Waterline detection and topography in the Wadden Sea using Synthetic Aperture Radar data

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Motivation

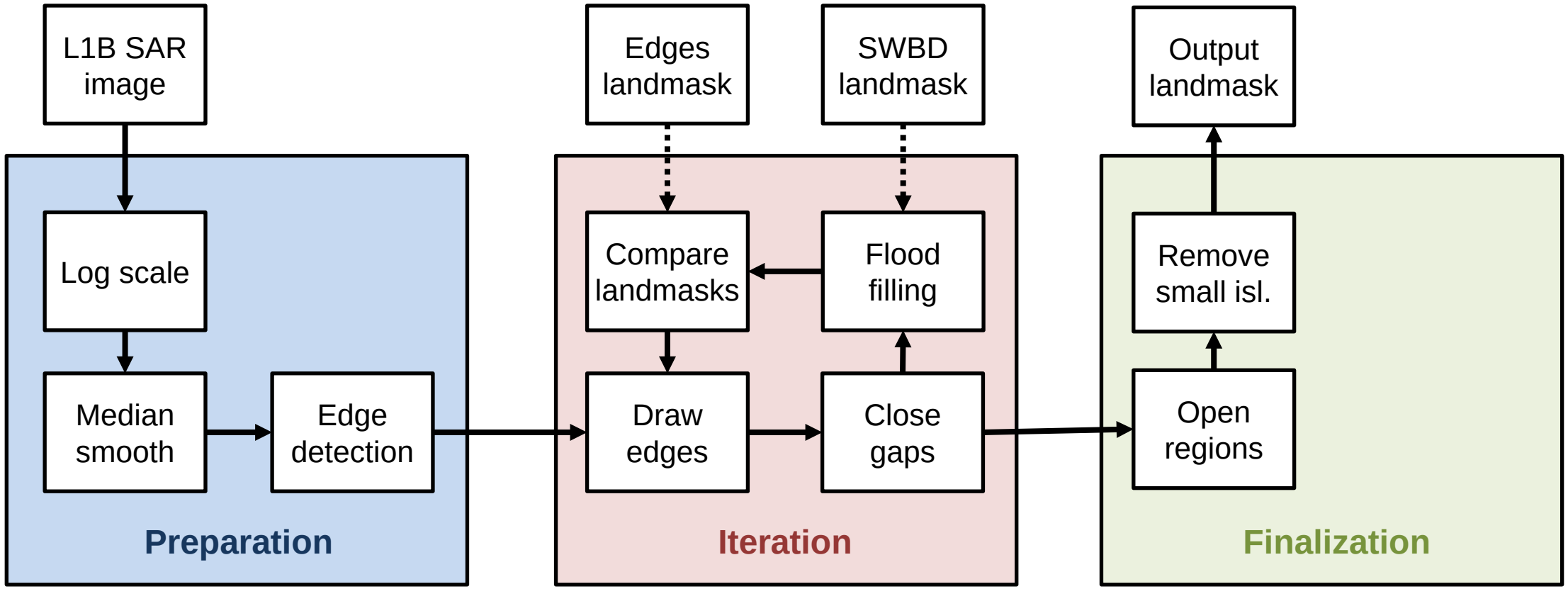
- Waterline Detection
  - Land-water-line for topography determination
  - Landmask as input for other maritime SAR products (ship detection, wind, sea state,…)
  - As automated as possible for Near Real Time applications
- Wadden Sea
  - Nature reserve, UNESCO World Heritage Site
  - Lots of ship traffic to Hamburg, Bremerhaven and other ports
- Topography
  - Topographic changes on timescales of months to a few years
  - Indication of natural processes, human activities or climate change
  - Changed positions of tidal channels or sandbanks pose a threat to tourism and ship traffic
  - Very costly when frequently done by ships and aircrafts
- SAR data
  - Reliable acquisitions independent of cloud coverage
  - Important to get different tidal states regularly

Waterline detection

- Landmasking for other maritime SAR products
  - Currently used: Shuttle Radar Topography Mission (SRTM) Water Body Dataset (SWBD) (2000)
    - No tidal flats
    - Inaccuracies over time
    - Available only within 60°N to 54°S latitude
  - Near Real Time (NRT) processing requires short runtime

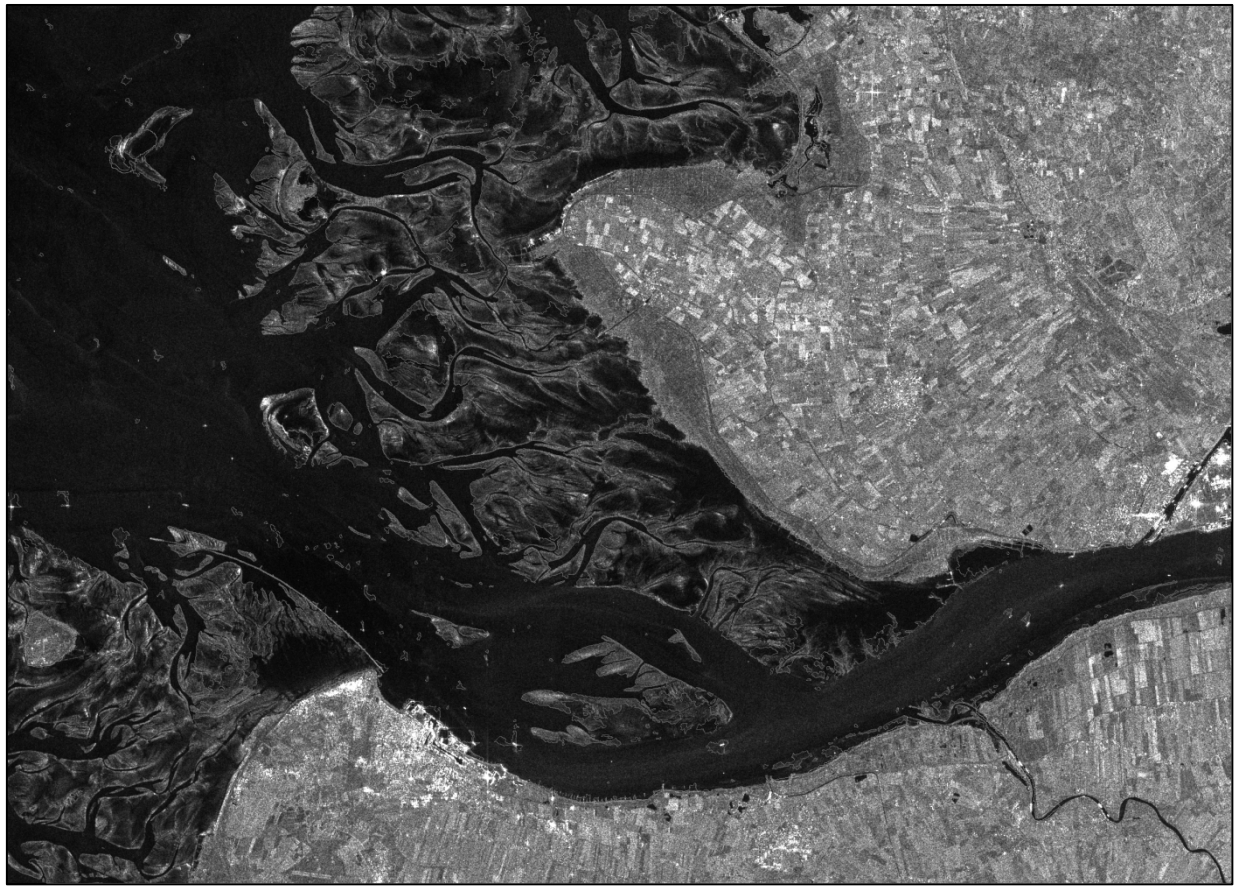
- Wadden Sea topography
  - Ongoing changes in tidal flats, islands and sand bank positions
  - Landmasks from acquisitions at different tidal states
  - Expanding the studies of Niedermeier (2005)/Heygster (2010)
  - Using high-resolution TerraSAR-X StripMap data, supported by also by Sentinel-1 data

Waterline retrieval algorithm: overview



Waterline retrieval algorithm: preparation

- Input image
  - TSX, S1 or other SAR scenes



Waterline retrieval algorithm: preparation

- Input image
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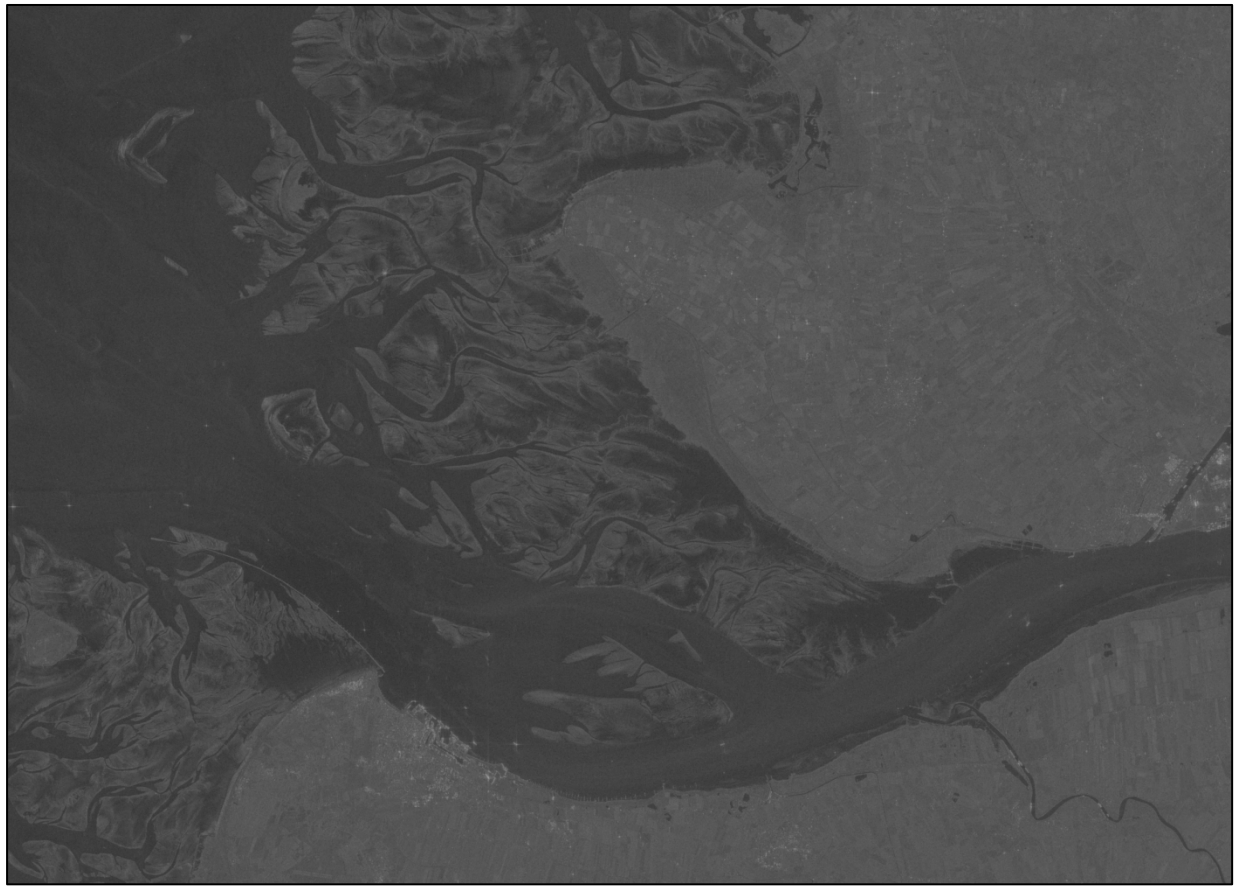
- Logarithmic scaling
  - Improves contrast in dark areas
  - Reduces contrast in bright areas



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- Median Smoothing
  - Removing noise
  - Preserving edges

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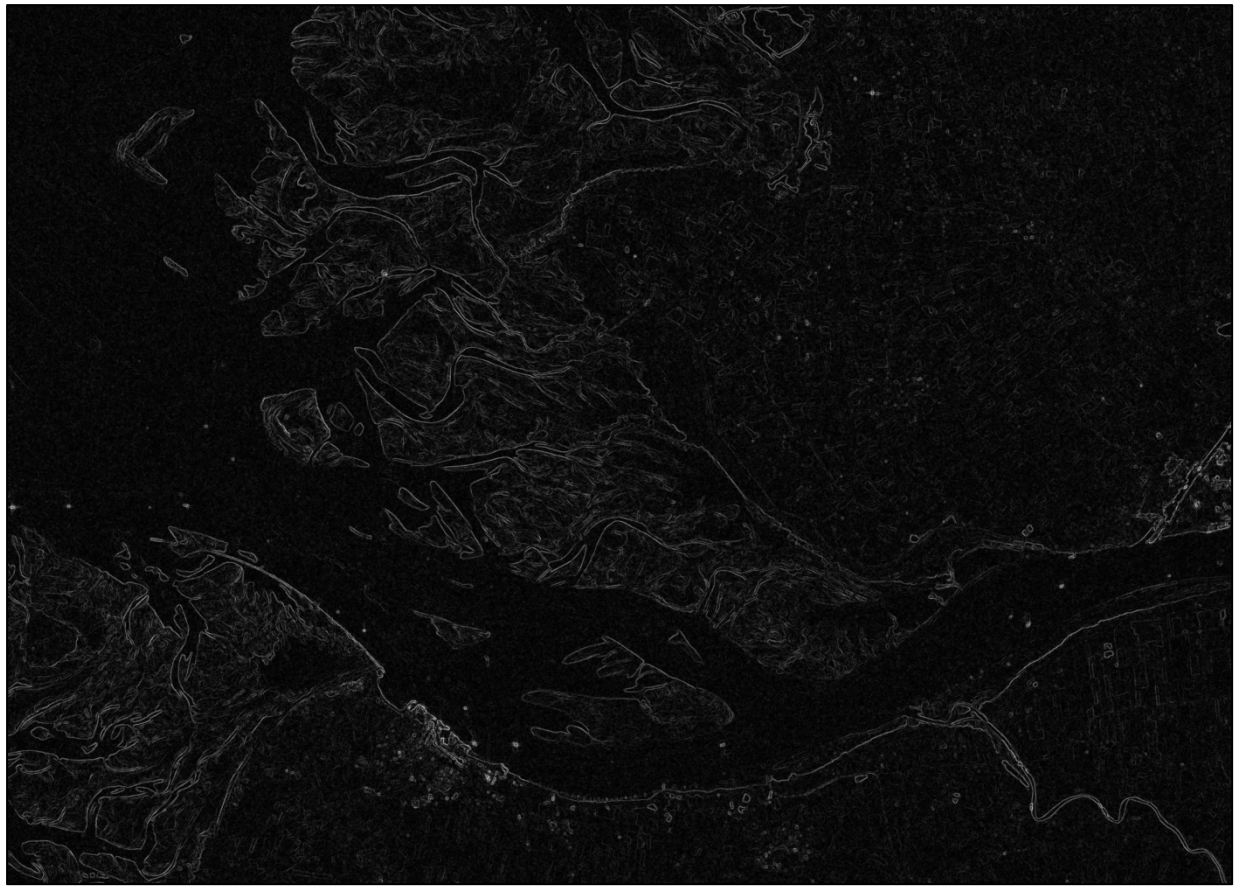
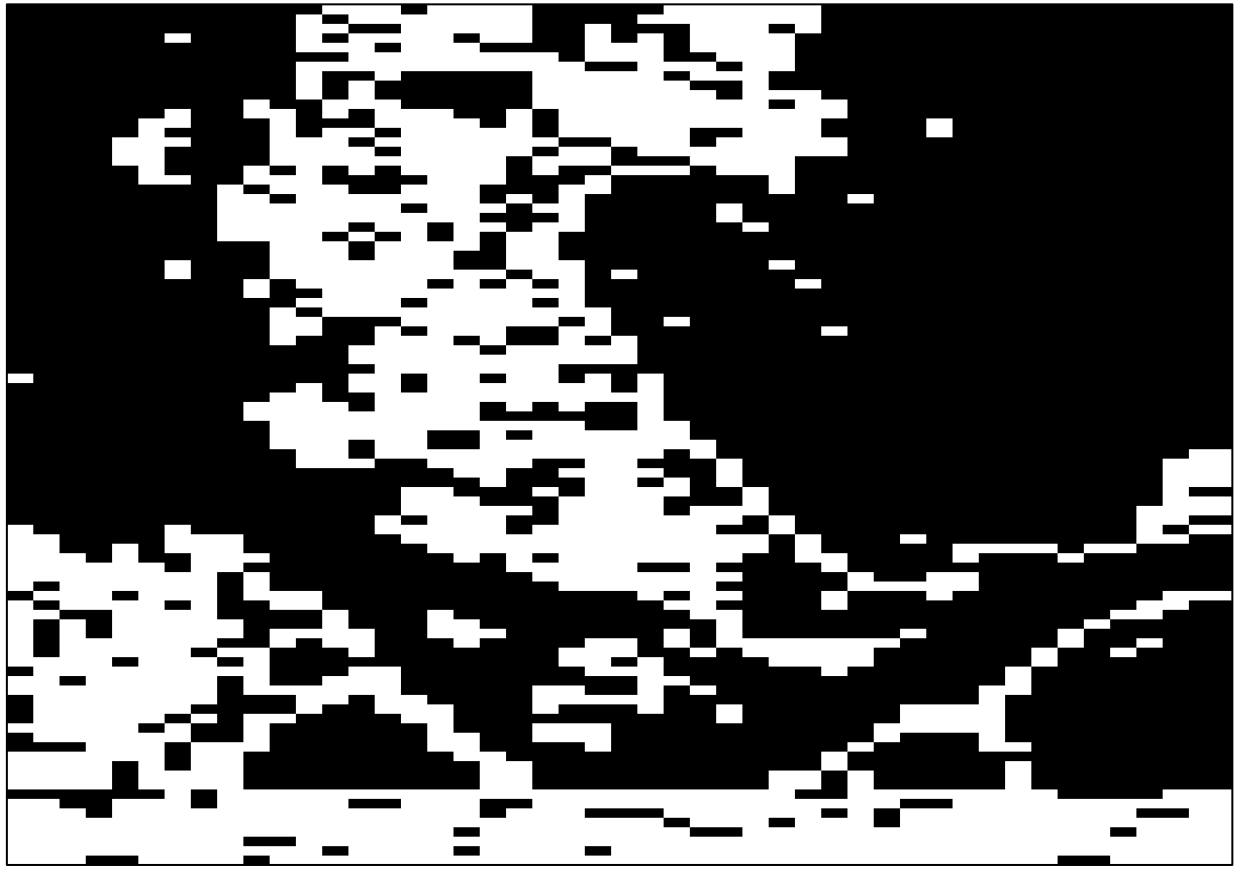


- Median Smoothing
  - Removing noise
  - Preserving edges
- Edge detection
  - 3x3 Sobel operator
  - Finds edges in all directions
  - Yields broad edges with varying intensities

Waterline retrieval algorithm: supporting landmasks

Edges landmask

- Sum edge strengths in small squares
- Threshold edge sums using Otsu‘s method
- Includes
  - Some mainland
  - Islands
  - Tidal flats
- Exludes
  - Some mainland
  - Water



Waterline retrieval algorithm: supporting landmasks

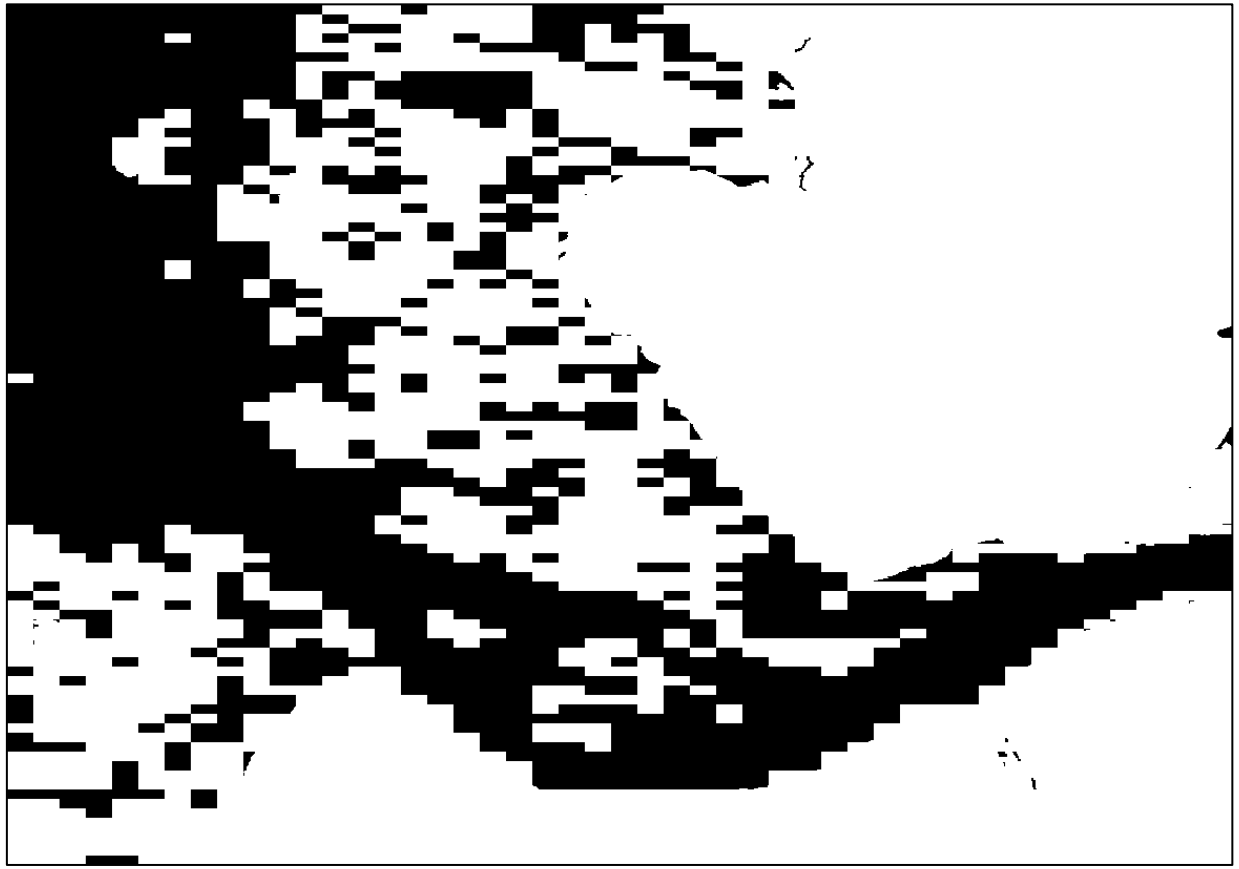
SWBD landmask

- Using Shuttle Radar topography (SRTM) Water Body Dataset (SWBD) (anno 2000)
- Includes
  - Mainlands
  - Islands
- Excludes
  - Water
  - Tidal flats
- Waterline position may be inaccurate

Waterline retrieval algorithm: supporting landmasks

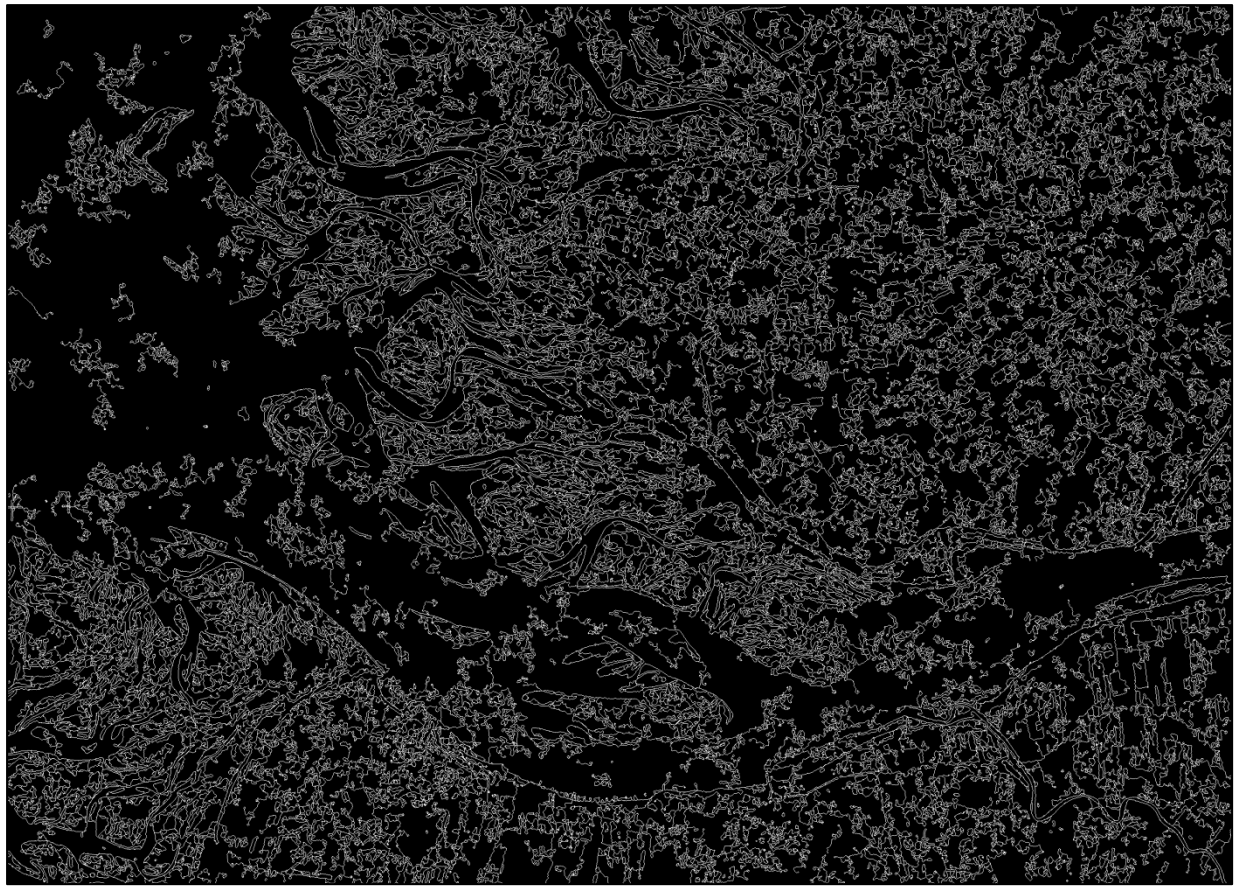
Added landmask

- Combination of edges and SWBD landmask
- Only edges landmask used if SWBD not available
- Includes
  - Mainland
  - Islands
  - Tidal flats
- Exludes
  - Water



Waterline retrieval algorithm: iterative part

- Edge drawing
  - Based on *Topal and Akinlar, 2012*
  - Upper threshold T_u: anchor points
  - Lower threshold T_l: valid edges



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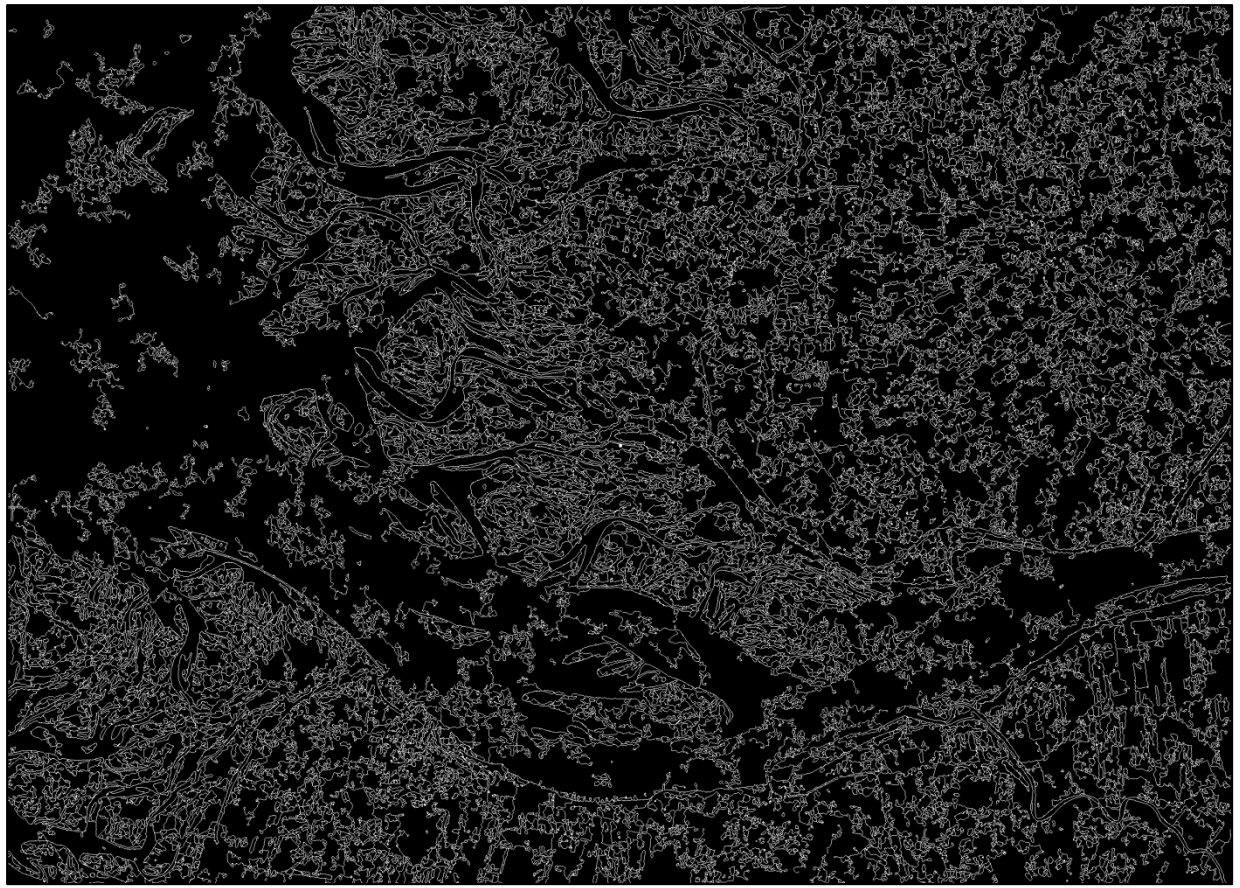
- Gap closing
  - Find single-ended lines
  - Search cone in previous direction
  - Connect closest boundary within maximum distance



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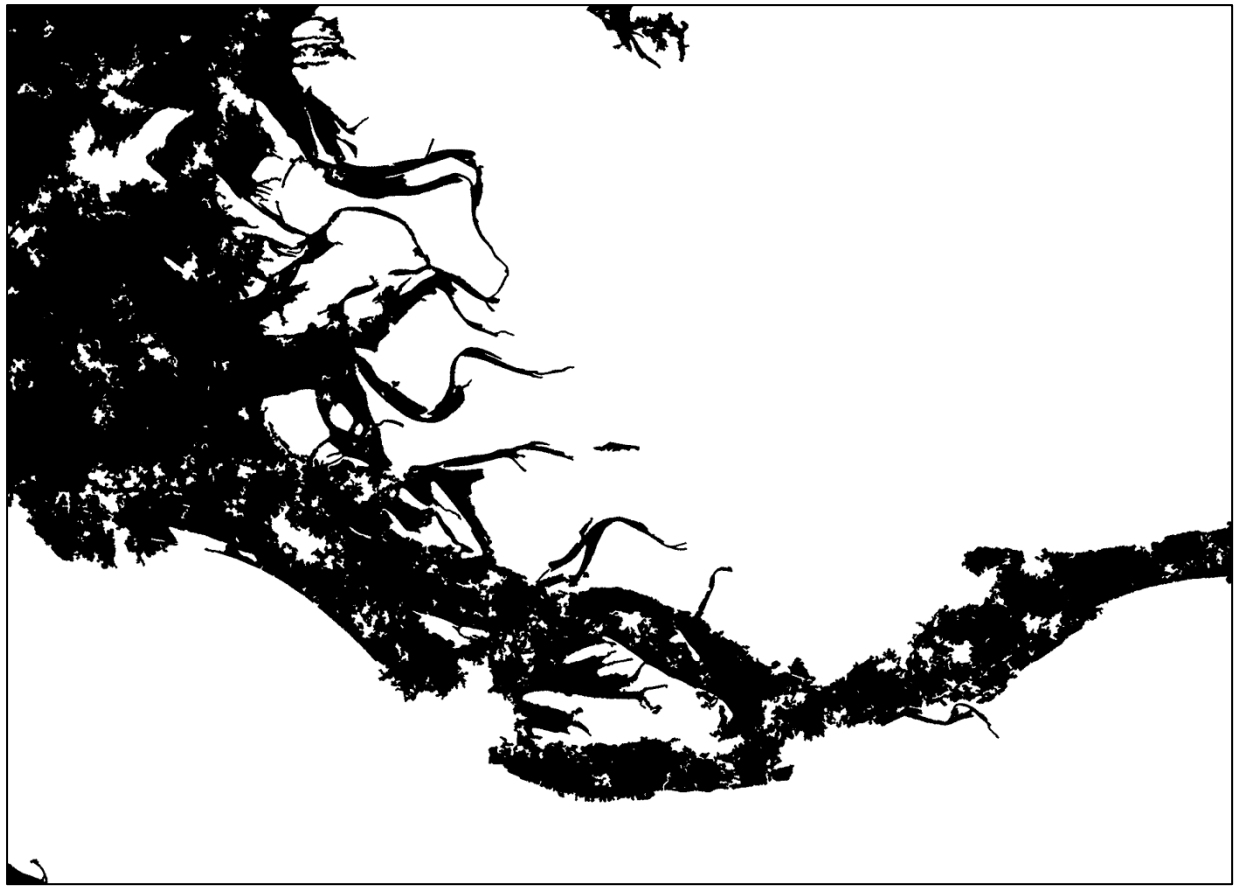

- Flood filling
  - Fills image until boundaries
  - Starting points from added landmask

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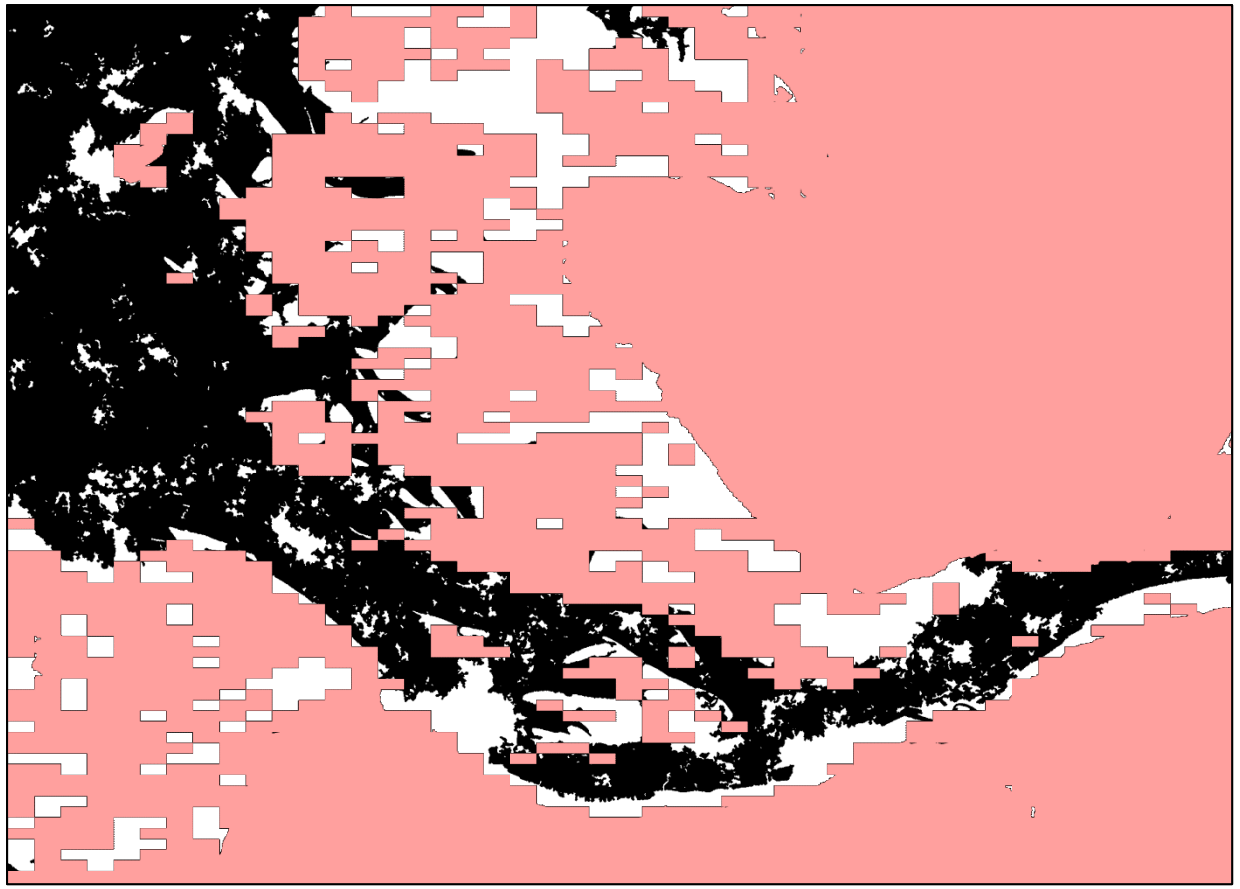

- Flood filling
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  - Starting points from added landmask
- Landmask comparison
  - Compare flood filling result to added landmask

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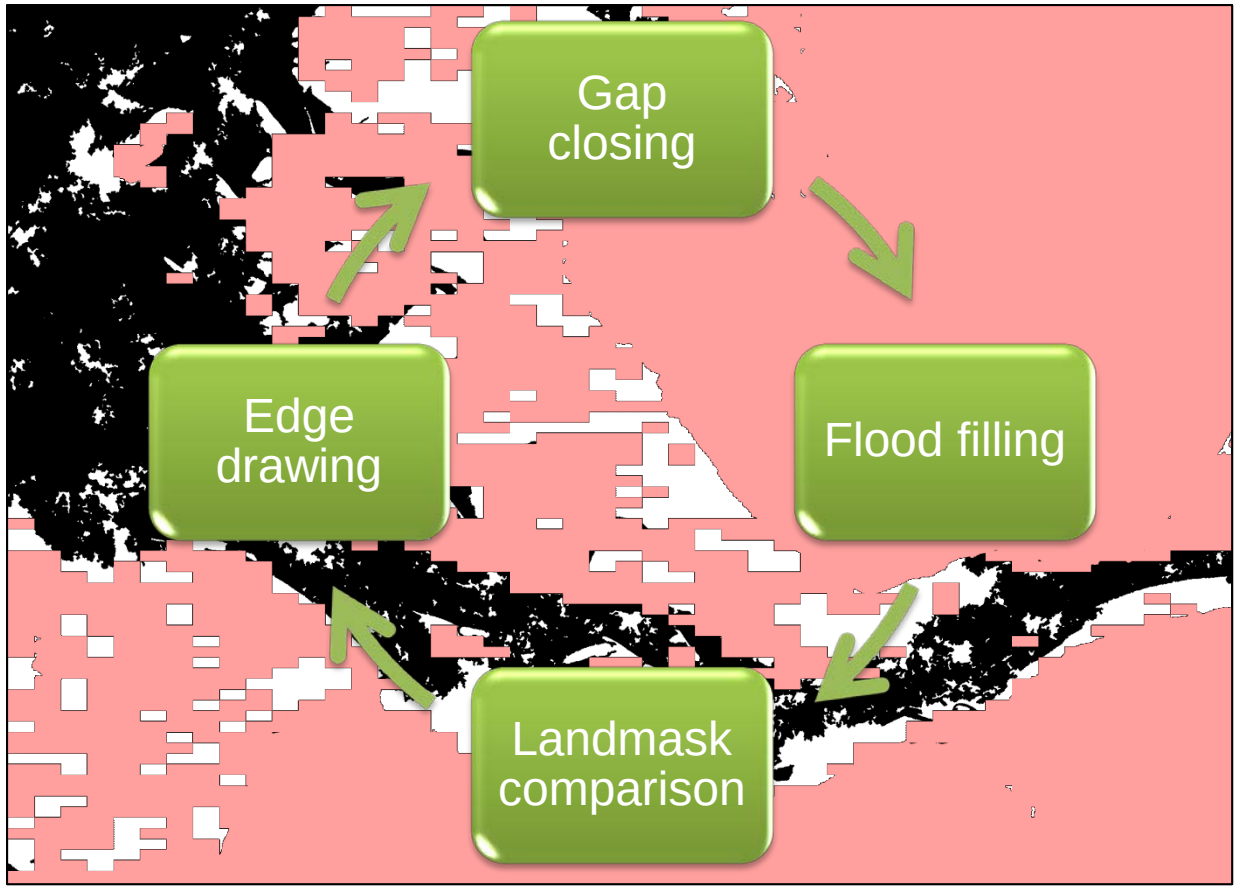

- Flood filling
  - Fills image until boundaries
  - Starting points from added landmask
- Landmask comparison
  - Compare flood filling result to added landmask
- Iteration
  - Adjust T_u, T_l
  - Choose best comparison score

Waterline retrieval algorithm: finalization phase

- Region testing
  - Test brightness difference between land and sea
  - If similar, land becomes water

Waterline retrieval algorithm: finalization phase

- Region testing
  - Test brightness difference between land and sea
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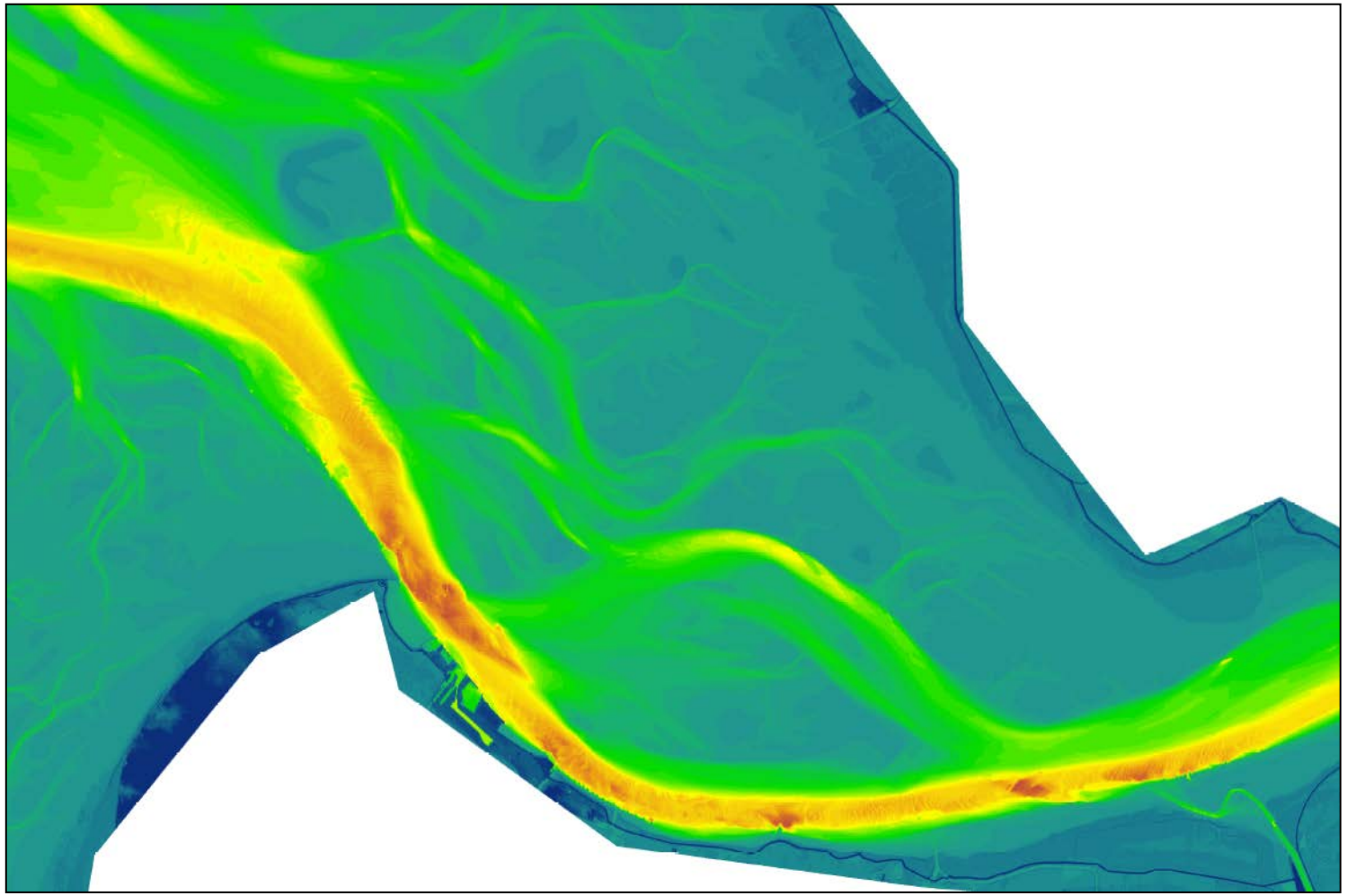
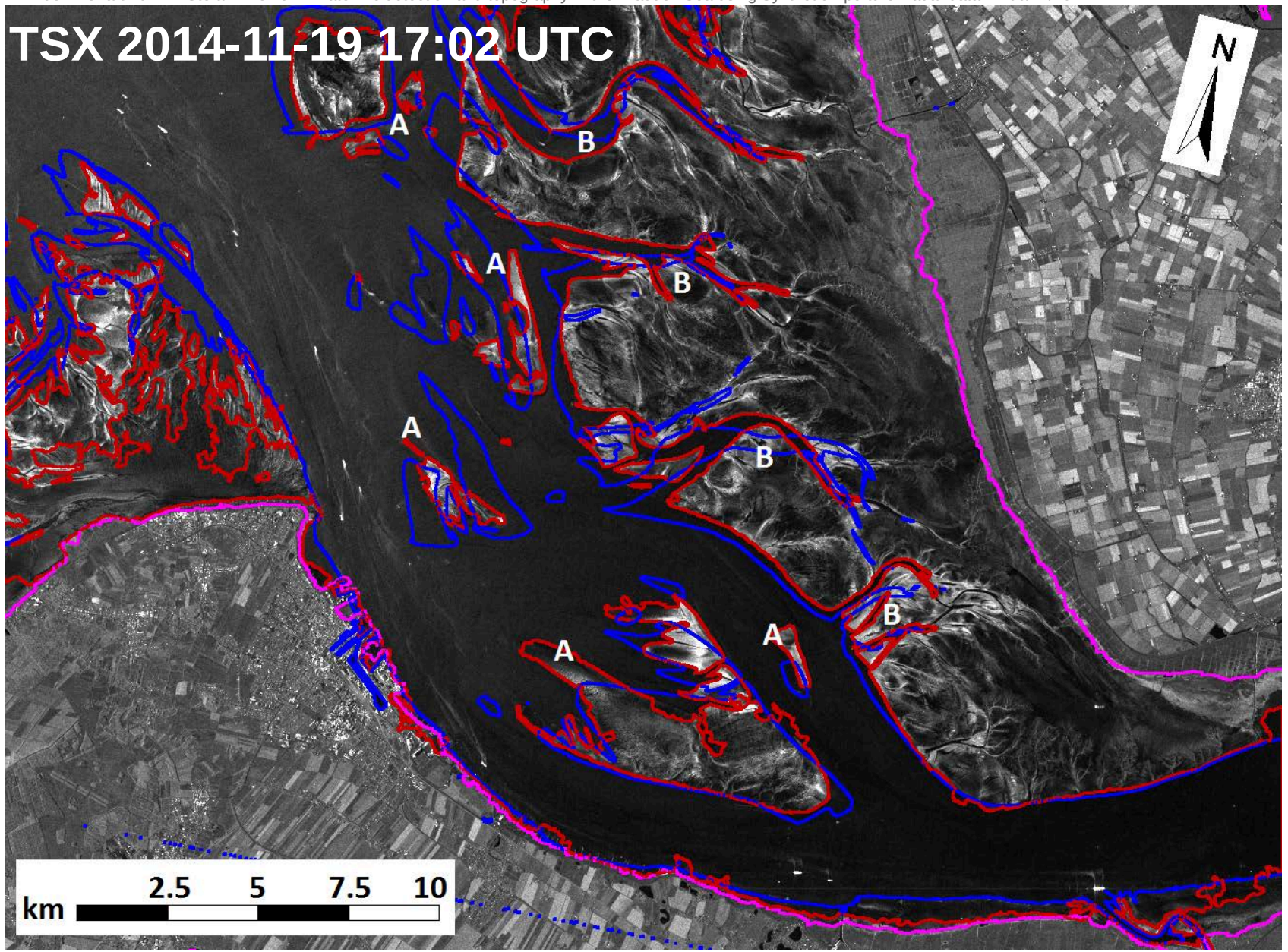
- Small islands removal
  - Islands below certain size become water
  - Removes small ships and buoys

Additional topography



- Provided by
  German Federal Waterways Engineering and Research Institute (BAW)
- Acquired in 2010
- 5x5m resolution
- Result of multi instrument in-situ campaign (echo sounding, airborne laser scanning, ….)
- Difficult to match tidal states, weather conditions, available flight times, …



Algorithm
NHN-2.06m / LAT (BAW, 2010)
SRTM SWBD (2000)

A: Changes in sand banks
B: Changes in tidal inlets

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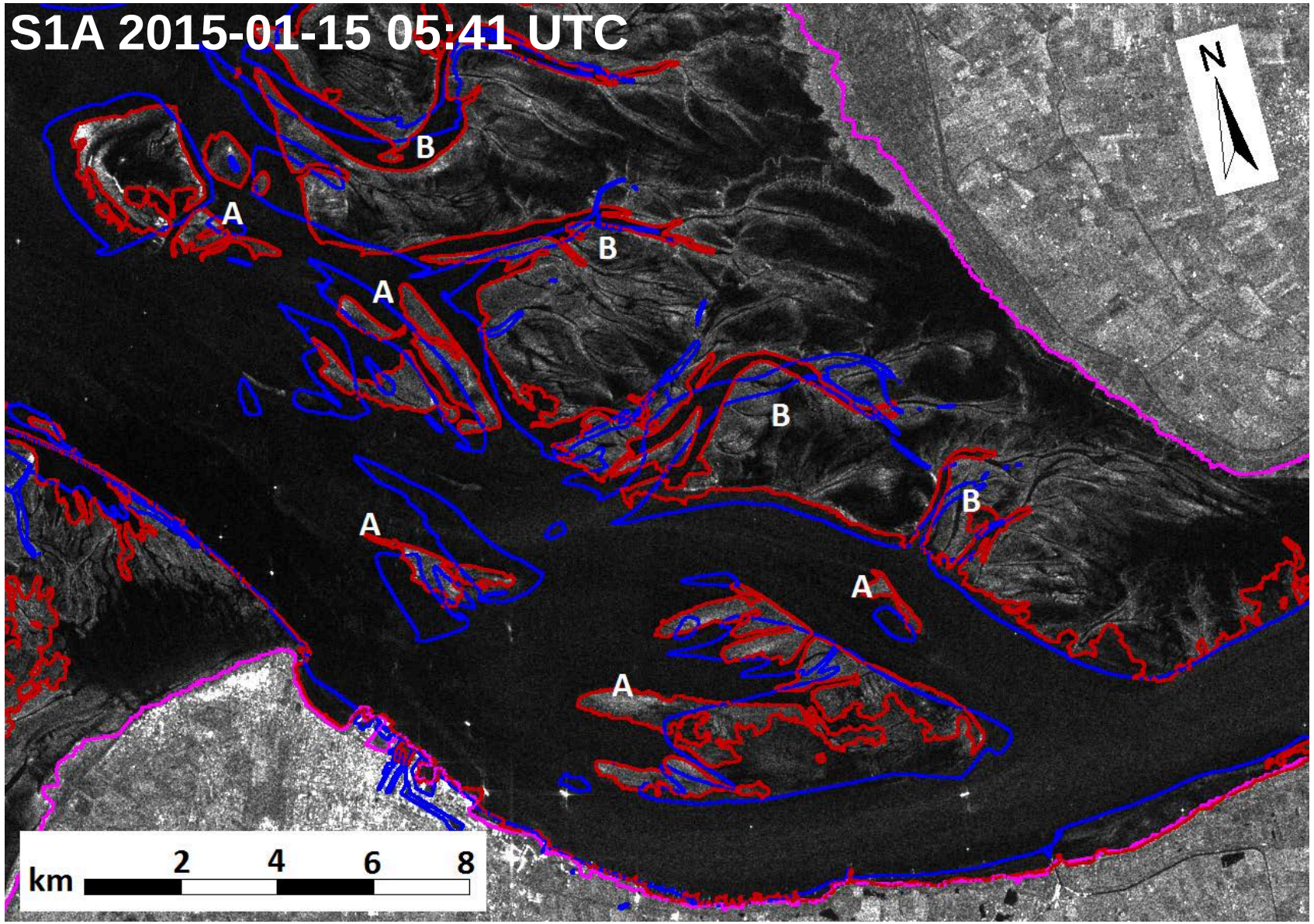

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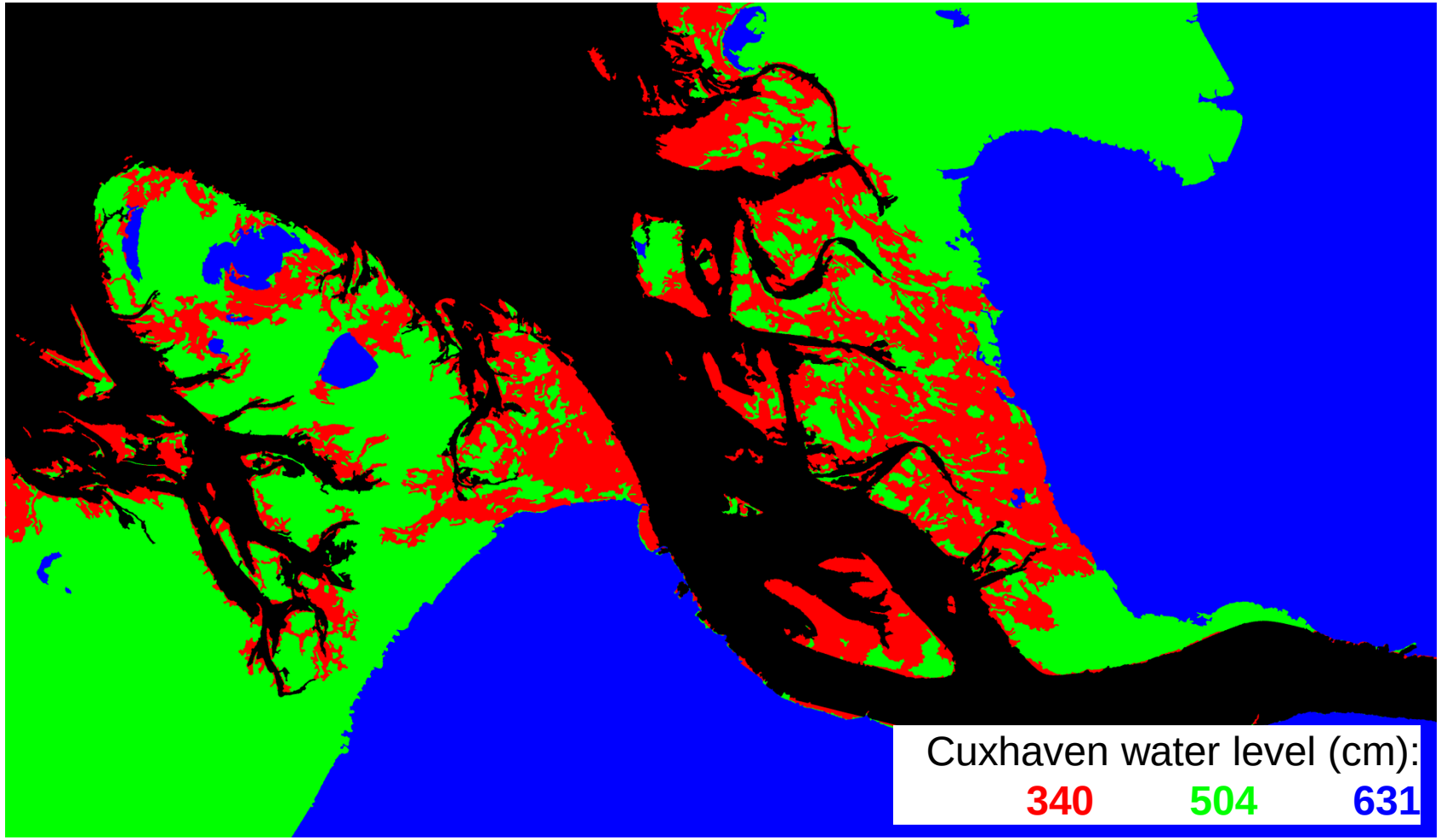
Combined landmasks for topography



- 3 Sentinel-1 scenes acquired at low (red), intermediate (green) and high (blue) tide
- All during ebb tide (decreasing water level) for comparability
- More scenes within short time now possible with Sentinel-1 A+B constellation
- Can be improved with waterlevel modelling to account for differences within area

Summary and outlook

- Waterline detection algorithm
  - Designed for tidal flats
  - Automatic operation envisaged
  - Runtime suitable for NRT
- Improving the algorithm
  - Error corrections
- Create topography from waterlines with combined data
  - TerraSAR-X (X-band)
  - Sentinel-1 (C-band)
  - Possibly others

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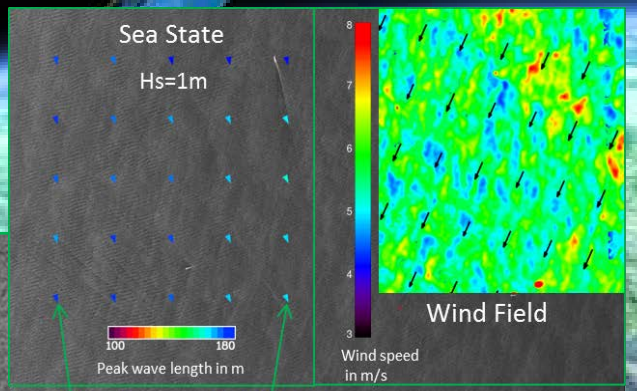
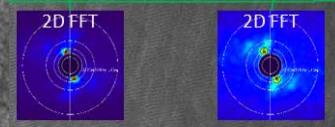
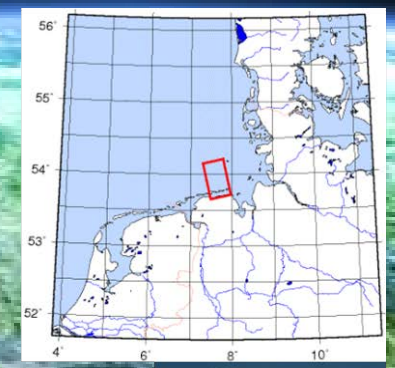
More from us on the EO Summit:

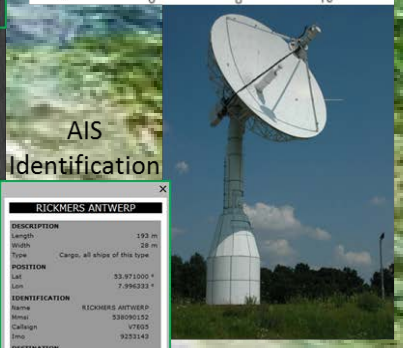
Thursday 09:10, Amphi: **Suman Singha**
Sea Ice Characterization Using Simulated Compact Polarimetric (RCM) and Compact Polarimetric (RISAT-1) SAR Data

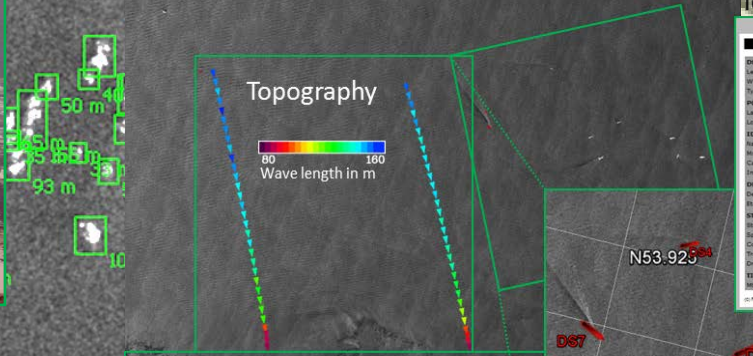
Thursday 14:10, SH-R810: **Anja Frost**
High Resolution Sea Ice Motion Estimation from C- and X-Band SAR Data Acquired During Antarctic Circumnavigation Expedition

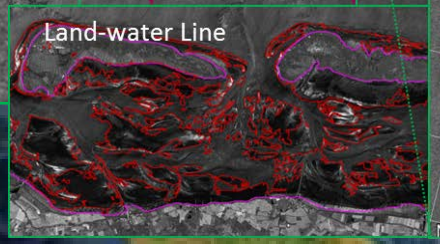


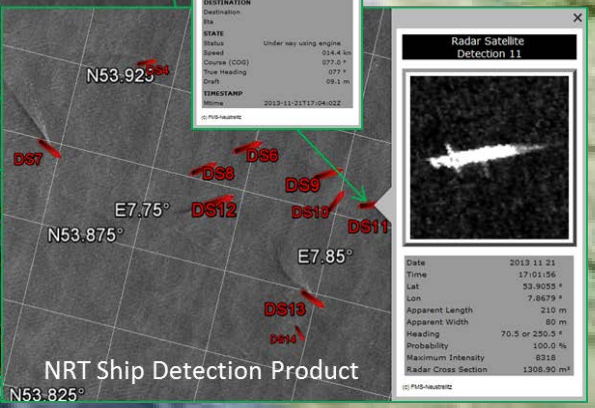












Thank you for your attention!

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