ARIA

Atmosphere-SeaIce Interaction in the New Arctic

Principal investigator

Richard Davy

richard.davy@nersc.no

Nansen Environmental and Remote Sensing Centre

Areas of contribution

Polar atmospheric processes

Modelling and forecasting

Sea ice processes

Summary

Arctic sea ice has undergone rapid changes in the last decade as thick, multi-year ice has been melting and replaced with thin, more dynamically-fragile first-year ice. This, coupled with a strong trend towards reduced sea-ice extent has led to a transition towards a new, blue Arctic. This brings uncertainty for atmospheric and sea-ice forecasts in the region as many aspects of air-ice coupling are poorly understood on both the small-scale and the mesoscale.
In this project, we seek to improve our understanding of the importance of air-ice coupling processes for atmospheric and sea-ice forecasts by using a hierarchy-of-coupling approach. We will use an advanced sea-ice model with a realistic rheology, NeXtSIM, in combination with the Weather Research and Forecasting model and an interfacial atmospheric boundary layer model to assess coupling processes and their importance for atmospheric and sea-ice forecasts.

Description

Arctic sea ice has undergone rapid changes in the last decades due to the greatly enhanced warming occurring in the region known as Arctic Amplification. As the Arctic warms, the sea ice has become thinner and its extent has been reduced, especially in the September minima. Thick, multi-year ice has been replaced with thinner and more dynamically-fragile first-year ice. In combination with a strong trend towards reduced sea-ice extent ,this has led to a transition towards a new, blue Arctic. The atmosphere-sea ice coupling plays a crucial role in determining the evolution of the sea ice during this transition to a blue Arctic. Wind is the primary driver of sea-ice transport, and storms can trigger rapid break-up events in the ice. Indeed, the exceptionally low sea-ice minima in 2007 and 2012 have been partially attributed to severe weather events.

This air-sea coupling is also crucial on forecast timescales, both for the sea-ice and atmosphere. Despite the importance of this coupling, there is still a lot we don’t understand about many of the coupling processes - in particular, how important specific processes are at different timescales. Of course, the wide range of time and spatial scales associated with different coupling processes - from the high-frequency breaking and forming of leads in the ice at the scale of a few meters and up, through to the interactions between sea-ice and atmosphere at the mesoscale - means that it is not possible to fully resolve ice-atmosphere coupling within a forecast model. Therefore, the question of what coupling processes are important on what timescales, and hence what level of sophistication is necessary in a forecast model is an urgent question for meteorological and sea ice forecasters.

To that end, the main goal of our project is to improve our understanding of atmosphere-ice interaction processes and our ability to model them and their impact. The direct application of this understanding is to determine what level of sophistication in coupling is necessary for atmospheric and sea-ice forecast platforms. To do this, we will run a set of case studies using the Weather Research and Forecasting (WRF) model in combination with NeXtSIM – an advanced sea-ice model capable of producing realistic sea-ice dynamics. We will run these case studies in a simplified coupling mode, in addition to a parallel set of experiments where we use an interfacial boundary layer model to couple the atmospheric and sea-ice forecasts. These model configurations will be used to explore (1) storm life cycles in the central Arctic and the role of surface interactions – the fracturing of sea ice – in these life cycles, and (2) rapid break-up events in the marginal ice zone.

This project is designed around two work packages which respectively focus on coupling processes in (1) the central Arctic and (2) the marginal ice zone. In both, we will employ the same coupling-hierarchy approach described below to shed light on the relative role of local thermodynamic coupling and coupling at the mesoscale.
We will dynamically downscale case-study periods from reanalysis using WRF. The results of the WRF runs will then provide the boundary conditions for NeXtSIM and NeXtSIM-ABL – a version of the sea-ice model with a thermodynamically active atmospheric boundary layer model acting as an interface between the atmospheric driving fields and the sea-ice model.
In addition to these novel model simulations, we will analyse the ECMWF operational model results for YOPP. Since these archives will include physics tendencies, this will be an invaluable resource for assessing these coupling processes.

Timeline

2019-01-14 - 2021-12-31

Regional emphasis

Northern hemisphere: Yes

Southern hemisphere: No

Key project deliverables

*Improved process understanding of local thermodynamic air-ice coupling in the central Arctic.
*A database of high-resolution case studies of break-up events and storm life cycles
*Improved understanding of the role of surface coupling in storm life cycles over the central Arctic.
*Report on how how new sea-ice conditions lead to a significant alteration of air-sea exchange in the marginal ice zone with implications for extreme weather events e.g., cold-air outbreaks.

Data management

NorStore - Norwegian national archives

Is data provided to WMO Global Telecommunication System

No

Real-time provision

None.