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Analysing water level trends and extremes in the Baltic Sea for the period 1950-2015

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The General Estuarine Transport Model (GETM) was applied to create a state estimate of the Baltic Sea for the period 1950-2015 with a horizontal resolution of 1 nautical mile . In the vertical 60 terrain-following layers were used, which during runtime automatically adapt to the highly variable stratification. This is associated with sporadicly inflowing bottom gravity currents of saline North Sea water, the seasonal thermocline and internal wave motions at the permanent halocline. These challenges need to be tackled by a model to correctly reproduce the mixing and entrainment of water masses in the Baltic Sea. The atmospheric forcing was taken from a regional reanalysis with a spatial resolution of less than 20 km and hourly values.

The analysis of the sea surface height (SSH) revealed a non-uniform absolute mean sea level (MSL) rise in the Baltic Sea. Lowest values are found in the western part with 1.4mm/year and highest values in the Gulf of Finland with values of 2.2 mm/year. This spatial heterogeneity is partially explained by an increase in the mean zonal winds but also by changes in air pressure. The warming trend of the sea surface temperature adds to the regional increase in SSH.

Analysing water level extremes, the simulations indicate a much faster rise in annual maximum SSH compared to MSL rise. This is well correlated with an increase in the annual maximum wind speed. The linear trends in annual maximum SSH are 2 mm/year in the western Baltic Sea and reach peak values of 6 mm/year in the Gulf of Finland. For the trends in annual minimum SSH we do not see any trend different from MSL rise.

As a further measure to quantify changes in extreme water levels, we computed the duration and intensity (duration times excess water height over 99 percentile). Whereas the mean duration does not change significantly, the model results indicate a significant increase in intensity.

To estimate the robustness of the results, their sensitivity to the atmospheric forcing was analysed for the period 1980-2005. For this, based on the global forcing from ERA40 and NCEP-NCAR, an ensemble of 4 regional atmospheric reconstructions was generated and provided to GETM. Within the 4 ensemble members, we see a common response in MSL rise. Only for the extreme water levels we see differences. However, these can be partially explained by the different grid resolutions of the atmospheric models and thus a different representation of extreme winds.