Geophysical Research Abstracts
Vol. 21, EGU2019-11030, 2019
EGU General Assembly 2019

Structural uncertainties in probabilistic storm surge impact assessments

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Storm surges are among the most destructive natural hazards worldwide. On a global perspective, average yearly global flood losses, considering the world's 136 largest coastal cities, have recently been estimated to approximately USD 6 billion per year [1]. This number is likely to increase dramatically without suitable adaptation measures when accounting for the inherent vulnerability of coastal areas, climate change, socio-economic aspects and local subsidence.

Reliable assessments of storm surges impacts under current and future climatic conditions are critical for managing associated risks and for implementing adequate adaptation strategies. Consequently, understanding and considering the uncertainties related not only to the future climate but also to socio-economic change is essential to, e.g., avoid maladaptation. For this aim, fully probabilistic approaches, propagating uncertainty through each step in the modelling chain used to project these impacts, are increasingly applied [2][3]. While it is certainly feasible to implement such a framework using suitable assumptions, it is critically important to recognize the inherent structural uncertainties owing from differences in perception and the numerical representation of uncertainties in each analysis step, often representing different scientific and technical disciplines such as economics vs. hydro-climatic modelling [4]. For example, economic damage functions are typically developed from historical data and thus when used in a future setting an inherent assumption of stationarity is implicitly made. Additional challenges in this domain include discounting and society's and local stakeholders' attitudes to risk, both of which may modify the damage function in ways that conceptually deviate from the representation of uncertainties in climate and hydrological modelling.

In this study, we carefully examine the role and potential implications of structural uncertainties along the full impact modelling chain for a location in Western Denmark, where the physical and economic models are in principle linked by stochastic extensions. Thus, we introduce a framework comprised by: (a) a semi-empirical downscaling of global to local sea level rise based on CMIP5 global climate model projections and local sea level observations [5]; (b) a probabilistic description of present and future storm surge heights based on extreme value theory; (c) a simplified flood inundation model; and (d) economic assessment of damages to select assets. Using results from our suite of models, we quantify and compare the relative importance of these sources in a temporal perspective, highlighting the importance of taking uncertainties into account when using storm surge impact assessments for adaptation planning.

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