

Project information

Project title

CASPER: Characterization of Arctic sea ice properties from remote sensing observations

Year

2013/2014

Project leader

Torbjørn Eltoft, UiT

Participants

Project leader:

- Prof. Torbjørn Eltoft, Department of Physics and Technology, University of Tromsø

Participants:

- Research Scientist Sebastian Gerland, Norwegian Polar Institute,
- Research Scientist Mats Granskog, Norwegian Polar Institute
- Postdoc Angelika H.H. Renner, Norwegian Polar Institute
- Research Scientist Gunnar Spreen, Norwegian Polar Institute
- Senior Researcher Rune Storvold, Northern Research Institute
- Senior Researcher Stian Solbø, Northern Research Institute
- Postdoc Anthony Doulgeris, University of Tromsø
- PhD student Mari-Ann Moen, University of Tromsø
- PhD student Ane Fors, University of Tromsø
- PhD student Thomas Kræmer

Flagship

Arctic ocean, Theme: Sea ice, ecosystems and models

Funding Source

Fram Centre, external (not specified)

Summary of Results

The objective of the project was to develop and validate remote sensing algorithms for characterizing and mapping Arctic sea ice properties. This was done by

- *Collecting multi-channel synthetic aperture radar (hereafter referred to as PolSAR) observations over ice infested areas north of Svalbard and in the Fram Strait in annual campaigns from April 2011 to September 2013.*
- In the same period, collecting, co-located with the satellite data, measurements on the ice and from air-borne instruments such as a helicopter-borne EM-bird, and optical sensors on board on UAV platforms. These data were used for validation of the satellite products.
- Developing algorithms to segment the PolSAR data into statistically homogeneous regions.
- Performing a detailed analysis of the radiometric -, polarimetric -, and statistical signal properties of PolSAR data.

The CASPER project has made important contributions in various ways. Below are some key contributions.

- Many contributions at international conferences.
- Several journal papers are published or are under review, more will follow.
- The project has gathered several unique data sets, which will be further analyzed, and which will found bases for future PhDs and scientific publications.
- 3 PhD students have been connected to the project. The first will graduate in 2014. Delays have been related to maternity leaves. 2 more PhDs will graduate in 2015.
- Segmentation algorithms has been developed and tested out. They will in the near future be further validated at Met.no and KSAT.
- A new strategy for sea ice velocity field estimation is under development and testing. Preliminary results are very promising.
- A method for creating 3D ice surface roughness and ice ridge volume using multi-angle image bundling of micro UAV was developed and tested with good results.

All in all, the CASPER project has been positive for collaboration on sea ice related research in Tromsø, and it has increased the visibility of the participating groups in the international research community. The partners have been actively participating at international conferences with oral and poster presentations, and they have been involved in the organization of international workshops, conferences

and summer schools, both in Tromsø and elsewhere (e.g. SEASAR 2012, A Norwegian-Chinese workshop, 2013, ArcticEO Summer School, 2013).

For the Management

Algorithms that can distinguish between ice and water, and do sea ice classification (when mature) could be of benefit to authorities in the sense that they can provide information of the location of the ice edge, the local ice cover, possibly about the degree of ice deformation. This information will be helpful for ship routing, and in connection with Arctic offshore operations. Similarly, this information could be helpful to fishermen, tourist traffic and seal hunters.

The project has also looked into sea ice velocity field estimation. This would also be important information to maritime industry in ice affected waters.

Published Results/Planned Publications

Journal papers:

Renner, A. H. H., S. Hendricks, S. Gerland, J. Beckers, C. Haas, T. Krumpfen: *Large-scale ice thickness distribution of first-year sea ice in spring and summer north of Svalbard. Annals of Glaciology*, 54(62), 13-18, doi:10.3189/2013AoG62A146, 2013a

Renner, A. H. H., M. Dumont, J. Beckers, S. Gerland, C. Haas: *Improved characterisation of sea ice using simultaneous aerial photography and sea ice thickness measurements. Cold Regions Science and Technology*, 92, 37-47, doi:10.1016/j.coldregions.2013.03.009, 2013b

Moen, M.-A.N., A.P. Doulgeris, S.N. Anfinsen, A.H.H. Renner, N. Hughes, S. Gerland and T. Eltoft: *Comparison of automatic segmentation of full polarimetric SAR sea ice images with manually drawn ice charts, The Cryosphere Discussions*, vol. 7, no. 3, pp. 2595-2634, June, 2013.

Mari-Ann Moen, Stian N. Anfinsen, Anthony P. Doulgeris, Angelika H.H. Renner, Sebastian Gerland *Assessing the robustness of sea ice classifications from polarimetric radar images, submitted to Annals of Glaciology, 2014.*

T. Eltoft, W. Dierking, A. Doulgeris, G. Kasapoglu, and T. Kræmer: *Sea Ice monitoring from space with synthetic aperture radar, Whitepaper, Proceedings of SEASAR, 2012, Tromsø.*

Some conference papers in 2013:

Eltoft, T., Doulgeris, A., Gerland, S., Moen, M/A.: *Polarimetric decomposition analysis of sea ice data, Proceedings of POAC 2013, Helsinki, June 2013*

Gerland, S., Renner, A., Spreen, G., Divine, D., Granskog, M., Hansen, E., Hudson, S., Eltoft, T., Doulgeris, A., Fors, S., Moen, M., Hughes, N., Storvold, R.: *Validation and complementing of SAR satellite surveys over Arctic Sea ice by multiple simultaneous sets of Measurements, Proceedings of POAC 2013, Helsinki, June 2013*

Gerland, S., Hansen, E., and Eltoft, T.: *Combining satellite remote sensing and field work to characterize Arctic sea ice properties. Fram Forum 2013, pages 30-33.*

Moen, M.-A., Doulgeris, A.P., Anfinsen, S.N., Hughes, N., Renner, A.H.H., Gerland, S., Robertsen, T., Lund, V., and Eltoft, T. (2013): *Comparison of feature based segmentation of SAR satellite sea ice images with manually drawn ice-charts. ESA Proceedings Earth Observation and Cryosphere Science Symposium Nov. 2012, Frascati, Italy. ESA SP-712, May 2013. 6 pages.*

Fernández-Prieto, D., Hogg, A., Bamber, J., Baeseman, J., Drinkwater, M., Ryabinin, V., Steffen, K., Dierking, D., Duguay, C., Gerland, S., Giles, K., Haas, C., Heim, B., Howell, S., Joughin, I., Kaleschke, L., Kern, S., Laxon, S., Macelloni, G., Painter, T., Paul, F., Payne, A.J., Pedersen, L.T., Pulliainen, J., Rack, W., Rignot, E., Rott, H., Scambos, T., Schrama, E., Shepherd, A., Strozzi, T., van den Broeke, M.R., Velicogna, I., and Zwally, J. (in press, 2013): *Earth Observation and Cryosphere Science: The Way Forward. ESA Proceedings Earth Observation and Cryosphere Science Symposium Nov. 2012, Frascati, Italy. ESA SP-712, May 2013. 14 pages.*

Gerland, S., H. H. Renner, A.H.H., Spreen, G., Wang, C., Beckers, J., Dumont, M., Granskog, M.A., Haapala, J., Haas, C., Helm, V., Hudson, S.R., Lensu, M., Ricker, R., Sandven, S., Skourup, and H., Zygmuntowska, M. (submitted, 2013): *In-situ calibration and validation of CryoSat-2 observations over Arctic sea ice north of Svalbard. Proceedings of the Conference Earth Observation and Cryosphere Science, Frascati, Italy, Nov. 2012, and for the 3rd ESA CryoSat Workshop. Dresden, Germany, March 2013. DVD/CD SP-712 and 717, respectively. 4 pages.*

Moen, M.-A.N., A.P. Doulgeris, S.N. Anfinsen, A.H.H. Renner, N. Hughes, S. Gerland and T. Eltoft: *Comparison of automatic segmentation of full polarimetric SAR sea ice images with manually drawn ice charts, The Cryosphere Discussions*, vol. 7, no. 3, pp.

2595-2634, June, 2013 (in review).

Doulgeris, A.P.: A Simple and Extendable Segmentation Method for Multi-Polarisation SAR Images, Proc. POLinSAR 2013, Frascati, Italy, 8 pp., 28 January - 1 February, 2013. (Had three sea ice examples, two ALOS PALSAR, one RS-2 wide-swath.)

Moen, M.-A., L. Ferro-Famil, A.P. Doulgeris, S.N. Anfinsen, S. Gerland and T. Eltoft: Polarimetric decomposition analysis of sea ice data, Proc. POLinSAR 2013, Frascati, Italy, 7 pp., 28 January - 1 February, 2013.

Communicated Results

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Interdisciplinary Cooperation

The project have links to “Olje i is”, managed by the Flagship “Hazardous substances – effects on ecosystems and human health”.

Links to ICE-Fluxes at NPI, esp. WP2: analysis of airborne photography in combination with EM-bird measurements and SAR image classification; methods paper Renner et al., 2013b is published now, more photos are being processed and analysed and results will be used in further work with SAR classification and interpretation of ice thickness observations. Very useful cooperation in terms of enabling data collection and algorithm developments, and widening the use of the collected data and results.

A new project “Sea ice conditions in Svalbard fjords” was funded in June 2013, as a part of the across flagship work funding. The work proposed links in the first place to “Polhavet”. The results also will be relevant for the two flagships “Effects of climate change on fjord and coastal ecosystems in the north” and “Ocean acidification and ecosystems in northern waters”, since the sea ice scenarios in fjords affect the regional hydrography, the regional ecosystem and also fluxes within biogeochemistry.

Field work in Storfjorden, Svalbard, in spring 2013 (helicopter EM-Bird flights, in situ snow and ice observations) was done for the PRODEX ThinIce and NPI Svalbard Fjord Monitoring projects, and was coordinated with satellite data acquisition (Radarsat-2 quad-pol and dual-pol) for this project. Results are interpreted in collaboration and a joint conference paper is under preparation.

Budget in accordance to results

The FRAM Centre funding helped the project in collecting co-located (in time and space) RS2 C-band scenes & TSX X-band scenes. This year data has been collected in Storfjorden and Fram Strait.

The FRAM Centre funding has enabled high focus on sea ice monitoring from satellite and UAS (unmanned aerial systems). Together with funding from other sources, the ongoing comprehensive studies involve multi-frequency polarimetric analysis, and a new approach to estimate sea ice drift from the SAR Doppler frequency. Promising results have been obtained.

The large focus on sea ice has made the partners visible to industry (KSAT & oil companies), and open for future funding opportunities.

An ice balance buoy is a very important device to support our CASPER work. We had such a buoy (not funded by CASPER) in Fram Strait installed for 1 full year and these measurements already help to interpret satellite data relevant for CASPER. A new buoy will help us significantly to have a better base for interpreting the remote sensing products, and to extend the findings got through cruises over longer time spans.

If Yes

As the shipping industry and oil and gas industry are moving northwards with the retreat of the sea-ice, the need for accurate mapping and forecasting of ice cover and properties becomes important. This will be the theme in a new SFI (senter for forskningsdrevet innovasjon) initiative from Tromsø.

Conclusions

Future research will use data collected within this project to

- understand EM scattering and propagation in sea ice
- produce improved sea ice type maps
- produce semi-automatic classification of aerial photography
- validate new methodology for sea ice drift estimation
- improve usability of satellite SAR and unmanned aircraft data to monitor sea ice, which will benefit ship traffic and industrial activities in the Arctic Ocean.