

## TAIFU-WindWaves©

Joint estimation of extreme winds and waves induced by tropical cyclones for offshore structure design

### Context

Current methods for estimating extreme winds and waves associated with tropical cyclones do not provide joint statistics and involve significant uncertainties. This is particularly true for waves, as they rely on statistical extrapolation based on hindcasts, leading to considerable uncertainties due to the rarity of events and the short observation period.

### Key Features

TAIFU-WindWaves© is based on a parametric wind model developed from SAR satellite observations, which provides wind speed at 10 m above sea level. This model also includes a vertical extrapolation to estimate hub-height wind speeds. It is coupled with two wave models: one from the literature and another specifically developed and enhanced within the OROWSHI project. The system is applied to the synthetic tracks of the STORM database to simulate the wind and wave fields associated with tropical cyclones.

- ✓ Joint wind-wave statistics induced by tropical cyclones
- ✓ Inclusion of underlying swell in significant wave height (Hs) statistics

In response to these limitations, TAIFU-WindWaves© jointly calculates extreme winds and waves caused by tropical cyclones for any exposed area. Based on Monte Carlo simulations, the tool provides joint statistics, including for 500-year return periods. It also incorporates the contribution of extratropical cyclones into the univariate statistics and accounts for swell in the total significant wave height, a major advancement absent from current methods.

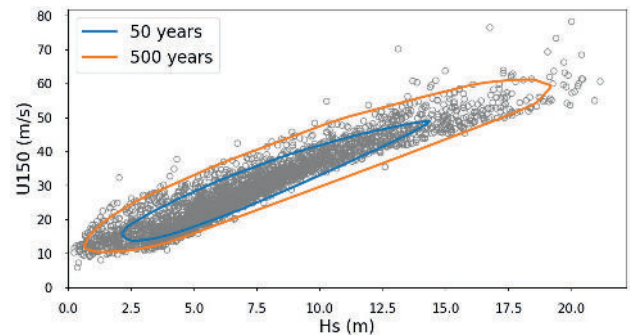


Figure: Relationship between the maximum significant wave height (Hs) and the maximum wind speed at 150 m (U150) for 10,000 years of cyclones simulated with STORM. The scatter points represent all (Hs, U150) pairs, while the curves show the contours associated with 50-year (blue) and 500-year (orange) return periods.

- ✓ Accounting for the contribution of extratropical cyclones

## Case Studies



### Design Phase

Reduction of uncertainties associated with extreme wind and wave estimates: input parameters for DLC, and 50- and 500-year return values of Hs and  $U_{10\text{min-hub}}$



### Development Phase

Contribution to risk analysis, aimed at identifying factors that may influence the design and performance of systems.



### Operational Phase

Estimation of environmental conditions induced by an actual cyclone to support system fatigue assessment and update their life extension. In case of damage, a failure analysis is conducted.



TAIFU-WindWaves© also enables the analysis of extreme winds at onshore sites, through the integration of the Ishihara & Yamaguchi wind model and the inclusion of a correction factor for upstream topographic effects.

## Our Associated Services

Thanks to the TAIFU WindWaves© tool, France Energies Marines offers a unique service: the only solution on the market capable of generating extreme wind–wave statistics under cyclonic conditions. Applicable to all exposed offshore sites, this solution provides data directly usable for wind turbine design.

### A Tailored Service Offer:

#### Full execution of TAIFU WindWaves© by France Energies Marines

- Generation of extreme winds and waves adapted to the chosen site
- Cyclone–wind–wave coupling and estimation of joint extreme statistics

#### Detailed technical deliverables

- Comprehensive technical reports
- Data sets ready for integration into calculation tools
- Summary files for engineering and insurance purposes
- Recommendations for use in design

#### Technical support and guidance

- Explanatory sessions for result interpretation
- Assistance with data integration



Production of joint extreme wind–wave statistics



Calculation of speed-up ratios using OpenFOAM



Extraction of ERA5 data



Execution of WW3 simulations

## Why Choose Us?

For the past seven years, France Energies Marines has conducted research projects dedicated to characterising extreme winds and waves. This expertise enables the generation of realistic scenarios, significantly reducing the risks associated with conventional estimation approaches.

### Client Benefits

Ready-to-use extreme conditions for engineering applications

TAIFU-WindWaves© generates:

- Joint return values (50-year, 500-year, etc.)
- Complete extreme metocean conditions for load simulations
- Realistic directional spectra

### Our Expertise to Support You

We have extensive expertise in identifying and managing model limitations, such as the impact of bathymetry on waves or the influence of small-scale topography on wind.

This expertise enables us to effectively support our clients in interpreting and applying the results.

### The Advantages of Our Solution

- Generation of joint wind–wave statistics from Monte Carlo simulations (compared to MASCOT, which calculates wind only)
- Flexibility and adaptability: globally applicable (compared to MASCOT, limited to the Western Pacific Basin)

