ScIMiTaR

forecasting summer Sea Ice MelT from winter ice surface Roughness

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Areas of contribution

User-aspects and verification

Modelling and forecasting

Observations

Sea ice processes

Data assimilation

Summary

Our capacity to forecast seasonal changes in sea ice cover, predict weather patterns and pursue responsible trans-polar shipping, during the High Arctic summer, will hinge on our understanding of sea ice melt processes. This project aims to exploit the influence of sea ice surface topography on the formation of meltwater ponds at the ice surface in summer, which regulate the sea ice albedo, to improve seasonal forecasts of ice melting rates and breakup timing. To achieve this, we will develop new techniques for measuring the sea ice surface roughness in winter from multiple sources of satellite data, including altimetry (Cryostat-2, AltiKa etc.) and MISR, over the period from 2000-present. These measurements will be used to develop a unifying relationship between the sea ice surface roughness and ice thickness distribution at relevant scales for numerical sea ice modelling. Roughness observations will then be assimilated into the CICE (Los Alamos sea ice model): Los Alamos sea ice model to develop a forecasting methodology for robustly predicting summer sea ice parameters (albedo, breakup timing), at lead times >6 months, based on the state of the winter sea ice cover. We intend to examine whether decadal changes in sea ice roughness may have enhanced Arctic climate warming through
amplification of the ice-albedo feedback mechanism. Finally, we aim to provide probabilistic forecasts of the ice melt parameters to the academic community and public/private sectors through the Sea Ice Prediction Network (SIPN).

**Description**

Recent studies have demonstrated that melt pond coverage and the area of open water at the onset of the Arctic melt season can be used to accurately predict the area of sea ice remaining at the end of summer in September. Our group has also shown that ICESat observations of sea ice surface roughness from March can explain most of the spatial variance in summer sea ice albedo, revealing that, in theory, the melt rate of sea ice can be accurately predicted from the roughness of the ice topography several months previously.

The principal aim of this project is to develop and validate a technique for predicting Arctic summer sea ice melt parameters from winter observations of ice surface roughness. Using this technique, we will examine whether decadal changes in sea ice roughness have contributed to the recent decline of the Arctic ice cover by intensifying the ice-albedo feedback mechanism. Our project will integrate the following four work packages:

WP1 = Compile and inter-calibrate existing Arctic sea ice surface roughness observations from airborne LiDAR data, collected during OIB and CryoVex field validation campaigns

WP2 = Develop and validate a set of techniques for deriving geophysical sea ice parameters (i.e. roughness) from satellite radar altimeter and spectro-radiometer data

WP3 = Understand the role of pre-melt sea ice surface roughness on the summer ice melt rate, through numerical sensitivity experiments performed with the CICE model (Los Alamos sea ice model), and examine potential long-term (2000-present) effects of changing sea ice surface roughness on ice-albedo-climate feedback processes within the Arctic

WP4 = Integrate winter sea ice observations into the CICE sea ice model for making seasonal forecasts of summer ice melt parameters (albedo, melt rate, breakup timing), with lead times >6 months, and disseminate probabilistic forecasts to stakeholders through the Sea Ice Prediction Network (SIPN)

The sea ice surface roughness observations will be used to develop, for the first time, a unifying relationship between the roughness and ice thickness distribution at relevant scales for numerical sea ice modelling. This relationship will allow us to use the roughness data as a proxy for the thickness distribution and, by assimilating this information into CICE, initialize our seasonal sea ice forecasts as a function of the pre-melt (winter) ice surface roughness. Two major processes should theoretically reduce the skill of winter sea ice roughness for forecasting summer ice albedo: (1) migration of mobile sea ice floes during the intervening period and (2) a smoothing effect caused by the snow cover overlying sea ice. Our numerical experiments in WP3 will characterize the sensitivity of the roughness-ice albedo relationship to these two factors and set up the methodology for seasonal forecasting. Simulations with CICE will then be performed to forecast summer sea ice parameters as probabilistic estimates, for instance the percentage chance of ice breakup within a week at a given location, at lead times >6 months. Such probabilistic forecasts are more readily applicable for non-academic stakeholders.
We anticipate that our seasonal forecasts will impact stakeholders in the academic community (atmosphere-ice-ocean modelling community, marine biogeochemical & ecological communities) and in the public & private sectors (scientific policy groups, marine transportation industry, general public). Our project will coincide with YOPP and will finish during the consolidation stage. It will contribute directly to the following YOPP objectives:

- Develop improved representation of polar key processes in uncoupled and coupled models used for prediction
- Develop improved data assimilation systems that account for challenges in the polar regions
- Explore the predictability of sea ice on time scales from days to a season

New data products and forecasts will be provided directly to the YOPP community through SIPN. We will contribute to the follow-on SIPN-2 effort, which will provide links to links to additional data sets and forecasts on top of predictions for the September Arctic sea ice minimum as part of the Sea Ice Outlook (SIO). Through this additional capacity, we will provide our sea ice roughness products and probabilistic seasonal forecasts for the sea ice albedo, melt rate and breakup timing as maps through SIPN-2.

**Timeline**

2018-01-01 - 2020-12-31

**Regional emphasis**

Northern hemisphere: Yes

Southern hemisphere: No

**Further specification**

Arctic

**Key project deliverables**

- Winter sea ice surface roughness derived from multiple sources of satellite data at two spatial resolutions: ~1 km and 10-25 km (2000-present)
- Forecasts of seasonal sea ice melt parameters (albedo, melt rate, breakup timing) at two spatial resolutions ~1 km and 10-25 km, delivered with a lead time >6 months
- Forecast of September minimum sea ice extent, delivered with a lead time >6 months
Data management

UK Polar Data Centre at BAS

Is data provided to WMO Global Telecommunication System

No

Real-time provision

Forecast products will be provided in March/April of the current year