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Comparison of coupled/uncoupled regional ocean-atmospheric model simulations in the North Sea and the Baltic Sea

Christoph Stegert[1], Manuel Dröse[1], Janna Abalichin[2], Birte-Marie Ehlers[2], Jennifer Brauch[1], Frank Janssen[2]

We use a coupled COSMO-CLM/NEMO_Nordic simulation in the North Sea and Baltic Sea to investigate the atmospheric influence on the hydrography and ocean dynamics comparing the results with an identical uncoupled simulation with NEMO_Nordic.
Through the atmosphere's influence on the ocean, feedback on the atmosphere itself has been investigated in a number of studies, promoting the importance of two-way model coupling. This is also relevant for the ocean specifically at longer time scales, where online computed values of air temperature, precipitation and wind influence the ocean dynamics.

Model setup and simulation

A coupled simulation with the atmospheric model COSMO_CLM 5.0.9 for the EURO-CORDEX area and the ocean model NEMO_Nordic including the LIM3 ice model was used.

Through the OASIS3_MCT3 coupler software surface temperature (SST) was transfered from ocean to atmosphere model, while air pressure, precipitation, evaporation, air temperature, humidity and wind are turned over to the ocean model. The uncoupled NEMO model was forced with COSMO REA6 data.

Coupled	uncoupled
Years	
1979-2015	1996-2015
Time step	
300s	300s
Resolution	
2 nm, 56 levels	2 nm, 56 levels
River runoff	
E-HYPE	E-HYPE

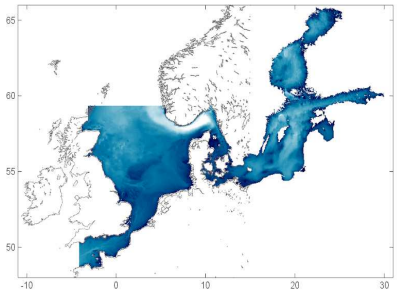


Figure 1: NEMO_Nordic model area and topography

Comparison of climatological results: temperature

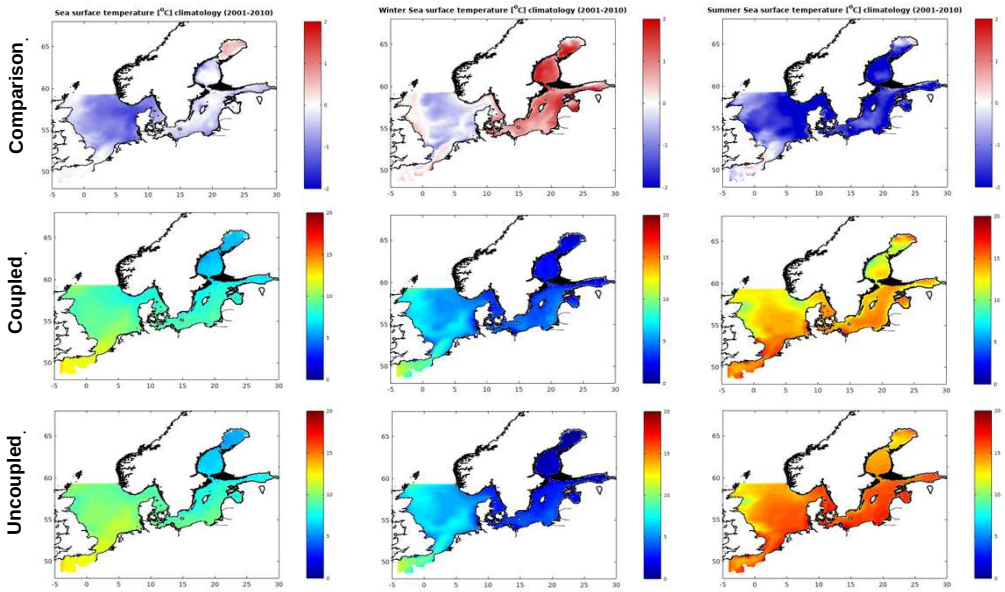
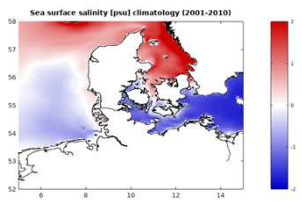


Figure 2: Sea surface temperature as comparison (upper) of the coupled (center) and uncoupled (bottom) simulation. Plots are given for annual mean temperature (left) as well as winter (DJF mean, middle) and summer (JJA mean, right). In the comparison red indicates higher values of the coupled simulation.

Comparison of climatological results: salinity



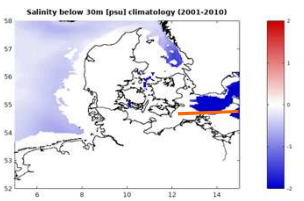


Figure 3: Comparison of annual mean salinity at the surface (left) and below 30m (right). Red indicates higher values in the coupled simulation. In the right position of the transect used in Figure 4 is plotted.

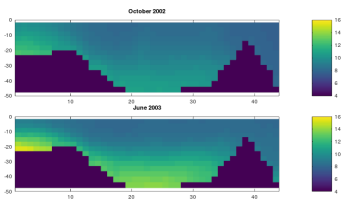


Figure 4: Salinity transect through the Arcona Basin in October 2002 (top) and June 2003 (bottom)..

Background ProWaS

Adapting to the consequences of climate change is an important task that was met by German Government through the "German Adaptation strategy to climate change" (DAS) in 2008 and international through the Paris Agreement in 2015. As a result a number of tools have been developed within research projects (e.g. KLIWAS) that support management decisions and infrastructure to adapt to medium and long term changes in climate, e.g. low water levels in major rivers, increase in sea-levels and extreme weather. A report on "climate and water" in 2016 expressed the idea of a national service based on longtime experience that led to "ProWaS".

ProWaS includes the German Federal Agencies
Deutscher Wetterdienst (DWD)
Bundesamt für Seeschifffahrt u. Hydrographie (BSH)
Bundesanstalt für Gewässerkunde (BfG) and
Bundesanstalt für Wasserbau (BAW)
led by the German Ministry of Transport and Digital Infrastructure (BMVI).

Ocean coupling

In the North Sea the annual cycle of sea surface temperatures is more similar between both simulations (Fig. 2) with the coupled simulation being generally colder. In contrast, for the Baltic Sea we find a warm bias in winter in the coupled simulation, while summer temperatures tend to be warmer in the uncoupled simulation. One reason could be that the North Sea is more influenced by the lateral conditions.
Difference in salinity are largest in the Skagerrak/Kattegat region (Fig. 3). At the surface higher values are calculated in the coupled simulation, while towards the western Baltic Sea the uncoupled simulation reveals higher salinity. In the bottom, the differences are smaller that indicate similar deep circulation.

Perspective

Ocean modeling challenges in this area are the occasional salinity inflows from the North Sea to the Baltic Sea (e.g. 2002/2003). Such inflow events, that ventilate the deep layers of the Baltic Sea (Fig. 4), are triggered by strong wind events and interrelation with climate conditions can be studied by the coupled model, where atmospheric and ocean variables are dynamically linked.

Affiliations
[1] Deutscher Wetterdienst (DWD), Offenbach am Main
[2] Bundesamt für Seeschifffahrt und Hydrographie (BSH), Hamburg/Rostock

Contact:
Deutscher Wetterdienst, Klima und Umwelt (Climate and Environment)
Christoph Stegert, christoph.stegert@dwd.de