Project:	**941**
Project title:	**Investigation of Labrador Sea Dynamics with the High-Resolution Finite Element Sea Ice – Ocean Model FESOM**
Project lead:	**Prof. Dr. Gerrit Lohmann, Christopher Danek**
Report period:	**1/2017 – 12/2017**

1 Project report

Five spinup cycles (each of them forced by the CORE2 atmospheric reanalysis from 1948-2009, Large and Yeager 2009) of the mesh configuration "HIGH" (see Table 1 and Figure 2 in the Request document for 2017) were performed with the Finite Element Sea-Ice Ocean Model (FESOM, Wang et al. 2014). The model was initialized by the Polar Science Center Hydrographic Climatology (PHC, Steele et al. 2001) and every spinup cycle was initialized with the last time step of its previous cycle.

Our results show a strong modification of the general circulation and properties of important water masses in the North Atlantic such as Nordic Seas overflow waters or Labrador Sea Water classes depending on both the horizontal mesh resolution and the number of modeled spinup cycles. For example, the Denmark Strait (DS) overflow (potential density $\sigma_\Theta > 27.8$ kg m^{-3}, southward transport) is strongly increased in the high resolution setup compared to the low resolution. In addition, it shows a rigorous change depending on the number of modeled spinup cycles (Fig. 1).

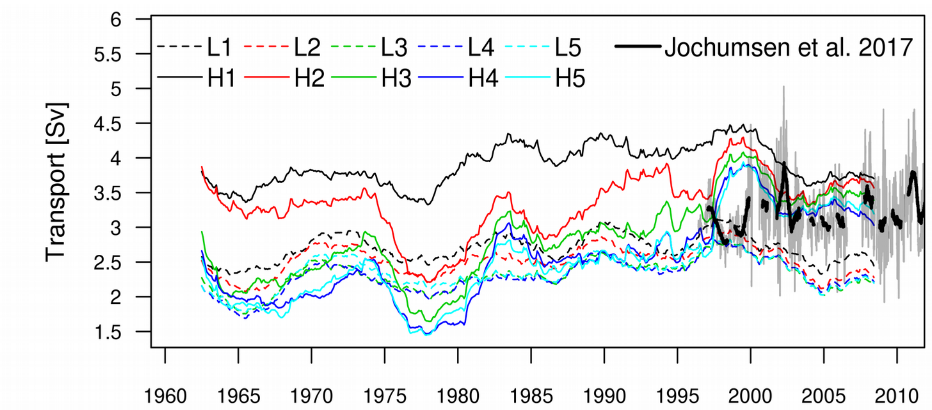

Fig. 1: Southward Denmark Strait (DS) overflow (in Sv, 1 Sv = 1 × 10^6 m^3 s^{-1}, $\sigma_\Theta > 27.8$ kg m^{-3}) as modeled with FESOM (lines, from 1961-2009, 3-year low pass filtered, 'L' and 'H' for low and high resolution models, numbers 1-5 for 1st to 5th spinup) and observed (Jochumsen et al. 2017, gray (black) line: 20-day (6-month) low pass filtered).

Furthermore, we were able to quantify meso- to submeso scale processes and their effects on the restratification after convective events in the Labrador Sea. Our results suggest that mainly baroclinic instabilities in winter (maximum in March) are responsible for a decrease of deep convection during winter (Fig 2). These instabilities are almost absent in our control experiment that exhibits a ~¼° horizontal resolution in the Labrador Sea.

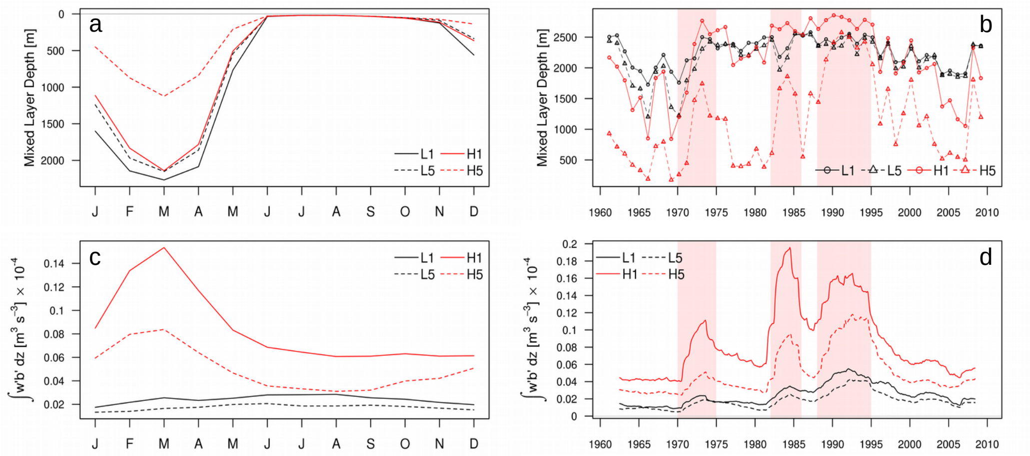

*Fig. 2: Average (1961-2009) seasonal (left column) and decadal (right column) evolution of **a**, **b**) Mixed Layer Depth (MLD, in m, symbols in **b** show March MLD), **c**, **d**) depth integrated eddy vertical buoyancy flux (in $m^3 s^{-3} \times 10^{-4}$) of 1st (solid) and 5th (dashed) low (black) and high (red) resolution models. The baroclinic instability $\overline{w'b'}$ is associated with eddy potential to eddy kinetic energy conversion, i. e. eddy-growth based on the energy stored in steep isopycnals and induced vertical velocities. All time series are averaged over Labrador Sea interior and a 3-year low pass filter is applied to **d**. Red shading in **b**, **d** shows periods of deep MLD in H5.*

Hence, we show that the general problem of too deep convection in state-of-the-art ocean models which use rather coarse resolutions is attributed to both missing local mixing processes associated with baroclinic instabilities and to wrong properties of water masses that enter the Labrador Sea which strongly change with the number of modeled spinup cycles.

A publication about the influence of the number of spinup cycles and mesh resolution on the hydrographic properties in the North Atlantic and Labrador Sea is in preparation.

2 References

Jochumsen, K., M. Moritz, N. Nunes, D. Quadfasel, K. M. H. Larsen, B. Hansen, H. Valdimarsson, S. Jonsson (2017): Revised transport estimates of the Denmark Strait overflow. ***J. Geophys. Res. Oceans***, 122, 3434-3450, doi:10.1002/2017JC012803.

Large, W. G. and S. G. Yeager (2009): The global climatology of an interannually varying air-sea flux data set. ***Clim. Dyn.***, 32, 2, 341-364, http://data1.gfdl.noaa.gov/nomads/forms/mom4/COREv2.html.

Steele, M., R. Morley, W. Ermold (2001): PHC: A global ocean hydrography with a high quality Arctic Ocean, ***J. Climate***, 14, 2079-2087. https://doi.org/10.1175/1520-0442(2001)014<2079:PAGOHW>2.0.CO;2.

Wang, Q., S. Danilov, D. Sidorenko, R. Timmermann, C. Wekerle, X. Wang, T. Jung, J. Schröter (2014): The Finite Element Sea Ice-Ocean Model (FESOM) v.1.4: formulation of an ocean general circulation model. ***Geosci. Model Dev.*** 7, 663-693. doi:10.5194/gmd-7-663-2014.