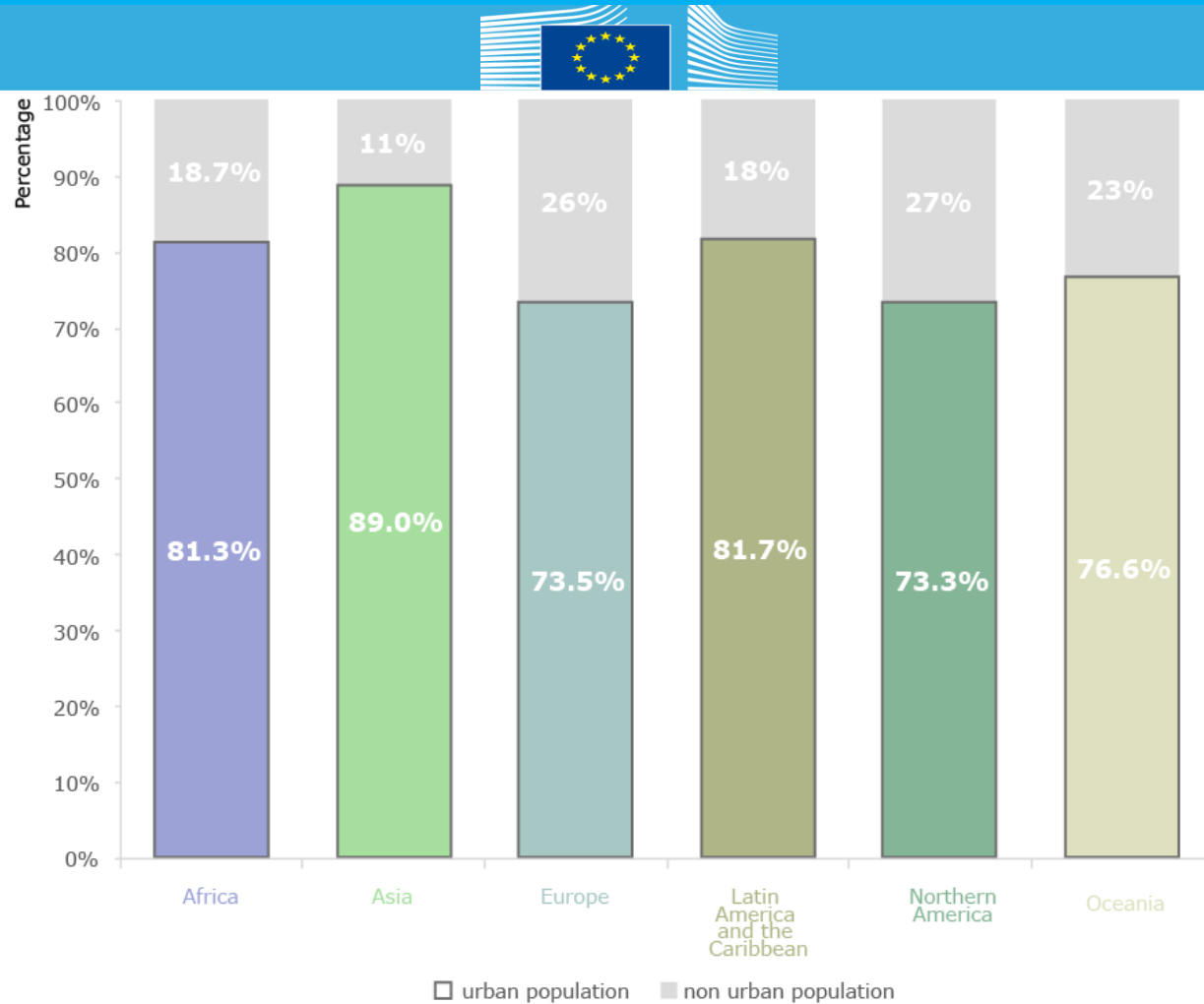
In the example on the left, the urban centre of Madrid, with relative urban clusters and rural settlements.

Dijkstra L., Poelman, H. 2014. A harmonized definition of cities and rural areas: the new degree of Urbanization. Working Paper, WP 01/2014, DGRegio, Brussels.

DISTRIBUTION OF GLOBAL POPULATION ACCORDING TO GHSL SMOD



DEGREE OF URBANISATION IN 2015 PER CONTINENT



An aerial satellite image of a coastal region, likely in the Gulf of Mexico. The image shows a mix of green land, brownish terrain, and dark blue water. A semi-transparent grey bar is overlaid in the center, containing the text "GHSL SENTINEL- 1".

GHSL SENTINEL- 1



Sentinel- 1 Ground Range Detected (GRD) – Dual polarization

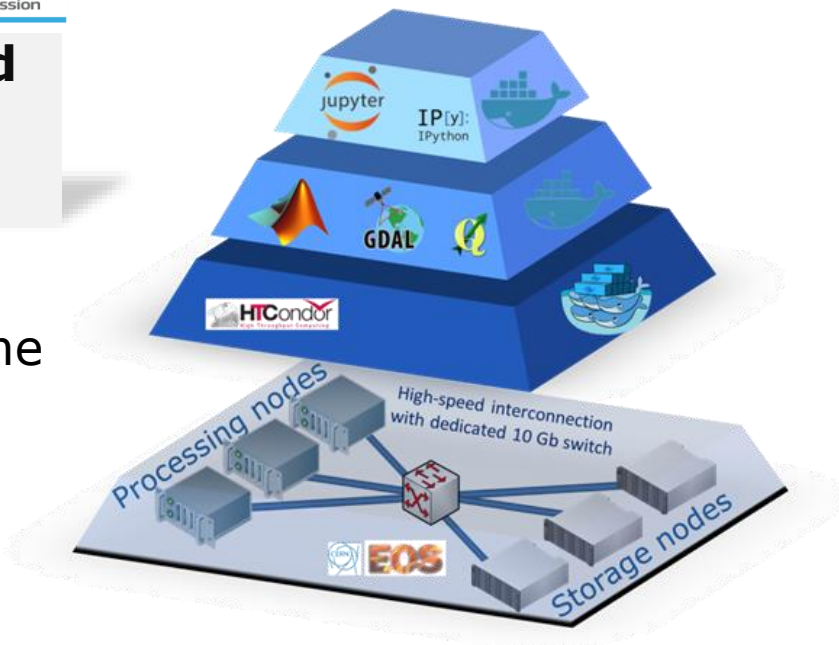
5000 scenes

Dec 2015 – June 2016

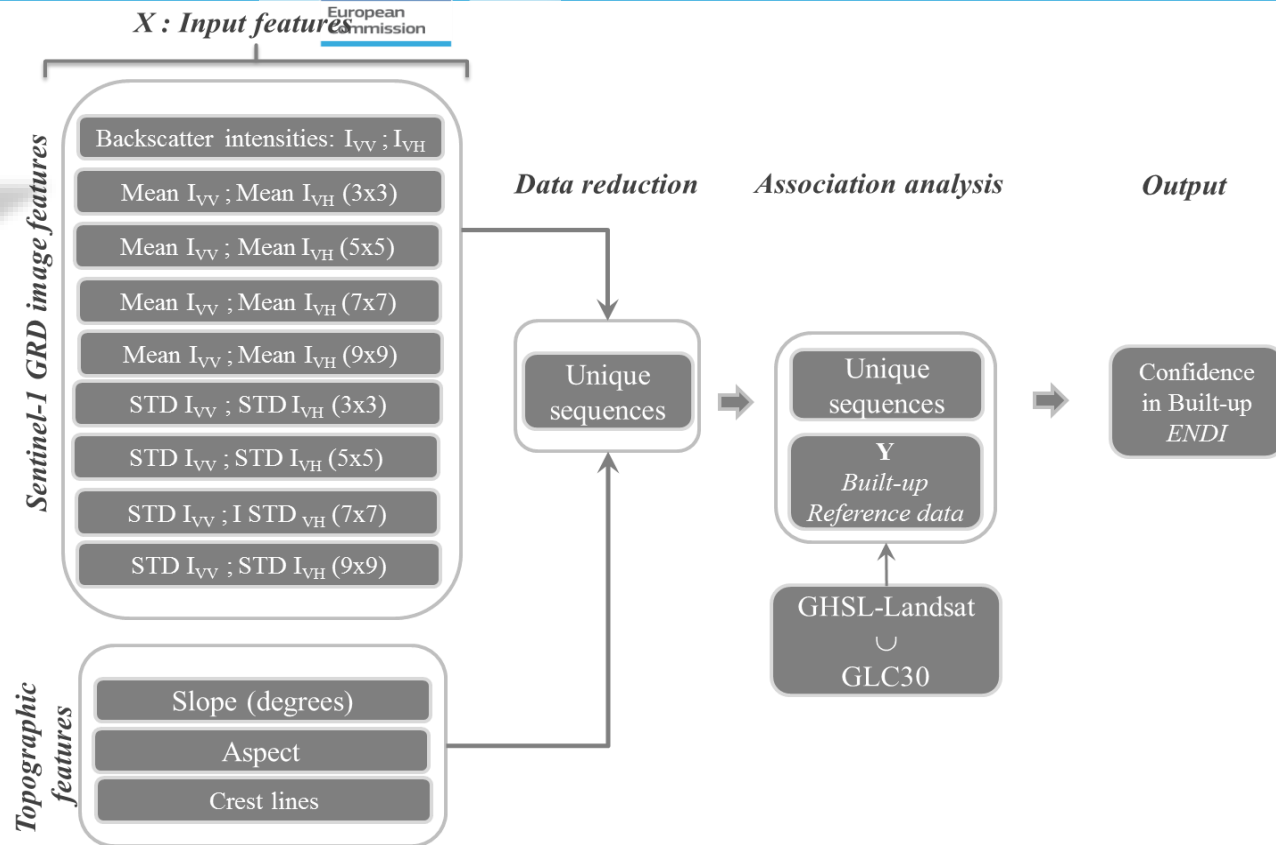


JRC Earth Observation Data and Processing Platform (JEODPP)

Cutting-edge storage technology thanks to a collaboration between the European Organization for Nuclear Research ([CERN](http://cern.ch)) and JRC



Adaptation of SML workflow to SENTINEL-1



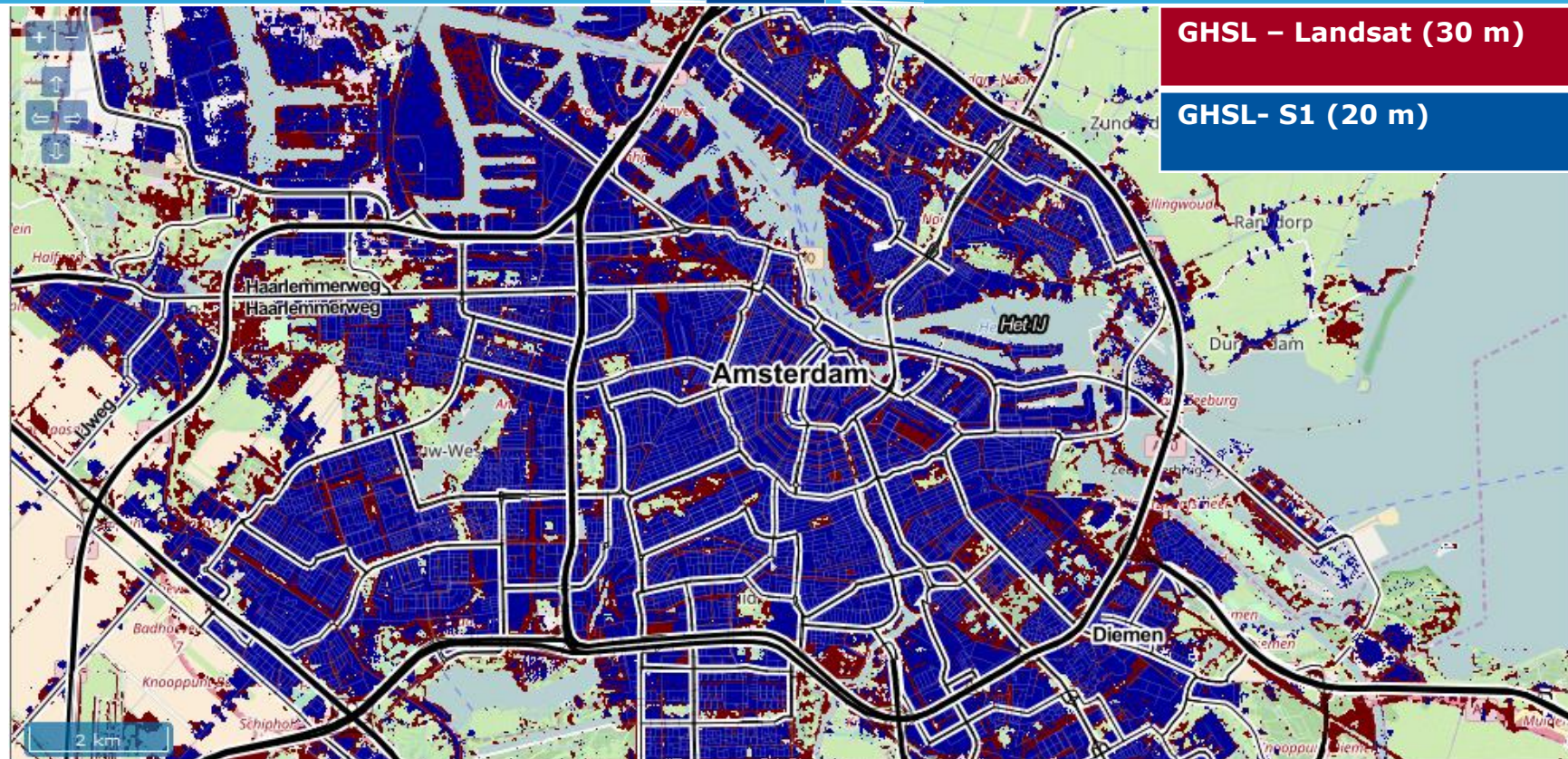
GHSL SENTINEL-1: ENHANCED BUILT-UP DETECTION



AMSTERDAM

Note: the images above have been generated using the ([JEODPP platform](#))

GHSL SENTINEL-1: ENHANCED BUILT-UP DETECTION



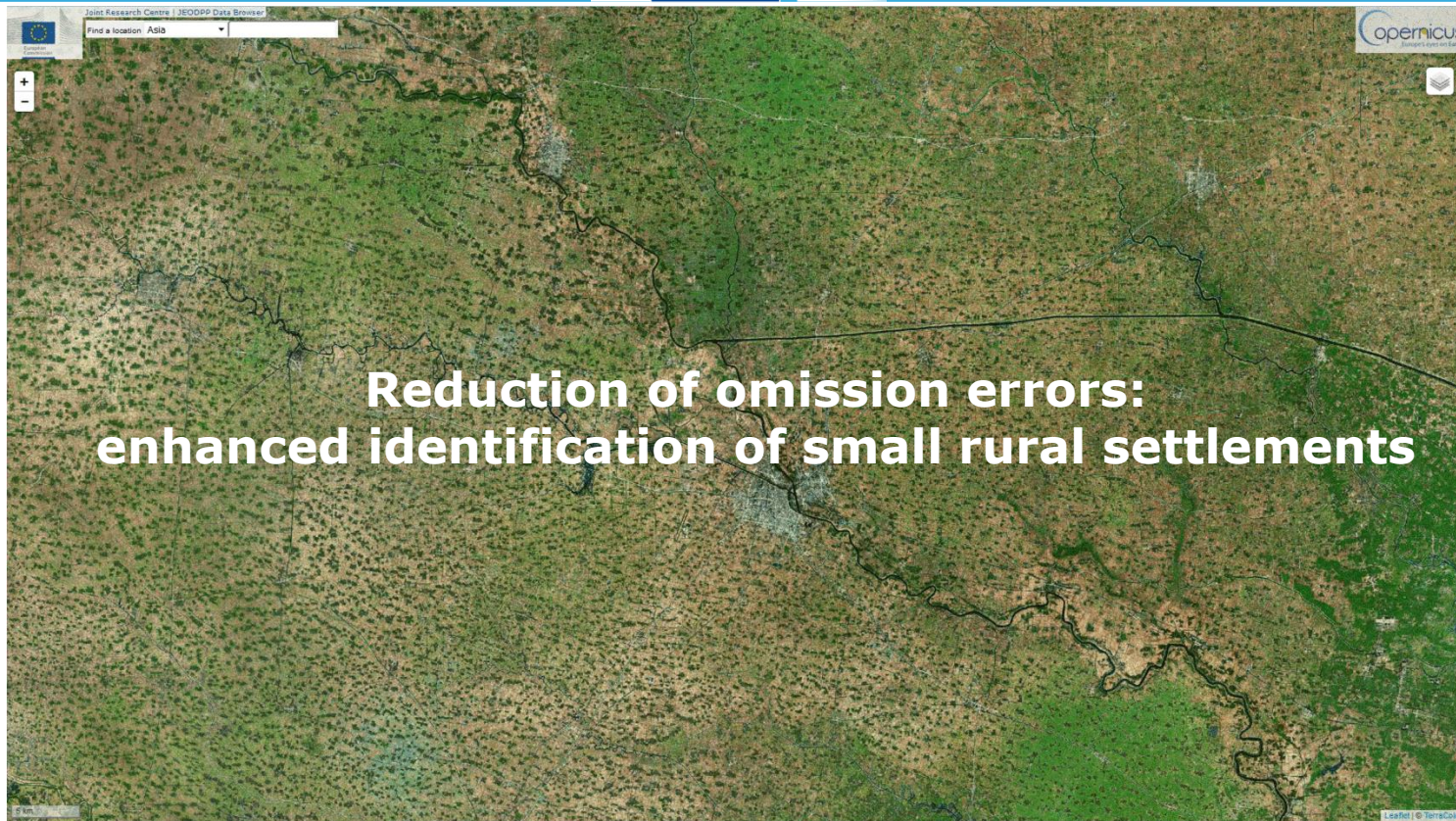
GHSL – Landsat (30 m)

GHSL- S1 (20 m)

AMSTERDAM

Note: the images above have been generated using the ([JEODPP platform](#))

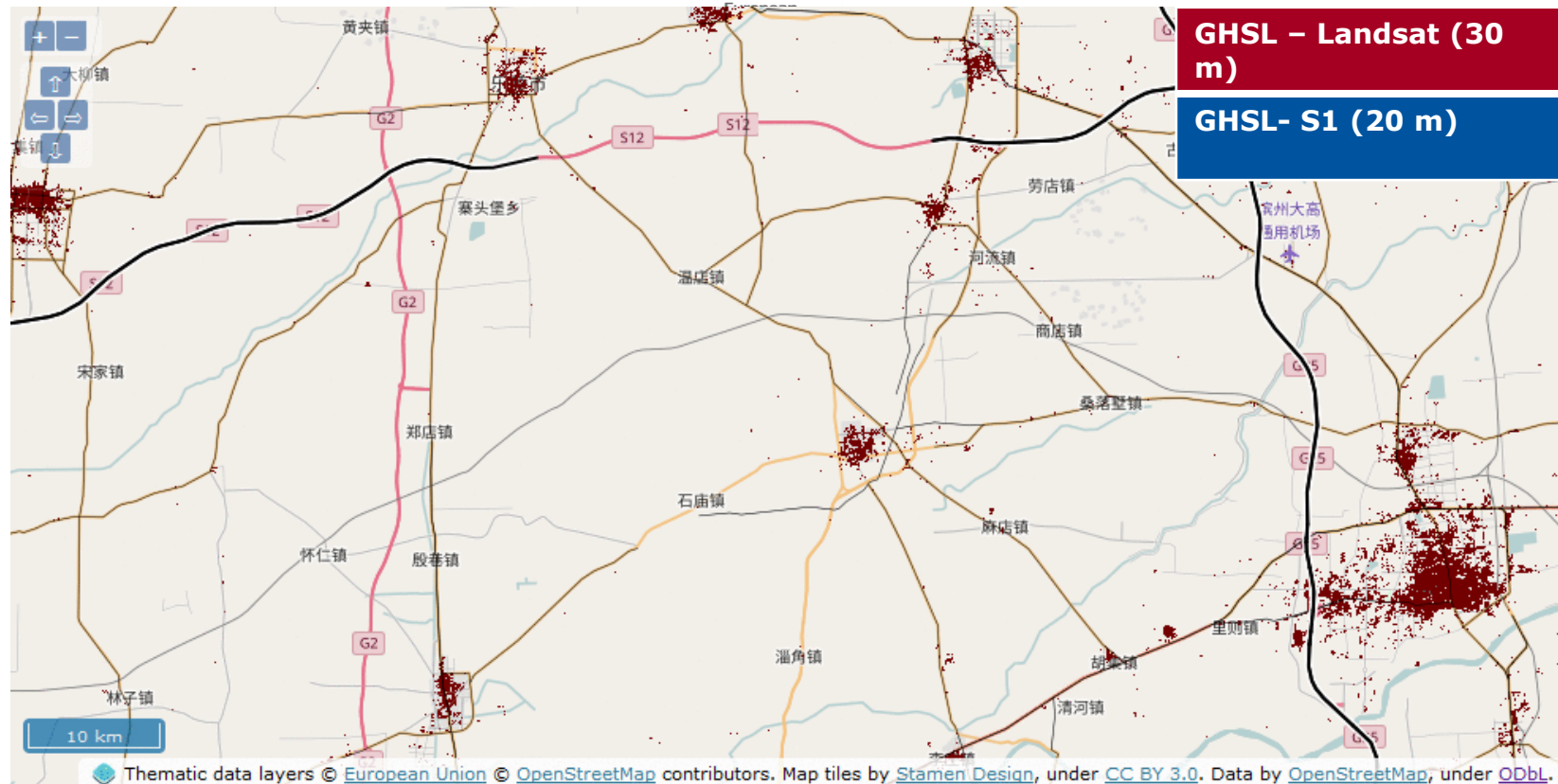
GHSL SENTINEL-1: ENHANCED BUILT-UP DETECTION



DENZHOU

Note: the images above have been generated using the ([JEODPP platform](#))

GHSL SENTINEL-1: ENHANCED BUILT-UP DETECTION



DENZHOU

Note: the images above have been generated using the ([JEODPP platform](#))

NEXT STEPS AND CHALLENGES



New global built-up layer derived from Sentinel-2



Integrated GHSL product: Landsat, Sentinel-1 and Sentinel-2



GHSL based indicators for Sustainable Development Goals and Sendai Framework for Disaster Risk Reduction

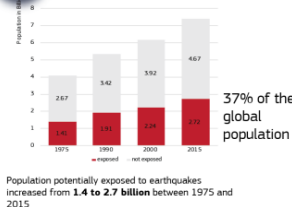


GEO Human Planet Initiative

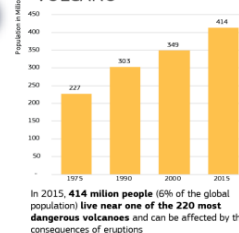
KEY FINDINGS FROM THE ATLAS OF THE HUMAN PLANET 2017 Global Exposure to Natural Hazards



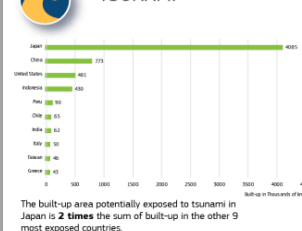
EARTHQUAKE



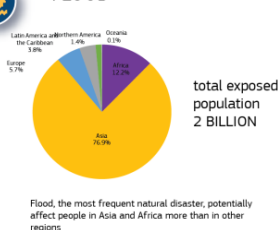
VOLCANO



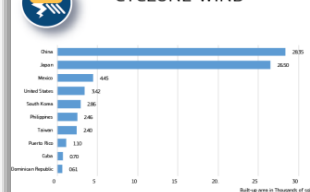
TSUNAMI



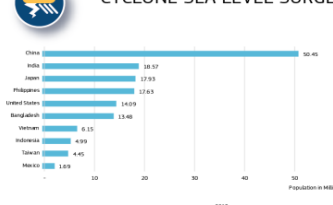
FLOOD



CYCLONE WIND



CYCLONE SEA LEVEL SURGE



Global Human Settlement... X +

ghsl.jrc.ec.europa.eu/index.php

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Global Human Settlement

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GHSL - Global Human Settlement Layer

A new open and free tool for assessing the human presence on the planet

- Produces new global spatial information, evidence-based analytics and knowledge describing the human presence on the planet
- Operates in an open and free data and methods access policy (open input, open method, open output)
- Supported by the Joint Research Centre (JRC) and the DG for Regional Development (DG REGIO) of the European Commission, together with the international partnership [GEO Human Planet Initiative](#)  GROUP ON EARTH OBSERVATIONS



1975

<http://ghsl.jrc.ec.europa.eu>

Click here to find out about the technology behind this image

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christina.corban@ec.europa.eu