Hydrodynamic-sea ice couplings in the Barents Sea and their consequences for marine productivity

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Summary

During the past decades the Barents Sea experienced pronounced changes in hydrodynamic-, biogeochemical and higher trophic level conditions. The sea ice cover showed a long-term decreasing trend, which seems to have slightly stabilized during the recent years (Karaskov et al., 2013). Barents Sea temperature is characterized by significant multidecadal variability, which correlates to the Atlantic Multidecadal Oscillation AMO (e.g. Levitus, et al., 2009) and co-variations with cyclone activity have been identified in earlier studies (e.g. Sorteberg and Kvingedal, 2006). These long-term variations in oceanographic conditions are accompanied by pronounced variations in the ecosystem with a.o. an increase in fish abundance and an expansion of key stocks northwards (e.g. Stiansen et al., 2009). Based on model simulations of contrasting years, it has earlier been suggested that sea ice retreat will result in increasing primary production in the Barents Sea (e.g. Wassmann et al., 2006).

We investigate long-term variations in bottom up controls on the lower trophic level production in the Barents Sea by employing a regional physical-biological model for a multi-decadal simulation. We will illustrate the impact of climatic forcing on lower trophic level production in the Barents Sea and discuss the variations in dominant climatic drivers over the decades.

Model description

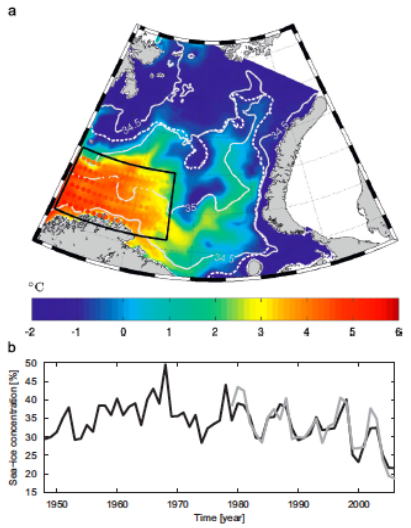

Figure 4: Mean simulated temperature (color) and salinity during February 1981-2004 over 0-200 m depth. The February mean ice edge (concentration 30%) is indicated by the dashed white line. b) Winter mean (November-April) sea ice concentration from ECOSMO (black) and from satellite data (SMMR/SSMI) between 70-81 °N and 15-60 °E (Årthun et al., 2012).

We applied the coupled physical-biological model ECOSMO (Daewel & Schrum, 2013) to the Barents Sea. The biogeochemical module simulates 3 nutrient cycles, 2 functional groups for phyto- and zooplankton respectively, and considers detritus and DOM as well as sediment pools for organic matter. The model was integrated over a 60 year time period (1948-2007) and results were analysed with special emphasis on identifying the most important climatic drivers. To validate the ECOSMO long-term model run (1948-2007) we utilized observational data from different databases (e.g. CARINA, NISE). Detailed validations were earlier performed (Årthun and Schrum, 2010; Årthun et al., 2011 and Barthel et al., 2012).

Based on the validation exercises, we could attribute a high potential predictability of the regional hydrodynamics and biogeochemistry to ECOSMO-Barents when forced by high quality atmospheric and ocean boundary forcing. We could identify small biases in temperature and salinity, however,

they decreased significantly when we moved from the highly diffusive upstream to the non-diffusive Lax-Wendroff TVD (using superbee limiter) (Barthel et al., 2012). The sea ice variability and average maximum sea ice extend was modelled with fairly high accuracy

Results

Our simulations could show that the Barents Sea experienced large variations in bottom up controls and primary production over the last 60 years. Compared the 1950ies the productivity has increased by 20-30% in the last decade of the simulation period (1998-2007). This increase is paralleled by an increase in Atlantic Water content and sea ice decrease during which both have implications for nutrient supply and light climate.

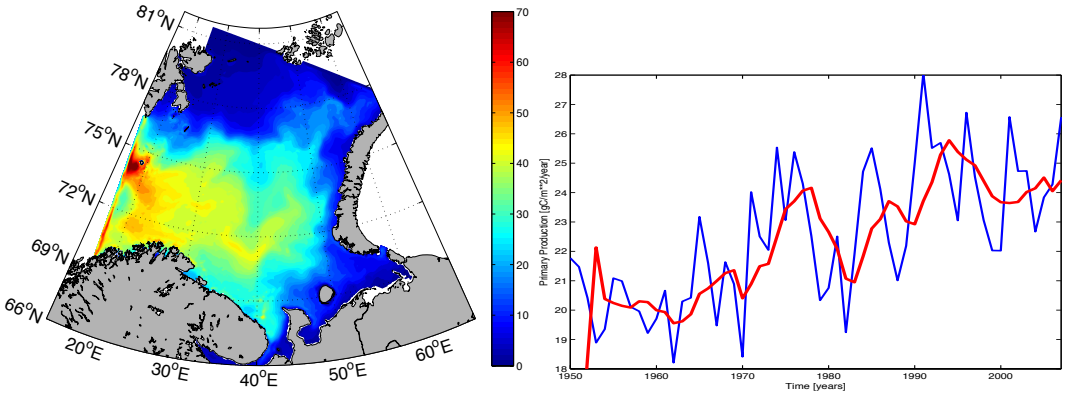

Figure 4: 60-yrs mean net primary production/yr (left) and annual productivity during 1948-2007 ($gCm^{-2}yr^{-1}$).

Literature

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