CIRFA

Norges arktiske universitet · UiT

sfi Centre for Research-based Innovation

2018 Annual Report

CIRFA – Centre for Integrated Remote Sensing and Forecasting for Arctic Operations

THE YEAR 2018 IN REVIEW

2018 is already history. The year was busy and exiting, with good progress in many fields. The collaboration and needs of CIRFA's user partners were further explored in dialog meetings and thematic workshops. A few of the most mature algorithms were taken from the development stage to operational testbeds at KSAT and MET Norway. CIRFA researchers published more than 20 journal papers, and two professors, Camilla Brekke and Wolfgang Dierking, contributed a book chapter each in a book entitled "Maritime Surveillance with SAR Data" edited by Antonio Iodice and Gerado Di Martino, that will be published by the Institution of Engineering and Technology (IET). The PhD students made good progress in their projects, and two of CIRFA's associated PhD-students, Jakob Grahn and Temesgen Gabrie Yitayew graduated. Both have continued their research careers at Norut. International collaboration was extended through in-going and out-going exchange stays. In 2018 RCN also started the midterm evaluation process for the SFI-III centers, and this occupied our attention the last few months.

Some important activities are summarized below.
Hiring: CIRFA has now hired 13 PhD students, and at least 2 more will be employed in 2019.

Research: Progress was made in all research areas. WP1 finalized an improved wind-from-SAR (Synthetic Aperture Radar) algorithm, which is now implemented and operationally running at user partner KSAT. The algorithm is continuously providing wind input to KSAT's products on oil spill and ship detection.

WP2 is targeting operational wide-swath sea ice image segmentation. This algorithm is a first step towards automatic sea ice from water separation and ice type charting from SAR data, and is being operationally tested at the Norwegian Ice Service (NIS) at MET Norway. These products display more high-resolution ice information (about 100-meter resolution), than the standard products delivered by NIS.

The WP3 team has worked together with the modelers (WP5) on data and model analysis based on data collected during previous "Oil on Water" (OPV) exercises, which resulted in improvements in the Open Drift Trajectory framework.

CIRFA's RPAS (Remotely Piloted Aircraft System) team has, together with WP6, carried out experiments on Svalbard to test out new technologies related to de-icing, sea ice and iceberg mapping, communication between the drone platform and ground base, and on-board handling of data. Achievements include an algorithm for real time onboard processing of live video for extraction of ice floes, iceberg size and position from drones, verified in field experiments.

The modelling WP (WP5) has developed a high-resolution ensemble prediction system (EPS) for coupled ocean-sea ice, and implemented the functionality for utilizing EPS forcing in the open source drift model used for operational decision support.

A keyword in CIRFA is integrated remote sensing, which refers to the process of combining information extracted from many sources. This integration has so far been limited to the combination of satellite information associated to the three application areas with modelling predictions.

Innovation: Current innovation activities are addressing improvements in satellite-based met-ocean and sea ice services. We are currently testing out algorithms for operational wind retrieval from SAR at KSAT, and for operational sea ice segmentation at the Norwegian Ice Service.

Publications: CIRFA's researchers published more than 20 papers in peer-reviewed scientific journals in 2018, and contributed to many international conferences and workshops.

The Centre maintains and extends international collaborations by hosting visiting researchers and students, and participating in relevant workshops and meetings.

CIRFA Events: CIRFA arranged a sea ice workshop at Gardermoen in September 2018 to discuss user requirements related sea remote sensing with partners. CIRFA had its annual conference at Sommarøy Arctic Hotel in October, with around 60 participants from partners, and collaborating institutions and companies.

We also organized a Young Scientist Forum in at Tromsø Villmarkssenter in March with focus on innovation and IPR issues.

CIRFA continues to organize monthly scientific seminars with internal and invited external presenters, and these are streamed for the interested parties outside of Tromsø.

Thanks to the efforts of the enthusiastic of dedicated staff, CIRFA has a good year, with great results in 2018.

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CIRFA – A PARTNER'S PERSPECTIVE

by Robert Bridges

The Arctic region possesses many unique qualities, such as special environmental conditions and a unique geography. Total is cognisant of this from its operations in cold climate regions and understands that these conditions require specific methods and approaches not just for design and operations but for all activities. This is true also for remote sensing applications which play an important role in safety and efficiency. This is reflected in the aim of CIRFA; to develop improved remote sensing and forecasting technology.

CIRFA is supported by the Total E&P Norge Research and Development centre which is within the exploration and production branch in the Total group. The objective of the centre is focused on challenges on the Norwegian Continental Shelf in technical domains such as subsurface including drilling and well technology, production and environment (with carbon capture, utilisation and storage). In addition, Total E&P research also undertakes and performs specific research activities with focus on extreme cold topics such as sea ice and permafrost.

The CIRFA programme includes topics and activities that are technically interesting for Total's activities in Norway and other cold climate and Arctic regions were Total has interests. For example, Total participates in various onshore and offshore projects in extreme cold regions, such as the Russian Arctic and Caspian Sea, where sea ice poses a number of hazards and may have significant consequences if not addressed. Thus, focus of activity is to investigate the influence of the ice interactions with particular emphasis on how these can be applied to marine structures and vessels from an engineering perspective. The use of remote sensing can provide a useful tool in understanding and managing these aspects, such as providing statistics of ice conditions including thickness, drift and deformation. These can be incorporated into improved and detailed ice charts for ice information to assist with ship route and voyage planning, or in emergency and response plans. Additional benefits can also include monitoring of coastal erosion due to ice interactions, snow drift predictions, and forecasts of Polar lows. It is therefore clear that Arctic areas will benefit from advanced remote sensing capabilities and support safer operations.

The participation in CIRFA has so far provided an informed and improved understanding of remote sensing techniques, such as an improved awareness of different remote sensing methods and also algorithms that can be applied to satellite data and images especially those related to oil spill. Of particular benefit has been improved understanding of state of the art and in transfer of knowledge and expertise, with collaboration alongside other universities and scientific organisations being developed wherever possible. One of the benefits of the centre is the ability to perform field work which is critical to validation and verification of remote sensing techniques, and gives confidence in using the data for operational use.

At this stage of the project the benefits are seen in terms of improved understanding and knowledge of remote sensing techniques in Arctic regions, however in the future development it is expected that implementation of an innovation platform of products will be created. Based on the progress so far we expect to see good results and all those involved in CIRFA are thanked for their contributions and to the achievements to date.

FOREWORD

Professor Torbjørn Eltoft
Centre Leader, CIRFA

As mentioned in the background documents, the main objective for the *Centres for Research-based Innovation (SFI)* is to enhance the capability of business and industry to innovate. This is to be achieved by placing stronger emphasis on long-term research, partnership and tight collaboration between the research partners in the Centre and its user partners. Given the research theme of CIRFA, and the composition of the user consortium, it is apparent that there are different expectations from different user groups. CIRFA's output is new satellite-based information products, which should generate *new monitoring services* for the service providing partners, new *specific information products* for oil companies and consulting engineering firms, and *improved forecast services* of value for society at large.

Innovations at service providers are to be realized through the implementation of new CIRFA algorithms in their processing chain, which subsequently cause improvements in the way the services are generated. Within the Norwegian Ice Service (NIS) at Met Norway, one goal is to automate the generation of ice charts. These are currently being produced manually by sea ice experts, but in the future, an efficient use the of massive amount of Copernicus and other satellite data will require more automatic processes. CIRFA researchers are currently working closely with NIS on development and testing of new ice charting algorithms. Accurate and reliable ice charts represent important sea ice information of interest to industries, climate researchers, and indigenous people living on the ice, and are provided by national ice services. In 2018, CIRFA attended the International Ice Charting Working Group meeting in Finland to inform about and get feedback on our achievements, and to learn about international needs and trends in this field. Likewise, CIRFA also work closely with the service provider KSAT on developing their met-ocean services by including satellite derived wind and wave information in their deliverables. We are also testing out new information products within KSAT's oil spill service.

Some of CIRFA's user partners are in need of specific information products in support of their Arctic operations. Examples of such products are: floe size distribution, ice edge localization, including a time series of the historical ice edge localization, time series of met-ocean data, sea ice concentration maps, including time series for certain areas, area fraction of first year and multi-year sea ice. These products must be based on further developments of sea ice classification maps currently being developed in the Centre, and will be part of the Centre's future deliverables.

CIRFA's research and development definitely also have value for the society at large. Improved remote sensing technologies is a fundamental tool for the continuous monitoring the vast and harsh Arctic environment. Sea ice monitoring is of high relevance to maritime operations (fishing, ship traffic, tourism, oil & gas), and in order to observe and understand global climate change. In combination with high-resolution models, integrated remote sensing contributes better forecasts of the ice and oceanographic conditions, and supports safer and more efficient Arctic operations. In general, by advancing sea ice and met-ocean information extraction from remote sensing data, and assimilating this information into numerical forecast models to produce improved forecast of meteorology and sea state would be of big value to all mariners. The technology developed in CIRFA on iceberg detection and drift modelling will also be of value to ship traffic. The work on improved oil spill characterization will benefit society with information which allows for more efficient clean-up operations in cases of oil spill accidents. Also, the improved models developed in CIRFA to predict oil spill drift will similarly help in protecting vulnerable coastal areas in cases of an oil spill close to the coast.

In conclusion, CIRFA makes a difference.

ORGANISATION

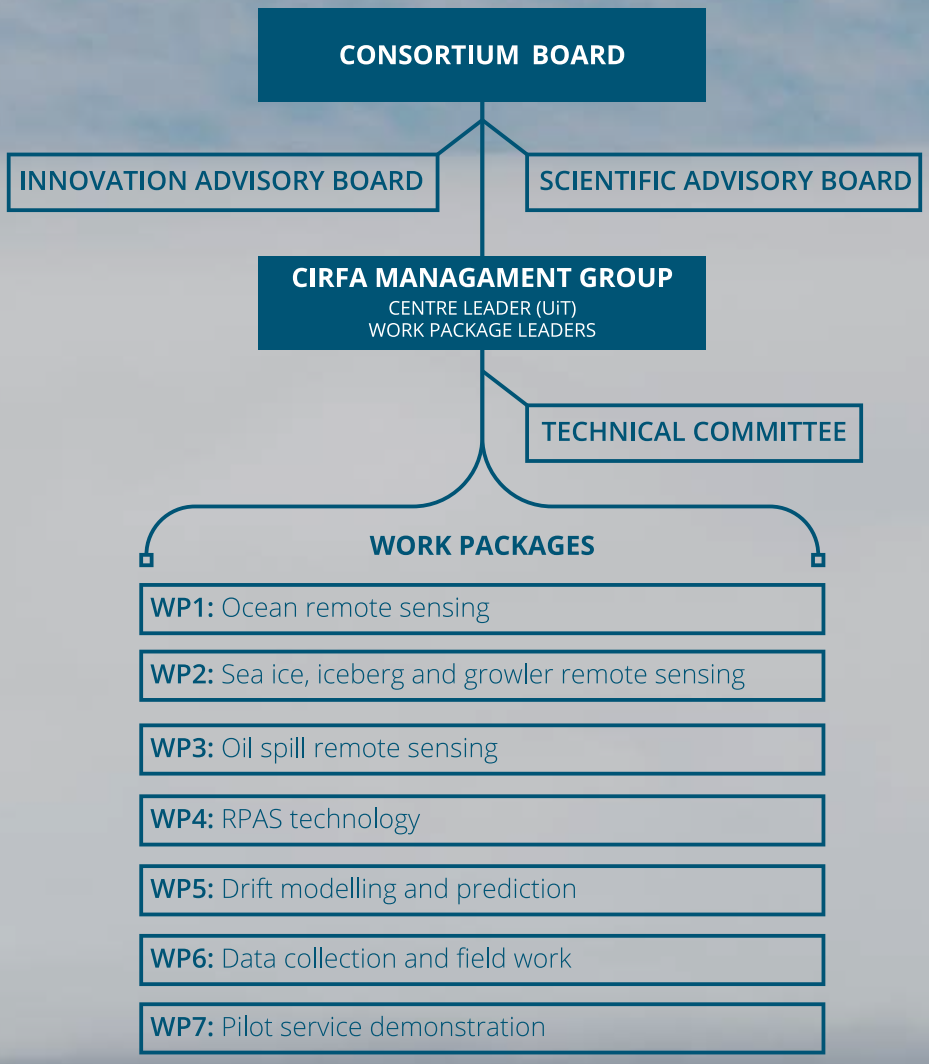

Photo: Johannes Lohse

Consortium Board

The CB is CIRFA's main decision-making body. The CB consists of representatives from the user partners and research partners. The CB is in charge of the overall direction of the Centre.

Arne O. Smalås (Chair)
Dean, Faculty of Science and Technology, UiT

Kjell Arild Høgda
Norut

Lars Anders Breivik
MET.no

Svein Olav Drangeid
OMV

Richard Hall
Equinor

Robert Bridges
Total

Jan Petter Pedersen
KSAT

Scientific Advisory Board

A SAB consisting of international experts with outstanding reputations in the relevant fields has been established to ensure excellence in research. The SAB will provide scientific input, review progress reports and provide support for networking and internationalizing of the centre's activities.

Henning Skriver
Technical University of Denmark (DTU)

James Maslanik
University of Colorado in Boulder, Colorado, USA

Charlotte Hasager
Technical University of Denmark (DTU)

Irena Hajnsek
Swiss Federal Institute of Technology (ETH) Zürich, Switzerland

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Martin Skedsmo, Norinnova
Julien Moisan, Innovation Norway
Jan Petter Pedersen, KSAT
Torbjørn Eltoft, CIRFA

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Harald Johnsen, WP 1 Leader, Norut
Wolfgang Dierking, WP 2 leader, AWI/UiT
Anthony Doulgeris, WP 2 Co-Leader, UiT
Camilla Brekke, WP 3 Leader, UiT
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Rune Storvold, WP 4 Leader, Norut
Tor Arne Johansen, WP 4 Co-Leader, NTNU
Kai H. Christensen, WP 5 Leader, MET Norway
Rune Graversen, WP 5 Co-Leader, UiT
Sebastian Gerland, WP 6 Leader, NPI
Torunn Tøllefsen, WP 7 Leader, KSAT
Nick Hughes, WP 7 Co-leader, Norwegian Sea Ice Service, Met Norway
Kjell-Arild Høgda, Norut

Photo: Sebastian Gerland

PARTNERS

Host Institution:

UiT The Arctic Univeristy of Norway
Faculty of Science and Technology,
Department of Physics and Technology

Research partners:

UiT The Arctic University of Norway (UiT)
Northern Research Institute (Norut)
Northern Research Institute Narvik (Norut Narvik)
Norwegian Meteorological Institute (MET Norway)
Norwegian Polar Institute (NPI)
Norwegian University of Science and Technology (NTNU)
Nansen Environmental and Remote Sensing Center (NERSC)

User partners:

Kongsberg Satellite Services
Kongsberg Spacetec
Equinor
Vår Energi
Aker BP
OMV Norge
Total E&P Norge
Aker Solutions
Multiconsult
Globesar
Aranica
Maritime Robotics

OBJECTIVES

CIRFA shall create knowledge, methods and technologies, which are a prerequisite for environmentally safe industrial operations in the Arctic.

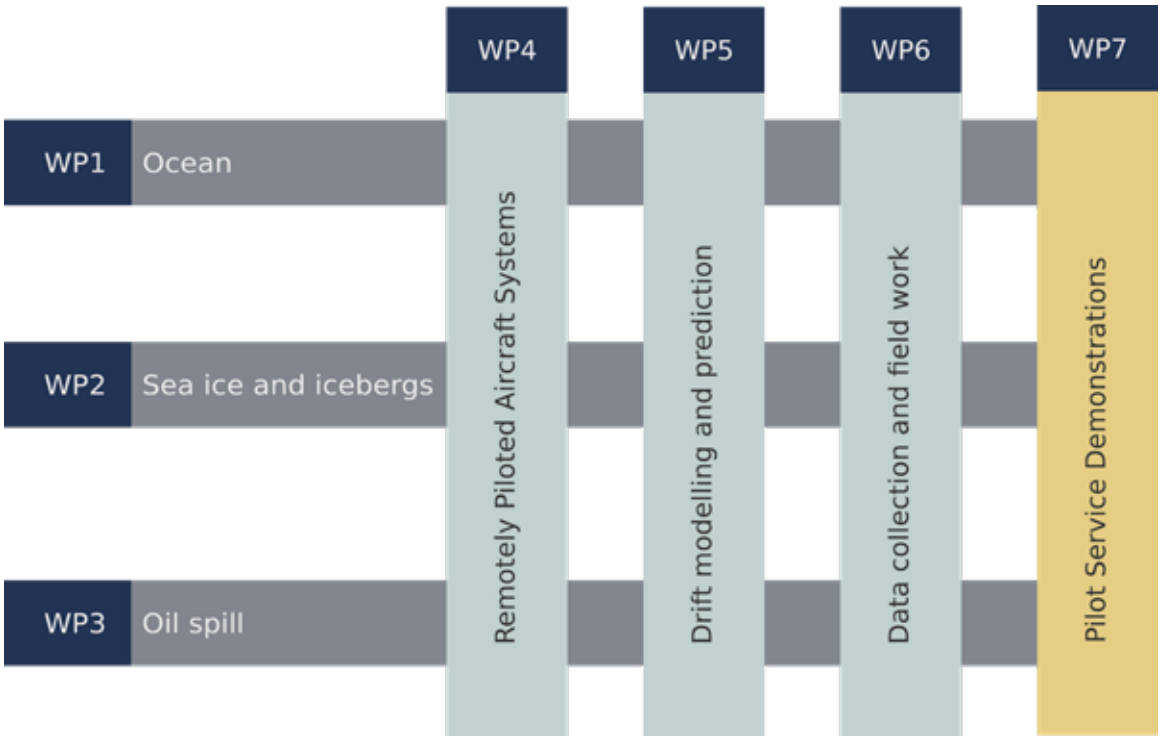
CIRFA will contribute to:

- Improved understanding of important geophysical processes in the Arctic
- Improved monitoring capabilities
- Improved assimilation methods and forecasting services

The research tasks are organized in seven work packages centered around three application areas:

- Ocean
- Sea Ice and Icebergs
- Oil Spill and remote Sensing

The work should generate new, innovative algorithms and processing schemes, which foster new services and products. The processing schemes are implemented and demonstrated in WP7. Integration and cross WP activities are key activities, as illustrated below.



Vision

CIRFA shall become an international leading research centre on integrated remote sensing and forecasting for the Arctic, providing:

- An attractive environment to scientists, young researchers and students
- Outstanding scientific contributions
- High-level research training for new researchers in the field

CIRFA shall become a facilitator for collaboration between industry and academia on issues related to remote sensing of Arctic phenomena, providing

- Innovative integrated solutions to challenges in Arctic operations
- Scientific support to industry on issues related to remote sensing technology
- Decision support to policymakers and authorities

Photo: Johannes Lohse

HIGHLIGHTS

A novel approach to SAR ocean wind retrieval

In a recently accepted journal paper, Nilsen et al. (2019) present a new methodology for retrieval of ocean surface wind vector from Sentinel-1 (S1) Synthetic Aperture Radar (SAR) instrument. The method takes benefit of the high bandwidth data of S1 and combines different metrics from the S1 data to invoke an ambiguity free estimate of ocean surface wind speed and direction. The massive global ocean data acquired by S1 is used to train semi-empirical model functions for the S1 metrics. The model functions are then inverted with respect to wind vector and validated against buoy measurements. The results show the capabilities of high bandwidth SAR to measure ocean surface wind vector without use of ancillary data such as numerical models

The paper will be published in IEEE Transactions on Geoscience and Remote Sensing. Read more in *Nilsen et al. (2019): "A novel approach to SAR ocean wind retrival"*.

Effect of wind direction and incidence angle on polarimetric SAR observations of slicked and unslicked sea surfaces

The objectives of this work is to investigate the dependency of oil spill observation in polarimetric SAR data on imaging geometry, i.e., on incidence angle and look direction relative to the wind. The study is based on a time series of quad-polarimetric Uninhabited Aerial Vehicle Synthetic Aperture Radar data acquired over experimental oil slicks under relatively high winds of 10-12 m/s over an 8-hour period. The results show that both the relative wind direction and the incidence angle, in combination with the signal-to-noise ratio, should be taken into account when developing operational methods based on multipolarization synthetic aperture radar data. Read more in *Skrunes et al. (2018): "Effect of Wind Dierection and Incidence Angle on Polarimetric SAR Observations of Slicked and Unslicked Sea Surfaces. Remote Sensing of Environment"*

A unified Chlorophyll-A estimation model for complexity-diverse waters

Chlorophyll maps are relevant to CIRFA because of the display ocean dynamics and areas of high primary production. When retrieving Chlorophyll-A (Chl-a) from the Sentinel 3 OLCI sensor, the approach is to apply one algorithm for open ocean, and another model for the complex coastal waters. In a recent paper by Blix et al. published in the open access journal *Water,* the authors present a single unified model, which provide excellent Chl-a estimates for all water conditions that are present in the Lake Balaton in Hungary, ranging from clear water (oligotrophic) conditions to highly CDOM-rich, complex waters (eutrophic conditions). The approach is to apply an automatic model selection algorithm to select the combination and number of spectral bands for the given water quality parameter to train a Gaussian Process Regression model. To provide a sufficiently large data set to train the model on, a synthesized dataset representing the different water conditions is generated. The model has also been tested on various Arctic water conditions, open Arctic waters and coastal conditions, showing good performance. The contribution is a model which can improve the accuracy of the S3 OLCI Chl-a product over diverse water complexity conditions, including Artic waters, where training data is limited, and thus support monitoring of the Arctic marine ecosystem in a changing climate. Read more in *Blix et al. (2018): "Remote Sensing of Water Quality Parameters over Lake Balaton by Using Sentinel-3 OLCI".*

Impact of assimilating sea ice concentration, sea ice thickness and snow depth in a coupled ocean-sea ice modeling system

The accuracy of the initial state is very important for the quality of a forecast, and data assimilation is crucial for obtaining a best possible initial state. For many years, sea-ice concentration was the only parameter used for assimilation into numerical sea-ice models. In the present study, a coupled ocean-sea-ice model is used to assess the assimilation impact of sea-ice thickness and snow depth on the model. The observations assimilated here are sea ice concentration from the Ocean and Sea Ice Satellite Application facility, thin sea ice thickness from the ESA's SMOS mission, thick sea ice thickness from ESA's CryoSat satellite, and a new snow depth product derived from the NASA's AMSR-E/AMSR-2 satellites. The model results are verified by comparing assimilated observations and independent observations of ice concentration from AMSR-E/AMSR-2, and ice thickness and snow depth from the IceBridge campaign. It is found that the assimilation of ice thickness strongly improves ice concentration, ice thickness and snow depth, while the snow observations have a positive effect on snow thickness and ice concentration. The seasonal forecast showed that assimilating snow depth lead to a worse estimation of sea-ice extent compared to the other assimilation systems, the other three gave similar results. Read more in *Fritzner et al. (2018): "Impact of assimilating sea ice concentration, sea ice thickness and snow depth in a coupled ocean-sea ice modeling system".*

Photo: Johannes Lohse

Supervised Ice Type Classification for Wide-Swath SAR Images

Two of the major issues for automatic pixel-based sea ice classification in Sentinel-1 wide-swath images are the incidence angle dependence of the backscattered signal and the variable noise-floor in the data. Researchers in WP2 have been implemented an approach to compensate for the incidence angle dependence by using a Bayesian Classifier that is based on multi-variate Gaussian probability density functions (PDFs) with a non-stationary mean.

The constant mean value of the PDF for a single ice class in the traditional Gaussian classifier is replaced with a mean varying over the swath width of a SAR image. At present, the variation is approximated by a linear function (for intensities at logarithmic scale). The slope of the linear function differs between ice classes and can be directly estimated from the training data. A projection of the pixels along the estimated slopes results in Gaussian distributions with smaller variance and better between-class separability.

This automatic approach allows us to mosaic large areas and assist in the production of cross-Arctic ice charts. Including currently ongoing work on noise-floor estimation will further improve classification results.

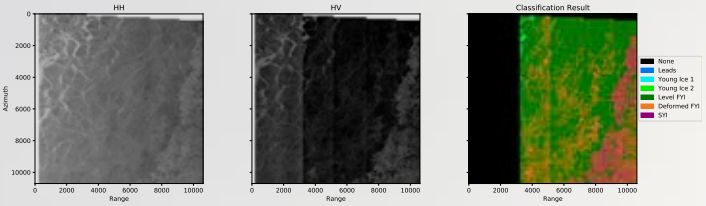


Image: Example of sea ice type separation (right image) from a combination of Sentinel-1 HH- and HV-polarized intensity (left and middle image)

Cross-Arctic Mapping of Sea Ice Types

Together with the Ice Service at the Met. No, WP2 of CIRFA has analyzed a total number of 85 Sentinel-1 wide-swath SAR images with overlapping optical satellite data to visually identify different ice types and learn their SAR signatures. An advanced classification algorithm that also accounts for the continuous variation of backscatter with incidence angle has been implemented and trained for the main ice classes. Classification results from several images can now be mosaicked together into a single ice type map. We are evaluating first results for cold, dry, winter conditions, and would need different training for summer melt conditions. Regional dependence may be achieved by adjusting prior probabilities of the different ice classes. Both seasonal and regional factors need to be integrated to produce a semi-operational ice type classification to improve services such as ice charts for navigation.

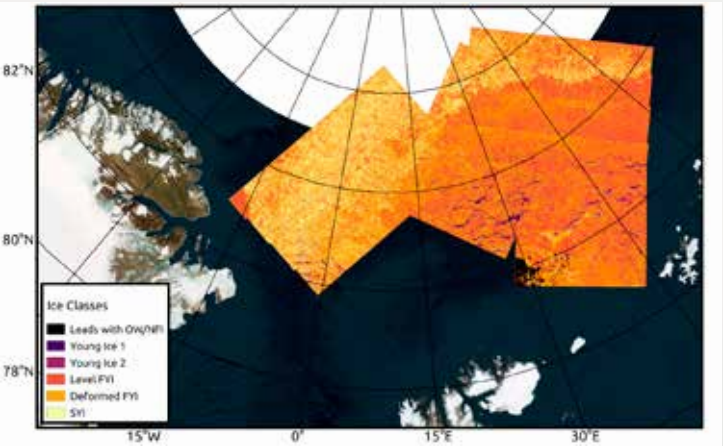


Image: Ice Type Chart

Photo: Johannes Lohse

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Work package 1

OCEAN REMOTE SENSING

Objectives and motivation:

Ocean surface is the complex boundary between two very dynamic and stochastic media, the ocean and the atmosphere. Better forecasting of the ocean state and understanding of the physical processes going on at the ocean/atmosphere interface require combined capacity in remote sensing, numerical modelling, and in-situ observations.

Synoptic maps made from space of ocean surface winds, waves and currents are core inputs to better characterization and parameterizations of oceanic mesoscale and sub-mesoscale dynamics, as well as important contributions to the understanding of ocean-atmosphere interaction and research on numerical modeling. The newly launched Sentinel satellites will greatly improve the capabilities of providing such high-resolution information from space due to the enhanced time and space coverage offered. This work package works on developing methodologies and algorithms to extract more accurate high-resolution sea state parameters from remote sensing observations over the oceans to improve modeling and forecasting.

Key research tasks:

- Develop physical and statistical methodologies to improve the reliability of satellite-derived geophysical parameters.
- Develop algorithms, products and a processing system for providing ocean state parameters from satellite observations beyond what is achievable today.
- Perform extensive product calibration and validation analysis.
- Support short range forecasting of ocean state through coupling with high-resolution numerical models in collaboration with work package 5

Achievements 2018

The R&D has been concentrated on the following activities:
- assessment of Sentinel-1 ocean coastal current measurements,
- evaluation of Sentinel-1 data for wave characterisation in the marginal ice zone (MIZ),
- operationalization of metocean processing system at Kongsberg Satellite Services (KSAT) based on achievements from CIRFA R&D.

Retrieval and geophysical validation of coastal current retrieved from Sentinel-1 data has been done by means of HF radar and surface drifters outside coast of Finnmark (see Figure). The results were presented at CIRFA annual conference, and an abstract is submitted to the Living Planet Symposium, 2019 in Milan. A peer-review publication is under preparation.

A research activity on exploiting the capabilities of Sentinel-1 to measure ocean wave characteristics in the MIZ is ongoing. Methods to process and extract sea ice characteristics from radar satellite measurements of waves in sea ice are developed. The results are validated using existing buoy network in the Barents Sea (BASMIN). A peer-review publication is under preparation.

A peer-review publication on novel algorithm for wind vector retrieval from Sentinel-1 has been accepted for publication.

An operational metocean processing system is established at KSAT, with direct ingestion of satellite and auxiliary data. The system is capable of processing in near real-time metocean parameters for input to external user services provided by KSAT. The system is designed to easily update and adapt R&D results from CIRFA.

Outreach:
The team has close cooperation with European Space Centre (both ESRIN (Italy) and ESTEC (The Netherlands)), as well as with research institutes in Europe such as Ifremer (France), OceanDataLab (France), TU Delft (The Netherlands), DLR (Germany), DTU (Denmark) and Chalmers (Sweden). The research activity has been presented at various international workshops/conferences such as SeaSAR2018, 7-10 May 2018, ESRIN (Italy), Doppler Oceanography from Space, 10-12 October, 2018, Brest (France), IGARSS2018, 22-27 July, 2018, Valencia (Spain), EGU, 8-13 April, 2018, Vienna (Austria)

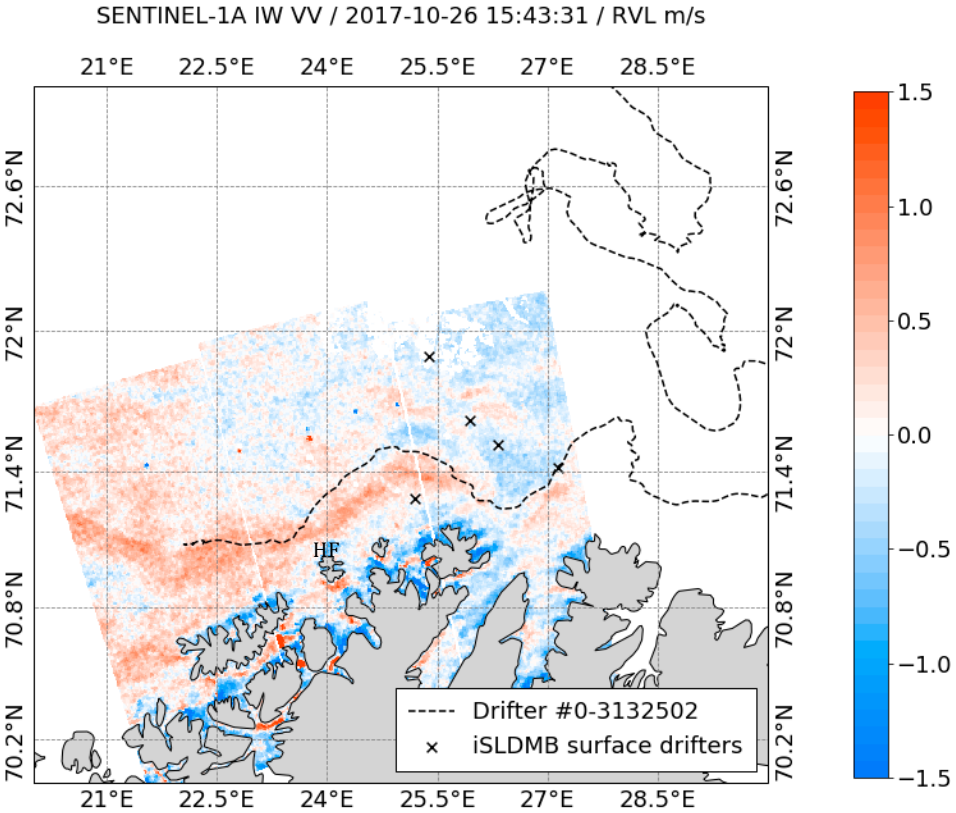

Figure: Coastal surface current measured by Sentinel-1a outside coast of Finnmark. (F. A. Moiseev).

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Associate PhD Fellow, UiT

Work package 2

MONITORING SEA ICE AND ICEBERGS

Objectives and motivation:

Sea ice is a very dynamic medium. It varies in thickness from a few centimeters, typical for the stage of a thin, skin-like new ice cover to several meters for multi-year ice. Remote sensing is a key technology for characterizing the ice surface and detecting ice objects to prevent hazards in Arctic operations.

Different zones of ice may drift with different velocities due to spatial variations of the driving forces, while obstacles may limit the mobility of fractions of the ice cover. This causes the ice to break and pile up, forming various compression structures such as linear ice ridges or extended rubble fields that pose a hazard to maritime traffic. A systematic analysis and monitoring of Arctic ice conditions thus not only requires the separation of different ice types, but also the monitoring of varying ice motion. Icebergs are still a hazard to maritime operations both in the open ocean and in ice-covered waters. The detection and monitoring of the smaller icebergs (lengths of less than 100 meters) still remain a challenge. The objective of this work package is to further develop remote sensing methodologies and algorithms to enable detailed characterization and mapping of Arctic sea ice conditions, and to provide improved detection and characterization of icebergs and growlers. Data products generated will be thoroughly assessed on the basis of the developed procedures, field campaigns from ships or coastal test sites in the Arctic are planned to collect in-situ ice data while satellite images are taken. This also includes data taken with remotely-piloted aircraft systems (RPAS)..

Key research tasks:

- Apply modern statistical methods and image processing techniques to
- develop robust and reliable procedures to classify and characterize sea ice.
- Develop improved methods for mapping and monitoring sea ice drift velocities.
- Investigate new, robust methods for iceberg and growler detection and characterization, including drift trajectory predictions.
- Optimize the developed procedures such that the new algorithms can be integrated into the workflow of the operational ice centers.

Achievements 2018

Major efforts were directed towards closely linking research and operational needs. In the beginning of September 2018 a sea ice remote sensing workshop was held in Oslo, which facilitated discussions and exchange of information between CIRFA and NORUT scientists, researchers from operational services and end-users from industry. This event and further discussions at the annual conference were valuable to improve strategies for further research in WP 2. In collaboration with WP 7 and colleagues from the ice service at Met.No, the implementation of an automated processing chain for ice-water separation and ice type classification was started (see below). In WP 5 the assimilation of the results into sea ice forecast models is tested.

The implementation of software tools for the detection of icebergs has also been started. At the Oslo workshop, the importance of iceberg monitoring was again emphasized. Required are analyses of the detectability under different "background" conditions (icebergs in calm or wind-roughened open water, in smooth level sea ice or deformed sea ice). Also ways of indicating the uncertainties are regarded essential. E.g. what size is necessary that an iceberg can be identified? Which maximum sizes are potentially not identified?

The PhD project of Ingri Halland Soldal, who collaborates with Anton Korosov (NERSC) and Wolfgang Dierking, helps to answer these questions. A first step for developing a detection strategy was to focus on small icebergs in smooth and rough fast ice in the Barents Sea. The advantage of this approach was that Ingri could identify more than 2000 icebergs in both SAR and optical satellite images for an assessment of false alarm rates and missed detections in the radar data. Considering the availability of dual-polarization SAR images, she used an intensity dual-pol ratio anomaly detector that provides much larger iceberg-background contrasts than possible with single-polarization intensity images. She introduced blob detection for initial identification of spots of potential iceberg occurrences before employing CFAR-detection in the next step, with the objective to keep computation time short. The selection of optimal thresholds for detecting a broad range of iceberg sizes is the most challenging task. In a recent publication, V. Akbari and C. Brekke investigated the use of quad-pol data, coupled with a segmentation approach and geometrical classifiers for iceberg detection.

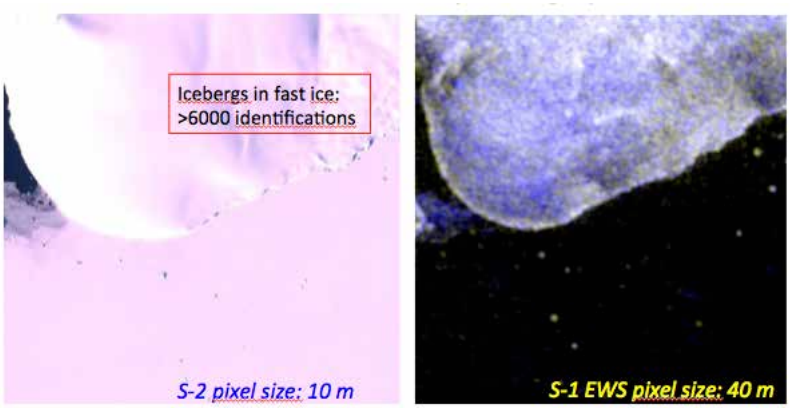

Image: Small icebergs in an optical (left) and a SAR image (right). Anthony Doulgeris

Other research progress in WP 2

- Jean Negrel processed EM-Bird data from the N-ICE 2015 campaign to quantify sea ice surface roughness. The goal is to identify ice classes on the basis of roughness and thickness and compare the results to classification maps from SAR images. This project includes the segmentation of the roughness/thickness data using the algorithm of Anthony Doulgeris and the determination of the roughness spectrum on different length scales. Jean Negrel implemented a computer program for estimation the sea ice fraction in the photos of a GoPro camera acquired during the EM-Bird flights and to synchronize them to the EM-Bird thickness measurements. This project is still ongoing in collaboration with Met. No.

- Together with Jakob Griebel from AWI, Wolfgang Dierking published a paper on the effect that statistical drift retrieval errors, on the one hand, and the discretization of the drift field and grid type, on the other hand, impose on calculations of sea ice deformation parameters. His collaboration with colleagues from the University of Bremen on detecting leads in Arctic sea ice is documented in another publication.

- Andrea Marinoni, started working at UiT/ CIRFA on Aug. 1, 2018 and supports WP 2 and WP 3. He devises or supports studies on multi-sensor and multi-resolution data for automatic classification of sea ice types and information extraction about sea ice characteristics; and on machine and deep-learning techniques for ice mapping and upscaling information in multi-resolution data. Moreover, he is involved in the activities of the ALSIM project (funded by FramCentre and CIRFA), which is focused on the research of automatic methods for investigation of large-scale datasets in order to achieve accurate sea ice mapping results.

Relation to users, stakeholders and research communities (e.g. workshops, conferences, field work)

- An important step to strengthen the relation to end-users and stakeholders was the workshop on sea ice remote sensing in Oslo mentioned above.

- Johannes Lohse and Jean Negrel participated in the ESA training course on remote sensing of the cryosphere at UNIS/ Svalbard in June.

- Johannes Lohse joined the INTPART summer school in Alaska and started a project on mapping of bottomfast sea ice in Elson Lagoon based on SAR imagery. For validation he used in-situ thickness profiles and data from drilling. It is planned to continue this project together with Andy Mahoney from the University of Alaska within the framework of an INTPART exchange in 2019.

- Johannes Lohse presented a poster at the EGU conference on sea ice classification from SAR on varying scales. At UiT's PhD course on "Society and Advanced Technology in the Arctic" he gave a talk entitled "Sea Ice in the Arctic: Remote Sensing and Ice Charting".

- In May, Ingri Halland-Soldal joined the SeaSAR conference with a poster on automated iceberg detection in the Barents Sea. During summer she visited the Alfred Wegener Institute for Polar and Marine Research (AWI) in Bremerhaven/ Germany for 3 weeks to collaborate with and get supervision from Wolfgang Dierking for a paper on the detection of icebergs.

- Jean Negrel took charge of the @OceanSeaIceNPI social media channel.

- Anca Cristea and Anthony Doulgeris reported about their work on integrating incidence-angle dependence in the segmentation of SAR images at SeaSAR and IGARSS.

- Anthony Doulgeris was involved in planning, implementation, and execution of the INTPART Arctic field school that was held in Alaska in May/June.

- Wolfgang Dierking was selected by ESA as a member of the Copernicus L-Band SAR Mission Advisory Group (MAG). In 2018 he joined three meetings of the MAG at ESTEC/ESA. The L-band SAR concept under discussion is called ROSE-L.

- Wolfgang Dierking and Anthony Doulgeris participated in the meeting of the International Ice Charting Working Group. Wolfgang Dierking finished his duty as co-chair of the Applied Science and Research Standing Committee and took over the task lead for investigating the benefit of ROSE-L for ice charting. The meeting was held in Helsinki at the end of September.

- Together with Torbjørn Eltoft, Wolfgang Dierking introduced CIRFA and UiT and held a lecture about remote sensing for a group of young students and their supervisors from AWI, who carried out field work on the Lofoten islands and visited UiT.

Photo: Johannes Lohse

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Work package 3

OIL SPILL REMOTE SENSING

Objectives and motivation:

In case of a major oil spill event, remote sensing will be instrumental in providing the authorities with both spatial information regarding distribution and qualitative properties of the spill guiding the clean-up operations.

To predict the spills transport is also important in a combat situation. Integration of remote sensing measurements and modelling efforts is essential in validating and improving drift models for oil spills. Remote sensing imagery from satellite is today applied in operational oil spill screening operations, where however false alarms are a major issue. There is also a need to establish proven methods for oil spill detection in ice-infested waters as oil & gas exploration, shipping, and tourism are expanding their activities into Arctic regions. To develop remote sensing techniques for sea ice conditions requires at first instance an understanding of the oil's interaction and migration within the sea ice medium, and secondly knowledge about the interaction between the remote sensing signal and the oil-ice layers. This work package aims to develop new techniques for solving the look-alikes ambiguity related to detection of oil on water, and to study methods for detecting and and monitoring of oil in ice.

Key research tasks:

- Develop accurate remote sensing information retrieval techniques for reliable oil slick detection and characterization on open water.
- Improve the modelling of oil behavior, transport and fate in open water and sea ice infested areas.
- Investigate the potential of remote sensing techniques for oil spill detection and characterization in sea ice-infested waters

Achievements in 2018

The year started well with a new two-year Norwegian-Russian research project being funded by the Research Council of Norway entitled "Oil spill and newly formed sea ice detection, characterization and mapping in the Barents Sea using remote sensing by SAR".

Researcher Malin Johansson participated together with Prof. Camilla Brekke at the ALOS PI Workshop organized by JAXA in Tokyo, Japan in January. Brekke, with contributions from colleagues at UiT and DLR, gave the following talk at the meeting: "Classification of Fram Strait Sea Ice by Synthetic Aperture Radar".

WP3 was well represented at SeaSAR 2018 in May in Frascati Rome. Members of WP3 contributed to four talks and posters at the meeting. WP3 contributed also to several other conferences and workshops in 2018. Examples are EUSAR in June in Germany and AMOP in October in Victoria, British Columbia, Canada.

Brekke was invited to give a keynote at ESA Cryosphere Remote Sensing Training Course in Longyearbyen, Svalbard in June. Several CIRFA PhD students participated in the course.

In June NOFO conducted their annual oil-on-water exercise, and WP3 PhD student Martine Espeseth was participating as an observer onboard the vessel Strilborg. She also visited NOFO headquarters while the exercise was on-going. This was a nice opportunity for her to observe how NOFO was conducting the on-shore activities like the logistics, status of the exercise, analyses of the satellite data received from KSAT, and the communication with the vessels at the exercise area. Representatives from the Norwegian Coastal Administration were also onboard the vessel Strilborg as they were responsible for one of the experiments during the exercise. This provided a great opportunity for Espeseth to do some networking also with this governmental agency that works with oil spill recovery. Satellite images were collected together with data (optical images and video) from airplanes. MET Norway (WP5) was also participating with different types of buoys that were released together with the oil slicks. During the exercise, KSAT collected data from different satellites, such as Radarsat-2 and COSMO-SkyMed. Additionally, data from the newer satellite missions PAZ and GAOFEN-3 was also acquired. These data sets were later analyzed by WP3.

The NOFO annual oil-on-water exercise is a well suited arena for KSAT, UiT and NOFO to jointly test out new satellite missions for oil spill monitoring. The 2018 oil-on-water exercise laid the foundation for a new innovation project involving KSAT, UiT and NOFO. Within this project, results from research in WP3 will be tested out in an operational environment under the up-coming oil-on-water exercise that is planned for June 2019.

A light-weight solution had been developed for data logging and remote data transfer from coastal regions. During her Ph.D. work, Megan O'Sadnick found that ice properties differ considerably between fjords. The constant thread of loss of monitoring equipment due to funnelled winds, strong currents and ice in fjords is now addressed by significantly reducing the capital investment. Multiple buoys based on the new concept were deployed toward the end of the year.

Several international research articles were published in 2018 by researchers within WP3 either as the lead author or as a coauthor. In particular, we would like to mention a study lead by Postdoctoral Research Fellow Stine Skrunes that was published in Remote Sensing of Environment in 2018 with the title "Effect of Wind Direction and Incidence Angle on Polarimetric SAR Observations of Slicked and Unslicked Sea Surfaces" and the joint WP3-WP5 Ocean Science publication lead by Johannes **R**öhrs at Met Norway with the title "The effect of vertical mixing on the horizontal drift of oil spills". Both studies can be tied to the NORSE2015 campaign.

Adjunct Professor Cathleen E. Jones is hired for two more years and continues to be associated with WP3. Jones contributes in research activities, seminars, supervision, and mentoring of female early carrier researchers.

Image: PhD student Martine Espeseth onboard Strilborg at Tananger terminal in Stavanger. Photo: Knut-Frode Dagestad, MET Norway

Image: Participants at the ESA Cryosphere Remote Sensing Training Course in Longyearbyen, Svalbard in June. Several CIRFA PhD students attended the course. Photo: Camilla Brekke

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Work package 4

RPAS TECHNOLOGY

Objectives and motivation:

Drifting sea-ice and icebergs may cause a threat to ships and installations in the high north, hence detailed knowledge of properties of sea ice and ice objects is critical for managing the operation in a safe and cost effective manner.

Both satellite based systems and RPAS (Remotely Piloted Aircraft Systems) have their strengths and weaknesses. Satellites have superior coverage and repeatability, but limitations when it comes to accurate fine spatial and temporal scale measurements of thickness distribution, drift, convergence and divergence. RPAS can achieve accurate high-resolution measurements, but have limited spatial coverage and range, and are weather sensitive. The systems needed by industrial operators in the Arctic should be robust and reliable, and the system should be able to handle disruption in service by individual components. This work package aims to develop robust and efficient RPAS and sensor technologies, that can handle the widest possible ranges of environmental conditions enabling high quality measurements of sea-ice and iceberg properties, as well as detecting and monitoring oil spills in ice affected areas.

Key research tasks:

- Develop platforms with improved take-off and landing capabilities, de-icing performance, wind tolerance, and fault tolerance.
- Improve communication links, robustness and bandwidth in Arctic RPAS operations.
- Develop RPAS sensors for sea ice characterization, ocean surface parameters measurements, and oil-in-ice detection.
- Develop onboard data processing and improve 'concepts of operation' allowing for integration in non-segregated airspace

Achievements in 2018

This year the prototype ultrawide band (UWB) radar prototype was upgraded by Prof Svein Jakobsen and Rolf-Ole Jenssen to allow for higher flight altitude (longer range). The system was successfully demonstrated to find buried objects and personnel under snow (simulated snow avalanche) to the National Road Authority.

A prototype stereo camera system and analysis software was built to enable 3D instant imaging. The purpose is to allow for accurate measurements of ice ridge volumes, freeboard and roughness. This is a lighter and less expensive solution than laser scanners. Has been tested on drone over land summer surfaces and will be tested on sea-ice in 2019.

Two field experiments used and demonstrated CIRFA technology. In October we performed a ESA funded demonstration of use of drones and broadband radio and satellite technology for maritime surveillance and real time situational awareness, streaming video and interacting with the data collection from Belgium when flying beyond line of sight. It also demonstrated integration of drones into airspace and real time coordination with air traffic control. This was tested successfully as an air ambulance had to pass through our flightpath and we went into a holding pattern to allow it to pass without delay, this was done through standar airband radio communication. This experiment was covered by the prime time NRK television news.

The other field experiment in April was funded by other NFR projects, where several CIRFA partners were involved, demonstrated real time mission control and data distribution when mapping sea-ice and ice-bergs in Kongsfjorden on Svalbard based on real-time data from ground based radar.

We collaborated with SPEC Inc from the US which conducted a field experiment in May 2018 where measurements of mixed phase cloud particles properties were conducted on UAS and tether Balloon flights in Ny-Ålesund. The purpose was to get realistic parameterization of mixed phase supercooled clouds for the aircraft icing modelling and experiments. We did not get to compare the measurements with icing aggregation in the field as they crashed their aircraft. But data from the balloon was collected.

Image: Field work WP4 (Photo: Rune Storvold)

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Work package 5

DRIFT MODELING AND PREDICTION

Objectives and motivation:

The objectives of this work package are to assimilate observations collected within CIRFA into forecast models for the ocean circulation and the sea ice, and to produce probabilistic ocean, sea ice and drift forecasts.

Ocean and ice forecasting at high latitudes, including the forecasting of drift of icebergs, oil-spills and other pollutants, is challenging due to the lack of observations, and improved operational forecast systems require increased amounts of high-resolution information and efficient algorithms for ingesting the observations into the ocean and ice models. Also, because of the observational uncertainties and the chaotic nature of the flow, the forecasts have to be probabilistic. Data assimilation and ensemble forecasting using coupled ocean-sea ice models is therefore central to the work in WP5. Other important contributions include collecting insitu data for validation of the models for oceanic transport, such as oil spills, and several field experiments with drifters have been executed.

Key research tasks:

- Develop, test, and utilize EPS-based ocean forecast system with variational data assimilation.
- Develop, test, and utilize EPS-based sea ice forecast system with Kalman filter data assimilation.
- Develop, test, and utilize EPS-based forecast system for Lagrangian drift (oil spills, icebergs, search and rescue).

Achievements in 2018

The coupled ocean-sea ice modeling system that has been developed in CIRFA was configured as an ensemble prediction system (EPS). PhD-student Sindre Fritzner integrated this modeling system with the assimilation algorithms already implemented for a standalone sea ice model, and extensive tests were made using observations of sea ice thickness, sea ice concentration and snow depth. The overall impact of assimilating snow depth was in our case limited compared to the impact of sea ice thickness and concentration. Assimilation of snow depth has to our knowledge not been tested before, and hence this work provides valuable information about what to expect from such data in an operational setting. The coupled ocean-sea ice model was also used in a nested configuration using an unstructured grid with very high resolution (100 m spatial scale). Such nested configuration could potentially be used for tactical predictions during offshore operations. The tactical sea ice prediction model of PhD-student Runa Skarbø was also finalized, and tested using observations collected previously for this purpose.

An observation operator for radial ocean current components has been implemented in a test version of the operational data assimilative ocean model run by MET Norway (with additional support from industry). This functionality will become part of the next system upgrade, and it will be used later on to assess the impact of SAR Doppler radial currents in close collaboration with WP1 researchers. Postdoc Ann Kristin Sperrevik also started work on assimilation of sea surface height satellite observations in collaboration with leading scientists in the US. Such observations are likely to prove of great value for constraining the mesoscale eddies on the continental shelf. She is currently visiting Rutgers University, New Jersey.

The software package OpenDrift, which is used at MET Norway for drift applications such as search-and-rescue and oil spill drift modeling, was further improved with better physics. In particular, the representation of oceanic turbulence was improved, which is highly relevant for oil spill drift predictions as it determines the vertical distribution of the oil. Since the ocean currents are highly sheared close to the surface, the oceanic turbulence plays an important role also for the horizontal dispersion. We also added functionality to calculate so-called Lagrangian coherent structures (LCS) that indicate whether or not floating material will convergence into filaments, thus leading to an anisotropic horizontal distribution of pollutants.

WP5 participated in two field experiments in 2018: the NOFO Oil-on-Water exercise in June and the Edvard Gried field experiment in September. In both cases we deployed drifters that sample the ocean currents at different depths, which provided valuable information about the upper ocean dynamics such as vertical shear and the transient response to changing weather conditions. During the Oil-on-Water exercise we also collected hydrographic data that were sent to MET Norway in near-real-time and used in the operational assimilative ocean model.

Image: Deployment of drifters during the Oil-on-Water exercise in June, 2018. CIRFA brought three different drifter types and our colleagues at Environment Canada provided an additional four types. Analysis of the data is still ongoing but preliminary results has already been published in Christensen et al. (2018). (Photo by Knut-Frode Dagestad).

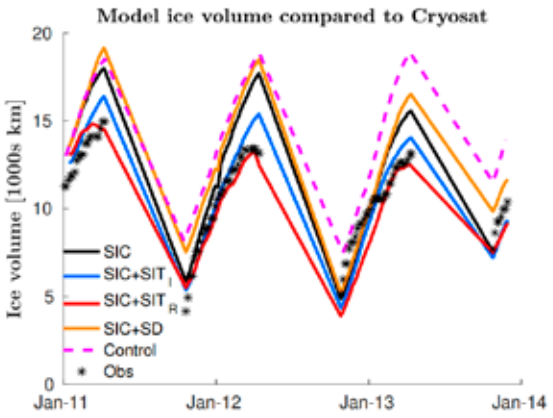

Figure: Results from sea ice data assimilation experiments (Fritzner et al., in review). The figure shows modeled and observed ice volume from several data denial experiments using sea ice thickness (SIT), sea ice concentration (SIC) and snow depth (SD).

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Work package 6

DATA COLLECTION AND FIELDWORK

Objectives and motivation:

Partners centrally involved in this work package are the Norwegian Polar Institute, Norut, and UiT The Arctic University of Norway. WP 6 functions as a validation and calibration platform for remote sensing data, as well as organizing the collection of ground truth data for assessing the work conducted in other work packages.

Aside new expeditions organized by CIRFA, also long-term monitoring data from land stations are used for calibration and validation purposes to support the remote sensing research. Examples of such auxiliary data sets obtained together with collaborating institutions, are archived data collected during previously conducted national and international campaigns, like N-ICE2015 (a half-year experiment where the research vessel "Lance" of the Norwegian Polar Institute was frozen into drifting ice in the Arctic Ocean north of Svalbard), annual campaigns of the Norwegian Polar Institute, NOFO's annual oil-on water exercises, and future data takes from the planned Arctic MOSAiC drift in 2019-20 www.mosaicobservatory.org, and the coming cruises within the Norwegian Nansen Legacy project www.nansenlegacy.org.

Hence, the objective of WP 6 is to design field campaigns in connection with satellite and RPAS measurements, and to carefully plan and conduct the measurements needed for calibration and validation of remote sensing products.

Key research tasks:

- Organize and implement dedicated field campaigns on Arctic sea ice, oceans, and oil spills to combine accurate direct measurements of surface properties, with data from remote operated aircrafts (RPAS or UAV), and satellites.
- Improve validation shortcomings by seeking and implementing new and refined measurement concepts and methods using new technologies and platforms.
- Provide quality ground-truth data from archives and new campaigns for assessing the theoretical work in other work packages.

Achievements in 2018

Work in WP6 in 2018 included planning and conducting Arctic fieldwork, as well as duties and scientific work that need to be done after the respective campaigns; including sample and data processing, and further on work with the data all the way to presentations and peer-review publications in scientific journals. The activity was closely coordinated with other work packages in CIRFA (WP2, 3 and 4). Post doc researcher Jean Negrel, Norwegian Polar Institute, who has 50% of his position in WP6, contributed to the work centrally with data processing and presenting and publishing of results, along with senior scientist Dmitry Divine and engineer Marius Bratrein, Norwegian Polar Institute, who participated in field campaigns on Svalbard and on the new Norwegian ice-going research vessel to the Barents Sea, Arctic Ocean and Fram Strait. Jean Negrel participated in the ESA cryosphere remote sensing training course 2018 at the University Centre in Svalbard (UNIS) in Longyearbyen (http://eoscience4society.esa.int/CTC18/).

Relation to users, stakeholders and research communities

Through fieldwork, CIRFA work was discussed and communicated with other scientists and non-scientists, through meetings before, alongside, and after the actual fieldwork, in Tromsø, Longyearbyen, on RV Kronprins Haakon and in Ny-Ålesund, Svalbard. Results from the project work in WP6 and collaborating WPs were disseminated in different ways: Presentations of results were given at important national and international conferences, workshops and seminars, thus reaching the scientific communities in different disciplines;Fram Day 2018, August 2018, Fram Centre, Tromsø, Norway; Seminar Mapping Sea Ice Characteristics Relevant for Arctic Coastal Ecosystems, Tromsø, Norway, October 2018; and AMAP Meteorology and Climate Workshop, Copenhagen, November 2018, . In addition, updates were also posted on social media on CIRFA`s website and @oceanseaicenpi (Instagram, Twitter, Facebook).

Fieldwork

CIRFA connected to three different sea-ice based fieldwork campaigns in 2018: A campaign in Kongsfjorden, working on landfast sea ice in the inner fjord, and two expeditions with RV Kronprins Haakon to the marginal ice zone north of Svalbard (Nansen Legacy Joint cruise 1-2, August 2018); northern Fram Strait), and to the western Fram Strait, the region where most sea ice that gets exported from the Arctic Ocean passes through (Norwegian Polar Institute annual Fram Strait monitoring cruise, August/September 2018). During the two cruises, planning and conducting in situ sea ice studies was closely coordinated with scientists back in the offices at CIRFA/UiT (Malin Johansson and others) and the Norwegian Polar Institute (Mikhail Itkin and others). From the offices, these scientists have much better access to remote sensing products than those on board of the research vessel. Therefore, they can investigate ice conditions and regional development of sea ice in much more detail, and give valuable advice.

The Kongsfjorden work was closely coordinated with WP2 of CIRFA and with the UAV survey done by the Norut team (collaboration with WP4). UAV flights flown simultaneous with in situ measurements were planned and conducted using input from field observations, and flight tracks were interactively adjusted depending on the shape and position of the fast ice edge in the fjord. Sea ice samples were taken, ice and snow thickness measured, and the exact shape of the ice edge mapped with GPS from a boat, this time along much longer lines than what we could manage earlier. Beyond new fieldwork, 2018 studies in WP6 included also data processing from data from the previous years of the CIRFA activity (2016-17, Fram Strait and Svalbard fjord studies). The results of the spring 2018 Kongsfjorden campaign were for the first time compiled in a test version of a free-access data portal featuring a user-friendly interface for data visualisation, and integrating in situ, UAV-based and remote sensing observations.

Peer-review scientific publications 2018

Parts of the work in WP6 ended up in scientific peer-reviewed publications which came out in 2018. Several of the publications are based on data collected during the N-ICE2015 expedition. First, two publications that were electronically appearing in late 2017 and reported in the previous annual report of CIRFA turned out to become 2018 publications (Negrel et al. 2018; Rösel et al. 2018). The new results from 2018 deal with mapping of sea ice areas with especially thin sea ice classes, relevant for climate research and shipping (Johansson et al. 2018); improved outreach of scientific results via social media such as the platforms Instagram, Twitter and Facebook (Meyer et al. 2018; Pavlov et al. 2018); Investigation of detection possibilities of ice classes around ridges and flooded sea ice, which are preferential features for ice algae and related part of the Arctic marine food web (Fernandez-Mendez et al. 2018); and detection and dimension retrivial of sea ice ridges in Fram Strait from satellite products (Yitayew et al. 2018). Publication work in WP6 was performed in close collaborations with other work packages of CIRFA, and partly also with other research projects.

Image: Sea ice fieldwork during Fram Strait cruise 2018 with the new Norwegian research vessel «Kronprins Haakon». Photo: Ann Kristin Balto, NPI

Image: Sea ice fieldwork during Fram Strait cruise 2018 with the new Norwegian research vessel «Kronprins Haakon». Photo: Ann Kristin Balto, NPI

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Work package 7

PILOT SERVICE DEMONSTRATION

Objectives and motivation:

Satellite-based operational capabilities including oil spill detection, ship traffic monitoring and sea ice mapping have been demonstrated and developed into regular use. However, there are still requirements for industrial maritime operations that have not been met.

Oil and gas companies operating in the environmentally sensitive Arctic areas need monitoring technologies integrated into their day-to-day operations for operational decision support. In this work package, we will demonstrate pilot services showing the provision of integrated environmental information to end-users involved in Arctic operations.

The objective of this work package is to demonstrate the implementation of R&D results into pilot services to be delivered to end-users with operational needs. The services will be based on multi-sensor data acquired from various sensors and platforms, accessed via improved communication infrastructure and brought into analysis and decision though dedicated interfaces.

Key research tasks:

- Establish an infrastructure that allows the WP partners to access and perform processing on the project data in a technically efficient way close to the data storage.
- Integrate the R&D results from the other WPs into service demonstrations at KSAT and/or MET to show the provision of integrated environmental information to end-users involved in Arctic operations.
- Develop a visualization solution associated with the integrated pilot services demonstrations.

Achievements in 2018

WP7 continues to support the other work packages in with data collection, development and testing of their analyses. Technical discussions with students continue to provide practical tips enabling better implementations that are easier to test in an operational setting.

Last year, KSAT made computing facilities available for CIRFA, which have been used for simple tests of individual algorithms. An object store solution has now been added to this to allow processing workloads which require large storage resources. The facilities at KSAT are being developed further, to add general cloud-technology services with virtualization layers and docker/container for dynamic processing resources and cloud-based interfaces for data access.

In addition to on-demand and near real-time experiments running at KSAT, CIRFA is gaining experience with using cloud based platforms such as the Copernicus Data Information and Access Service (DIAS) and the Polar Thematic Exploitation Platform (TEP) provided by ESA. These systems allow moving our algorithms to computing platforms where the entire Copernicus archive is easily available, supporting time series analysis of archive data. A supervised sea ice classification algorithm was tested on DIAS together with WP2 and demonstrated that such cloud based platforms are very relevant tools for operationalization of CIRFA information products.

SAR wind and wave information developed in CIRFA WP1 is provided operationally by KSAT. Improvements to the algorithms are continually being integrated into the KSAT processing chain by Norut. The information is also made available to CIRFA researchers on demand and has supported WP3 during the oil-on-water exercise in 2018.

In 2018, WP7 has mainly supported WP2. Collecting large scale training data for sea ice analysis is labor intensive. Vebjørn Karisari (a CIRFA graduated M.Sc. student) was hired as a WP7 engineer and is working together with WP2 and MET/NIS to assemble a solid and representative training dataset for developing sea ice analyses. This training data is not only important for CIRFA, but is also very important for the H2020 project ExtremeEarth where CIRFA is a partner.

Based on feedback from Equinor at the CIRFA Sea Ice Workshop, a simple demonstration showing near real-time point target detection has been set up. At the moment the system does not include any target labeling (ship/iceberg), but rather represents a first demonstration of a working end to end system. Feedback from industry partners will guide the continued development and validation.

MET has been running an unsupervised segmentation algorithm developed by UiT for several months. The experience is that the algorithm itself runs as intended, but the noise in the Sentinel-1 images are still a challenge for producing consistent results. We are evaluating different methodologies for correcting this noise and aim to have a working solution early next year. This should improve not only the segmentation, but contribute to any analysis based on Sentinel-1 data.

A simple web based visualization solution has been set up. We are testing products from different work packages to evaluate if the visualization tool is a good way of communicating CIRFA results.

Point target detection

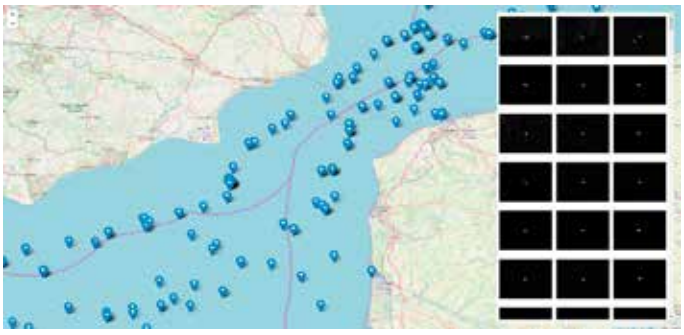

Image: A simple demonstration for SAR based point target detection has been set up as a starting point for evaluating ship and iceberg detection performance. (Image by UiT)

Segmentation at MET

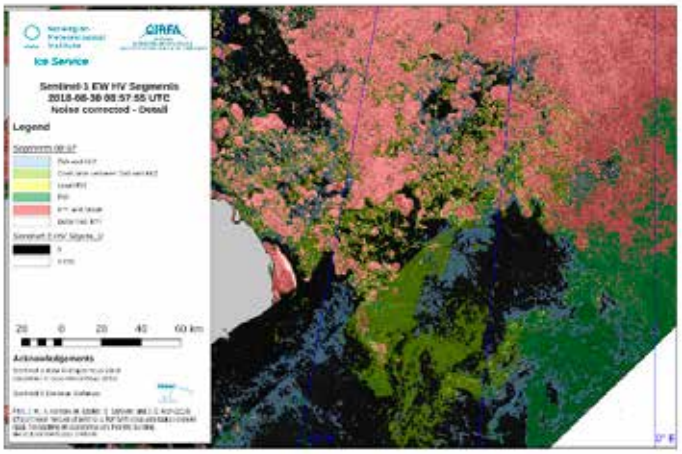

Image: The SAR segmentation algorithm is running on incoming Sentinel-1 images at METNorway and is being evaluated as part of the Ice Service operations.(Image by MET Norway)

FIELDWORK AND DATA COLLECTION

Brage

Productive collaboration between Wintershall, KSAT and UiT lead to satellite data collection taking place over the operational oil platform Brage from June to September. The platform legally releases produced water; a mixture of low concentration oil and water, and these releases can often be observed in satellite images. The platform is run by Wintershall and they kindly measured the concentration and volume of produced water being released at pre-determined intervals before the satellite image acquisitions. The platform also hosts two meteorological stations and the combination of know quantities of produced water, percentage of oil in the mixture and wind speed and direction means that we now have a very promising dataset to work with

Edward Grieg

In August a new ground-based radar, a so called ISPAS oil detecting radar, was tested out on the operational oil platform; Edvard Grieg. The platform and the radar system are run by Equinor and Lundin oil and a series of planned oil-on-water releases were conducted to test the ISPAS radar. In conjunction with these releases multi-frequency SAR and optical satellite images were acquired, and three different types of drifters were deployed. The satellite images were used to monitor the extent and drift of the oil spills and will be further compared with the ISPAS data.

OIBSAR (RCN, PETROMAKS 2)

The RCN PETROMAKS 2 project entitled Oil spill and newly formed sea Ice detection, characterization, and mapping in the Barents Sea using remote sensing by SAR (OIBSAR) kicked-off in April 2018 with Malin Johansson hired as a full time researcher on the project. Johansson is associated with CIRFA WP3 with links also to WP2. The project is a joint Norwegian-Russian project with P. P. Shirshov Institute of Oceanology Russian Academy of Science in Moscow as our main partner. The project has a particular focus on pollution from the petroleum industry & ship traffic and its look-alikes in the Barents Sea.

The Nansen Legacy (RCN)

The Nansen Legacy annual meeting 2018 took place in Bergen 20-22 November with approximately 130 participants. Prof. Camilla Brekke and Dr. Sebastian Gerland participated from CIRFA.

Mohammad Asim started as a PhD student on this project in December. His position is funded through The Nansen Legacy and he will also be associated with CIRFA WP1 and WP2. Mohammad is set to work on optical remote sensing from satellite combined with in-situ instruments for information retrieval about the water quality in the Northern Barents Sea. The project shall investigate the correlation between estimated Chl-a and the characteristic properties of sea ice in the marginal ice zone.

As a part of the first Nansen Legacy research cruise satellite images were collected to overlap with the in-situ data collection onboard R/V Kronprins Håkon. In-situ data consisted of both on the sea ice work, such as sea ice thickness and type data collection as well as sea ice observations made from the bridge onboard the research vessel. Collaboration with MET Norway and the Norwegian Polar Institute ensured that the in-situ data and the satellite images were collected in such a way that they will also aid the "H2020 Extreme Earth" project. Special attention was focused on the marginal ice zone an area of interest for all three organizations. The highly dynamic ice edge is of interest not only from a research perspective but also from a shipping perspective.

Image: From the Nansen Legacy Annual Meeting

Ultra Wideband Snow Sounder (UWiBaSS)

The ultra wide band snow sounder (UWiBaSS) is a ground penetrating radar developed for drone mounted operations. UWiBaSS will enable autonomous, drone based measurements of snow-cover over large, and hard-to-reach regions.

The task of extracting snow state parameters from sea ice sheets by manually digging snow pits, is a time consuming and potentially high risk- task, and yields low area coverage. A practical solution to this problem can be found by mounting an Ultra Wide Band (UWB) radar system onto a unmanned aerial vehicle (UAV) to obtain information about depth, density and stratigraphy of the snowpack. Hence, increasing personnel safety and extending coverage area.

Test results show that the radar system is capable of obtaining snow depth information, and works well while mounted on a UAV platform with little additional noise from vibrational movement.

The radar system has gone through several improvements over the last year. These include a significant weight reduction (approx. 1.5 kg), improved antennas with higher directivity, faster data acquisition code, live feed capabilities, improved power handling and filtering, onboard GPS logging position in a parallel process and a radiolink to ground for live data transfer.

During a campaign in Bardu (March 2018), the radar system was flown over a snow covered fresh water lake. The system was able to measure the snow and ice thickness of the lake.

Future work includes fixed wing implementation, further software development and antenna design.

The field work is performed in cooperation with Norut (Northern Research Institute) where a specially build octocopter drone was built for the purpose of carrying the UWiBaSS as payload.

Image: Radar system mounted on Octocopter UAV "Kraken" (Photo: Rolf Ole Rydeng Jenssen).

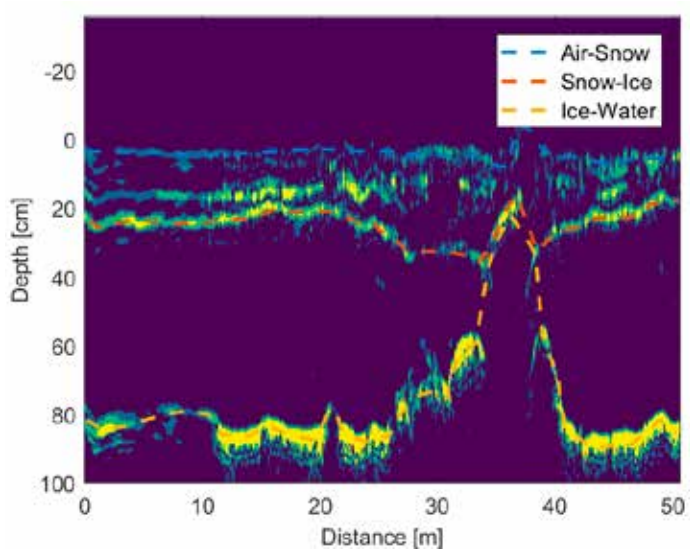

Figure 3: 50 m transect of snow covered fresh water lake where snow and ice thickness is measured. This transect is passing over a small peninsula.

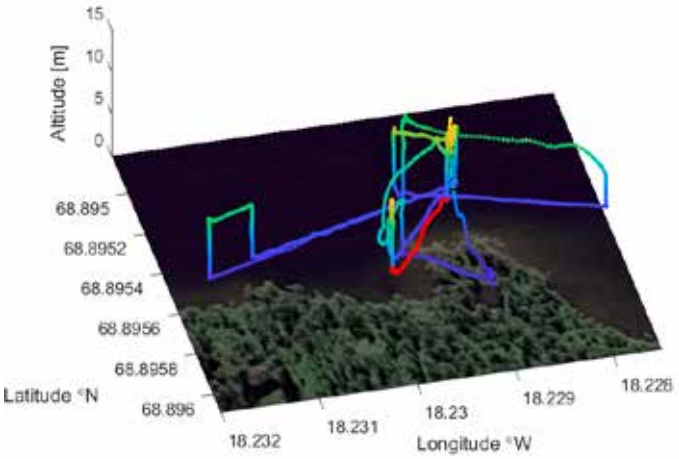

Image: Map position of transect in Figure 4. Red line shows the transect, blue/yellow line is the full flight path. (Image by Rolf Ole Rydeng Jenssen)

EXTREME EARTH: AN UPCOMING H2020 PROJECT

Two of CIRFA's research partners, UiT and Met Norway, are also partners in the H2020 project ExtremeEarth, which was granted funding by the EU Commission last August. This project aims at developing *"Extreme Earth" Analytics techniques and technologies* that scale to the petabytes of big Copernicus data, and applying these technologies in a Food Security Use Case and a Polar Use Case using the affiliated ESA Thematic Exploitation Platforms (TEPs). Keywords defining the project are: *Deep Learning Algorithms, Big Data, and Cloud Computing*. The project shall advance the state-of-the-art in the area of multimodal remote sensing by developing distributed, scale-out deep learning techniques for the classification of remote sensing data based on architectures that can effectively exploit the spatial, spectral, and temporal properties of Sentinel data.

The CIRFA partners are heavily involved in the Polar use case, where the work is aimed at producing high resolution ice maps over the entire Arctic from massive volumes of heterogeneous Copernicus data. Scalable deep learning algorithms will here be tailored for sea ice classification, and integrated in the Hops (Hadoop Open Platform as a Service) data platform to produce high resolution ice information products from Sentinel and supportive data.

The project nicely supports CIRFA's work in WP2, WP6, and WP7.

The ExtremeEarth consortium consists of: National and Kapodistrian University of Athens (EL), University of Trento (IT), UiT the Arctic University of Norway (NO), KTH (SE), National Center for Scientific Research – Demokritos (EL), Norwegian Meteorological Institute (NO), the German Aerospace Center (DLR) (DE), Vista (DE), Polar View (UK), British Antarctic Survey (UK), and Logical Clocks (SE). The consortium is led by the National and Kapodistrian University of Athens, and starts in January 1, 2019 and will have a duration of three years.

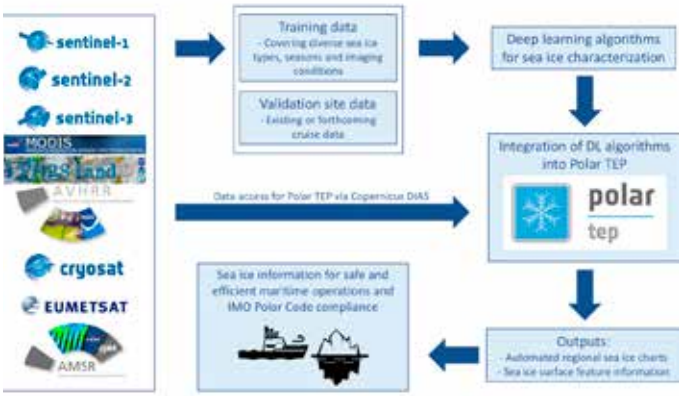

Image: Use of EO big data to derive new sea ice informatio

Image: from kick off meeting january 2019

EDUCATION AND TRAINING

Arctic Field Summer Schools
Norway–Canada–USA Collaboration

CIRFA received support to establish "Arctic Field Summer Schools", a project that will engage graduate students from Norway, USA and Canada in exploring science questions related to Arctic challenges through a series of summer schools.

This **INTPART** project supports research and education collaboration among UiT the Arctic University of Norway, University of Alaska Fairbanks (UAF), USA and University of Calgary (UC), Canada. Three summer schools will engage graduate students in exploring science questions related to Arctic challenges, and give the education partners material that can be used in their university teaching courses and publications.

The **first field school** in the Spring of 2017 included a one-week field cruise on board R/V Lance to the ice edge north-west of Svalbard, plus a one-week workshop in Tromsø. The school introduced the 15 students to in situ water, snow and ice sampling techniques, plus UAV/drone and satellite remote sensing, on drifting Arctic sea ice.

The **second field school** in the summer of 2018 included a ten-day field course in Utqiaġvik (Barrow), on the North Slope of Alaska, plus a one-day workshop in Fairbanks. This year's focus was land-fast sea ice, lagoon ice, and the coastal environment. The course introduced the 16 students to techniques for snow, lake and ice thickness monitoring, snow pit and ice coring measurements, lake/sea water sampling, UAV/drone and satellite images acquisition/processing, image time sequences (histories and change), navigation and safety in the Arctic, as well as cultural and general awareness. Lecture topics included marine mammals, Arctic-global connections and amplified Arctic warming in the global context, plus the adaptation of indigenous people in the Arctic to the changing environment. An outreach 'Soup and Science' event during the field part of the course in Utqiaġvik gave the students the opportunity to connect with people living and working in Utqiaġvik. The workshop in Fairbanks consisted of student project reports and attracted a number of listeners from UAF and Fairbanks in general. A reporter from Alaska Public Media followed the group to Utqiaġvik and created two web media and voice pieces based on the material she collected and played statewide on the radio. The students were very active participants throughout the course and workshop and submitted reports in the months following. The reports demonstrated that the students have learned the connections between field measurements and remote sensing imagery, and the 'big picture' perspective relating to Arctic monitoring and the climate. Several students expressed their interest in continuing the international scientific collaboration that began during the course. A joint data repository has been set up at UiT to share the data-sets (field data, satellite imagery, lectures, reports) collected during the course. By all reports from participants and partners, this year's field school appears to have been a great success.

The final field school will be a Capstone Synthesis Workshop at Kluane Lake base, Canada, in June 2019. The school will add Glaciers to our Arctic topics, and re-visit the sea ice and snow topics already covered in the first two field schools.

Measuring ridge height profiles by laser. (photo A. Doulgeris)

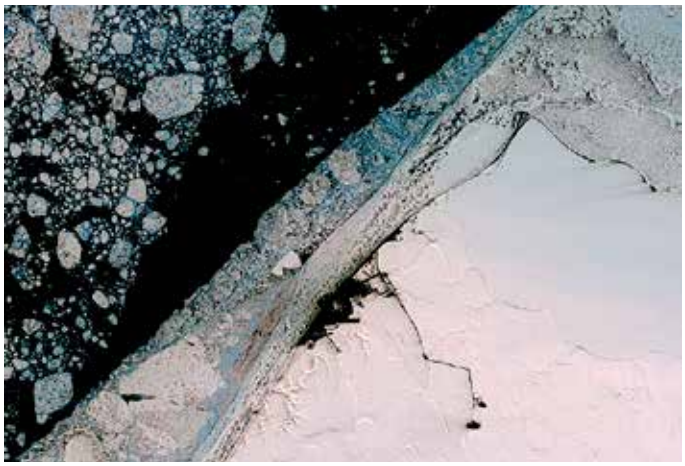

Image: Barrow Alaska from Sentinel-2. (image preview A. Doulgeris)

ESA cryosphere remote sensing training course June, 2018

As part of the Earth Observation Science for Society – Scientific Exploitation element of the EOEP-5 program, the European Space Agency (ESA) organized an advanced training course on remote sensing of the cryosphere at the University Centre in Svalbard (UNIS) in Longyearbyen. CIRFA was well represented with several PhD students and PostDocs, who learned how to use a wide range of sensors and techniques to measure the Arctic environment. Lectures were also presented by Prof. Camilla Brekke (CIRFA / WP3) and Penelope Wagner from our CIRFA partner MET/Norwegian Ice Service. http://eoscience4society.esa.int/CTC18/

CIRFA students and post-docs in front of the Sentinel-1 downlink antenna at KSAT's Svalbard station. Photo: Anja Strømme

Science and Advanced Technology in the Arctic (SATA).

CIRFA is involved in a "Norwegian Russian Triple Helix PhD Course" at UiT, called Society and Advanced Technology in the Arctic (SATA) (Project leader Prof. Rasmus Gjedssø Bertelsen, UiT). This project will train Norwegian and Russian PhD students and Master's students (graduate students) across social sciences, humanities, natural sciences and technology in analysis and problem-solving concerning the interplay of society and advanced technology in the Arctic.

The topic is transdisciplinary application of fundamental research for improving living conditions in the Arctic using advanced technology (especially remote sensing and spacebased technologies). The graduate students are supposed to be challenged to develop socio-technical solutions moving between demands and possibilities of society, economy, culture, regulation, natural science and technology. In 2018, the course was in Tromsø at UiT and Thomas Kræmer (Head Engineer), Malin Johansson (Researcher) and Johannes Lohse (PhD) from CIRFA were involved and gave presentations. In 2019 the course will be in Longyearbyen and in 2020 the course will be in Moscow.

Young Scientist Forum

The CIRFA Young Scientist Forum offers PhD fellows and PostDocs within CIRFA an excellent opportunity to acquire new, complimentary skills in a relaxed and informal setting. As well as this, the event is also designed to encourage dialogue between participants about their ongoing research and to discuss current problems and future avenues of inquiry that may be explored. The CIRFA YSF 2018 took place on the 16 March in the Vilmarksentret on the island of Kvaløya just outside Tromsø. The event included presentations from Martin Skedsmo from Norinova and Kent Nordby from the Institute of Psychology. Martin talked about the topic of innovation and demonstrated the process of taking a scientific idea to market while bypassing the traditional route of applying for a patent. An exercise was also conducted where participants had to create a commercially viable satellite derived product and go through the Declaration of Invention (DOFI) process. Ken talked about the topic of time and stress management and was able to highlight some of the pitfalls that PhDs fall into, in terms of managing their time, when conducting their PhD. The entire event also included team participation exercises throughout the day.

Image: CIRFA students and post-docs at the YSF 2018

PhD thesis completed on projects in the centre

Name	Title of thesis
Temesgen Yitayew	Investigation of Sea Ice Using Single and Multiple Synthetic Aperture Radar Acquisitions
Jakob Grahn	Multi-frequency radar remote sensing of sea ice

Image: From Temesgen Yitayew`s defense

Image: From Jakob Grahn`s defense

M.Sc. thesis completed in centre in 2018

Name	Title of thesis
Magnus Wilhelmsen	Classification of Marine Oil Spills and Look-alikes in Sentinel-1 TOPSAR and Radarsat-2 ScanSAR Images.
Vebjørn Karisari	A Sensitivity Study of L-Band Synthetic Aperture Radar Measurements of the Internal Variations and Evolving Nature of Oil Slicks.
Magnus Hvidsten	Comparing sea ice areas identified within quad-polarimetry high-resolution SAR satellite scenes with the same areas in dual-polarimetry medium resolution SAR scenes.
Stein Cato Lindberg	SAR imaging and detection of partially coherent targets
Ole Baadshaug	Iceberg Drift-Trajectory Modelling and Probability Distributions of the Predictions
Jon Anders Hallaråker	Incidence Angle dependency in SAR

OUTREACH

CIRFA seminars

The topics addressed during the seminars in 2018 were:

- Examination of Sea Ice Cover in Norwegian Fjords and its Application to Oil Spill Response Activities, Megan O'Sadnick, Norut Narvik.
- Norwegian Space Centre and its activities towards ESA and the Copernicus program, including the national ground segment, Anja Strømme, Norwegian Space Centre.
- Sea Ice Image Generation and Analysis based on Arctic SAR Data and Generative Adversarial Networks. Ding Tao, School of Information Science and Technology, Fudan University.
- Modern 3D SAR Imaging Options, Prof. Dr. Andreas Reigber, Department of SAR Technology, DLR.
- Overview of research topics at the Radar Remote Sensing Group at Chalmers, Leif Eriksson, Department of Space, Earth and Environment, Microwave and Optical Remote Sensing.
- Innovation – application of CIRFA results as seen from the industry, Edmond Hansen, Multiconsult.
- Satellite-based sea ice products – near-real-time production towards climate data records, Signe AABOE, MET.no.
- KSAT oil spill detection service, Line Steinbakk, KSAT.
- Machine Learning Gaussian Process Regression for Remote Sensing Applications, Katalin Blix, UiT.
- Ocean Current from Spaceborn Radars – challenges and opportunities, Harald Johnsen, Norut.
- The role of (sub-)mesoscale dynamics in high-resolution sea ice drift forecasts, Tore Hattermann, Akvaplan Niva AS.

Conferences/Workshop

- Arctic Frontiers 2018
- MOSAiC Implementation Workshop, Potsdam, Germany, May 2018
- European Geosciences Union 2018 (EGU)
- POLINSAR 2018
- 12th European Conference on Synthetic Aperture Radar (EUSAR 2018)
- SeaSAR 2018
- Shanghai FORUM 2018
- BAR, the 3rd Digital Belt and Road Conference
- International Geoscience and Remote Sensing Symposium (IGARSS) 2018
- Atmospheric and Space Environments Conference
- AIAA AVIATION Forum
- The 18th international conference on harmful algae – From ecosystems to socio-ecosystems; 2018-10-21 – 2018-1026
- Mapping Sea Ice Characteristics Relevant for Arctic Coastal Ecosystems, Workshop
- 3rd DBAR Conference, December 2018
- 1st EARSEL UAS for mapping and monitoring workshop, Warszaw, Poland, Sept 5-7th 2018
- IICWG-XIX Meeting, Helsinki, Finland, September 24-28th, 2018
- AGU Annual Meeting, Washington DC, USA, December 10-14th, 2018.
- Fram Sea-Ice Workshop, Tromsø. Norway, October 30th,2018

Tromsø commune

Representatives from Tromsø-, Trondheim- and Stavanger municipality were visiting CIRFA in 2018. The idea was to discuss how different approaches may provide basis for innovation. In this meeting Camilla Brekke and Thomas Kræmer presented the different research areas within CIRFA and the SFI scheme.

Oulu business school

A delegation from Oulo business school and representatives from UiT visited CIRFA in 2018 and presented a project called "Cross-border cooperation on innovation – A joint taskforce". Five main universities of Northern Finland, Sweden and Norway are involved in this joint taskforce where the idea is to improve networking between academia, local and regional authorities, business development organizations and firms. UiT is one of the universities involved.

CIRFA Annual Conference

CIRFA arranged its third annual conference at Sommarøy Arctic Hotel in October 2018. About 60 participants attended the conference. CIRFA partners, collaborating institutions and companies were represented at the Conference.

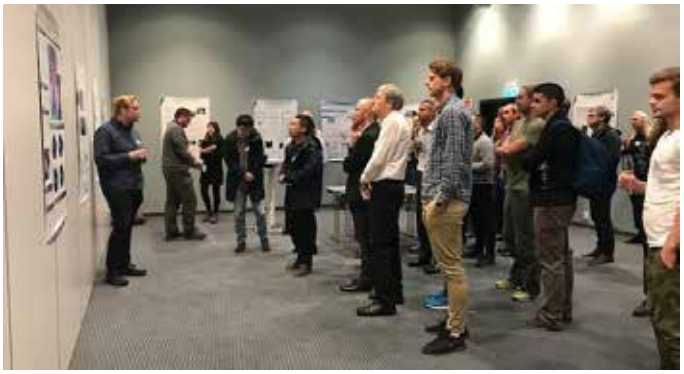

Image: From the CIRFA Annual Conference at Sommarøy (Photo: Lise Nordgård)

Image: From the CIRFA Annual Conference at Sommarøy (Photo: Lise Nordgård)

OPPORTUNITIES ABROAD

Research exchange to Jet Propulsion Laboratory (JPL)/NASA

Name:
Martine Mostervik Espeseth

Current education:
PhD in Oil Spill Remote Sensing WP3 at CIRFA

In the period August to December 2019 Martine went on a research exchange to Jet Propulsion Laboratory (JPL)/NASA together with Camilla Brekke. JPL is a research and development center and NASA field center located in Pasadena, California, USA.

Throughout the stay Martine and Camilla worked closely with Banjamin Holt and Cathleen E. Jones, researchers at JPL. Martine's focus was to analyze a time series of Uninhabited Aerial Vehicle Synthetic Aperture Radar (UAVSAR) scenes that were acquired in the Gulf of Mexico showing a persistent large oil seep. The UAVSAR instrument is from JPL, and was also used in the oil-on-water exercise in 2015 outside the Frigg field in the North Sea. The goal was to explore methods for extracting information from a SAR time series of evolving oil in terms of spreading and weathering. These methods demonstrated the importance of a time series compared to a single scene of an oil spill. This study was submitted to the journal "IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing" after the stay.

Almost every week, a special interest meeting for discussions related to oil-spill remote sensing was held at the JPL campus. The purpose of these meetings was to discuss and present current research, and to identify possible issues and further try to resolve these together.

The exchange to JPL has provided Martine with a great opportunity to focus on her research within oil spill remote sensing and to further strengthen the collaboration with Cathleen E. Jones and Benjamin Holt.

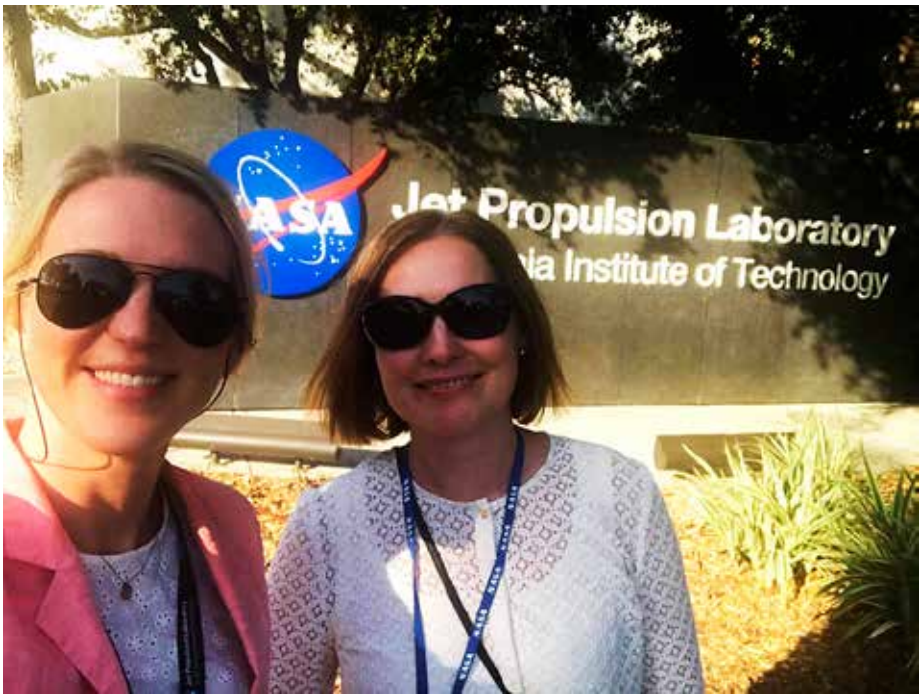

Photo: Martine Espeseth and Camilla Brekke

Research visit at Balaton Limnological Institute (BLI) – Katalin Blix

Name:
Katalin Blix

Current education:
PhD at CIRFA

Tihany and BLI
In 2018 I was a visiting researcher at the Hungarian Academy of Science, Center for Ecological Research, Balaton Limnological Institute. The institute is located by Lake Balaton, on Tihany Peninsula, known for its special Mediterranean climate and lavender fields. BLI has over a century of experience in conducting limnological (lake related) research in an interdisciplinary environment. They have in house laboratories, equipment's, their own boat, a team of experts with a wide range of background and even guest accommodations.

My apartment was literally next to the institute with a view to the lake. I enjoyed the amazing sun rise over Lake Balaton every morning with a cup of coffee from my own room. My neighbors were my colleagues, which made the visit very social. My office was just a step away of the beach. This came quite handy at the summer time, when the only way to survive the heat and humidity was to take a dip in the lake. This is common practice among the employees of the institute.

The work
My project aims to develop algorithms to monitor water quality in challenging aquatic environments, such as coastal and Arctic waters. This requires data and knowledge about the properties of these waters. It turns out that Lake Balaton is very unique. It is representative for a great variety of aquatic environments in terms of optical - biophysical properties. The goal of the visit was to collect data, develop the model, and after the visit evaluate its robustness.

Field work
I borrowed a TRIOS Ramses hyperspectral radiometer from NORUT. This was used to scan the lake, while collecting in situ water samples. We started the field work by steaming to the western most part of the lake, to the first station. At station, we took the measurements. Then we visited every station on the lake, representing different kind of water properties. It was amazing to experience how rapidly water color and conditions can change.

Outcome
I learned to collect in situ samples, process the data and match it with satellite measurements. Most importantly, the team taught me how to interpret the data. The results were not only model outputs anymore, but they were representing the biophysical signatures of the lake. For me this is the greatest value one could possibly gain from a research visit.

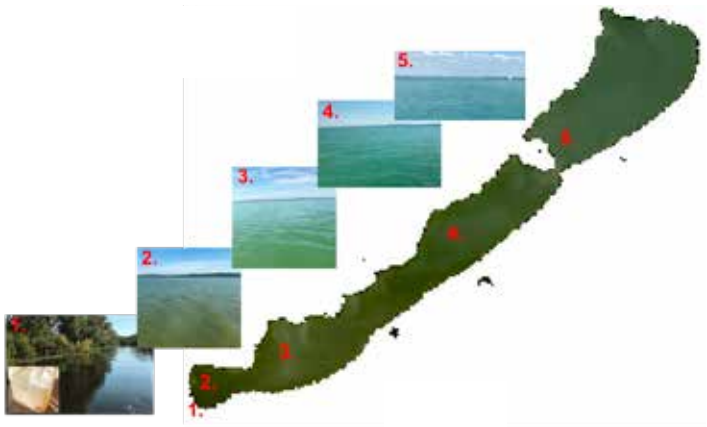

Image: Colortransition (image by Katalin Blix)


Image: Fieldwork together with the Captain

COLLABORATION WITH CIRFA PARTNERS

Visit at the Meteorological Institute

The Norwegian Ice Service provides regular feedback and helpful insights. Within the project on supervised classification of sea ice types, CIRFA engineer Vebjørn Karisari and PhD student Johannes Lohse from WP2 visited the Norwegian Meteorological Institute in December. The meeting started with a short presentation by Johannes on the classification strategy, including image examples as well as key issues and open questions. Afterwards followed a discussion and joint visual interpretation of various Sentinel-1 EW images and overlapping optical satellite data. One of the key issues is the identification of different ice types for training areas in the SAR and in the optical data. The expert knowledge of our partners from the ice service was very helpful to better identify more ice types in the images and to understand abundances of particular ice types in certain areas. Furthermore, the ice service expressed interest in a semi-operational product for ice type classification that will result from this work in the future. MET have also provided Ingrid Solli high resolution data and iceberg observations for her continued work on iceberg detection from SAR.

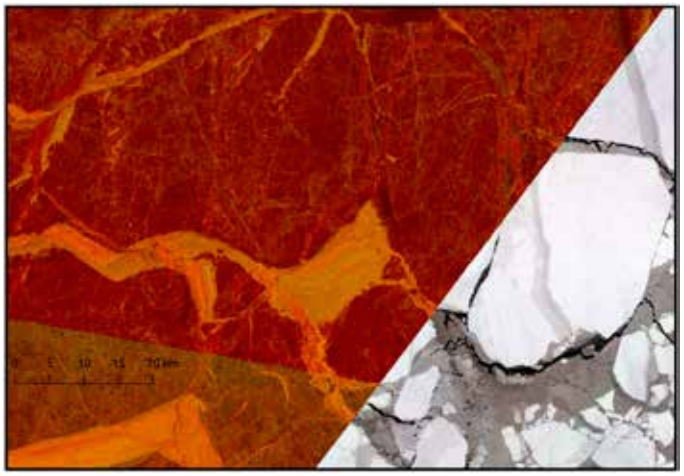

Figure: Sentinel-1 image (R-HH, G-HV) over sea ice north of Svalbard on April 3rd, 2018. In the lower right corner, optical data from Sentinel-2 is overlaid. The time difference between the images is less than 15 minutes. The images mostly level FYI, interrupted by leads in which young sea ice has formed.

KSAT

In August, WP7 was invited to attend a half-day meeting between Equinor and KSAT. The meeting was intended to give KSAT operators an understanding of Equinor's monitoring including to ice observations from satellite. For CIRFA this was a nice opportunity to have discussions on operational requirements with representatives from an industry end user (Equinor), a service provider (KSAT) and a research partner (UiT).

Image: SAR wind and wave algorithms by Norut has been fully integrated at KSAT and is running operationally as part of KSAT's oil spill service (Photo:KSAT)

Sea Ice Remote Sensing, Workshop

CIRFA organized a thematic workshop at a hotel at Gardermoen Airport in September 2018 with focus on sea ice remote sensing.

The objectives of the workshop (WS) were to present the activities and status of sea ice research in CIRFA, and to discuss and clarify the industries' needs. The WS's format was intended to allow for a free and open discussion between researchers in CIRFA involved in the sea ice WP, and experts within the User Partners (UPs), who have good insight into the users' needs on sea ice information.

Image: From the Sea Ice Workshhop at Gardermoen (Photo: Lise Nordgård)

International Collaboration

CIRFAs international network is largely based on the network the partners themselves have established. Some are listed bellow:

- Alfred Wegner Institute (Germany)
- Jet Propulsion Laboratory (USA)
- DLR (Germany), JAXA (Japan)
- University of Rennes (France)
- CLS (France) IFREMER (France)
- OceanDataLab (France)
- Chalmers University (Sweden)
- ONERA (France)
- University of Alaska Fairbanks (USA)
- University of Calgary (Canada)
- SMHI (Sweden)

Visiting senior researchers from other countries in 2018

Name and position	Organisation	Nationality
Cathleen E. Jones, Adj. Prof	Jet Propulsion Laboratory	USA
Wolfgang Dierking, Prof.	Alfred Wegner Institute	GE
Laurent Ferro-Famil, Adj. Prof.	University of Rennes 1	FR
Suman Singha, Researcher	German Aerospace Centre	GE
Ding Tao, Assoc. Prof.	School of Information Science and Technology, Fudan University	CN
Fabrice Collard	Ocean Data Lab	FR

MIDWAY EVALUATION

In 2018 and 2019 CIRFA will be evaluated by an international team of experts as part of the mandatory midway evaluation for all SFI`s. In December 2018, the CIRFA management and CIRFA`s partners submitted the evaluation forms to the Research Council of Norway. The written documentation and discussions during the upcoming site visit in April 2019, will form the basis for a decision by the Research Council about whether Centre will get funding for the remainder of the overall eight-year term, or to wind it up after five years. The results will be published in late summer.

CIRFA RESEARCH FELLOWS

Vegard Nilsen
PhD Fellow Norut

Johannes Lohse
PhD Fellow, UiT

Ingri Halland Soldal
PhD Fellow, NERSC

Martine M. Espeseth
PhD Fellow, UiT

Cornelius Quigley
PhD Fellow, UiT

Marianne Myrnes
PhD Fellow, UiT

Richard Hann
PhD Fellow, NTNU

Rolf-Ole Jenssen
PhD Fellow, UiT

Sindre Fritzner
PhD Fellow, UiT

Runa Skarbø
PhD Fellow, NTNU

Muhammad Asim
PhD Fellow

Jakob Grahn
Associate PhD Fellow, UiT

Katalin Blix
Associate PhD Fellow, UiT

Xu Xu
Associate PhD Fellow, UIT

Temesgen G. Yitayew
Associate PhD Fellow, UIT

Megan O'Sadnick
PhD Fellow, Norut Narvik

Stine Skrunes
Postdoc, UiT

Jean Negrel
Postdoc, NPI

Vahid Akbari
Associate Postdoc, UiT

Ann Kristin Sperrevik
Associate Postdoc,
Met Norway

Malin Johansson
Researcher

Anca Cristea
Researcher

Saloua Chlaily
Researcher

FINANCES

Funding sources

The Research Council	12 660
Industry partners	6 132
The Host Institution (UiT)	7 479
Research partners	2 960
Total	29 231

Costs per activity

Management	4 998
WP1 Ocean RS	2 146
WP2 Sea Ice RS	3 898
WP3 Oil Spill RS	6 655
WP4 RPAS Technology	4 464
WP5 Modeling and prediction	5 025
WP6 Field work and data collection	1 290
WP7 Pilot Service Demonstration	756
Total	**29 231**

Costs per partner

Research partners:	
UiT/NT	12 552
Norut	4 212
Norut Narvik	2 470
NTNU	2 288
Norwegian Polar Institute	1 812
Met.no	3 109
NERSC	1 191
Industry partners:	
Equinor	368
Vår Energi	73
Total E&P Norge	206
OMV Norge	174
Aker BP	110
Aker Solutions	143
Multiconsult	169
KSAT	353
Spacetec	
Maritime Robotics	
Aranica	
Globesar	
Total	**29 231**

PUBLICATIONS 2018

Peer reviewed publications

Blix, K., Pàlffy, K., Tòth, V.R., and Eltoft, T. (2018) *Remote Sensing of Water Quality Parameters over Lake Balaton by Using Sentinel-3 OLSI.* Water, *10*, 1428; https://doi.org/10.3390/w10101428

Blix, K., Eltoft, T. (2018) *Evaluation of feature ranking and regression methods for oceanic chlorophyll-a estimation.* IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 11: 1403-1418; https://doi.org/10.1109/JSTARS.2018.2810704

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About the SFI scheme

The main objective for the Centres for Research-based Innovation (SFI) is to enhance the innovation in the industry sector through long-term research based on close collaboration between industry and academic partners.

The SFI scheme will:

- Encourage enterprises to innovate by placing stronger emphasis on long-term research and by making it attractive to establish R&D activities in Norway.
- Facilitate active alliances between innovative enterprises and prominent research groups.
- Promote industrially oriented research on the cutting edge of international research.
- Stimulate researcher training in fields relevant to the industry, and encourage the transfer of research-based knowledge and technology.

The SFI centres are managed by the Research Council of Norway (RCN), and are co-financed by the host institution, partners and the RCN. The centres are established for a period of maximum eight years.

Photo: Johannes Lohse