Title: Atmosphere-Ocean-Ice (AOI) Interactions in Polar and sub-polar Regions
Project leader: Einar Olason (NERSC)

Personnel (Institution): Einar Olason, Pierre Rampal (NERSC), Thomas Spengler, Lars Henrik Smedsrud, NN Researcher (UiB), Mehmet Ilicak, Chuncheng Guo (Uni), Kjell Arne Mork, Vidar Lien, Henrik Søiland, Øystein Skagseth (IMR)

Budget: 9 Mio NOK (from SKD): 2.5 MNOK UiB, 2.5 MNOK NERSC, 2.0 MNOK Uni, 2.0 MNOK IMR. In kind: 1 MNOK (Nansen Legacy), 1 MNOK (EU-APPLICATE), 1 MNOK (NorArgo2), salary for TS, LHS. We will also submit joint proposals to the POLARPROG call in September and to the ONR to further strengthen this project.

Short background / purpose: We will investigate AOI interaction processes, which play a crucial role for the polar and global climate, and show how an improved understanding and representation in numerical models can benefit current prediction systems, increase predictive skill, and aid services.

Methodology: The project consists of 3 WPs:
WP1: AOI interactions in the Arctic and Nordic Seas (leader: PR, members: EO, VL, NN Researcher, MI, LHS, TS). Investigate the role of missing or improperly represented AOI interaction processes using neXtSIM and CICE with varying resolutions (5, 20km) and on up to multi-annual time scales. Evaluate resolution dependence of mean state and variability of heat fluxes between atmosphere, ocean, and sea ice, as well as its impact on large-scale circulation, freshwater export, and sea ice volume.
WP2: Physical understanding of subgrid-scale processes (leader: TS, members: NN Researcher, PR, EO, MI, ØS, HS). Extend physical understanding of AOI interactions on up to synoptic time scales and suggest new parameterizations related to mesoscale eddies in the ocean. Investigate the effect of the atmospheric driven gyre circulation on the ocean heat transport toward the Arctic and air-sea heat exchange as well as diagnose the role of mesoscale atmospheric circulation on sea ice break-up and the intensity of associated air-sea heat fluxes through cracks and leads.
WP3: Predictability and Model Development (leader MI: members: CG, TS, KAM, ØS, EO, PR, MB). Investigate and assess predictability aspects with NorESM including the new parameterization of mesoscale eddies from WP2. Estimate monthly to inter-annual variations in ocean heat content using hydrographic data including ARGO drifters as well as NorESM simulations and investigate the relative role of local air-sea fluxes versus advection for hydrographic anomalies in observations versus model. Implementation plan for the new generation sea-ice model neXtSIM into NorESM, creating a novel climate modelling framework that can be used in prediction systems.

Deliverables: D1: Quantification of missing AOI interaction processes in coupled models (2020). **D2:** Identifying relevant physical processes in the coupled AOI system (2022). **D3:** Assessment and investigation of predictability (2022). **D4:** Implementation plan for neXtSIM in NorESM (2022).

Strategic considerations:
All four BCCR institutions are involved in the project, creating a unique synergetic team among the different expertise that are available at BCCR. International visibility through MOSAIC, EU-APPLICATE, YOPP, NORPAN, and SI Outlook. New sea ice model and physical understanding will aid the scientific community and create an internationally recognized team for AOI interactions in the polar regions that can apply for EU or SFF funding. Strengthening of BCCR international collaborations (Ian Renfrew (UK), Robert Hallberg (USA), Hiroyasu Hasumi (Japan), among others). This project will be a collaboration of both young and established BCCR scientists, working as WP leaders and PI.

Detailed budget and work tasks:

Researcher NN (UiB)

2.5 MNOK; 60 kNOK p/m, 41 months (2.46 MNOK) + travel and computer (40 kNOK)
(UiB took out the overhead, which implies that we need to budget computer etc. separately)

The Researcher NN will work on two main tasks. One associated with mainly atmosphere-ocean, analysing the anomaly runs for the gyre circulation and the second task related to the idealized simulation with the sea-ice atmosphere at higher resolution, e.g., 2 km. Both tasks in WP2 with the Researcher NN have an allocation of around 20 months each in collaboration with the team in WP2. If time permits, the Researcher NN will contribute to the analysis of the different model resolution runs in WP1.

Chuncheng Guo (Uni)

2.0 MNOK; 135 kNOK p/m, 14 months (MNOK) There is 3.3% increase every year.

Chuncheng Guo will conduct the anomaly coupling experiments for the gyre circulation and new mesoscale parameterization experiments in WP2. He also will help to investigate the results from those simulations.

Einar Olason Pierre Rampal (NERSC)

2.5 MNOK; 119 kNOK p/m, 21 months

Einar Olason will take the lead of the overall project and prepare and run neXtSIM in the runs in WP1 and WP2 and participate in the analysis of the results. His main focus will be on WP1, while the task in WP2 will be co-lead by the Researcher NN. He will also be the main person preparing the implementation plan in WP3, with help from the NorESM team (Mats and Mehmet). Pierre Rampal will lead WP1.

Henrik Søiland, Kjell Arne Mork, Vidar Suren Lien and Øystein Skagseth (IMR)

2.0 MNOK; 100kNOK p/m, 20 months

IMR will take a lead role in investigating processes in the Nordic Seas with respect to transports and water mass transformation toward the Arctic. We will address the scales of processes using a wide range of in-situ ocean observations. This will be used to evaluate 5 and 20 km ocean model outputs from WP1 (MYCOM-CICE forced by CORE-II), focusing on oceanic quantities. Contribute to the efforts by Uni and UiB In WP3 on estimating the monthly to interannual variations in ocean heat and freshwater content, using the ARGO floats and other observations together with NorESM results. IMR will also analyse the anomaly perturbed gyre simulations in WP2 jointly with UiB and Uni and compare to observational data.