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**Winter and summer seasonal forecasts of the pan-Arctic and regional sea ice cover with a coupled atmosphere-ocean model**

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The state-of-the-art CNRM-CM5.1 coupled global climate model is used to perform ensemble seasonal forecasts of the Arctic sea ice cover. CNRM-CM5.1 is developed jointly by Météo-France (CNRM-GAME) and CERFACS and is used to produce centennial climate projections as well as seasonal-to-decadal climate forecasts. CNRM-CM5.1 includes the ARPEGE-Climat spectral atmospheric model, the SURFEX platform for surface processes modeling, the NEMO ocean dynamics component and the GELATO multi-category sea ice model. The resolution of the ocean-sea ice component is roughly 50km in the Arctic ocean. Ensemble seasonal forecasts of March and September Arctic sea ice cover are initialized on November 1st and May 1st. Initial states are provided by a NEMO-GELATO forced simulation driven by ERA-Interim atmospheric forcing. Skills of seasonal hindcasts over the period 1990-2009 are promising for both summer and winter predictions of the pan-Arctic sea ice extent, in spite of model biases. In the present talk, we address the performance of the system using several metrics. We especially assess the fraction of pan-Arctic sea ice predictability due to the initial conditions alone ('predictability from initial value'), and show that the long-term trend does not explain all predictive skills of our system. We finally address system performance in forecasting the winter sea ice conditions in the marginal ice zones (Barents Sea, Baffin-Labrador area, Bering and Okhotsk seas). Winter forecasts are especially skilful in the Barents Sea, and we discuss whether model-based forecasts such as ours could be beneficial for operational planning in this area.

CERFACS : Centre Européen de Recherches et de Formation Avancée au Calcul Scientifique. Toulouse, France.

**Long term Baltic Sea ensemble ice forecasts: current state and future prospects**

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Long term forecasting offers significant cost reduction possibilities and safety benefits for winter navigation. A Baltic Sea seasonal ensemble forecasting system has been set up and tested in order to develop a more accurate forecasting system and easy to use forecasting products. In this work the feasibility of the ensemble approach for long term forecasting and the future plans for the system
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The system is based on a general circulation model MITgcm with an integrated ice module MITgcm/sim. The seasonal forecast is forced by European Centre for Medium-Range Weather Forecasts (ECMWF) ensemble forcing. Ensembles in our study were created from an unperturbed initial ocean condition by running the model several times with perturbed sets of weather forcing. The forecasting system produces probabilistic predictions including sea surface temperature, ocean currents, sea-ice thickness and ice concentration.

U.S. Navy Arctic Cap Nowcast Forecast System

Sean Helfrich, National Ice Center

No abstract received.

Towards a quality-controlled sea ice drift product generated from SAR data

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Sea ice drift can be automatically determined from a sequence of SAR satellite images. We use a pattern-based multi-resolution cascaded motion tracking algorithm to determine sea ice drift from SAR images. Without field data for validation, it is difficult to assess the accuracy of the derived drift product. The cross-correlation coefficient is often used as a measure for the reliability of the result. It can be shown that it is not a robust criterion for the quality of the drift vectors. We will present an improved quality measure which integrates image statistics and texture as well as a consistency check for the drift estimate and show examples from the Ronne Polynia (Antarctica).

Twenty Years of Imaging the Arctic: Synthetic Aperture RADAR Imagery from 1991 to 2011 from the Alaska Satellite Facility

Vicky Wolf, Alaska Satellite Facility

The Alaska Satellite Facility archive contains extensive synthetic aperture radar data from around
the globe. Data are available online through the Vertex interface for download. The Vertex interface was built specifically to enable data discovery of downloadable data. The greatest depth of coverage occurs in the Arctic region. As a downlinking station for real-time data collections of ERS-1, ERS-2, JERS-1, RADARSAT-1, and ALOS PALSAR, ASF acquired data for use by researchers and operational agencies. Data acquisitions started in 1991 with the launch of ERS-1 and continued until the loss of ALOS in April 2011. There is coverage of the Bering Strait and the Bering Sea as well as the Chukchi Sea and Arctic Ocean over twenty years that can used by researchers interested in the changing ice dynamics of the Western Arctic.

Examples of in situ calibration and validation of satellite remote sensing observations over Arctic first year sea ice

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Large areas of the Arctic Ocean are covered with sea ice, and the sea ice extent, concentration and properties change seasonally, interannually and on longer time scales. The Arctic Ocean is often difficult to access, making satellite remote sensing the only means to obtain information about the sea ice on a pan-Arctic scale. In order to process and interpret satellite data and imagery sufficiently, in situ calibration and validation are necessary. In April and May 2011, measurements on first year sea ice north of Svalbard were performed during two scientific cruises with the ships KV Svalbard and RV Lance, respectively. In parallel, high resolution SAR satellite images, satellite altimeter data, and airborne measurements were obtained over the research area. Different high resolution SAR satellite products, including quadpole Radarsat images were obtained for developing and testing sea ice classification methods. Different signatures of radar signals were identified, and corresponding in situ and airborne measurements were made concerning snow and ice thickness, snow and ice physical properties, and surface roughness. Preliminary results show several distinguishable sea ice classes. Calibration and validation experiments are also crucial for use of advanced radar altimetry for sea ice thickness calculation. Recently, the ESA radar altimetry satellite CryoSat-2 was launched. One of the aims of the satellite is to retrieve freeboard levels, meaning the distance between sea ice surfaces and ocean. Knowing the freeboard, ice thickness can be calculated, assuming hydrostatic equilibrium and certain snow, ice and water densities. In the
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Experiment in spring 2011 detailed measurements of snow and ice thickness, freeboard and snow density were performed. Data are currently being integrated with satellite data and airborne observations from a Twin-Otter flight carrying the ASIRAS system, a radar sensor similar to the radar on board the satellite. The status of this ongoing work will be presented.

Current status of SAR data assimilation at EC

Lynn Pogson and Tom Carrières (Environment Canada - Canadian Ice Service), Mark Buehner (Environment Canada - Data Assimilation and Satellite Meteorology)

Satellite borne SAR is a primary data source for ice information services. For this application, effective use of SAR requires expert analysts that understand its behaviour in a wide variety of environmental conditions. Automated ice classification from SAR imagery is an active area of research as it promises to support or even replace some aspects of the ice analyst's work. An alternative approach to automated analysis of SAR imagery is through data assimilation. There are a number of advantages to this approach, including: the relationship between the SAR data and analysis variables (e.g., Ice concentration) is both simple and explicit and therefore easy to understand; areas of ambiguity in the image will have little impact on the final ice analysis; SAR observations can be assimilated in conjunction with complementary data from a variety of sources; and, errors associated with using the SAR data can be assessed and specified as a function of time and location. While this project is still a work in progress, the current status of using SAR data to support an automated sea ice analysis system using a data assimilation approach will be reviewed.

A Backscatter Simulation Tool for the Improved Characterization of SAR - Sea Ice Interaction

Thomas Puestow, C-CORE

This project was carried out under the European Space Agency’s Support to Science Element (STSE). Project objectives included exploring the potential of multi-parameter SAR constellations, to quantify the added-value of such constellations with respect to Sentinel-1, quantifying improvements in sea ice products in terms of radar frequency, polarization and incidence angle, investigating the trade-offs with current and planned SAR missions and prototyping potential improved sea ice products from SAR constellations.

To this end, a Backscatter Simulation Tool (BST) was developed to carry out a series of constellation tests. The candidate tests for the BST were selected to support the derivation of relevant sea ice parameters required by operational ice services, including ice-water discrimination,
ice deformation, ice typing, ice thickness, ice melt and snow cover condition. Tests available within the BST to assess the ability of a constellation to provide useful information for an attribute include quantitative separability metrics between categories of ice as well as the qualitative assessment of ambiguities. The attributes that are able to be tested for some of the available radar configurations include ice-water discrimination, ice typing and melt state.

The constellation analysis has highlighted several areas that warrant further work. In particular, the constellation analysis carried out to date has been limited by the data available in the BST database. The C Band database is the most complete at present (relative to other frequencies), and it is recommended that focus now turn to populating the database with data at other frequencies. It is expected that filling these data gaps will greatly assist in understanding where future benefits are possible for improved products from synergy between different radar frequencies.

Regarding the addition of new data into the BST database, the best candidate frequency identified is L Band, and it is recommended that this be the initial focus of further data reduction efforts. ALOS PALSAR data that are coincident in space and time with existing ice charts may already exist at various national ice centers. It is therefore recommended that an international collaboration be commenced on this effort to understand where useful data exists and where potentially new data gathering campaigns would be needed. This international collaboration should be facilitated through the International Ice Charting Working Group (IICWG) and through the Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM).