

OROWSHI : Offshore wind turbine design : Towards new standards for the design of offshore wind turbines exposed to tropical cyclones

Webinar, February 3, 2026



With the financial support of:



Welcome words



Jean-François FILIPOT



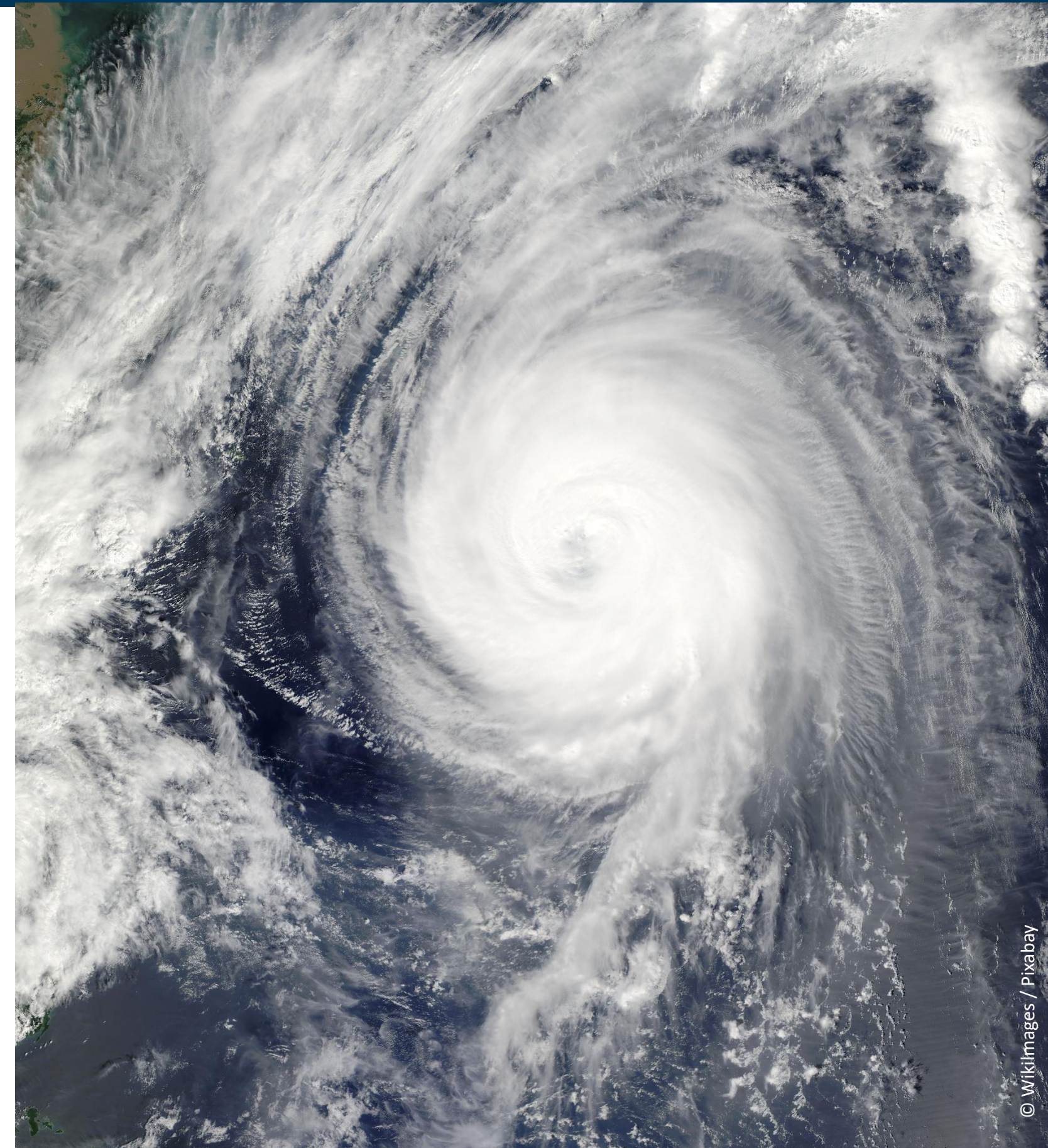
Nicolas RAILLARD



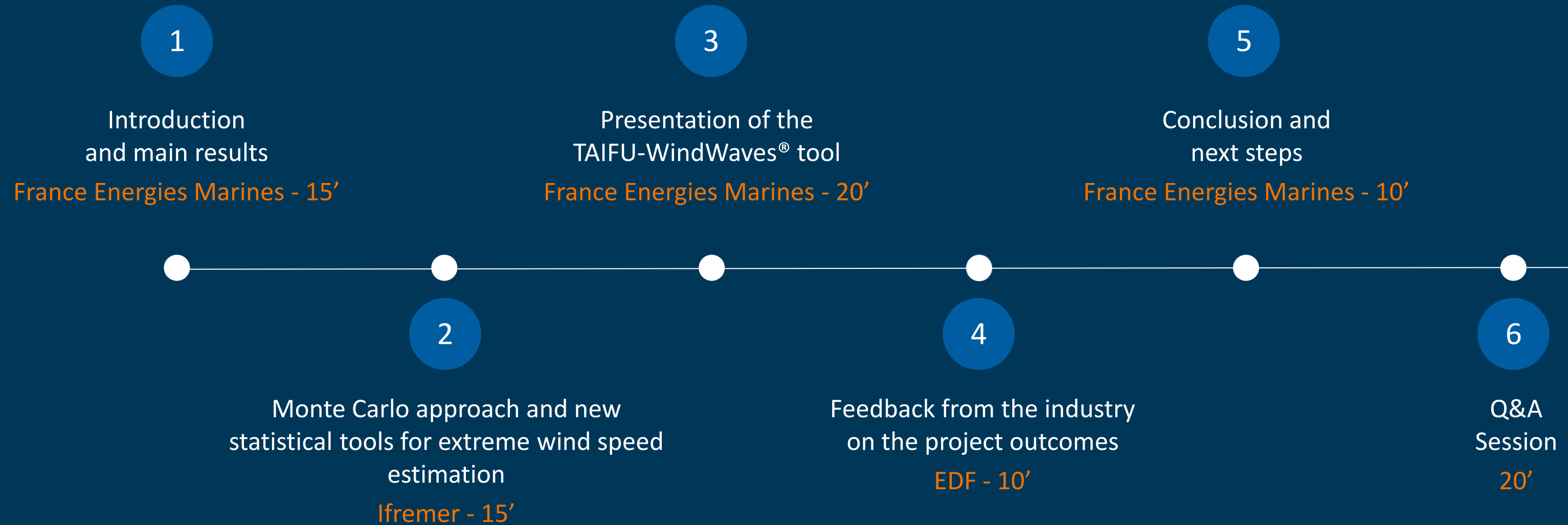
Paul RENAUD



Will HODDER



Agenda



"Q&R" or "Q&A" to ask questions that will be addressed during Q&A session

Design of Offshore Wind Turbines at sites exposed to Tropical Cyclones (from IEC 61400-3-1):

The industry needs to know the 50 (500)-year wind and wave conditions at a given site.

50 (500)-year Wind speed and wave height are estimated using 2 different methods :

- Wind : Monte Carlo based approach from Ishihara & Yamaguchi (2015)
- Wave : Hindcast-based statistical extrapolation

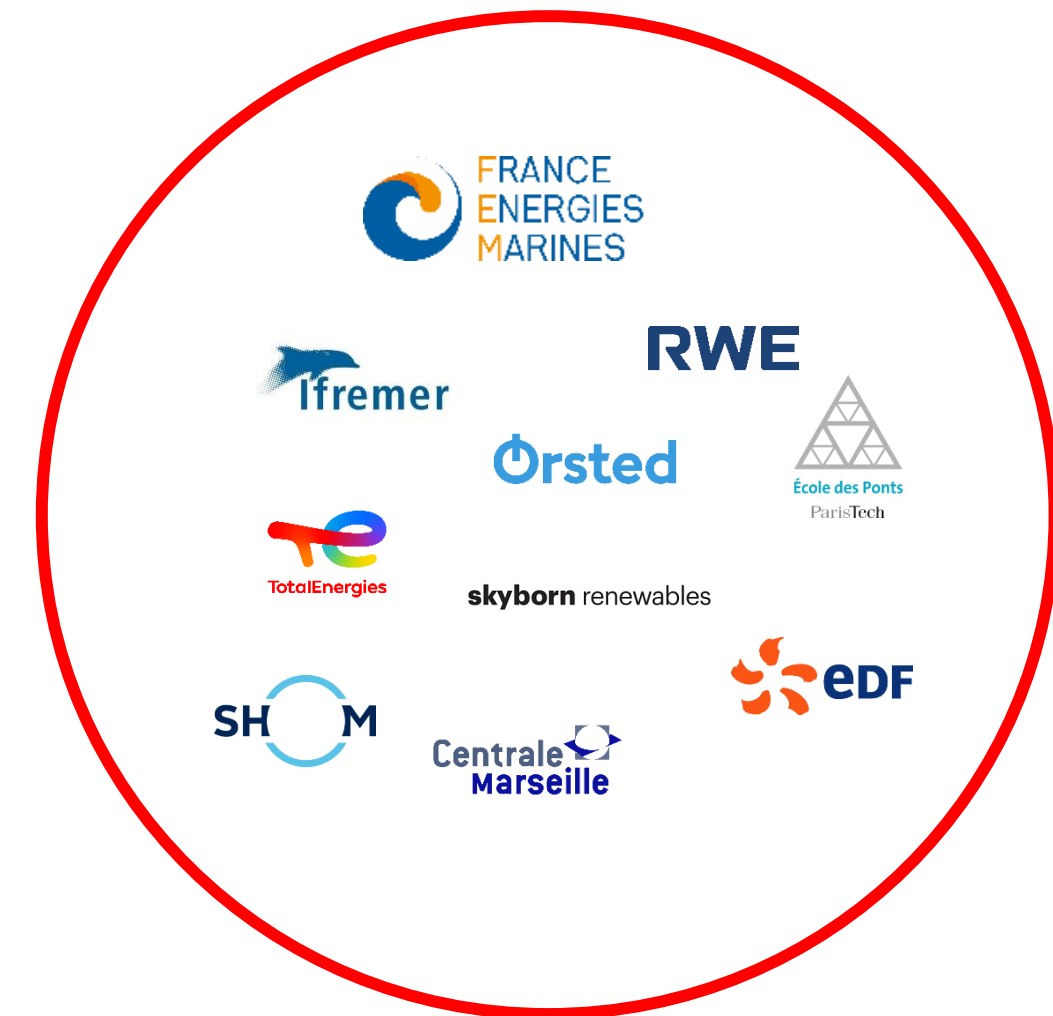
2 issues (at least):

- 1) Leads to potential inconsistencies : no joint wind-waves extreme statistics
→ Potential over-conservative design (use of worst wind & wave conditions together)
- 2) Historical hindcasts not long enough to capture a large number of Tropical cyclones :
→ Significant uncertainties in the extreme wave statistics estimation

OROWSHI objective :

- 1) Improve the IEC approach for extreme wind speed statistics estimation
- 2) Mimic the Monte Carlo approach for the wave parameters to evaluate jointly the 50 (500)-year wind and wave conditions

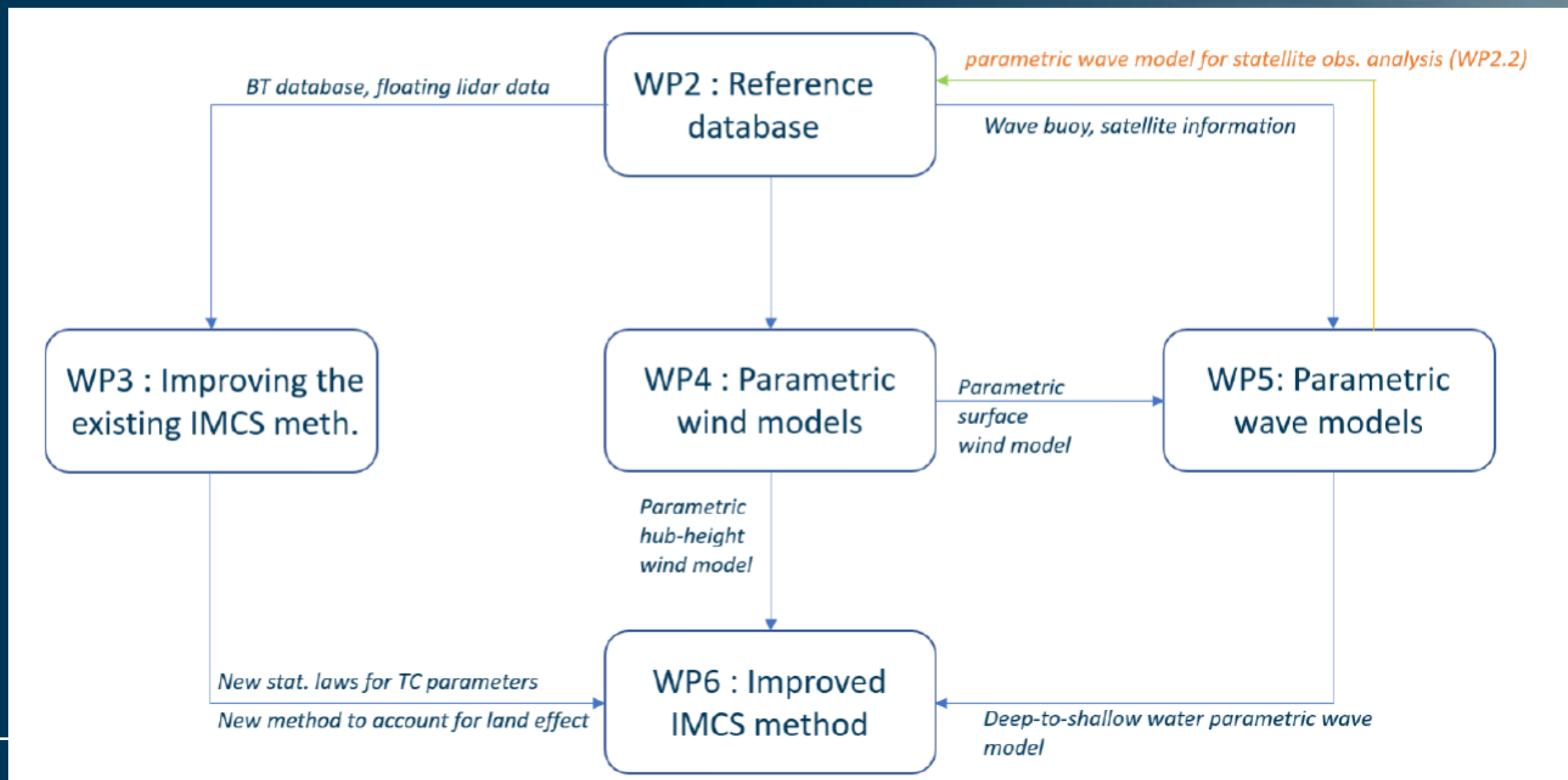
PARTNERSHIP



Duration :

3 years (Nov. 2022-Nov. 2025)

OROWSHI : main results of the first phase



Deliverable :

- D2.1 Large database of observational and numerical data, relevant for wind and wave assessment under TC
- D2.2 Wave dataset under TC conditions derived from SAR images

Key achievements :

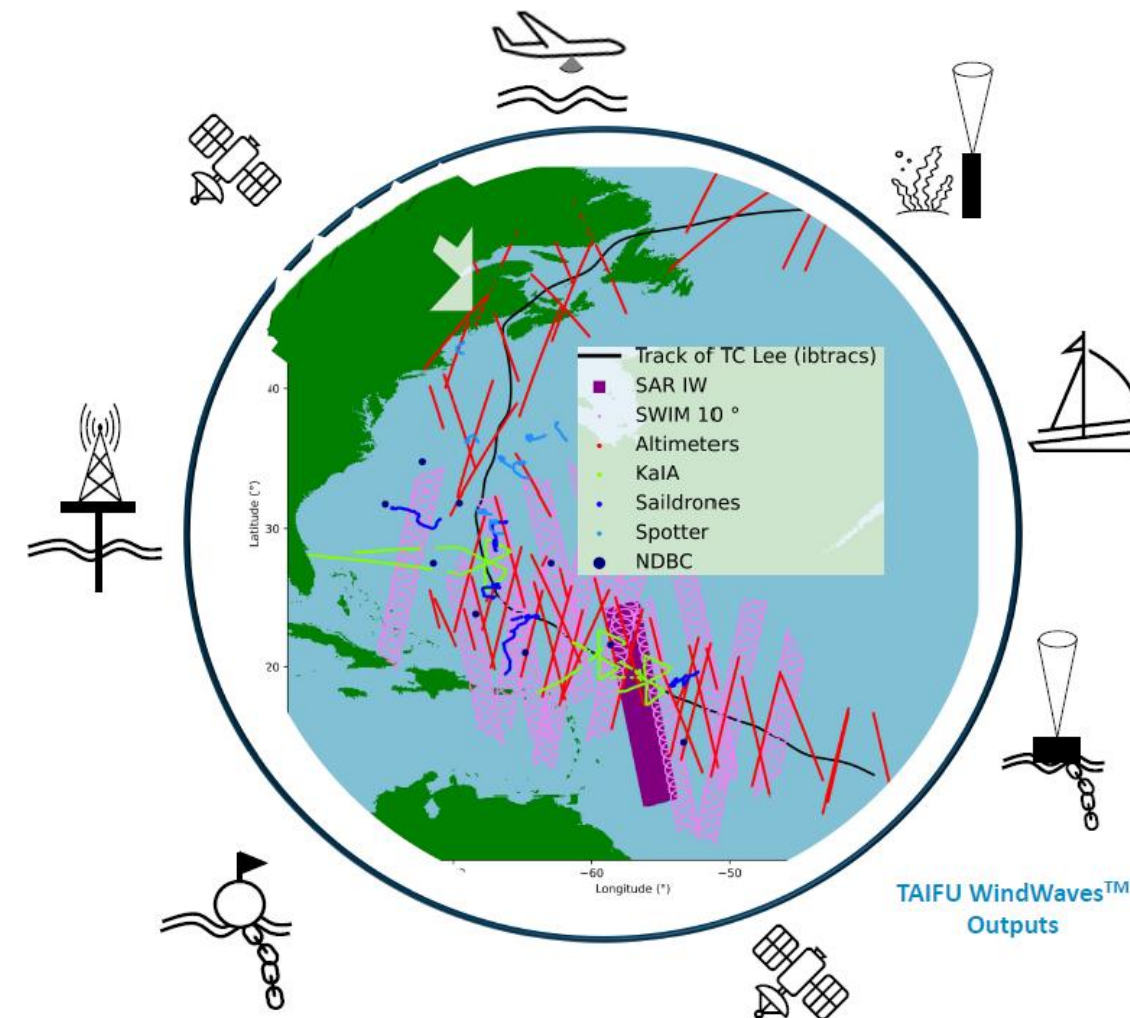
- Collections of a large variety of sensors data to described wind and wave field + wind profiles under tropical cyclones

Wind :

- Met mast
- floating lidar data
- SAR : for wind spatial distribution

Waves :

- Moored wave buoy (e.g. NDBC)
- Drifting wave buoys (Spotter)
- Sail drones
- ADCP
- pressure sensors
- Altimeters
- SAR-derived wave information

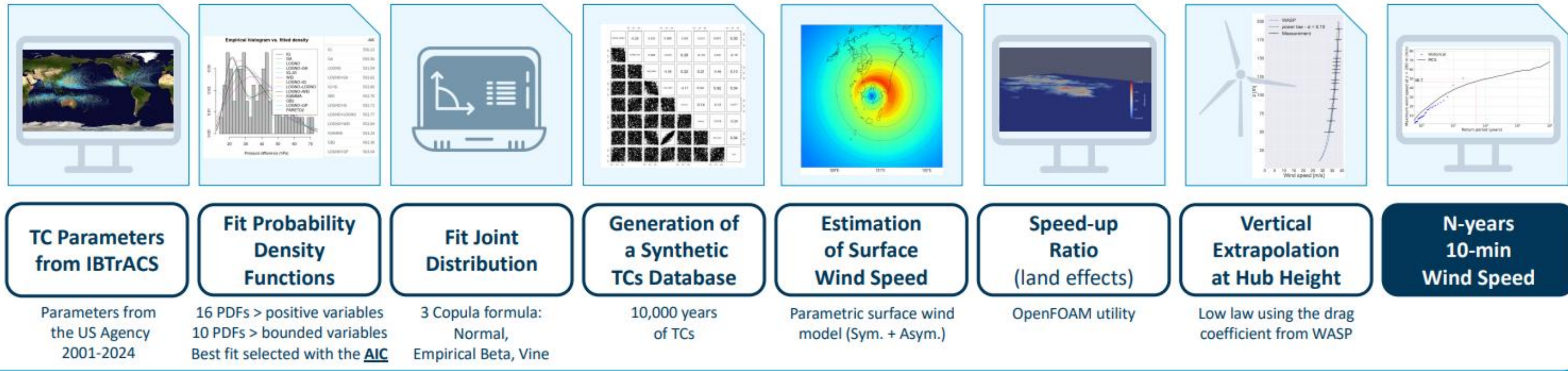


Deliverables :

- L3.1 New parameterization for TC statistical laws
- L3.2 Report on the best solution for assessing wind modification by land effect
- L3.3 Python Code for assessing wind modification by land effect

Implemented in R in a Shiny application

Improvements of the Monte Carlo Simulation Method recommended in 61400-1



Main achievements done through WP3 :

- Shiny application enabling to reproduce IEC 61400-1 method (Raillard & Renaud, 2026)
 - Using Ishishara & Yamguchi (2015) (non trivial implementation)
 - Using OROWSHI breakthroughs : enabling use of IBTrACS (USA), with new statistical distributions, Vinour et al. (2026)'s parametric wind field, Renaud's extrapolation
- OpenFOAM utility to capture speed-up ratio, circumventing MASCOTT use (P. Renaud)

Paper to come:

- Raillard et al. (2026)

Deliverables :

L3.1 New parametric surface wind model : code and report

L3.2 New parametric wind model at hub height : code and report

Model from Loridan et al. (2015)

Inputs: r, V_m, R_m, ϕ

Fitted parameters: V_0, X_1, Y_1, n

$$V_s(r) = \begin{cases} V_0 + (V_m - V_0) \left(\frac{r}{R_m}\right)^n \exp\left(-\frac{r-R_m}{X_1} \left(\frac{r}{R_m}\right)^{Y_1}\right) \\ V_m \exp\left(-\frac{r-R_m}{X_1} \left(\frac{r}{R_m}\right)^{Y_1}\right) \end{cases}$$

Symmetric surface wind model:

+

Asymmetric surface wind model:

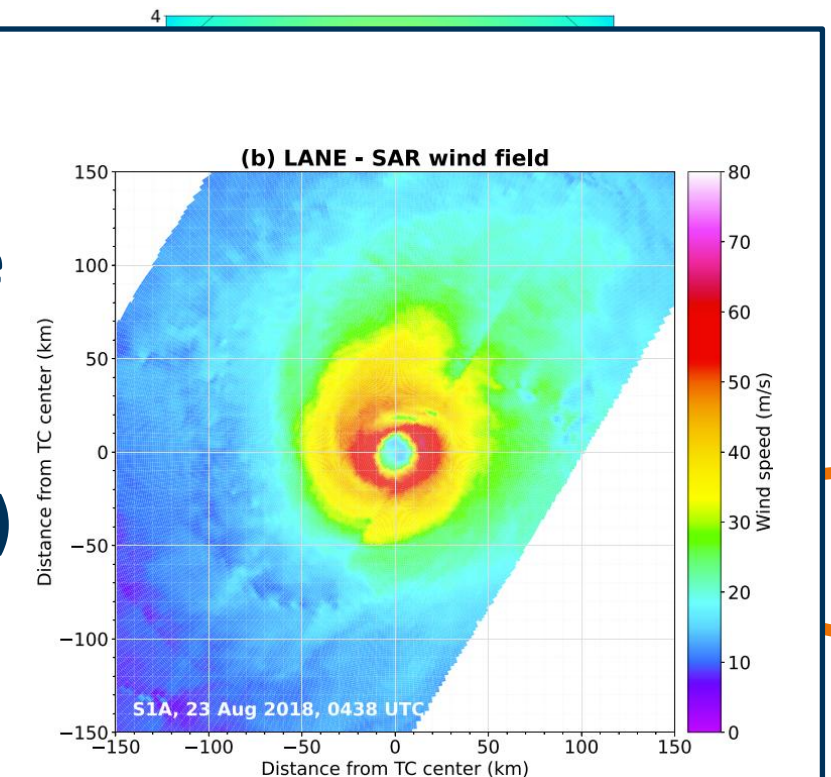
Model from Olfateh et al. (2017)

Inputs: $r, V_s, V_m, R_m, C, \theta, \beta$

Fitted parameters: Φ, D, ϵ, R_a

$$V_{as}(r) = \epsilon V_m \sin(\theta + \Phi) \left[e^{-\frac{r-R_m}{D}} \right]$$

Parameters of the Surface wind model adjusted on SAR observations (976 between 2016-2025) (Vinour et al. 2025)



Deliverables :

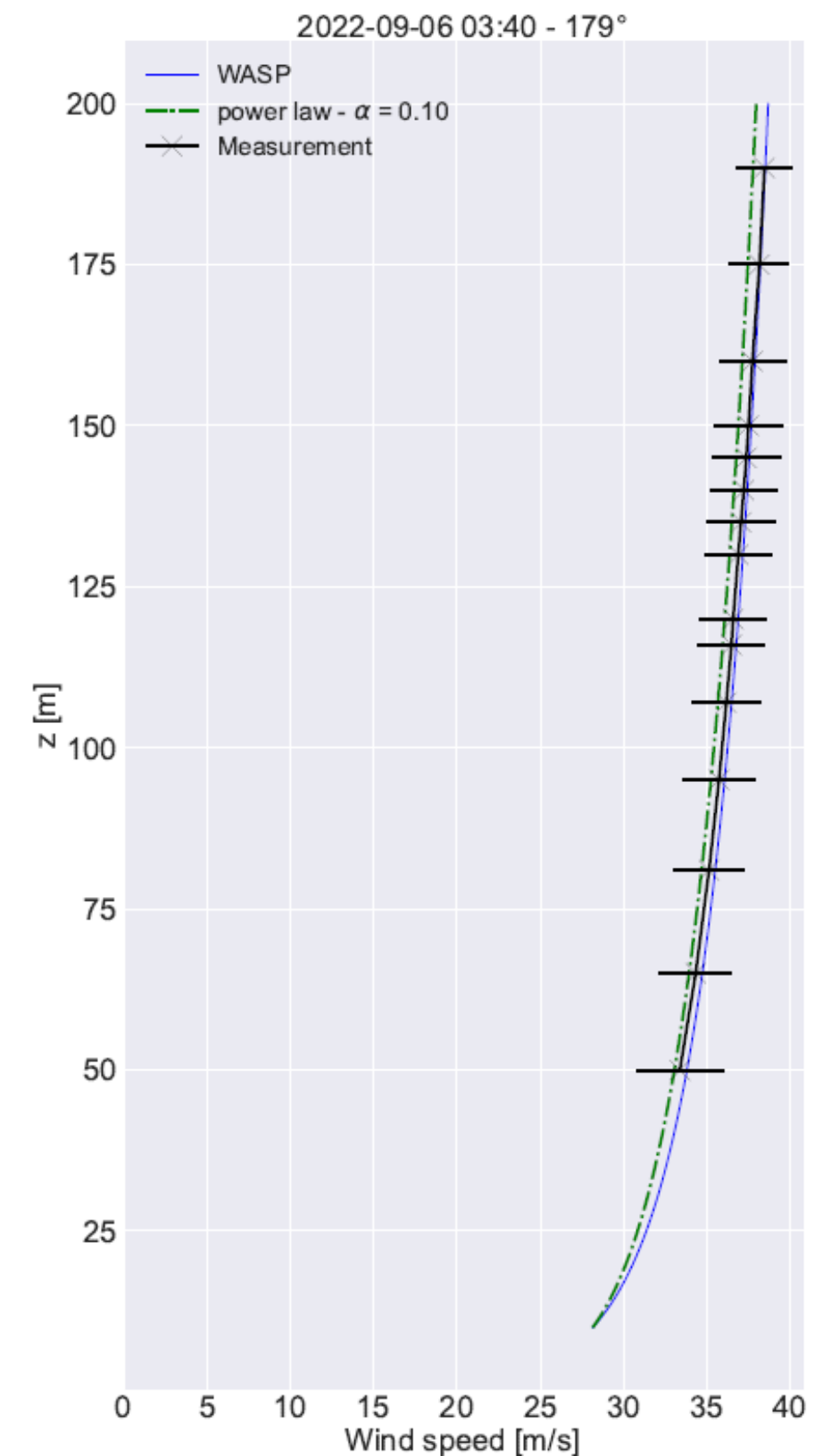
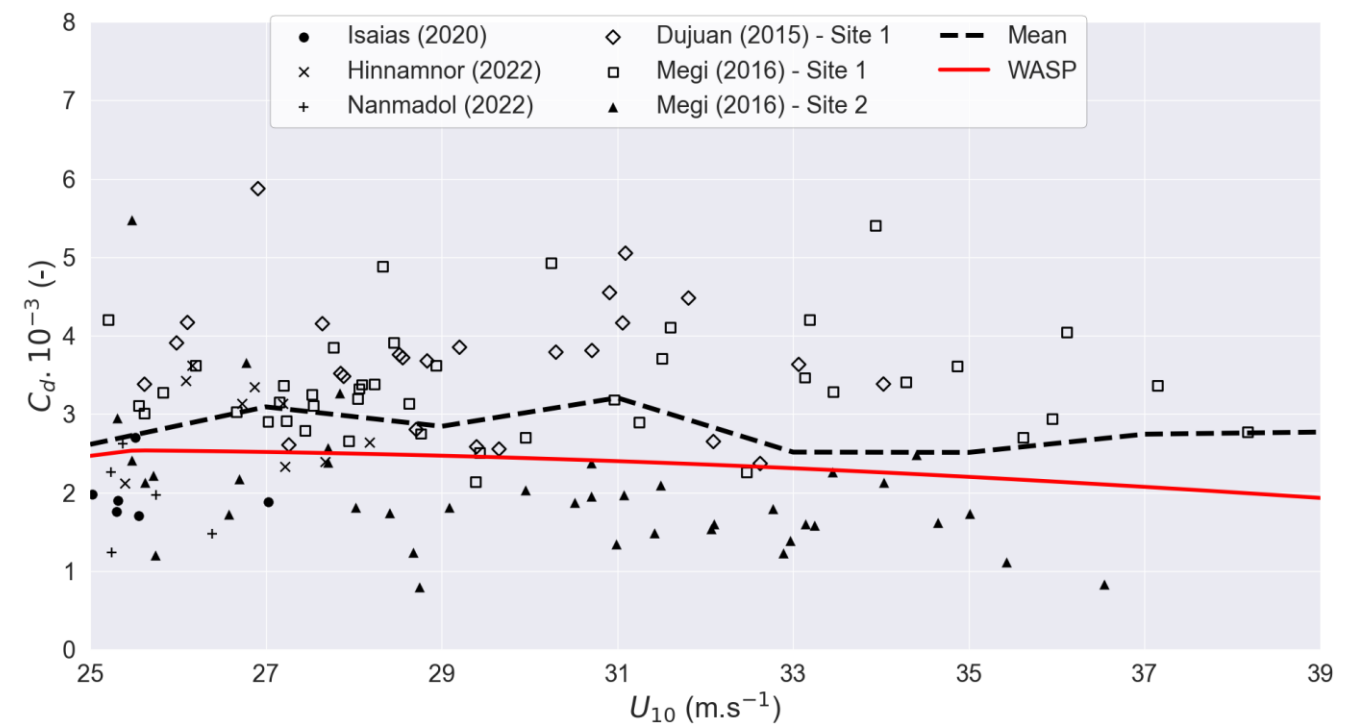
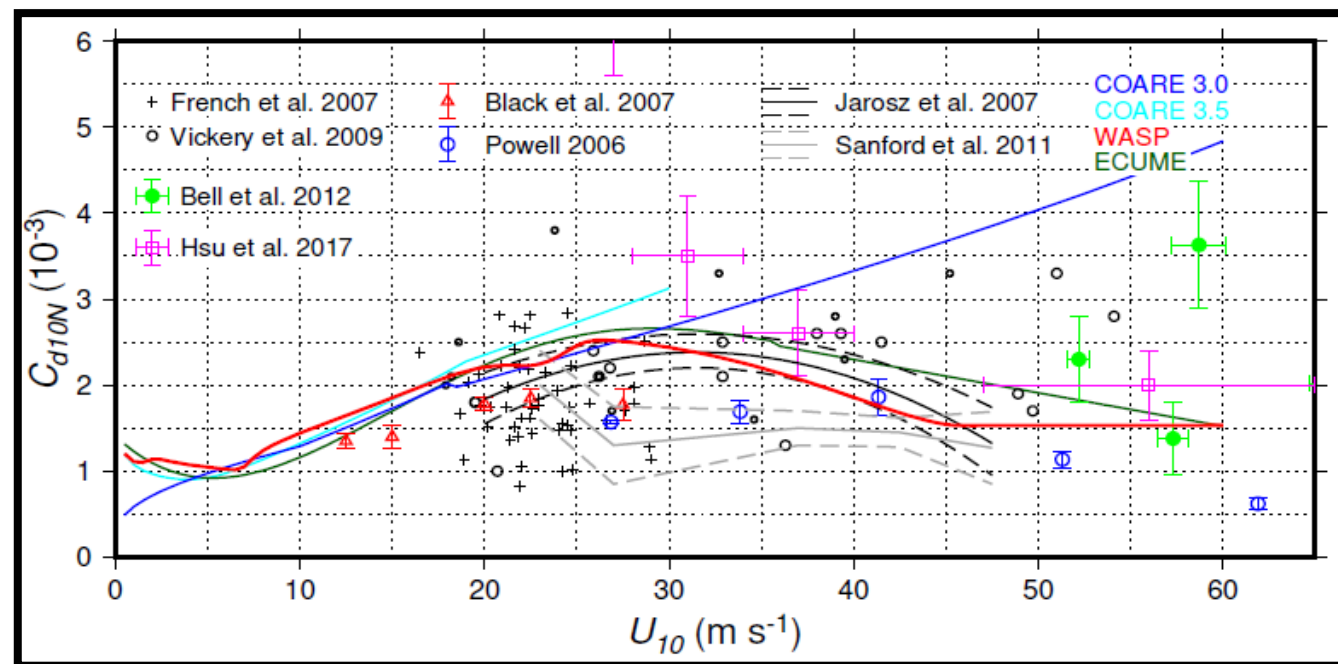
L3.1 New parametric surface wind model : code and report

L3.2 New parametric wind model at hub height : code and report

Surface wind extrapolated to hub height using a logarithmic profile

$$U(z) = \frac{u^*}{\kappa} \ln\left(\frac{z}{z_0}\right) \quad \tau = \rho u^{*2} = \rho C_d U_{10}^2$$

WASP drag coefficient (Bouin et al. 2024)

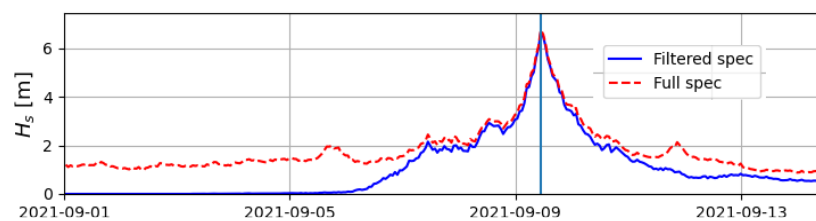
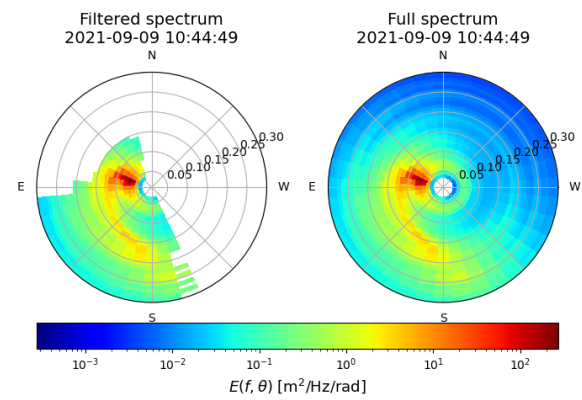


Deliverables :

D5.1 : deep to shallow parametric wave model

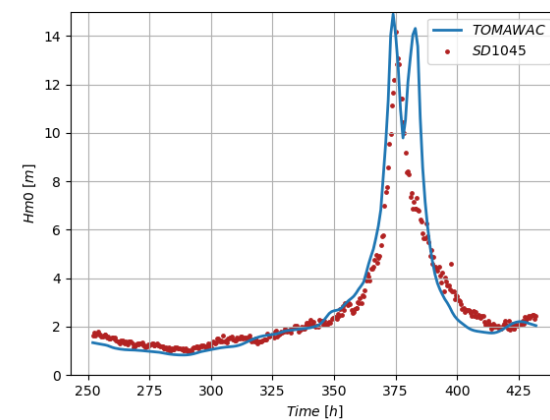
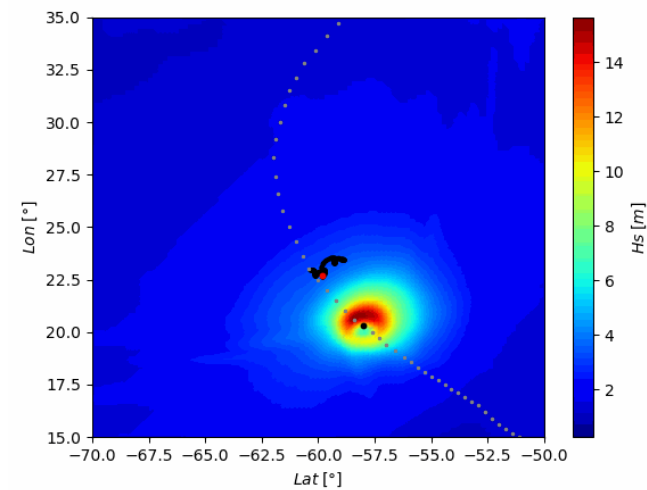
WaveWatchIII – TC version

- On-the-fly wind field computations
- Calibrated for OROWSHI wind model
- To be implemented in WW3 release
- Method for TC-only wave validation
- Paper to come



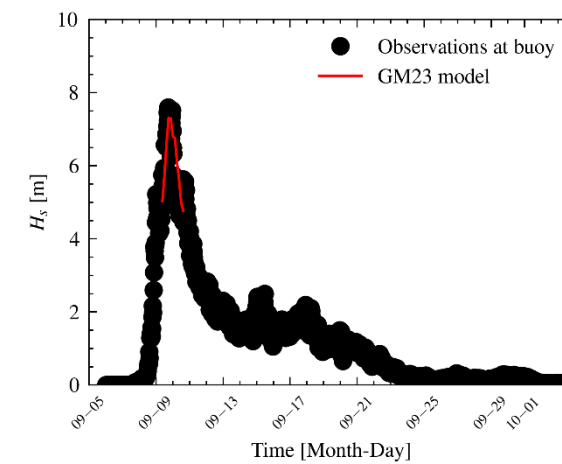
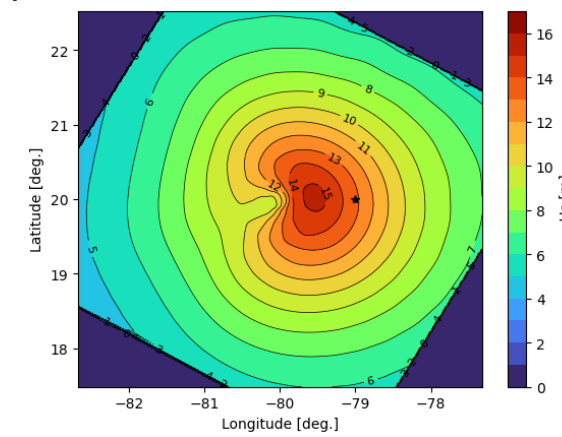
TOMAWAC model

- New wind input generation term
- Tests with quadruplets interactions



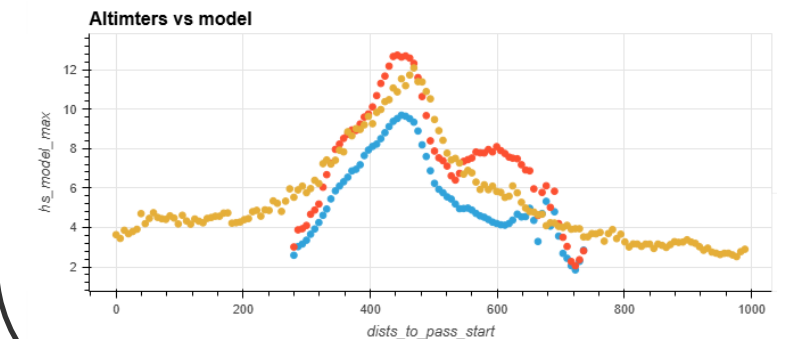
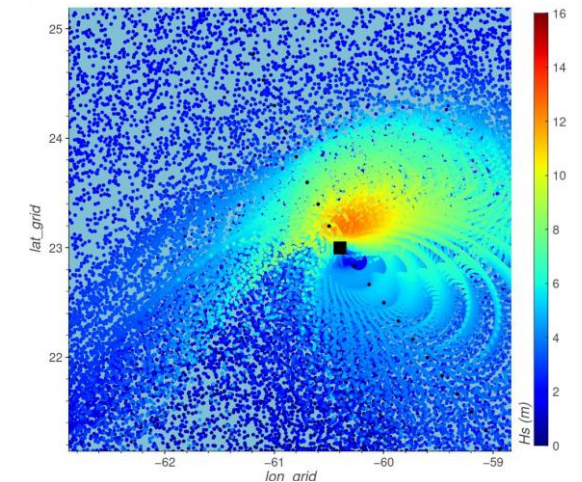
GM23 model (Grossman-Matheson & al. 2023)

- Translated in Python and optimized
- Implemented in Taifu Wind-Waves
- Adapted to Monte Carlo runs



KYC model (Kydryatsev & al. (2021)

- Translated in Python and optimized
- Method to compute « full » Hs
- Implemented in Taifu Wind-Waves
- Adapted to Monte Carlo runs

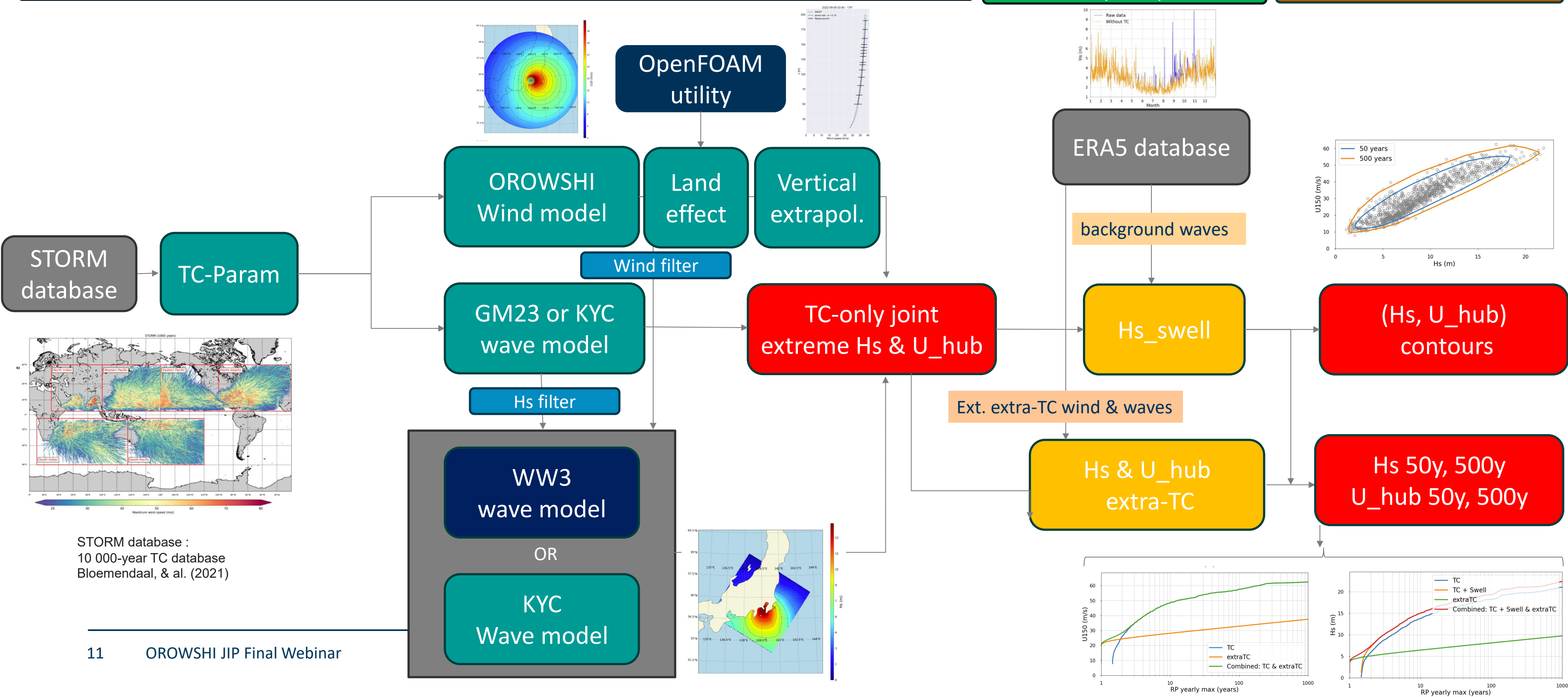


WP6 : Improved IMCS method

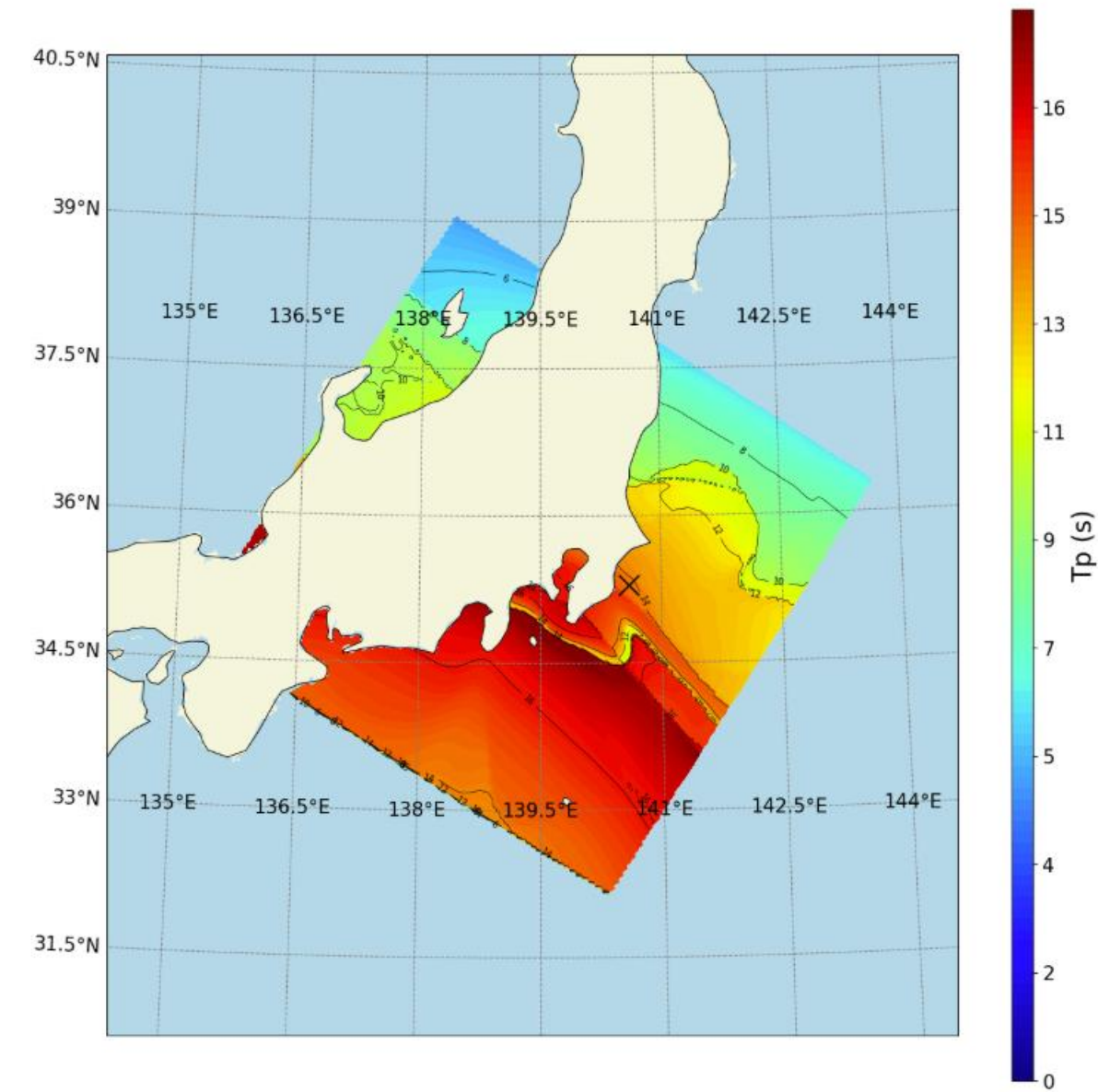
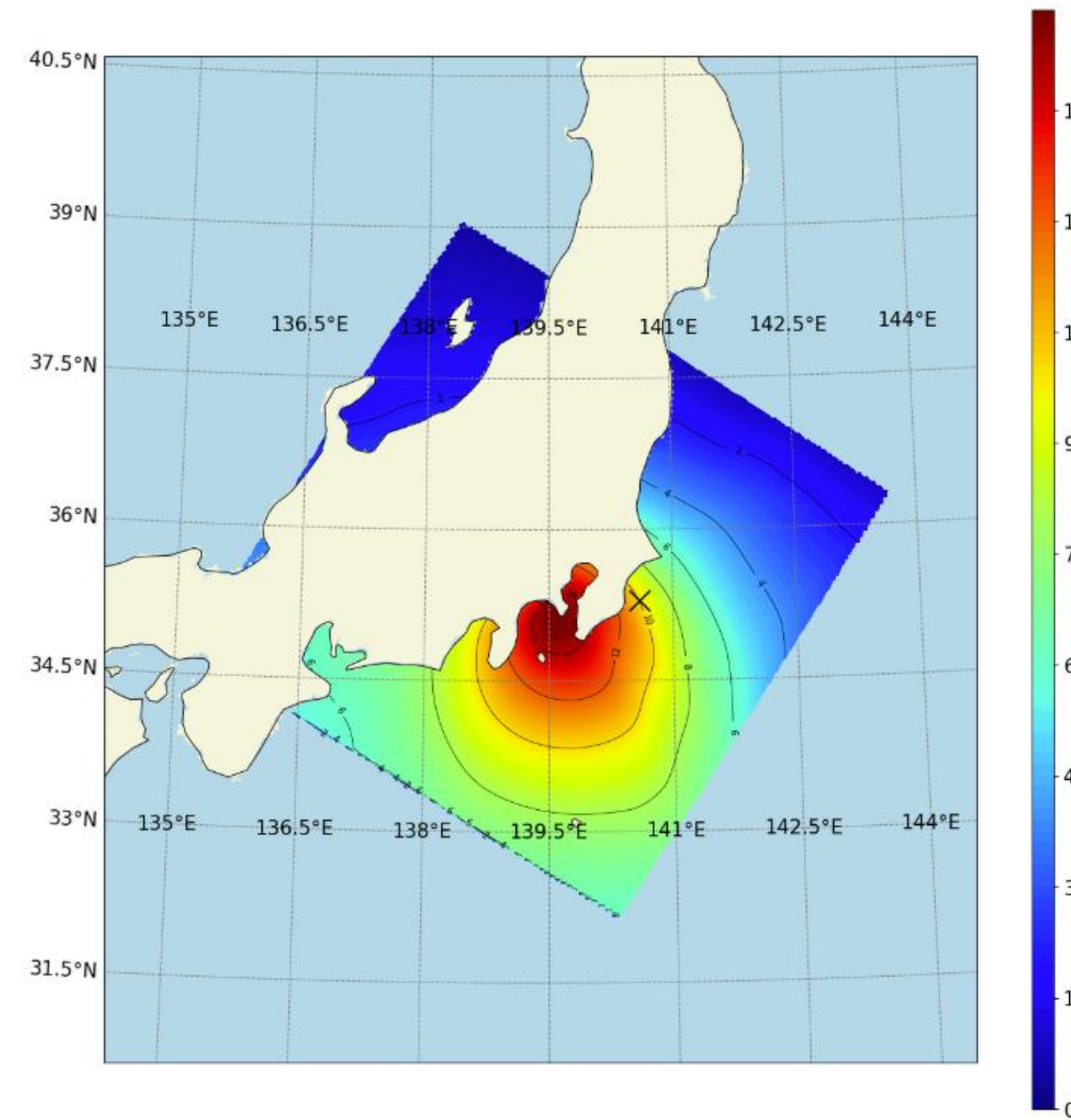
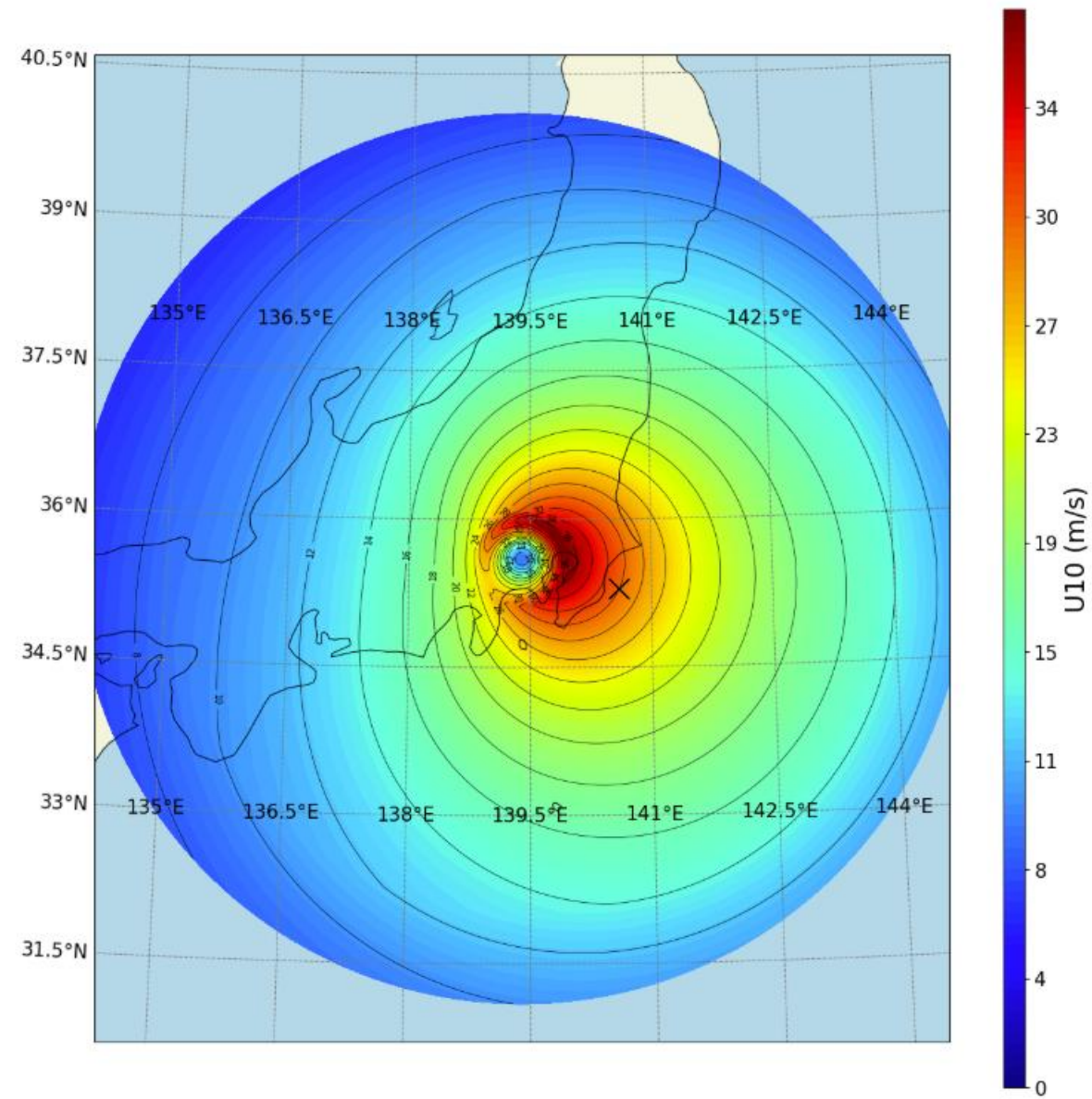
Tropical Cyclones conditions only

Extra Tropical Cyclones

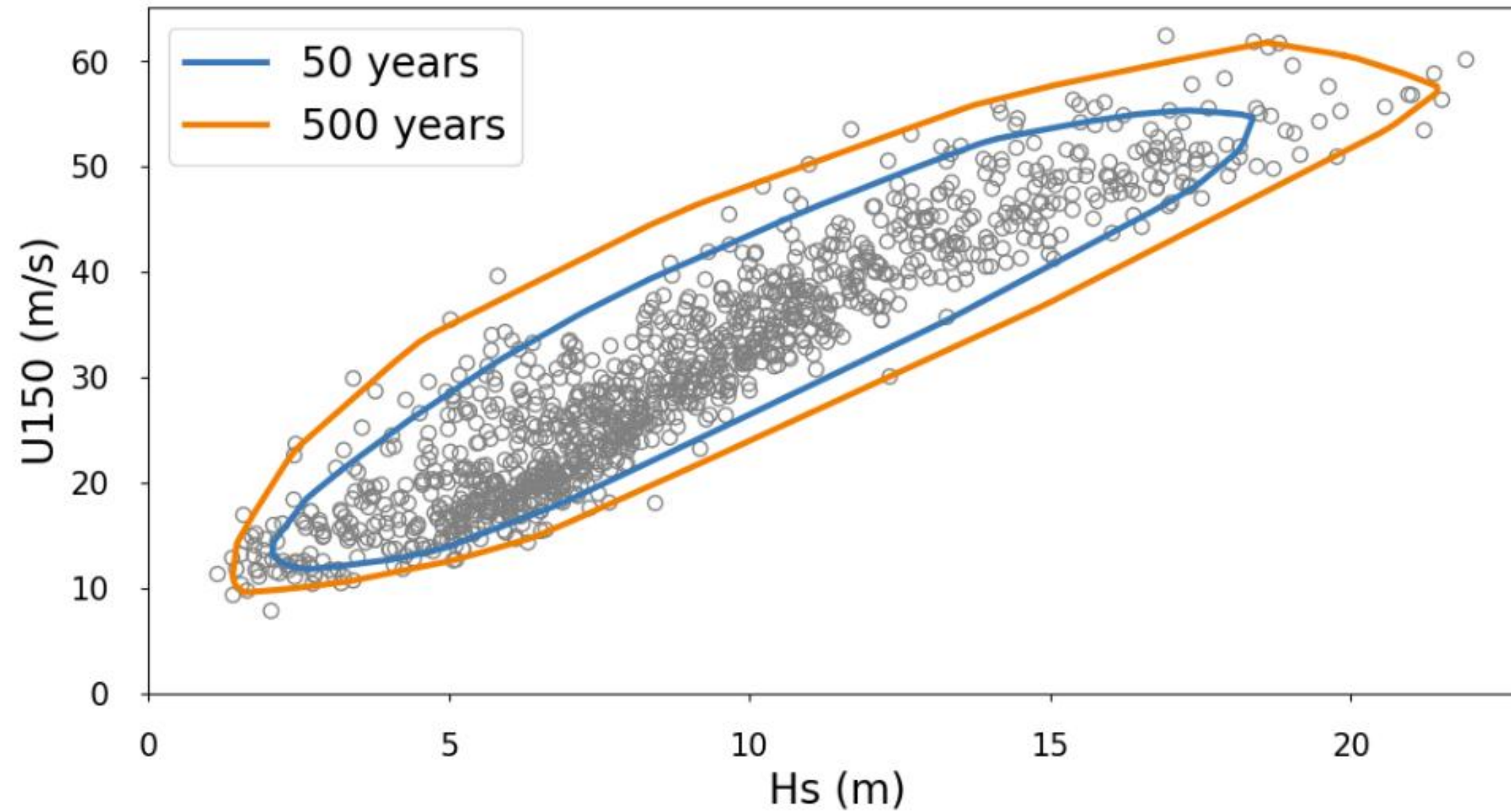
Combined



Application to Habigis (2019) Typhoon

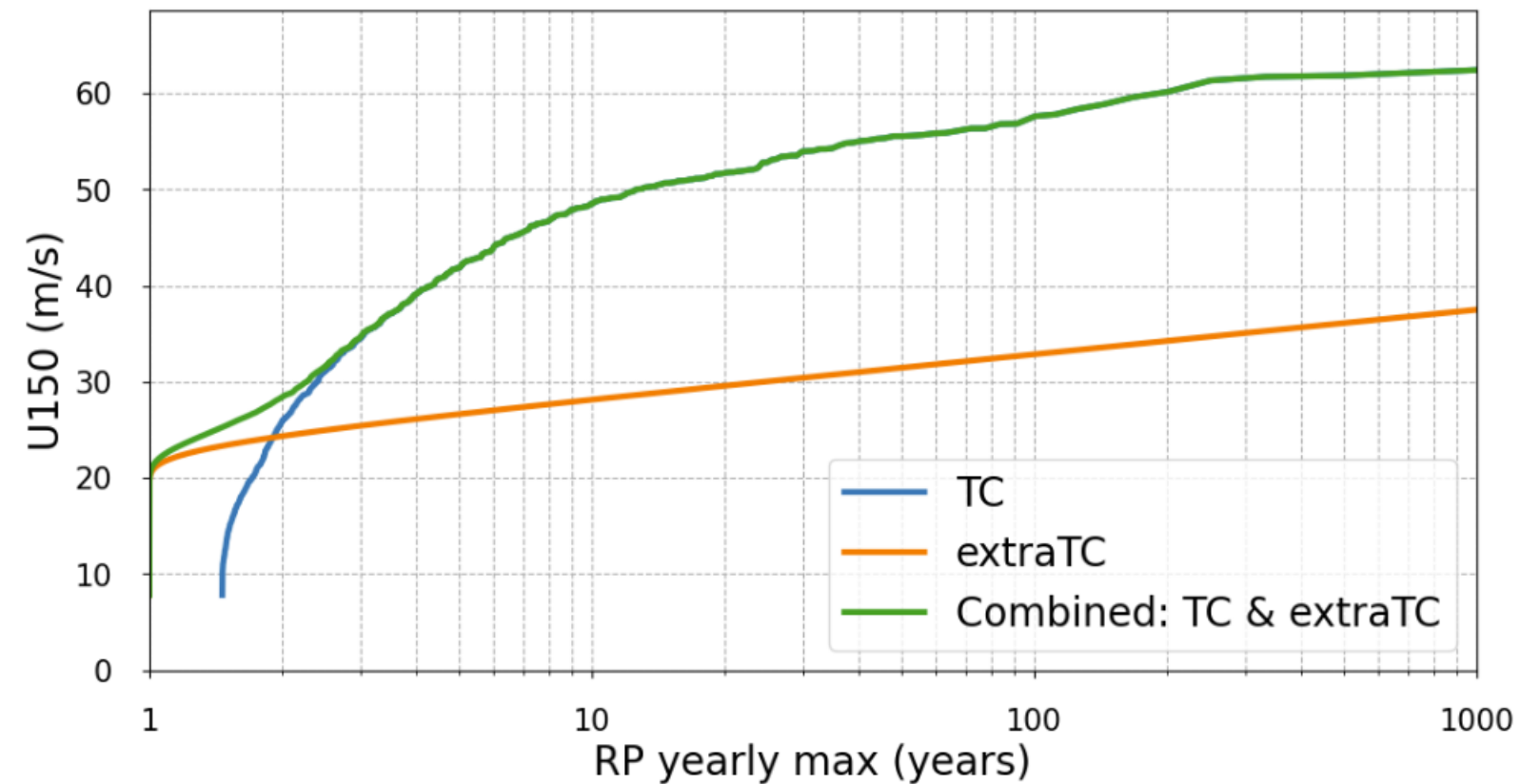


Application to Habigis (2019) Typhoon – environmental contours

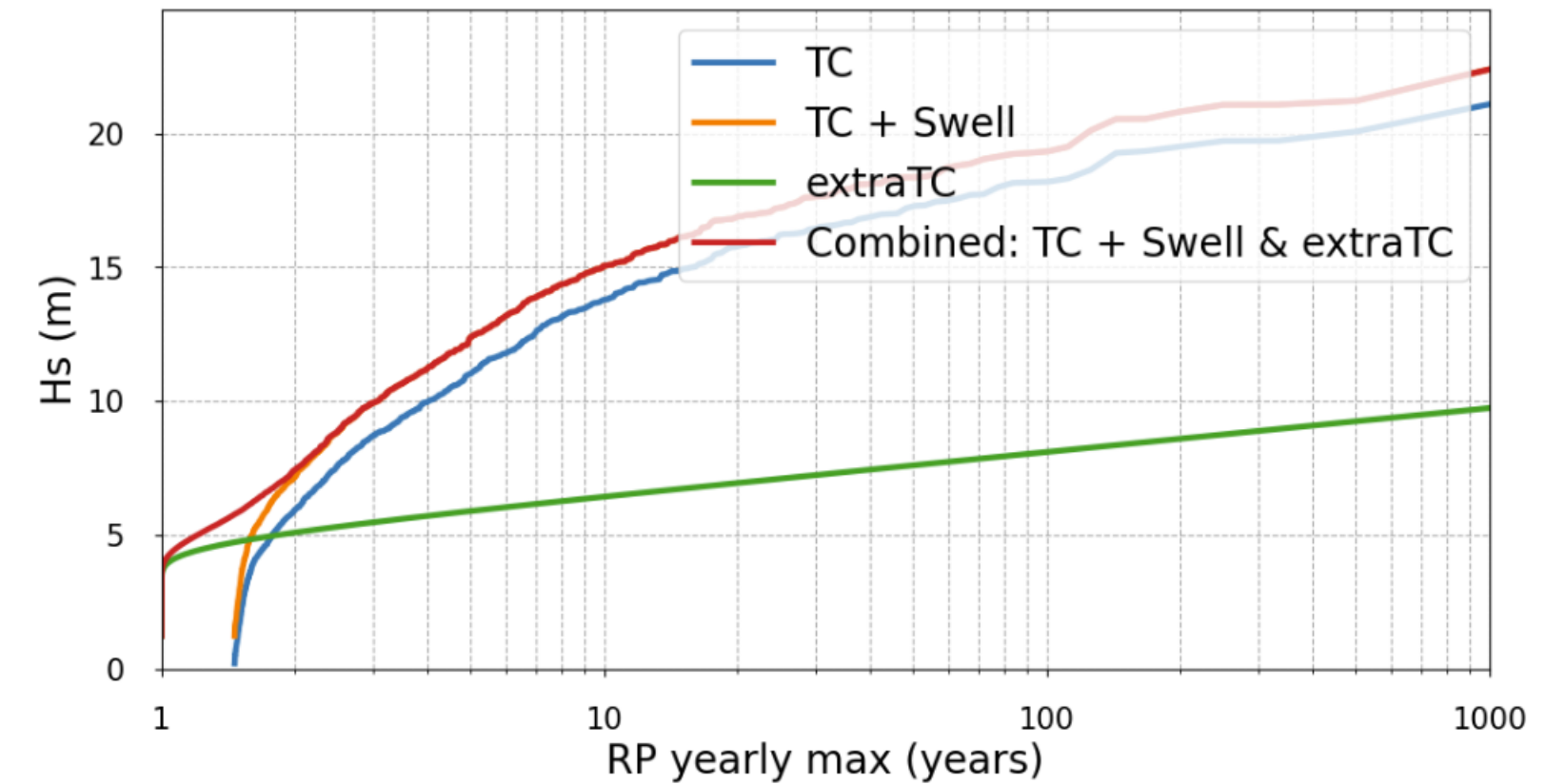


Application to Habigis (2019) Typhoon – extra-tropical contributions

Wind speed at hub height – return values



Significant Wave height – return values



😊 **Many scientific results obtained**

- 😊 Statistical Distribution of TC param
- 😊 Land effect with OpenFOAM
- 😊 Vertical wind extrapolation
- 😊 New parametric surface wind model consistent with SAR observations
- 😊 WW3 & TOMAWAC version adapted to TC wave generation
- 😊 Simplified wave models adapted to Monte Carlo generation of TC waves (in deep water)
- 😊 Filters to limit the number of TC to be run with spectral models (WW3 or TOMAWAC) in shallow water
- 😊 Incorporation of background swell and extra-TC contributions in the extreme wind and wave stats
- 😊 New observations databases used (sofar, saildrone) and created through the project (SAR wind & wave)

😊 **Formed a new methodology for joint extreme wind-waves statistics under tropical cyclones**

😊 **Implentated in Taifu Wind-Wave (& shiny app) software**

Next steps : publish all the results and incorporate **OROWSHI's method in certification/standardization documents**

