EGU21-2081
https://doi.org/10.5194/egusphere-egu21-2081
EGU General Assembly 2021


# Spatial stochastic simulation to aid local extreme value analysis of cyclone-induced wave heights when numerical hydrodynamic simulations are scarce

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To estimate return levels of wave heights (Hs) induced by tropical cyclones at the coast, a commonly-used approach is to (1) randomly generate a large number of synthetic cyclone events (typically >1,000); (2) numerically simulate the corresponding Hs over the whole domain of interest; (3) extract the Hs values at the desired location at the coast and (4) perform the local extreme value analysis (EVA) to derive the corresponding return level. Step 2 is however very constraining because it often involves a numerical hydrodynamic simulator that can be prohibitive to run: this might limit the number of results to perform the local EVA (typically to several hundreds). In this communication, we propose a spatial stochastic simulation procedure to increase the database size of numerical results with synthetic maps of Hs that are stochastically generated. To do so, we propose to rely on a data-driven dimensionality-reduction method, either unsupervised (Principal Component Analysis) or supervised (Partial Least Squares Regression), that is trained with a limited number of pre-existing numerically simulated Hs maps. The procedure is applied to the Guadeloupe island and results are compared to the commonly-used approach applied to a large database of Hs values computed for nearly 2,000 synthetic cyclones (representative of 3,200 years – Krien et al., NHESS, 2015). When using only a hundred of cyclones, we show that the estimates of the 100-year return levels can be achieved with a mean absolute percentage error (derived from a bootstrap-based procedure) ranging between 5 and 15% around the coasts while keeping the width of the 95% confidence interval of the same order of magnitude than the one using the full database. Without synthetic Hs maps augmentation, the error and confidence interval width are both increased by nearly 100%. A careful attention is paid to the tuning of the approach by testing the sensitivity to the spatial domain size, the information loss due to data compression, and the number of cyclones. This study has been carried within the Carib-Coast INTERREG project (https://www.interreg-caraibes.fr/carib-coast).