ILMATIETEEN LAITOS
METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE

Sea Ice SAR Segmentation and Drift Based on Edges

Juha Karvonen
juha.karvonen@fmi.fi
Finnish Meteorological Institute
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Outline

Background

- RADARSAT-2 ScanSAR Wide mode dual-polarized (HH/HV) data used in operational sea ice monitoring at FMI.
- Automated algorithms for estimating ice parameters based on SAR data have been developed (ice conentration, ice thickness, ice drift, ice type).
- SAR segmentation is necessary for computing ice parameters, such as ice thickness, ice concentration, etc.
- Preferrably SAR segments should present homogeneous natural areas of the target area. For sea ice these are e.g. ice floes of different ice types.
- For example ice floe size distribution and ice drift are important ice parameters, and possible to estimate from SAR imagery, at least visually.
- Automated estimation of these parameters from SAR imagery may be problematic.

Background

- Ice floe distribution:
  - Connected ice floes.
  - Floes with size smaller than SAR resolution.
- Ice drift:
  - Cross-Correlation (CC) based methods are unable to capture drift if ice has deformed (changed) much and CC's become low.
  - If rotation of sea ice has occured between the two time instants, CC search over rotated search space is required, this is very time consuming.
- Here some solutions are suggested to deal with these problems.

SAR Preprocessing

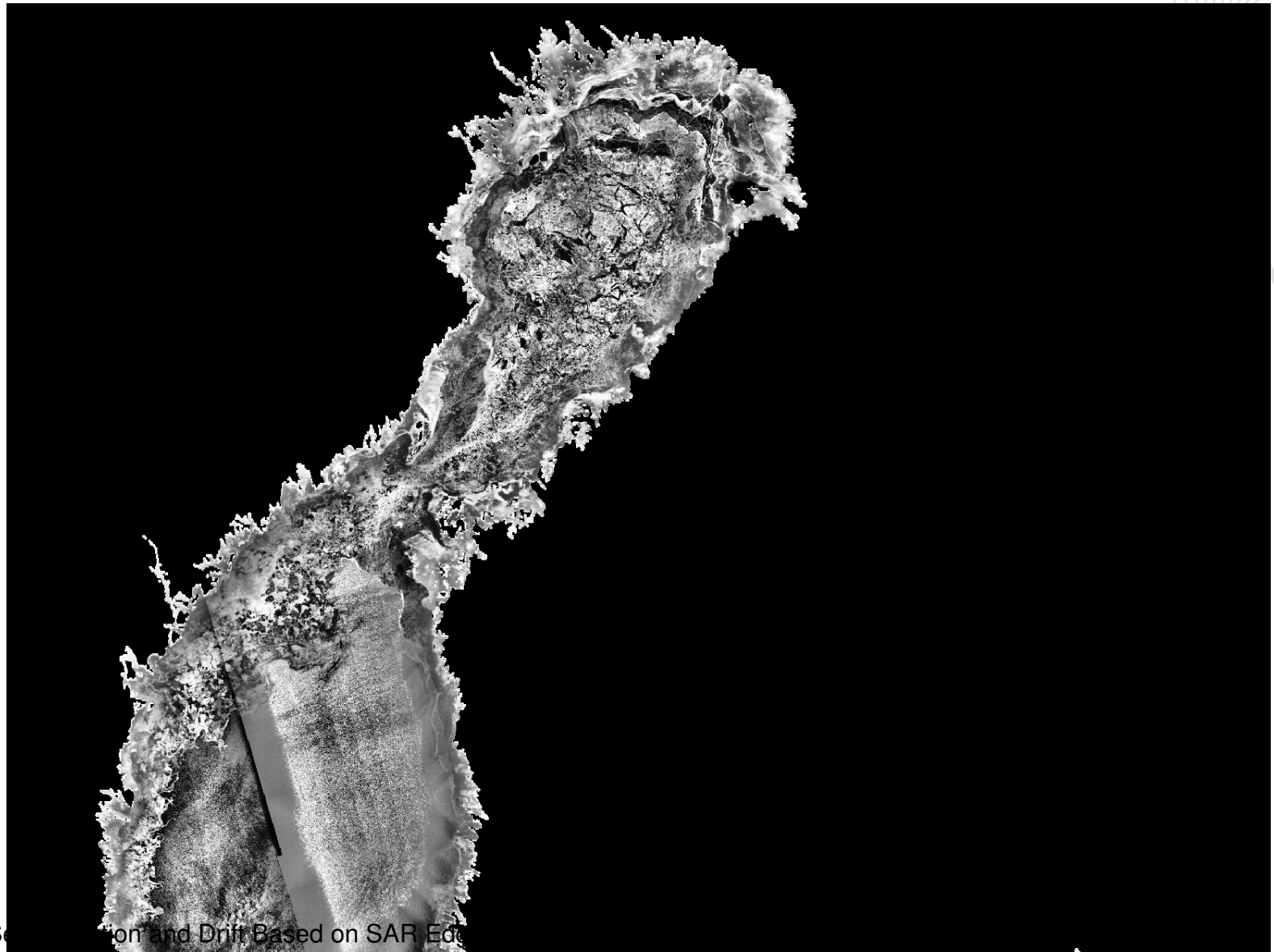
- Calibration
- Rectification to a map projection: Mercator, in the Arctic areas polar stereographic.
- Incidence angle correction, linear correction for HH band, nonlinear correction for HV band.
- Mosaicking, daily SAR mosaics over Baltic Sea.
- Windowed and smoothed PCA image to capture the variations of both the SAR channels.
- In ice drift detection preserving of local similarity is necessary $\rightarrow$ adaptive histogram equalization (AHE).

Segmentation

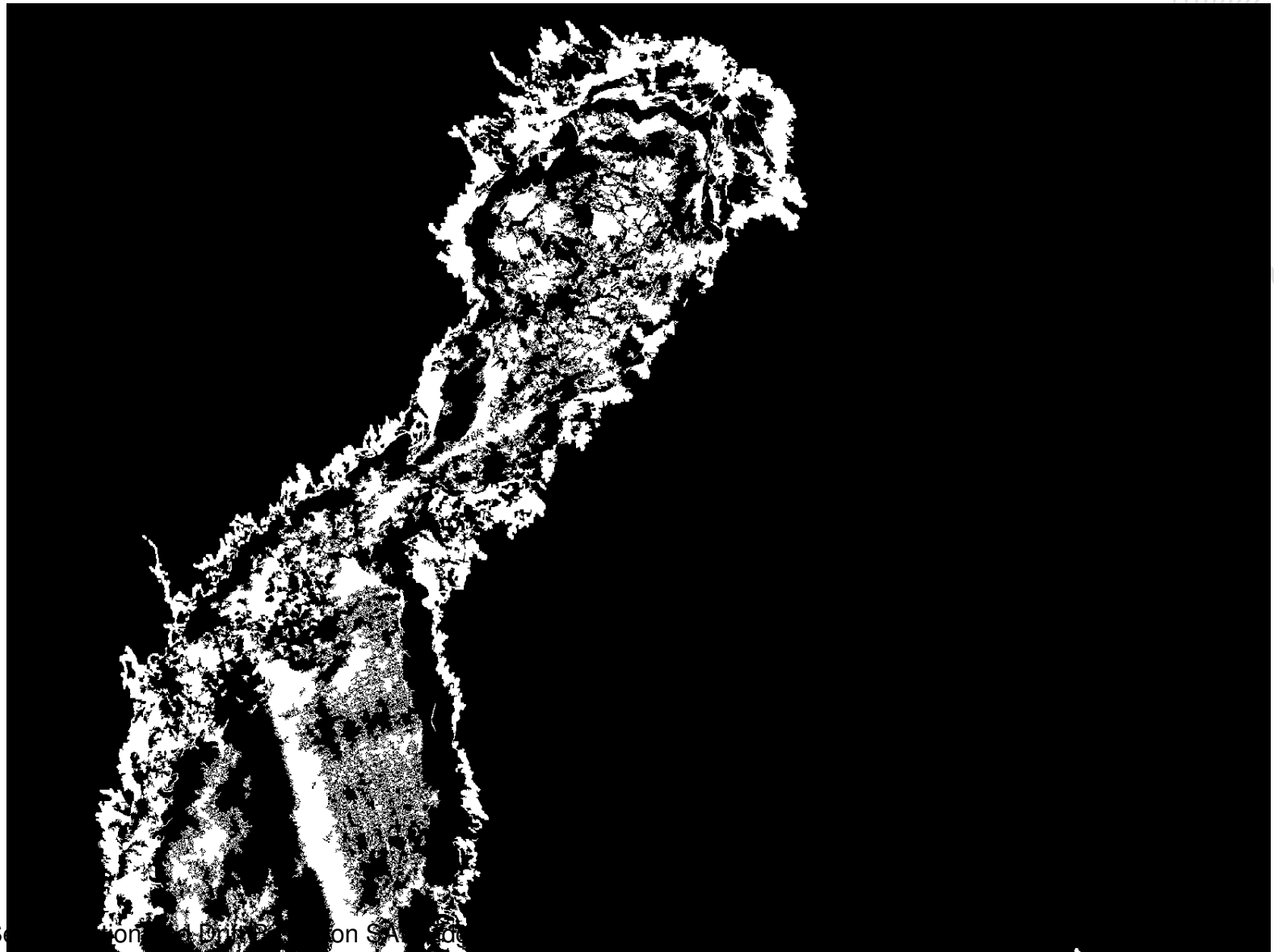
- Otsu thresholding of the AHE images $\rightarrow$ binary image.
- Removing of very small (e.g. < 20 pixels) dark and bright segments.
- Segment edges of the binary image $\rightarrow$ edge image.
- Edge thinning (e.g. Hilditch).
- Watershed Transform (WST) Principle:
  1. For each image pixel compute the distance to the (closest) edge. Scale such that Dmax=1.
  2. Invert the scaled distance values: D' = 1-D.
  3. Fill starting from the local minima $\rightarrow$ Segmentation.
- A preliminary estimation for ice floe size distribution.
- The truth of floe size distribution is somewhere between the result given by a conventtional (e.g. MRF) segmentation and WST segmentation. A mapping is required, but this will require in-situ data (visual interpretation of high-resolution imagery).
- Extrapolation to smaller floe sizes below SAR resolution?

SAR mosaic, Feb 25, 2013.

AHE applied to SAR mosaic, Feb 25, 2013.



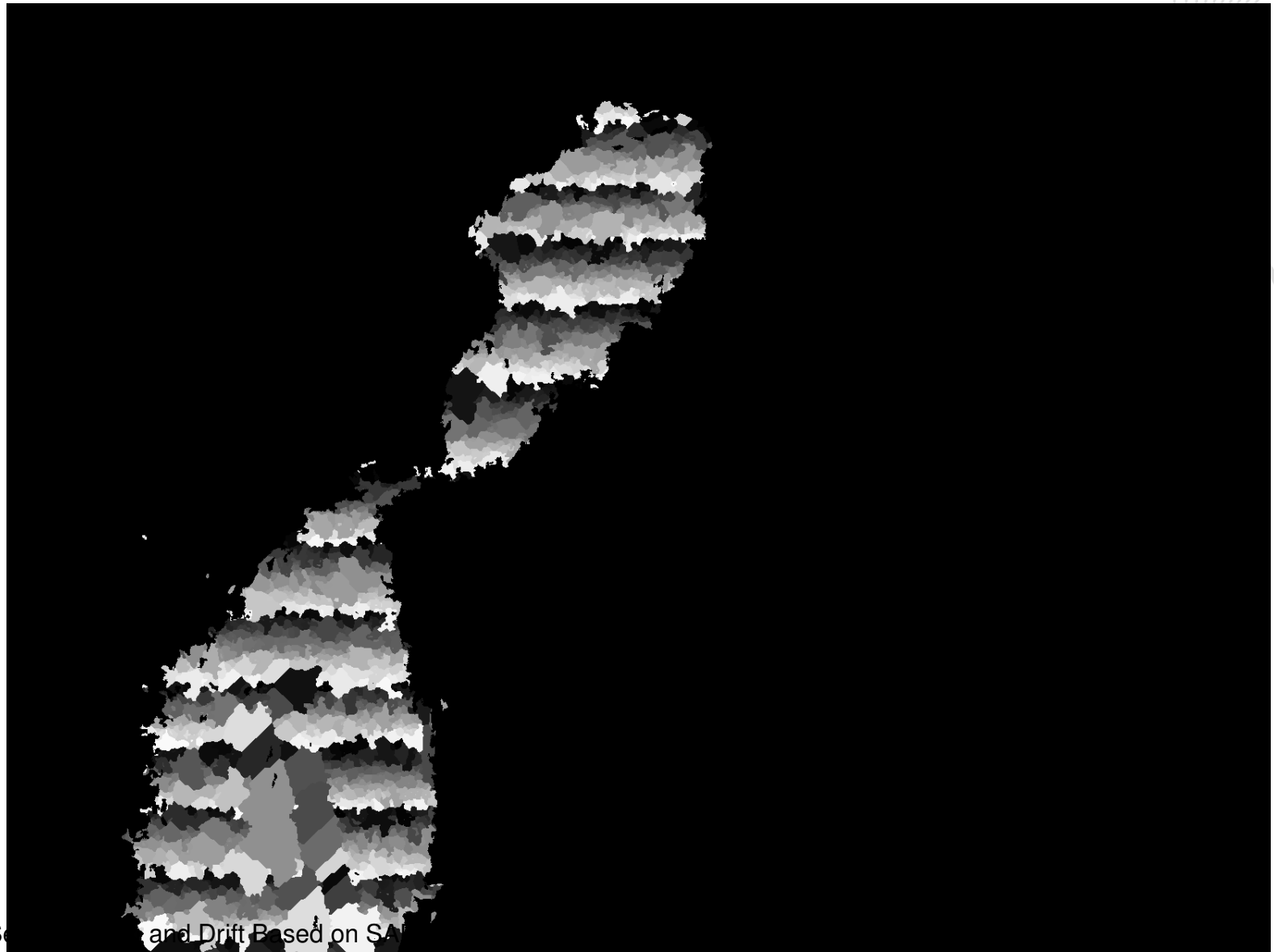
Otsu thresholding, Feb 25, 2013.



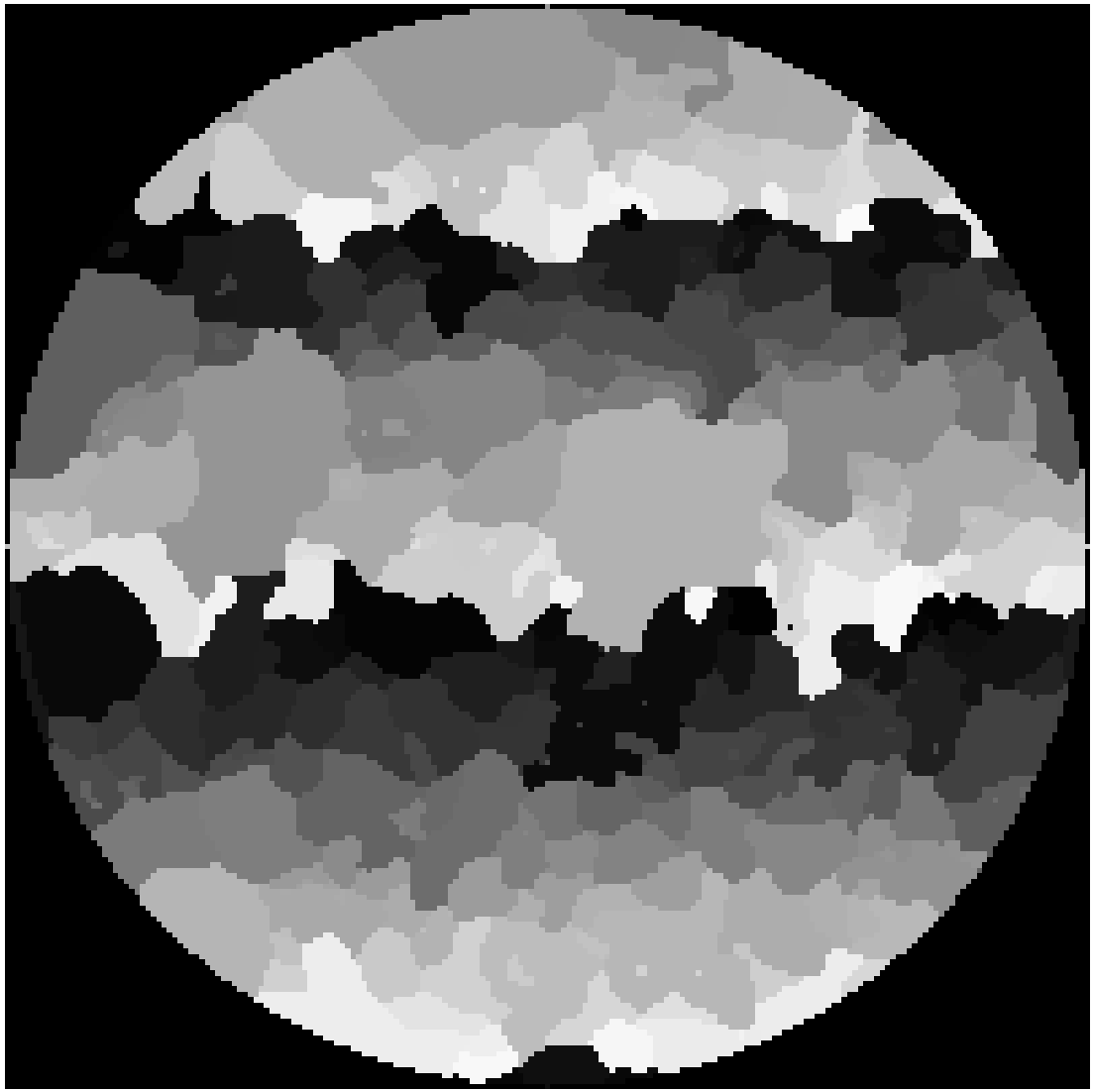
Edge image, Feb 25, 2013.

Edge thinning, Feb 25, 2013.

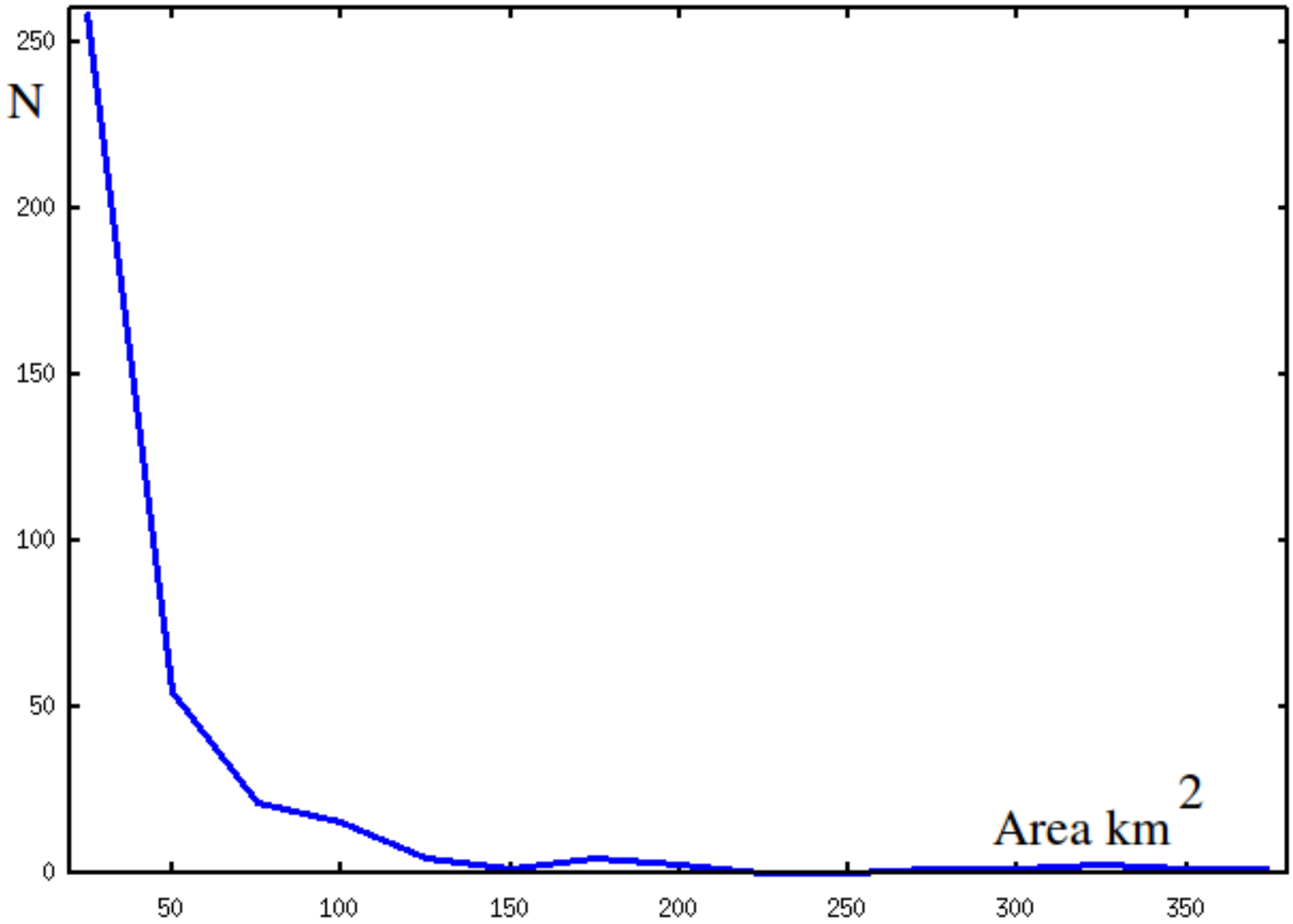
WST segmentation, Feb 25, 2013.



WST segmentation detail (R=50km), Feb 25, 2013.



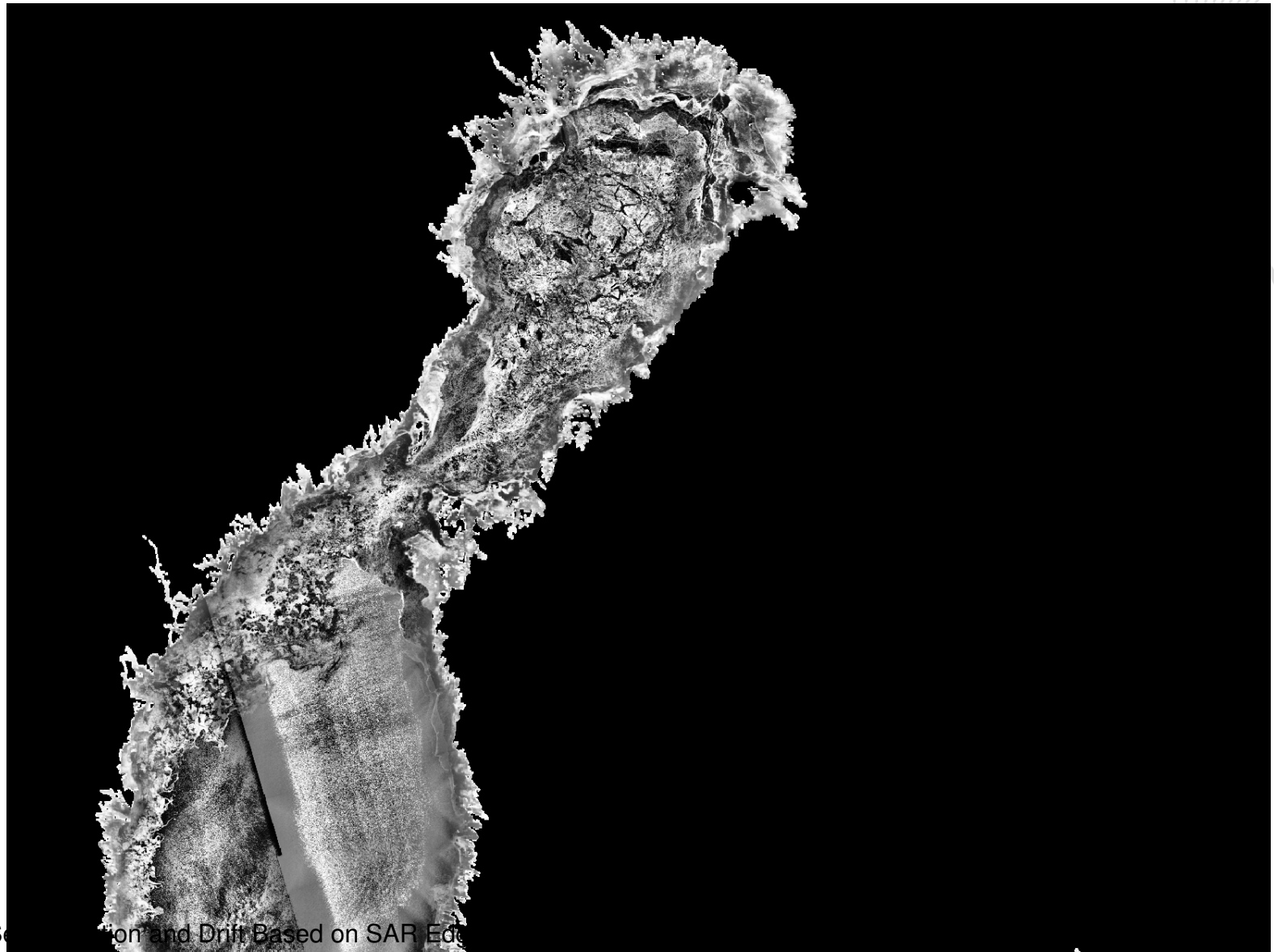
Estimated segment size distribution over the detail area.



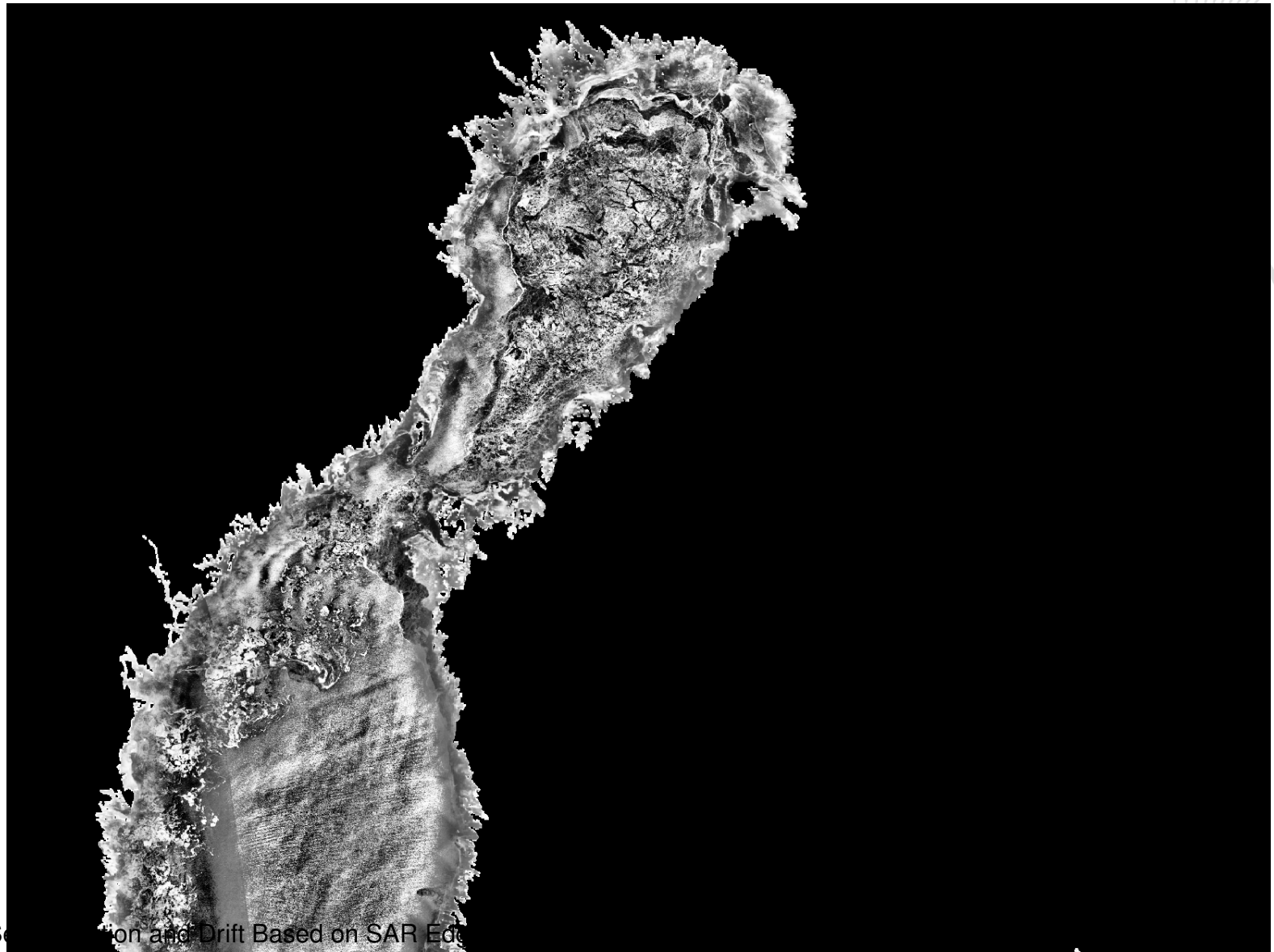
Ice Drift Estimation

- Based on comparison of small edge segments of the edge image.
- Round-shaped windows with a given radius R.
- Rotationally invariant features are computed for each window.
- Features: relative number of edge points as function of the distance from the window centre-pixel, aspect ratio, center of mass distance from the centre-pixel.
- Comparison for feature vectors of the second image (mosaic) within a given radius R_g.
- Comparison by Euclidean distance. Minimum distance corresponds to the best single estimate.
- Weighted vector median filtering (WVMF) to get the final ice drift estimates. With small R (e.g. R=3) a large number of vectors should be included to get reliable estimates.

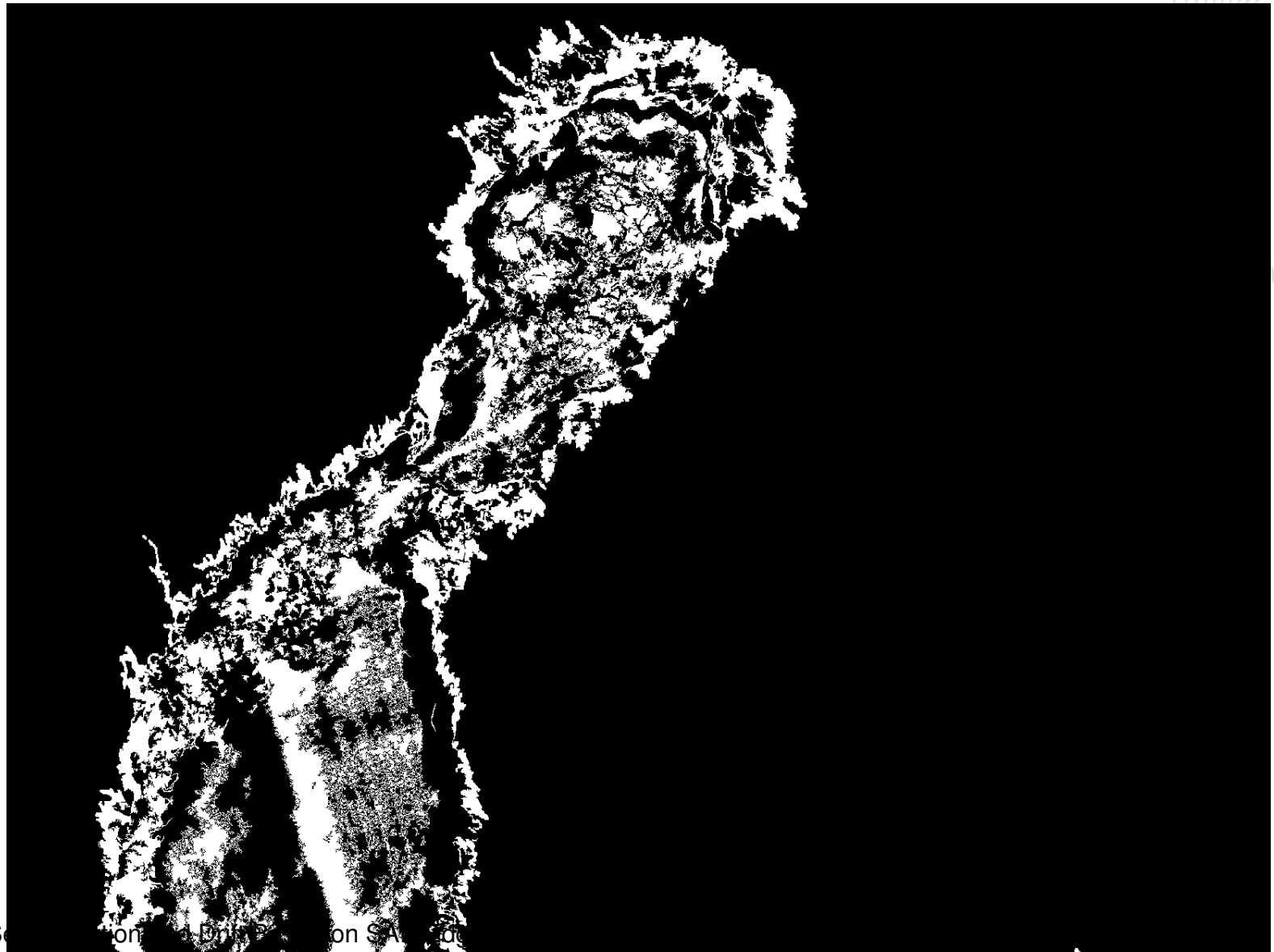
AHE applied to SAR mosaic, Feb 25, 2013.



AHE applied to SAR mosaic, Feb 26, 2013.



Otsu thresholding of SAR mosaic, Feb 25, 2013.

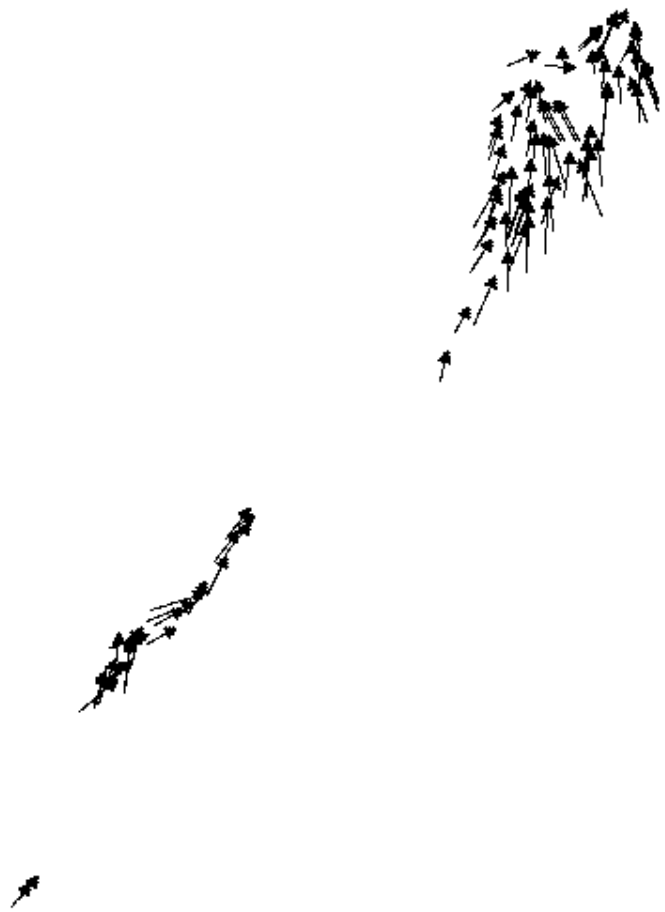


Otsu thresholding of SAR mosaic, Feb 26, 2013.

Edge image of the thresholded Feb 25 mosaic.

Edge image of the thresholded Feb 26 mosaic.

First result of the ice drift estimation.



Conclusions

- According to our studies edge information can be used for estimation of ice drift, ice floes, ice deformation, and even ice concentration.
- Work still much under construction. A lot of tuning is still required before operational utilization of the methodology.
- Suitable parametrization for ice drift estimation will require testing.
- Feature-based ice drift estimation more robust than cross-correlation based methods, should be used as complementary method with the CC approach.
- Floe size distribution estimates biased due to WST. A mapping to correct this required.
- Is it possible to extrapolate the floe size distribution to the sizes below SAR resolution?

ILMATIETEEN LAITOS
METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE

Ilmatieteen laitos
Erik Palménin aukio 1
FI-00560 Helsinki
PL 503, FI-00101 Helsinki
puh. 029 539 1000

» www.fmi.fi

Meteorologiska institutet
Erik Palméns plats 1
FI-00560 Helsingfors
PB 503, FI-00101 Helsingfors
tel. 029 539 1000

» Twitter: @meteorologit, @IlmaTiede

Finnish Meteorological Institute
Erik Palménin aukio 1
FI-00560 Helsinki
P.O.Box 503, FI-00101 Helsinki
tel. +358 29 539 1000

» Facebook: FMIBeta