Earth Observation in support of Global Urban Monitoring

the SAR4Urban project

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Motivation

• At DLR we generated the **Global Urban Footprint (GUF)**, a mask of built-up areas derived from TerraSAR-X and TanDEM-X data acquired between 2011 and 2013;
Motivation

- At DLR we generated the **Global Urban Footprint (GUF)**, a **mask of built-up areas** derived from TerraSAR-X and TanDEM-X data acquired between 2011 and 2013;
- SAR data proved extremely effective for mapping urban areas.
- ESA SAR data are available:
  - from 1991 to 2012 (**ERS-1/2, ASAR**);
  - from 2014 onwards (**S1A, S1B, S1C, S1D, ...**).
**Objective:** mapping past and current urbanization by means of ESA radar imagery.

SAR4Urban is one of the 12 ESA DUE Innovators III projects;

**Project Manager:** Dr.-Ing. Mattia Marconcini (DLR)

**Technical Officer:** Marc Paganini (ESA)

**Budget:** 200K;

**Duration:** April 2015 – March 2017;

**Users:**

The World Bank Group (contact point: Nancy Lozano - Social, Urban, Rural and Resilience);

GEO Global Urban Observation and Information Task for Societal Benefits (GEO SB-04) – contact point: Prof. Qihao Weng
Areas and Periods of Interest
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ASAR WSM 2002-2003
~75m spatial resolution
Areas and Periods of Interest

- **ASAR WSM 2002-2003**
  - ~75m spatial resolution

- **ERS-1/2 PRI & ASAR IMP 2002-2003**
  - ~15m spatial resolution

Areas of interest include: Los Angeles, Atlanta, Mexico City, Athens, Beijing, and Pearl River Delta.
Areas and Periods of Interest

- **ASAR WSM 2002-2003**: ~75m spatial resolution
- **ERS-1/2 PRI & ASAR IMP 2002-2003**: ~15m spatial resolution
- **S1A IW GRDH 2014-2016**: ~10m spatial resolution

Locations of Interest:
- Los Angeles
- Atlanta
- Mexico City
- Athens
- Beijing
- Pearl River Delta
- Addis Ababa
- Kigali
- Nairobi
- Dar es Salaam
- Uganda

Map credits: DLR
Rationale

Given a series of multi-temporal SAR images for a given study area, the **temporal dynamics of urban settlements are sensibly different than those of all other non-urban classes.**

- **urban areas** → always high backscattering
- **complex topography areas** → high backscattering (can be masked by properly analyzing the DEM)
- **other non-urban areas** → lower backscattering (high only under specific conditions)
Implemented Methodology

S1A IW GRDH VV multitemporal series -
20 scenes ascending pass -
10m spatial resolution
Implemented Methodology

Idea: extract multi-temporal indices “compressing” all the available information.

temporal $\sigma^0$ mean slope  \hspace{.5cm} temporal $\sigma^0$ mean  \hspace{.5cm} temporal $\sigma^0$ standard deviation
Implemented Methodology
Implemented Methodology

High-Resolution SRTM 1 arcsec
(~30 m)
Implemented Methodology
Implemented Methodology
Envisat ASAR WSM

ASAR WSM HH 2009-2012
75m spatial resolution
71 scenes
Envisat ASAR WSM

ASAR WSM HH 2002-2003

ASAR WSM HH 2009-2012

Kampala
Envisat ASAR WSM

ASAR WSM HH 2002-2003

ASAR WSM HH 2009-2012

Kampala
Envisat ASAR WSM

2002-2003

2009-2012
Envisat ASAR WSM
Envisat ASAR WSM

ASAR WSM HH 2009-2012

Landsat-8 OLI 2014
Envisat ASAR WSM

ASAR WSM HH 2009-2012
Envisat ASAR WSM

ASAR WSM VV 2009-2012

Landsat-8 OLI 2014
Envisat ASAR WSM

Benin

Nigeria

Lagos

Non Urban

Urban 2003

Urban 2012

DLR
Sentinel-1 A

S1A IW GRDH VV 2014-2015
10m spatial resolution | ASCENDING PASS
Sentinel-1 A

S1A IW GRDH VV
2014-2015
10m spatial resolution
48 scenes
ASCENDING PASS
Sentinel-1 A

Dar es Salaam

S1A IW GRDH VV 2014-2015
10m spatial resolution
First Results

Dar es Salaam

Google Earth
First Results

S1A IW GRDH VV
2014-2015
10m spatial resolution
Sentinel-1 A

S1A IW GRDH VV
2014-2015
10m spatial resolution
First Results
First Results

S1A IW GRDH VV
2014-2015
10m spatial resolution
Sentinel-1 A
Sentinel-1 A

S1A IW GRDH VV | 2014-2015 | 10m spatial resolution
Urban Growth

ERS-2 PRI & ASAR IMP VV
2002-2003
15m spatial resolution
48 scenes
Urban Growth

S1A IW GRDH VV
2014-2015
10m spatial resolution
31 scenes
Urban Growth

ERS-2 PRI & ASAR IMP VV 2002-2003 | 15m spatial resolution
Urban Growth

S1A IW GRDH VV 2014-2015 | 10m spatial resolution
Outlook

• Implemented system proved very promising for all considered type of data;

• Great potential for operational employment with ASAR WSM data for the past and S1A data for the present at the global scale;

• Further experimental trials for further improving the methodology and assessing the robustness;

• Validation (yet ongoing) also in collaboration with local representatives for getting reference data.
thanks a lot for your attention

@SAR4Urban

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