Module 3105: Urban Areas

Urban footprints

Michael Voltersen[1], Thomas Esch[2], Christian Berger[1], Robert Eckardt[1]

1 Friedrich-Schiller-University Jena
Department for Earth Observation
Jena, Germany

2 German Aerospace Center (DLR)
German Remote Sensing Data Center
Oberpfaffenhofen, Germany

SAREDU Remote Sensing Education Initiative

Content of Module Urban Areas

- Introduction (Module #3104)
- Urban footprints (Module #3105)
- Urban land cover / land cover change classification (Module #3106)
- Extraction of urban objects (Module #3107)
- Urban DSM (Module #3108)
- Synergy of optical remote sensing and SAR (Module #3109)
- Tutorial – Urban footprint mapping utilizing Sentinel – 1 data (Module #3110)

Educational Objectives

- Understand the importance of urban footprint mapping
- Understand SAR features relevant for urban footprint mapping
- Learn about Global Urban Footprint project of DLR

Requirements

- You know and understand the mathematical and physical basics
  (Module ID 1100: Mathematics & physics)
- You know and understand SAR technology
  (Module ID 1300: SAR basics)
- You know and understand main SAR processing steps
  (Module ID 1200: Data processing)
- You know and understand main image interpretation techniques
  (Module ID 2100: Image processing)
- You know and understand urban areas and their varieties
  (Module ID 3104: Urban Introduction)

Structure

- What are urban footprints
- Demand for urban footprint mapping
- Mapping the extent of urban areas with SAR data

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What are urban footprints

- Spatial extent of urbanized areas
- Area dominated by buildings, streets and impervious surfaces → man-made structures
- Natural surfaces within cities not taken into account
- Binary settlement mask (urban / non-urban) commonly derived by remote sensing data
- Multitemporal settlement masks enable quantification of urban growth / shrinkage

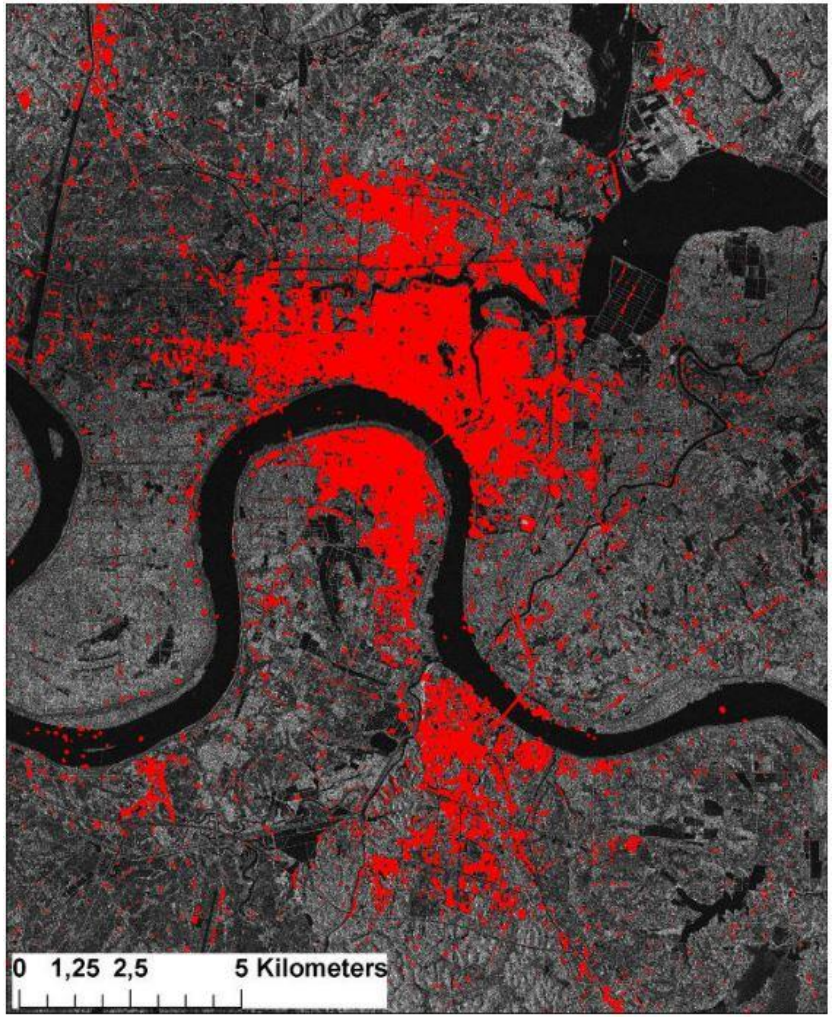

Fig.: Urban footprint of the region of Changsha, China (Esch et al., 2011)

Structure

- What are urban footprints
- Demand for urban footprint mapping
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Demand for urban footprint mapping

- Population shift from rural to urban areas
- Often rapid (uncontrolled) growth of cities
- Especially in developing countries area-wide information about quickly changing mega cities are rare
- Industrialized countries suffer from urban sprawl: consumption of green areas due to predominant delevopment with single-family houses induced by increasing living conditions

Fig.: Uncontrolled urban growth in Mumbai, India (http://www.seos-project.eu/modules/landuse/landuse-c02-p23.de.html)

Demand for urban footprint mapping

- Urban footprints required for regional-scale planning
- Global spatial distribution of urban areas as key element of sustainable development
- Automated mapping of urban growth with multitemporal data
- Comparison of sizes and shapes of cities
- Knowledge of extent of cities (especially within developing countries)

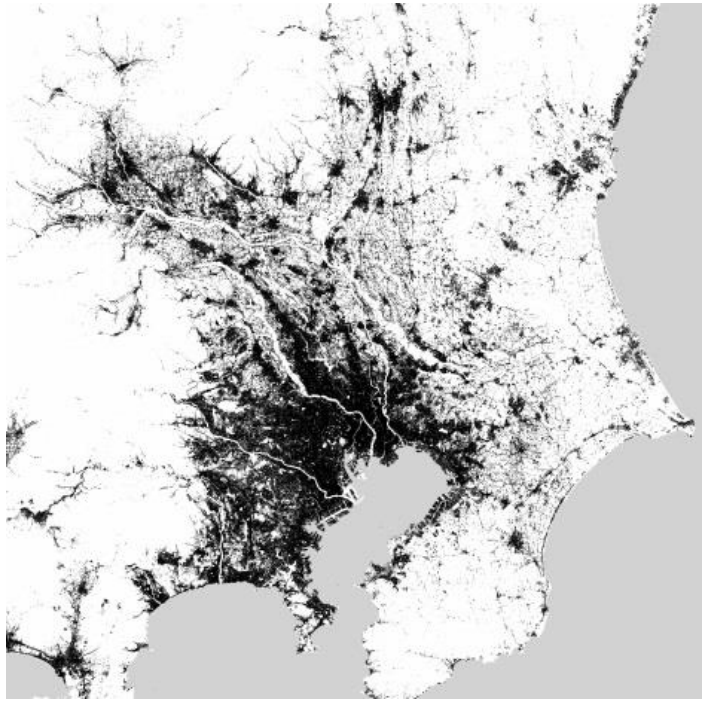


Fig.: Megacities like Tokyo, Japan, demand for urban extent / growth mapping with remote sensing data (DLR)

Structure

- What are urban footprints
- Demand for urban footprint mapping
- Mapping the extent of urban areas with SAR data

Basic characteristics of urban areas in SAR data

- High backscatter: predominance of single- and double-bounce
- High phase stability of anthropogenic structures between SAR images
- Orientation of buildings to azimuth angle affects backscatter

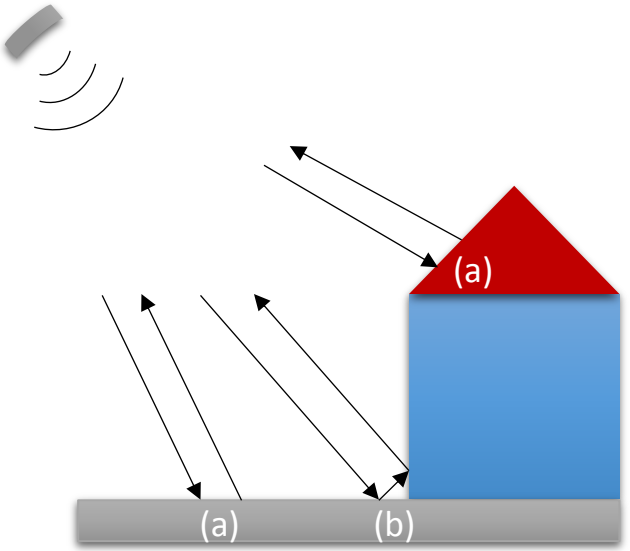


Fig.: Single- (a) and double-bounce (b) as general scattering mechanisms in urban areas

Basic characteristics of urban areas in SAR data

- Strong double-bounce scattering results in certain image texture for urban areas
- Heterogeneity and texture can be used to map urban footprint

→ Automated discrimination between urban / non-urban for large areas based on texture thresholds

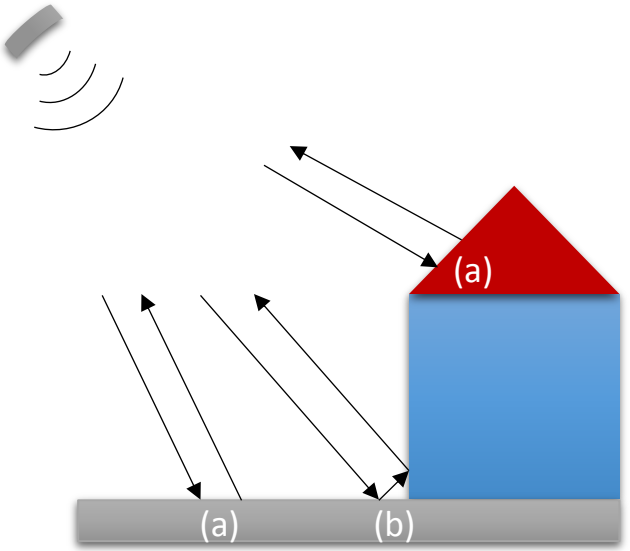
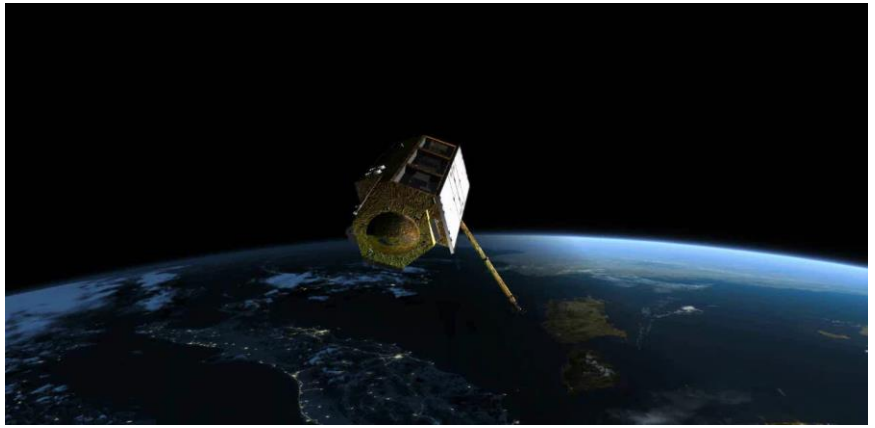


Fig.: Single- (a) and double-bounce (b) as general scattering mechanisms in urban areas

Example: Global Urban Footprint project by DLR

- Based on TanDEM-X mission
- Worldwide inventory of human settlements (urban & rural) using one global coverage of SAR data with 3 m ground resolution collected by TerraSAR-X / TanDEM-X in 2011-2013
- Analysis of 182.249 images (308 TB), processing and management of >20 million data sets
- Output: binary settlement mask with 0.4'' (12m) spatial resolution



Click to start animation of TanDEM-X mission

Example: Global Urban Footprint project by DLR

Global Urban Footprint Processor

- Fully-automatic, generic and autonomous processing environment orchestrating extensive suite of processing and analysis modules
- Set of automated post-editing procedures for large-scale quality enhancement

Publication

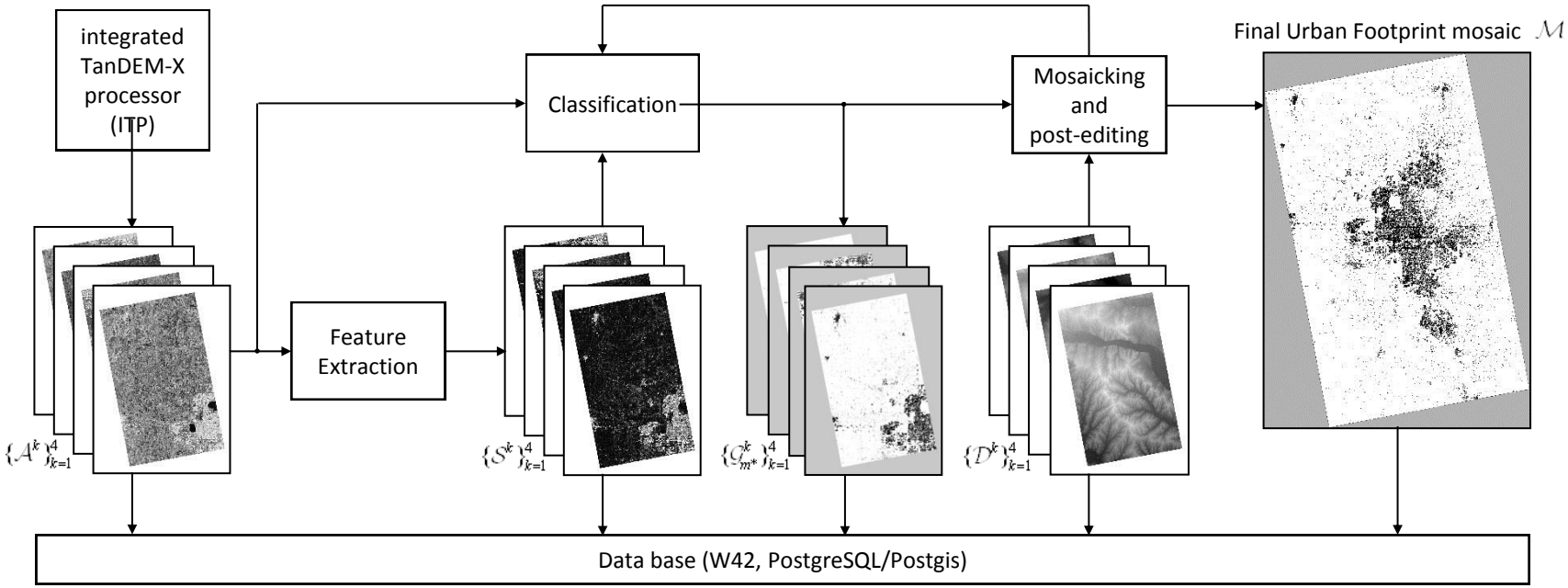


Fig.: Processing management system (DLR)

Example: Global Urban Footprint project by DLR

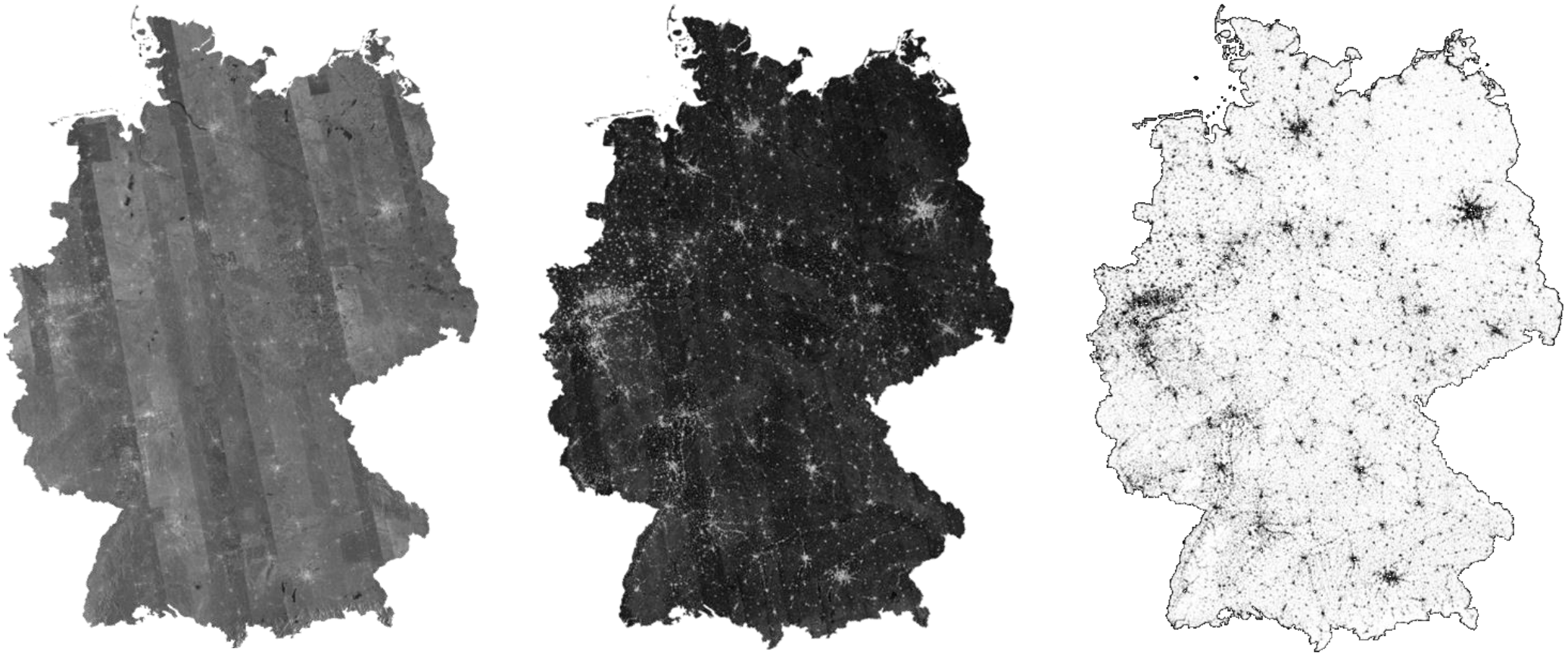
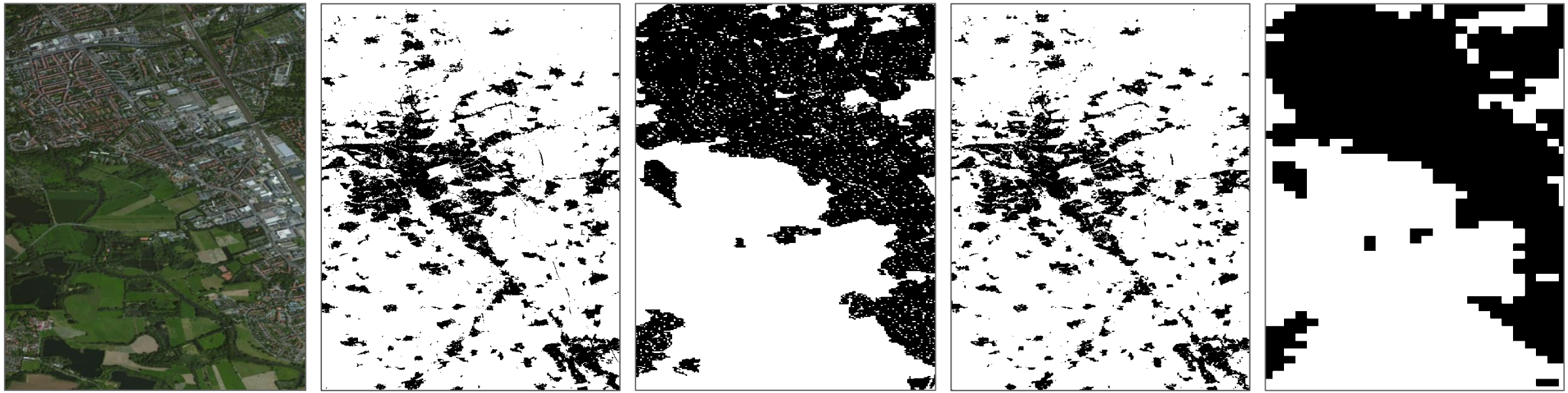


Fig.: SAR backscattering amplitude (left), extracted texture image (center), and Global Urban Footprint (right) (DLR)

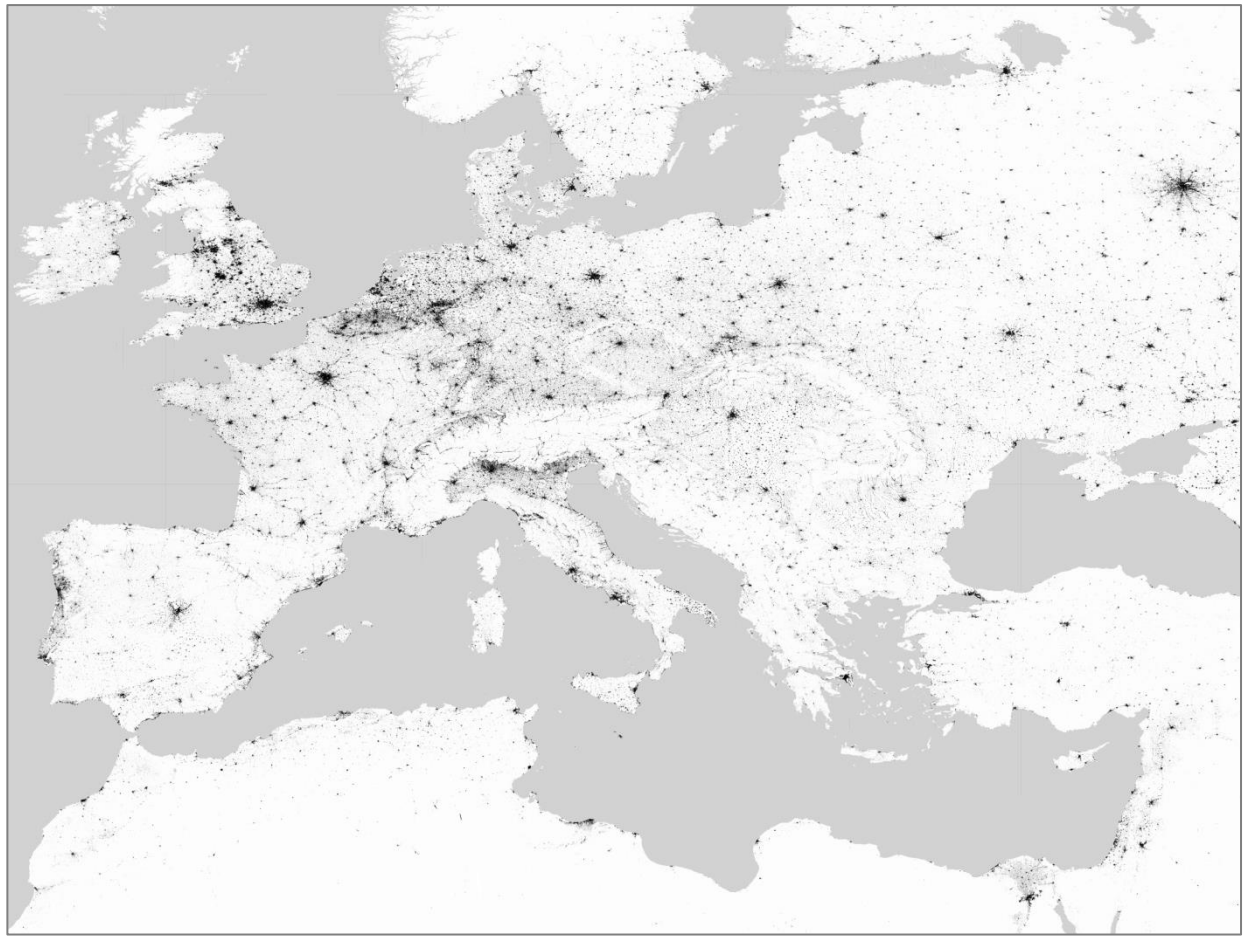
Example: Global Urban Footprint project by DLR



(a) (b) (c) (d) (e)

Fig.: Global Urban Footprint (GUF) product, (a) example area, (b) GUF 0.4 " resolution for scientific use, (c) detailed view of 0.4 " GUF, (d) GUF 2.8 " resolution public domain version, (e) detailed view of 2.8 " GUF (DLR)

Example: Global Urban Footprint project by DLR



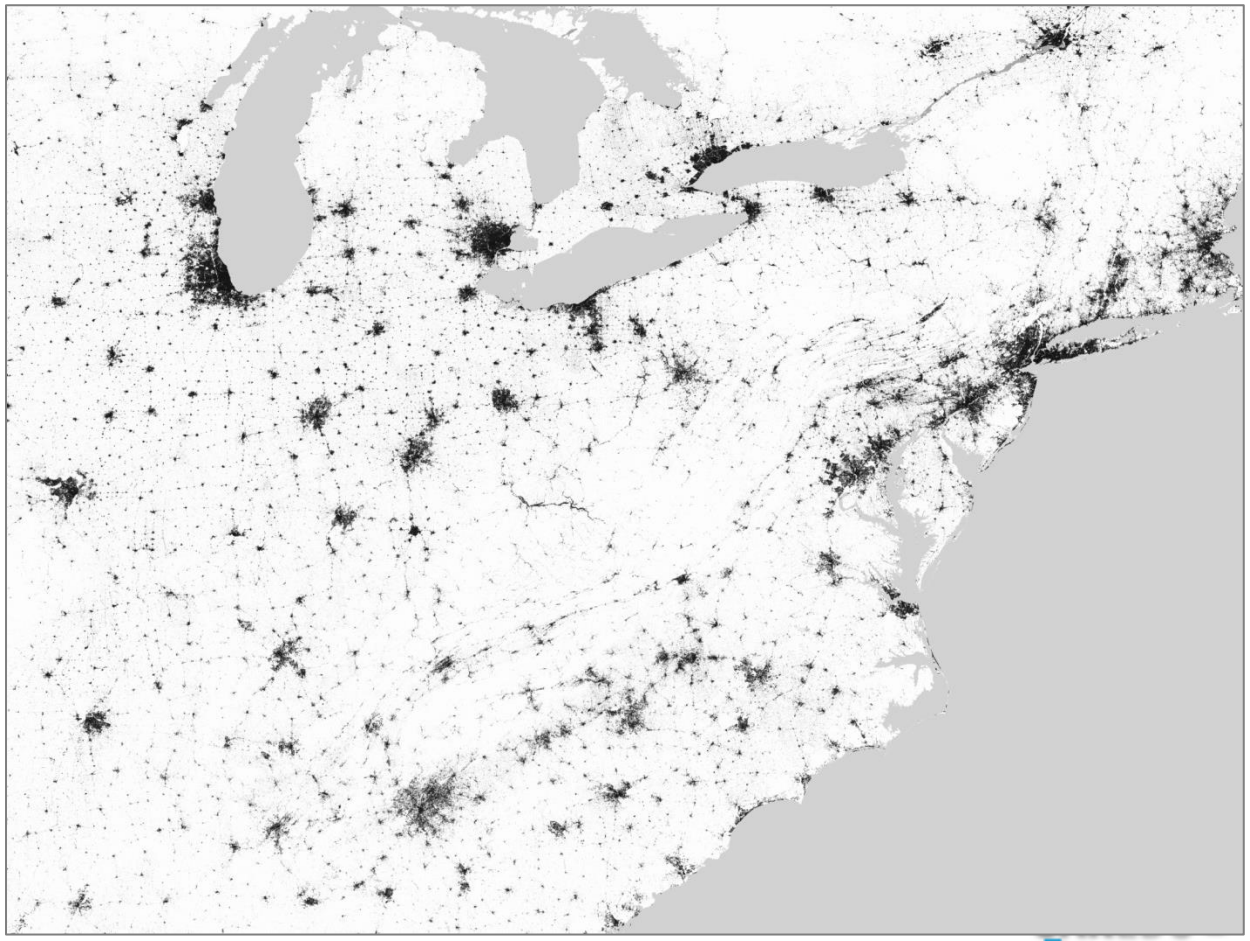
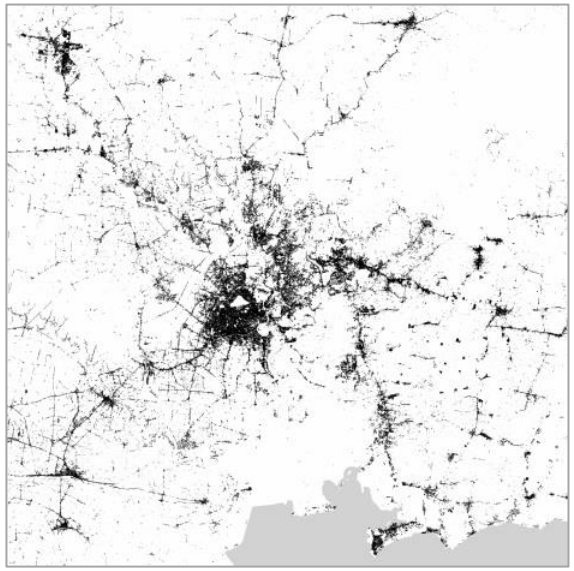
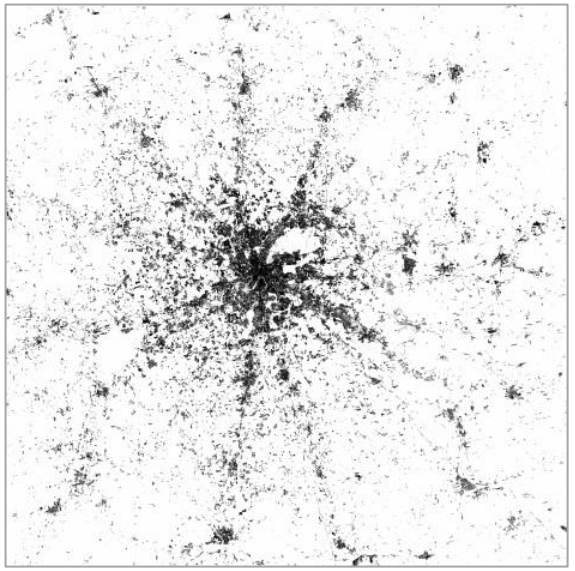


Fig.: Global Urban Footprint for Europe (left) and North-East United States (right) (DLR)

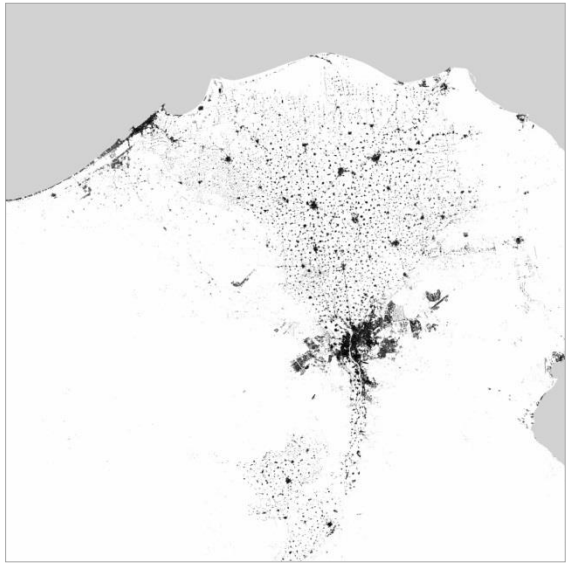
Example: Global Urban Footprint project by DLR



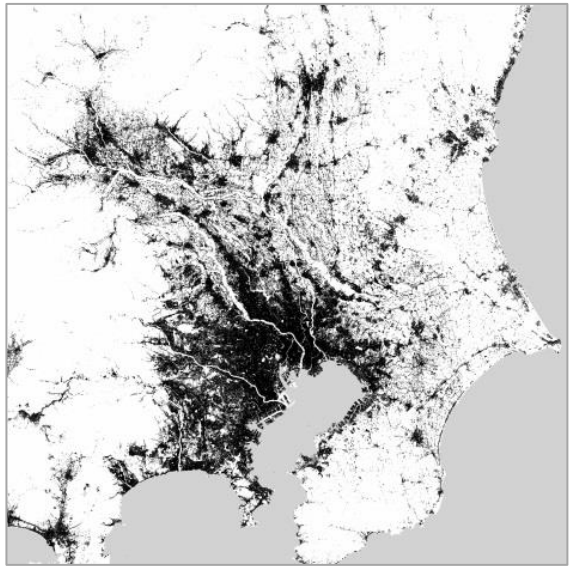
Ho-Chi-Minh City, Vietnam



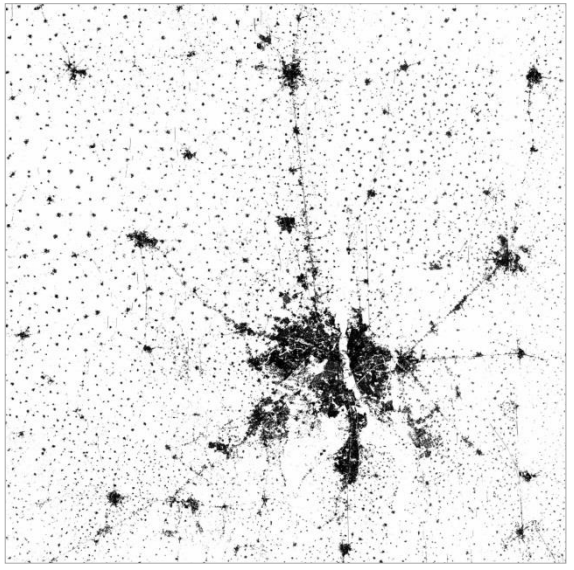
Moscow, Russia



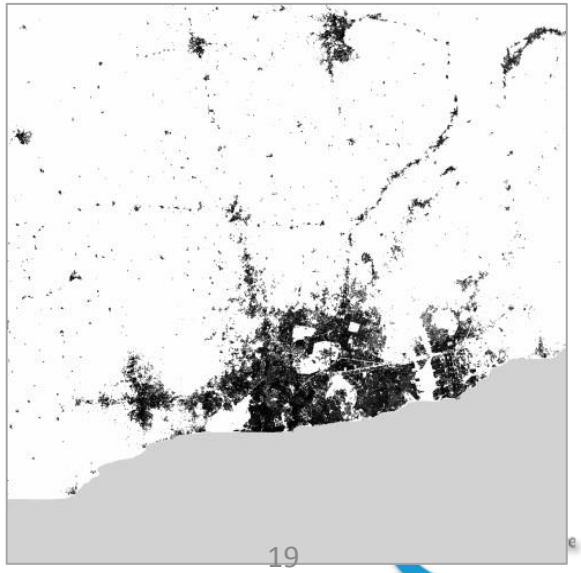
Cairo, Egypt



Tokio, Japan



Delhi, India

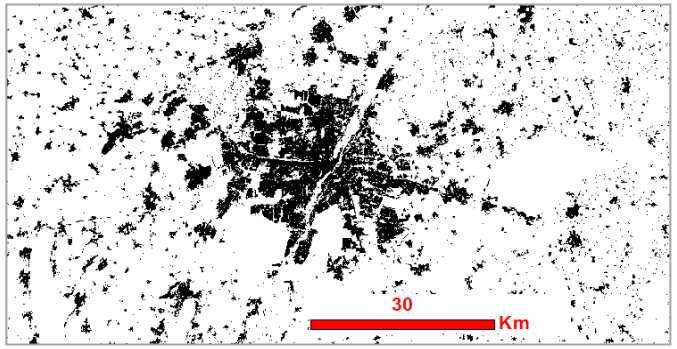


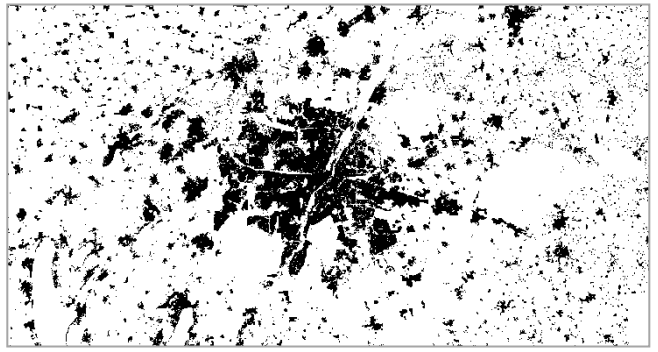
Accra, Ghana

Example: GUF – Quality Assessment

Kappa: 0.75

GUF (2.8'')

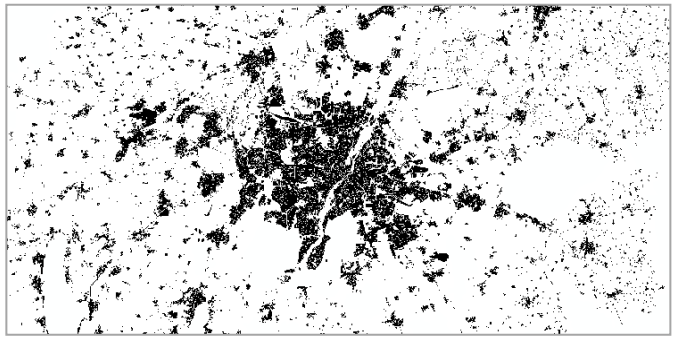




Reference building layer

Kappa: 0.74

European Urban Atlas

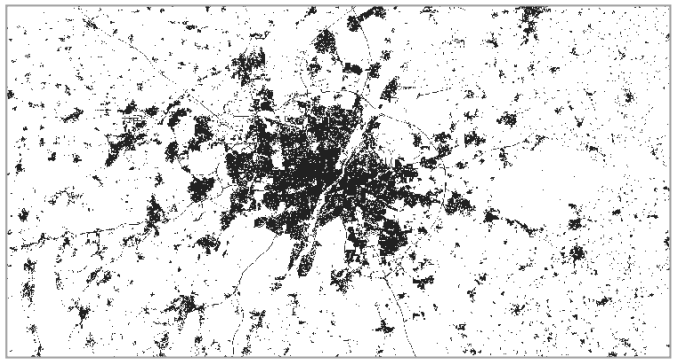


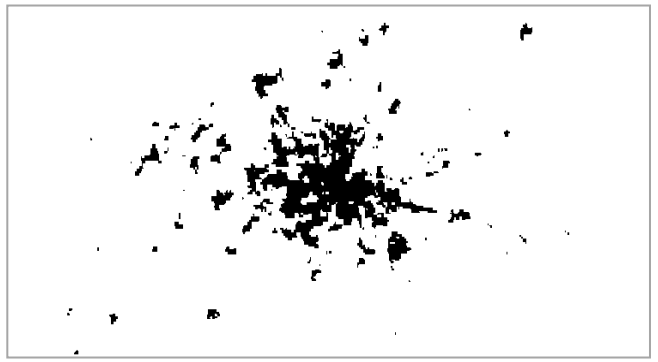
Kappa: 0.40

MODIS 500

Kappa: 0.70

FTS European Soil Sealing





Kappa: 0.34

GlobCover 2009

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Example: Spatiotemporal Urbanization Mapping

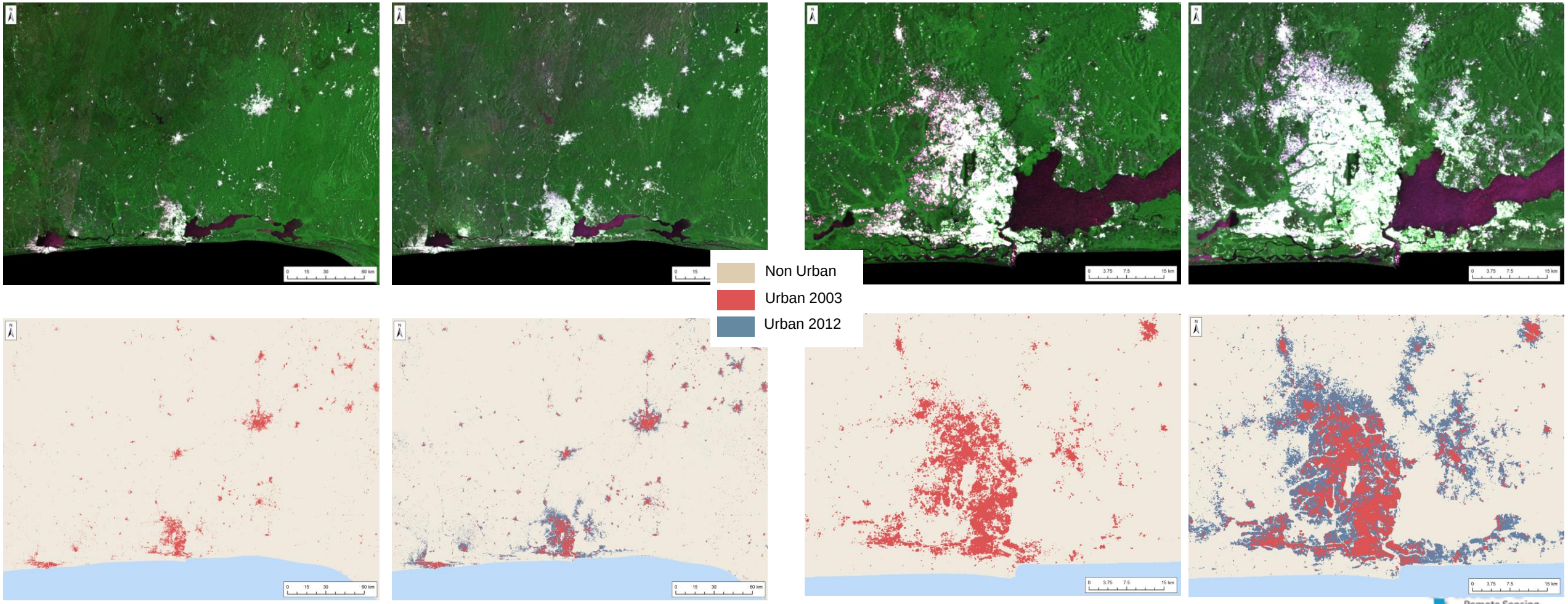

Fig.: Urban extent mapping for Benin/Nigeria (left) and Lagos (right) for the years 2003 and 2012 (DLR)

Example: Spatiotemporal Urbanization Mapping

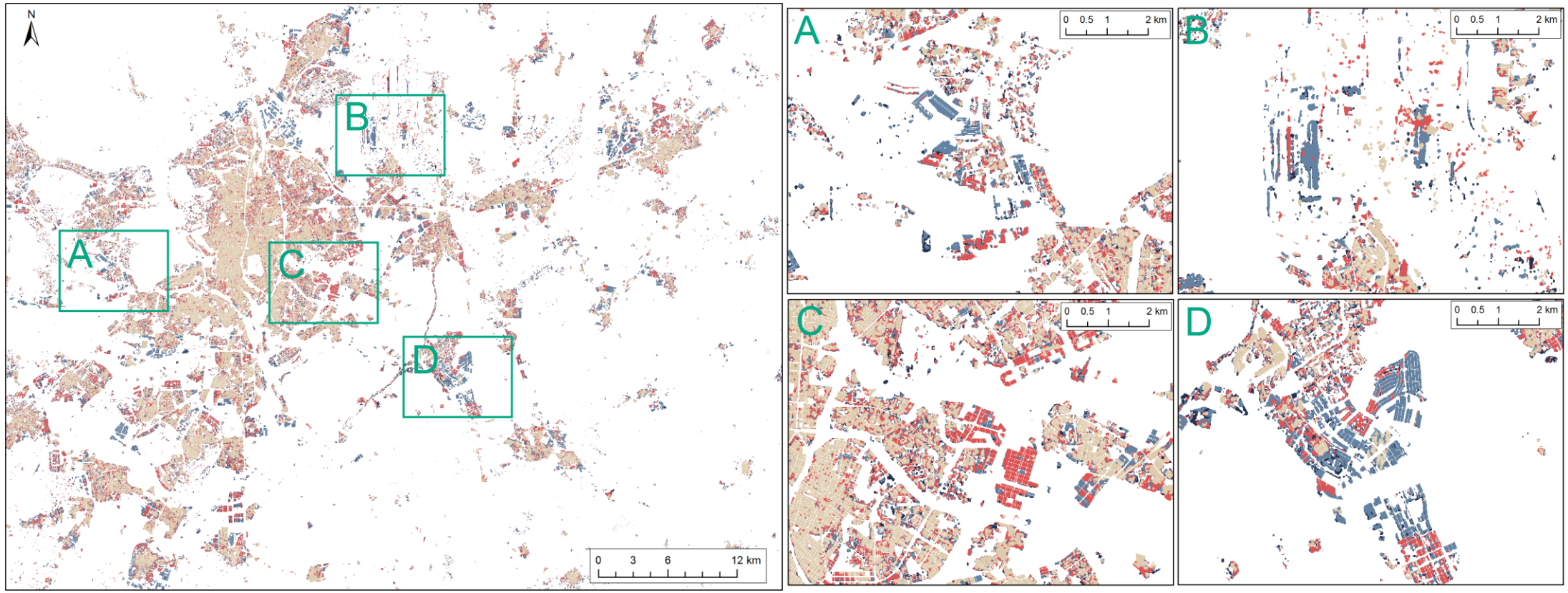

Fig.: Urban extent mapping for Madrid, Spain for different years and detailed view of selected areas (DLR)

References and ***further reading***

- Esch, T., Marconcini, M., Felbier, A., Roth, A., Heldens, W., Huber, M., Schwinger, M., Taubenbock, H., Muller, A., and Dech, S. 2013. Urban footprint processor-Fully automated processing chain generating settlement masks from global data of the TanDEM-X mission. IEEE Geoscience and Remote Sensing Letters 10:1617–1621.
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- Taubenböck, H., Felbier, A., Esch, T., Roth, A., and Dech, S. 2012. Pixel-based classification algorithm for mapping urban footprints from radar data: A case study for RADARSAT-2. Canadian Journal of Remote Sensing 38:211–222.
- ***Weng, Q., editor. 2014. Global Urban Monitoring and Assessment through Earth Observation. CRC Press, Boca Raton.***

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