Nordic Seas high resolution model system - a first test run

Nina Gjerde Winther

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Contents

1 Introduction

This work is part of the Norwegian Research Council funded project "Ocean weather and ecosystem in the Nordic seas -a Norwegian component to the Global Ocean Observing System (GOOS)". (See NERSC report.) The principle objectives and sub-goals are:

> To further build on our competence in "operational oceanography" focusing on basic research:
>
> - For improving and validating our TOPAZ system nested for the Nordic Seas and key Norwegian coastal regions.
> - To implement and validate a new formulation for the ecosystem of the Nordic Seas.
> - To incorporate measurements of the internal ocean and biochemical variability.
> - To design and assess a cost effective configuration of a Nordic Seas network of observations.
> - To demonstrate the improved TOPAZ modelling and data assimilation system in operation over a period of one year and compare the output with other existing operational products.
> - To prepare the model system for world wide operational use by the company Ocean Numerics Ltd.

The work presented in this report is a first trial to set up a realistic model system for the Nordic Seas. The physical ocean model used is HYCOM (Bleck, 2002). This report presents the model set up and results from a two month test simulation.

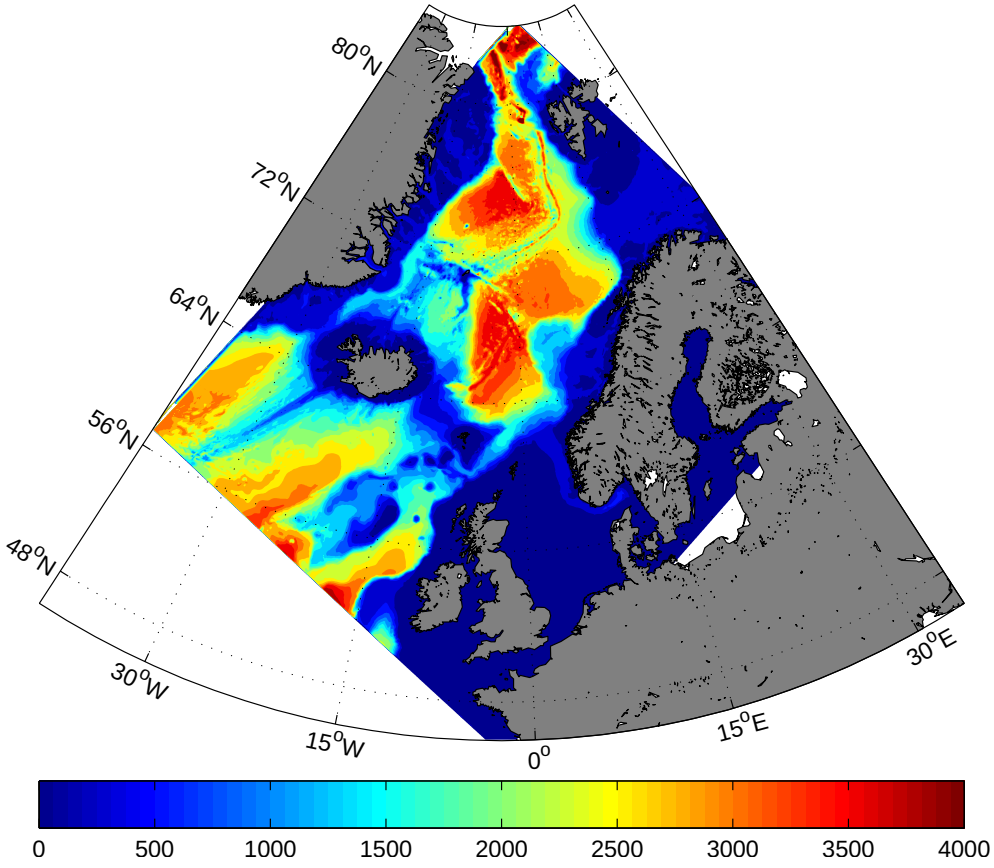

Figure 1: Topography of the nested high resolution Nordic Seas model.

2 Model setup

The overall model system consists of a nested system, where the large scale TOPAZ3 model provides nesting conditions to a regional Nordic Seas model, see Figure 1. TOPAZ3 has a horizontal resolution of 10-16 km, while the Nordic Seas model has a horizontal resolution of about 4 km. The model system does not include nesting of ice.

This model system is very CPU demanding. It was run on the cluster machine called FIMM, using 12 CPU's, and needed one month to simulate one year. All files needed to run the model system are located at FIMM. The necessary information is listed below.

Program files location:	/home/fimm/nersc/winther/Progs/Code/ HYCOM_2.1.03_MPI/Build_Nordic4km
Input files location:	/home/fimm/nersc/winther/Progs/Nordic4km
Work directory:	/work/winther/Nordic_4km (At present, it contains only necessary links)
Result files location:	/migrate/winther/Nordic

Explanation of result files follows below.

Nesting files:	Nordic_nest_???_???_???.tar.gz
Restart files:	N01restart_1995_001_???.tar
Daily averaged files:	N01DAILY_1995_001_???.tar
Snapshots:	N01y1995_001_???.tar

For more detailed information on how to set up a model system using NERSC HYCOM I refer to the following document:

"A short introduction to how to organize the work-directory when working with HYCOM models", by Cecilie Hansen, NERSC

3 Results

The model system has been run for the first 66 days of 1995. Considering that this is a first test run, the results look quite promising. Figure 2 shows the two month average of surface velocity and surface salinity for the Norwegian and North Seas. The general circulation is well simulated. We see both the western and eastern branch of the Norwegian Atlantic current. Atlantic water enters the Nordic Seas through the Faroe - Shetland channel and over the Faroe - Iceland Ridge. Atlantic water enters the North Sea at three locations; between Orkneys and Shetland, at the Shetland shelf, and in the Norwegian trench. The cyclonic circulation in Skagerrak is present, and we see the northwards flowing Norwegian Coastal Current.

Figure 3 shows a snapshot of surface velocity from the 22nd of February 1995. The figure illustrates the rich mesoscale current field in the Norwegian Sea, with a many meanders and eddies.

Figure 4 shows a two month average of surface current in the northern part of the model grid. Th area covers the entrance to the Barents Sea, the Greenland basin down to the Denmark Strait. We see the division of the Norwegian Atlantic current; one branch enters the Barents Sea together with the Norwegian Coastal Current and another branch follows the continental shelf northwards towards Svalbard and the Fram Strait. The strength of eastern Greenland current increases from north to south.

Transport estimates from the Nordic Seas model are shown in Figure 5. Upper panel shows daily transport values of Atlantic water through the Faroe - Shetland channel, and lower panel shows the Atlantic inflow through the Svinøy section. Faroe - Shetland inflow in January/February 1995 varies from 1 to 8 Sv, with a mean of 4 Sv. Atlantic inflow at the Svinøy section varies from about 1 to 12 Sv, with a mean of 6 Sv.

At the Nordic Seas workshop at NERSC 3rd of May 2006 Svein Østerhus, GFI, presented results from the MOEN measurement program, which monitors the Atlantic inflow to the Nordic seas. See webpage: http://www.uib.no/-People/ngfso/ under projects. Measurements presented were from the time period 1995 to 2005. From these measurements transport estimates were computed, which represents a good source for first hand evaluation of the model results. Transports are summarized in Table 1. From the model only the Atlantic inflow through the Faroe - Shetland channel is computed so far. This should of course be done also for the other inflow locations, both to the Nordic Seas and the North Sea.

	Data	Model
Faroe - Shetland	4.2	4.0
Iceland - Faroe	3.7	
Iceland west shelf	0.8	
Total inflow	8.7	

Table 1: Transports estimates based on measurements from the MOEN project. Values given in Sv. Faroe - Shetland inflow does not include re-circulated water in the Faroe Shetland channel.

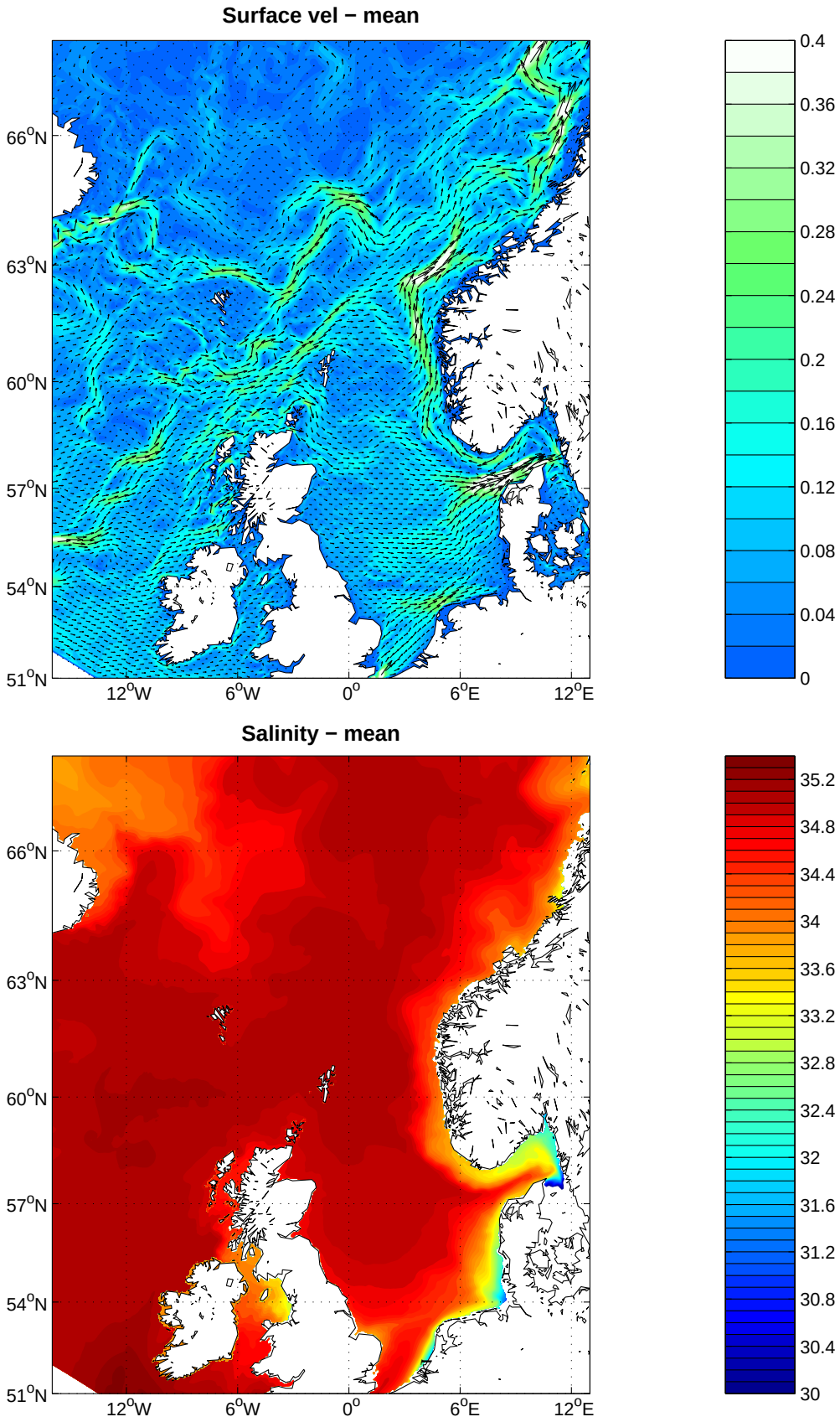

Figure 2: Two months average of surface velocity (left) and surface salinity (right), January/February 1995.

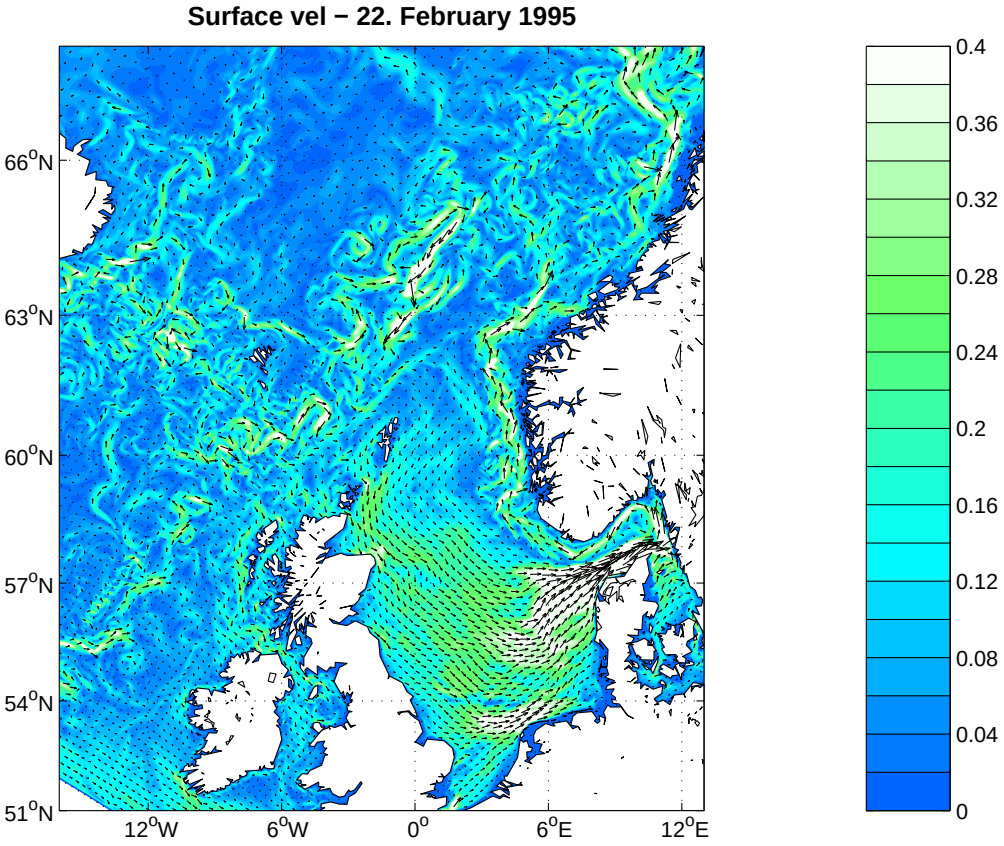

Figure 3: Surface velocity from the 22nd of February 1995.

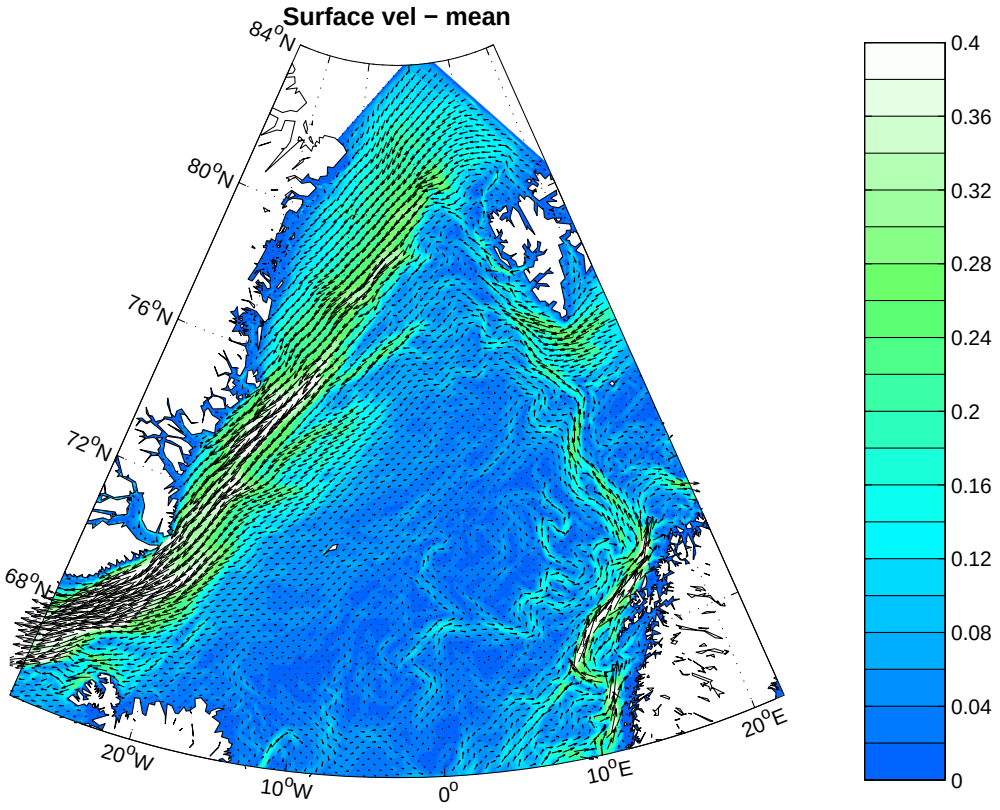

Figure 4: Two months average of velocity, January/February 1995

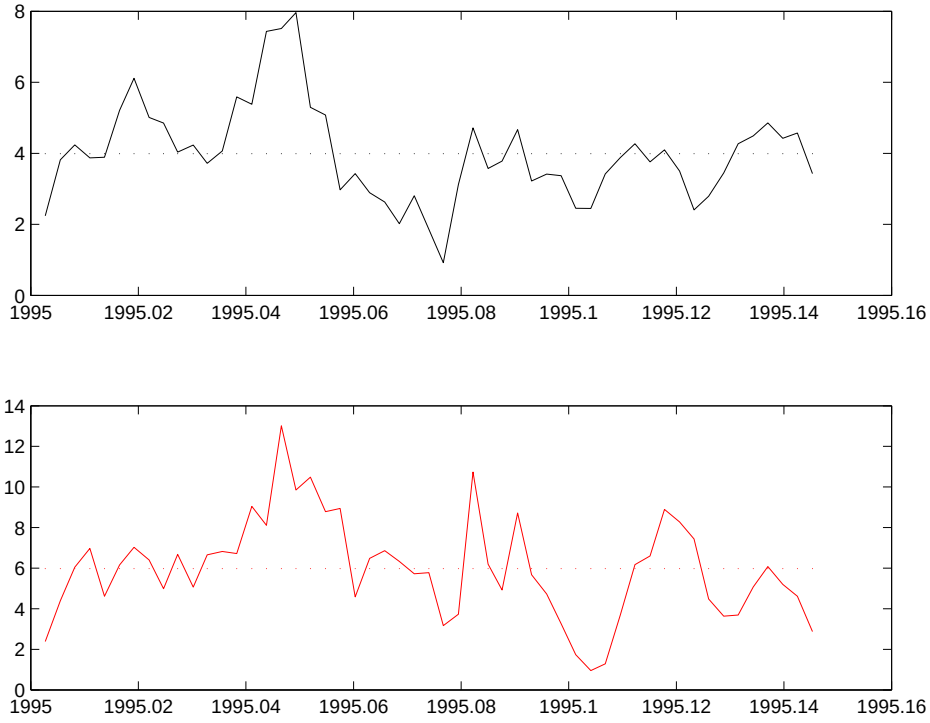

Figure 5: Transport estimates from the model runs. Top: Atlantic inflow between Faroes and Shetland. Bottom: Atlantic inflow through Svinoy section.

4 Future work

Future work should include:

- Update to the latest version of NERSC HYCOM.
- Transfer to the new cluster machine in Trondheim called NJORD.
- Evaluation of horizontal resolution. Remember the small Rossby radius in the area. Should have horizontal resolution down to 1-2 km. Is this feasible for such a large area?
- Extend the grid at the north boundary to include the Fram Strait?
- Evaluation of rivers, more rivers should be included.
- QUICK scheme must be used in future runs. Can this account for some of the lack in horizontal resolution? See Winther et al. (2006).
- Should use updated HYCOM code with inverted KPP mixing scheme; mixing scheme that includes bottom boundary layer. This will reduce the erroneous mixing at the shallow continental shelf. See Winther and Evensen (2006).
- Evaluate target densities. The target densities used in this model setup and in TOPAZ are not ideal for resolving the vertical distribution of Atlantic water along the continental shelf.
- Evaluation of sigma-0 versus sigma-2. In this model setup we use sigma-0, which means that the potential density is referenced to the surface. In sigma-2 simulations potential density is referenced to 2000 m, and are shown to give different results, see Chassignet et al. (2003). Both set-ups have strengths and weaknesses, what is the best set-up for the Nordic Seas?

References

Bleck, R., 2002. An oceanic general circulation model framed in hybrid isopycnic-cartesian coordinates. Ocean. Mod. 4, 55–88.

Chassignet, E., Smith, L., Halliwell, G., Bleck, R., 2003. North Atlantic simulation with the HYbrid Coordinate Ocean Model (HYCOM): Impact of the vertical coordinate choice, reference density, and thermobaricity. J. Phys. Oceanogr. 33, 2504–2526.

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