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Spatial variability in sea level rise and storm surge levels along the Danish coastline

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The long-term changes in relative sea level vary on a local to global scale. Glacio-isostatic uplift (≈ 0-2 mm/y) and geologically induced local subsidence rates (of up to 10 mm/y), meteorologically forced water level variations on the coastline, morphological changes in basin bathymetries etc all add complexity to the interpretation of tide gauge records in Denmark. We identify and discuss causes and magnitudes of variability in both SLR and in surge levels along the Danish coastline.

Central to measurements of sea level rise and assessments of the impacts of climate change is the evaluation of the changes of the absolute sea level. Based on GPS-measurements at permanent stations, long tide gauge records (+100 y) and three national high-precision leveling campaigns performed over the last century absolute height changes at tide gauge stations have been documented. Here, the strategy has been to calculate absolute changes from GPS and couple these to the tide gauges via the leveling data in assuming that the rates of movement have been constant over the century (year 1900-2000). The results show absolute land uplift rates between 0.61 mm/y at Esbjerg in the SW part of Denmark to 2.08 mm/y at Frederikshavn in the northern part. Rates of absolute SLR are close to the global average for the century with a mean value of 1.83 mm/y (1.64 - 2.21mm/y) from the ten tide gauge stations used. Correspondingly, rates of absolute SLR in the period 1990-2006 average 3.2 mm/y (0.98 mm/y – 4.91 mm/y). The relatively large variation between individual stations in the inner Danish waters is a topic for further investigation. Furthermore, upcoming tasks include a regional to local absolute uplift model and investigations into local variations that incorporate more tide gauge stations.

Regarding storm surges, extreme water level statistics have been made for 55 tide gauge stations around Denmark and results show both large variations in statistical return periods and water levels between stations. This also means that statistical return periods under projected SLR scenarios will differ greatly between stations. As an increase in extreme water level events at some stations in recent years cannot be ascribed to the meteorological conditions alone, the causes have been examined for selected stations. Results show that changes in bathymetries and morphologies on a local to regional scale can explain much of the change. Together with the abovementioned results on absolute rates of SLR this will aid interpretation of the extreme water level statistics and give more robust zero level reference and de-trending algorithms of the data used in the statistics.

The results will improve the knowledge platform and methodology for the assessment of the consequences of climate change in relation to coastal flooding and coastal erosion in Denmark.