

SHYTCWAVES: A STOP-MOTION HYBRID TC-INDUCED WAVES METAMODEL

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INTRODUCTION

Waves produced by tropical cyclones (TCs) can be estimated using numerical models and non-stationary simulations forced with vortex-type time-varying wind fields. However, dynamical simulations are time and computationally demanding at regional-scale domains since high temporal resolutions are required to correctly simulate wave propagation. Early warning systems, as well as risk induced assessments, would benefit from fast and accurate estimates of the wave climate induced by close-to-real tracks geometry. For this reason, the objective of the proposed methodology is to obtain a tool capable of estimating the spatial and temporal variability of directional wave spectra produced by TCs at regional scale in deep waters using a hybrid approach, and statistical techniques, to reduce CPU time effort.

METHODOLOGY

SHyTCWaves is a metamodel that provides estimates of the directional wave spectra produced by TCs, which can be used as boundary conditions for local-scale models at nearshore coastal areas, in addition to providing faster than dynamically simulated TC forecast predictions. Here, the TC historical global database IBTrACS (Knapp et al. 2010) from all available Regional Specialized Meteorological Centers are employed to characterize the full diversity of 6-hour storm segments' key features: minimum central pressure (P_{min}), maximum wind speed (W_{max}), mean forward speed (V_{mean}), radius of maximum winds (RMW), latitude (lat), the variation rate between consecutive preceding segments (dP , dW , dV , dR) and the relative change of azimuths (dA). Since the computation of a large number of simulations can be too time consuming, the goal is to define a library of independent and parameterized 6h-segments well distributed in the full parametric space, that can be dynamically precomputed so that afterwards the metamodel can be applied to any given storm track by ensembling the full track using analogue 6-hour units.

The methodology can be defined as: first a library of storm segments is generated (steps 1, 2, 3), followed by its application at any target location (steps 1 and 4):

1. *Storm track parameterization*: historic available TC tracks are split into 6-hour segments, parameterized according to 10 key variables: P_{min} , dP , W_{max} , dW , V_{mean} , dV , RMW, dR , lat, dA .
2. *Selection*: the Maximum Dissimilarity Algorithm is applied to select a subset of historical TC track parameterized segments, representative of the variability of the multivariate parametric space.
3. *Numerical modelling*: non-stationary simulations of the SWAN wave model forced with time-varying wind

fields, parameterized according to the modified Holland vortex model (Fleming et al. 2008). A library of 5,000 independent 6-hour segments is precomputed.

4. *Application*: for any given storm track (parameterized according to step 1), analogue segments are selected from the SHyTCWaves library and the associated pre-run results are used to reconstruct the directional wave spectra at the target points, with the output contributions from individual segments. Therefore, it is possible to obtain fast estimates for historical as well as for high-fidelity storm tracks.

RESULTS

Figure 1 illustrates the results obtained for TC Ofa (1990) with the vortex-type parameterized maximum winds forcing and the maximum significant wave height for a full dynamic simulation (top row), compared with the SHyTCWaves estimate (bottom row). Furthermore, the metamodel has been applied to historical TCs from all oceanic basins, for which satellite data is available in order to calibrate the storm intensity parameter and avoid underprediction of significant wave height, especially for low intensity categories and storm depressions.

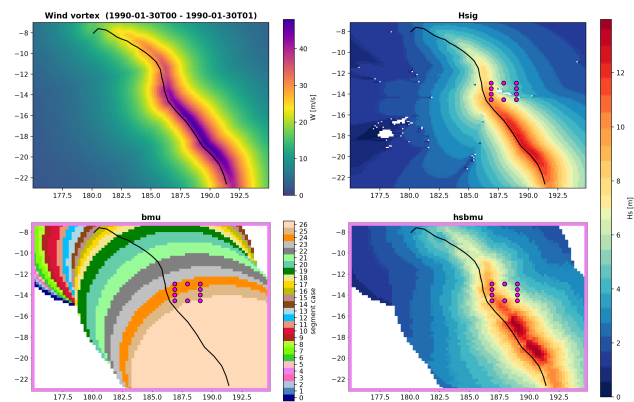


Figure 1 - Results comparison from SWAN simulation (top) and SHyTCWaves metamodel (bottom).

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