AN EFFICIENT HYBRID IMPACT SWELL INUNDATION SYSTEM FOR SMALL ISLANDS

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INTRODUCTION

Coastal flooding events generated by the combination of different simultaneous Meteorological and Oceanographic processes that occur at different spatial and temporal scales, are a big concern for Pacific nations. Although for many applications, the full wave directional spectra aggregated into its bulk parameters (i.e., significant wave height, peak period and mean or peak direction) is used, this is especially unsuitable for islands located in large ocean basins where concurrent seas and swells approaching from every direction are common and including the directional complexity of the full spectrum becomes crucial. Moreover, when attempting to assess coastal flooding, it is imperative to analyze the setup and the energy released by infragravity waves at the coast in a high spatial and temporal resolution in order to generate the adequate conditions to force a flooding model. However, dynamically simulating the propagation of wave spectral energy to the coast in order to obtain setup and infragravity waves to feed a flooding model is a very computationally expensive task, particularly for Small Island Developing States (SIDS) where computational resources are often limited. For this reason, we propose the use of metamodels that combine statistical and numerical modeling to efficiently downscale waves and obtain the flooding extents needed to assess the impact associated to a particular event.

METHODOLOGY

A cascade of metamodels has been developed in order to build the impact forecasting swell inundation system proposed (Figure 1).

First, we have developed BinWaves, a metamodel that allows to downscale the directional wave spectra from a regional Super-Point (Cagigal et al., 2022) into a local area of interest. BinWaves is composed by a library of monochromatic cases run with SWAN covering all the possible directions and frequencies. Based on that library of cases, any wave directional spectra can be reconstructed by linearly superposing the propagation of all the spectral energy bins.

Then, HyBeat allows to further downscale the local waves from BinWaves, and the water levels to obtain the high-resolution mean setup and infragravity wave at the coast using Radial Basis Functions (RBFs). HyBeat is composed by a library of Xbeach cases selected with the Maximum Dissimilarity Algorithm (MDA) from a set of samples obtained following a Latin Hypercube Sampling (LHS) technique in the full parameter space.

The output of HyBeat is then the input of HyFlood, an inundation metamodel built from a set of representative cases selected by following the same technique as in HyBeat and run with Lisflood-FP, an efficient model used to generate a library of flooding extents that will be used with an analogue technique to obtain the inundation for any given event.

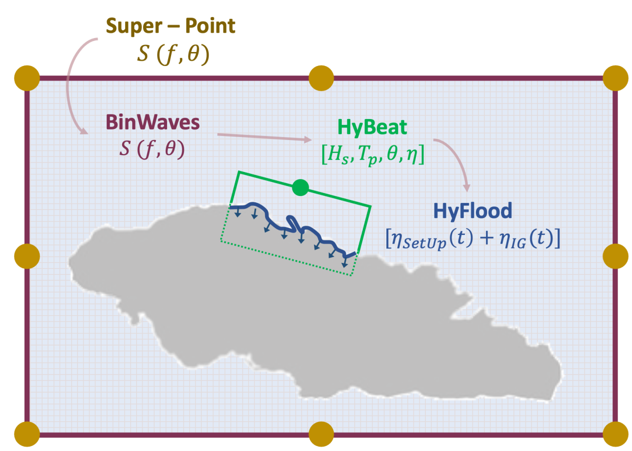

Figure 1 - Conceptual methodology for the cascade of metamodels developed.

RESULTS

The suite of metamodels proposed allows to generate the flooding extents for any event in a matter of seconds at a very low computational effort. To assess the impact of the event, these flooding extents will finally be combined with the damage functions from a set of assets (e.g., roads, buildings, crops…) by means of the RiskScape engine (Paulik 2022). This efficient set of models allows for the system to be used not only for early warning systems and short-term forecast systems, but also to assess risk and future climate change scenarios in a probabilistic way. The demonstration of the system has been set up in the developing Pacific Islands of Samoa and Tonga.

REFERENCES

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