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A multi-scale and model approach to estimate future tidal high water statistics in the southern German Bright

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The interactions of tides, external surges, storm surges and waves with an additional role of the coastal bathymetry define the probability of extreme water levels at the coast. Probabilistic analysis and also process based numerical models allow the estimation of future states. From the physical point of view both, deterministic processes and stochastic residuals are the fundamentals of high water statistics. This study uses a so called model chain to reproduce historic statistics of tidal high water levels (Thw) as well as the prediction of future statistics high water levels. The results of the numerical models are post-processed by a stochastic analysis. Recent studies show, that for future extrapolation of extreme Thw nonstationary parametric approaches are required. With the presented methods a better prediction of time depended parameter sets seems possible. The investigation region of this study is the southern German Bright.

The model-chain is the representation of a downscaling process, which starts with an emissions scenario. Regional atmospheric and ocean models refine the results of global climate models. The concept of downscaling was chosen to resolve coastal topography sufficiently. The North Sea and estuaries are modeled with the three-dimensional model HAMburg Shelf Ocean Model. The running time includes 150 years (1950 – 2100). Results of four different hindcast runs and also of one future prediction run are validated. Based on multi-scale analysis and the theory of entropy we analyze whether any significant periodicities are represented numerically. Results show that also hindcasting the climate of Thw with a model chain for the last 60 years is a challenging task. For example, an additional modeling activity must be the inclusion of tides into regional climate ocean models.

It is found that the statistics of climate variables derived from model results differs from the statistics derived from measurements. E.g. there are considerable shifts in in time and spectral properties. Based on multi-scale analysis', two optimization steps are applied: First, time series can be shifted on multiple scales with time in such manner that they fit optimal in the sense of least squares. Second, based on the uncertainties of this fitting procedure, Monte Carlo Simulations are possible. The resulting method can be interpreted as something like multi-scale bias-correction for uncertain climate model results.

To represent statistics results of the simulations are transformed into cumulative distribution functions for recent and future states. Statistics of the multi-scale approach differ from them, which based simply on numeric models. We conclude that climate change unavoidable means changes of spectral characteristics and thus non-linear changes of Thw statistics. Thus, no conclusions from individual historic hazards for an assessment of future hazards can be drawn. Finally, due the procedure described here we are in a better position to determine uncertainties and the determination of future exceedance probabilities of Thw is more traceable. This is one fundamental basis to quantify vulnerabilities of coastal regions and for the design of coastal defense structures.