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Erosion risk in the northern Gulf of Mexico – the effects of climate and weather

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Oceanographic variables such as mean sea level, tides, storm surges, and waves are drivers of erosion, and they act on different time scales ranging from hours (associated with weather) to seasonal and decadal variations and trends (associated with climate). Here we explore how the related sea-state conditions affect the erosion risk in the northern Gulf of Mexico for past and future climate scenarios. From the climate perspective we find that long-term trends in the relevant variables have caused an increase of ∼30% in the erosion risk since the 1980s; at least half of this increase was due to changes in the wave climate. In the next decades, sea level rise will likely become the dominating driver and may, in combination with ongoing changes in the wave climate (and depending on the emission scenario), escalate the erosion risk by up to 300% over the next 30 years. We also find significant changes in the seasonal cycles of sea level and significant wave height, which have in combination caused a considerable increase of the erosion risk in summer and decrease in winter (superimposed onto the long-term trends). The influence of weather is assessed with a copula-based multivariate sea storm model in a Monte-Carlo framework; i.e. we simulate hundreds of thousands of artificial but physically consistent sea-state conditions to quantify how different our understanding of the present day erosion risk would be if we had seen more or less extreme combinations of the different sea-state parameters over the last three decades. We find, for example, that total water levels (tide + surge + wave run-up) associated with 100-year return periods may be underestimated by up to 30% and that the average number of impact hours – when total water levels exceeded the height of the dune toe (collision) or dune crest (overwash) – could have been up to 50% higher than what we inferred based on the actually observed oceanographic conditions. Assessing erosion risk in such a probabilistic way while accounting for non-stationarity due to climate variability and change can help decision makers and planners to implement improved monitoring and adaptation strategies for long-term sustainability of the coastline and barrier islands.