Project information

Project title

Mesoscale modeling of Ice, Ocean and Ecology of the Arctic Ocean

Year

2012/2013

Project leader

Ole Anders Nøst, ApN

Participants

Project leader:

- Ole Anders Nøst (Akvaplan-niva AS, APN)

Participants:

- Øyvind Leikvin and Frank Gaardsted (APN),
- Arild Sundfjord (Norwegian Polar Institute, NPI),
- Bjørn Adlandsvik (Institute of Marine Research, IMR),
- Ingrid Ellingsen and Morten Alver, (SINTEF Fisheries and Aquaculture AS, SINTEF),
- Pal Erik lsachsen, Keguang Wang and Jens Debernard (Met.no).

Flagship

Arctic Ocean

Funding Source

Fram Centre

Summary of Results

Setup and basic tuning of the model: The main part of the work in 2012 has consisted of setting up the Regional Ocean Modeling System (ROMS) for the Arctic Ocean and the surrounding seas. The chosen model domain covers the Arctic Ocean and the Nordic Seas and has dimensions 4804 x 6404 km. The distance between grid points is 4km, giving a 1201 x 1601 computational grid. The grid has open boundaries towards the North Atlantic Ocean, the Bering Sea, the Baltic Sea and the Hudson Bay. Model domain is shown in Figure 1. A number of test simulations without forcing have been carried out to minimize unwanted currents in the model by finding the optimal combination of topography smoothing and vertical coordinates.

Initial full-scale runs of Arctic-4km: We have conducted a three-month long (1 April to 30 June, 2000) test run of the Arctic-4km model. Initial conditions and lateral boundary conditions came from the 0.25-degree global FOAM model (www.ncof.co.uk/foam-system-description.html) run by the UK MetOffice. Monthly averaged fields from the global model were interpolated onto the Arctic-4km polar stereographic grid by use of the software FIMEX (wiki.met.no/fimex/start). Atmospheric forcing was taken from ECMWF's 0.25-degree ERA-interim reanalysis (www.ecmwf.int/research/era/do/get/era-interim), and here too FIMEX was used to interpolate the global fields onto our domain. These initial runs were done without freshwater input from rivers and without tides. The three-month run took about nine wall-clock hours when parallelized and distributed over 1024 cpu's.

Figure 2 shows sea surface temperature (SST) at the onset of the simulation (1 April) and the end of the three-month run (30 June). We see that ice-free regions have warmed considerably over the simulation period while SSTs in the ice-covered central Arctic are largely unchanged. More importantly, however, we see that the field at the end of the three-month spin up is much more turbulent than the initial field (representing the coarser-scale model). As anticipated, the 4-km model is both more baroclinically and barotropically unstable than the global simulation, and mesoscale variability has developed along all major currents and fronts.

The Svalbard-800m model: A physical model for the ocean around Svalbard at 800 m horizontal resolution ("Svalbard-800m") has been set up and tested. The external forcing applied for this model includes ocean and sea ice variables from a ROMS-4km simulation of the Nordic Seas (provided by the SVIM-project within PROOFNY/Havet og Kysten, financed by the NRC), atmospheric forcing from ECMWF's ERA-interim analysis and freshwater runoff from land estimated from a glaciological mass balance model (Jack Kohler and Christopher Nuth, NPI and UiO, pers. comm.). The configuration of the ROMS model is similar to the setup of NorKyst-800 (Albretsen et al., 2011).

The Svalbard-800m has been run for 2010 and 2011, and daily averages of surface speed, salinity, temperature and sea ice concentration are shown in Figure 3-6, respectively, for August 1st and December 31st 2011. The surface salinity west of Spitsbergen reveals the relatively fresh waters due to summer melting from land (Figure 4, upper panel).

Development of ice algae model: The SINMOD ecosystem module does not include biology in ice. A literature survey has been conducted to get an overview of existing models of sea ice biology. A 1D sea ice algae model has been developed that is planned to be incorporated into the SINMOD ecosystem module and implemented to run online with ROMS. The model results from the 1D testing and comments regarding implementation into ROMS have been described in a separate working paper. The coupled SINMOD system

with 20 km horizontal resolution for the Nordic Seas and Arctic Ocean have been run to produce input data for the 1D simulations (nutrient concentrations in the upper layer, ice formation rate, sea ice thickness and incoming irradiance). The 1D model results show a strongly silicate limited production in the Barents and Kara seas, while the production is nitrate limited for the locations in the Laptev Sea, East Siberian Sea and Chuckchi Sea. For the locations chosen, the onsets of the blooms all start in April. Duration and production are controlled by ice thickness and nutrient availability, respectively. Light controls the onset of the blooms, but growth rapidly becomes nutrient limited and depends on supply of nutrient rich water from below the ice (Figure 7).

Published Results/Planned Publications

As this project is primarily an effort to set up and tune an Arctic Ocean Model, i.e. mainly technical work to prepare for future scientific work, no results have yet been published.

Communicated Results

The results of the project are communicated between the partners. A proposal for the continuation of the project is sent to the Framsenter at the 10th of January 2013. In the proposed continuation of the work we will use the tools that is developed in this project to produce results that will be communicated through workshops, press and papers in international journals.

Interdisciplinary Cooperation

The work of setting up the model is distributed between the project partners to utilize each partner’s expertise in the best possible way.

Budget in accordance to results

In which way has the funding from the Fram Centre helped the project?

The task of establishing a state of the art physical-biological model for the Arctic Ocean would be too large for most of the project partners individually. The funding from the Fram Centre has provided a valuable possibility for the partners to collaborate on such model development.

Did the Fram Centre funding act as a sufficient boost for completing the project through other sources of funding?

No funding from other sources has yet been received, but we are continuously looking for funding possibilities.

Could results from the project be subject for any commercial utilization

No

Conclusions

The established model will be available to all the project partners and applied to a wide range of studies. APN and SINTEF specialize in risk assessment and environmental impact assessments, Met.no is responsible for day-to-day operational forecasting of weather, ocean and ice conditions, IMR provides the scientific basis for the management of the use of the marine ecosystems and NPI are actively involved in a range of observational programs. An Arctic Ocean Ecosystem model will greatly enhance each partner’s ability to carry out work in their respective area of research.