Earth Observation & GeoSpatial Information for Monitoring Urban SDG Indicators

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KTH Royal Institute of Technology

Global Urbanization Trend

- In 2008, more than 50% of the world live in cities.
- By 2050, the world is expected to add an additional 2.5 billion urban dwellers;
- Nearly 90 percent of the increase is concentrated in Asia and Africa. (United Nations, 2014).
- China, India and Nigeria expected to account for 37% of the projected growth of the world's urban population

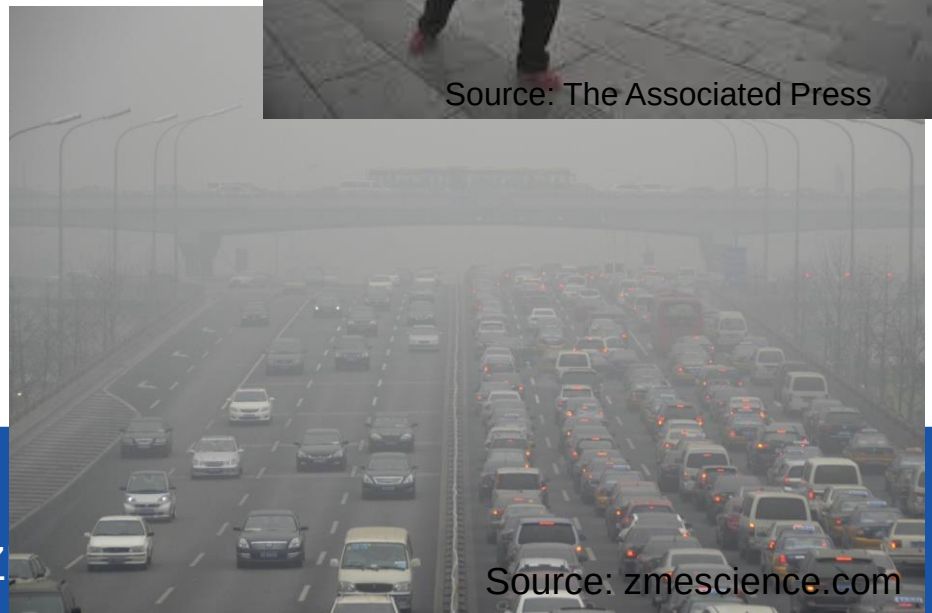
Environmental Consequences

High concentrations of aerosols, exhaust gases, pollution and dust

- Hazardous to health
- Increased smog, haze, fog, clouds

Source: The Associated Press

Source: Suicup via Wikimedia



Source: zmescience.com

Environmental Consequences

- **Paved surfaces -> rainfall water -> flooding**
  - Urbanization results in more impervious surfaces, thus reducing the area where infiltration to ground water can occur. Thus, more storm water runoff occurs.
  - 79 people died in July 2012 Beijing flooding

Source: rendezvous.blogs.nytimes.com

Source: BBC News

Source: www.theatlanticcities.com

Environmental Consequences

Urban heat island (UHI) and heat waves

- UHI – urban air temperatures higher than surrounding rural areas.
- The average air temperature in a city with 1 million inhabitants is 1-3 degrees warmer.
- Heat waves: In the afternoon, the difference can be 12 degrees warmer, no night time cooling. Death rate raise during heat waves.

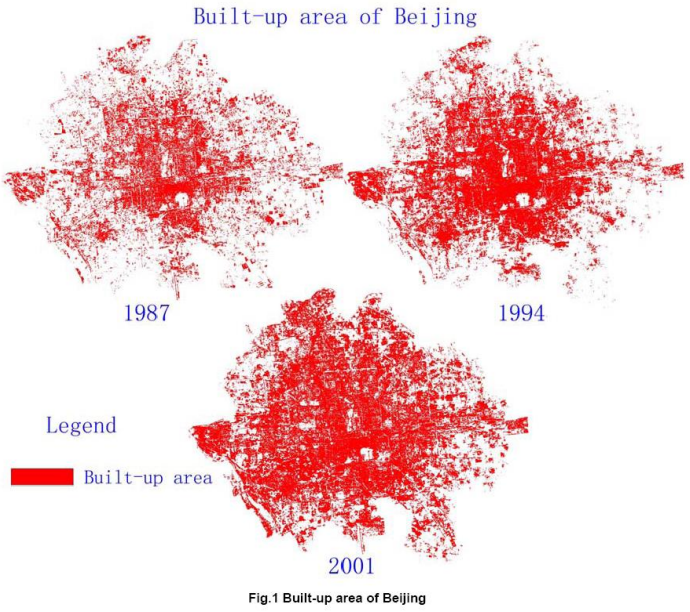
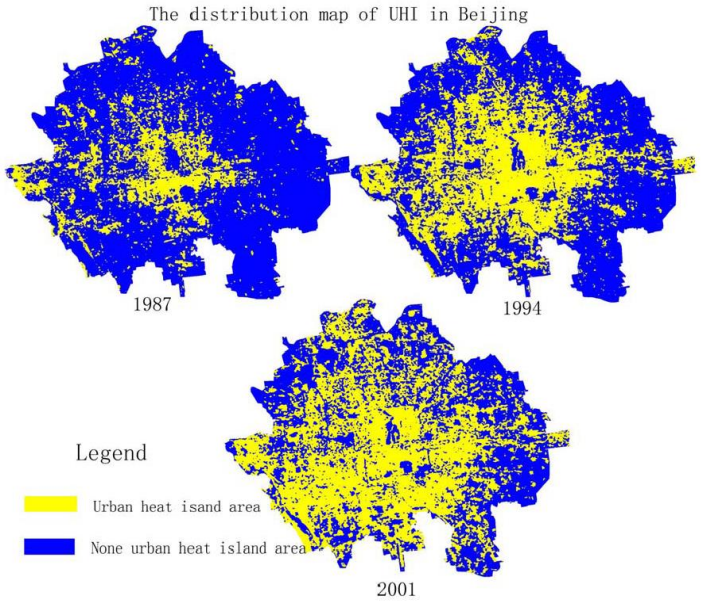


Fig.1 Built-up area of Beijing



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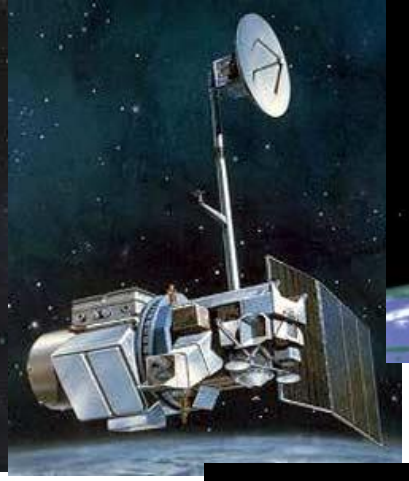
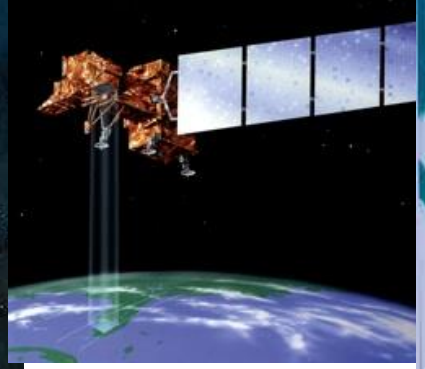

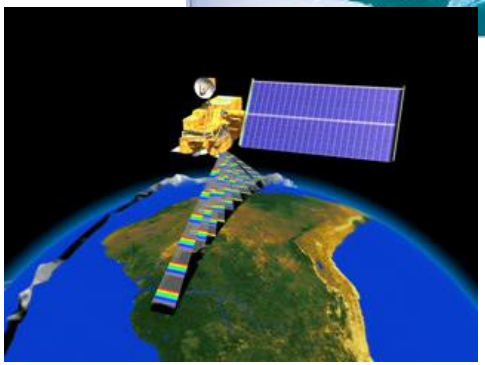

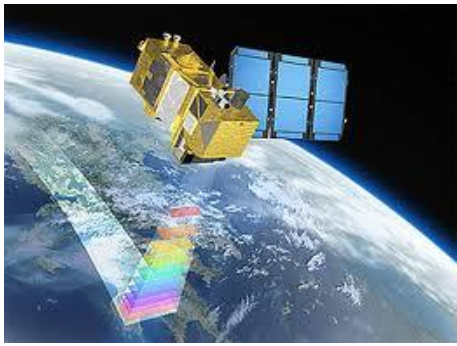
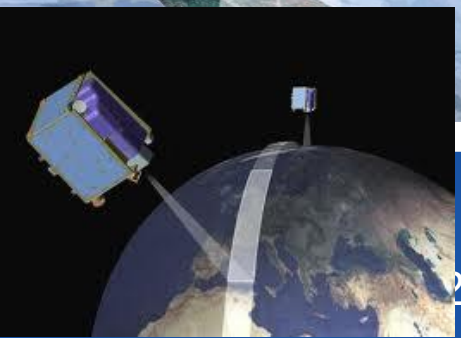

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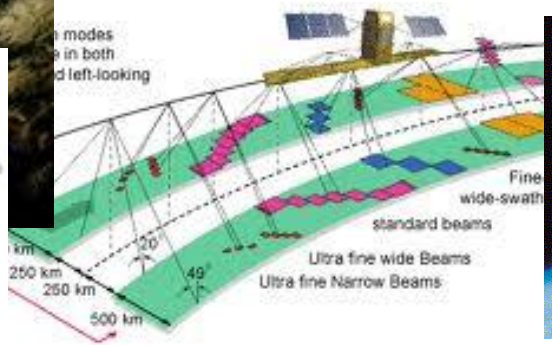
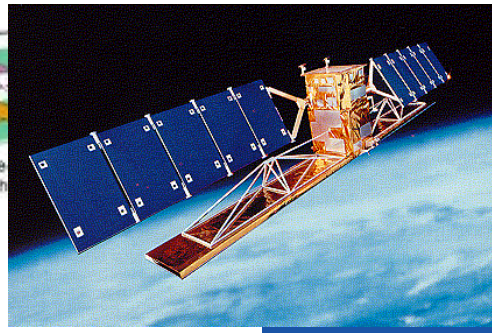
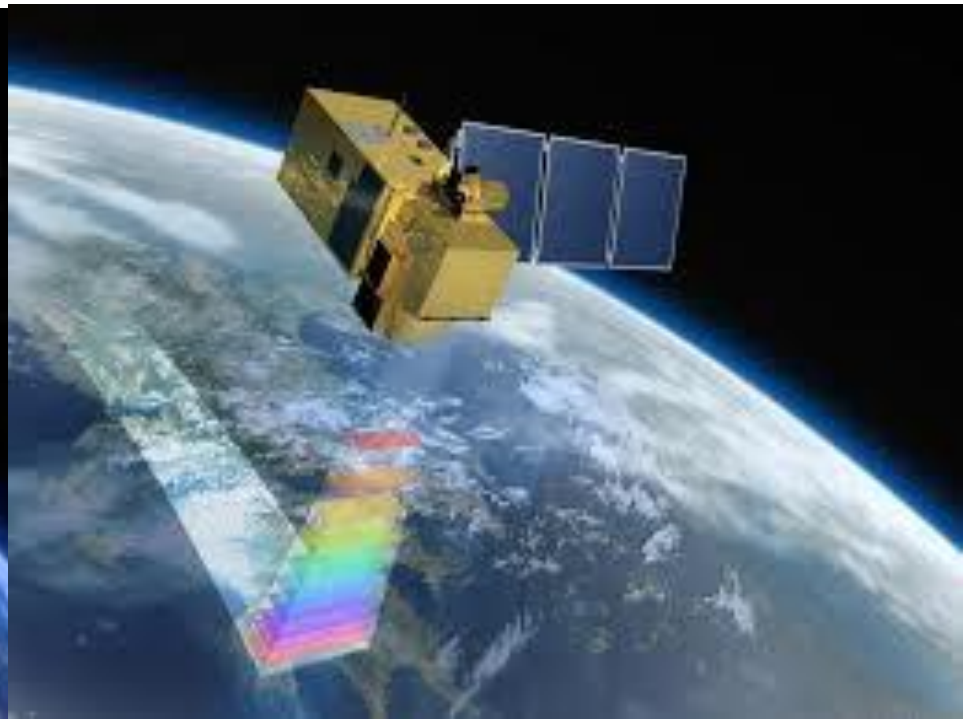
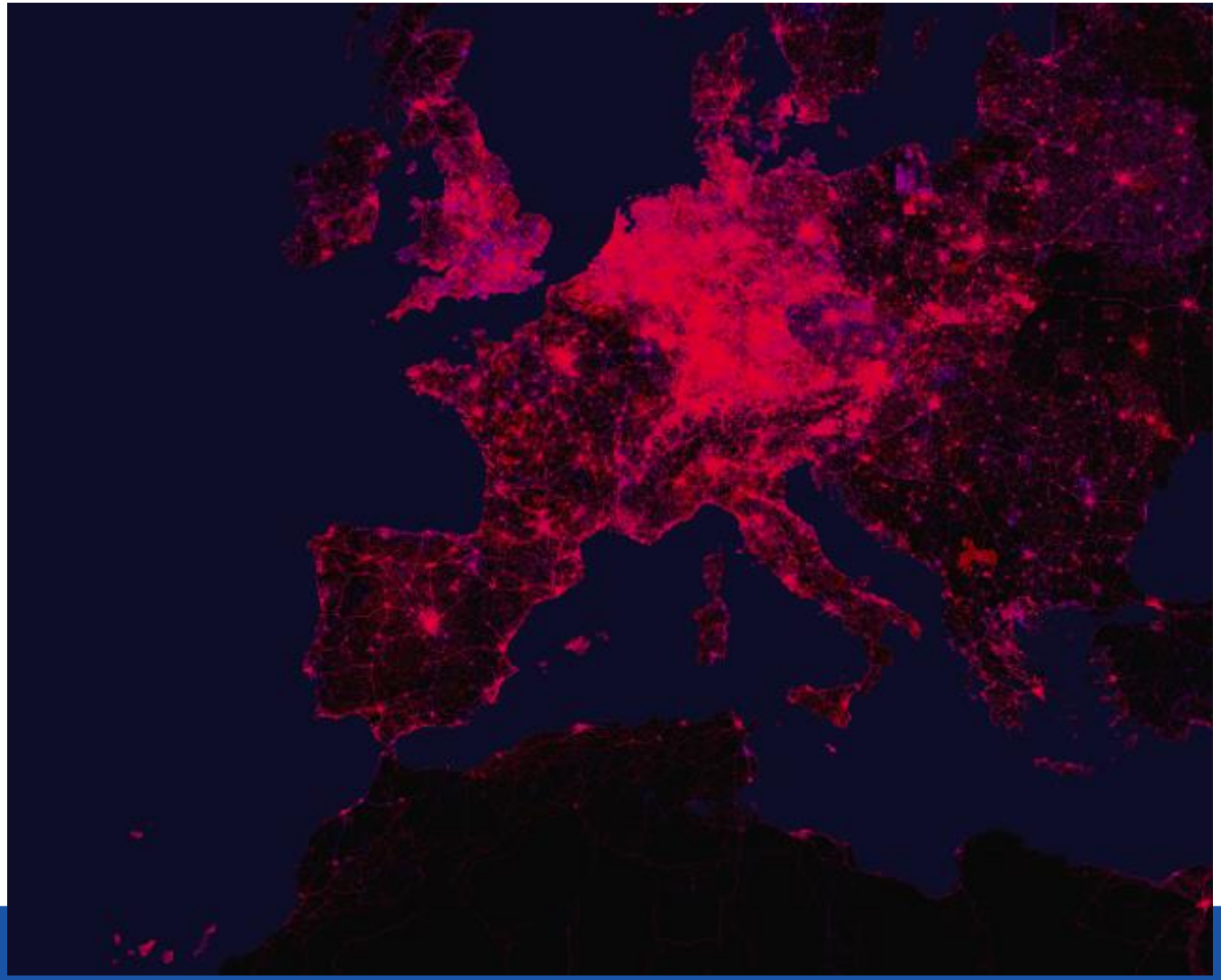

modes
in both
left-looking
Fine
wide-swath
standard beams
20°
49°
Ultra fine wide Beams
Ultra fine Narrow Beams
250 km
250 km
500 km


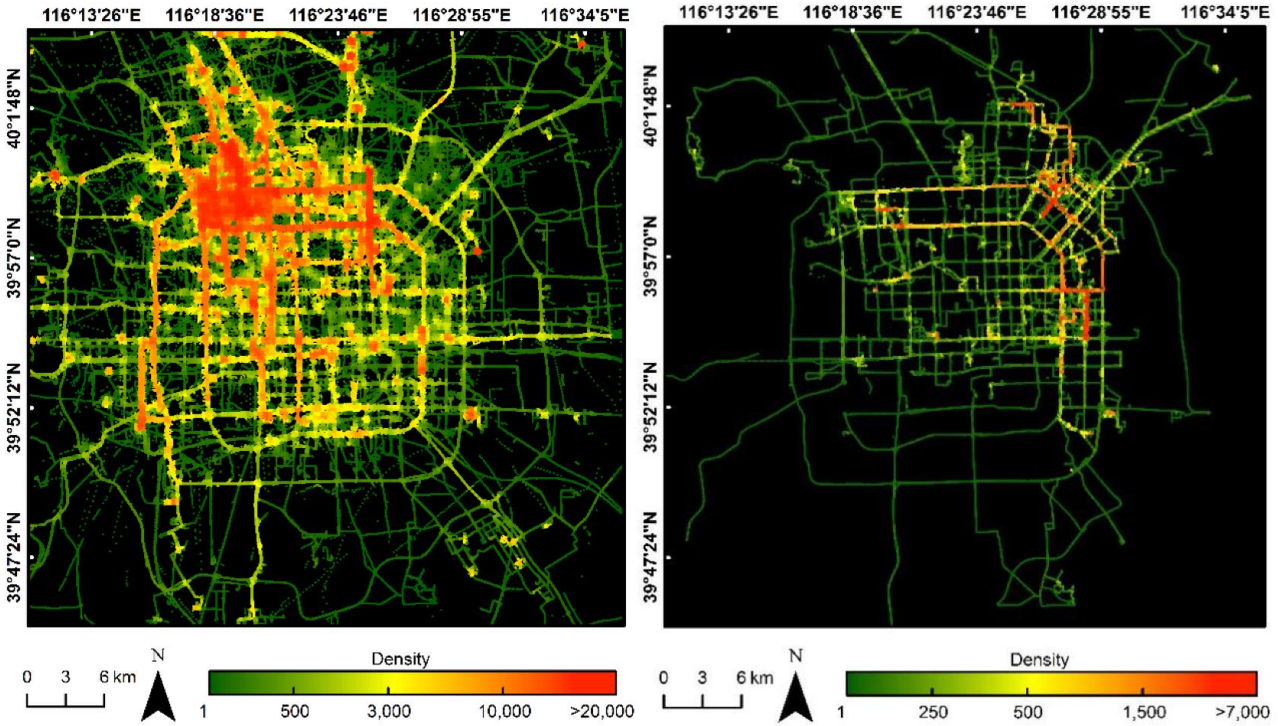
Sentinel Big Data: Free



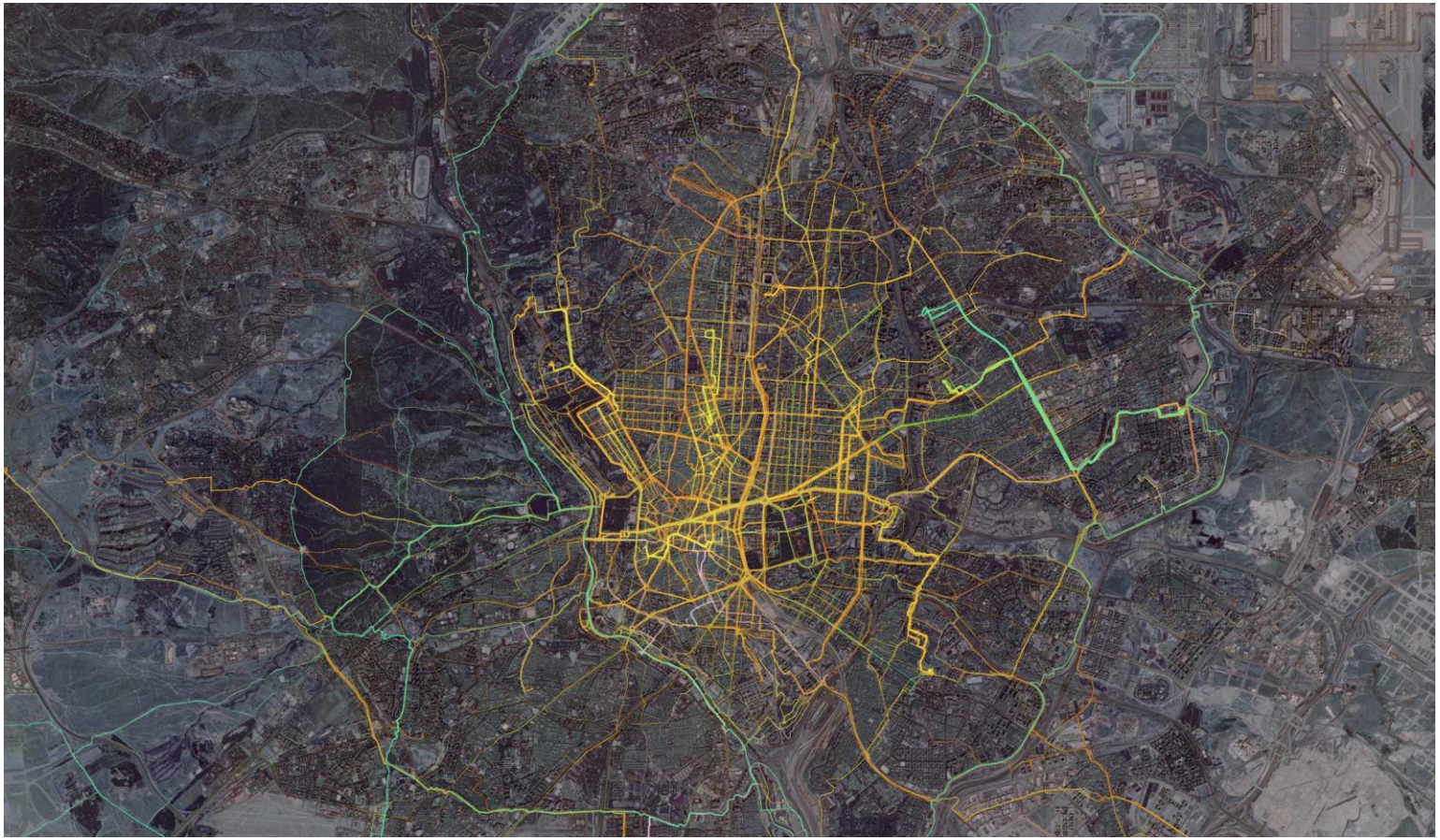
Volunteered Geographic Information



Mobility Data: GeoLife Beijing



Mobility Data:
Cycling footprint of Madrid



UN Urban SGD Indicators

Goal 11: Make cities inclusive, safe, resilient & sustainable

Target 11.3: By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries.

Indicator11.3.1 Ratio of land consumption rate to population growth rate – Land use efficiency

Target 11.7: is providing universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities.

11.7.1 Average share of the built-up area of cities that is open space for public use for all, by sex, age and persons with disabilities

EO4Urban

- **The overall objective is to evaluate multi-temporal multi-resolution Sentinel-1A SAR and Sentinel-2A MSI data for developing a pilot global urban services based on user requirements to support smart and sustainable urban development.**

Team	KTH Royal Institute of Technology, Sweden
	University of Pavia, Italy
Users	Stockholm County Administrative Board, Sweden
	National Geomatics Center, China

User Requirement Baseline

- Global Urban Mapping
  - Urban Extent Maps
- Semi-Global Urban Mapping
  - Urban Land Cover Maps
- City-Level Urban Mapping
  - New Builtup Area Maps
  - Urban Green Structure Maps
  - Urban Green Structure Change Maps

User Requirements: Urban Extent Maps

- 2015 and 2016 Urban extent maps for Stockholm and Beijing
- Minimum Mapping Unit at 30m x 30m.
- Historical urban extent maps from 1995, 2005 and 2010 if possible.

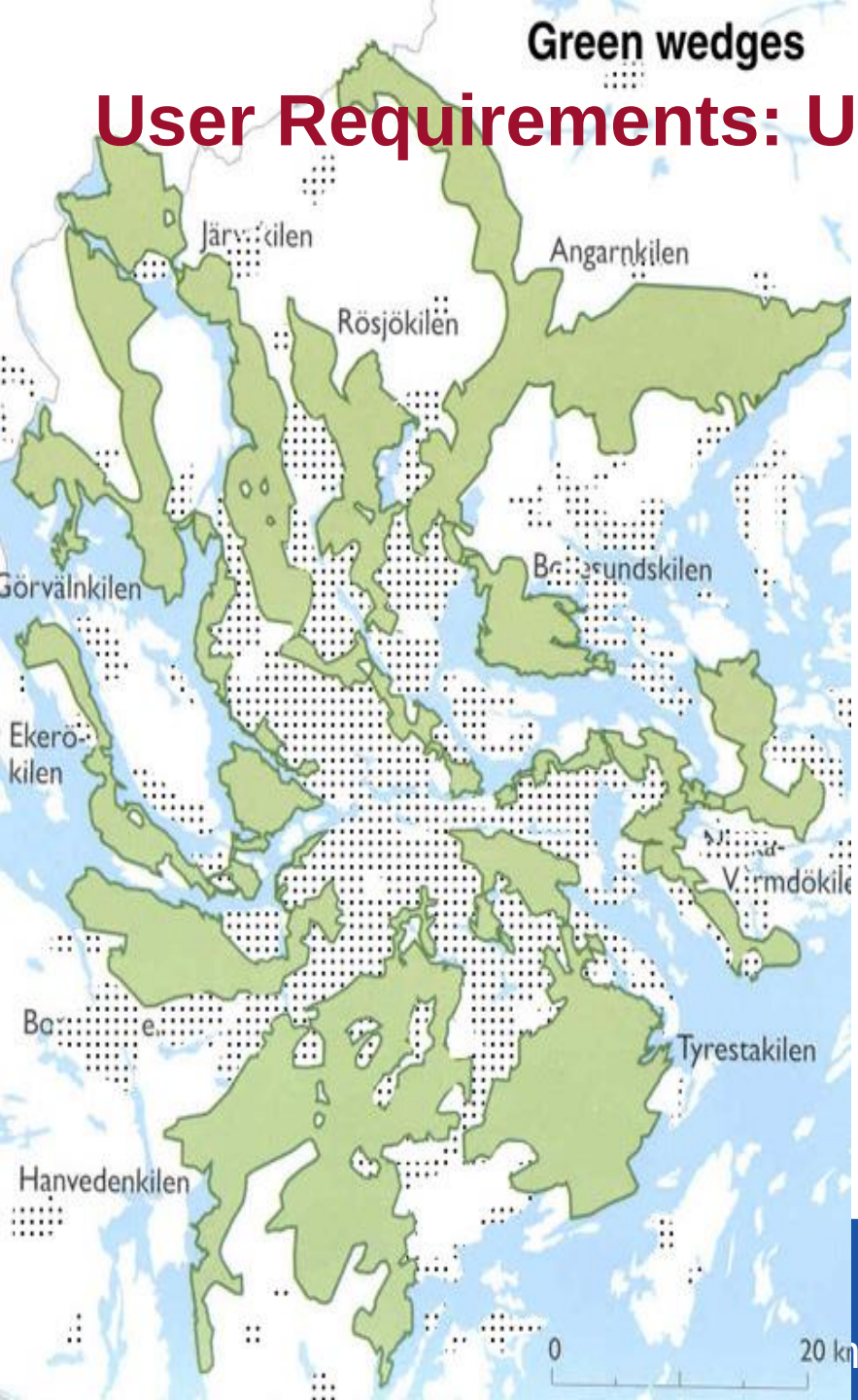
Zhejiang, China

User Requirements: New Builtup Area Maps

- Maps of new built-up areas: base map in 2015 and updated yearly
- Minimum Mapping Unit at 30m x 30m.

2019, Deqing, Zhejiang, China

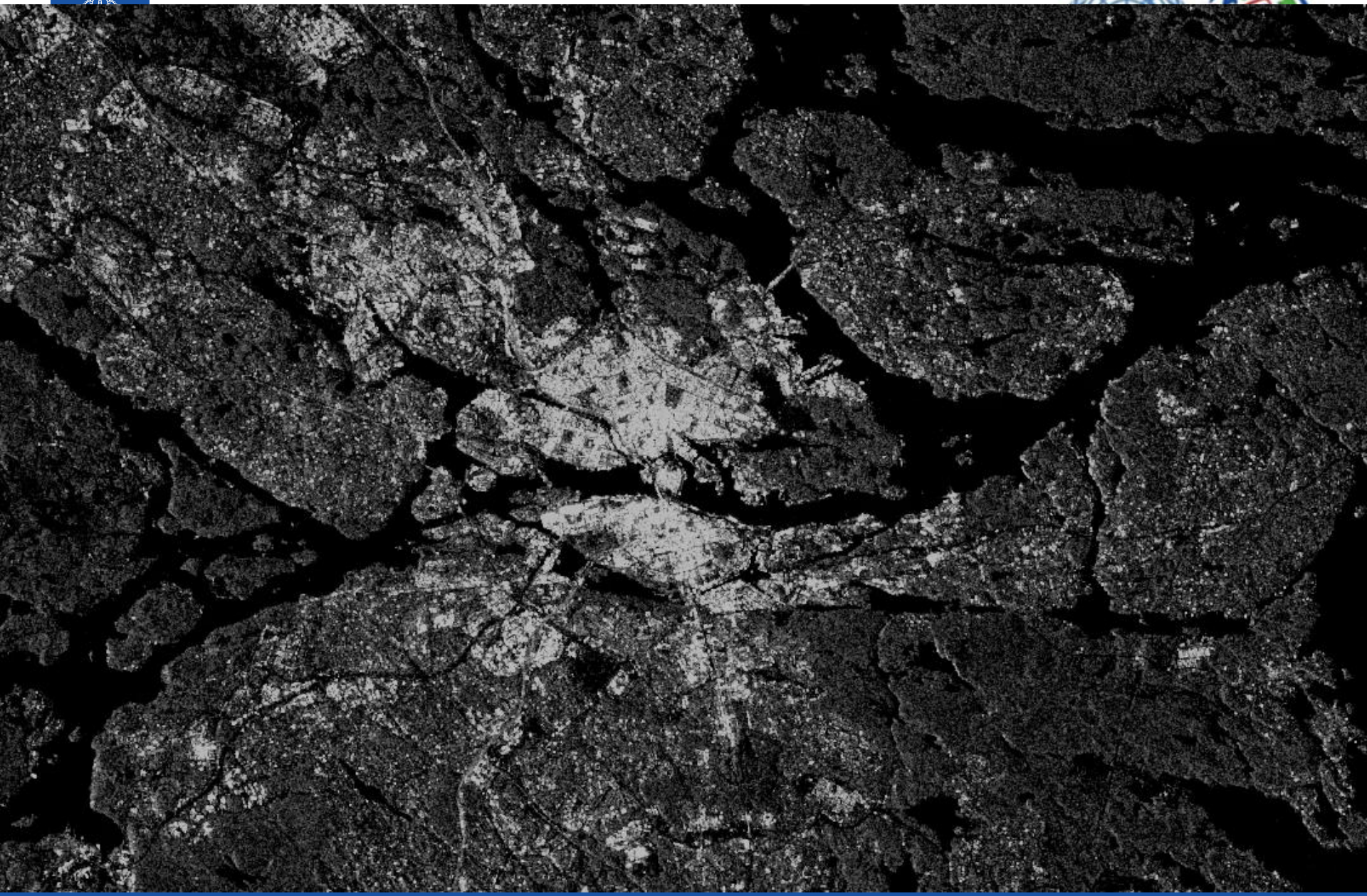
User Requirements: Urban Green Structure Maps



- Maps of Urban Green Structure in 2015 and updated yearly
- Minimum Mapping Unit at 30m x 30m.

User Requirements: Urban Green Structure Change Maps

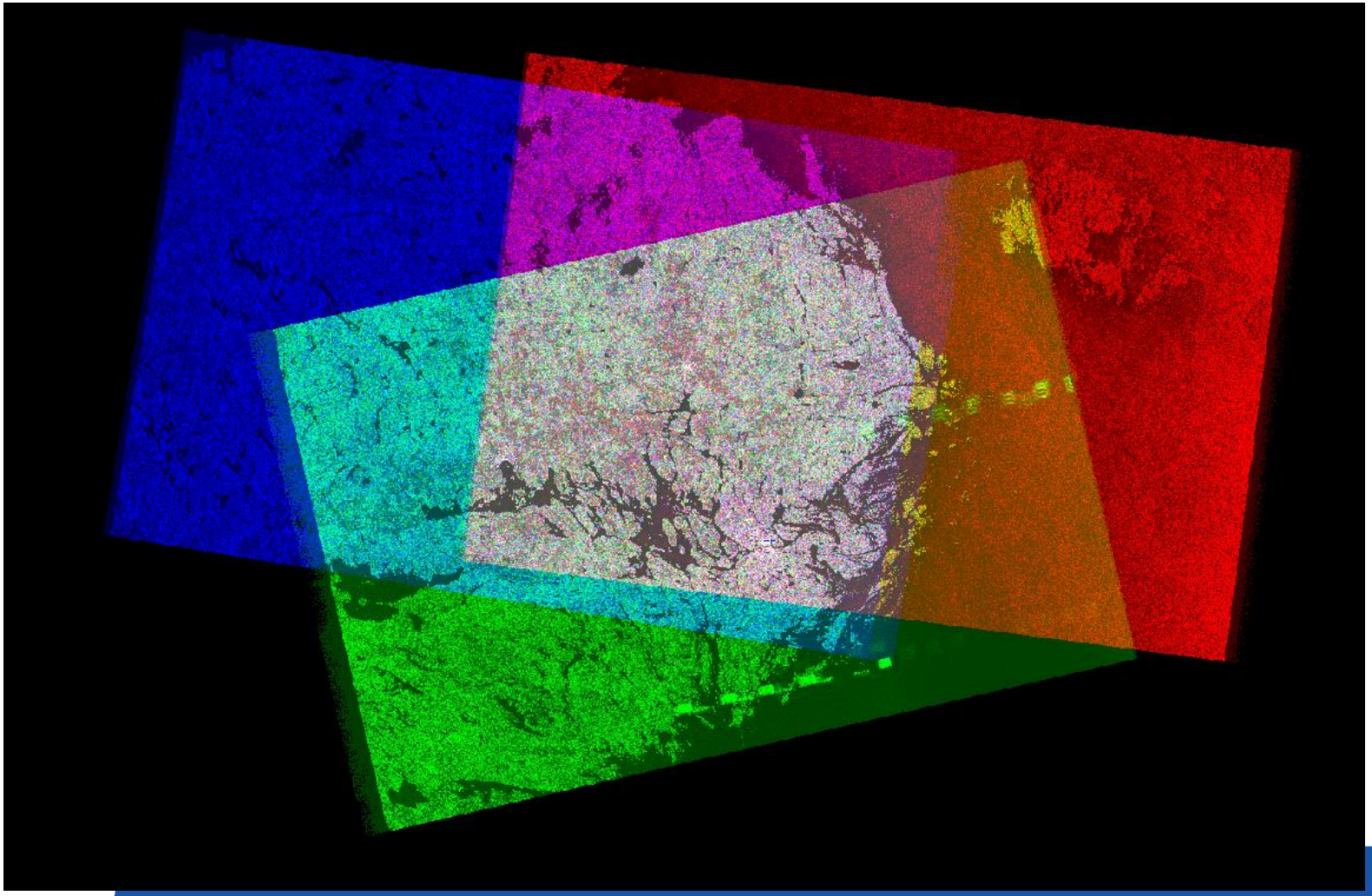
- Maps of urban green structure changes in 2015 and updated yearly
- Minimum Mapping Unit at 30m x 30m.



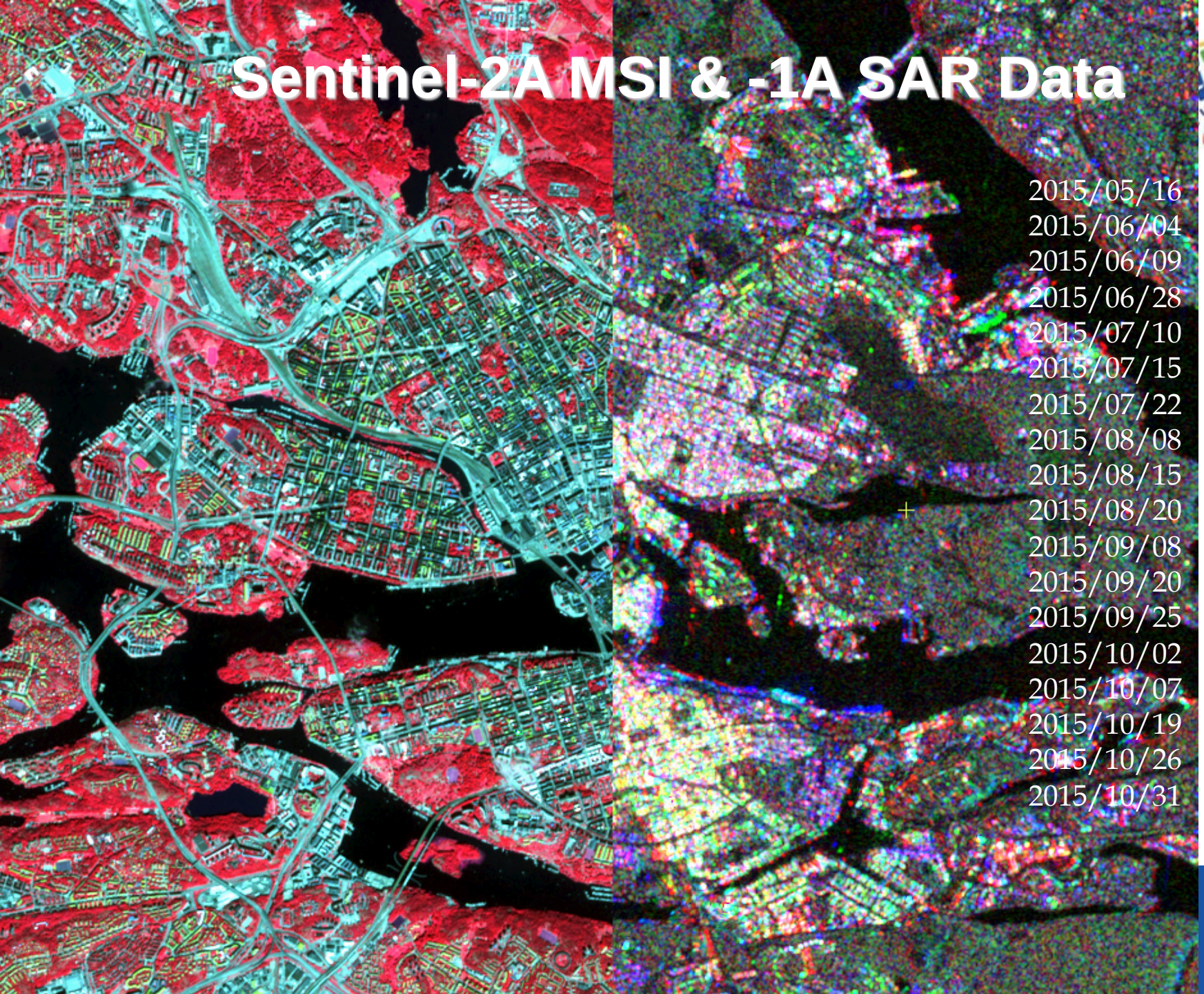
Study Areas

Stockholm
EUROPE
NORTH
AMERICA
New York City
North
Atlantic
Milan / Lombardy
ASIA
Beijing
Mexico City
Mumbai
Lagos
AFRICA
SOUTH
AMERICA
Jakarta
Indian
Ocean
Rio De Janeiro
South
Pacific
South
Atlantic
AUSTRALIA
Sydney

Sentinel-1 SAR Data

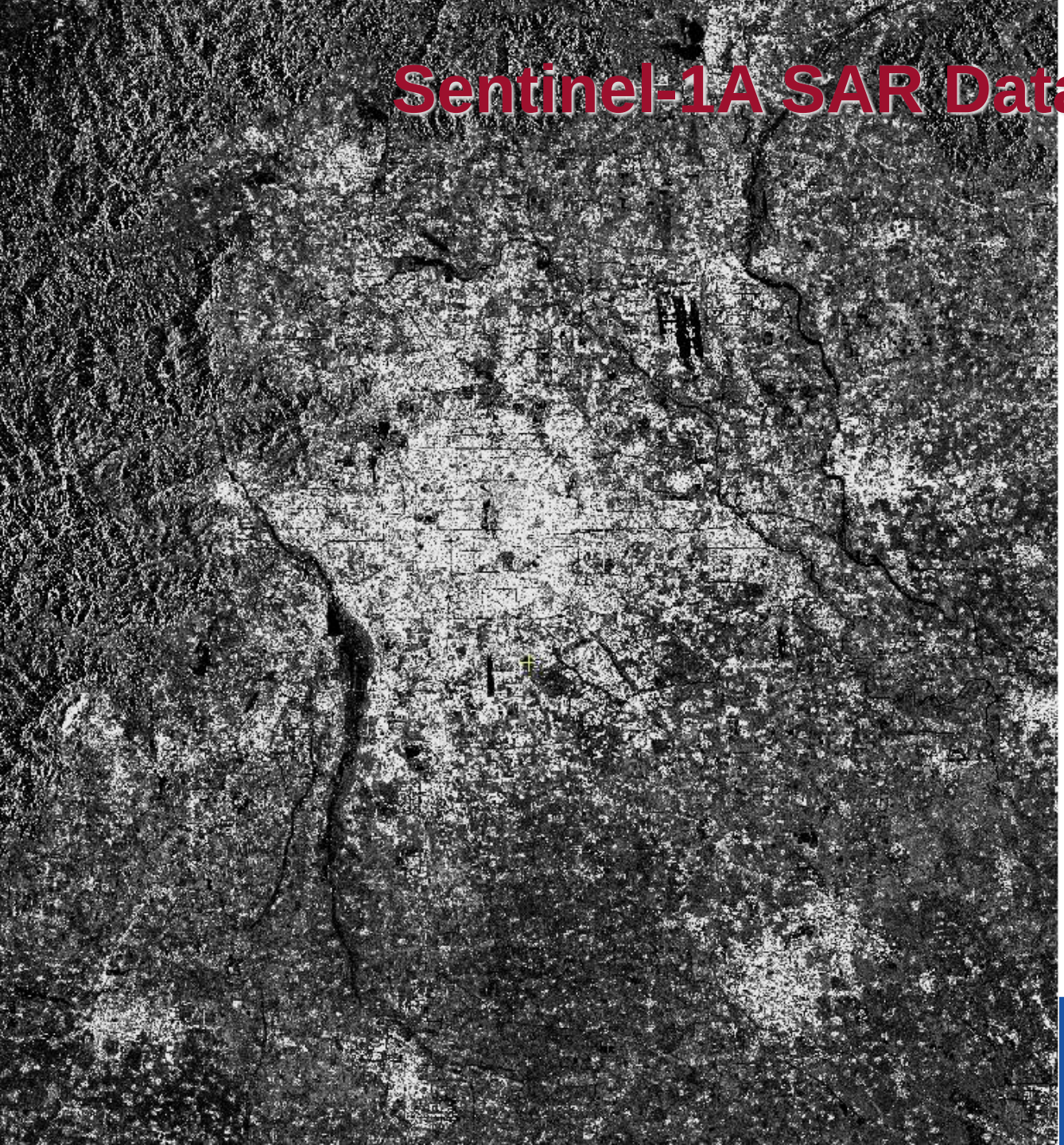


Sentinel-2A MSI & -1A SAR Data

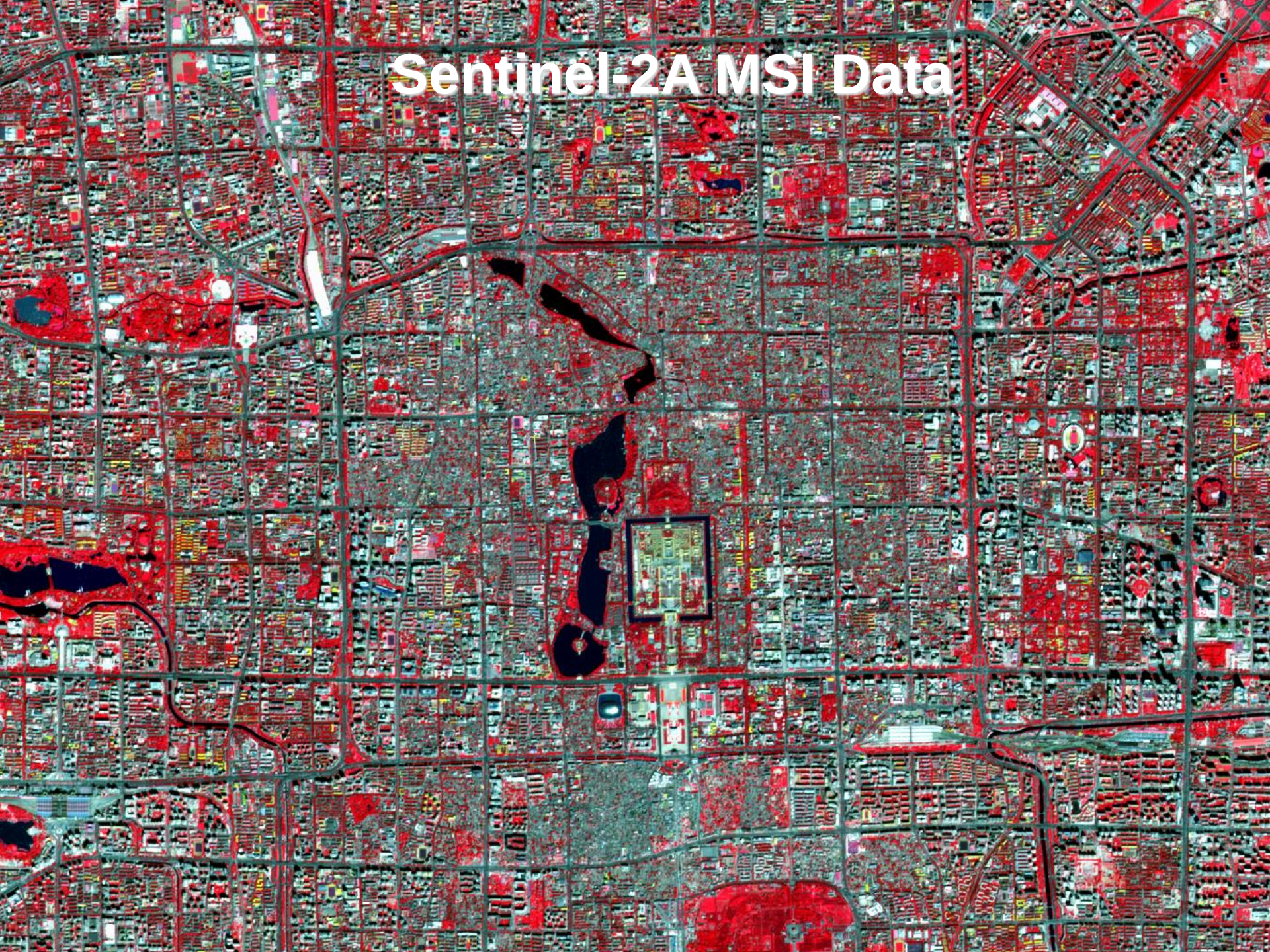


2015/05/16	ASC
2015/06/04	DSC
2015/06/09	ASC
2015/06/28	DSC
2015/07/10	DSC
2015/07/15	ASC
2015/07/22	DSC
2015/08/08	ASC
2015/08/15	DSC
2015/08/20	ASC
2015/09/08	DSC
2015/09/20	DSC
2015/09/25	ASC
2015/10/02	DSC
2015/10/07	ASC
2015/10/19	ASC
2015/10/26	DSC
2015/10/31	ASC

Sentinel-1A SAR Data

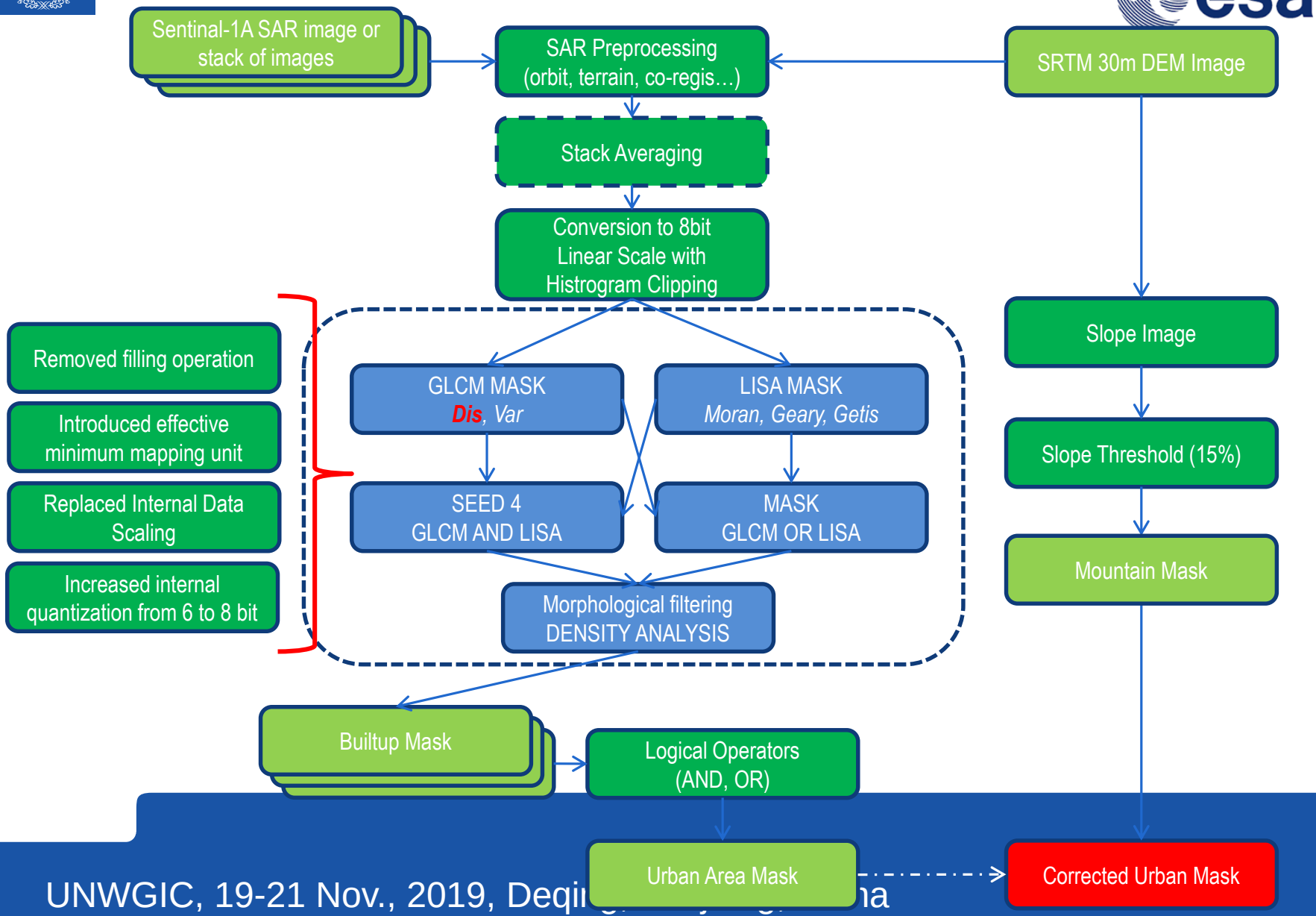


2015/05/24	DSC
2015/06/05	DSC
2015/06/17	DSC
2015/07/23	DSC
2015/07/30	ASC
2015/08/23	ASC
2015/09/09	DSC
2015/09/16	ASC
2015/10/03	DSC
2015/10/10	ASC

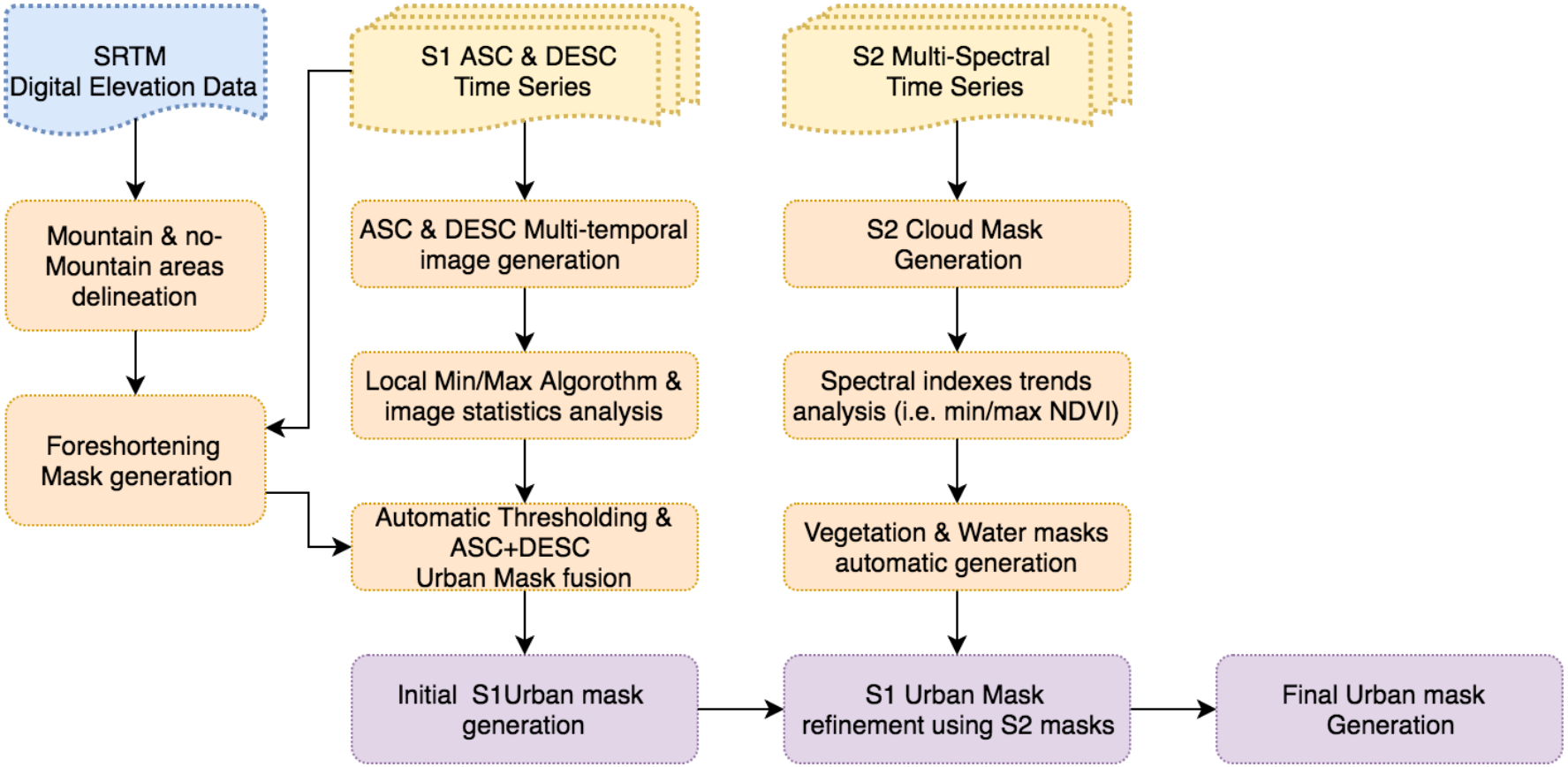

Sentinel-2A MSI Data

Sentinel-2A: Pan-sharpening

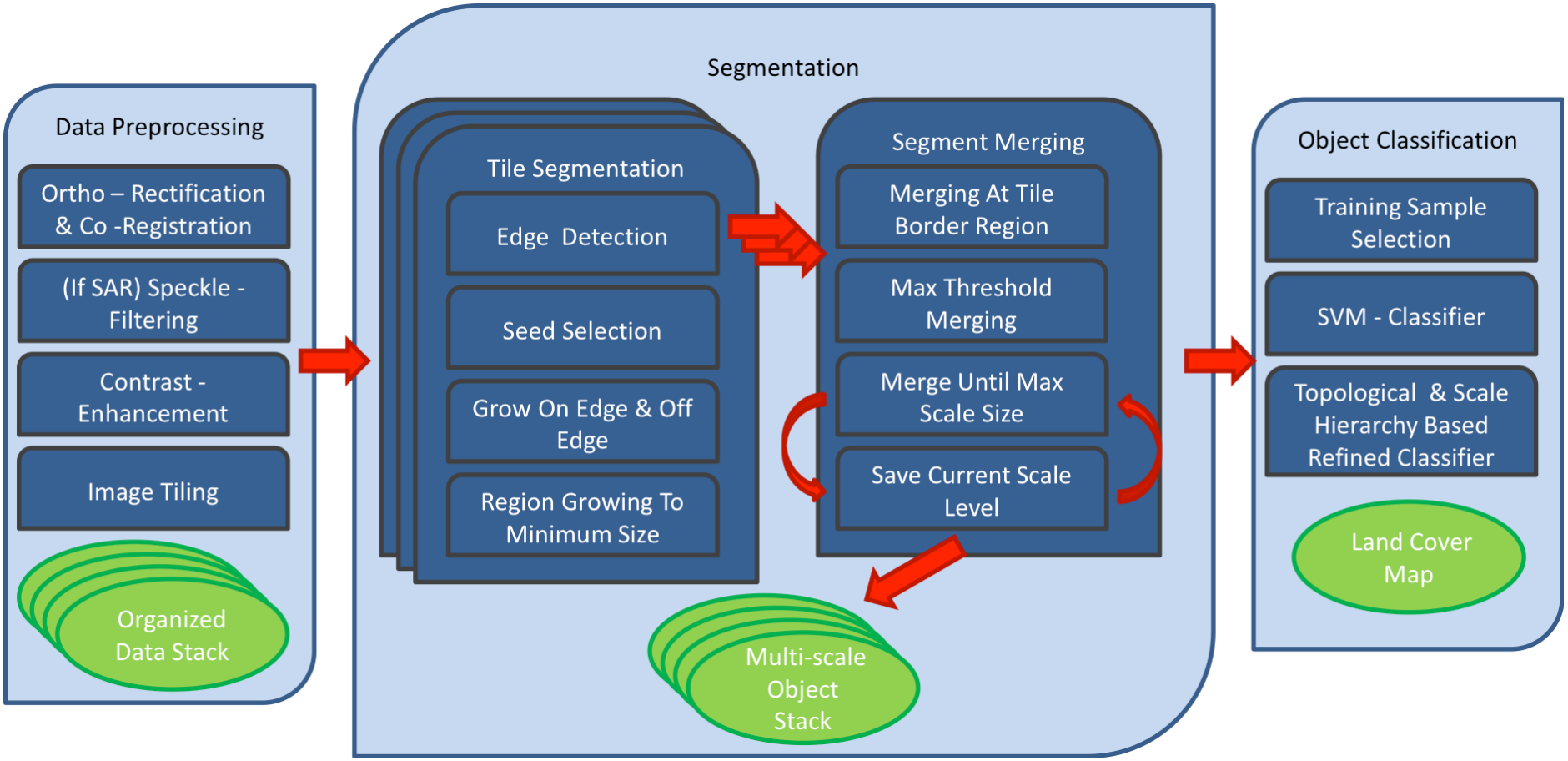
KTH-Pavia Urban Extractor



Sentinel-1 SAR & Sentinel-2 MSI Time Series for Urban Extent Extraction

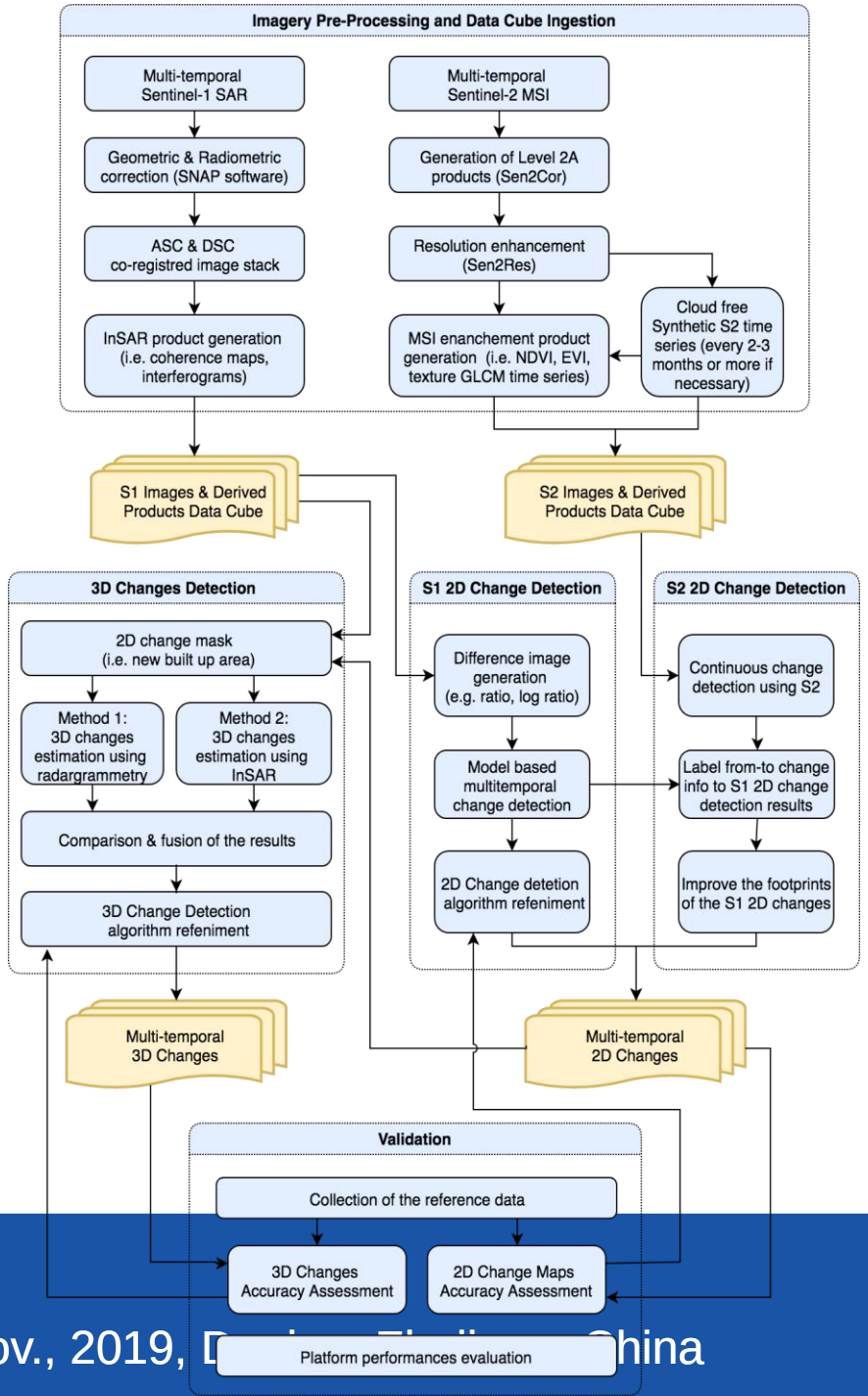


KTH-SEG: Edge-Aware Region Growing & Merging Algorithm

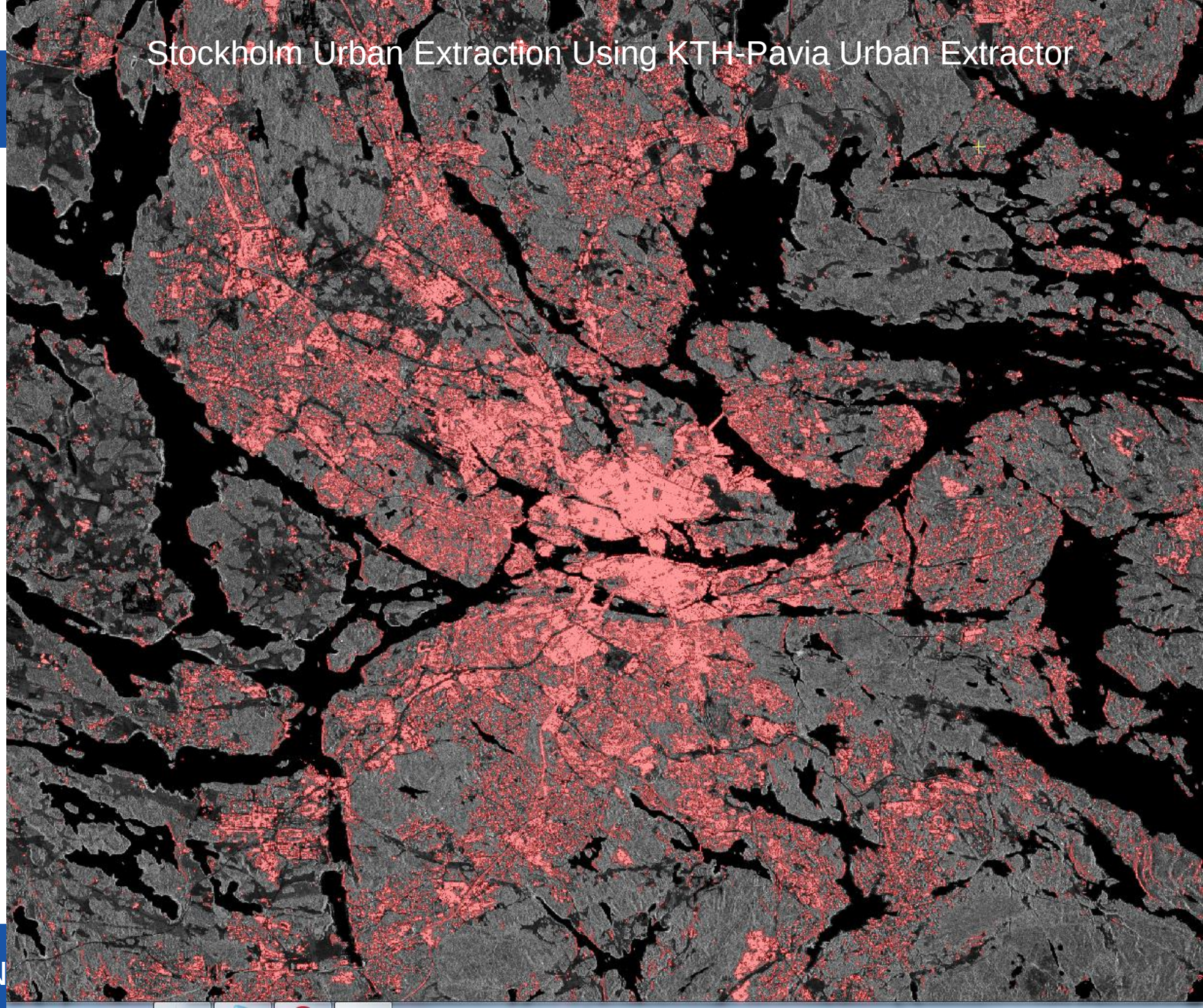


Ban, Y. and A. Jacob, 2013. Object-based Fusion of Multitemporal Multi-angle ENVISAT ASAR and HJ-1 Multispectral Data for Urban Land-Cover Mapping. *IEEE Transaction on GeoScience and Remote Sensing*, Vol. 51, No. 4, pp. 1998-2006.

Sentinel Data Cube for Urban Change Detection

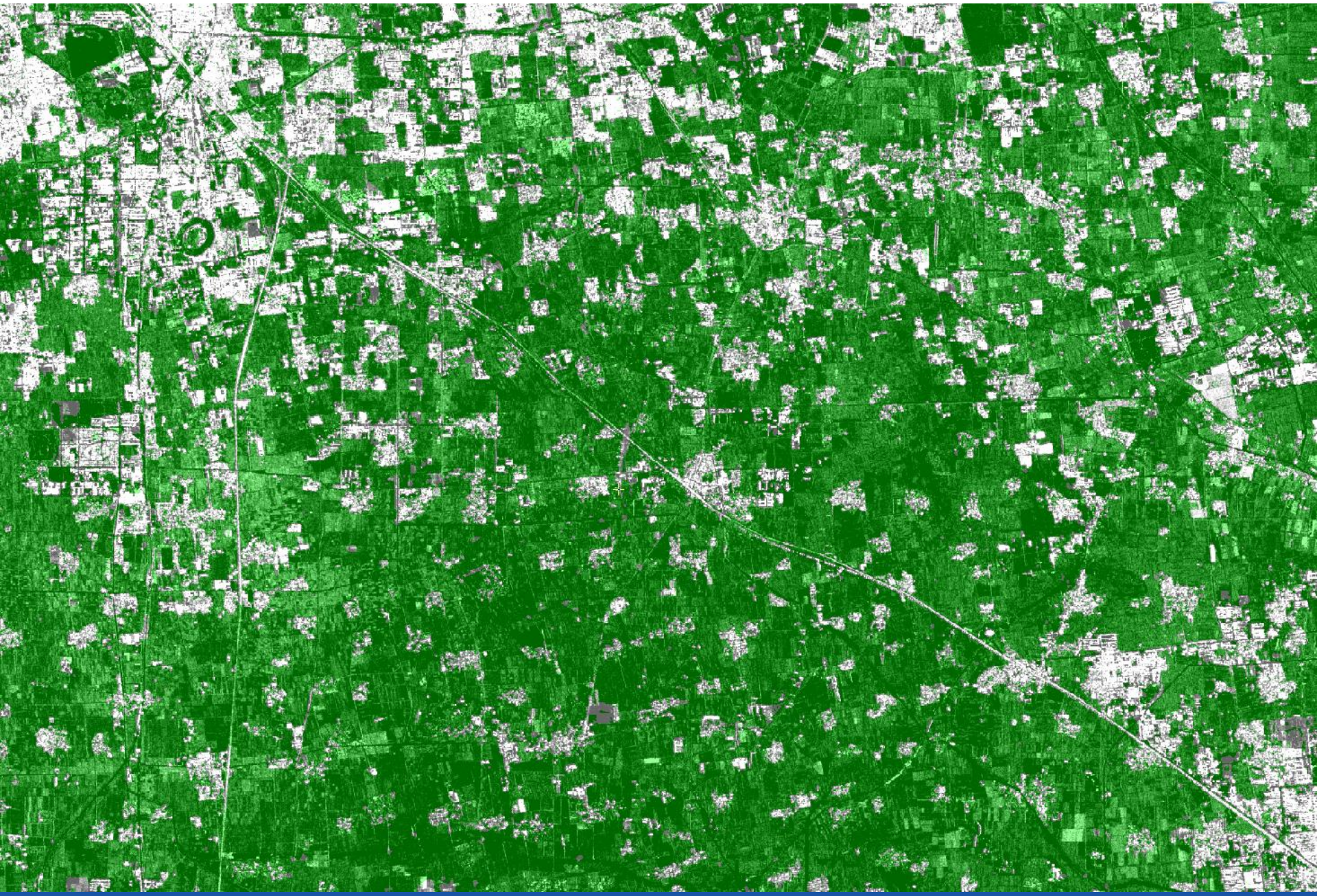


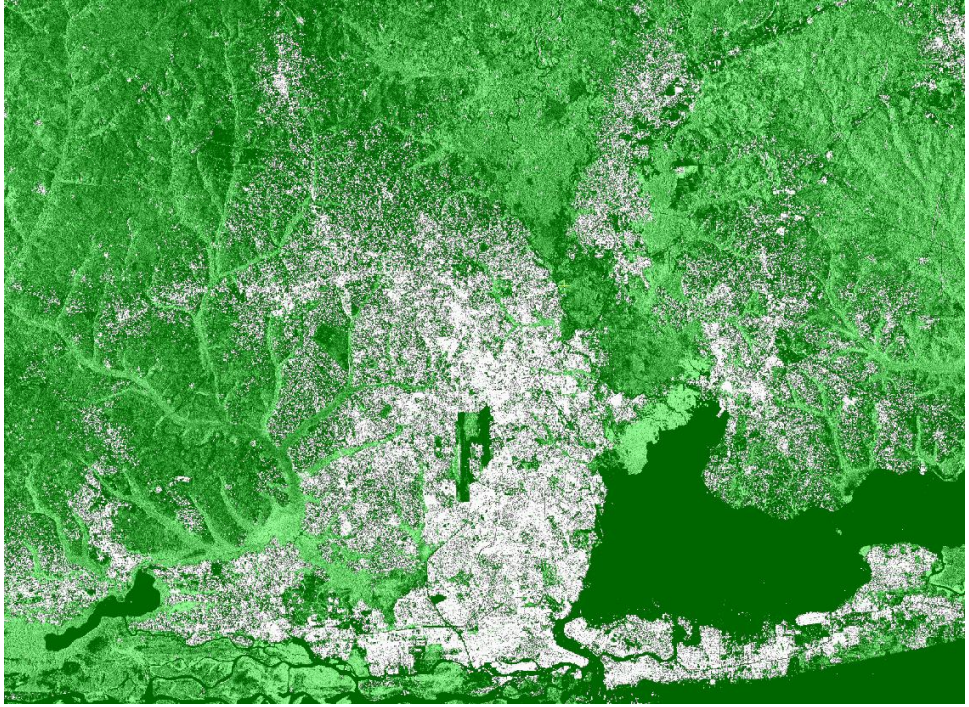
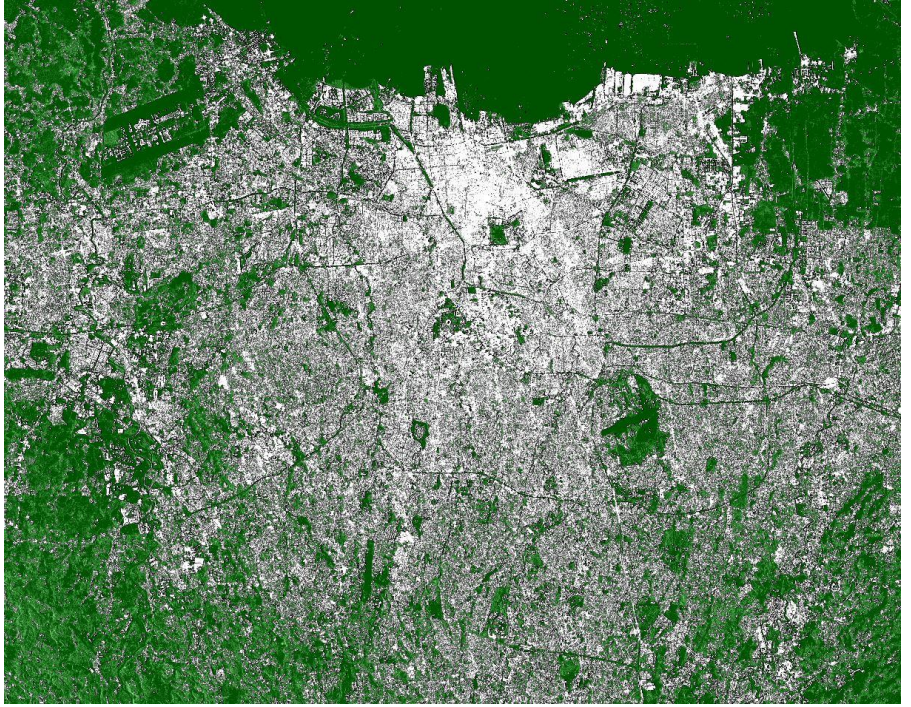
Stockholm Urban Extraction Using KTH-Pavia Urban Extractor

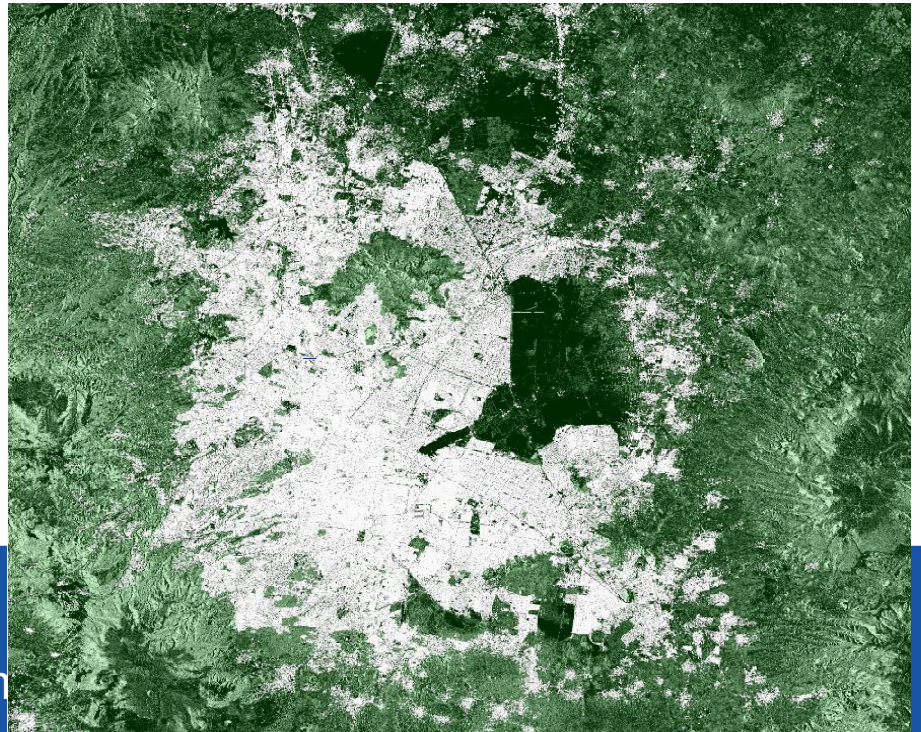


UN

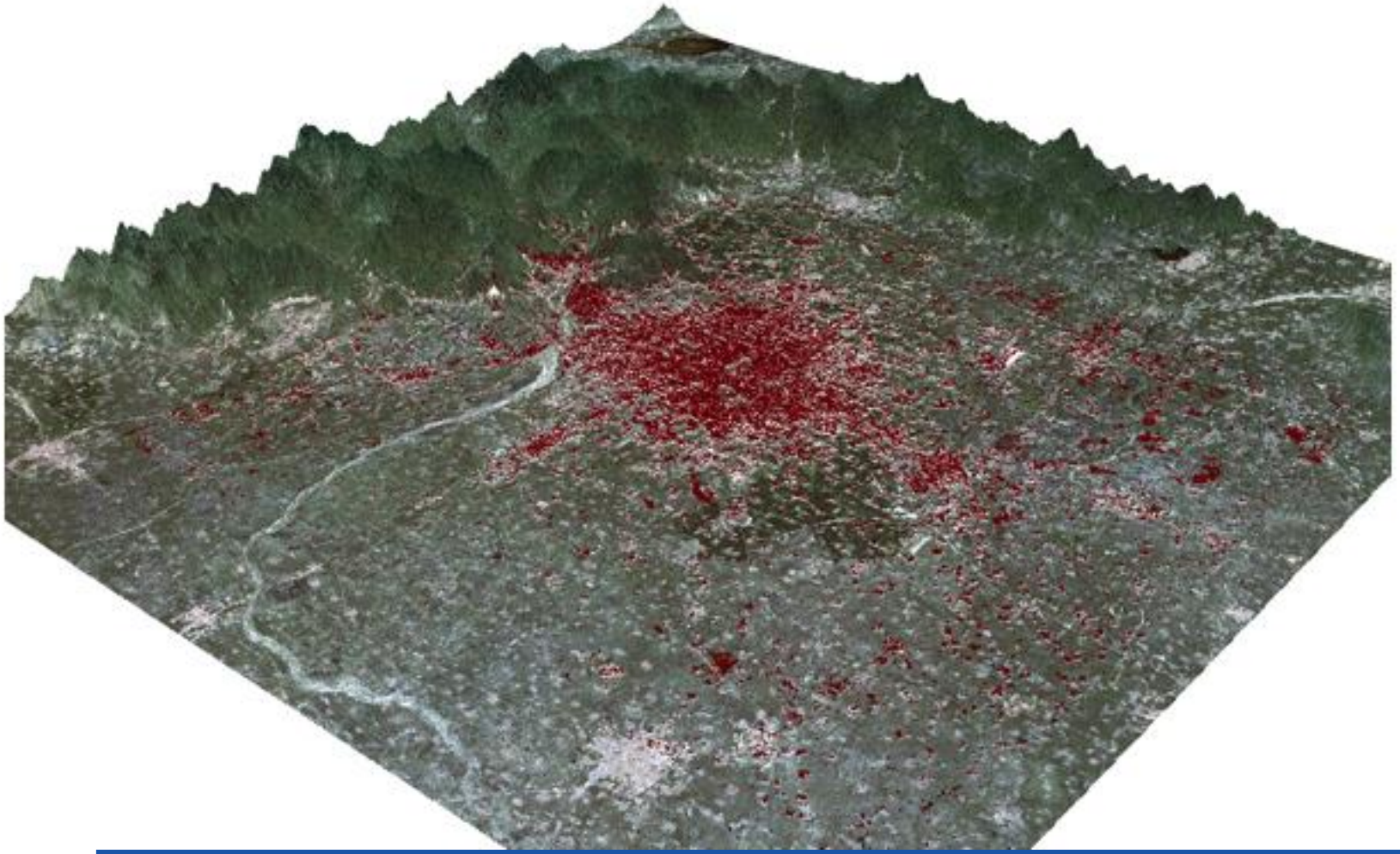
Urban Extraction: Beijing



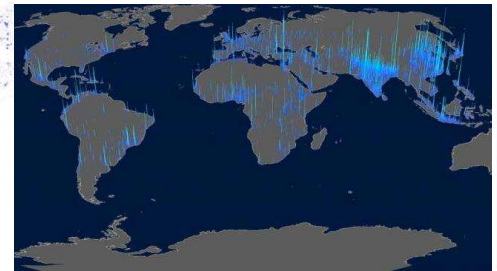


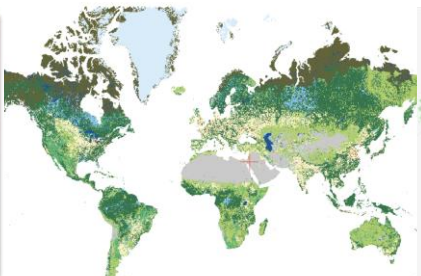
Urban Expansion in Beijing

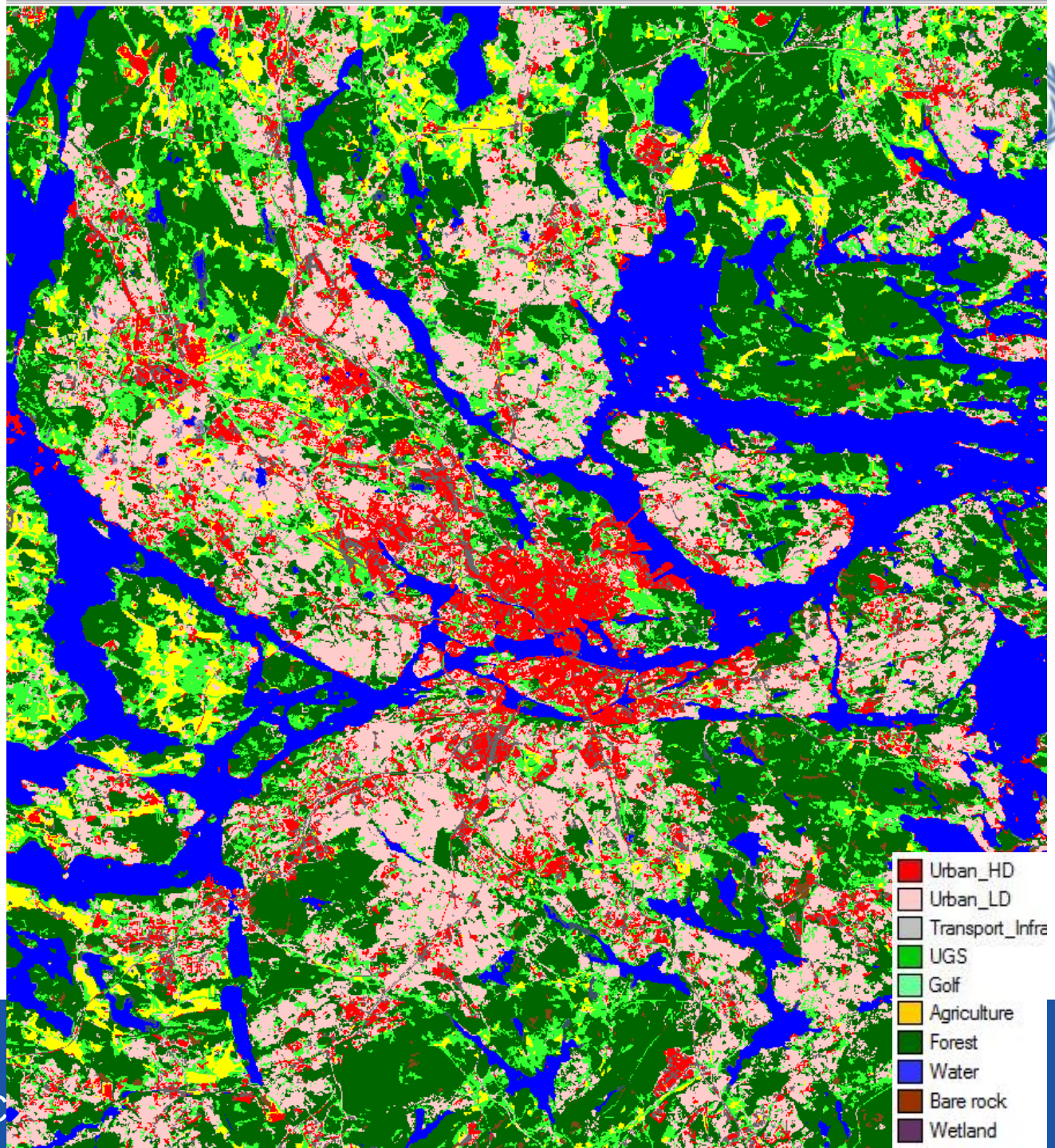


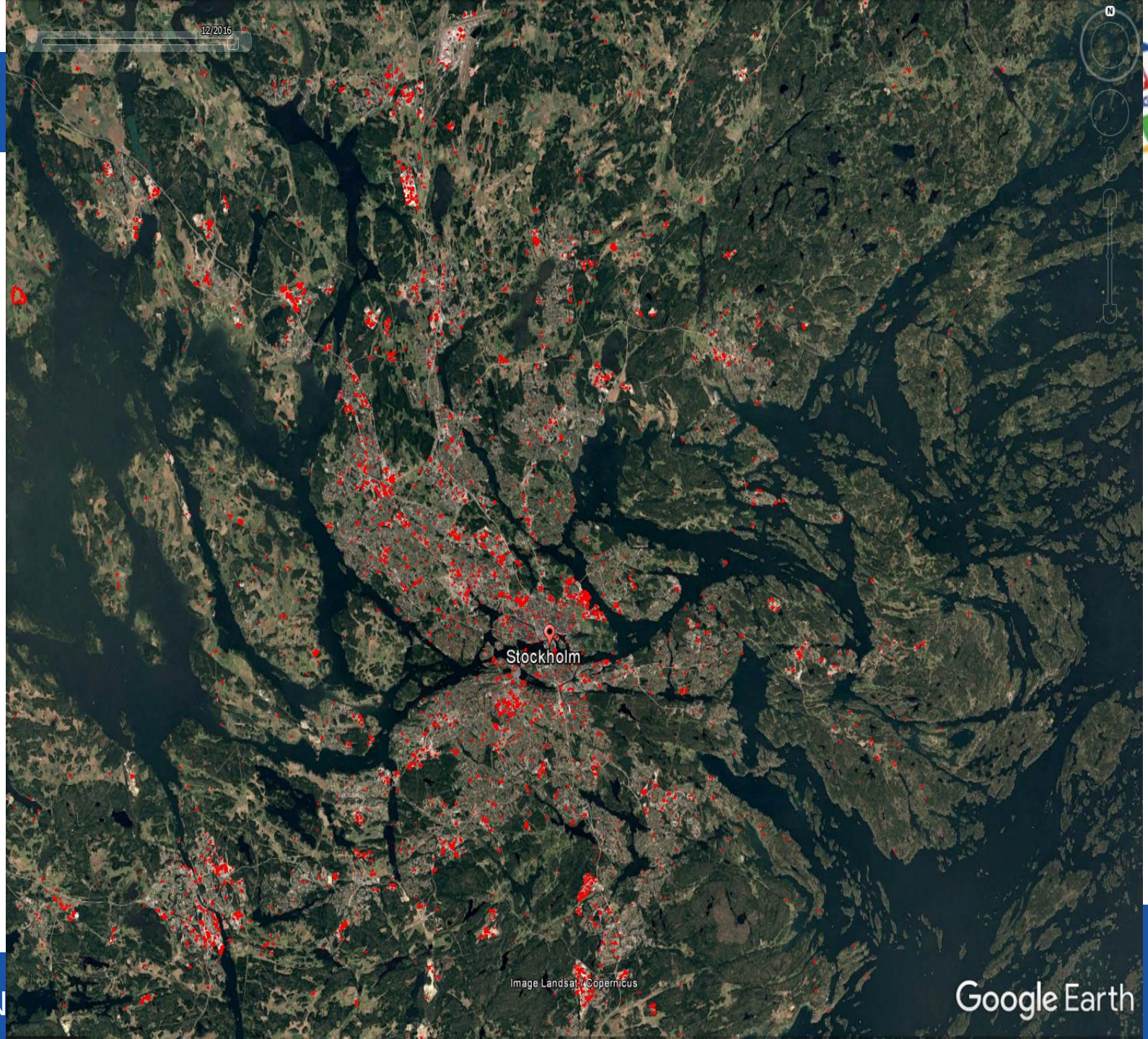
Existing Global Urban Datasets

- Global Urban Footprints Plus, 2015 (GUF+, global, derived from Sentinel-1 SAR and Landsat data)
- Global Urban Footprints, 2012 (GUF, global, derived from TerraSAR-X data)
- Global Human Settlement Layer (GHSL, global, derived from Landsat data)
- Urban layer in GlobeLand30, 2000 & 2010 (GlobeLand30, global, derived from Landsat data)
- Atlas of Urban Expansion (NYU, 200 cities global, derived from Landsat data)

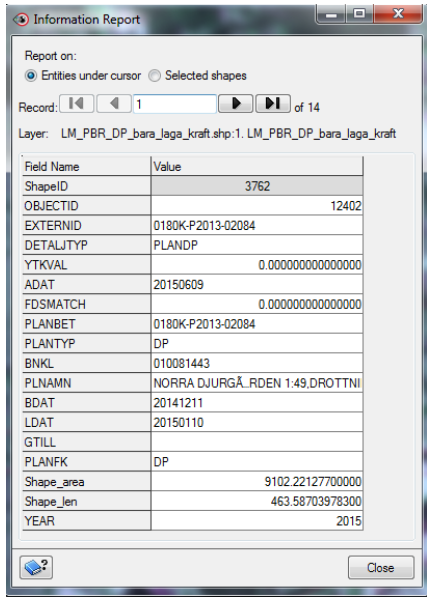





Urban_HD
Urban_LD
Transport_Infra
UGS
Golf
Agriculture
Forest
Water
Bare rock
Wetland


12/2016
Stockholm
Image Landsat / Copernicus
Google Earth

Detection of New Builtup Areas



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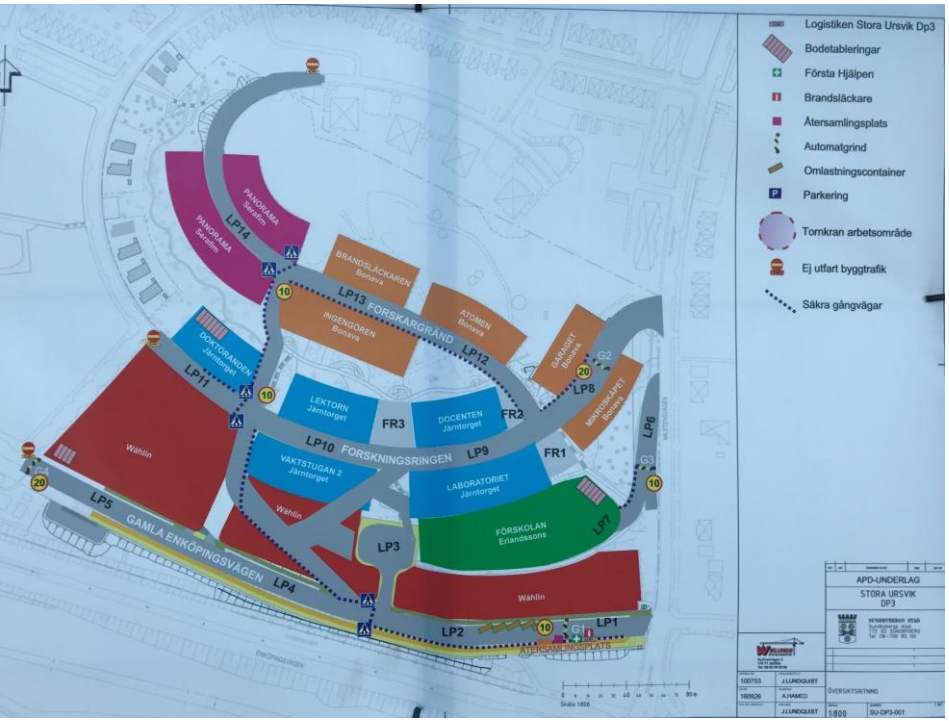
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Bodetableringar
Första Hjälpen
Brandsläckare
Återsamlingsplats
Automatgrind
Omlastningscontainer
Parkering
Tornkran arbetsområde
Ej utfart byggtrafik
Säkra gångvägar
PANORAMA Serafim
BRANDSLÄCKAREN Bonava
INGENGÖREN Bonava
ATOMEN Bonava
GARAGET Bonava
MINNESGÅRDET Bonava
DOKTORANDEN Järntorget
LEKTORN Järntorget
DOCENTEN Järntorget
VAKTSTUGAN 2 Järntorget
LABORATORIET Järntorget
FÖRSKOLAN Erlandssons
Wåhlin
LP1
LP2
LP3
LP4
LP5
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FR3
FÖRSKARGRÄND
FORSKNINGSRINGEN
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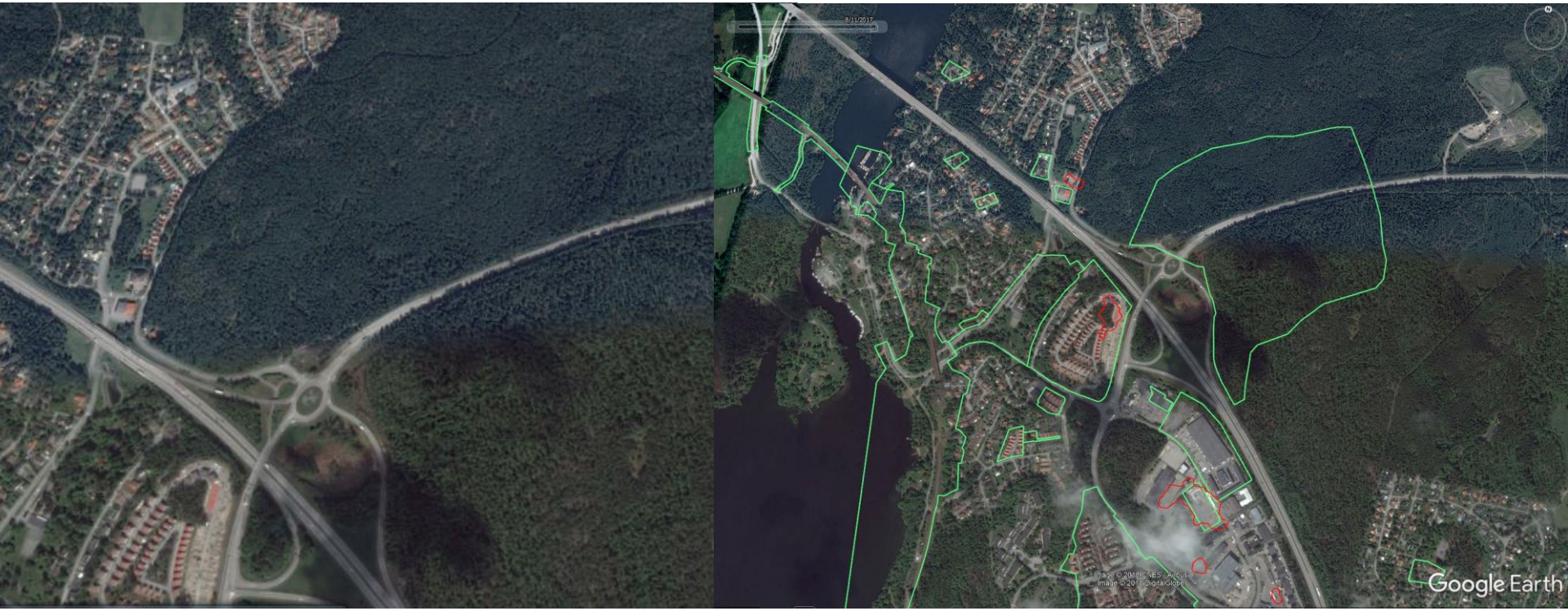
APD-UNDERLAG
STORA URSVIK
DP3

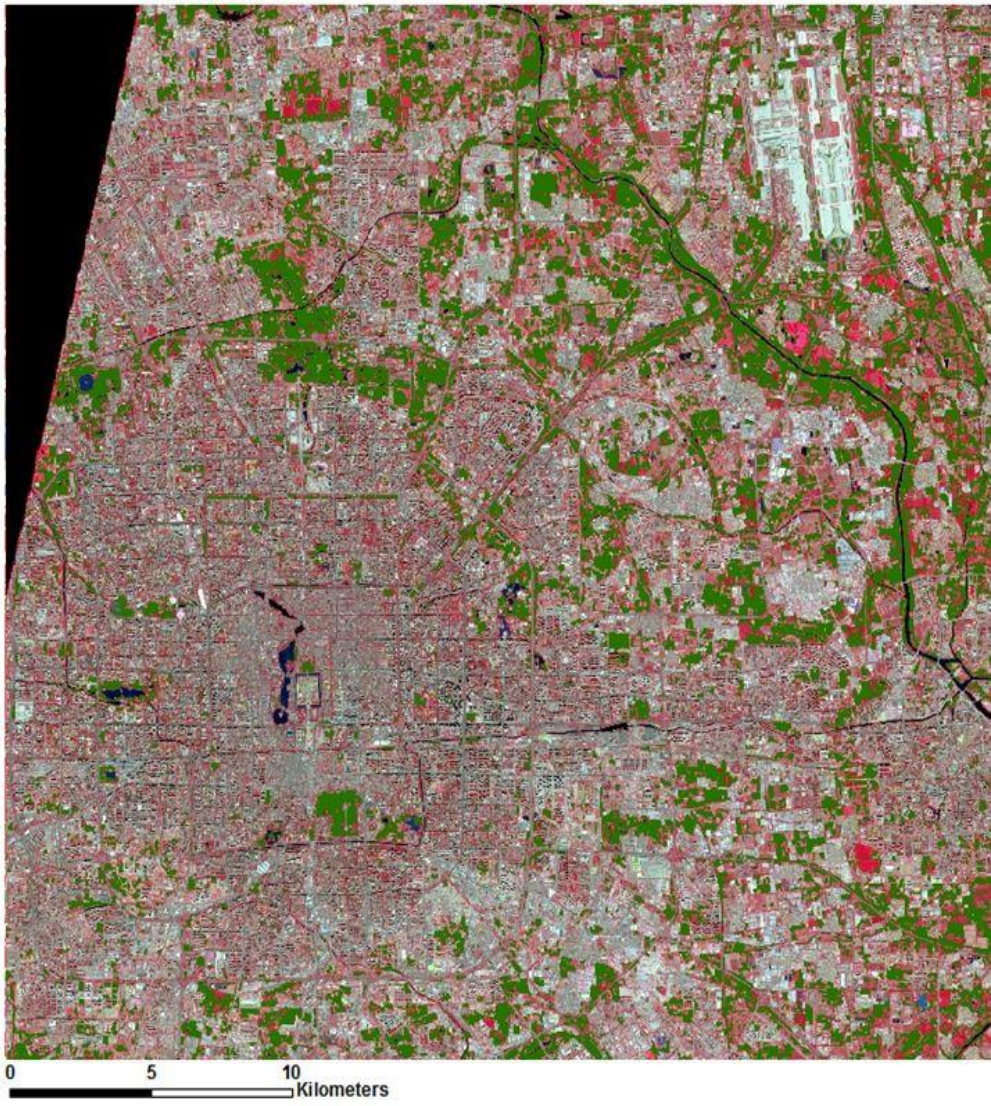
Google Earth

Google Earth

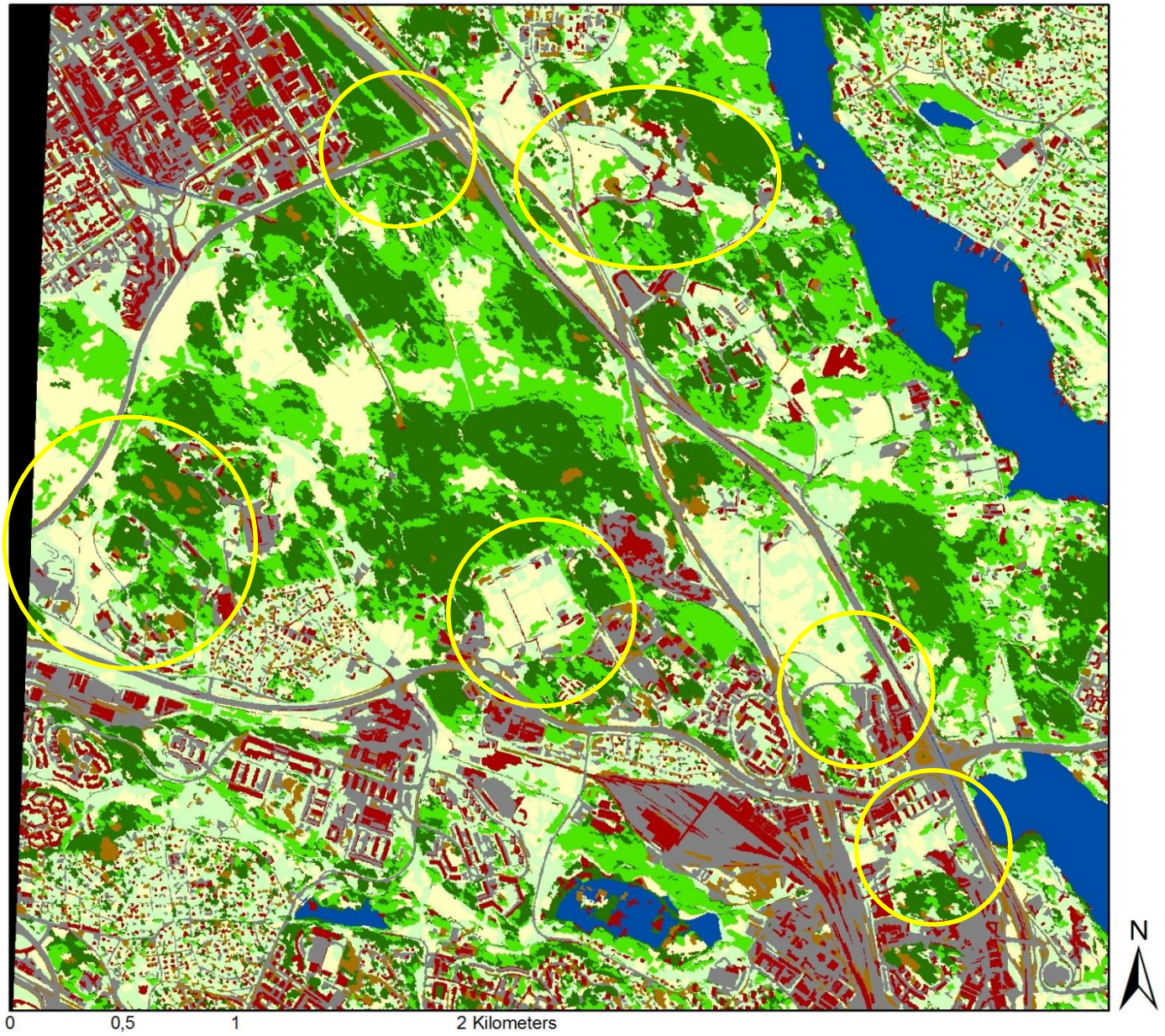
Un-Built After Plan Approval



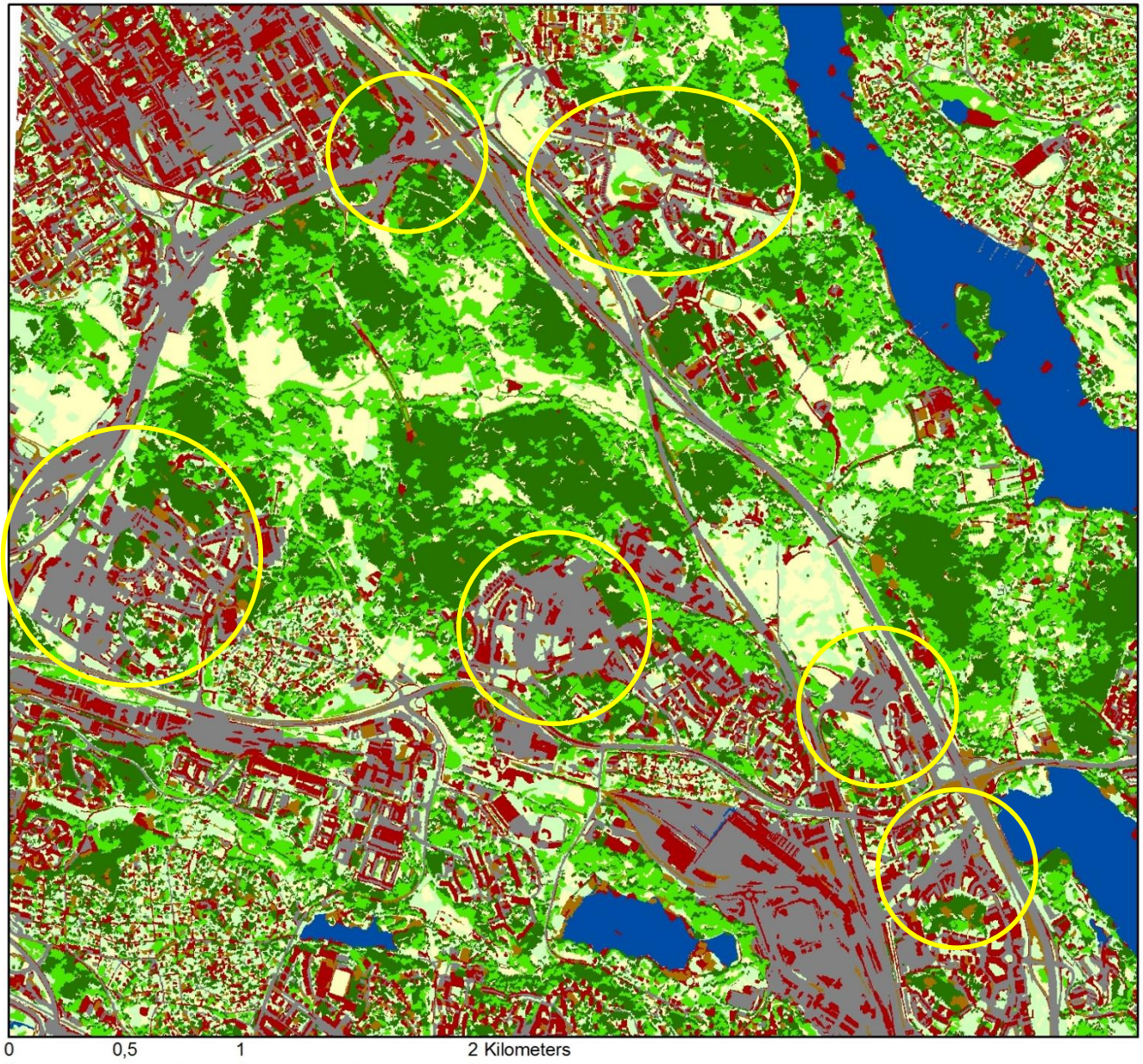
Urban Green Structure



2001



2011



Conclusions

- EO time series data can play a significant role in measuring and monitoring Urban SDG indicators.
- Existing urban and other geospatial datasets are also very important data sources for measuring and monitoring Urban SDG indicators.