Project Title: Global storm surge modelling under diverse climate scenarios and modes.

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Summary

Climate change is predicted to amplify coastal flooding globally. Drivers include sea level rise and changes to storminess, although signal and sign vary. Historically, interannual variability, linked to climate modality, dominates extreme events. Risk quantification of storm surge related flooding is difficult, with observational records of boundary conditions short, resulting in incomplete probability distributions, particularly in distribution tails. Accordingly, modelling of extreme events is required. However, global dynamic storm surge simulation across multiple climate scenarios is prohibitively expensive. The number of simulations required to cover the full range of climate scenarios and hurricane events numbers in millions. This is impracticable when a single ~30m global run can take weeks even when deploying HPC clusters, resulting in compromises in model framework. These include coarser resolution, scenario interpolation, event aggregation, and simplification of elements including tides, waves, and fluid dynamics. Further, efforts are hampered by data scarcity, particularly of high quality bathymetry. This project addresses these challenges by combining dynamical modelling with machine learning, allowing decreased computational cost while maintaining fidelity. Further, it produces a framework for deriving bathymetry from both wave kinematics and multispectral imagery, and coupling this with machine learning. Finally, these methods will be tested against dynamically simulated events, and once validated used to investigate varying climate modality.

Methods

This project contains three elements. The first focuses on bathymetry generation and will build on prior work of S2SHORES,[1] where wave kinematics are utilised to produce bathymetry using globally available satellite imagery. However, these methods are computationally expensive at granular resolutions, making global scaling impracticable. Therefore, a downscaler will be trained with multispectral satellite imagery, high fidelity bathymetry, and coarse S2SHORES outputs. The downscaler will use methods such as neural networks. The second component will involve dynamic modelling of storm surge and waves, simulated using the 2D coastal hydrodynamic model SCHISM.[2] SCHISM will be driven by wind and pressure fields generated from synthetic storm tracks obtained from STORM,[3] a statistical model simulating storm tracks and intensities using meteorological data. Modelling will be performed at granular resolution, using high fidelity bathymetry, with wave physics enabled. Outputs will be utilised when training a machine learning emulator, with other inputs including event wind and pressure, bathymetry, and reanalysis data. The third component will first validate machine learning outputs against dynamically simulated models using high quality input data, allowing comparison to current state of the art. Once validated the described framework will be used to investigate effects of climate modality, by simulating several locations across multiple scenarios, with two distinct climate modes.

Background reading and references

1. Almar, R. et al. (2021) 'Global Satellite-based coastal bathymetry from waves', Remote Sensing, 13(22), p. 4628. doi:10.3390/rs13224628.

2. Zhang, Y.J. et al. (2016) 'Seamless cross-scale modelling with schism', Ocean Modelling, 102, pp. 64–81. doi:10.1016/j.ocemod.2016.05.002.

3. Bloemendaal, N. et al. (2020) 'Generation of a global synthetic tropical cyclone hazard dataset using storm', Scientific Data, 7(1). doi:10.1038/s41597-020-0381-2.

How to Apply: The deadline for this position is 8th April 2024. The studentship will begin in September 2024. Please apply to the "PhD in Geographical Sciences (Physical Geography)" at https://www.bristol.ac.uk/study/postgraduate/apply/