Project information

Keywords
Marine Ecology, Biogeochemistry, Physical Oceanography, Mathematical modeling
Project title
Mesoscale physical and biogeochemical modeling of the ocean and sea-ice in the Arctic Ocean
Year
2019
Project leader
Pedro Duarte
Geographical localization of the research project in decimal degrees (max 5 per project, ex. 70,662°N and 23,707°E)
Pan-Arctic for the A4 model. The domain of the S800 model is limited by the following coordinates: 79.22o N 22.56 W, 83.47o N 80.33o E, 74.17o N 55.40o E and 72.04o N 07.99o E.
Participants

Project leader

Pedro Duarte/NPI/pedro.duarte@npolar.no

Participants

Arild Sundfjord/NPI/arild.sundfjord@npolar.no

Tore Hattermann/NPI/tore.hattermann@npolar.no

Jon Albretsen/Institute of Marine Research (IMR)/jon.albretsen@hi.no

Magnus Drivdal/Akvaplan-niva (APN)/magnus.drivdal@akvaplan.niva.no.

Administrative responsible for lead institution: Nalân Koç /NPI/nalan.koc@npolar.no

Flagship
Arctic Ocean
Funding Source

Fram Center

Summary of Results

The main goals of this project are to: (i) validate two ocean and sea-ice coupled physical-biogeochemical models; (ii) use the models to test the hypothesis that phytoplankton and ice algal blooms may occur deep into the ice pack and not only as a “primary production front” following the marginal ice zone (MIZ); (iii) find proper parameterizations of mesoscale processes to use in Pan-Arctic models. The models used in this project were implemented in previous Fram Centre projects: the A4 Pan-Arctic model, with horizontal resolution 4 km, and the S800, covering a large domain around Svalbard, with resolution 800 m.

As explained in the previous report, we begun the validation of both models by comparing their outputs with various data sources: (i) Ocean and sea-ice data collected during the N-ICE2015 drifting expedition (https://data.npolar.no/dataset/7f7e56d0-9e70-4363-b37d-17915e09a935). (ii) NOAA Arctic climatology (https://data.noaa.gov/); (iii) Regional high resolution sea-ice charts for the Svalbard region (http://cmems-resources.cls.fr/documents/PUM/CMEMS-OSI-PUM-011-002.pdf and http://marine.copernicus.eu/services-portfolio/access-to-products/?option=com_csw&view=details&product_id=SEAICE_ARC_SEAICE_L4_NRT_OBSERVATIONS_011_002); (iv) Radar freeboard from Level L2i Cryosat2 (baseline C) (ftp://ftpsrv2.awi.de/sea_ice/product/cryosat2_smos/v202/nh/); (v) Sea-ice + snow thickness from Cryosat2 AWI data (monthly data on a 25 km grid) (ftp://ftp.awi.de/sea_ice/product/cryosat2/v2p2/nh/l3c_grid/monthly/); (vi) Sea-ice + snow thickness from Cryosat2-SMOS AWI data (monthly data on a 25 km grid)ftp://ftpsrv2.awi.de/sea_ice/product/cryosat2_smos/v202/nh/.

These comparisons are still under way given the large amount of model and observations to be compared. The pdf file annexed to this report shows some of the figures produced so far and includes some preliminary analysis of the results that will be summarized in the next lines. The main results are the following:

1) The A4 model has a surface salinity bias of ~-0.5, a sub-surface and a deeper bias for temperature of ~ +1.0^{o}C (see pages 1 – 7 of the attached pdf annex). A similar analysis for the S800 model is still underway.

2) When comparing A4 results with climatology, for the period 2007-2017, along a transect at 120^{o} longitude, the model seems to reproduce well the cold surface layer, but it underestimates the temperature below this layer and until ~500 m depth by ~-0.5^{o}C (see page 8 of attached pdf annex).

3) Both models reproduce well sea-ice concentration patterns, except for the S800 model during summer, when sea-ice concentration is underestimated. We believe that this bias results from the underestimated sea-ice thickness (see below and pages 9 to 15 of attached pdf annex).

4) The A4 model shows ice thicknesses in the Nansen Basin comparable to average values observed during N-ICE2015. However, snow thicknesses are grossly underestimated. The S800 underestimates ice thickness but does a better job with snow thickness which is still underestimated. A more in-depth analysis is being carried out by comparing model data with data sources (iv), (v) and (vi) shown above (see pages 16-25 of the attached pdf annex).

5) The surface layer salinity and temperature are similar in both models, but a more in-depth analysis of these results is still being carried out (see pages 26-35 of the attached pdf annex).

Highlights

This project involves one of the most complete evaluation exercises of Arctic models ever done. We identified the main shortcomings of the A4 and the S800 models. The next step is trying to improve model performance.

Master and PhD-students involved in the project

There will be a master student from France doing an internship between January and May 2020.

For the Management

A retreating sea ice cover will produce potentially important changes in associated ecosystems and corresponding services. Therefore, a deep understanding of ecosystem processes is crucial for the implementation of models

allowing accurate prediction of future trends so that appropriate measures may be taken. This work will add to the tools already available at the involved institutions, improving their understanding of the Marginal Ice Zone and the Arctic Ocean. Efforts are being done to conciliate the modeling work developed here with that developed in other Fram Center projects to make sure that the model physical background and setup are the same, avoiding any compatibility issues in the future.

Published Results/Planned Publications

A paper about the coupling methodology ROMS-CICE-Biogeochemistry is in prep. In fact, this paper has been delayed considerably due to the workload required for the implementation and testing of the modeling system. We believe that the paper will be submitted before next summer. Meanwhile we finished two papers related with the work done here (Tidewater glacier retreat impact on the pelagic ecosystem of Kongsfjorden by Duarte et al. and Warm Atlantic Water explains observed sea ice melt rates north of Svalbard by Duarte et al.). The former paper went through the first round of revisions and a revised version was sent a few weeks ago to the Journal of Geophysical Research. The second paper is being reviewed by the various co-authors. None of the papers is based on the core work of the current project but they are based on common modelling tools which they serve to test under different scenarios. Moreover, obtained results will serve as a “control” for the S800 model runs.

Communicated Results

The results obtained with modeling work described in one of the papers mentioned above were presented as an oral communication to the XI Portuguese Polar Conference at the University of Coimbra in the 24th October 2019 and, as a poster to the Svalbard Science Conference in Oslo, in 5-6 November.

Interdisciplinary Cooperation

This project benefits from inter-disciplinary cooperation. In fact, the modeling work done so far includes ice physicists and marine biologists. Therefore, the main disciplines involved in the project are Ice and Ocean Physics and Marine Biology and Ecology. Furthermore, contacts were established with the CICE modeling team at the Los Alamos National Laboratory (USA) and the Finnish Environmental Institute. Recently, the project PI participated in a workshop and tutorial about the new CICE+Icepack model, organized by the CICE consortium at the National Center for Atmospheric Research in Boulder, Colorado, USA. Likely, this new CICE version should replace the one we have been using so far.

Budget in accordance to results

Funding from the Fram Centre is fundamental to pay most of the project expenses, with emphasis on labor and technical assistance. The Fram centre acted as a necessary boost but, completing the project, requires also support from UNINETT Sigma2 AS for the usage of super-computer clusters.

Could results from the project be subject for any commercial utilization

No

Conclusions

At this stage we have some understanding of the model shortcomings. We restarted simulations with the S800 model after changing parameters that may help improving ice thickness prediction and, thereafter, improve also sea-ice concentration results during the summer months. We believe that the snow underestimation in the A4 model will also contribute to a snow underestimation in the S800 model, since this model is influenced by the boundary conditions provided by the former one. Therefore, improving snow results in the A4 model is necessary. We are investigating the reasons for the large snow underestimation in the A4 model. Likely this is due to the atmospheric forcing, based on ERA-interim. We are going to compare atmospheric forcing data with similar data collected during N-ICE2015 to check whether ERA-interim is to blame for the snow bias in the A4 model and whether, WRF data used for atmospheric forcing for the S800 model is more adequate.

This project allowed us to test some software changes we implemented in the CICE model allowing it to use time-varying boundary conditions from the A4 or any other model. The technicalities are described at: https://github.com/metno/metroms/pull/21. This technology is now being used by the Meteorological Institute of Norway as well.

Once the physical models are validated, we will be able to couple to them the biogeochemical models for the ocean and the sea ice, using the coupling methodology developed in previous Framcenter projects.