SPECIAL PROJECT PROGRESS REPORT

All the following mandatory information needs to be provided. The length should *reflect the complexity and duration* of the project.

Reporting year	2021
Project Title:	Towards a coupled atmosphere-wave-seaice-ocean high resolution Arctic forecasting system
Computer Project Account:	spnomuel
Principal Investigator(s):	Dr. Malte Müller
Affiliation:	Norwegian Meteorological Institute
Name of ECMWF scientist(s) collaborating to the project (if applicable)	n/a
Start date of the project:	1/1/2020
Expected end date:	31/12/2022

Computer resources allocated/used for the current year and the previous one
(if applicable)
Please answer for all project resources

		Previous year		Current year	
		Allocated	Used	Allocated	Used
High Performance Computing Facility	(units)	7000000	6564686.41	7000000	0
Data storage capacity	(Gbytes)	20000	80000	20000	0

Summary of project objectives (10 lines max)

The main objective 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), upper ocean (GOTM) are utilized in a configuration for the European Arctic domain. The model system components will be coupled by utilizing the OASIS-MCT coupler (Voldoire et al. 2017). Verification methods based on in-situ and satellite observations for all model components are developed (Müller et al. 2017, Melsom et al. 2019, Bohlinger et al. 2019).

Summary of plans for the continuation of the project (10 lines max)

n/a

List of publications/reports from the project with complete references

Løken, T.K., J. Rabault, E.E. Thomas, M. Müller, K.H. Christensen, G. Sutherland, and A. Jensen (2020) A comparison of wave observations in the Arctic marginal ice zone with spectral models. submitted to 25 th IAHR Symposium on Ice Conference Proceedings.
https://arxiv.org/abs/2003.09472

Summary of results

1. Evaluation of the impact of sea-ice leads on weather forecast uncertainties.

A 10-member ensemble simulation with the operational weather model setup AROME-Arctic (Müller et al. 2017) has been performed for a 3 week period in March 2018. These ensemble forecasts have been utilized to force the sea-ice lead resolving model nexSIM. The high-resolution sea-ice fields are then, in turn, used as boundary conditions to the AROME-Arctic model system (weakly coupling). The ensemble simulations have been produced on the ECMWF HPC and are currently transferred to the local cluster of MET Norway.The simulations will be analysed with a focus on the impact of sea-ice leads on weather forecast uncertainties, and have also been compared to a standard ensemble setup.

2. Towards full coupling of atmosphere, waves, and sea-ice.

A. A fully coupled AROME-Arctic – WAVEWATCH III simulation has been produced for September 2018 to compare against waves-in-ice field observations. In this model setup the sea-ice concentration is not simulated by a numerical model, instead intialized by the sea-ice fields from ECMWF IFS. The first results show that the waves are realistically damped within the sea-ice (Løken et al. 2020). The goal is to tune the attenuation of waves in the coupled model system.'

B. A fully coupled AROME-Arctic – WAVEWATCH III simulation has been performed for Jan/Feb, 2020 to perform a statistical assessment of the skill of weather and wave prediction in the coupled model framework. It is the first longer simulation performed by this coupled model setup. A detailed verification of the sensitivity experiments with ocean surface wind from satellite ASCAT observational products, as well as, satellite significant wave height observations (Bohlinger et al. 2019) has been performed. We find that the coupled forecasting system performs better, specifically

for strong winds and large waves. The results have been summarized in a manuscript and submitted for peer review to Weather and Forecasting.

As a next step we are currently implementing the 1D ocean turbulence model GOTM to our weather forecasting framework. This model system is technically working but we need to have an additional focus on the initialization procedure for the vertical upper ocean temperature and salinity profiles. In the second half of 2021 we plan to transfer this system to the ECMWF HPC and we plan to perform various (ensemble) simulations with the coupled model setup in order to analyse sensitivities in a fully coupled atmosphere-wave-ocean forecasting model. A specific focus will be on the spread of forecast variables over the ocean and in coastal areas.

References

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

Løken, T.K., J. Rabault, E.E. Thomas, M. Müller, K.H. Christensen, G. Sutherland, and A. Jensen (2020) A comparison of wave observations in the Arctic marginal ice zone with spectral models. submitted to 25 th IAHR Symposium on Ice Conference Proceedings. https://arxiv.org/abs/2003.09472

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

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.

Thomas E., M. Müller, P. Bohlinger, Y. Batrak, N. Szapiro (2021) A kilometer-scale coupled atmosphere-weave forecasting system for the European Arctic. submitted https://www.essoar.org/doi/10.1002/essoar.10506320.1

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.