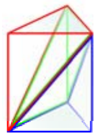
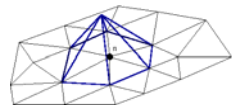
# Validation of a global finite element sea ice-ocean model



Ralph Timmermann, Sergey Danilov, Jens Schröter

Alfred Wegener Institute for Polar and Marine Research, Bremerhaven



FESOM
Finite-Element Sea-ice Ocean Model

## 1. Introduction

Results from a global Finite Element Sea ice–Ocean Model (FESOM; *Timmermann et al., 2009*) are evaluated using eulerian and lagrangian datasets. We demonstrate that the model captures many of the typical features of sea ice distribution and global ocean circulation, but also shows a couple of weaknesses. Local refinement of the grid is expected to improve results further.

## 2. Model Description: Finite Element Sea Ice Ocean Model (FESOM; *Timmermann et al. 2009*)

- hydrostatic, free-surface, primitive-equation Finite Element Ocean Model (grown up from FENA model of *Danilov et al., 2004*)
- tetrahedral mesh, P1-P1 discretization
- global domain, 1.5° horizontal resolution, 26 layers, shaved cells
- dynamic-thermodynamic Finite-Element Sea-Ice Model (FESIM)
- Heat storage in ice/snow neglected
- EVP rheology
- atmospheric forcing from NCEP reanalysis 1948-2007

## 4. Results: Sea ice cover

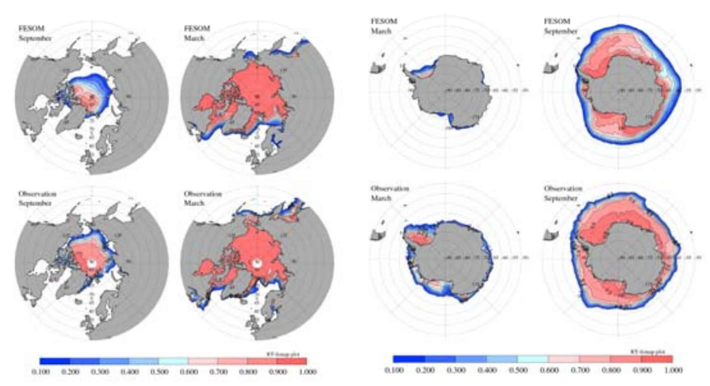


Fig. 5: Simulated and observed minimum and maximum sea ice extents

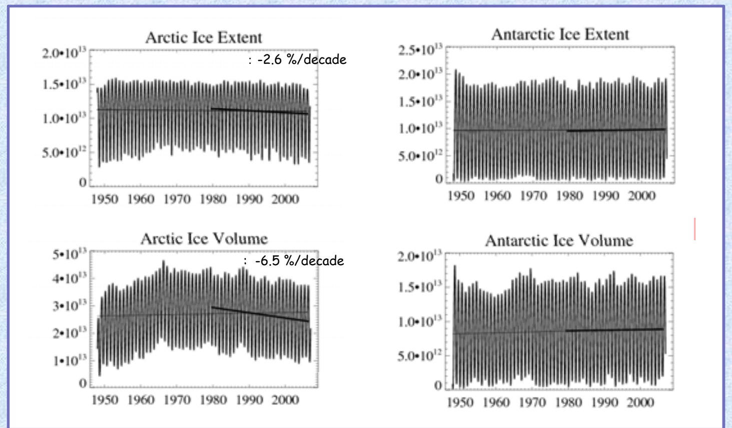
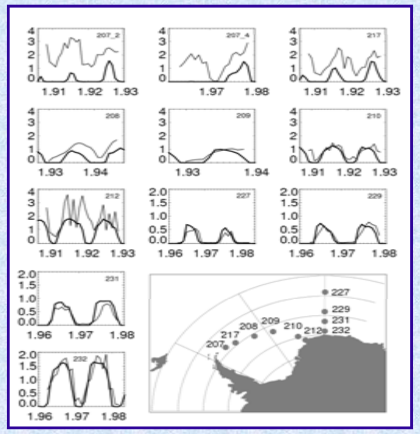



Fig. 6: Time series of simulated ice extents and volume

Fig. 7: FESOM ice thickness validation: comparison to upward looking sonars (ULS)



## 3. Results: Ocean circulation, meridional overturning and bottom water formation

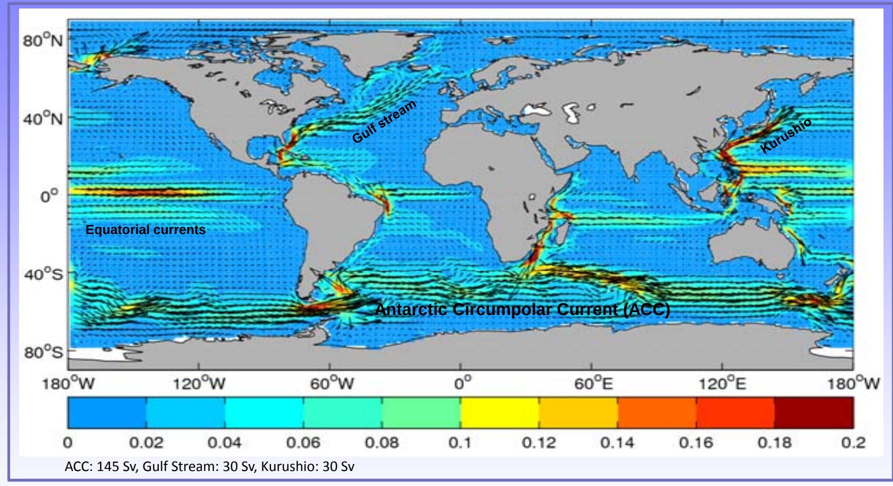



Fig. 1: Annual mean velocity at 150 m depth after 10 years of integration (displayed on 3°x3° grid)

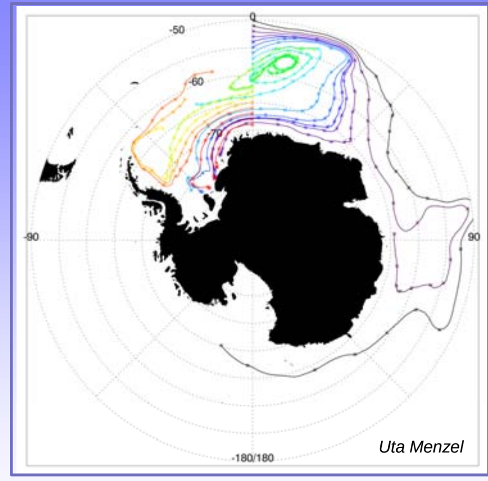



Fig. 2: 16 yrs of simulated trajectories (200 m depth)

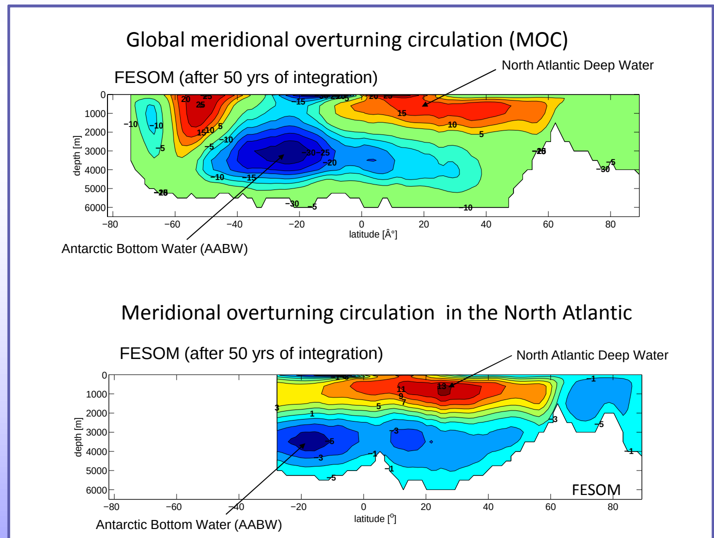



Fig. 3: Meridional overturning circulation (global mean and North Atlantic)

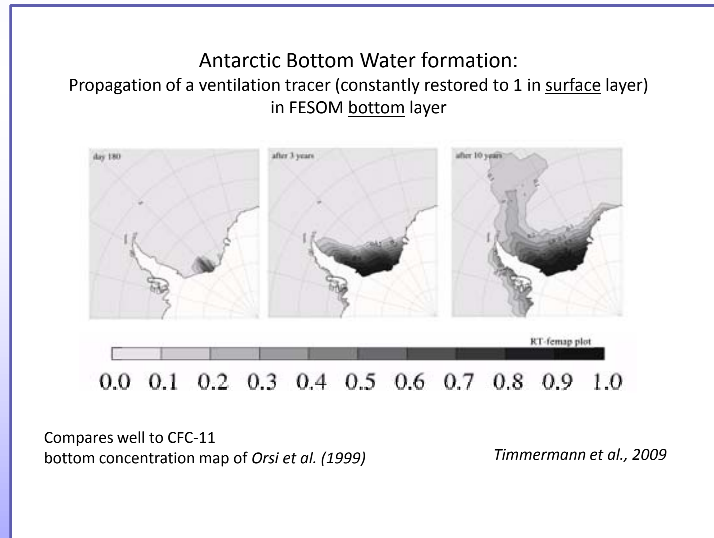



Fig. 4: Bottom spreading of a numerical tracer released at the surface

## 6. Conclusions

- good representation of ocean general circulation; subsurface velocities on the small side. Strong AABW cell, ventilation at correct locations.
- summer ice extent too small, winter ice extent excellent. Realistic trends. Ice thickness comparison for Weddell Sea very good, except for northwestern corner.

## 5. Results: Estimating net freezing rates

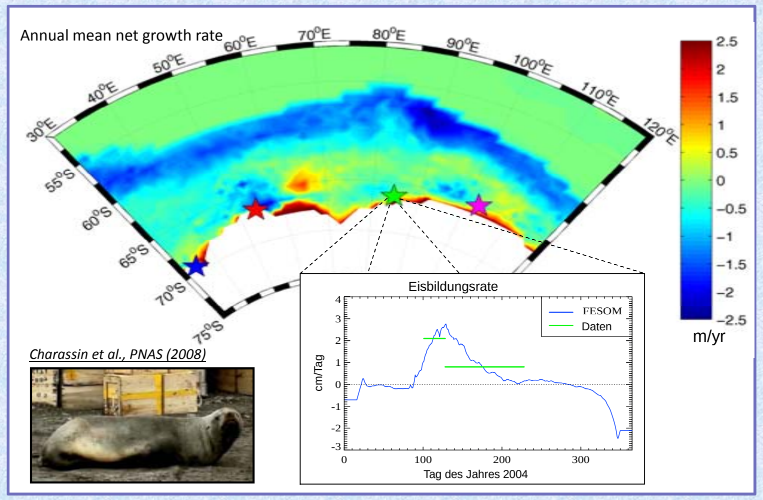



Fig. 8: Comparison of FESOM freezing rates to estimates derived from repeated salinity profiles obtained from Southern Elephant Seals (Charrassin et al., PNAS 2008). Similar agreement for other positions.

## 7. New "Weddell Sea grid": global with local refinements

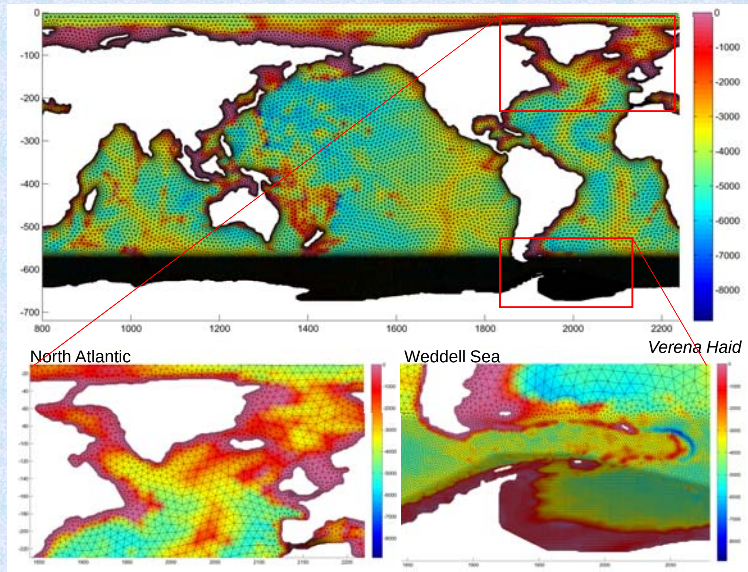



Fig. 9: Surface grid to be used for study of ice-ocean-atmosphere interaction in the Weddell Sea. 106959 surface nodes, resolution varies from 0.25° to 2.5°.

## 7. Outlook

- Local refinements in the Weddell Sea
- Implementation of ice shelf-ocean interaction
- Coupling to COSMO (coop. with D. Schröder / G. Heinemann, Uni Trier)

## Further reading:

**Charrassin, J-B., et al.:** Southern Ocean frontal structure and sea ice formation rates revealed by elephant seals, Proceedings of the National Academy of Sciences, 105(33), 11634-11639, doi: 10.1073/pnas.0800790105, 2008.

**Rollenhagen, K.**, R. Timmermann, T. Janjic, J. Schröter, and S. Danilov: Assimilation of sea ice motion in a Finite Element Sea Ice Model. Journal of Geophysical Resarch (in press)

**Timmermann, R.**, Danilov, S., Schröter, J., Böning, C., Sidorenko, D., Rollenhagen, K.(2009): Ocean circulation and sea ice distribution in a finite element global sea ice -- ocean model, Ocean Modelling, doi:10.1016/j.ocemod.2008.10.009.

**Contact:** Ralph Timmermann (Ralph.Timmermann@awi.de), Alfred Wegener Institute for Polar and Marine Research, Bussestraße 24, 27570 Bremerhaven, Germany