Project information

Project title
Mesoscale modeling of Ice, Ocean and Ecology of the Arctic Ocean
Year
2013/2014
Project leader
Ole Anders Nøst, ApN
Participants

Project leader:

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

Participants:

- Tore Hattermann and Frank Gaardsted (APN)
- Arild Sundfjord (Norwegian Polar Institute, NPI)
- Jofrid Skardhamar, Jon Albretsen (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, Theme: Sea ice, ecosystems and models

Funding Source
Fram Centre
Summary of Results

Multiyear simulations

The basics of the 4km model were setup in 2012 and the main work in 2013 has been to conduct a 4-year hydrodynamic simulation covering the period from June 2006 to June 2010. Comparisons of these simulations with observations lead to further improvements of the model setup (see model validation below) and new hindcast simulations for the period from 1993 to 2010 are currently being performed, forming the basis for the studies outlined in the 2014 ModOIE proposal.

The Svalbard-800m model which was setup in 2012 has been extended to cover larger areas of the Svalbard continental shelf and the Fram Strait (Figure 1). Multiyear simulations have been performed nested into the Arctic-4km and forced with ECMWF's ERA interim re-analysis, and freshwater runoff from land estimated from a glaciological mass balance model (Jack Kohler and Christopher Nuth, NPI and UiO, pers. comm.). This is the first complete dataset of glacial runoff data covering the total Svalbard archipelago, and the discharge positions are shown in Figure 2.

Validation of the 4 km model

In addition to the freely available NOAA World Ocean Atlas Regional Arctic climatology, data from current meters in the Fram Strait and in the interior of the Arctic Ocean were collected and prepared for comparisons with model results (Figure 3). Station data from corresponding positions in the model grid were saved during the multiyear runs.

An initial comparison of the model results with the observations showed a water mass distribution that was within the right range, but with some differences in the detailed three-dimensional structures being evident. These deficiencies could significantly be improved, by optimizing the vertical resolution of the model, as illustrated in Figure 4, which shows a more realistic mid-depth temperature distribution through the Fram Strait from the first results of the new multiyear run, as compared to the old four-year simulation. A more detailed analysis of the current meter time series also showed an improved representation of the currents in the Fram Strait, which earlier showed an unrealistically strong southward flow of the East Greenland Current (Figure 5).

An initial comparison of the simulated sea ice cover with satellite observation also indicated promising results (Figure 6), and the details of the sea ice model performance will be further scrutinized when the new multiyear simulations are available.

Ecological modeling

One of the main goals in 2013 was to include the SINMOD ecological model into Arctic-4km. The implementation of the SINMOD biological model (Wassmann et al. 2006) in a form suitable for ROMS is finished, and the model has been integrated in a recent ROMS version. This includes definition of states/tracers, input of boundary values and parameters, and integration between physics and biology. By utilizing the passive tracer mechanism in ROMS, the biological model can handle local ecosystem dynamics and vertical sinking terms, while the ROMS core model handles advection and diffusion of the biological tracers. The stability and local dynamics of the

biological model has been tested, and initial tests have been run in the Arctic-4km model setup.

An ice algae model based on Jin et al. (2006) has been implemented and tested for integration with the SINMOD biological model. Work on integrating this model with the ice module in the Kate Hedström branch of ROMS has started.

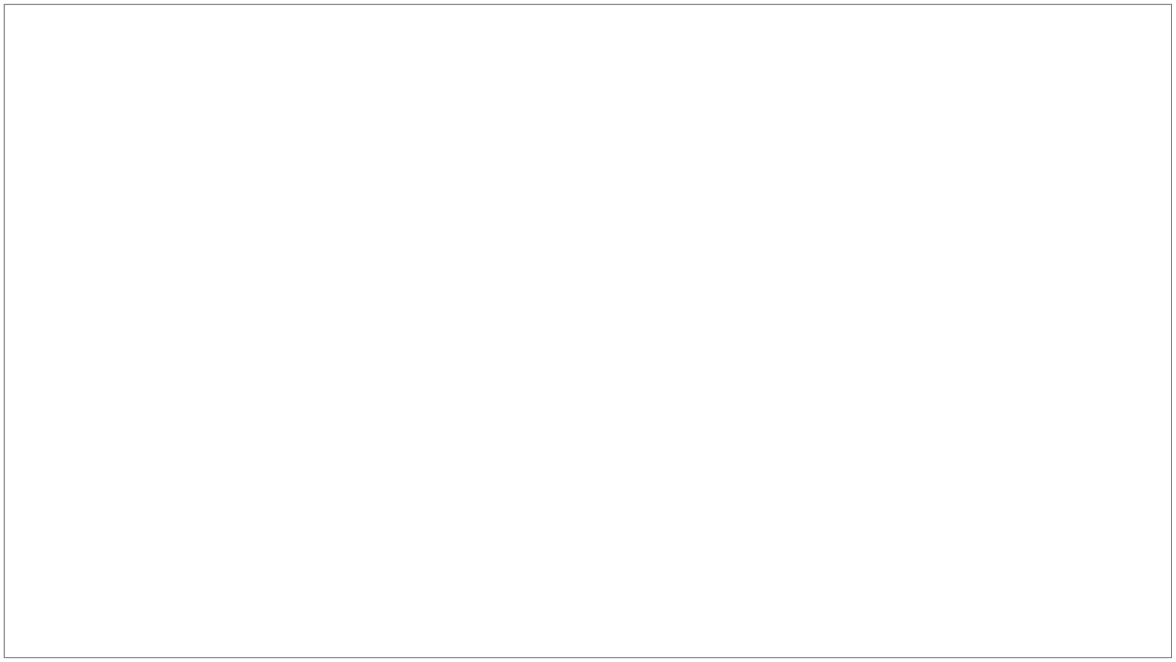


Figure 1. Extended Svalbard-800m model domain with bathymetry contours.

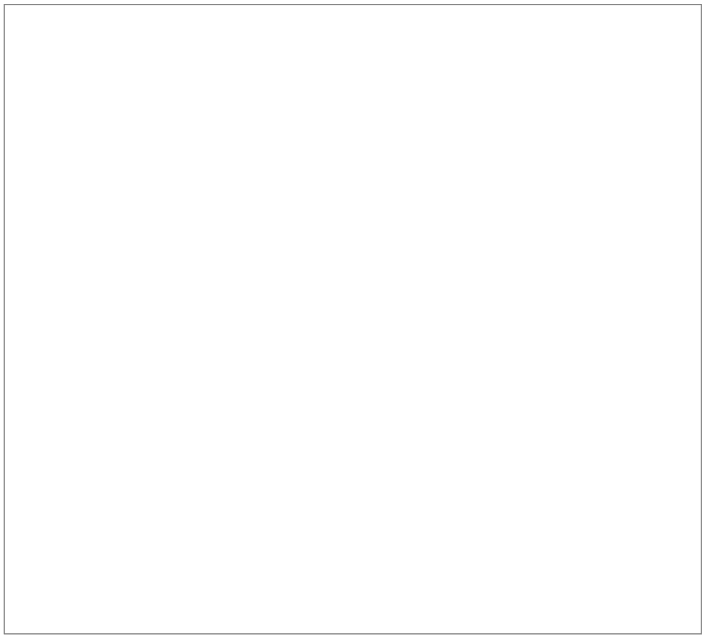


Figure 2. Fresh water discharge positions applied in the Svalbard800 model, estimated from a glaciological mass balance model (red circles). The circle size is scaled with the logarithm of the annual mean freshwater runoff.

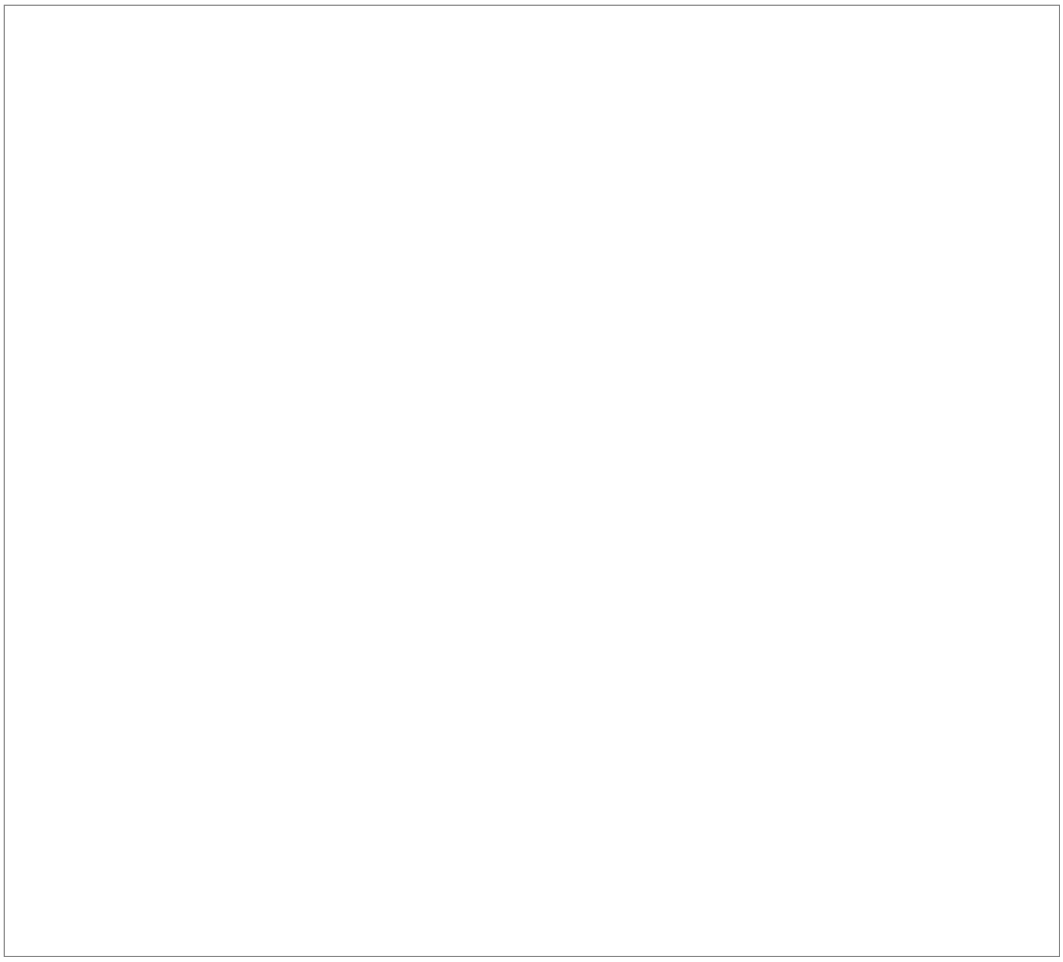
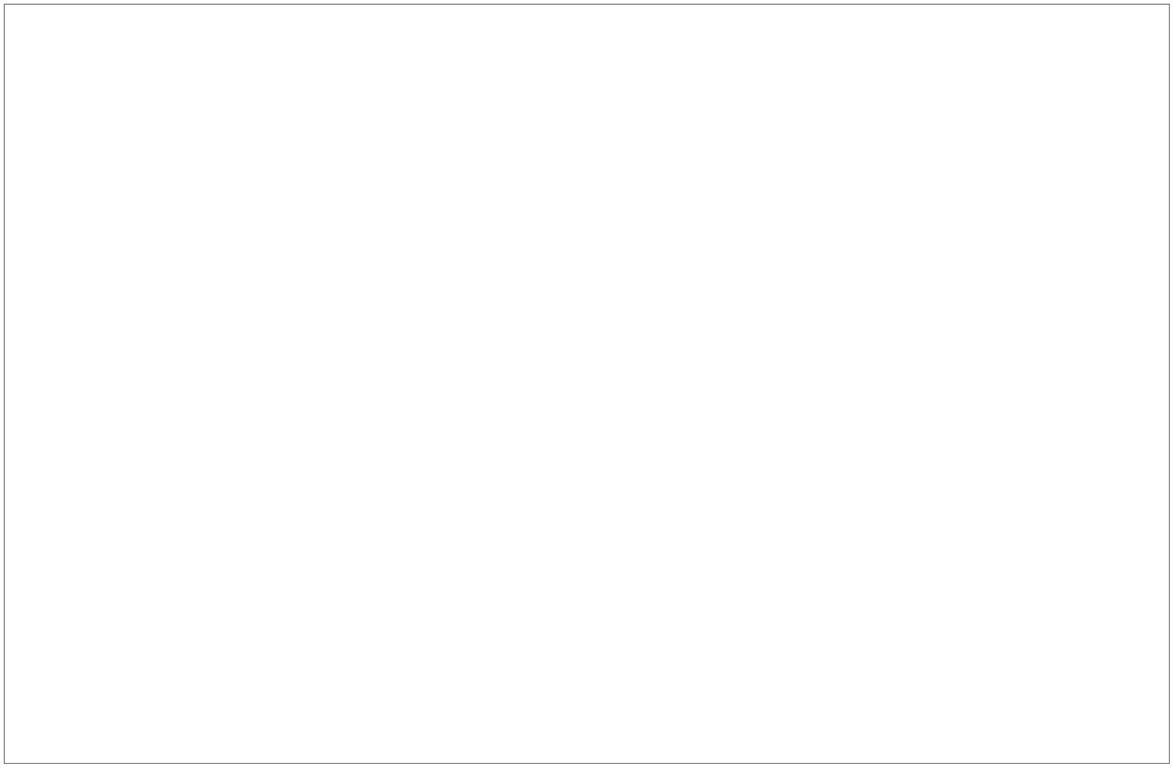


Figure 3. Locations of current meter data used for validation of the model. Bathymetry data was taken from ETOPO1 database.



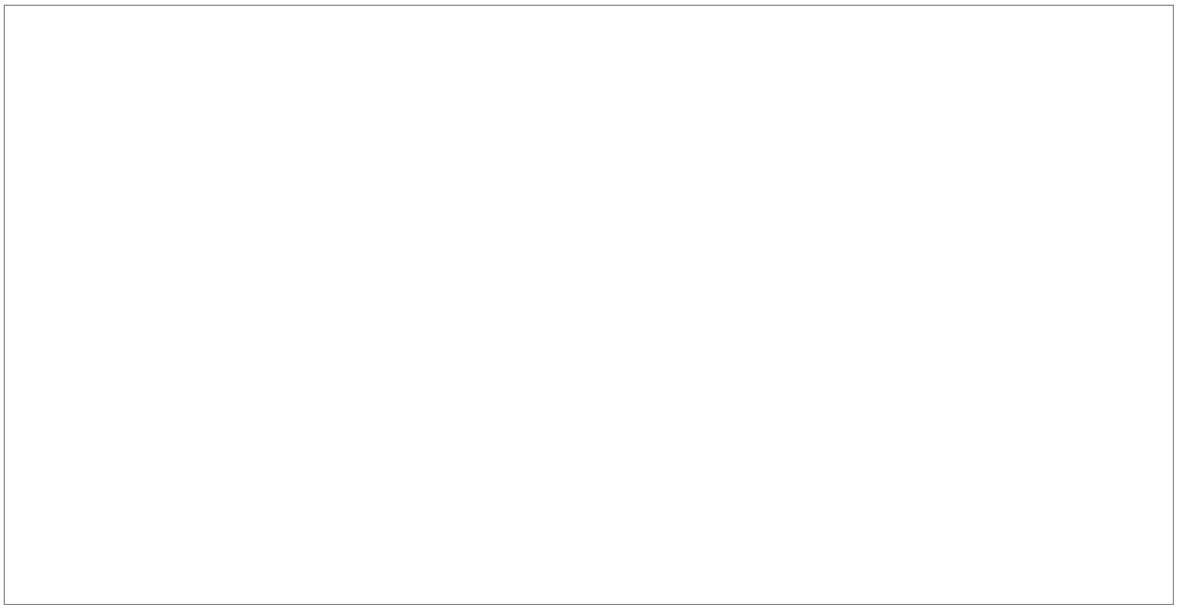
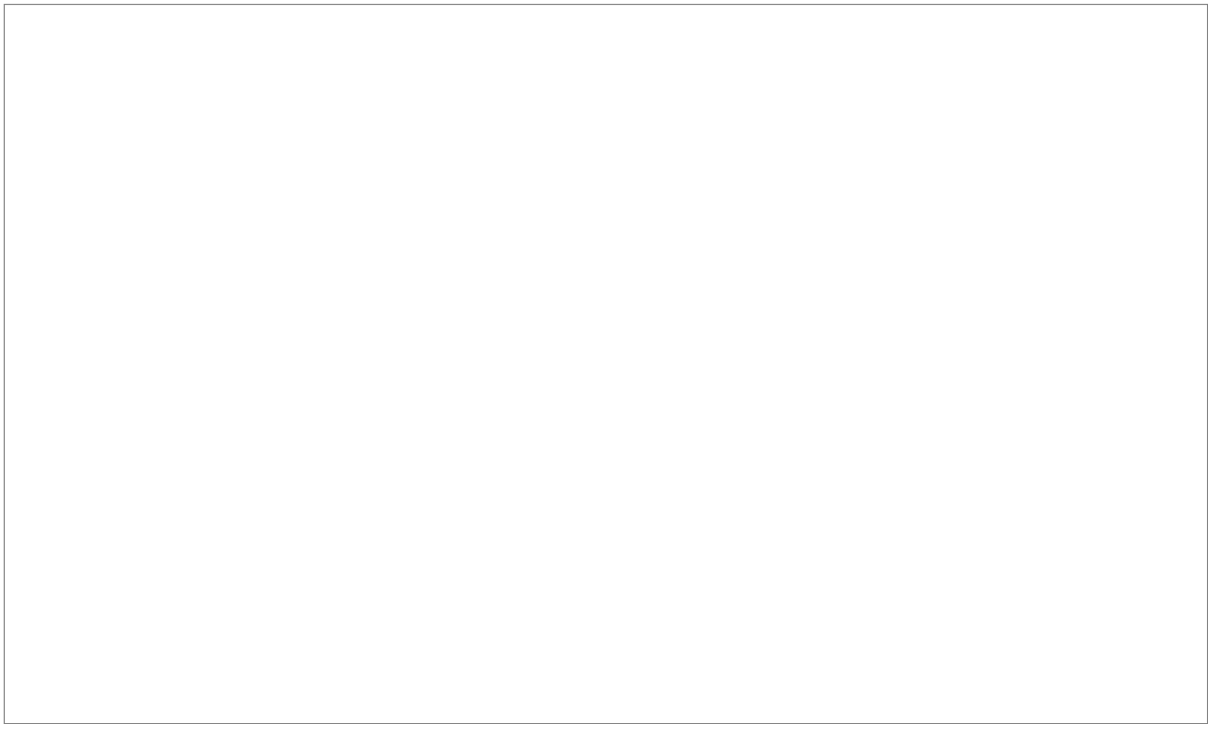


Figure 4. Comparison of time averaged NOAA WOA-Arctic regional climatology (left) with model results (right) from old multiyear runs (upper) and the second year of the new simulations that are currently performed (lower). Constant density contours are shown in black and colored dots show time averaged temperatures at the mooring locations.



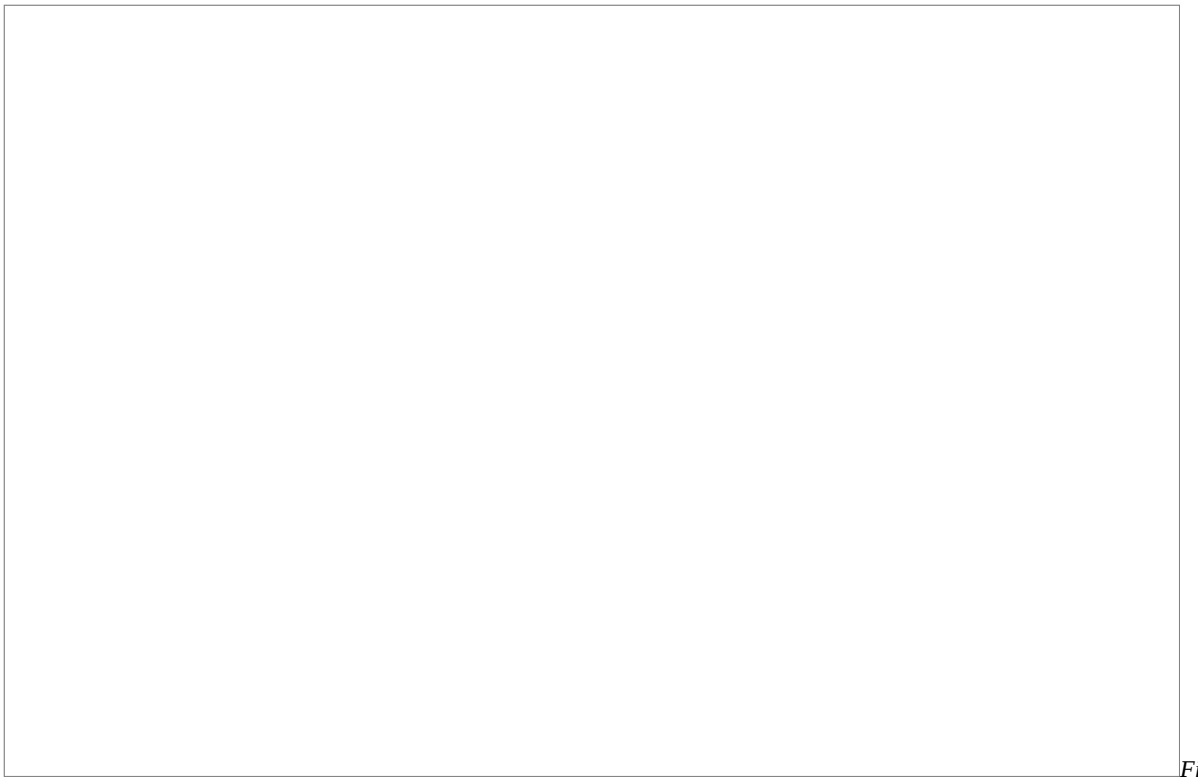


Figure 5. Comparison of upper ocean time averaged current vectors and variance ellipses from the Fram Strait mooring data (red) and the model results (blue) for the old multiyear run (upper) and the one year of the improved model version (lower).

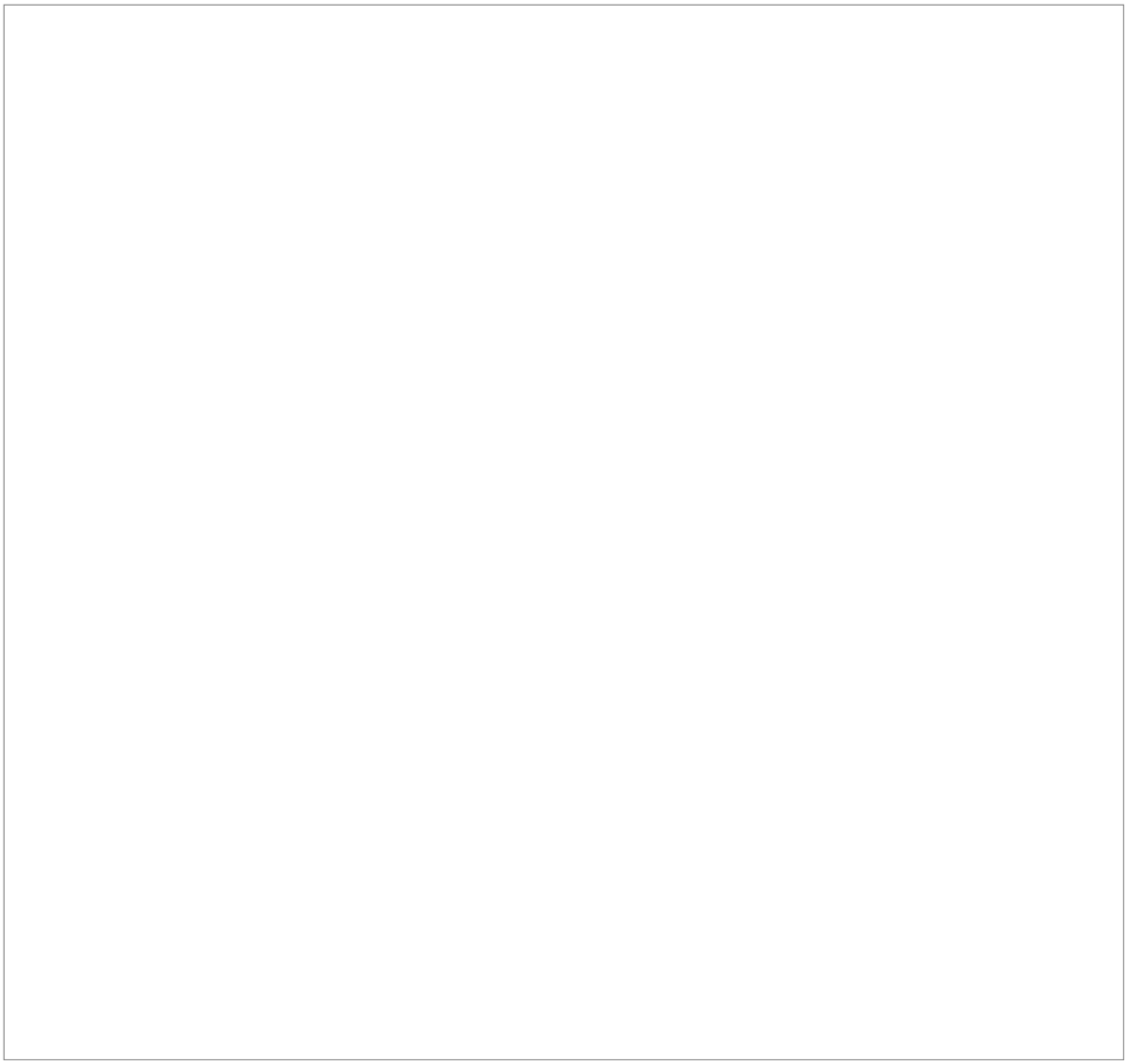


Figure 6. Top: Minimum observed sea ice extend in October2007 (left) and maximum sea ice extend in April 2010 (right). Below: Simulated sea ice extend from October 2007 (left) and April 2010 (right). The simulated fields show a high similarity to the observed fields.

For the Management

The Arctic Ocean model that has been setup in this project is of potentially great interest for the management. The model gives basic input to studies of the ecosystem and pollution in the Arctic Ocean. Initiatives proposing these types of studies are underway.

Published Results/Planned Publications

In October 2013 we were represented in the Forum for Arctic Ocean Modeling and Observational synthesis FAMOS). There we presented the poster:

Isachsen et al., Mesoscale eddy dynamics in e Arctic Ocean: Requirements for tracer transport parameterizations.

In Novermber 2013 the progress of the project was presented at the Framdagen workshop.

For planned publications see also the 2014 ModOIE proposal.

Communicated Results

In December 2013 an interdisciplinary modeling workshop was held at the Fram Centre to gather the local community, outlay common goals and identify possibilities for further collaboration. It was clear that the Arctic-4km model was of interest for many users and will potentially become a central modelling tool that is currently being developed within this project.

For planned dissemination of the results see also the 2014 ModOIE proposal.

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. Furthermore, the present achievements of the projects have spawned several initiatives, which aim at using the new modeling tools developed in this project for interdisciplinary and multidisciplinary studies, and proposals using the Arctic-4km and Svalbard-800m model were submitted, both, within the Fram Centre as well as externally.

However, successful interdisciplinary modelling bears several challenges, mainly being associated with diverging assumptions, techniques and requirements of the different disciplines involved. In particular the variety of temporal and spatial scales that need to be resolved for answering different modelling questions does not allow developing one single modelling tool that may be used for the various interdisciplinary objectives.

Another drawback of interdisciplinary-cooperation is that certain modelling improvements require dedicated focus on single aspects of the model (e.g. the representation of certain aspect of the model physics), that may be elementary for the overall results, but that can not sufficiently be treated in an interdisciplinary project.

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 the Norwegian Meteorological Institute is planning a substantial in kind contribution for the continuation of the project in 2014. In addition, there are several proposals open which would after having completed the model development with the Fram Centre funding, we are now having a unique tool at hand which enables us to approach other sources.

Could results from the project be subject for any commercial utilization

No

Conclusions

The model that is developed is of great interest to research in the Fram Centre and initiatives proposing interdisciplinary studies based on the results produced by the model is underway. The established model will be available to all the project partners and applied to a wide range of studies