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Projections and uncertainties of sandy beach loss due to sea level rise at the European scale

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Climate change driven sea level rise (SLR) is expected to rise with even higher rates during the second half of the present century. This will exacerbate shoreline retreat of sandy coasts, which comprise one third of the global coastline. Sandy coasts have high touristic and ecological value while they are the first level of defense against storms, protecting valuable infrastructures and buildings. 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 SLR on shoreline retreat are the detection of different coastal types and, in particular, of sandy erodible beaches, and the nearshore 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 shoreline retreat are however very sensitive to the variation in these inputs. Here we quantify SLR driven potential shoreline retreat and consequent land loss in Europe during the 21st century by employing different combinations of geophysical datasets for (a) the location of sandy beaches and (b) their nearshore slopes. For the estimation of the shoreline retreat, 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 conditions. 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. For nearshore slopes we apply the commonly used constant slope assumption of 1:100 and a newly produced global dataset which captures the spatial variation of coastal slopes.

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 combination 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. Using data-based spatially-varying nearshore slope data, a European averaged median shoreline retreat of 97 m (54 m) is projected under RCP 8.5 (4.5) by year 2100, relative to the baseline year 2010. This retreat would translate to 2,500 km2 (1,400 km2) of land loss. A variance-based global sensitivity analysis indicates that the uncertainty associated with the choice of geophysical datasets can contribute up to 45% (26%) of the variance in land loss projections for Europe by 2050 (2100).