REQUEST FOR A SPECIAL PROJECT 2020–2022

MEMBER STATE: Norway

Principal Investigator[1]: Malte Müller

Affiliation: Norwegian Meteorological Institute

Address: Henrik Mohns plass 1

0313 Oslo

E-mail: maltem@met.no

Other researchers: Erin Thomas, Yurii Batrak, and Nicholas Szapiro

Project Title: Towards a couple atmosphere-wave-seaice-ocean high resolution Arctic forecasting system

……………………………………………………………..……

If this is a continuation of an existing project, please state the computer project account assigned previously.	**SP** __________________	
Starting year: (Each project will have a well-defined duration, up to a maximum of 3 years, agreed at the beginning of the project.)	2020	
Would you accept support for 1 year only, if necessary?	YES x	NO ☐

Computer resources required for 2020-2022: (To make changes to an existing project please submit an amended version of the original form.)		**2020**	**2021**	**2022**
High Performance Computing Facility	(SBU)	7 Mill.	7 Mill.	7 Mill
Accumulated data storage (total archive volume)[2]	(GB)	20 000	20 000	20 000

***An electronic copy of this form must be sent via e-mail to**:* *special_projects@ecmwf.int*

Electronic copy of the form sent on (please specify date):

…………………………………………

Continue overleaf

[1] The Principal Investigator will act as contact person for this Special Project and, in particular, will be asked to register the project, provide an annual progress report of the project's activities, etc.

[2] If e.g. you archive x GB in year one and y GB in year two and don't delete anything you need to request x + y GB for the second project year.

Principal Investigator: Malte Müller

Project Title: Towards a couple atmosphere-wave-seaice-ocean high resolution Arctic forecasting system

Extended abstract

Background

The Norwegian Meteorological Institute, is operating a convectivion permitting high-resolution weather prediction system for the European Arctic, with a 2.5km resolution and assimilation of various conventional and satellite observations. The system has been systematically evaluated over the last years and is in operation since November 2015 (*Müller et al. 2017b*). The forecasting system is based on the AROME model, a 2.5km non-hydrostatic regional weather and climate model coupled to simplified sea-ice and ocean models (*Seity et al. 2011*). The model developments are coordinated internationally within the European HIRLAM-consortium. MET Norway has long-standing experience to apply the model system to high-latitude conditions, concerning data assimilation of snow, coupling to wave, sea-ice, and snow models (*Süld et al. 2015, Batrak et al. 2018, Batrak and Müller 2018,2019*).

In the framework of the Nansen Legacy Project (2018 - 2023), the Norwegian Meteorological Institute is extending the AROME Arctic model system by coupling the atmospheric component to wave, ocean, snow and sea-ice models, by utilizing OASIS-MCT as part of the surface model SURFEX (*Voldoire et al. 2017*). First milestones have been already reached by coupling to a multilayer snow model, which is in operation since February 2019 (*Batrak and Müller, 2019*) and by an atmospheric sensitivity study to kilometer-scale sea ice effects in the Marginal Ice Zone (*Batrak and Müller, 2018*). AROME Arctic will be coupled to CICE-ROMS a coupled ocean - sea-ice model using Rutgers version of the ocean model ROMS and the Los Alamos CICE5 ice model. This coupled modeling system is planned to be the new operational ocean - sea-ice model system at MET Norway. ROMS is an open source three-dimensional, free-surface, terrain-following numerical model that solve the Reynolds-averaged Navier-Stokes equations using the hydrostatic and Boussinesq assumptions. CICE is an multi-category sea ice model with explicit representation of the sea ice thickness distribution. This allows for detailed treatment of interactions between sea ice and the lower atmosphere that are important in a coupled model framework. The wave model component will be WAVEWATCH III®, which is the third generation wave model developed at NOAA/NCEP.

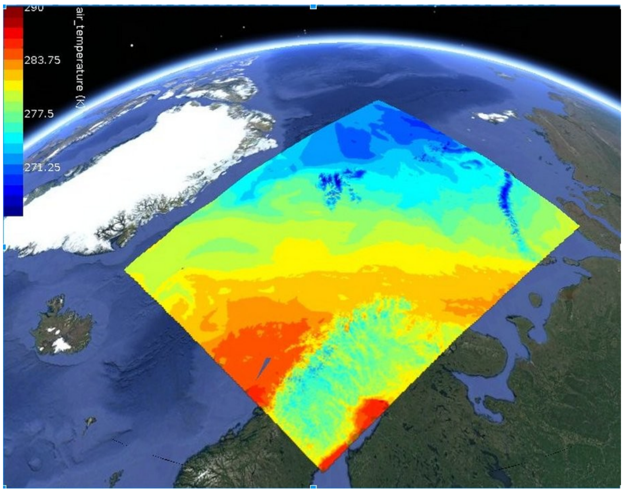

Figure 1: AROME Arctic domain

Scientific Plan:

The main goal of the project is to advance short-range forecast capabilities of weather, waves, ocean, and sea-ice, by coupling model components in an physically consistent and operationally efficient way. The (stand-alone) forecasting systems for weather (AROME-Arctic), waves (WAVEWATCH III), ocean and sea-ice (CICE-ROMS) are already set up in a pre-operational configuratiion for the European Arctic domain (Figure 1). The model system components will be experimentally coupled by utilizing the OASIS-MCT coupler. Verification methods based on in-situ and satellite observations for all model components are developed (*Müller et al. 2017ab, Melsom et al. 2019, Bohlinger et al. 2019*).

We will perform sensitivity studies by testing various coupling strategies. These re-forecast experiments will be used to statistically verify the forecasts and to explore high-impact events. A specific focus will be on the Marginal Ice Zone, e.g. the predictability of its extend by allowing for wave-seaice-atmosphere intereactions and the feedback on atmospheric short-range weather forecasts. Towards the second half of the project, the optimal use of the model coupling will also be assessed in an ensemble model framework.

In 2020 we will perform fully coupled model sensitivity experiments for a to be specified 2-month period. We estimate that we will test about 5 different model setups with daily short-range forecasts. In 2021 and 2022, we will perform a number of 10-member ensemble forecast experiments focused on a 1-month period. About two ensemble model experiments are planed.

Computational Costs and Storage:

	High Performance Computing Facility (SBUs)	**Data Storage (GByte)**
66 hour forecast with the coupled system	20 000	60
Atmosphere and Ocean/Ice Data assimilation	1200	5
5x deterministic eperiment, 2-months	6572000	20150
2x 10-member ensemble eperiment, 1-month	13144000	40300

References

Batrak, Y. and M. Müller (2018) Atmospheric response to kilometer-scale changes in sea ice concentration within the marginal ice zone. Geophysical Research Letters, 45: 6702-6709. https://doi.org/10.1029/2018GL078295

Batrak, Y. and M. Müller (2019) On the warm bias of atmospheric reanalyses over Arctic sea-ice in winter, Nature Communications, (in revision).

Bohlinger, P., T. Economous, Ø. Breivik, M. Müller (2019) A novel approach to computing super observations for probabilistic wave model validation. Ocean Dynamics, accepted

Melsom, A., C. Palerme, M. Müller (2019) Validation metrics for ice edge position forecasts. Ocean Sci. Discussions, 15, 615-630,

Müller, M., et al. (2017a) AROME-MetCoOp: A Nordic Convective-Scale Operational Weather Prediction Model, Wea. Forecasting, 32, 609–627.

Müller M., Y. Batrak, J. Kristiansen, M.Ø. Køltzow, G. Noer, A. Korosov (2017b) Characteristics of a convective-scale weather forecasting system in the Arctic, Mon. Wea. Rev., 145, 4771–4787.

Seity et al. (2011) The AROME-France convective-scale operational model, Mon. Wea. Rev., 139, 976-991.

Süld, J.K, A. Rasheed, J. Kristiansen, Ø. Sætra, A. Carrasco and T. Kvamsdal, (2015): Mesoscale numerical modeling of ocean-atmospheric interactions. Energy Procedia, 80, 433-441.

Voldoire et al. (2017) SURFEX v8.0 interface with OASIS3-MCT to couple atmosphere with hydrology, ocean, waves and sea-ice models, from coastal to global scales. Geosci. Model Dev., 10, 4207-4227.