Multi-year Envisat ASAR observations
in support of global mapping of inland water bodies

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In the Climate Change Initiative Land Cover (CCI-LC) project supported by the European Space Agency, climate modellers expressed the need for a global land/water mask that could serve a wide range of global applications in satellite data processing, climate variables monitoring and modelling.

Global water body datasets, mostly based on optical EO data, existed but they were not free of caveats.
Technical and scientific challenges of this work

• Radar observations can be planned and the backscattered intensity is typically (very) low over water bodies → property typically used to map water bodies with SAR data

• However, this is not always the case
  • Windy conditions → increased surface roughness → high backscatter
  • Frozen conditions → low or high backscatter

• Global datasets of SAR data are available and several in a multi-temporal fashion
  → Are there additional metrics that have unique properties over water bodies?
  → Are these consistent across different environments?
  → Can a straightforward algorithm use the unique features of such metrics and classify water bodies?
  → Are data available to support the generation of such metrics and be used in large-scale mapping operations?
Counting Envisat ASAR observations

Envisat ASAR backscatter data (2005-2012) @ 150 m and 1,000 m is publically available. Particular feature: dense time series
Multi-temporal metrics

From a hyper-temporal time series of SAR backscatter measurements it is possible to derive multi-temporal metrics such as

- Average backscatter
- Minimum backscatter
- Temporal variability, i.e., standard deviation of backscatter
Pan-boreal hyper-temporal RGB - Eurasia

R: Average backscatter  G: Minimum backscatter  B: Temporal variability
Clear separability of water and other land cover classes → temporal variability and minimum backscatter suitable for detection of open water bodies

- Study area: Netherlands
- Reference dataset: Corine Land Cover CLC2006, edge-eroded
- Only "pure" water and "pure" land pixels considered
Effect of "events" on TV and MB

- **Thaw**
  - TV = 2.7 dB, MB = -20.3 dB

- **Wet snow (on glacier)**
  - TV = 7 dB, MB = -20.8 dB

- **Flooding (rice field)**
  - TV = 4.2 dB, MB = -19.7 dB
Water body classification algorithm

No classification if less than 10 backscatter observations

If slope angle from a DEM > 10 degrees → land

\[ y = 3.5x - 28 \]
• Commission errors in desert, arid landscapes, glaciated land areas, inundated regions and long-lasting sea ice
• Omission errors when Global Monitoring Mode (1,000 m) data was used or for very sparse ASAR datasets
• Removed large-scale artifacts
• Local commission errors in areas where refinement method did not work correctly
• Omission errors due to low spatial resolution of input SAR data could not be corrected for
1) Merging SAR-based indicator with SRTM Water Bodies dataset

2) Spatial analysis of discrepancies and correction

   - Coastal areas, deserts/salars
   - Snowy mountainous areas
   - Temporarily inundated areas

   WB omission
   - Sea ice, coastal areas

3) Consolidation (reaching global coverage, compliancy with CCI Land Cover maps at 300 m)
The CCI Water Bodies Product (WBP)

- Static map of open permanent water bodies, ca. year 2010
- Overall accuracy: 96% - Details at poster by C. Lamarche
- Available as a stand-alone product of the climate research data package produced by the CCI-LC project

http://maps.elie.ucl.ac.be/CCI/viewer
The CCI Land Cover data viewer

http://maps.elie.ucl.ac.be/CCI/viewer/
First test with Sentinel-1 SAR multi-temporal data

S1 data: Oct. 2014 and Mar. 2015
Availability of IWS and EWS data

Note: EWS is not common over land

16 IWS dual-pol (vv,vh) images
17 EWS dual-pol (hh,hv) images

6 IWS dual-pol (vv,vh) images
26 EWS dual-pol (hh,hv) images
SAR-WBI of southwest Sweden
Sentinel-1 EWS (HH,HV) @ 150 m
Sentinel-1 IWS (VV,VH) @ 30 m
SAR-WBI (spat. res. 150 m) @ 30 m
Some final considerations

• SAR observations in the form of multi-temporal metrics of C-band observations support the mapping of open water bodies
• The dense ASAR time series are now investigated to characterize water dynamics (2002-2012)
• ERS data would expand the time line to 1990s: will they be available?
• Sentinel-1 is potential to improve spatially and thematically WB mapping
• However we still miss data over critical areas (northern latitudes, Africa) → observations needed as soon as possible to capture spring thaw
• Acquisition strategy of Sentinel-1: consider EWS over land to have data continuity with ASAR ScanSAR (2002-2012)