High resolution sea ice-ocean modeling of the Canadian Arctic Archipelago

Claudia Wekerle, Qiang Wang, Jens Schröter and Sergey Danilov

Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany

Contact: Claudia.Wekerle@awi.de

FESOM
Finite-Element Sea-ice Ocean Model

I. INTRODUCTION

The freshwater outflow (liquid and sea ice) of the Arctic Ocean into the Atlantic Ocean through the Canadian Arctic Archipelago (CAA) is an important component of the Arctic freshwater cycle. The freshwater export into the North Atlantic could have great impact on deep water formation, which is crucial for the Meridional Overturning Circulation.

As the CAA is characterized by complex coastlines and narrow straits, properly resolving this region in a global configuration is very difficult with traditional ocean models. To study the ocean and sea ice conditions in the CAA region, we use the Finite Element Sea ice Ocean Model FESOM (Timmermann et al, 2009) developed at the Alfred Wegener Institute which allows to refine the computational mesh in regions of interest.

II. MODEL SETUP

FESOM solves the primitive equations on the sphere. A dynamic-thermodynamic sea ice model is coupled to the ocean component. The global configuration obviates the need for boundary conditions and traditional nesting.

Figure 1 depicts the resolution of the global unstructured mesh. It ranges between 2.5km in the CAA area and 90km in the open ocean. Bathymetry is taken from IBCAO (north of 64°N) and GEBCO data sets.

2d-nodes	242246
3d-nodes	2.8 mil
z-levels	47

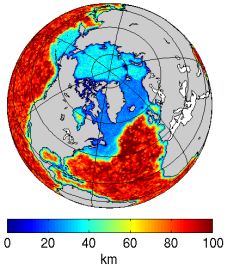


Figure 1: Resolution of the global mesh.

The model is initialized with PHC2.0 hydrographic data. Forcing data is taken from the CORE2 data set. The simulation starts in 1974 and is integrated until 2001 with a time step of 10min.

III. MEAN CIRCULATION OF THE ARCTIC OCEAN

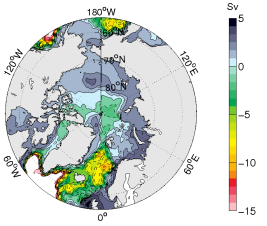


Figure 2: Mean barotropic streamfunction for the years 1979-2001.

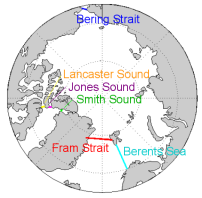


Figure 3: The map of the Arctic Ocean shows locations where volume, freshwater and sea ice transports were calculated.

IV. SEA ICE CONDITIONS

Figure 4 depicts the mean sea ice concentrations for March and September 1979-2001 from satellite data (top) and simulation (bottom). In summer, the model overestimates the sea ice area slightly.

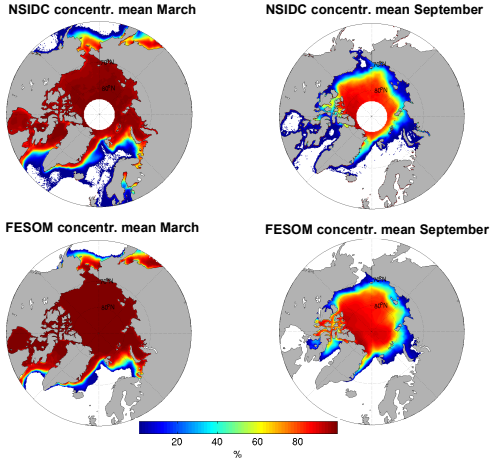


Figure 4: Sea ice concentration from model and satellite data.

V. VOLUME AND FRESHWATER BUDGET OF THE ARCTIC OCEAN

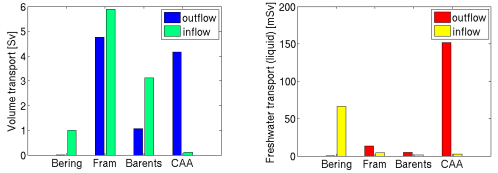


Figure 5: Mean liquid volume and freshwater transports (exports and imports) of the Arctic Ocean for the years 1979-2001. Freshwater transports are calculated with a reference salinity of 34.8 psu.

VI. SEA ICE EXPORTS OF THE CAA

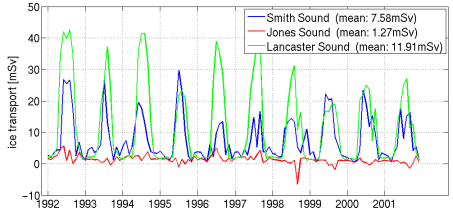


Figure 6: Sea ice exports of the CAA for the years 1992-2001.

VII. VOLUME AND FRESHWATER TRANSPORTS

Transports through the CAA show a strong seasonal cycle. Freshwater transport is dominated by Lancaster Sound.

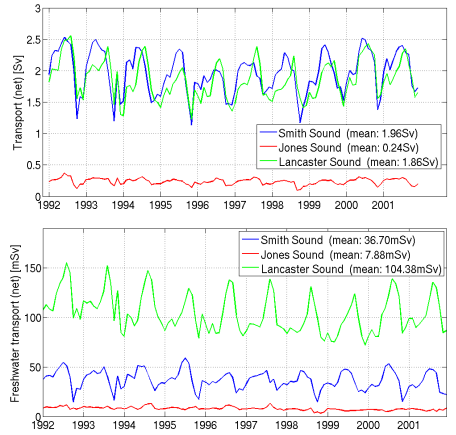
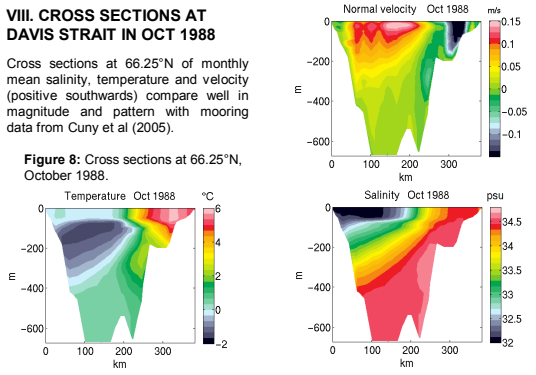


Figure 7: Volume and freshwater transports through the CAA.

VIII. CROSS SECTIONS AT DAVIS STRAIT IN OCT 1988

Cross sections at 66.25°N of monthly mean salinity, temperature and velocity (positive southwards) compare well in magnitude and pattern with mooring data from Cuny et al (2005).

Figure 8: Cross sections at 66.25°N, October 1988.



IX. CONCLUSIONS AND OUTLOOK

- The model reproduces well the general circulation of the Arctic Ocean like the Beaufort Gyre and the cyclonic circulation in the Eurasian Basin. The sea ice area matches well with satellite data. Transports through the main gates of the Arctic Ocean are slightly higher compared to other high resolution model studies like Lique et al (2010).
- The CAA plays an important role in the Arctic liquid freshwater cycle.
- Sea ice export of the CAA accounts for 0.5% of the total volume transport through the CAA and therefore plays a minor role in the freshwater export of this region.
- It is planned to study the sensitivity of model results to mesh resolution in the CAA area.

REFERENCES:

Cuny, J., Rhines, P.B. and Kwok, R.: Davis strait volume, freshwater and heat fluxes. Deep-Sea Research I 52, 2005.

Lique, C., Treguier, A.M., Blanke, B. and Grima, N.: On the origins of water masses exported along both sides of Greenland: A Lagrangian model analysis. Journal of Geophysical Research 115, 2010.

Timmermann, R., Danilov, S., Schröter, J., Böning, C., Sidorenko, D. and Rollenhagen, K.: Ocean circulation and sea ice distribution in a finite element global sea ice-ocean model. Ocean Modelling 27, 2009.