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EOS NETWORK

Monitoring of sea ice drift and deformation with SAR satellite data of different resolution

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Abstract

Sea ice drift and deformation fields were obtained from sequences of synthetic aperture radar images using a method based on pattern recognition. The error induced by the method is estimated and differences between motion fields extracted from images of different spatial resolution are discussed. Preliminary results for the calculation of deformation fields based on the calculated shift information are presented. Envisat ASAR "Image Mode" (IM) and "Wide Swath" (WS) data acquired in 2006 in the Weddell Sea were employed for this study. Preliminary results for the calculation of deformation measures are presented.

Motivation

• Sea Ice is subject to constant change. Its drift and deformation are influenced by forces from wind and ocean currents, by obstacles such as islands and coastlines, and by its properties such as ice thickness and roughness.

• In order to increase the spatial and temporal coverage as well as study details of drift and deformation in key regions it is necessary to use satellite images of different spatial resolution and swath widths and to quantify the differences in the estimated drift.

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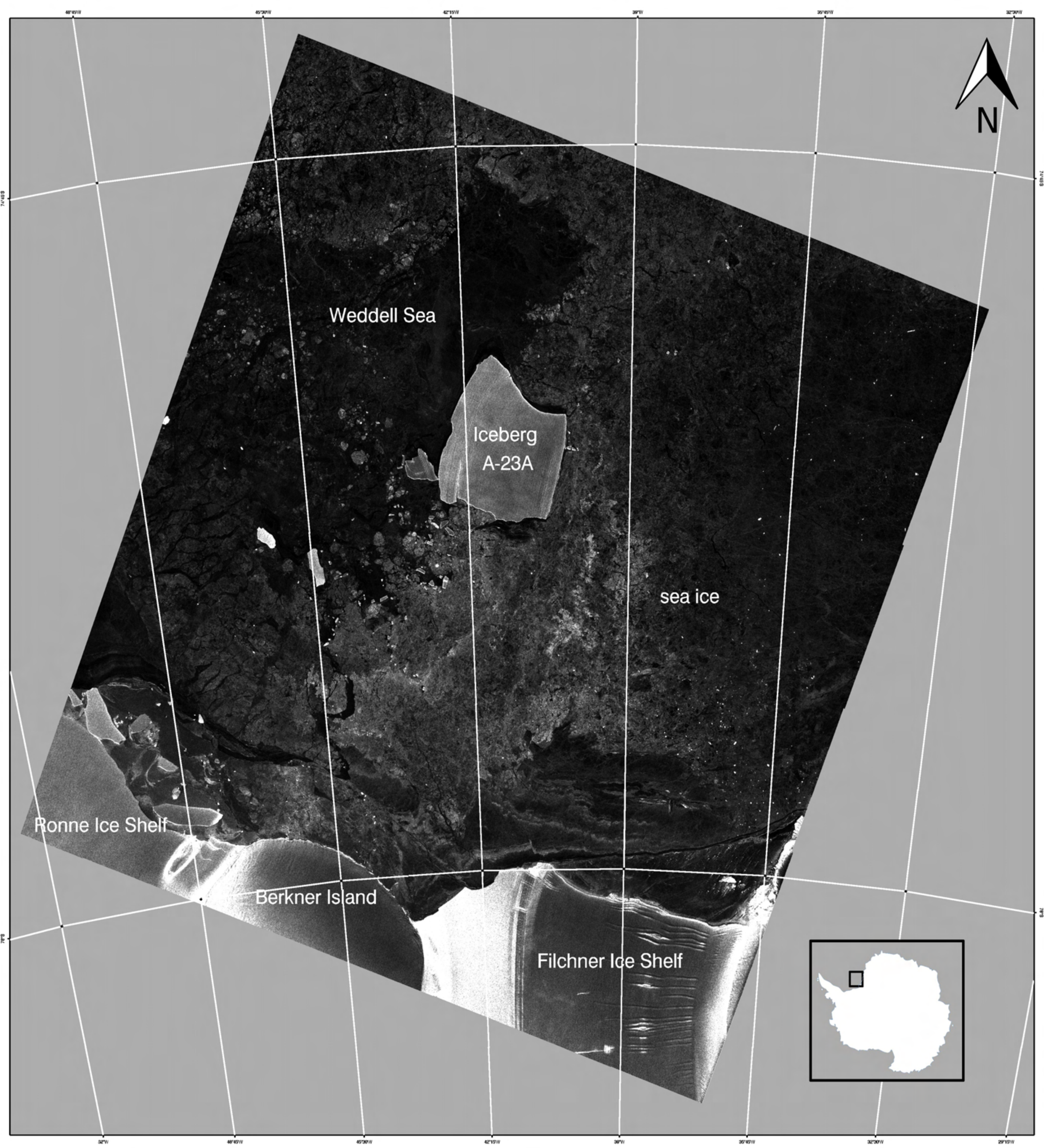
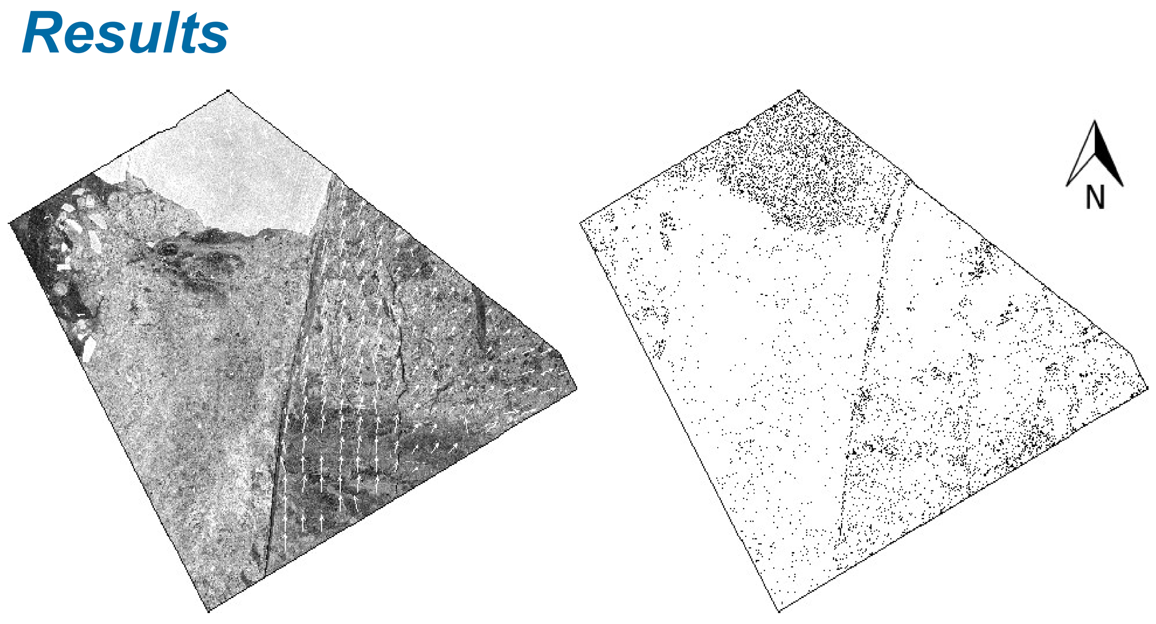


Figure 1: Envisat ASAR WS scene fromthe south eastern Weddell Sea (22. June 2006) close to the grounded Iceberg A-23A north of Berkner Island.

• The drift is estimated employing a correlation based sea ice motion tracking algorithm outlined by Thomas (2008).

• To assess the reliability of the implemented method, the introduced error is calculated based on a comparison with manually collected reference drift data.

Results



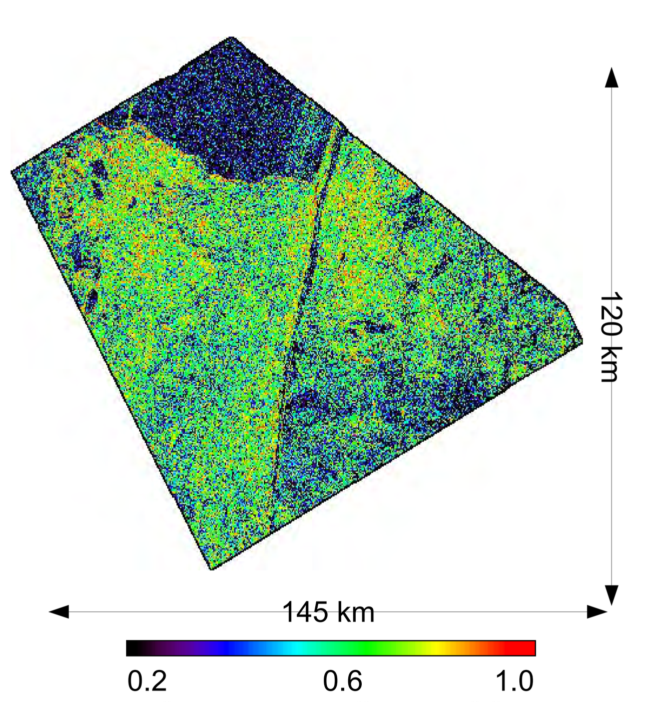


Figure 2: Drift vector field extracted from the August IM data pair, corresponding drift gap map, and correlation map. The time gap is 1 day. The "gap map" shows resolution cells where the algorithm failed to estimate a drift vector. The comparison between image and gap map reveals that drift estimation failures are often correlated with low contrast regions, icebergs and discontinuous regions.
This observation is supported by the presented correlation map, showing the respective correlation coefficient for each resolution cell.

Data and Processing

Table 1: Overview of data sets used for the estimation of sea ice motion vector fields. The test site is located south of the ground Iceberg A23-A close to Berkner Island in the Weddell Sea. To reduce the influence of speckle the data were re-sampled to 25 x 25 m for IM data and 150 x 150 m for WS data, respectively.

	January	June	August	JuneWS	AugustWS
Acquisition date	28.01.2006 29.01.2006	17.06.2006 23.06.2006	26.08.2006 27.08.2006	16.06.2006 20.06.2006 22.06.2006	25.08.2006 29.08.2006
Mode	Image	Image	Image	Wide Swath	Wide Swath
Resolution [m]	25	25	25	150	150
Dimensions [px]	5520 x 6263	6206 x 6163	6141 x 6089	1036 x 1029	1025 x 1016
Resolution cells	512 x 512	512 x 512	512 x 512	128 x 128	128 x 128
Shift resolution [m]	300	300	300	1200	1200
Number of collected reference shift vectors	135	Ref1: 150 Ref2: 150	151	---	---

Table 2: Error statistics of Image Mode based Motion vector fields. The calculated differences between reference drift and calculated drift are fitted to a Student's t-distribution.

	28./29.01	17./23.06.	26./27.08.06		16./20.06	16./22.06		20./22.06		25./29.06
			horizontal	vertical		horizontal	vertical	horizontal	vertical	
Sample size	270	594	149	149	286	159	159	163	163	324
$Error_{99\%}$ [px]	± 11.57	± 4.69	± 4.48	± 4.81	± 3.65	± 4.02	± 3.09	± 2.71	± 3.07	± 3.07
RMSE [px]	3.07	1.74	1.47	1.46	1.22	1.56	1.20	1.03	1.18	1.01
MAE [px]	1.84	1.19	0.98	0.98	0.91	1.07	0.84	0.82	0.90	0.75
Season	Summer	Winter	Winter		Winter	Winter		Winter		Winter
Mode	IM	IM	IM		WS	WS		WS		WS

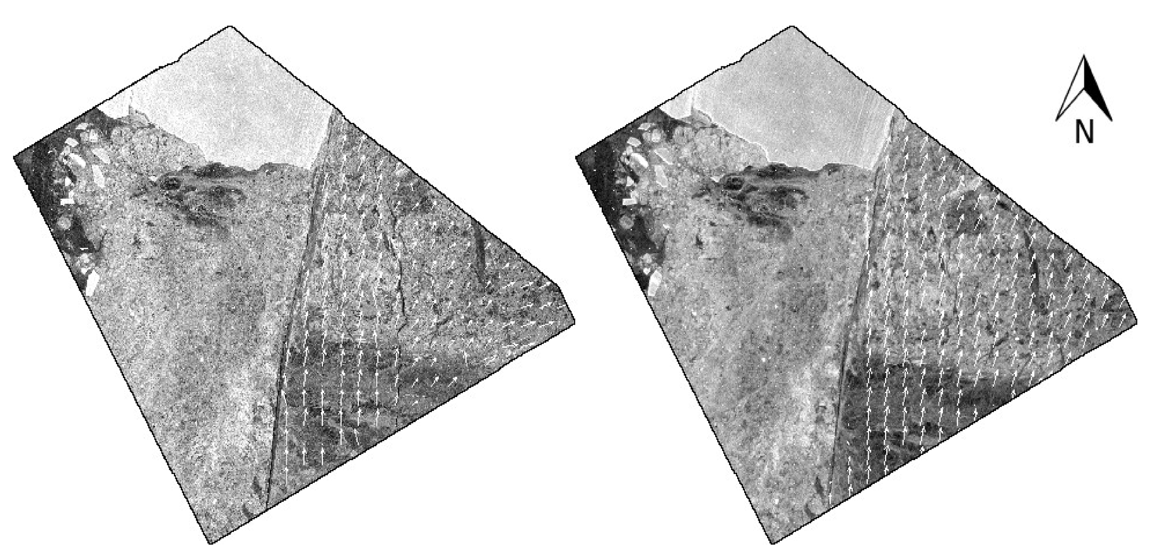


Figure 3: August IM drift vector field (left) and August WS vector field (right). Both vector fields compare well. The mean absolute difference between the re-sampled IM drift vector field and the WS vector field is about 123 m (< 1px) in horizontal direction and about 420 m (<2.8 px) in vertical direction.

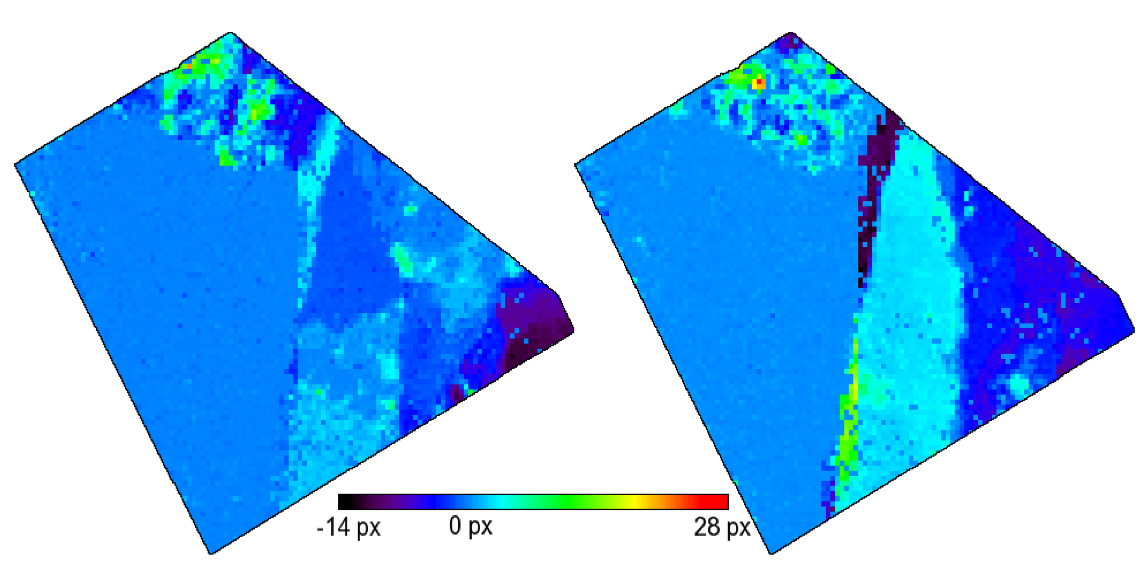


Figure 4: Horizontal drift difference (left) and and vertical drift difference (right). The figure shows the differences between the resampled IM based drift field and its corresponding WS scene. Clear differences between both drift fields can be recognised that are mainly related to the influence of iceberg A23-A and the different spatial resolutions..

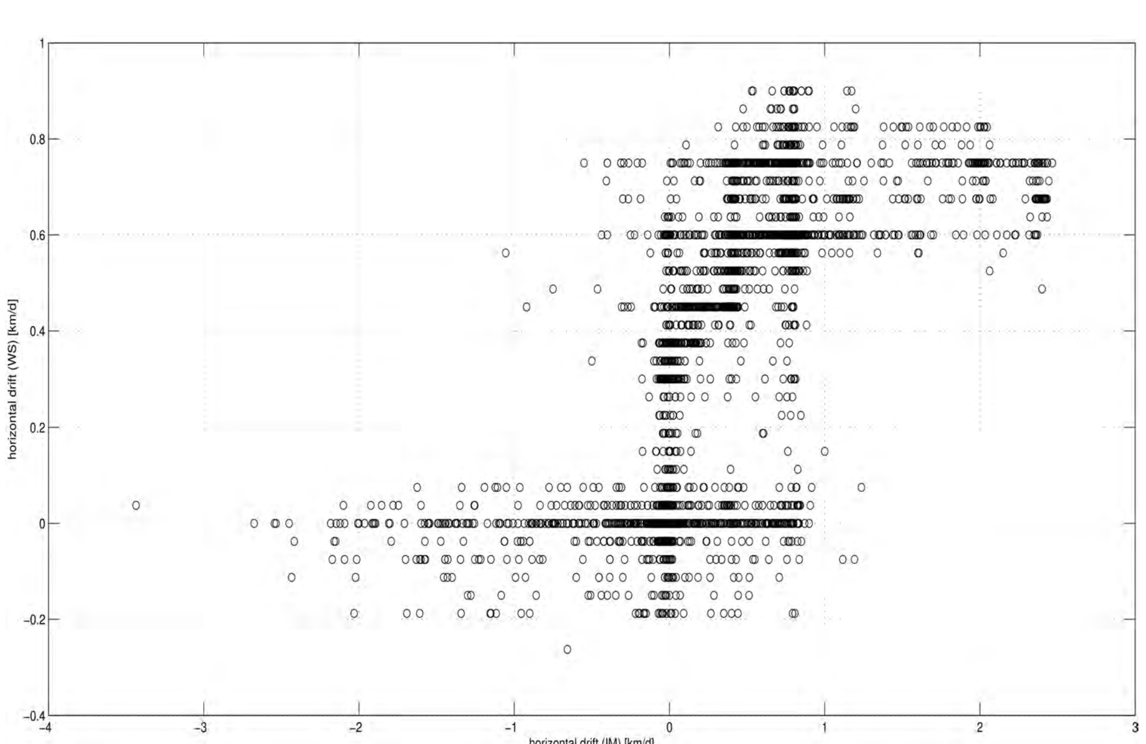


Figure 5: Scatter plot of horizontal drift. The IM drift is shown on the x-axis and the WS drift on the y-axis. .

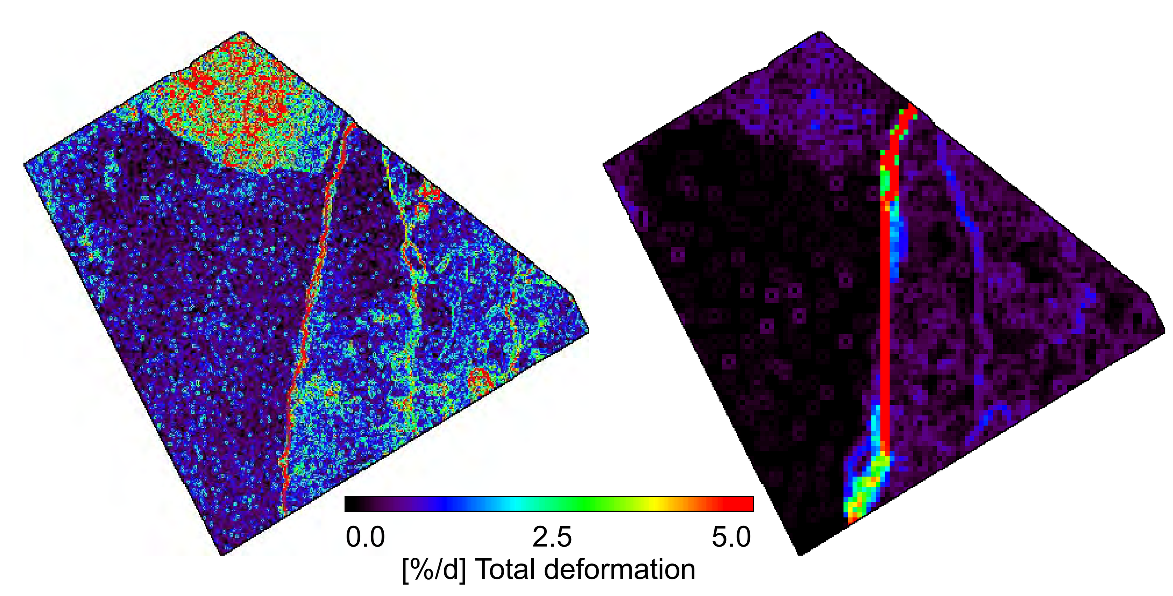


Figure 6: August IM total deformation field (left) and August WS total deformation field (right). Both fields show similar characteristics. The WS data shows less details due to its lower resolution. The maximum total resolution is about 18%/d for the IM data and about 8 %/d for the WS data. Calculated values are based on the calculated pixel shift.

Conclusion

• The implemented algorithm shows a good performance for the case of a closed sea ice cover with mainly translational motion and allows the calculation of deformation fields.
• It would however fail for the tracking of rotational motion and therefore as well for motion tracking on Ice margins.
• The quality of the extracted vector field strongly depends on pattern stabiliy in the analysed data sets as the differences between the January data set (summer) and the June and August data sets (winter) indicate.

Outlook

• Compare drift calculations for different radar frequencies and polarisations.
• Implement and utilise algorithms for the marginal ice zone.
• Study regional ice dynamics for selected test sides.

Acknowledgment

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References

Thomas, Mani V., 2008. "Analysis of large Magnitude Discontinuous Non-Rigid Motion" (PhD thesis), University of Delaware.

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