Trends in the amplitude of Baltic sea-level annual cycle in the 20th century

Baltic Sea level shows a mean annual cycle that usually peaks in the winter month and attains its minimum in early spring and have been found to have increased in the 20th century (Plag and Tsimplis, 1999). As the annual cycle has undergone the strongest variations in the last decades of the 20 century, the question of the influence of anthropogenic climate forcing (due to the response of the atmospheric circulation; in particular the NAO) arises, which is still much under debate (Stephenson et al., 2006).

The presented study is focused on the centennial trends in the amplitude of the annual cycle of sea-level in the Baltic Sea by using tide gauge station data obtained from the Permanent Service for Mean Sea level (PSMSL) and the observational record of climatic data sets.

The analysis showed an increase of the amplitude in almost all stations, i.e. winter sea-level is found to be rising relatively to spring sea-level. These trends are not large compared to the decadal variations of the annual cycle, but they are statistically significant. The magnitude of the trends is almost uniform in the station data set analysed here, with exception of the Skagerrak area. Since interannual and decadal variability of sea-level displays a clear spatial pattern, the mechanism responsible for the trends in the annual cycle seem to be not regional, but affect the Baltic Sea basin as a whole.

The question arises which processes can be invoked to explain this behaviour. This question is probably best adressed by simulations with a Baltic Sea model (Meier et al., 2006) driven by different forcing combinations. However, in this study we try to explore possibilities by statistical analysis of the observational record. Several hypothesis are proposed as mechanism to explain the centennial trends in the winter-minus-spring sea level: the effect of wind (through the SLP field), temperature, the barometric effect and precipitation. Since the Baltic Sea climate variables tend to be correlated, the results of statistical analysis is usually prone to different interpretations. Of all explanations tested, the long-term trend in seasonal Baltic precipitation seems to be the most plausible candidate for the increasing amplitude of the annual cycle. For the other three either the sign or the magnitude of the trend make them problematic to be included as a sole explanation. However, the barometic effect was found to contribute potentially to the trend in the sea-level annual cycle.

Other possible mechanism, e.g. shifts in the main discharge due to shifts in the melting season or the change in river discharge due to changes in water reservoir management, have not been analysed here, mainly due to a lack of long-term data.