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Climate change, modelling and monitoring; impacts on coastal hazards for Small Island Developing States

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Small Island Developing States (SIDS) are at risk of coastal erosion and flooding from extreme water levels and waves. Waves can contribute to sea level change by setup and runup and also cause damage to coral reefs, mangroves, and offshore structures. Locally-generated wind-sea and long-period swells, generated by remote storms, can cause different types of coastal impacts. Steep volcanic islands such as those in the Lesser Antilles of the Caribbean, e.g. Saint Vincent, with no shelter from neighbouring landmasses, may be threatened by long swell waves several times per year, as well as occasional direct hurricane impact on annual to decadal time-scales. Direct impacts from individual hurricanes are quite infrequent, especially south of the main hurricane track. The effects of climate change are causing sea level rise and an increased incidence of hurricanes. The slow changes due to increasing sea level combine with occasional storm-induced surges, waves and regular tides, modifies the return period of extreme water levels and the duration and frequency that waves can have impact. With limited resources, SIDS have a need for information on climate change impacts, but a paucity of local observational data.
Regional hydrodynamic and wave models can be used to explore the effects of hurricanes in the Caribbean Sea. The NEMO model has been used in pseudo-2D mode to generate surges, driven by the inverse barometer effect and local winds in shallow water (which have a limited contribution in steep volcanic islands). The WWIII wave model is able to accurately capture a variety of wave conditions in the Caribbean Sea, including large significant wave heights observed during hurricane events. We have compared different forcing fields from reanalysis and synthetic storms to test the worst-case scenarios, Downscaling the wave model to local scale using the SWAN wave model can capture nearshore wave processes and wave setup. We have also applied the XBeach model for coastal wave transformation and cross-shore morphodynamic change to bring the impacts to the relevant local level.
Through collaboration with local stakeholders in St Vincent, we have identified particular areas at risk from changing water level and wave conditions. The Caribbean Sea, particularly the Lesser Antilles, suffers from limited observational data due to a lack of coastal monitoring, making numerical models even more important to fill this gap. The current project brings together improved access to tide gauge observations, as well as global, regional and local water level and wave modelling to provide useful tools for coastal planners.