Geophysical Research Abstracts
Vol. 13, EGU2011-2565, 2011
EGU General Assembly 2011

The future of the Western Baltic Sea: two possible scenarios

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Global coupled climate models are generally capable of reproducing the observed trends in the globally averaged atmospheric temperature. However, the global models do not perform as well on regional scales. Here, we present results from two 100-year, high-resolution local ocean model experiments (resolution approx. 1km) with the General Estuarine Transport Model (GETM) for the Western Baltic Sea. The forcing is taken from a regional atmospheric model CLM (forced by the global model ECHAM5/MPI-OM of the Max-Planck-Institute for Meteorology) and a regional ocean model (MOM), imbedded into two greenhouse gas emission scenarios, A1B and B1, for the period 2000 to 2100. For both scenarios, two realisations are used. A control run (C20) from 1960-2000 is used for validation.
The findings of this study can be summarised as follows:

1. The model results indicate the expected warming, with an increase of 0.5-2.5 K at the sea surface and 0.7-2.8 K below 40 m. The response of the water column is nearly linear to changes in the air temperature.

2. The simulations show a decrease in salinity by 1.5-2 g/kg for both scenarios, with slightly lower values for B1. Although the decrease is consistent with simulations of the whole Baltic Sea, uncertainties associated with changes in salinity are high. The bottom-surface salinity difference is nearly constant in the projections, indicating a shift in the salinity profiles.

3. Based on present day bottom temperature extremes (99^{th} percentile), we see a prolongation of heat waves based on this threshold. Especially for the Arkona Basin, the projections show that these extremes (present day duration 10 days) will last for 50-60 days (A1B) and 30 days (B1) respectively.

4. The mean stratification (measured by the potential energy anomaly) in the deep basins is not influenced by the climate changes. This persistence is caused by a shifted salinity profile but also a shifted temperature profile, where both effects cancel each other. Due to changes in the Major Baltic Inflows (MBIs), there is a tendency for higher variability of the stratification. The persistence of the stratification and associated the location of the halocline/thermocline is consistent with the findings other studies.

5. An analysis of the occurrence of MBIs showed a significant decrease in salt and volume transport. This decrease in transport is mainly caused by the increase of westerly winds. Sensitivity experiments indicate a dependence on sea level height (an increase in sea level leads to an increase in salt transport) and air temperature (an increase in air temperature leads to a decrease of salt transport). Especially for simulating the inflow events, we show the benefit of downscaling regional climate simulations with high-resolution local models.

6. Although the freshening of the Baltic Sea will increase the barotropic pressure gradient over the Danish straits, the simulations indicate no increase of baroclinic inflows (B1) or even a decrease (A1B). The changes in baroclinic inflow events can be consistently explained by the changes in calm wind periods, which are a necessary preconditioner.