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

**M. Santoro [1], U. Wegmüller [1], C. Lamarche [2], S. Bontemps [2], P. Defourny [2], O. Arino [3]**

*[1] GAMMA Remote Sensing AG, Switzerland*

*[2] Université catholique de Louvain, Earth and Life Institute, Belgium*

*[3] ESA-ESRIN, Italy*

*Support by*

*R. Cuccu, S. Pinto, J. Farres – G-POD Team @ ESA*

# Context

- 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?

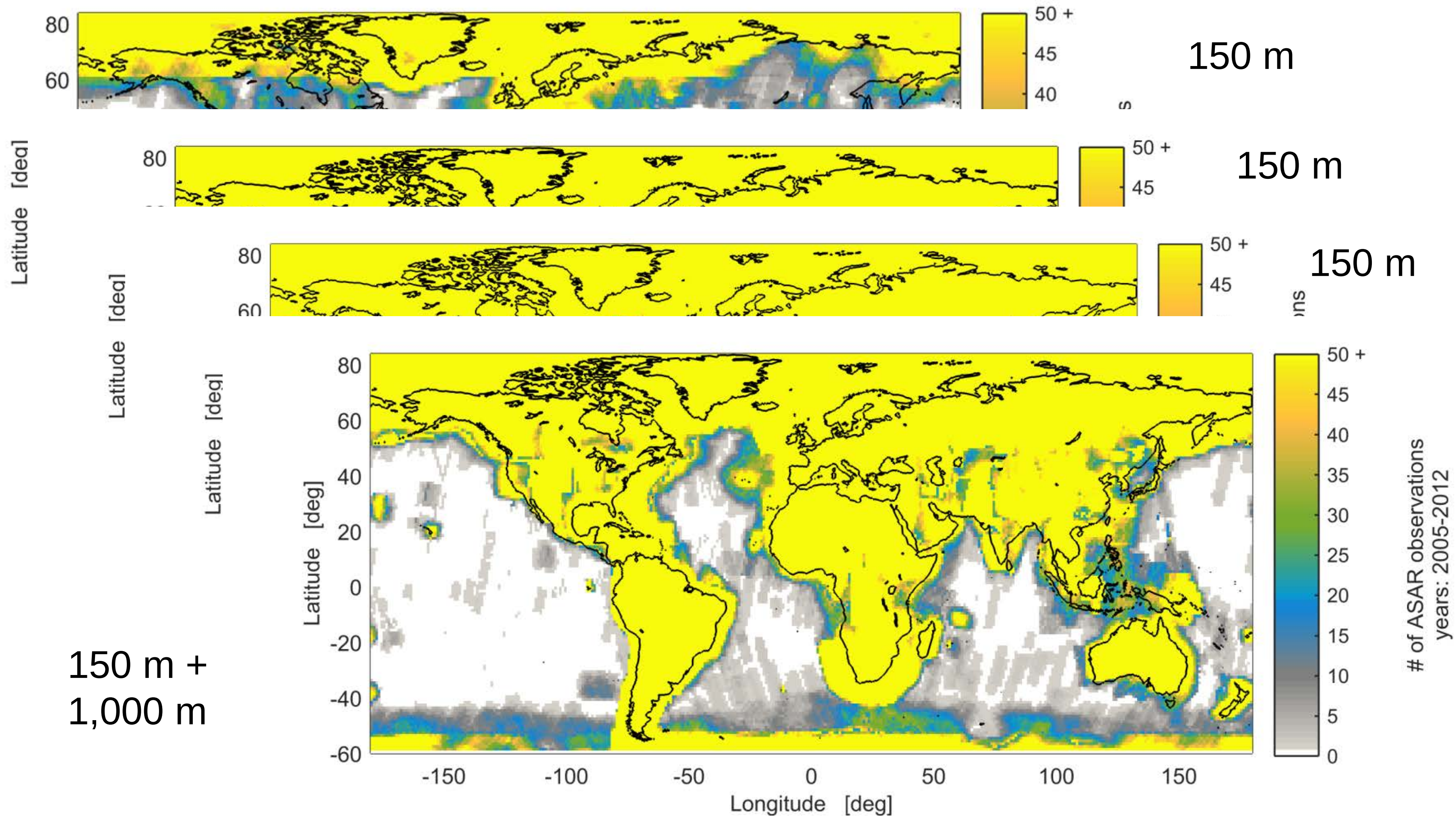
  → Are these consistent across different environments?

  → 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

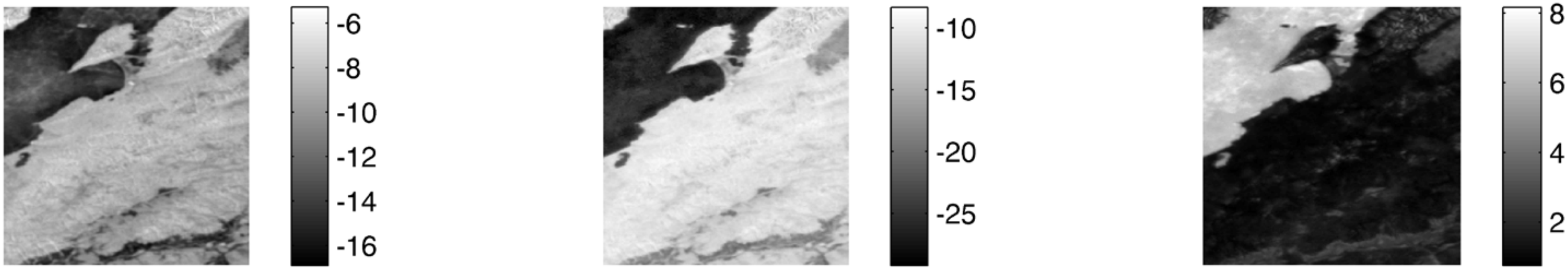
From a hyper-temporal time series of SAR backscatter measurements it is possible to derive multi-temporal metrics such as

- Average backscatter

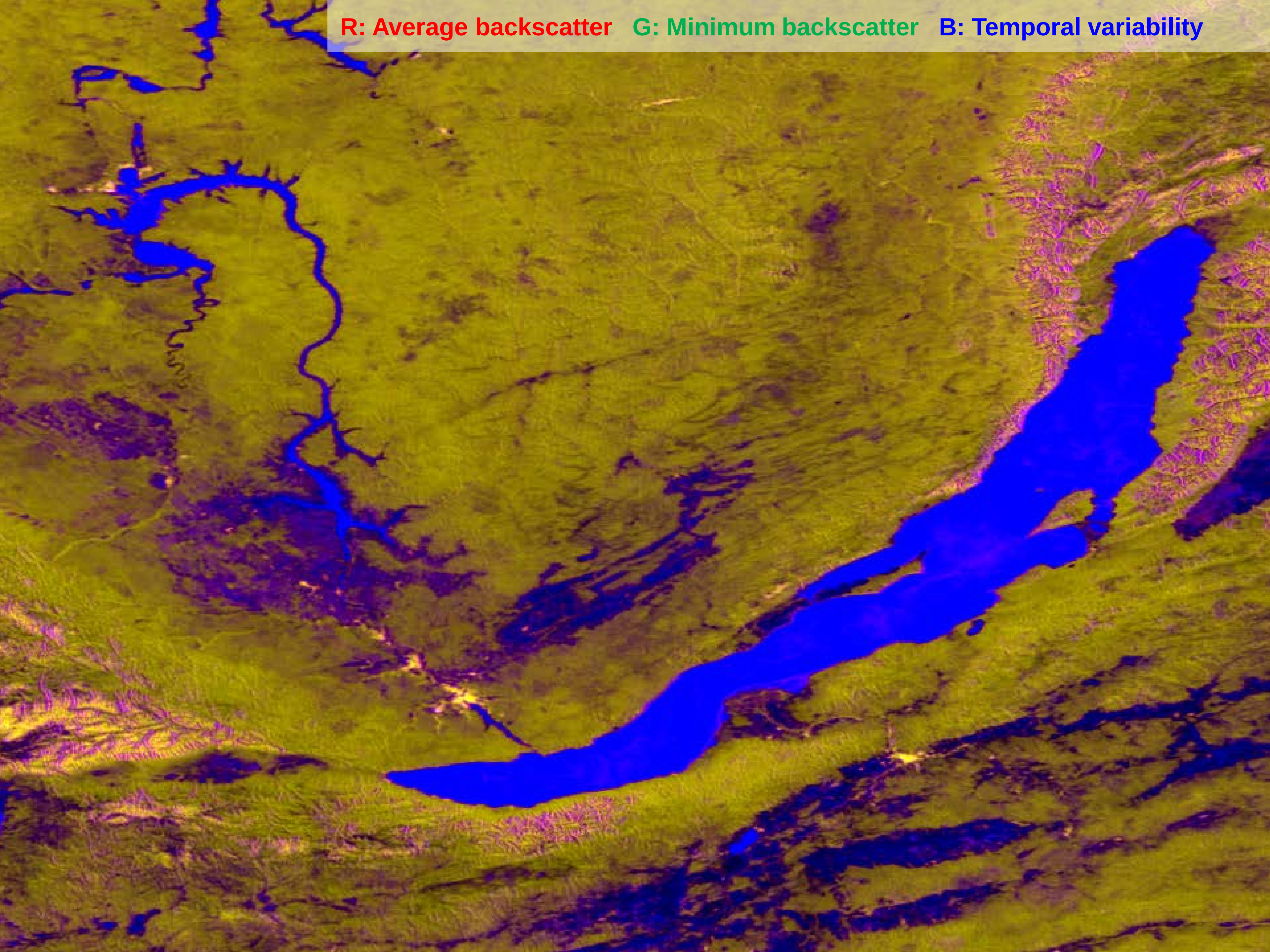
- Minimum backscatter

- Temporal variability, i.e., standard deviation of backscatter

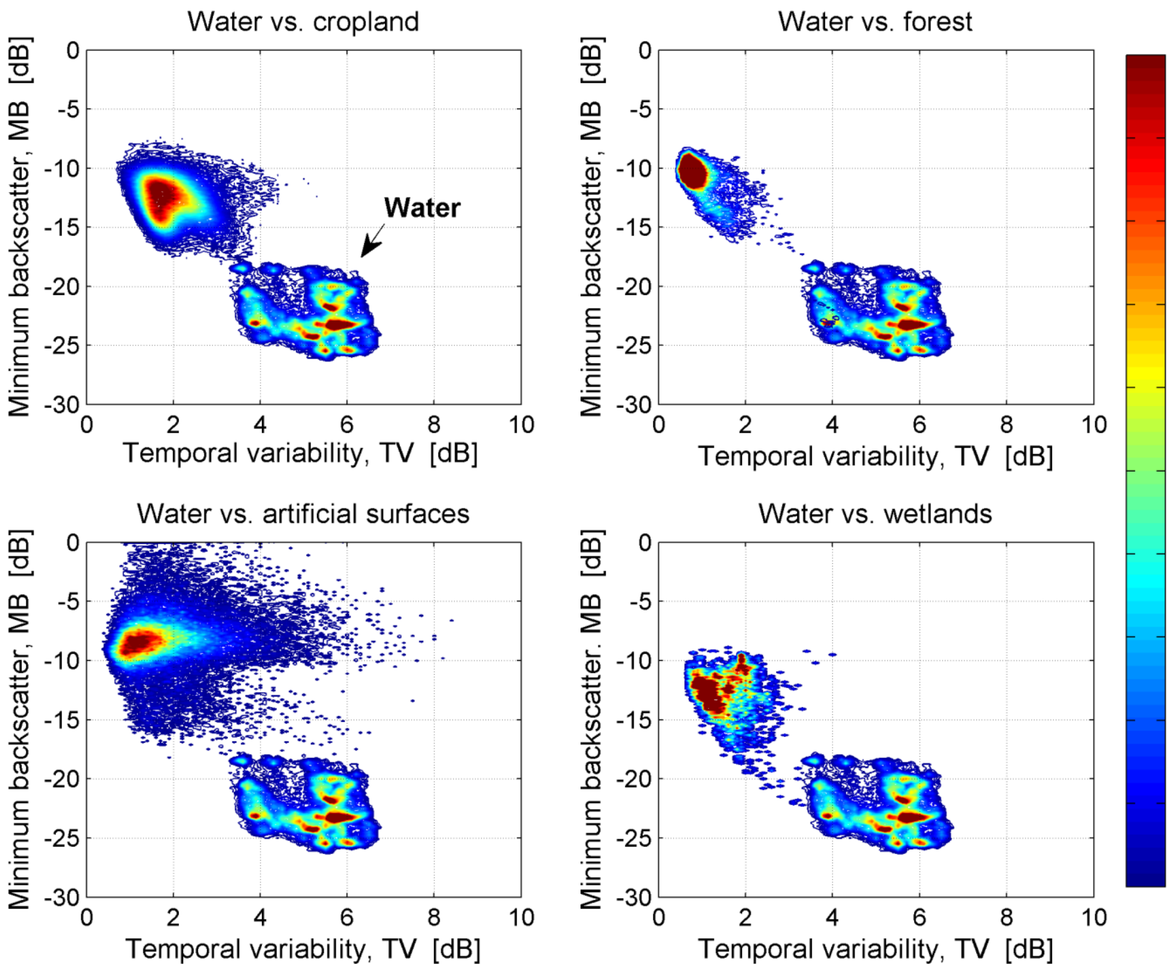
**C-band co-pol SAR backscatter**




Average backscatter (dB) Minimum backscatter (dB) Temporal variability (dB)


R: Average backscatter
G: Minimum backscatter
B: Temporal variability

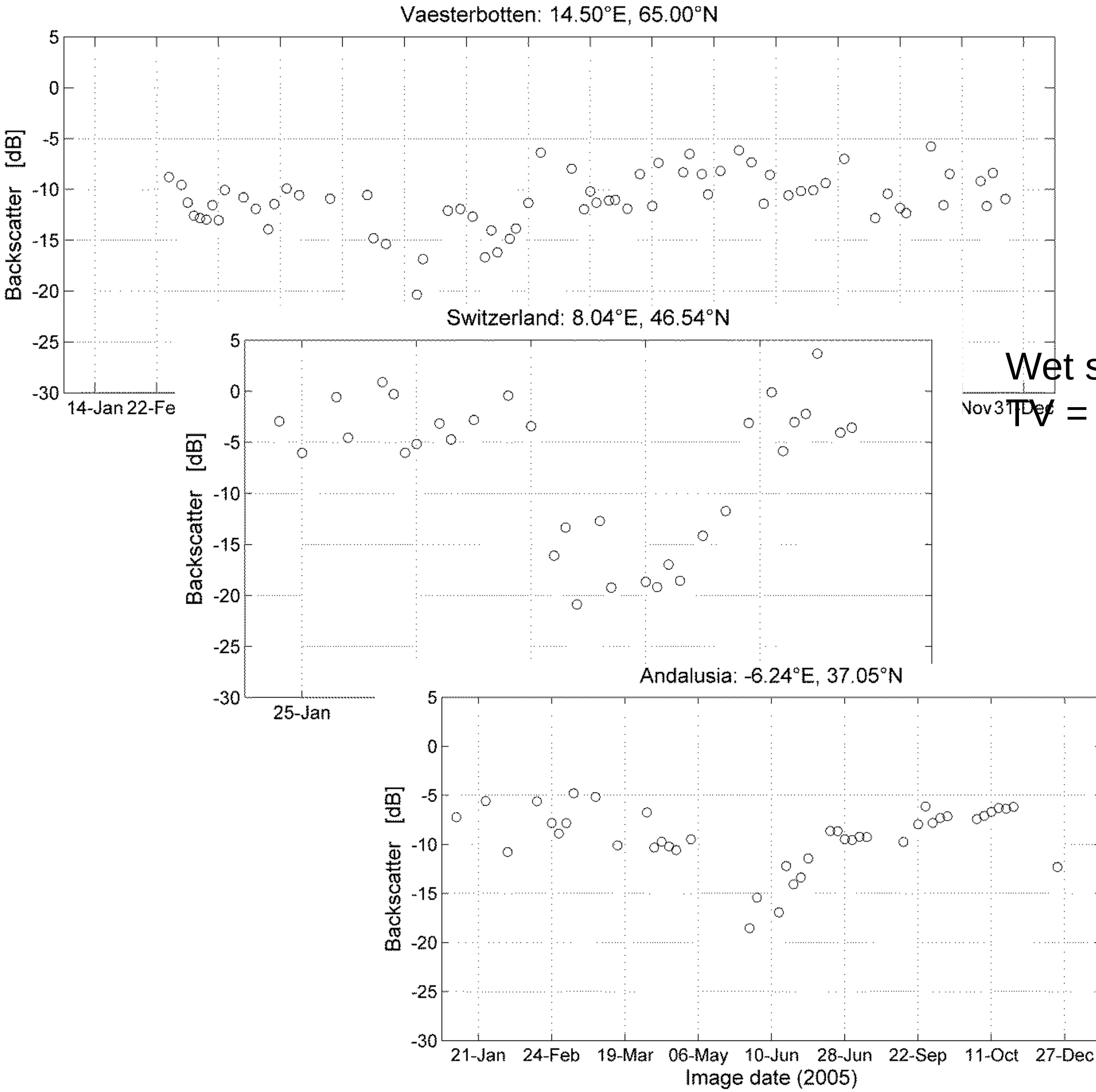
# Signatures of TV and MB




- ***Study area: Netherlands***
- ***Reference dataset: Corine Land Cover CLC2006, edge-eroded***
- ***Only „pure“ water and „pure“ land pixels considered***

Clear separability of water and other land cover classes → <u>temporal variability and minimum backscatter suitable for detection of open water bodies</u>

# Effect of ”events” on TV and MB



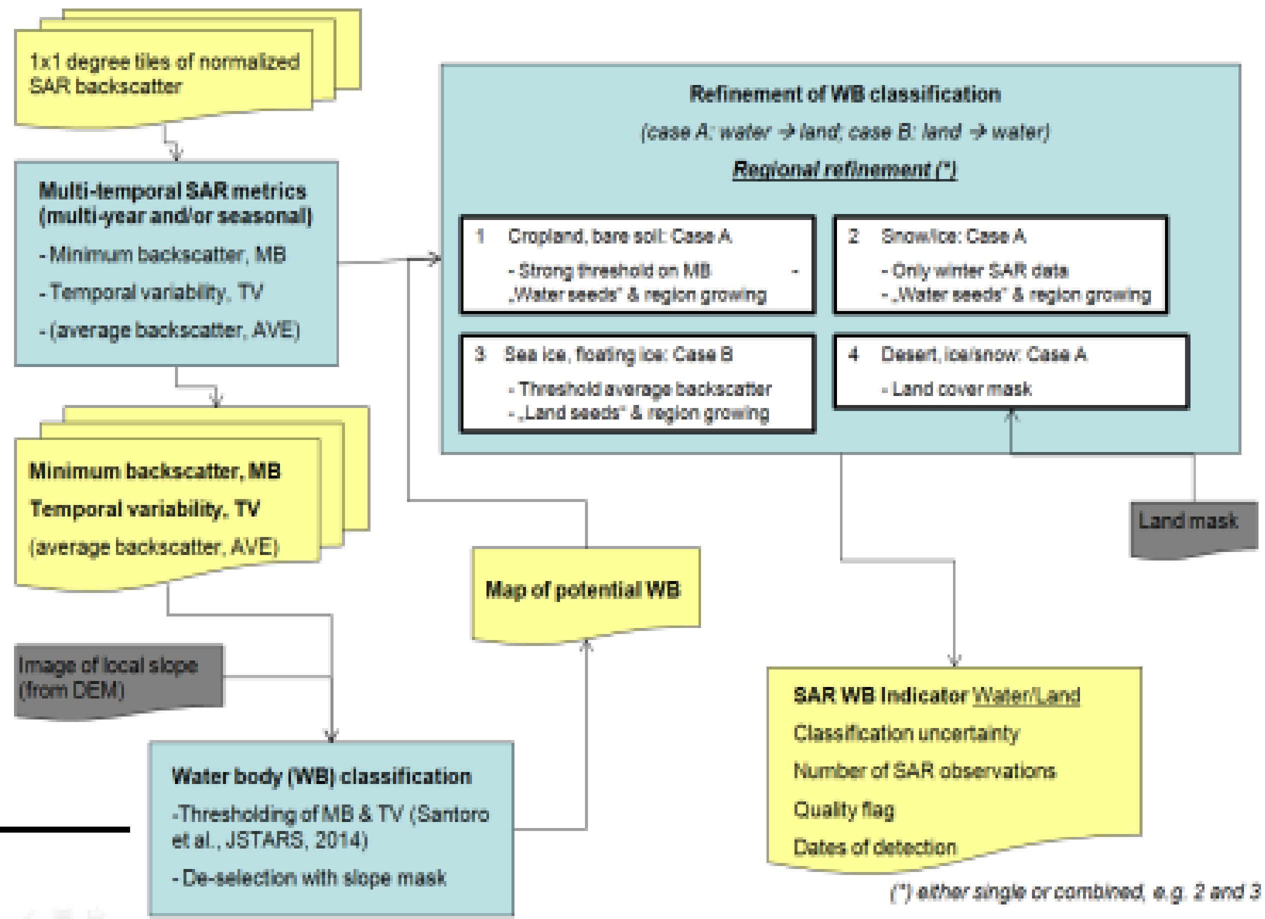

Thaw
TV = 2.7 dB, MB = -20.3 dB

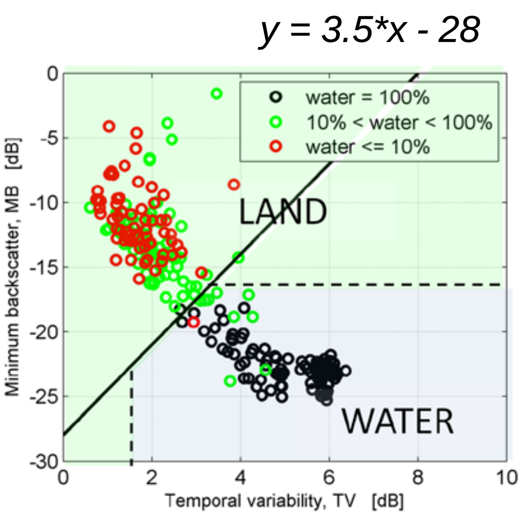
Wet snow (on glacier)
TV = 7 dB, MB = -20.8 dB

Flooding (rice field)
TV = 4.2 dB, MB = -19.7 dB

# Water body classification algorithm

## Water/Land Classification

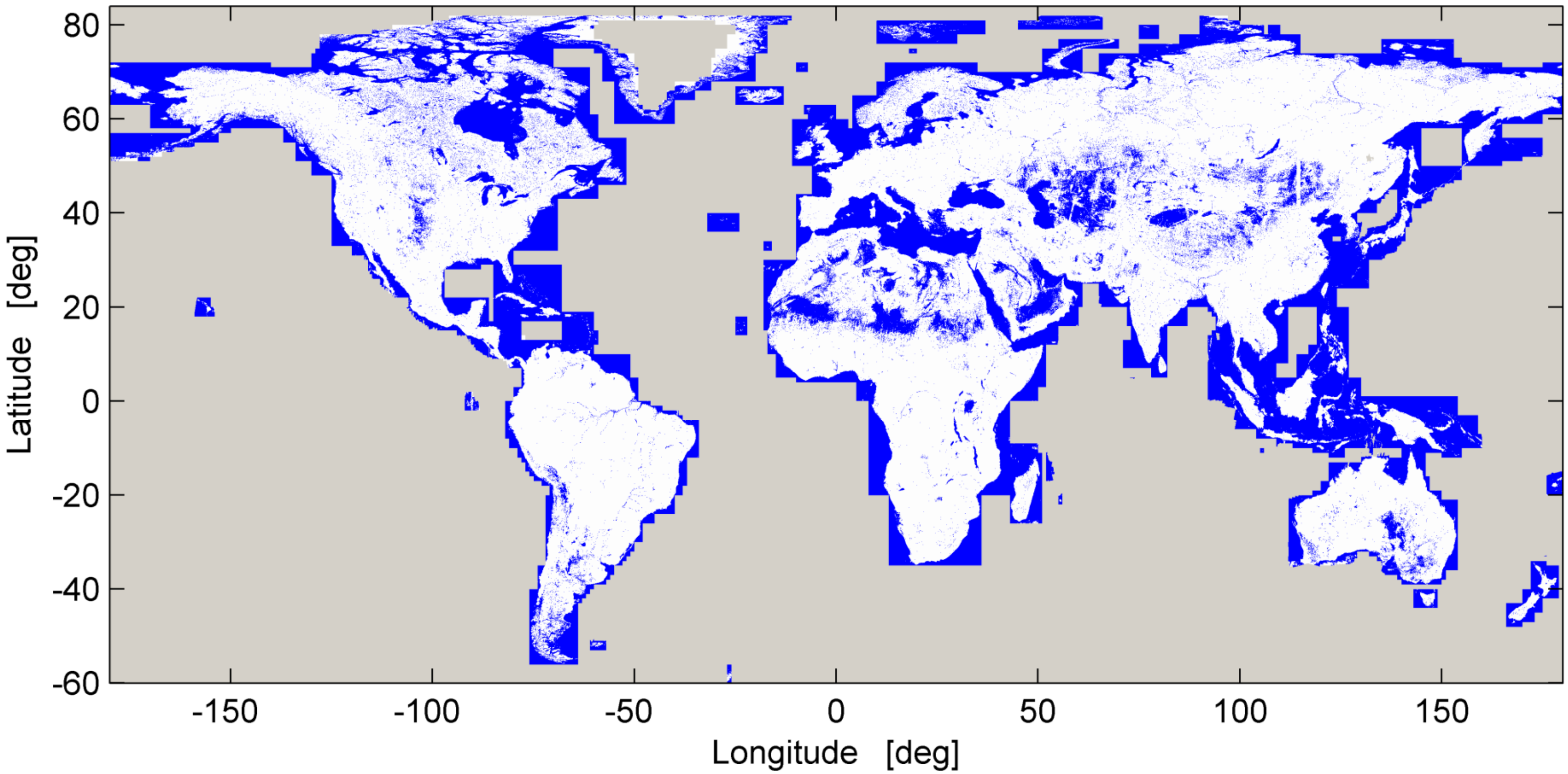



No classification if less than 10 backscatter observations

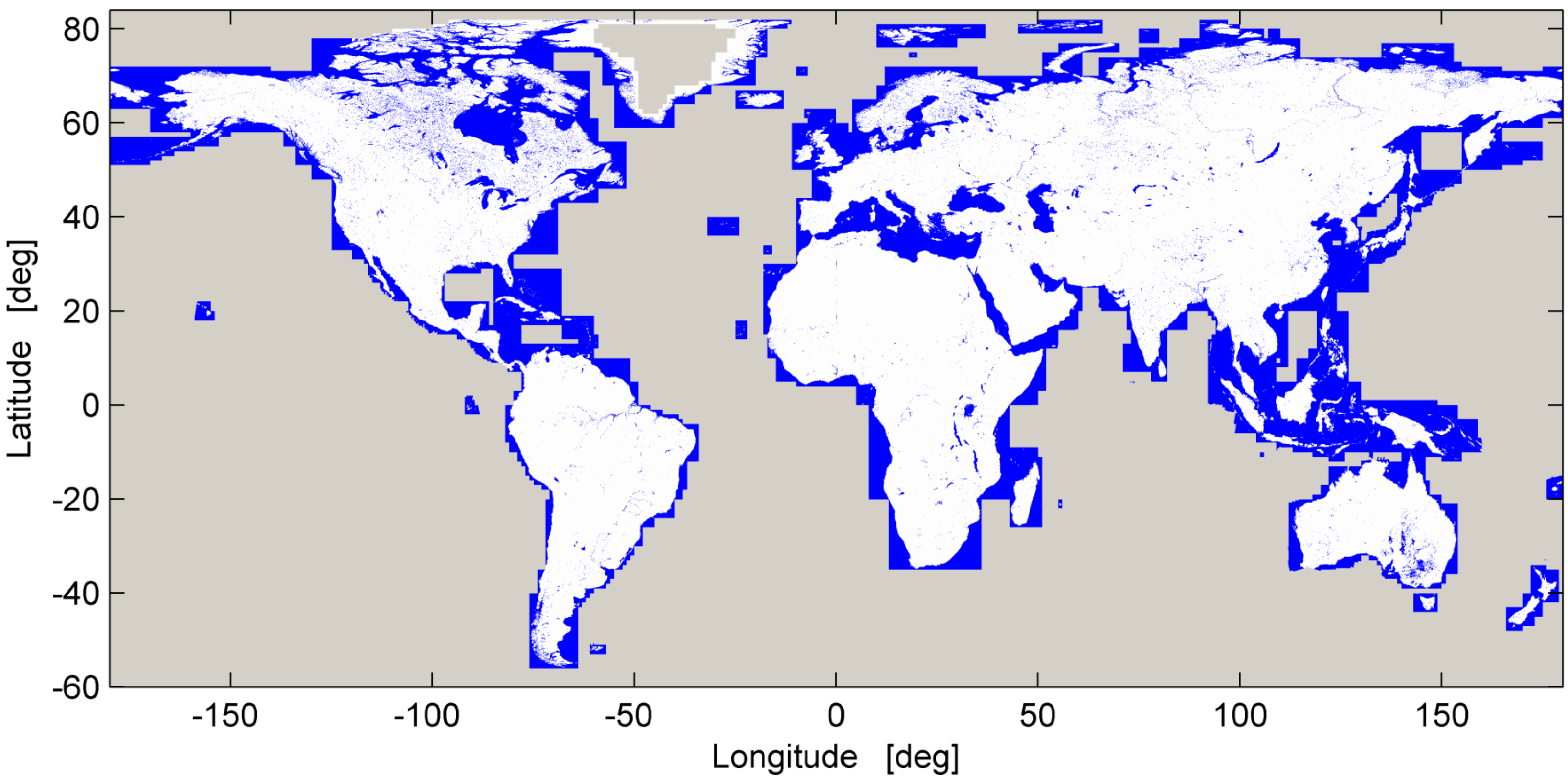
If slope angle from a DEM > 10 degrees → land

# Map of potential open water bodies (150 m)




- 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

# SAR-based indicator of water bodies (150 m)

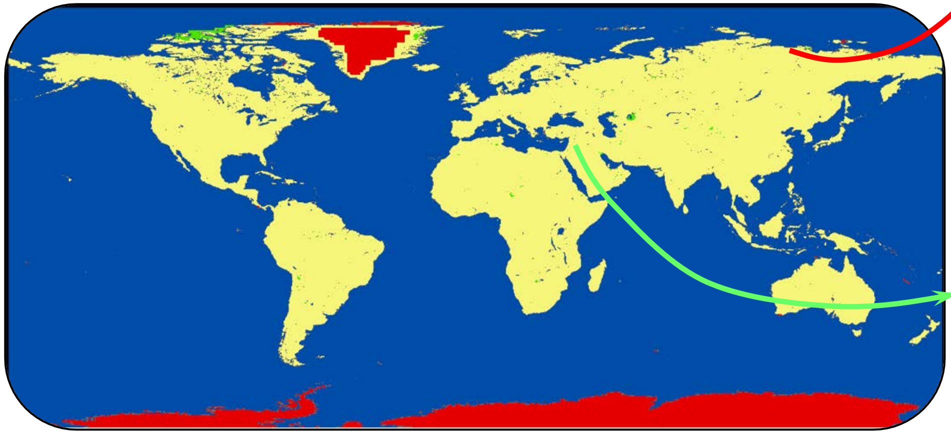



- Removed large-scale artifacts
- Local commission errors in areas where refinement method did not work correctly
- Omission errors due to low spatial resolution of input SAR data could not be corrected for

# Consolidation of the SAR-based indicator

1) Merging SAR-based indicator with SRTM Water Bodies dataset

2) Spatial analysis of discrepancies and correction



**WB commission**

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

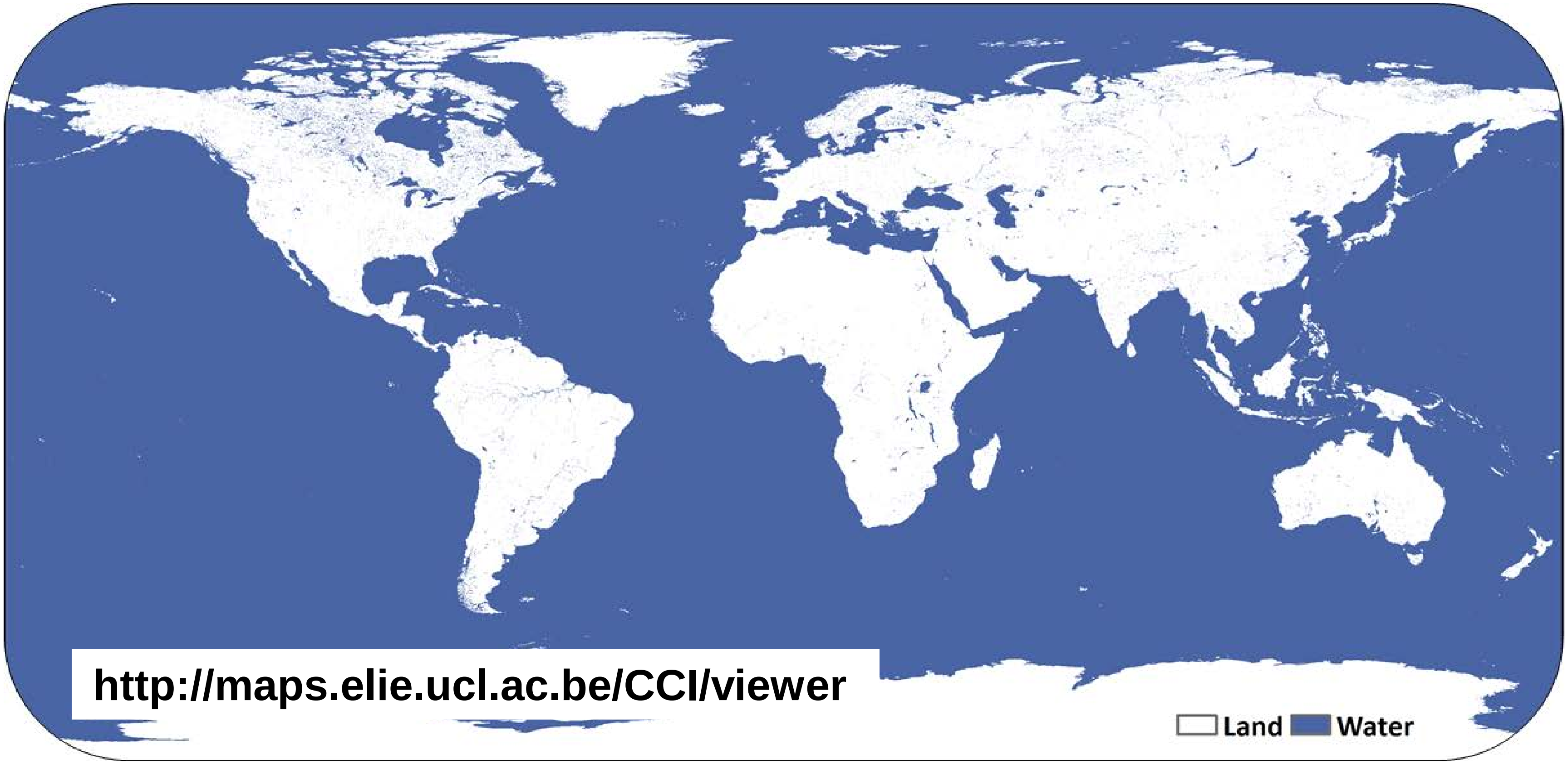
**WB omission**

- **Sea ice, coastal areas**

3) Consolidation (reaching global coverage, compliancy with CCI Land Cover maps at 300 m)

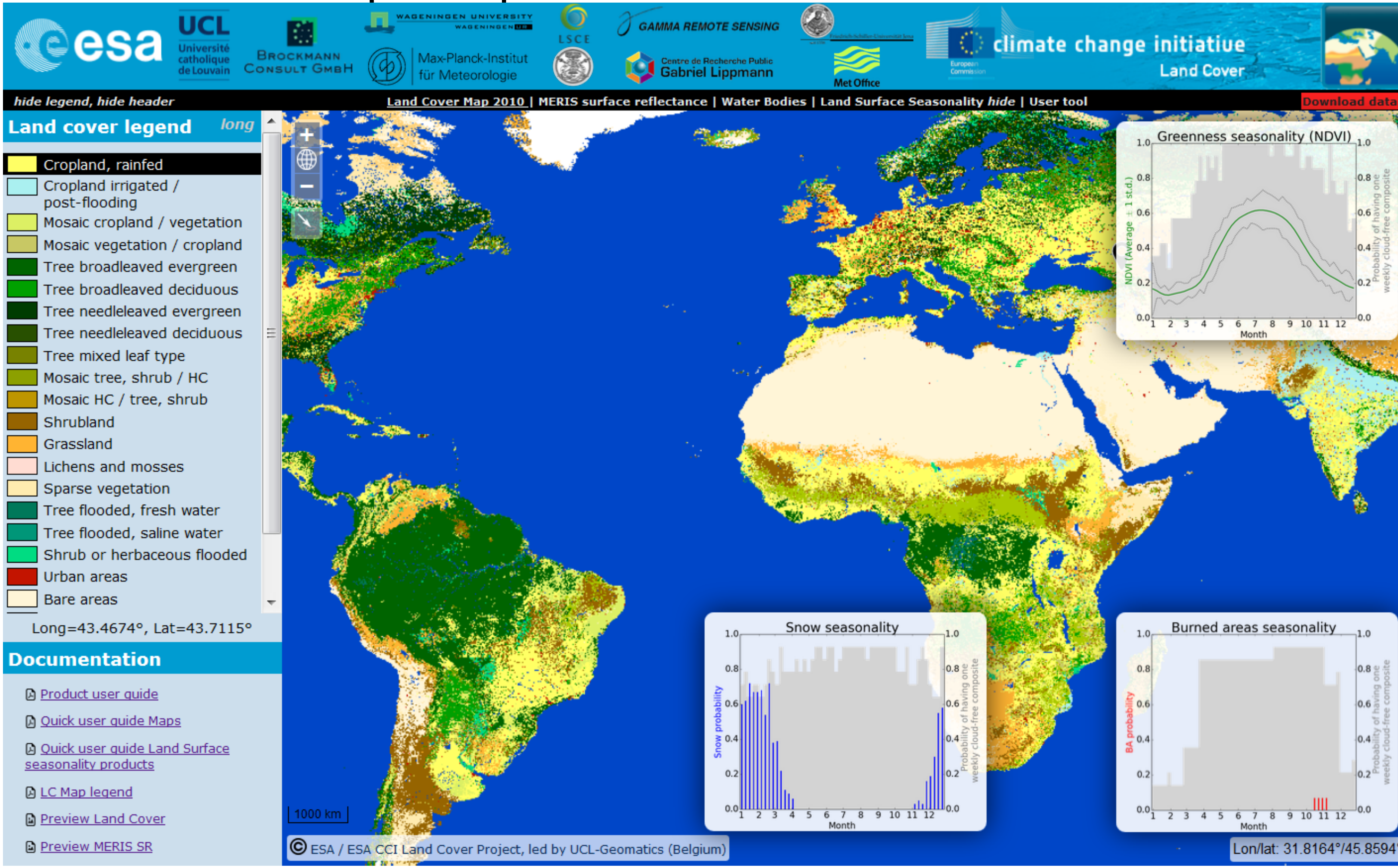
# The CCI Water Bodies Product (WBP)

- 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

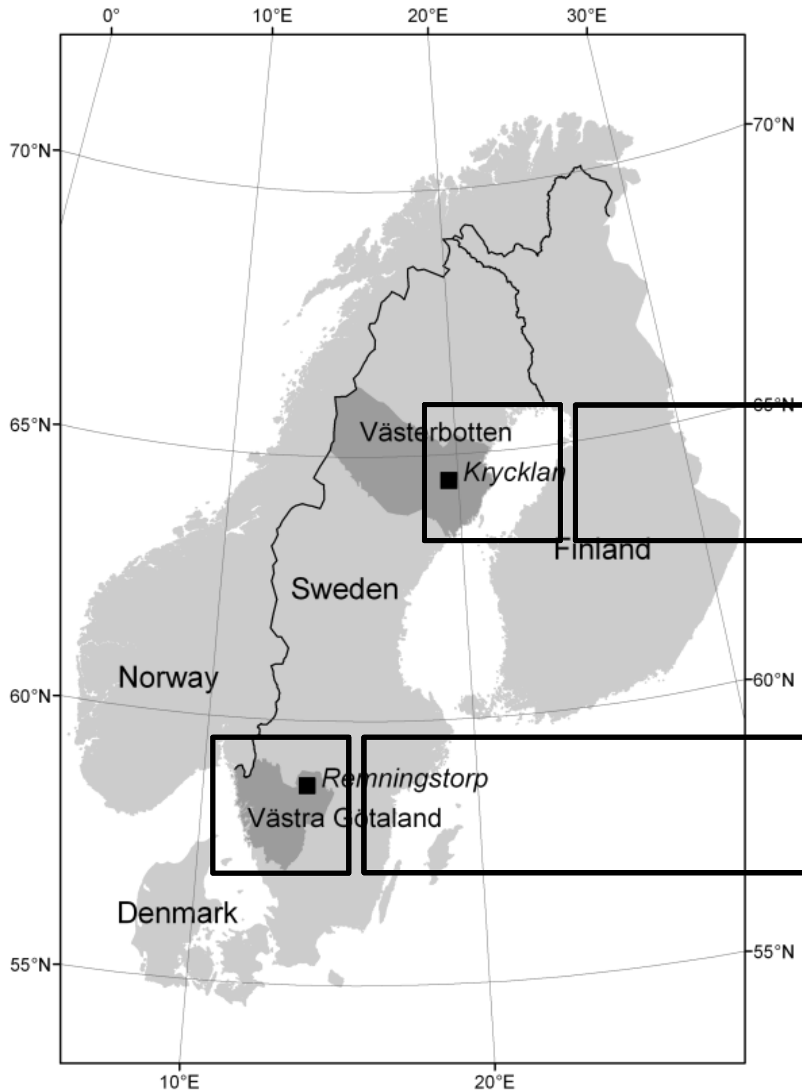


# The CCI Land Cover data viewer

http://maps.elie.ucl.ac.be/CCI/viewer/



# First test with Sentinel-1 SAR multi-temporal data

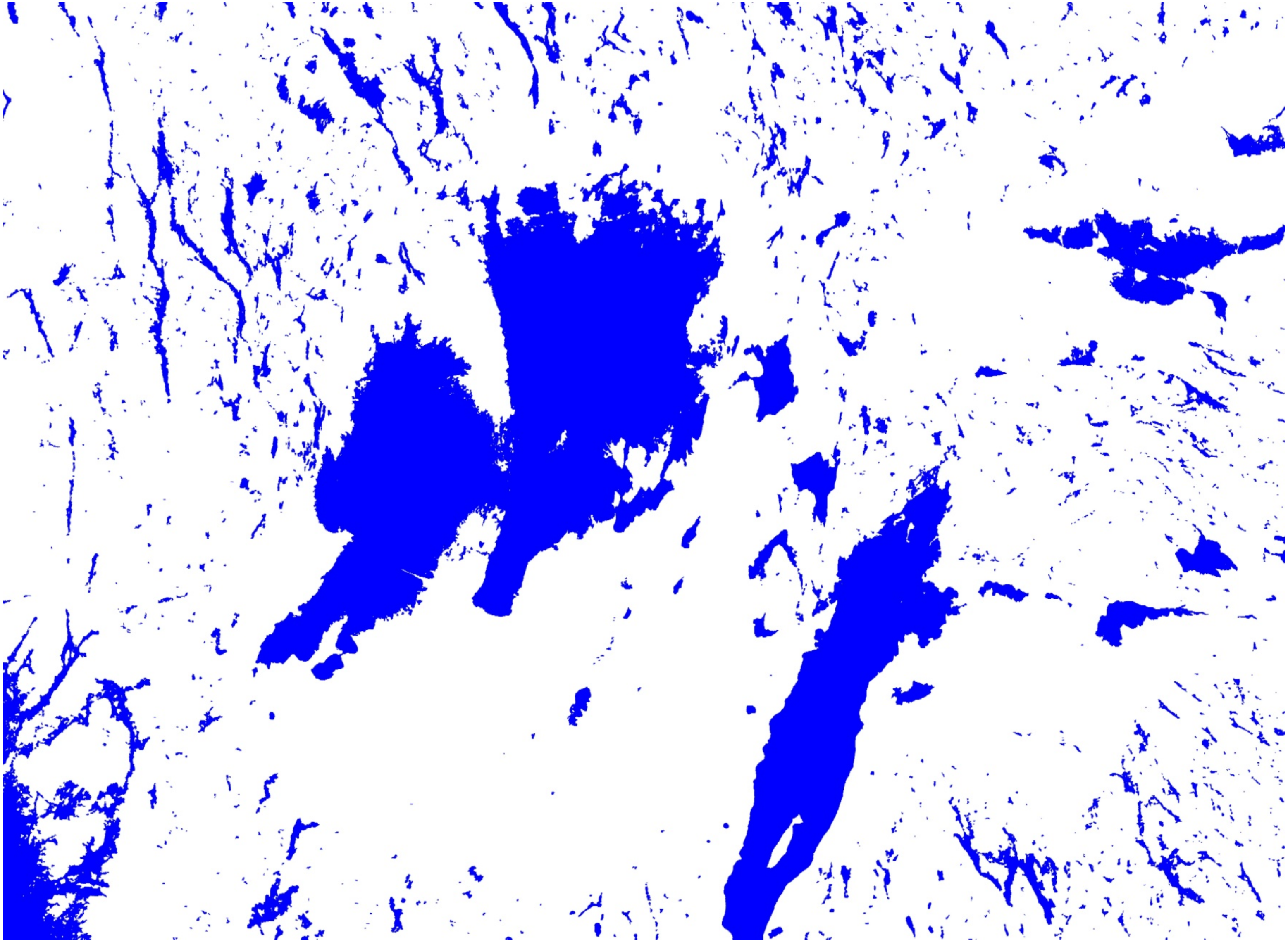



**S1 data: Oct. 2014 and Mar. 2015**
**Availability of IWS and EWS data**
***Note: EWS is not common over land***

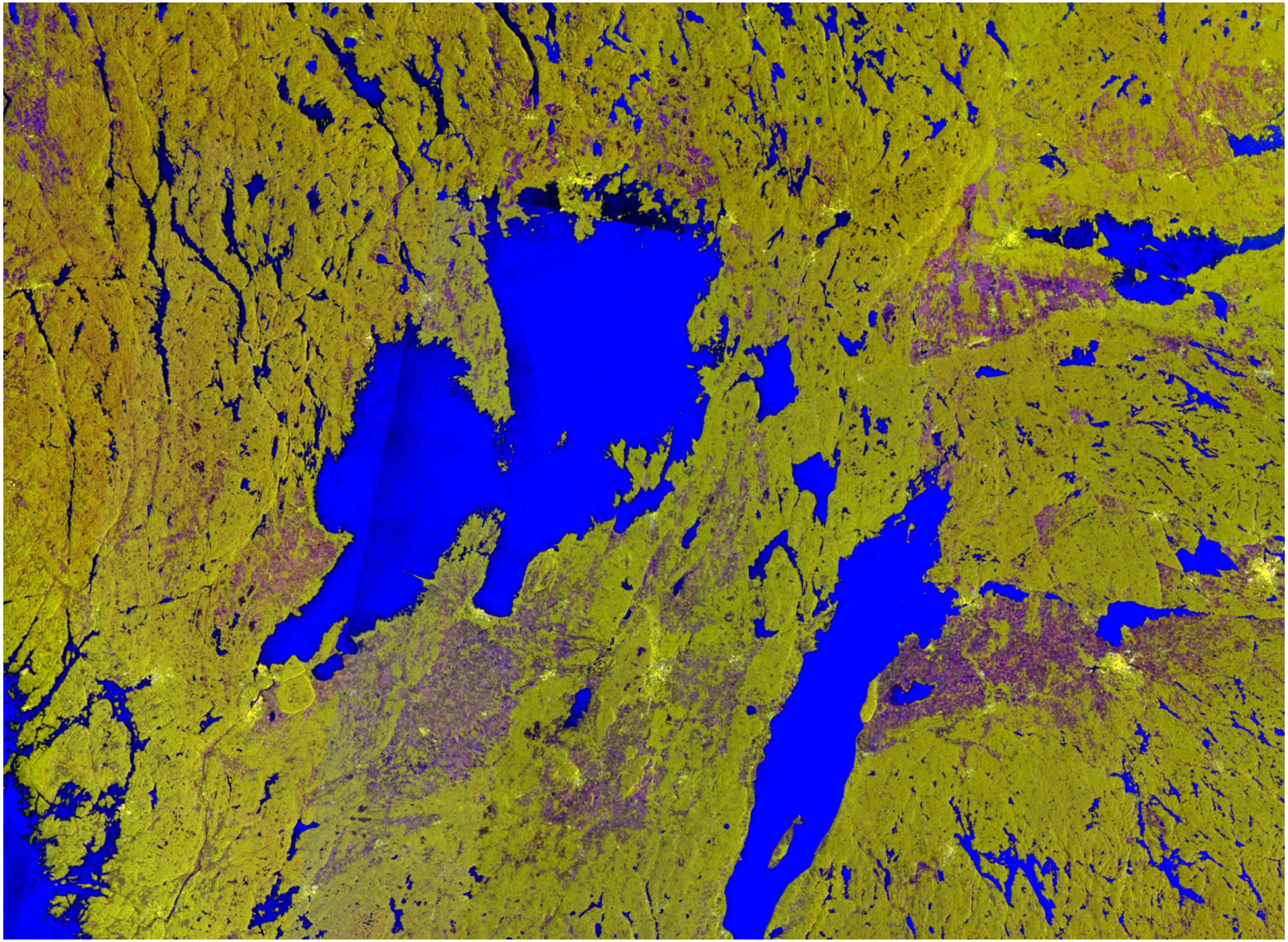
**16 IWS dual-pol (vv,vh) images**
**17 EWS dual-pol (hh,hv) images**

**6 IWS dual-pol (vv,vh) images**
**26 EWS dual-pol (hh,hv) images**

# SAR-WBI of southwest Sweden

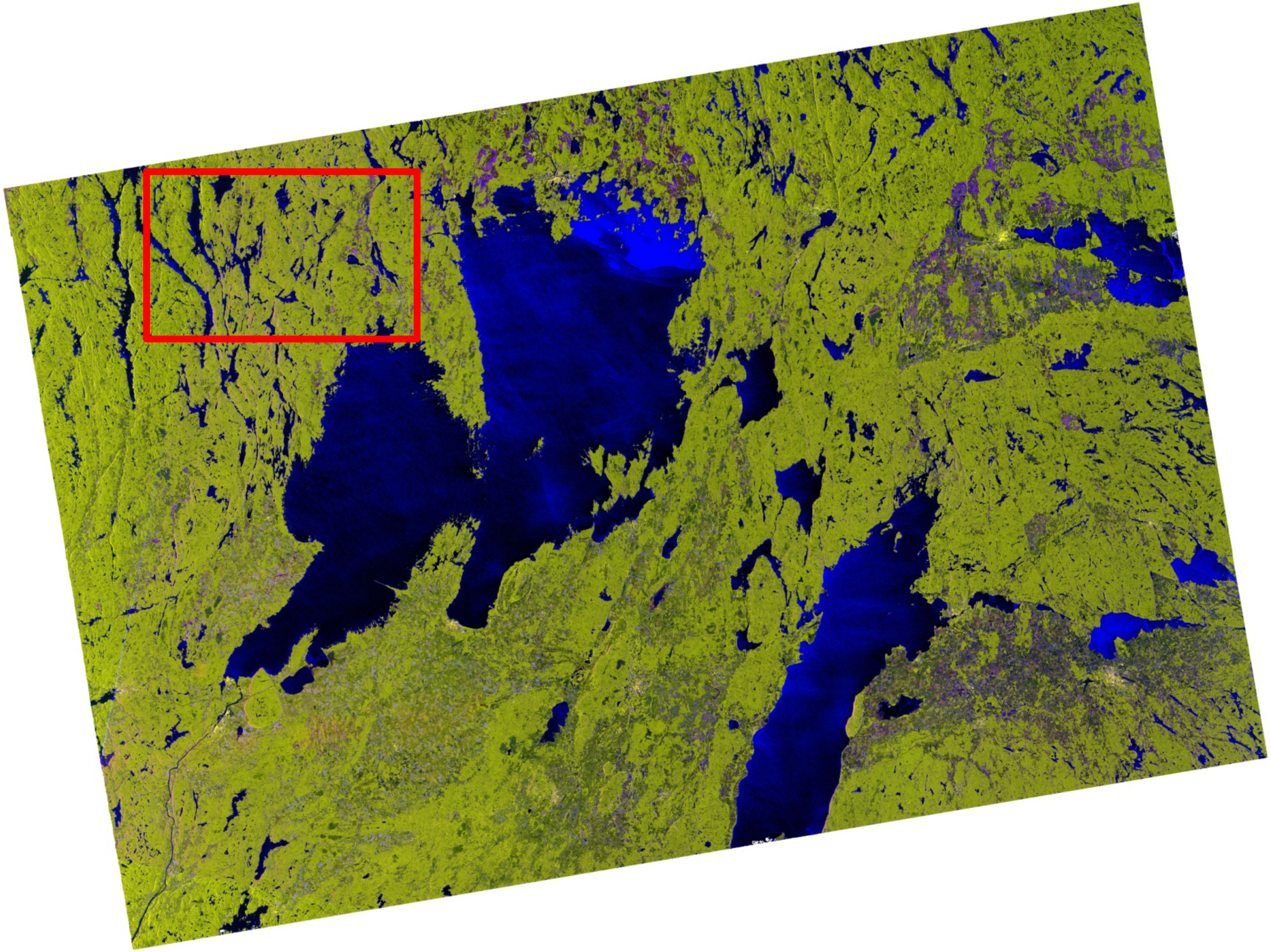


# Sentinel-1 EWS (HH,HV) @ 150 m



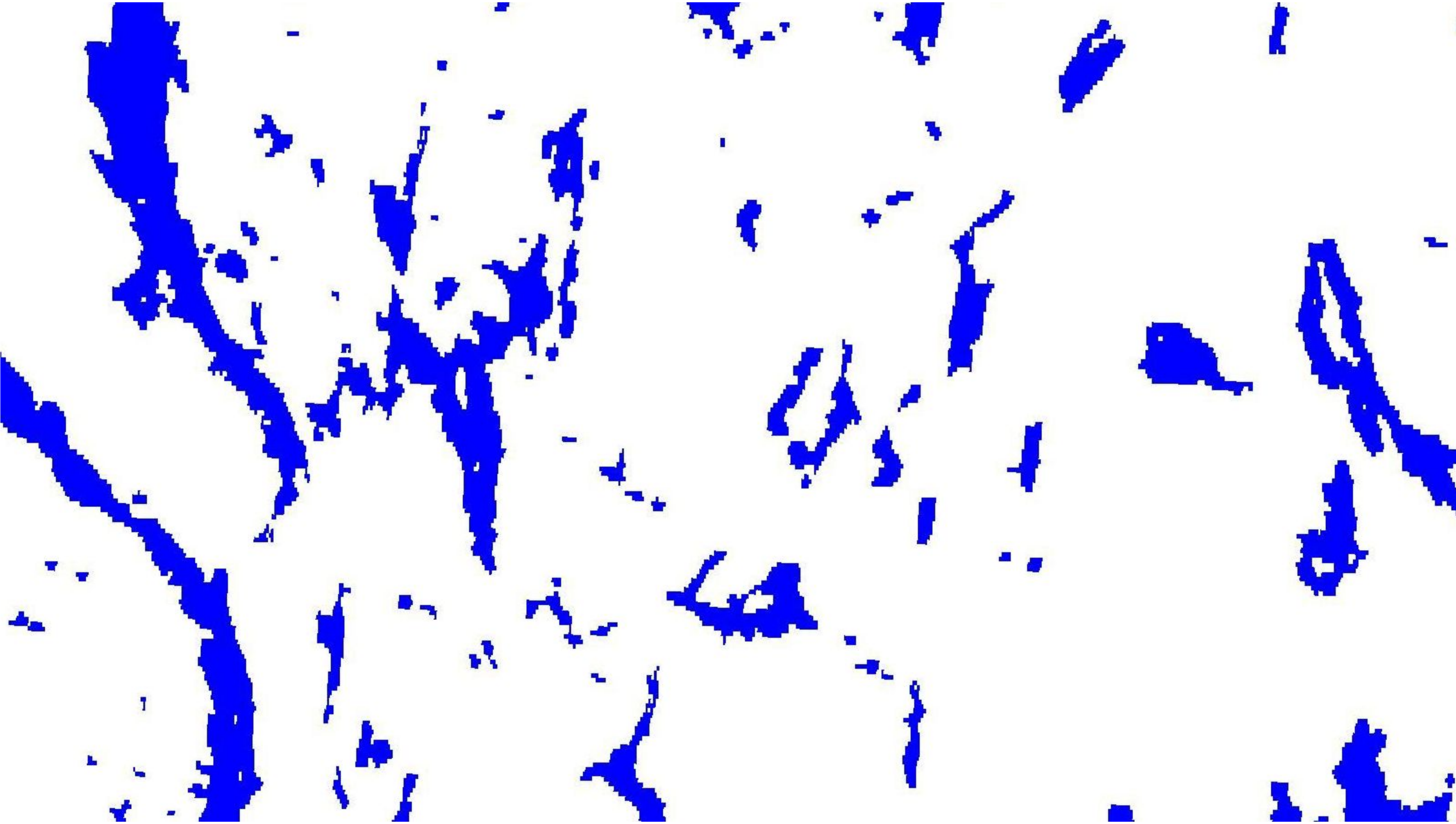
**Average HV** **Minimum HV** **Temporal variability HH**

# Sentinel-1 IWS (VV,VH) @ 30 m

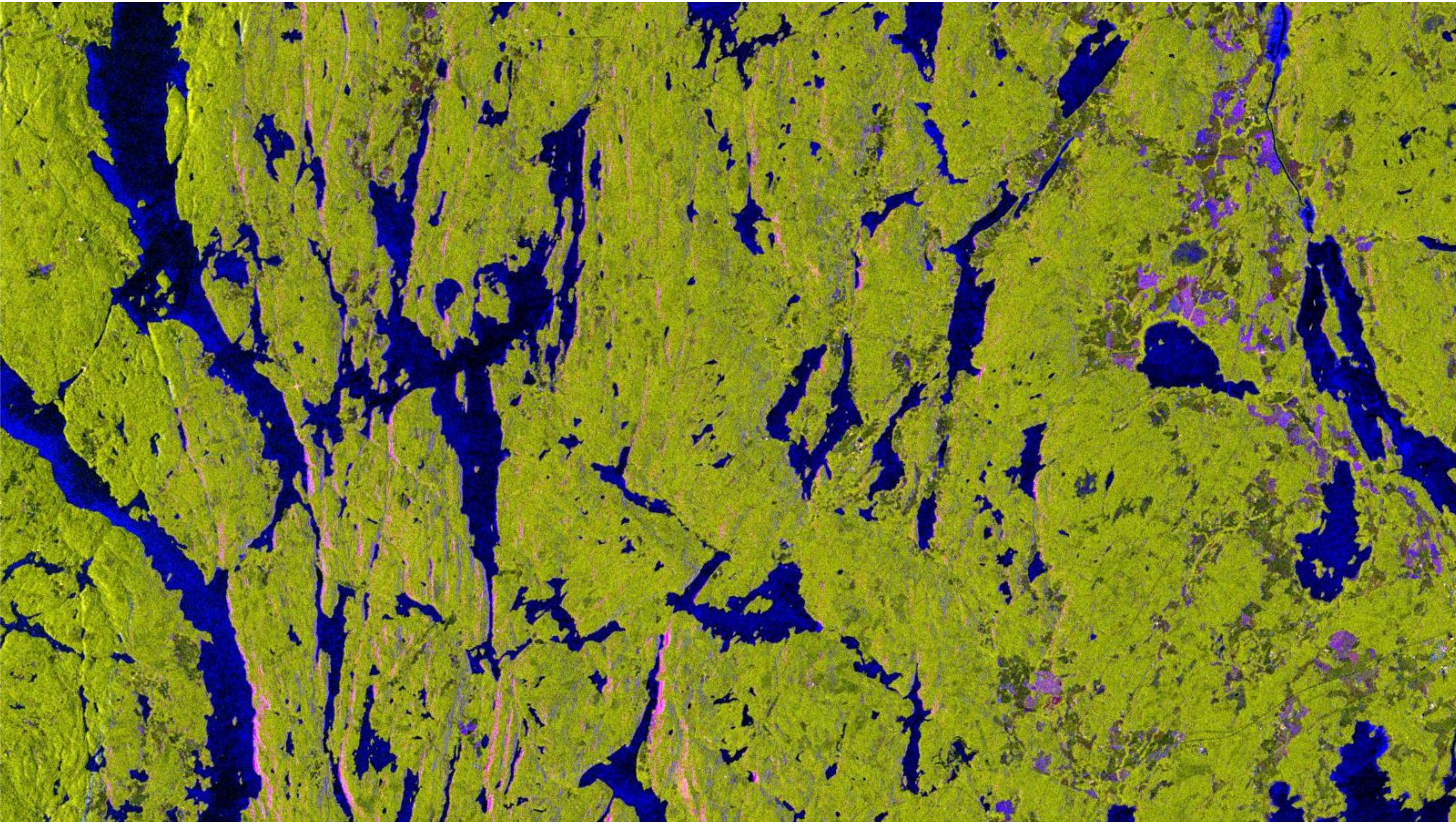


Average HV   Minimum HV   Temporal variability HH

# SAR-WBI (spat. res. 150 m) @ 30 m



# Sentinel-1 IWS (spat. res. 30 m) @ 30 m



Average HV   Minimum HV   Temporal variability HH

# 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)

# The CCI Land Cover data viewer

http://maps.elie.ucl.ac.be/CCI/viewer/