Geophysical Research Abstracts
Vol. 21, EGU2019-5263, 2019
EGU General Assembly 2019

Uncertainty analysis in land loss prediction due to sea level rise, for sandy systems, at the European scale

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An increase of the global mean sea level has already been observed and it is expected to continue with even higher rates during the second half of the present century. This can lead to sandy shoreline retreat and permanent and increased episodic inundation of parts of the coastal zone. In order to protect human lives and assets, adaptation measures are necessary. Therefore, in recent years, large scale risk assessments are considered useful tools for the guidance of policy makers to identify high risk hotspots. Reliable input data at this scale are required in order to make useful estimations. Among others, crucial data to assess the impact of sea level rise on coastal recession are the detection of different coastal types and, in particular, of sandy erodible beaches, and the coastal slope, which is usually assumed to be uniform.

The important issue of input data uncertainty and spatial variation and consequent impact on predictions has been so far ignored in most large scale studies. Estimates of coastal erosion are however very sensitive to the variation in these inputs. In this study, we present sea level rise (SLR) related coastal recession estimates at the European scale, using different datasets for the location of sandy beaches and their coastal slope. Our results demonstrate how the choice of input data can affect the land loss predictions. For the estimation of the coastal recession, the Bruun Rule is used, which offers a suitable approach for a first approximation of erosion impacts at large scales. Sea level rise projections associated with the moderate-emission- mitigation-policy (RCP4.5) and the high-end, business-as-usual scenario (RCP8.5) are used as boundary conditiions. The location of sandy beaches is determined from two different datasets. One is based on manual visual estimation from satellite images and the other on automatic detection from satellite images using machine learning techniques. The differences of the sandy beach locations between the two datasets used are quite pronounced at some EU countries, with an overall agreement across Europe of almost 60%. This is due to the different methodologies used to describe sandy coastlines. For coastal slopes we apply the commonly used constant slope assumption (1/100) and a newly produced global dataset which captures the spatial variation of coastal slopes. This is expected to give much improved estimates as the shoreline retreat predicted by the Bruun Rule varies linearly with the coastal slope.

With this approach, we create four different combinations for each SLR scenario, for which we estimate and compare land loss at EU, country and NUTS3 regional level. We find that the land loss estimations for each scenario can differ significantly, especially at the regional and local level. At the European or country level, even though differences in total land loss projections can be significant, they can be concealed by the spatial aggregation of the results. Additionally, there is a distinct spatial variability across the NUTS3 regions with respect to the year when the SLR scenario uncertainty becomes higher than then input data uncertainty.