Global Human Settlement Information from High-Resolution Remotely Sensed Data

JRC-CERN Collaboration Workshop
Geneva, Monday 27 January 2014

Session Big Data Challenge: Part II

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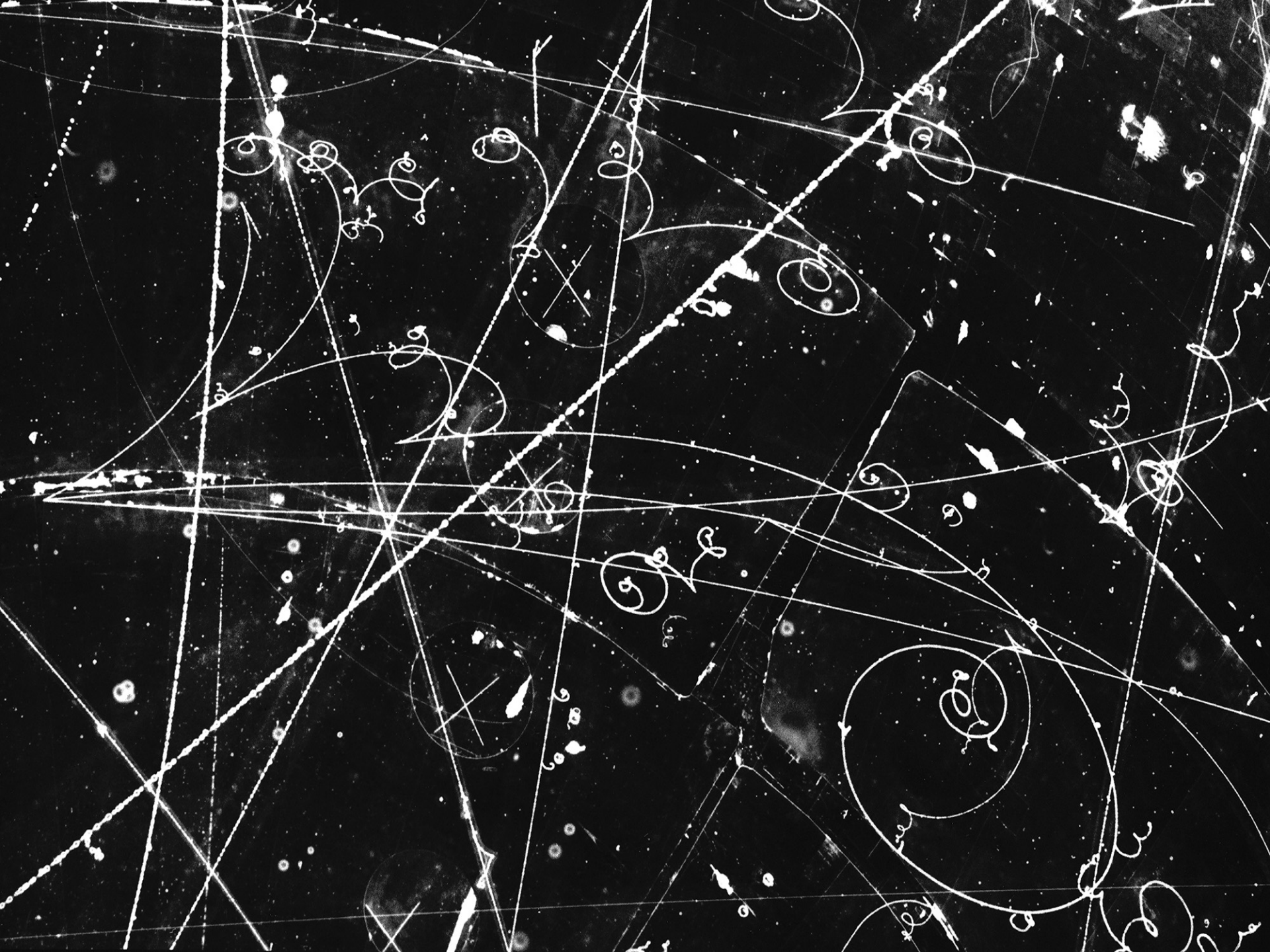
Roadmap – institutional frame

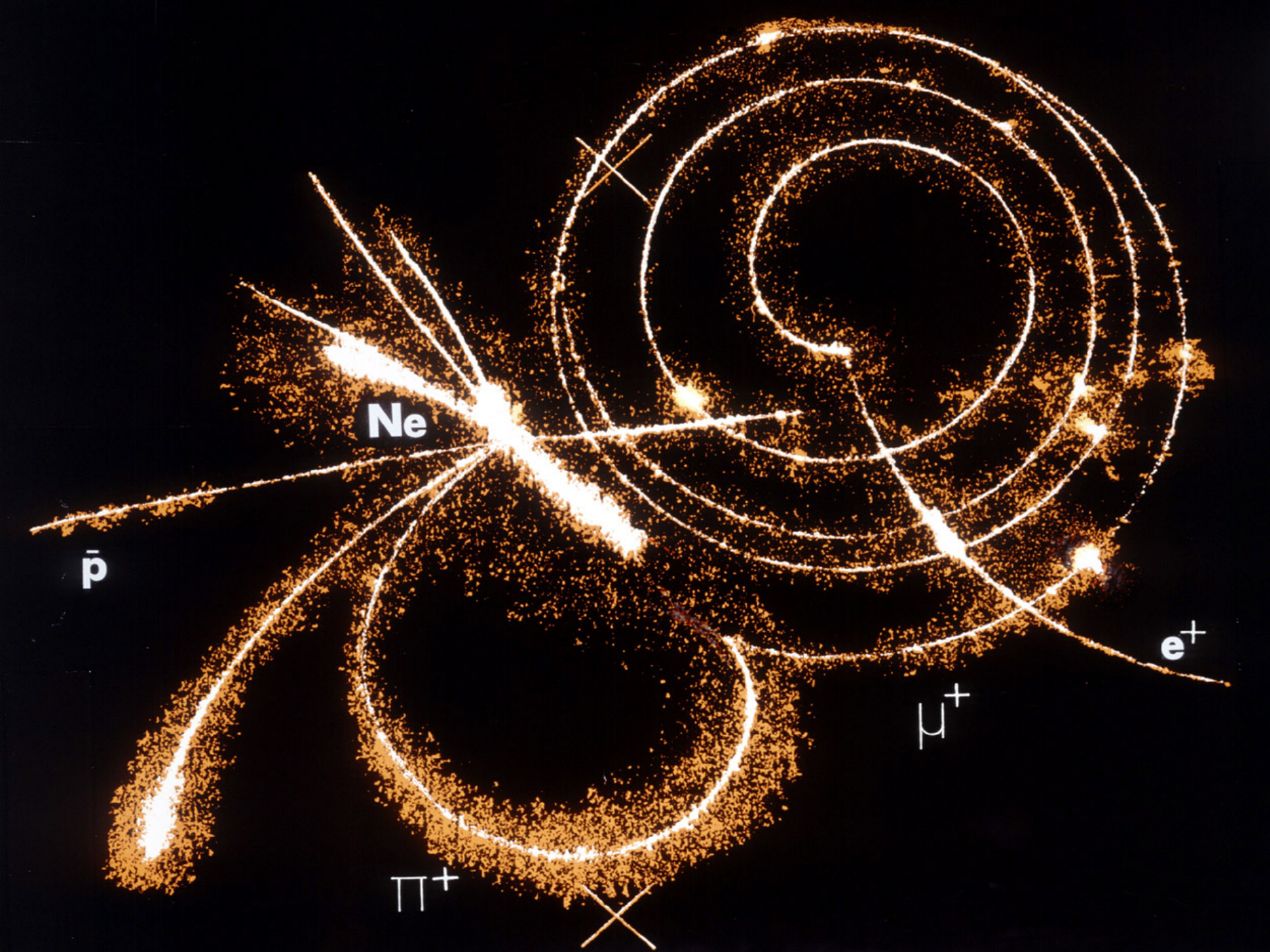
European Commission, Joint Research Centre (JRC)
Institute for the Protection and Security of the Citizen (IPSC)
Global Security and Crisis Management Unit

automatic geoinfo monitoring and analysis

Illegal crop eradication monitoring (poppy, coca)
Conflict modelling, border permeability modelling
Kimberley process support (diamond certification schema)
Post-conflict situation awareness, damage assessment
Vulnerable population monitoring (refugees/IDP camps)
Urban poor (slum) analysis and monitoring
Disaster management information support (risk, mitigation, damage assessment, reconstruction)
Regional Planning
Global Human Settlement Layer (GHSL) initiative

→ **Remote Sensing Image Information Mining**




Ne
$\bar{p}$
e^+
μ^+
π^+

4/7/2013
Image © 2014 DigitalGlobe
93 m
2001
Google earth
Imagery Date: 4/7/2013 lat 33.854130° lon 35.509309° elev 47 m eye alt 432 m

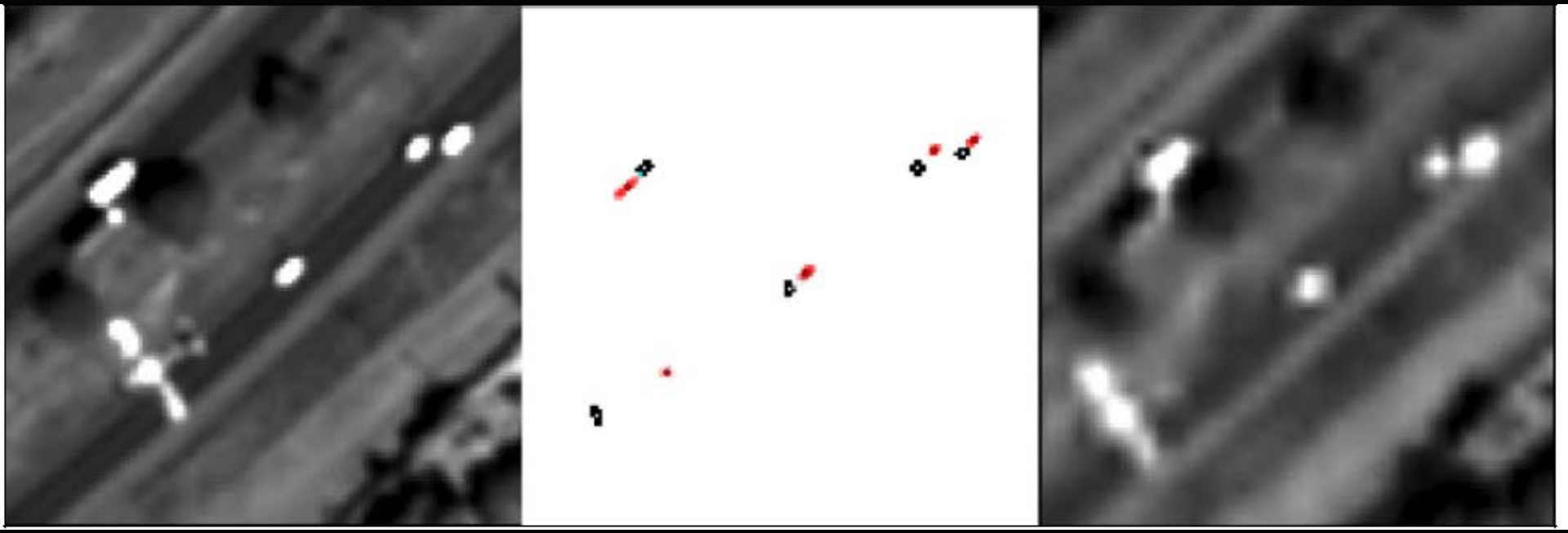
Image Information Mining Challenges

- Unstructured heterogeneous data, large volume
- Uncontrolled data collection parameters
- Large data gaps, atmosphere influence
- Data degradation (compression, fusion)
- Undocumented sensor tolerances, spatial inconsistencies
- Heavy image processing tasks
  - Radiometric, textural, morphological criteria
  - Background/foreground ambiguity
  - Multi-scale, contextual and geometrical analysis
- Complex interpretation schemas
  - Multi-level abstraction semantics
  - Multi-scale and dynamic phenomena

9/14/2012
N
Image © 2014 DigitalGlobe
93 m
2001
Imagery Date: 9/14/2012 lat 33.8541130° lon 35.5093090° elev 47 m eye alt 432 m
Google earth

REMOTELY SENSED IMAGERIES AND INFORMATION GATHERING

moving objects



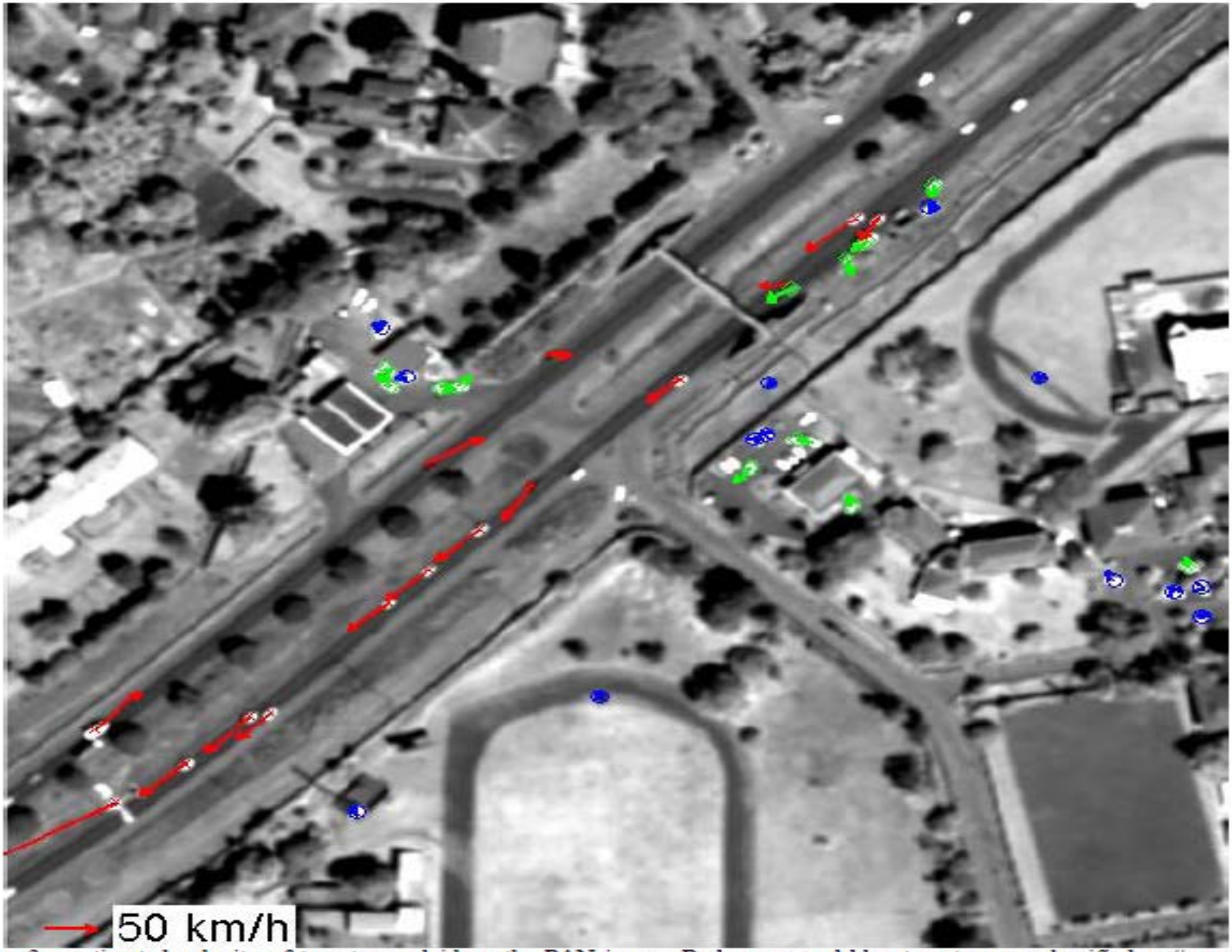
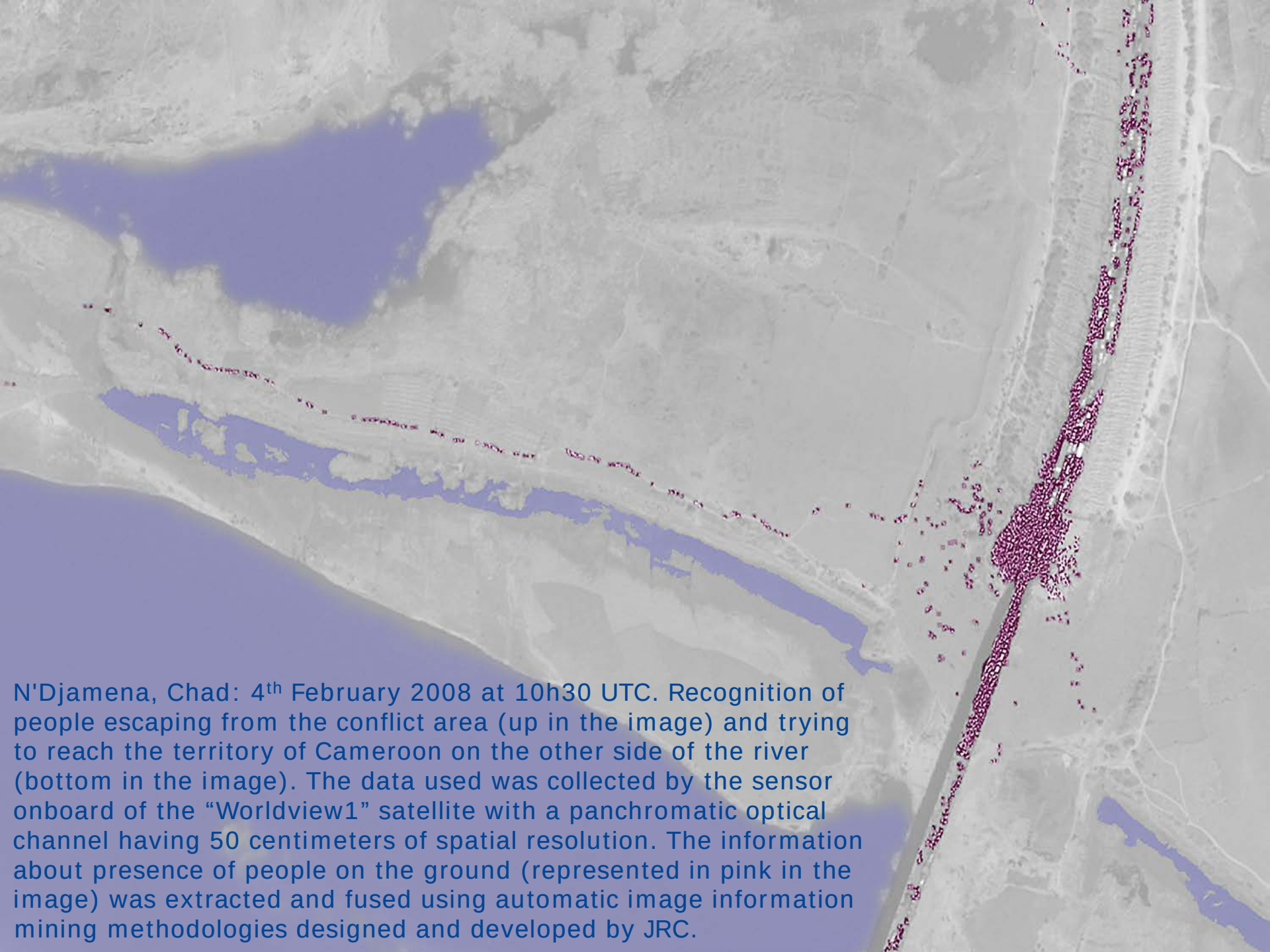


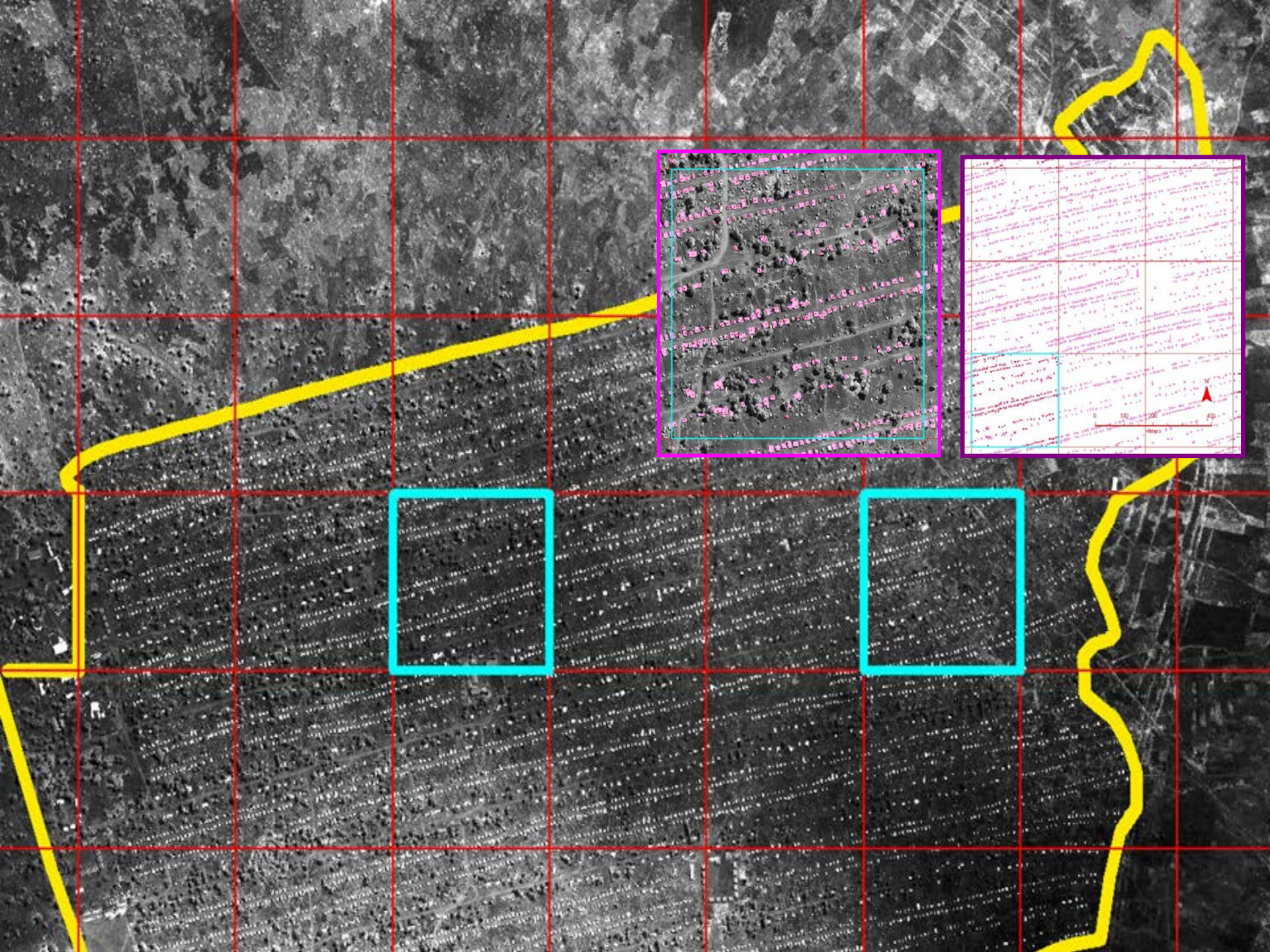
Figure 3 – estimated velocity of targets overlaid on the PAN image. Red, green and blue targets were classified as "moving", "unknown", and "non-moving", respectively, by visual inspection.

people



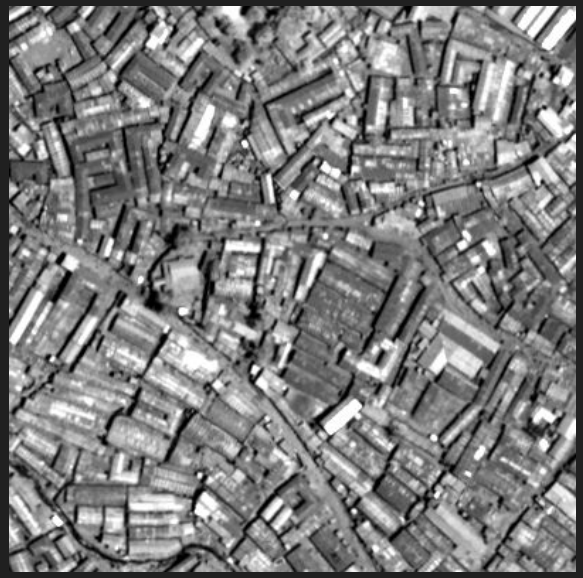
N'Djamena, Chad: 4th February 2008 at 10h30 UTC. Recognition of people escaping from the conflict area (up in the image) and trying to reach the territory of Cameroon on the other side of the river (bottom in the image). The data used was collected by the sensor onboard of the “Worldview1” satellite with a panchromatic optical channel having 50 centimeters of spatial resolution. The information about presence of people on the ground (represented in pink in the image) was extracted and fused using automatic image information mining methodologies designed and developed by JRC.

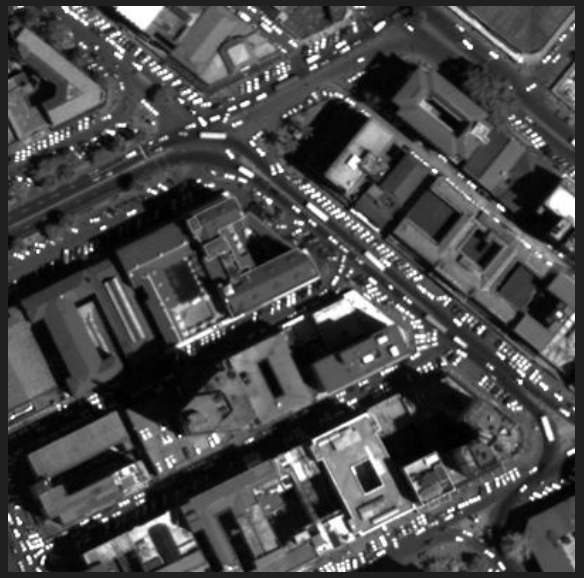
refugees / IDP camps

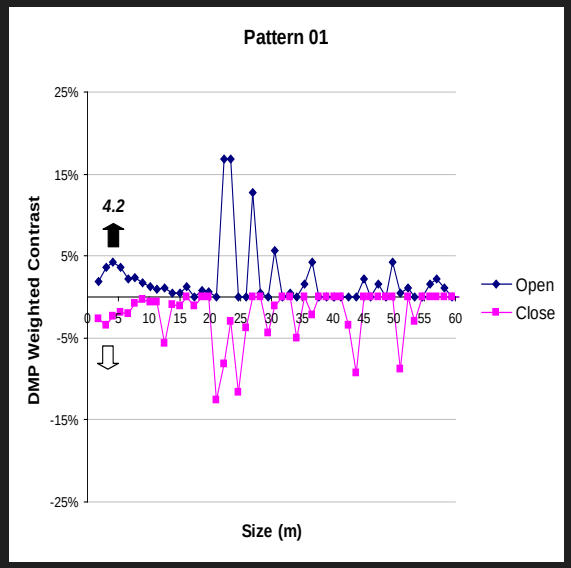


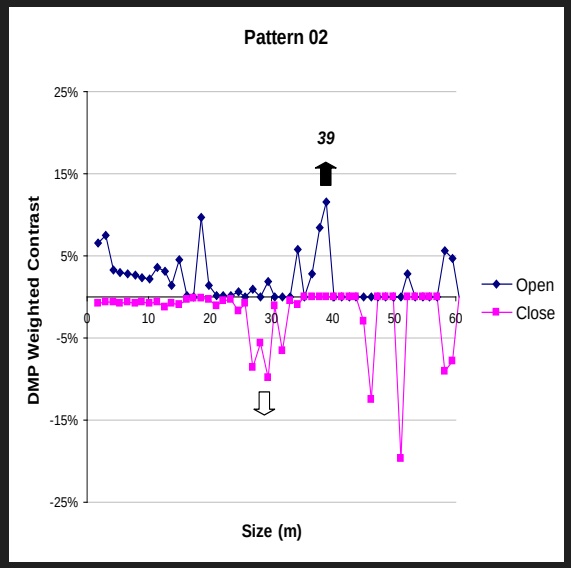
human settlement characterization poor, slums

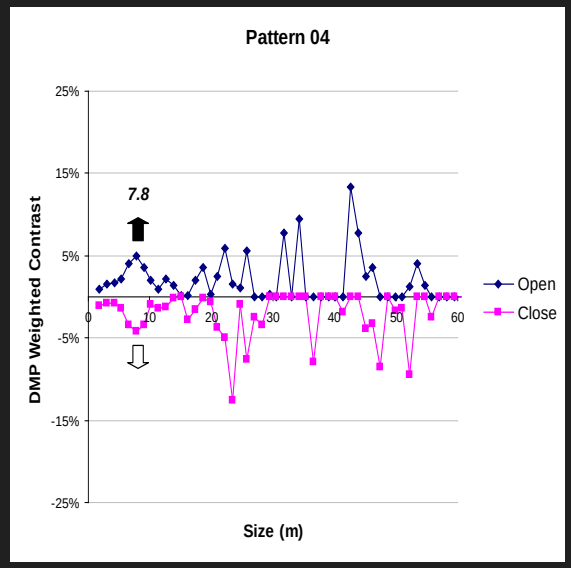
Human settlement characterization
Image multiscale morphological decomposition (DMP)



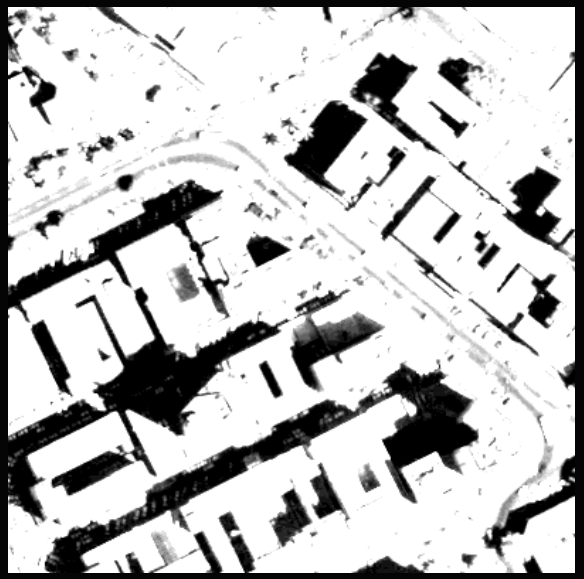


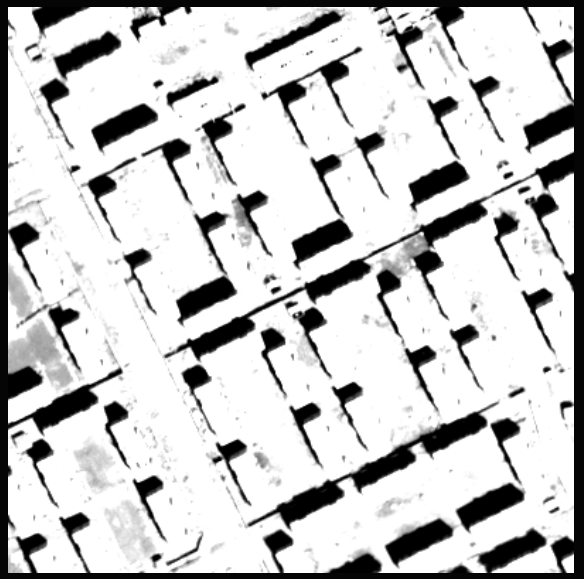


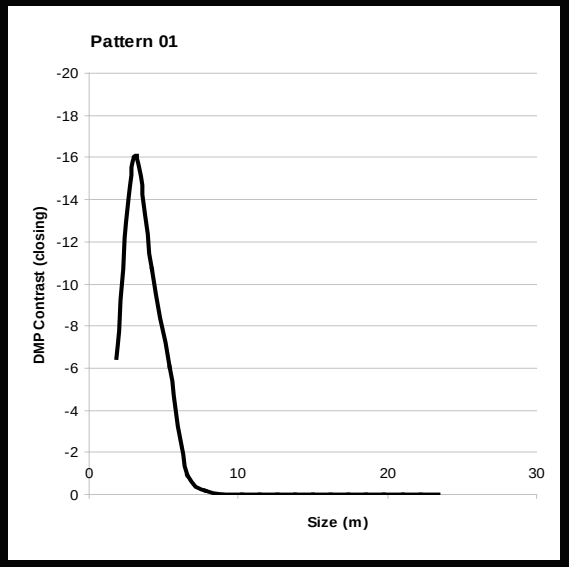


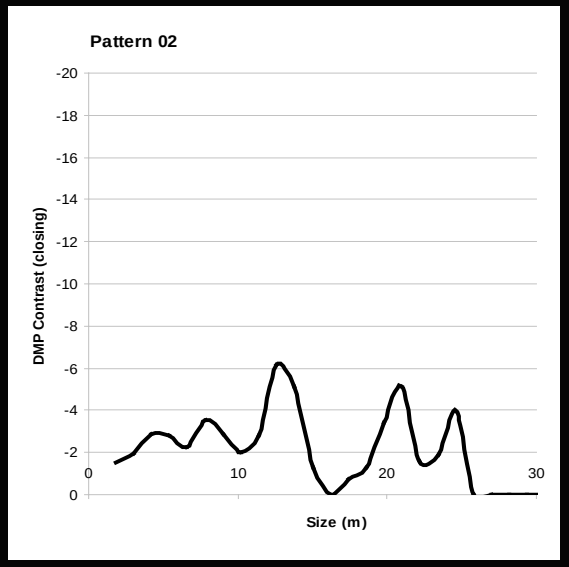


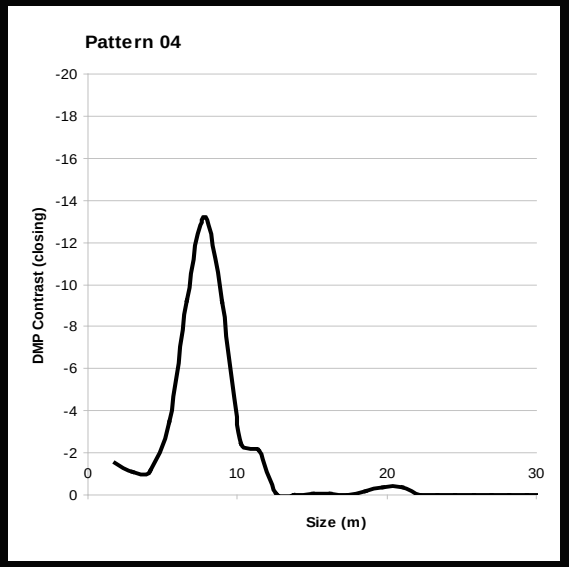
Human settlement characterization
Image multiscale morphological decomposition (DMP) shadow

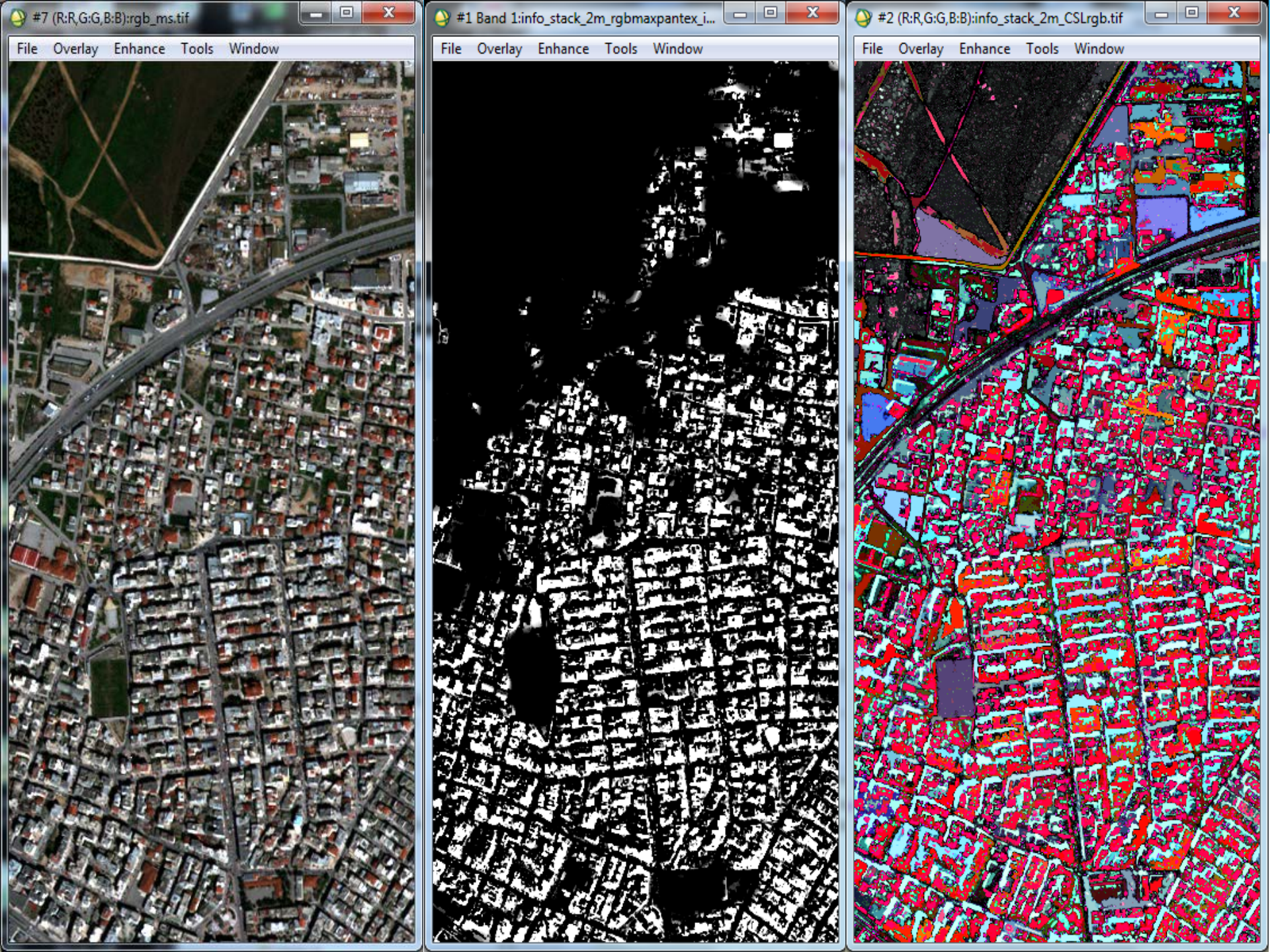








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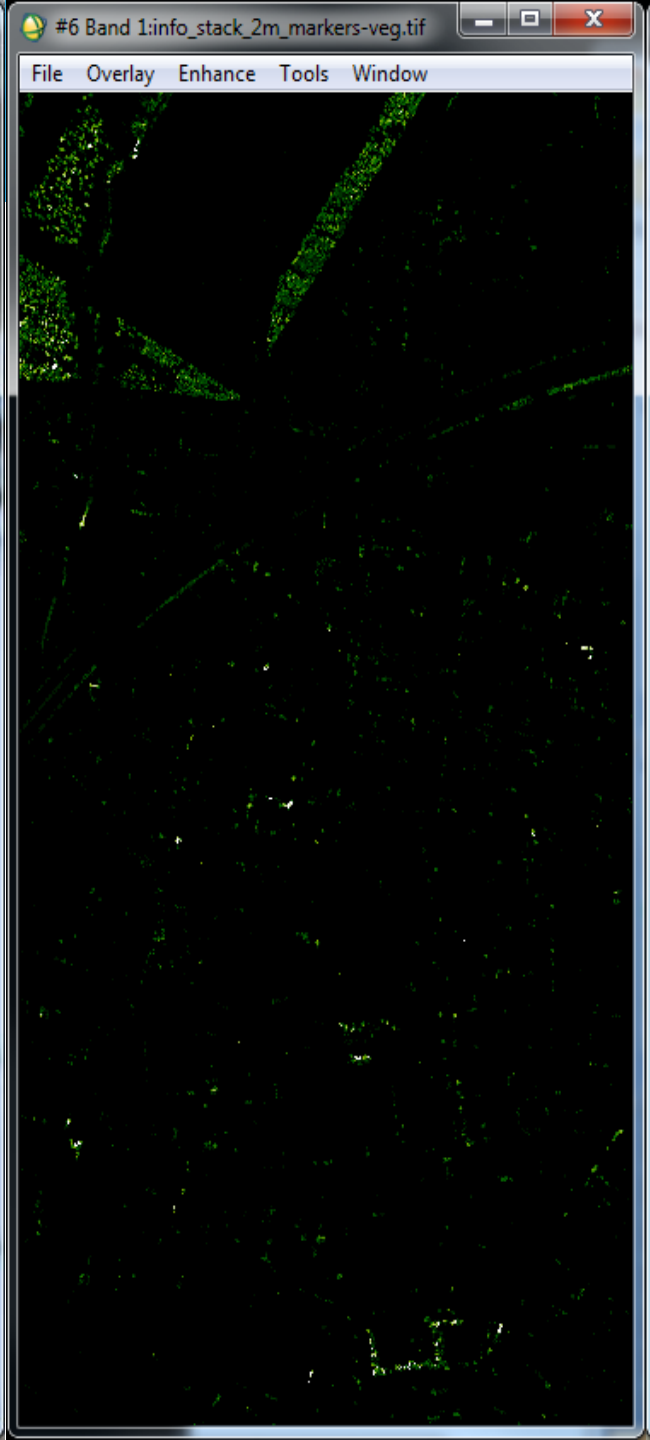
File Overlay Enhance Tools Window
#1 Band 1:info_stack_2m_rgbmaxpantex_i...
File Overlay Enhance Tools Window
#2 (R:R,G:G,B:B):info_stack_2m_CSLrgb.tif
File Overlay Enhance Tools Window

#7 (R:R,G:G,B:B):rgb_ms.tif
File Overlay Enhance Tools Window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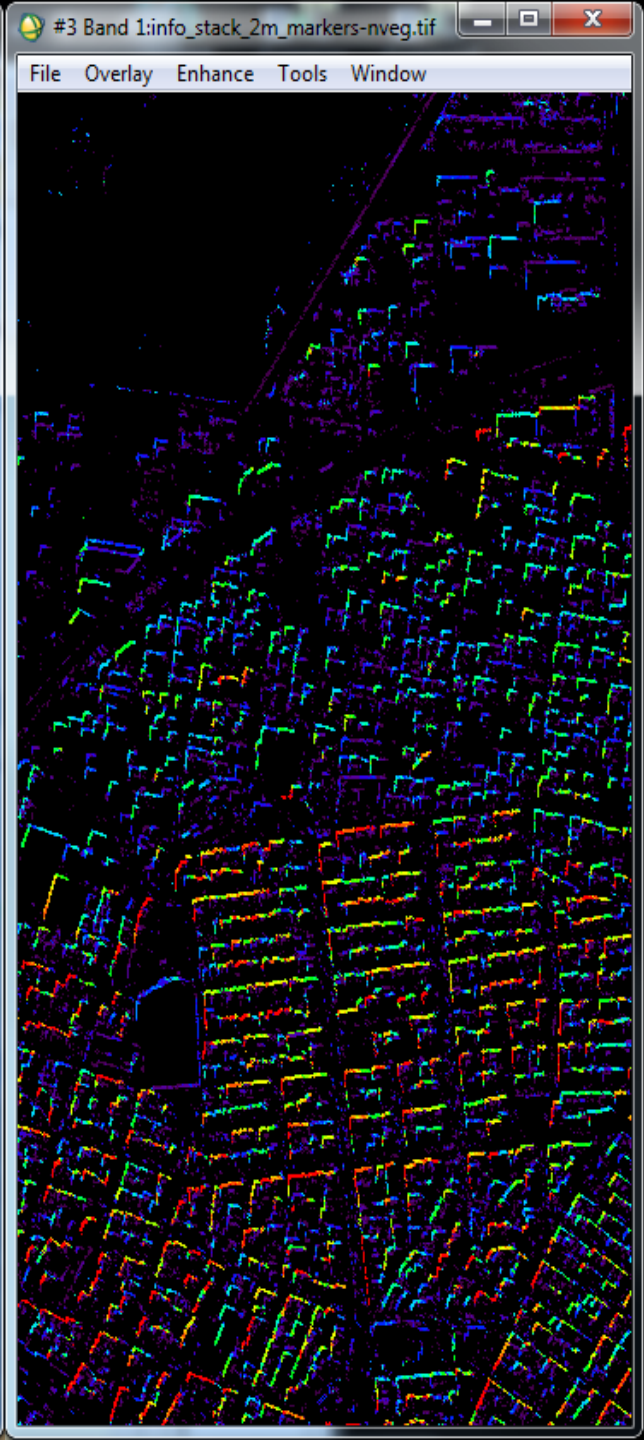
File Overlay Enhance Tools Window


#3 Band 1:info_stack_2m_markers-nveg.tif
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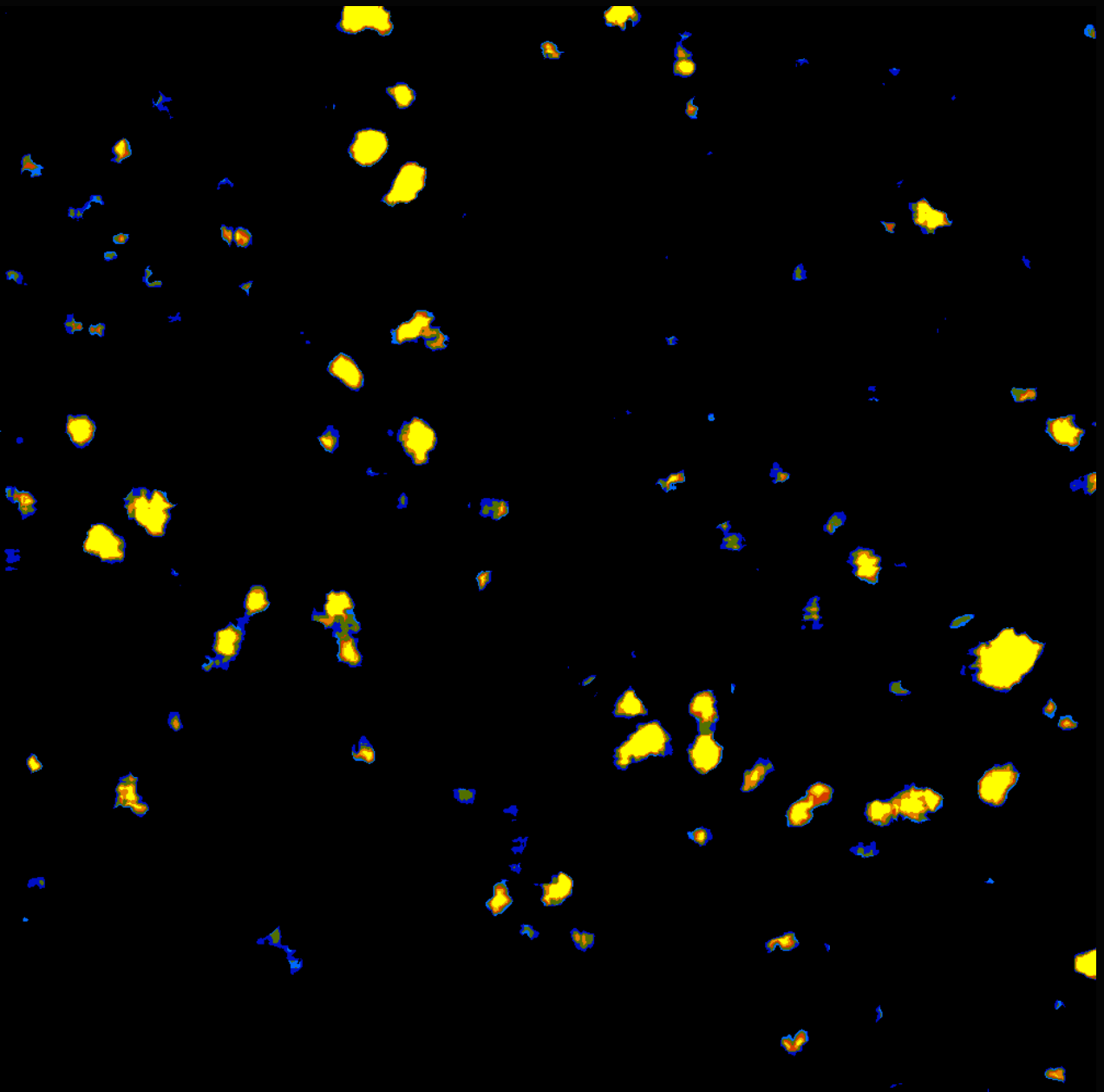
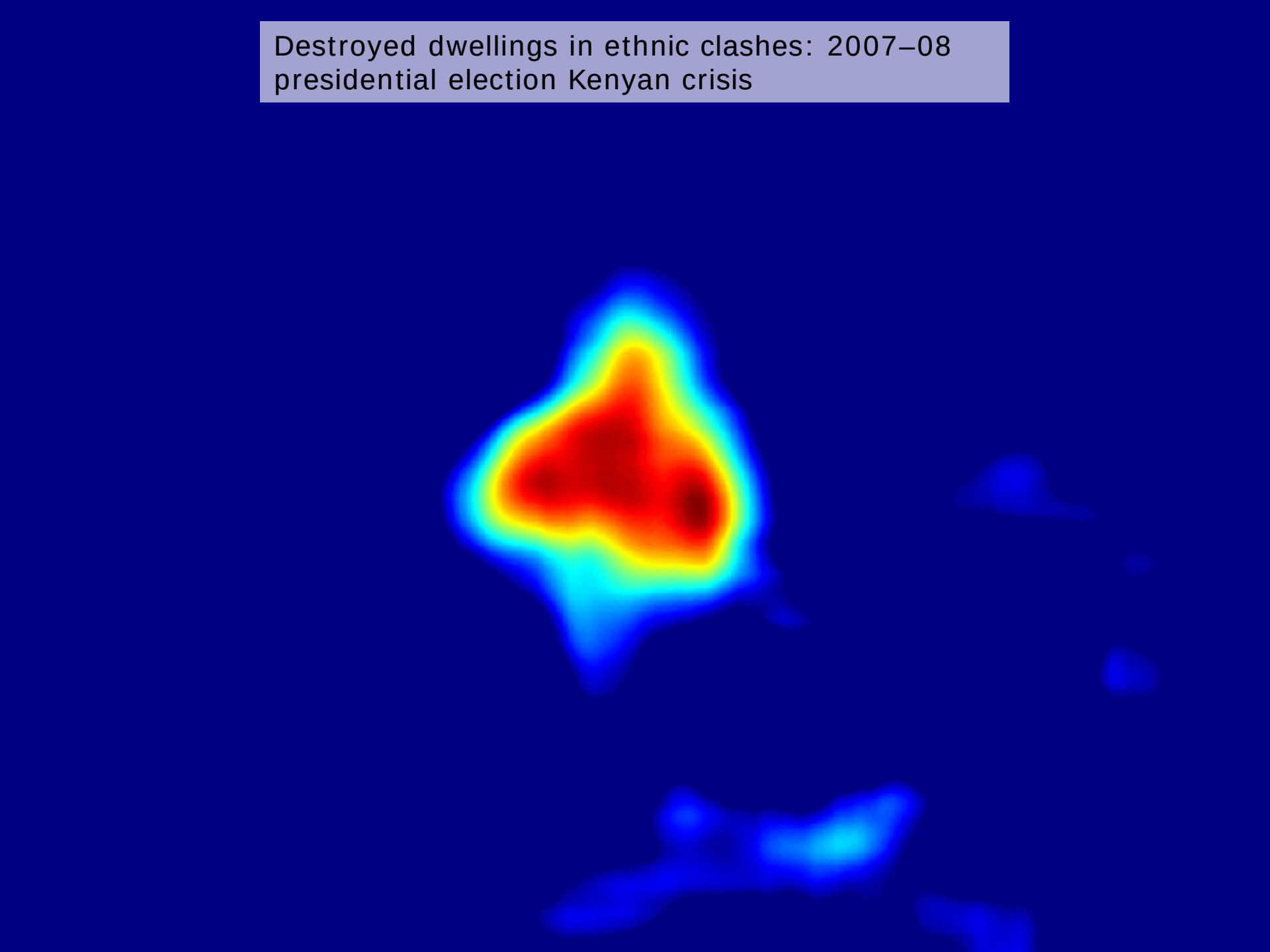
post-confict damage

Tskhinvali, Georgia - South Ossetia
8 August 2008

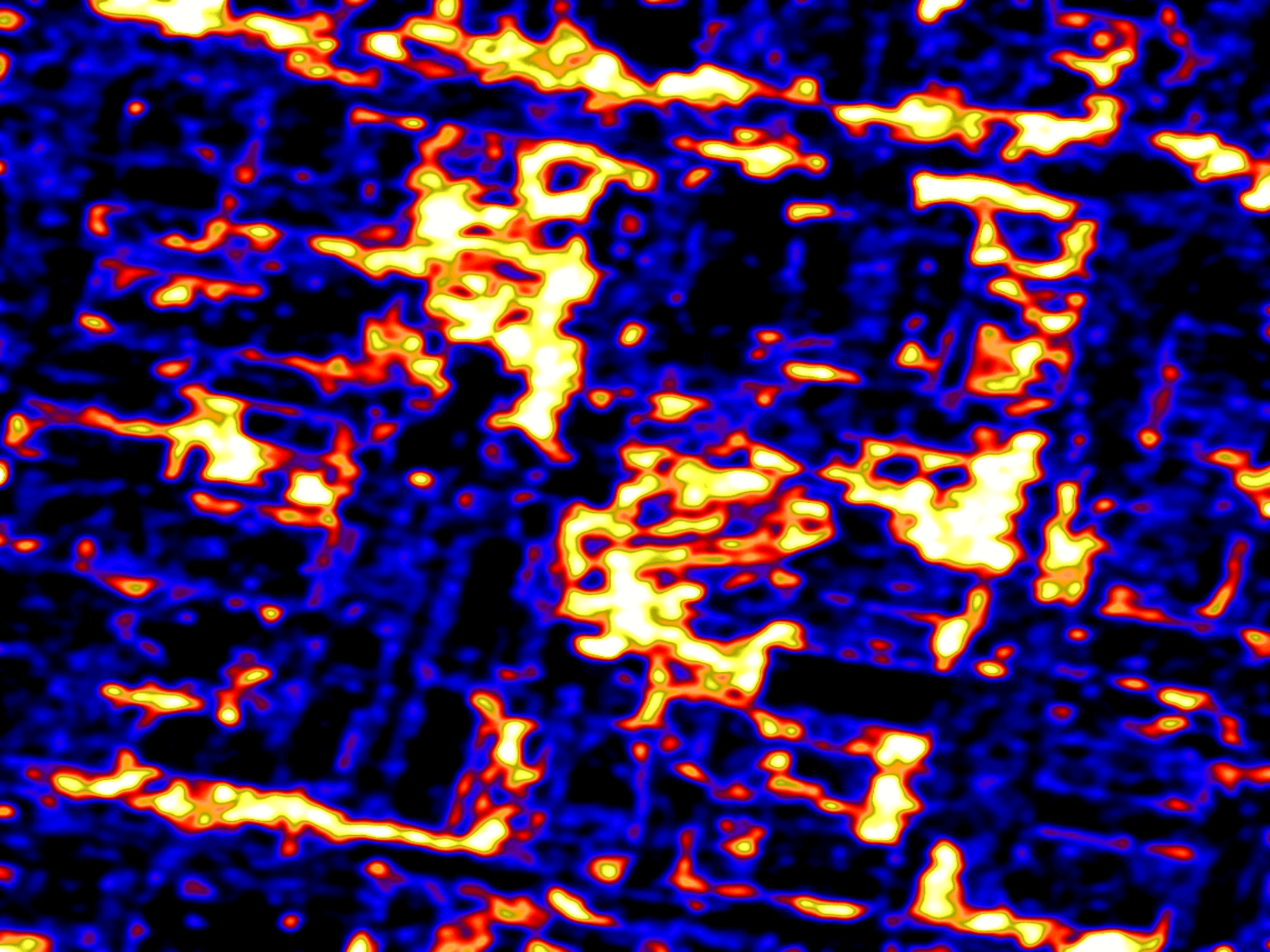


- "Roofless Destroyed Building index"
- "Damage" membership function derived from specific local combination of DMP values
- Threshold on high values
- More than 90% accuracy in this sample

Destroyed dwellings in ethnic clashes: 2007–08 presidential election Kenyan crisis



post-natural-disaster damage



«Big Data» scenarios

fine-scale (high resolution) Global Human Settlement Mapping

HR Global Human Settlement Layer

Proof of concept 1st operational test 2012
Big Data Analytics, Remote Sensing

Total 11438 panchromatic and multispectral satellite data sets from several different sensors. *(SPOT 2 and SPOT 5, RapidEye, CBERS-2B, QuickBird-2, GeoEye-1, WorldView 1 and WorldView 2. Airborne data sets covering large areas were available as RGB imagery).*

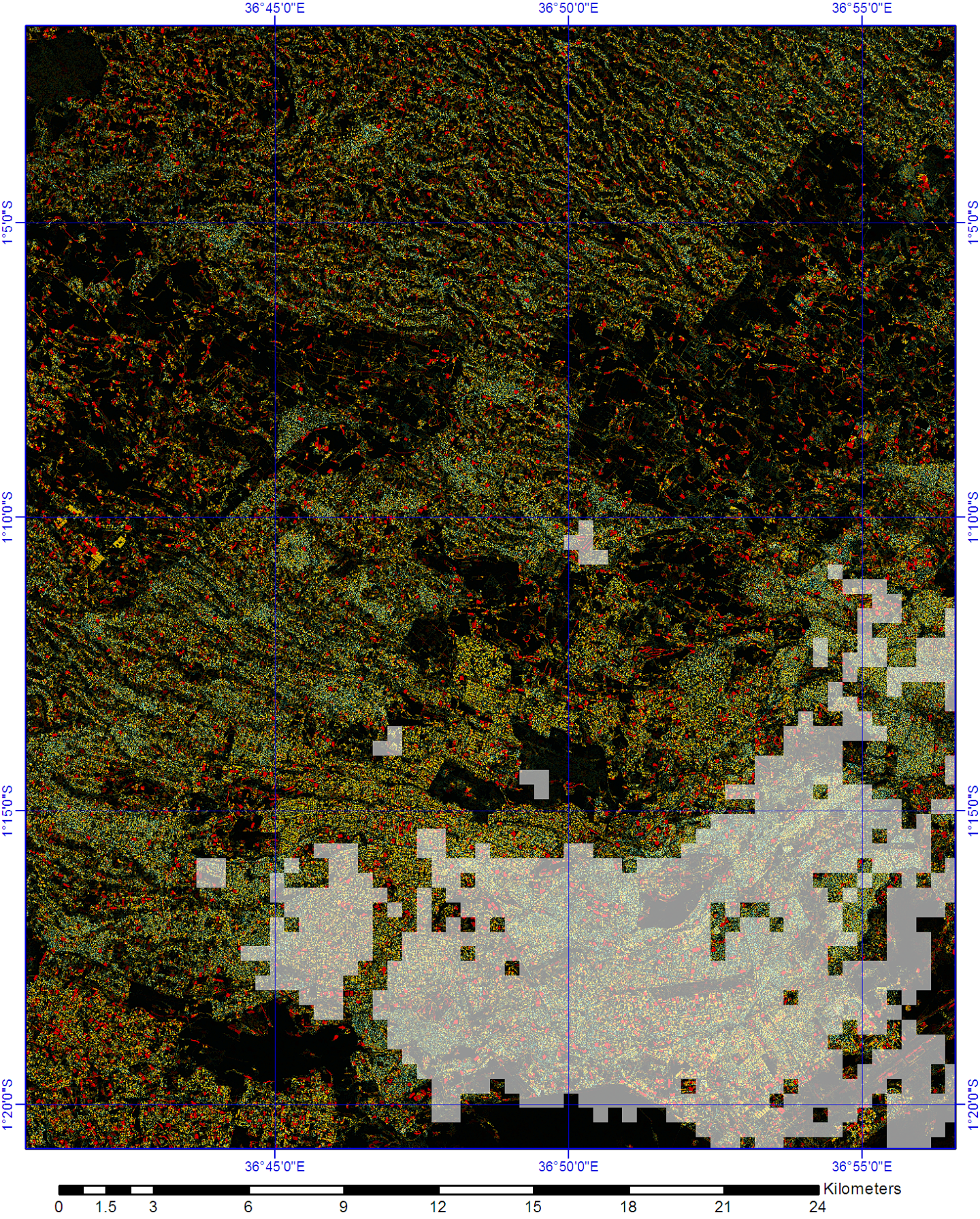
Tested resolutions: **from 0.5 to 10 meter**

Tested Radiometry: the entire visible and near infrared part of the spectrum.

Tested Data Heterogeneity: more than 50 combinations of bands, bit depth and compression formats.

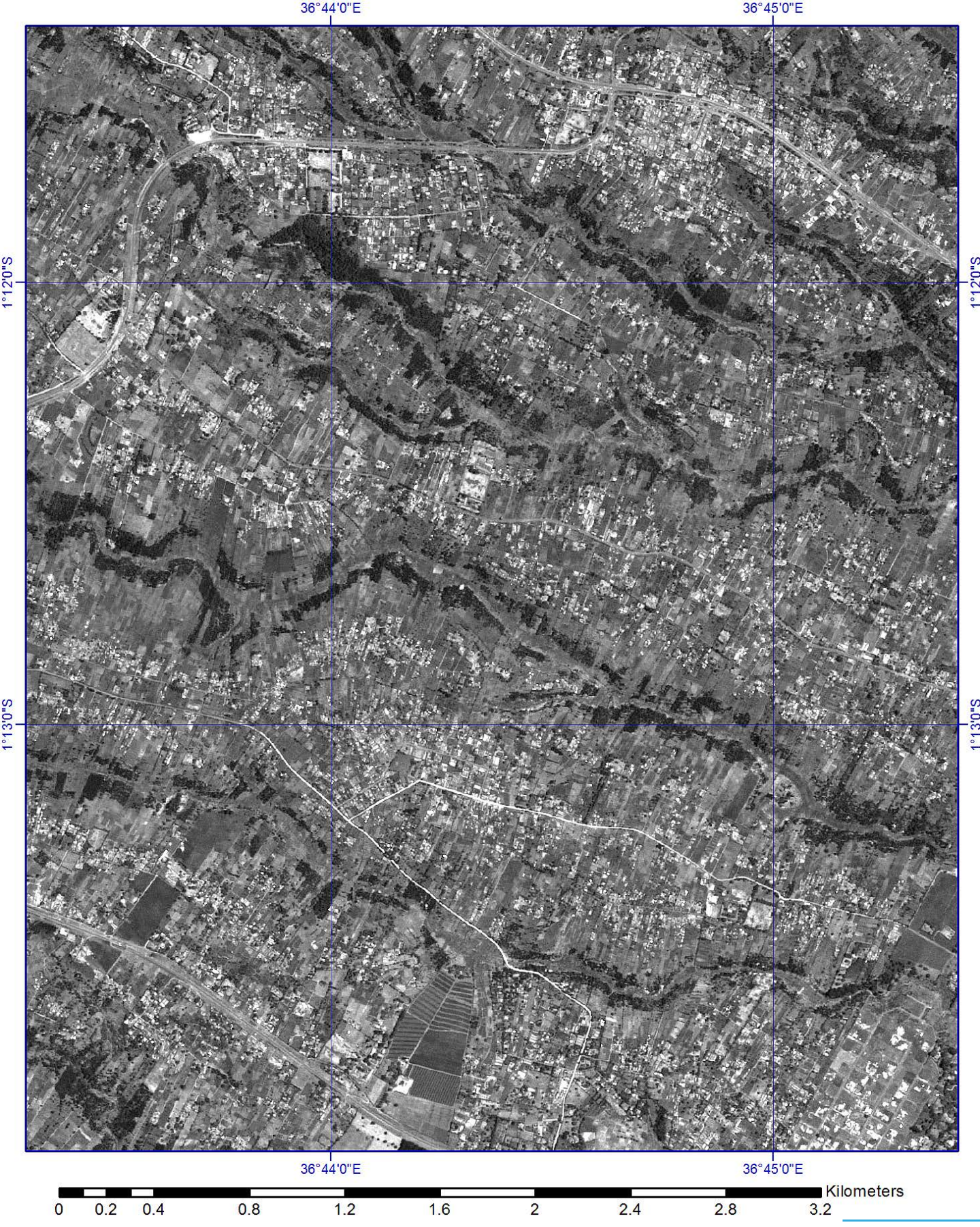
Test size: total mapped surface of more than **24 millions of km2**. (16% of the global landmass)

Input data volume: in the order of **4.00+12 picture elements** (pixels), stored in approximately **30Tbyte**



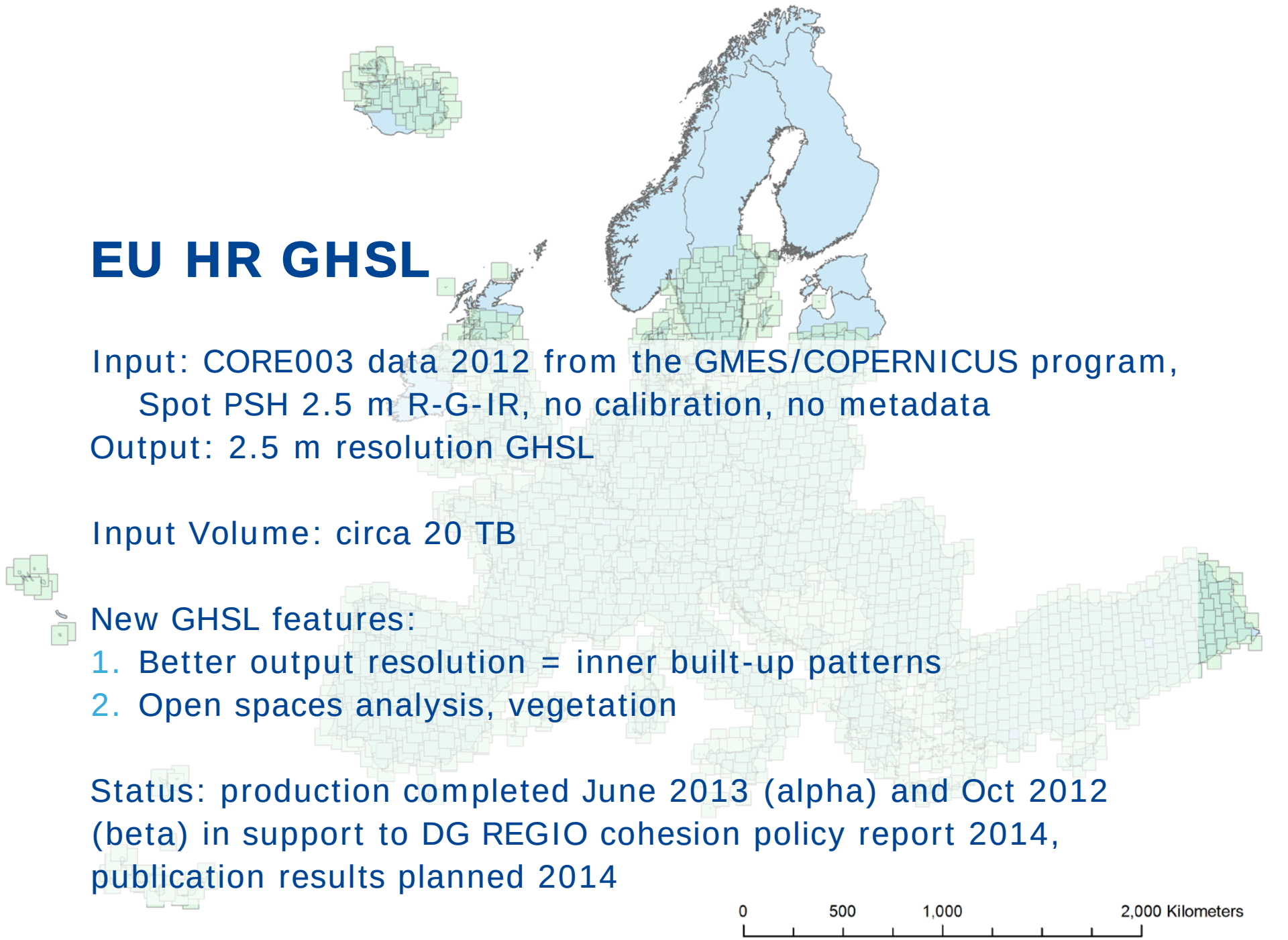
Naiobi, HR GHSL

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



What is lost with LR input data

EU HR GHSL



Input: CORE003 data 2012 from the GMES/COPERNICUS program,
Spot PSH 2.5 m R-G-IR, no calibration, no metadata
Output: 2.5 m resolution GHSL

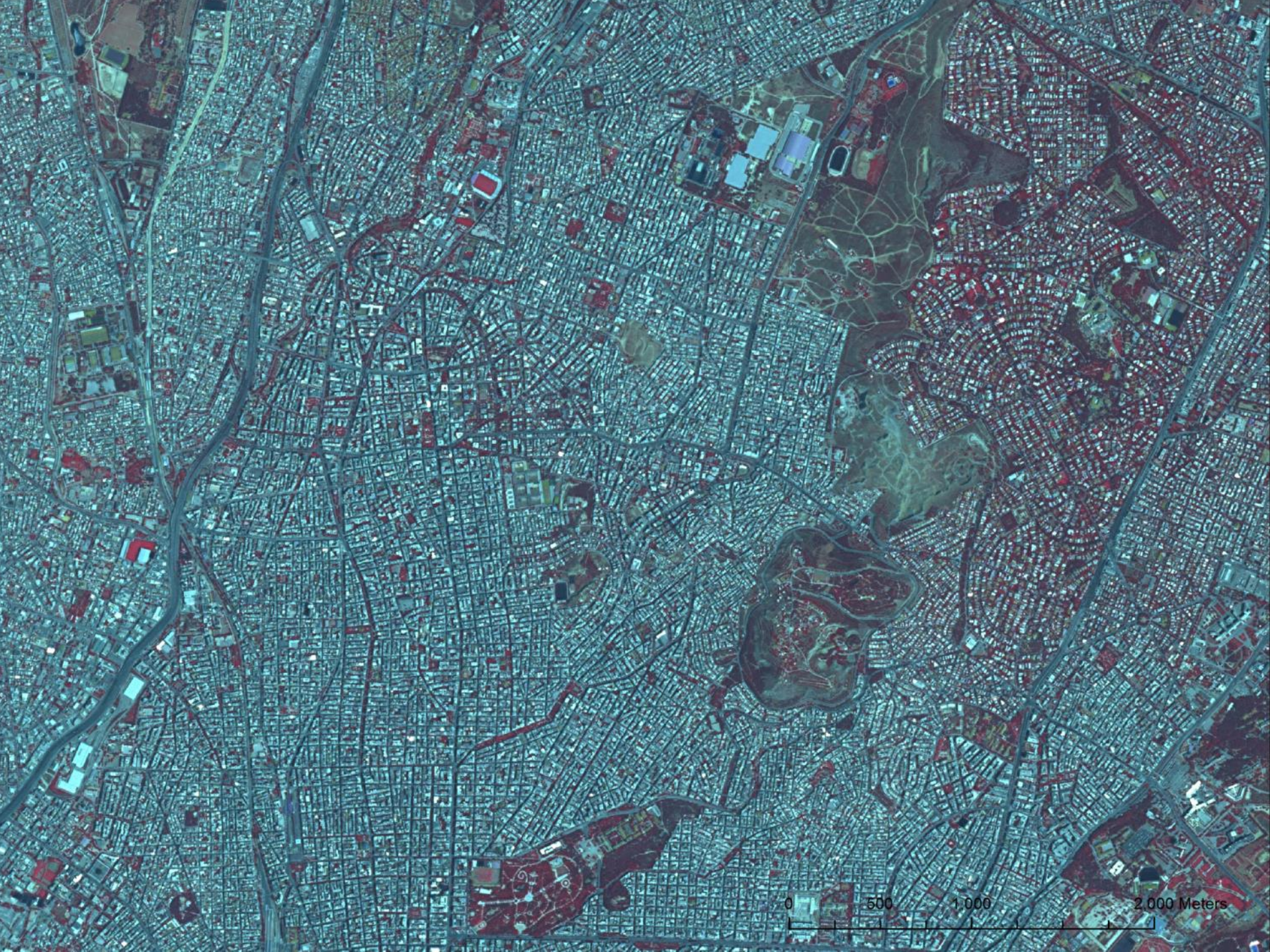
Input Volume: circa 20 TB

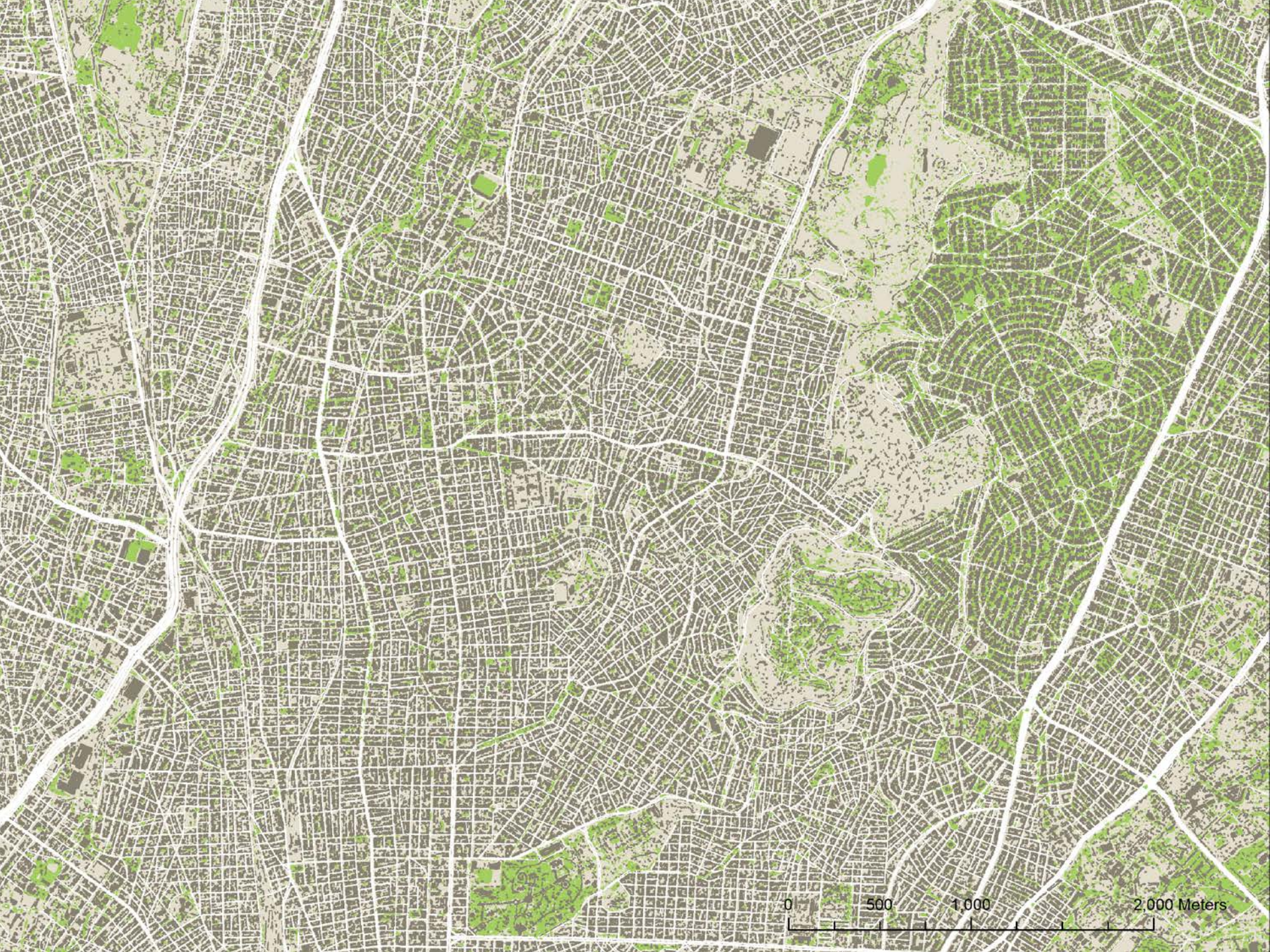
New GHSL features:

1. Better output resolution = inner built-up patterns
2. Open spaces analysis, vegetation

Status: production completed June 2013 (alpha) and Oct 2012 (beta) in support to DG REGIO cohesion policy report 2014, publication results planned 2014

0 500 1,000 2,000 Kilometers


0
500
1,000
2,000 Meters


0
500
1,000
2,000 Meters

What next?

esa

sentinel-1

→ ESA'S RADAR OBSERVATORY MISSION FOR COPERNICUS OPERATIONAL SERVICES

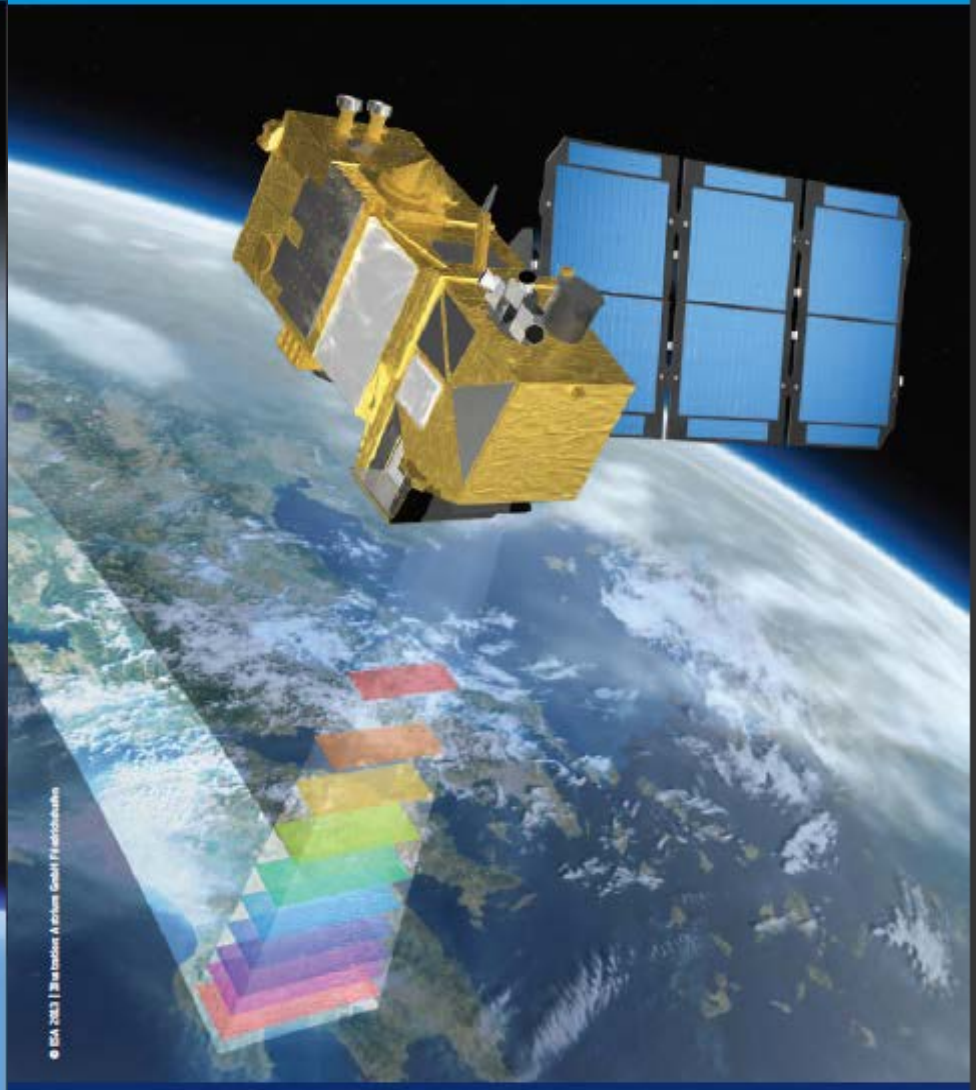
www.esa.int/copernicus

European Space Agency

esa

sentinel-2

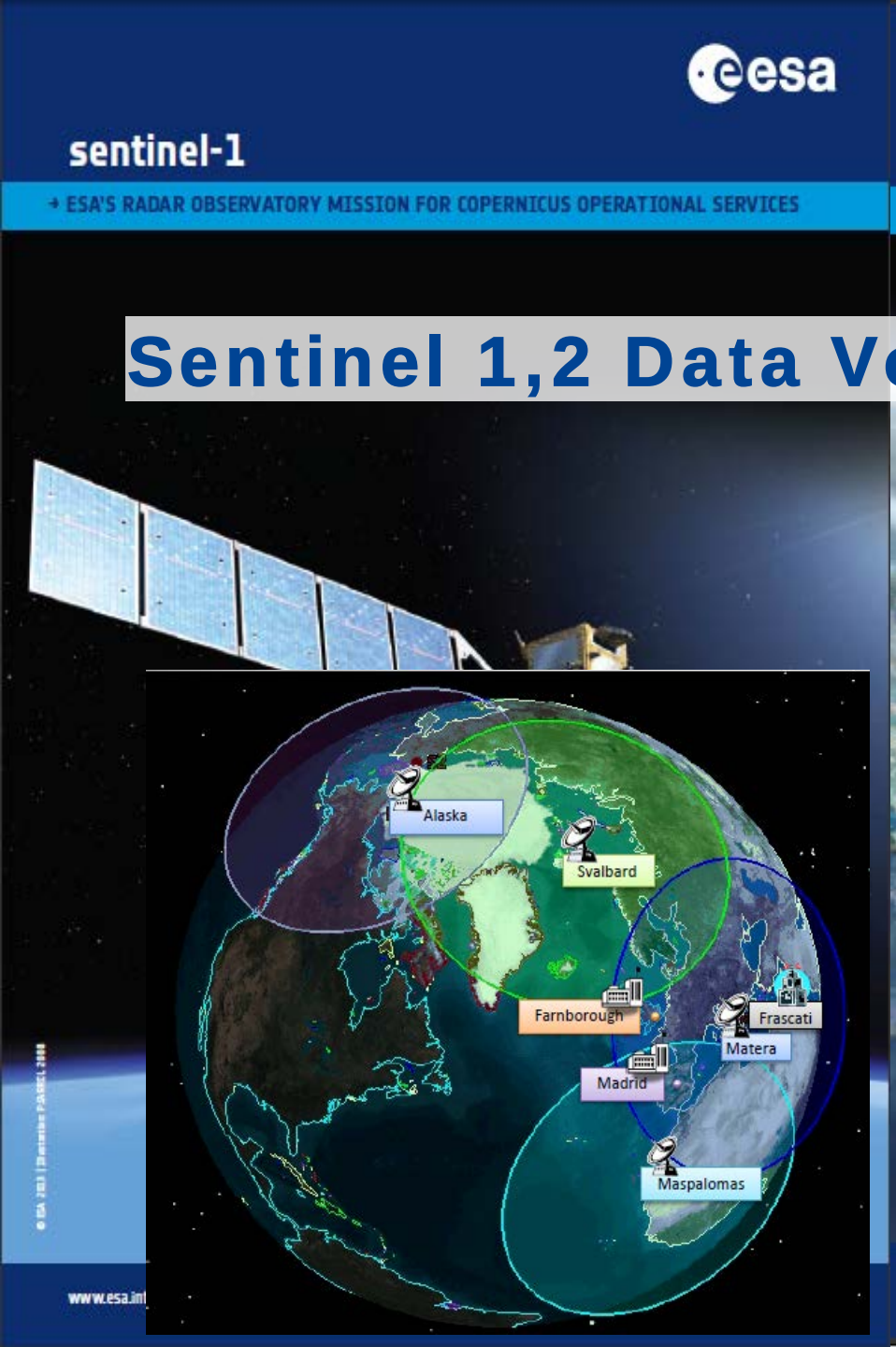
→ THE OPERATIONAL COPERNICUS OPTICAL HIGH RESOLUTION LAND MISSION

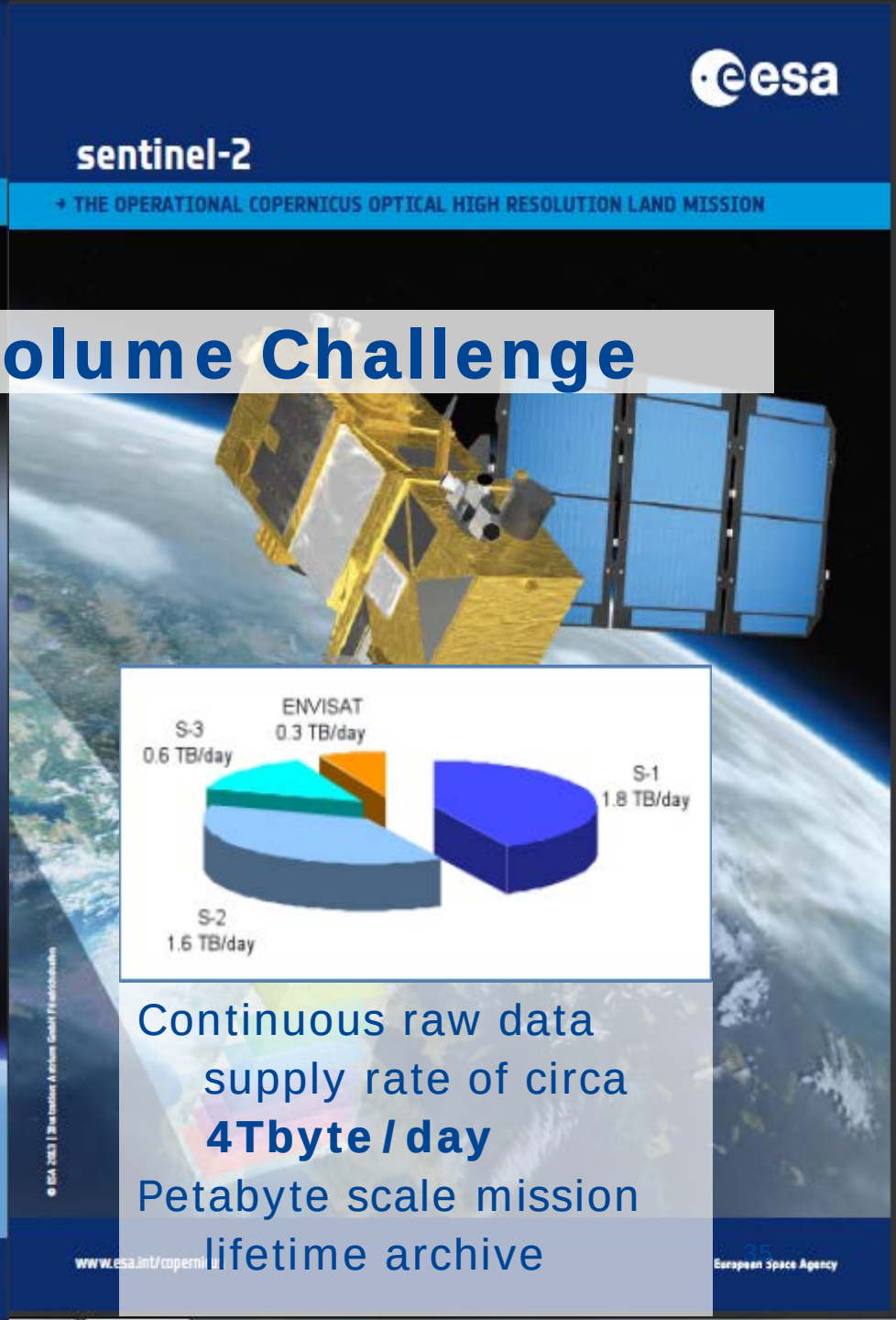


www.esa.int/copernicus

European Space Agency

Sentinel 1,2 Data Volume Challenge





Continuous raw data supply rate of circa **4Tbyte/day**

Petabyte scale mission lifetime archive

Conclusions

The JRC IPSC GlobSec Unit works on automatic image information analysis in support to crisis management

Testing “Big Data” analytics in Remote Sensing: image data sensor heterogeneity, data volume and interpretation task complexity

Global Human Settlement Layer in support to population exposure and risk assessment – proof of concept

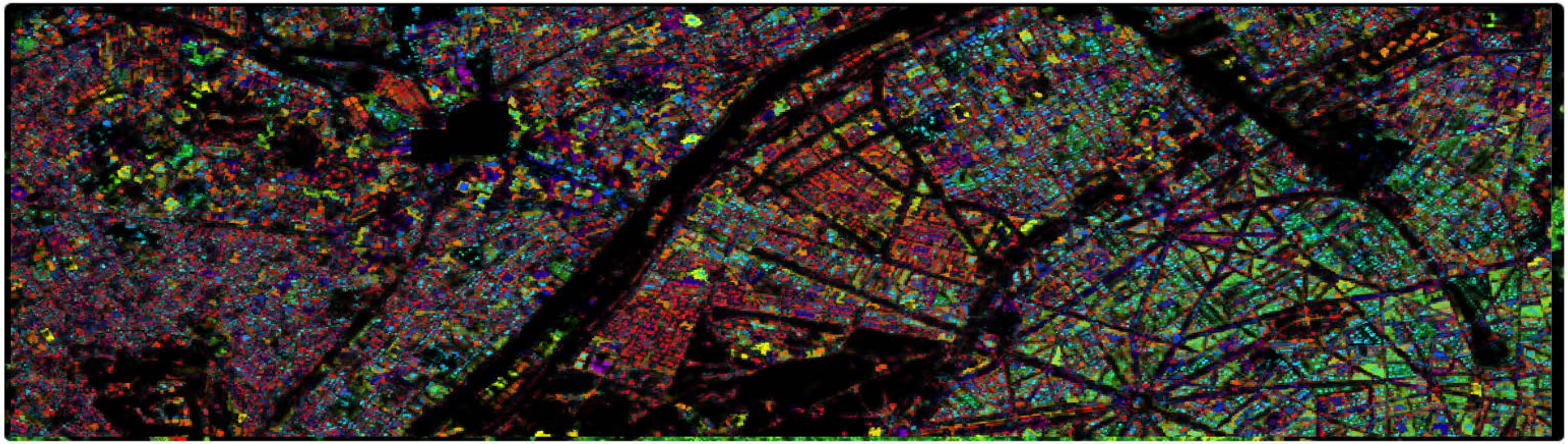
Next Sentinel satellite platform increasing dramatically the availability of open data for scientific community

Seeking for partnerships, federate efforts

European Commission

JOINT RESEARCH CENTRE

Global Human Settlement Layer



Concept | Technology | Products & Services | Collaboration | References

Global Human Settlement Layer

The Global Human Settlement Layer (GHSL) is developed and maintained by the JRC

The GHSL proposes a new way to map, analyze, and monitor human settlements and the urbanization in the 21st century.
GHSL integrates several available sources reporting about the global human settlement phenomena, with new information extracted from available remotely sensed (RS) imageries. In fact, the GHSL is the largest and most complete known experiment on automatic image information retrieval using high and very high remotely sensed image data. The GHSL automatic image information extraction workflow integrates multi-resource, multi-platform, multi-sensor (pan, multispectral), and multi-temporal image data.

The GHSL is an evolutionary system, with the aim of stepwise improving completeness and accuracy of the global human settlement description by offering free services of image information retrieval in the frame of collaborative and derived-contents sharing agreements.

http://ghslsys.jrc.ec.europa.eu

JRC GHSL Senior Scientist team

Martino Pesaresi (team leader)
Daniele Ehrlich (risk/vulnerability)
Matina Halkia (regional planning/development)
Thomas Kemper (IDP/refugees)
Pierre Soille (image processing)
Luigi Zanchetta (IT infrastructure)

~15 Phd and other short-term contracts

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THANKS