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Combining high and low resolution sea level data for MSL computations in shallow seas

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In 2003 it has been estimated, that about 23% of the world population lives within a distance of 100 km of a shoreline and less than 100 m above sea level (Small & Nicholls 2003). Furthermore high economic values are located in those areas. Whereas the fact that coastal zones are facing an advancing threat, resulting from climate change processes, is nowadays beyond controversy, scientific efforts now focus on the quantification of the regional and global effects of e.g. sea level rise (SLR) and its nonlinear behaviour. Although great progress is made in predicting future developments, there is still considerable uncertainty in global and regional SLR projections. Due to the fact, that most climate models currently seem to under-estimate the observations (Rahmstorf 2007), the aim of the research project AMSeL is the detailed analysis of the huge amount of available German North Sea tide gauge data. After reconstructing sea level variability over the last 50 to 100 years, the estimation of SLR scenarios for the next 2 to 3 decades seems possible and might help verifying climate models for the North Sea area.

A widely used definition describes MSL as the arithmetic mean of hourly heights of the sea at the tidal station observed over a period of at least 19 years. In the project altogether 17 gauge stations were selected for investigation. They provide nearly 1,800 individual years of sea level records, of which almost 1,400 years consist of measured peak values of every tide. Only about 400 years consist of high resolution data (at least hourly values) and are usable for MSL computations by simple averaging, according to the above definition. The averaging of peak values leads to the Mean Tide Level (MTL), which differs partially strong from the MSL in shallow seas (up to 25 cm at the German North Sea coastline), due to shallow-water tidal harmonics, such as the M4 or M6 lunar fourth- and six-diurnal terms (Pugh 2004). Therefore trend estimations based on time series consisting of both, MSL values and MTL values, lead to wrong results and are not recommended, but still found in practise. An easy method to consider any shallow-water harmonics is to calculate so called k-factors, describing the difference between MSL and MTL for single gauges and particular time periods. The adaption of k-factors allows the combination of MSL and MTL values for long term trend estimations. Before correcting MTL values, it has to be proven whether the k-factor is a time-dependent parameter for the particular site or not. Potential non-stationary behaviour has to be considered.

Using the described method, a continuous MSL time series (1953 to 2006) for the gauge of Heligoland, which provides high quality data due to its exposed location, has been estimated. The results indicate e.g. an acceleration of sea level rise around the 1970‘s and another one in the 1990‘s, which is consistent with the results, Jevrejeva et al. (2006) found for the North East Atlantic region. The estimated linear trend for 1953 to 2006 amounts to 1.7 mm/yr and the present day rate of SLR was found to 3 to 3.5 mm/yr. The dataset was corrected for datum shifts and glacial isostatic adjustment (Peltier 2004). More detailed information about vertical land movements are expected from a research project (IKÜS) currently finalized in Germany. MSL time series for 16 other gauge stations are in process.