



# R&D Webinar - OROWSHI Project Outcomes

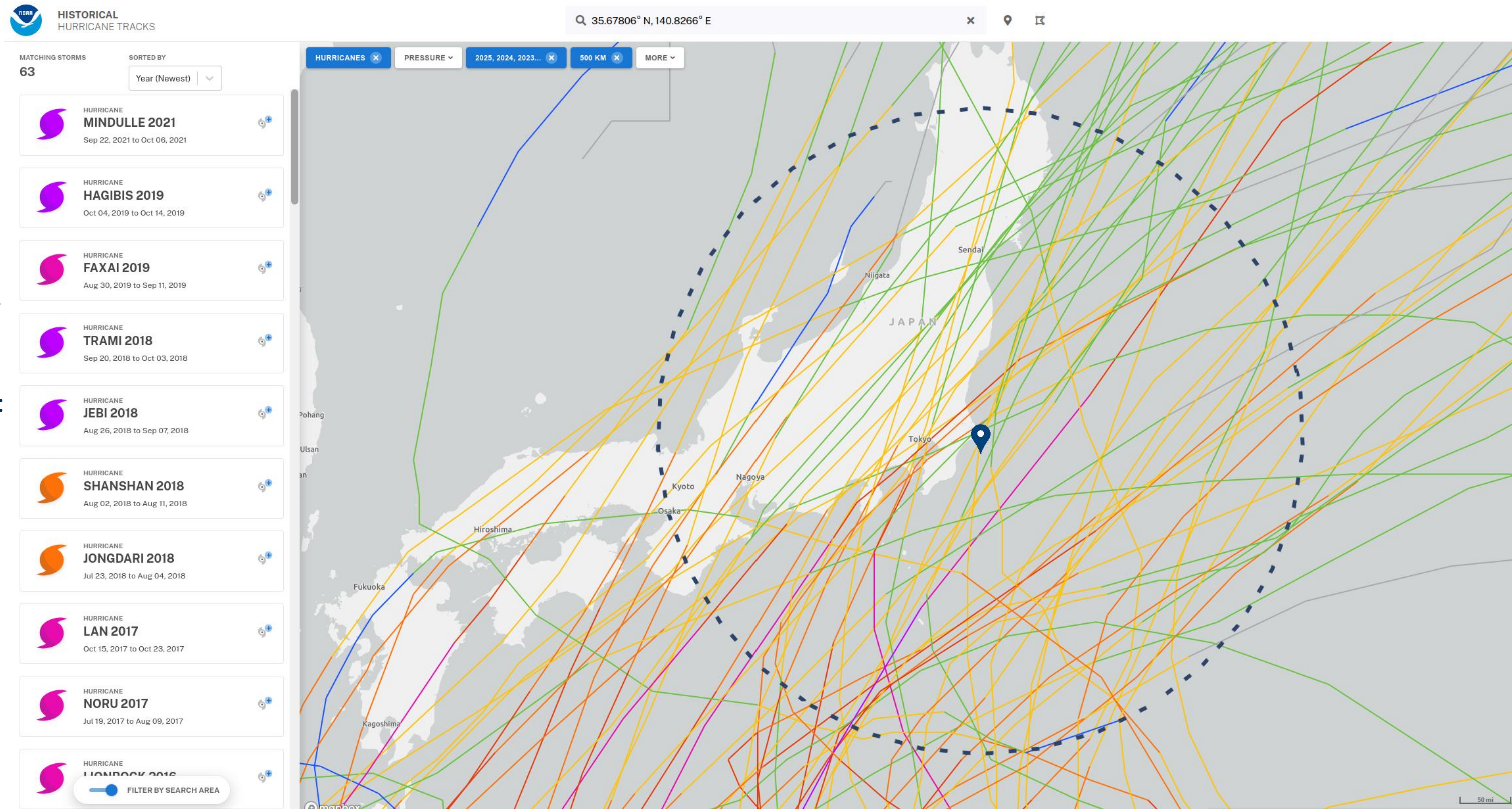
## Towards new standards for the design of the offshore wind turbines exposed to tropical cyclones



# WP3 – Improved Monte-Carlo Simulation Method

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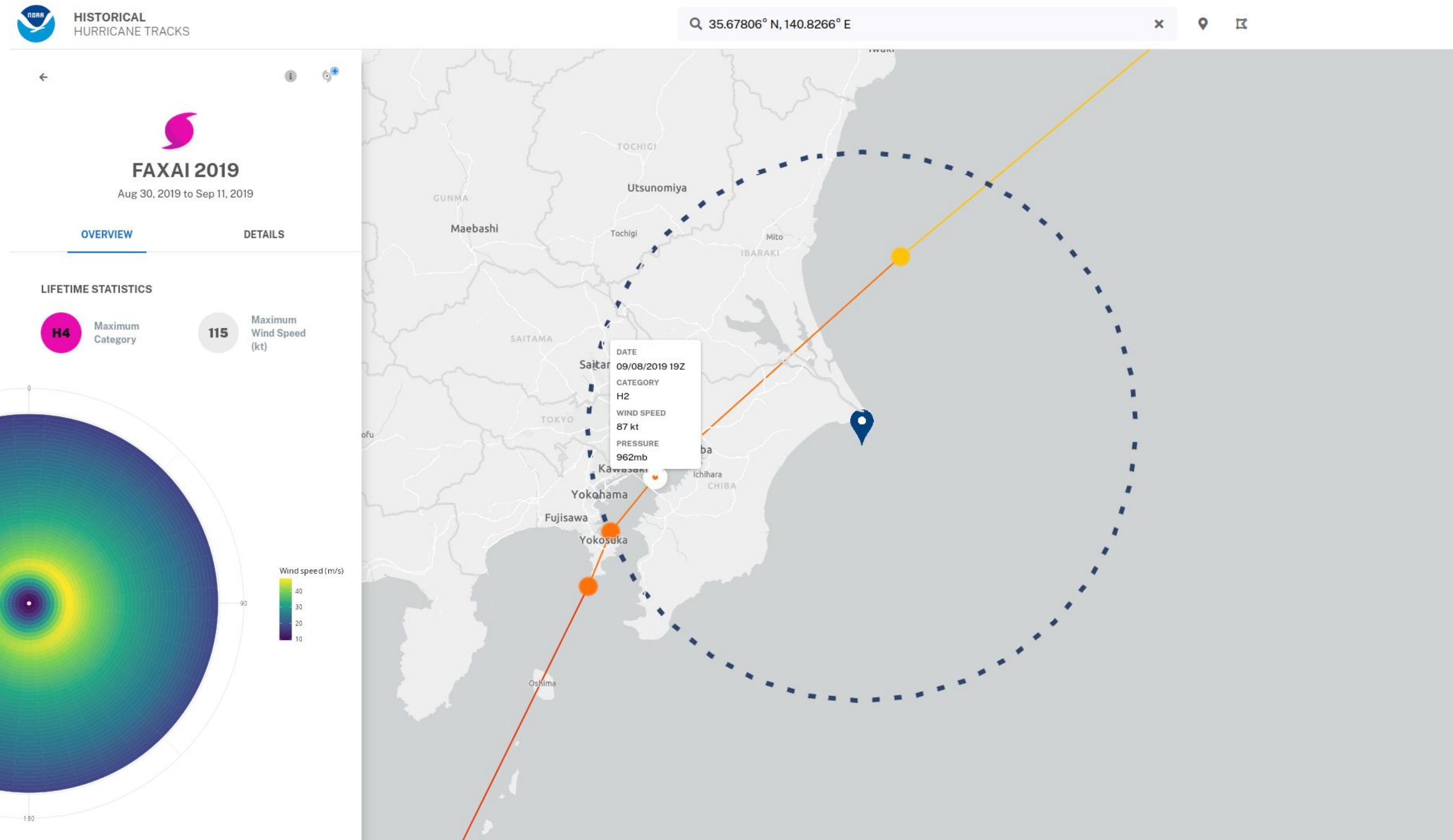


## Typhoon are scarce by nature

- Offshore location as in Ishihara & Yamaguchi, 2015
- From 2001 to 2025 : 63 events at a distance < 500km

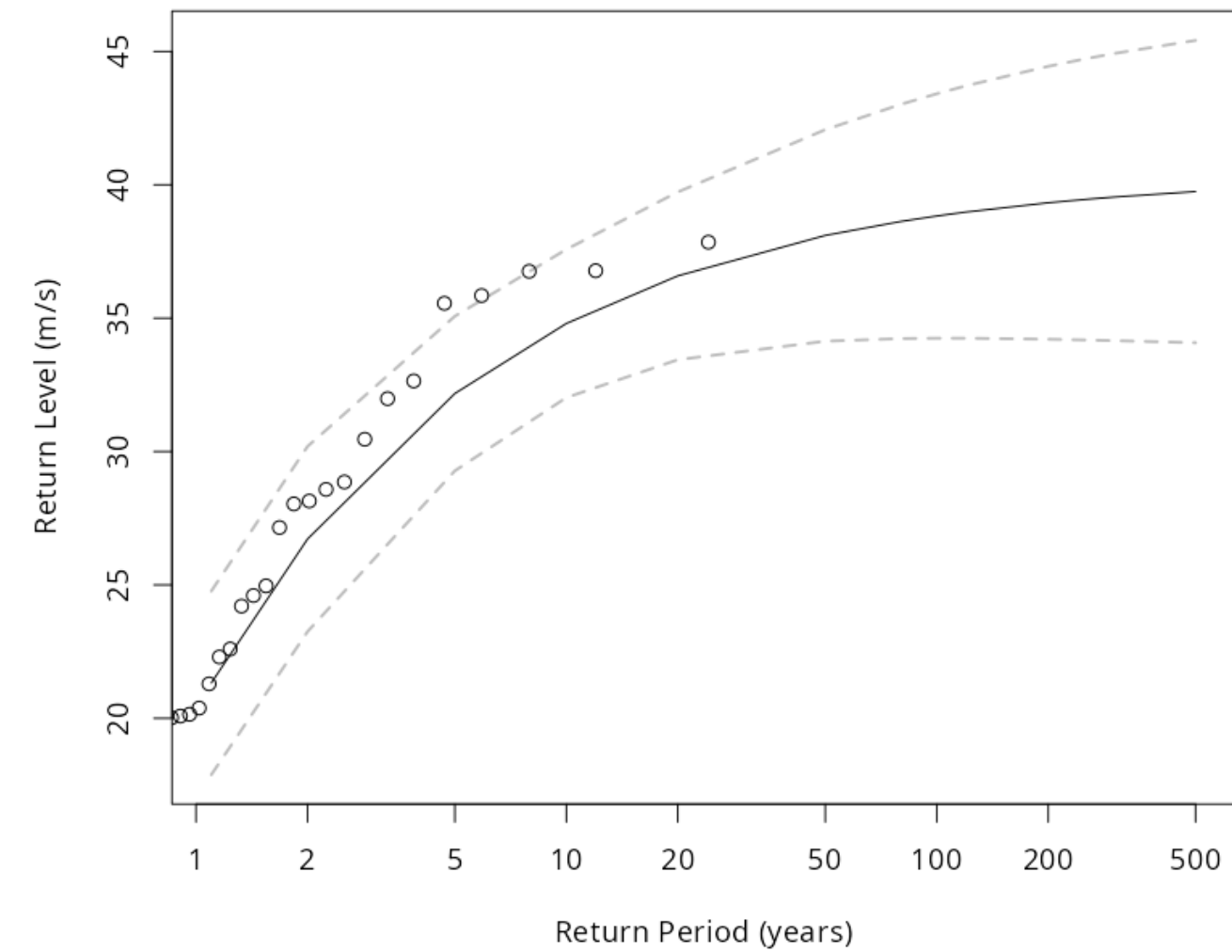
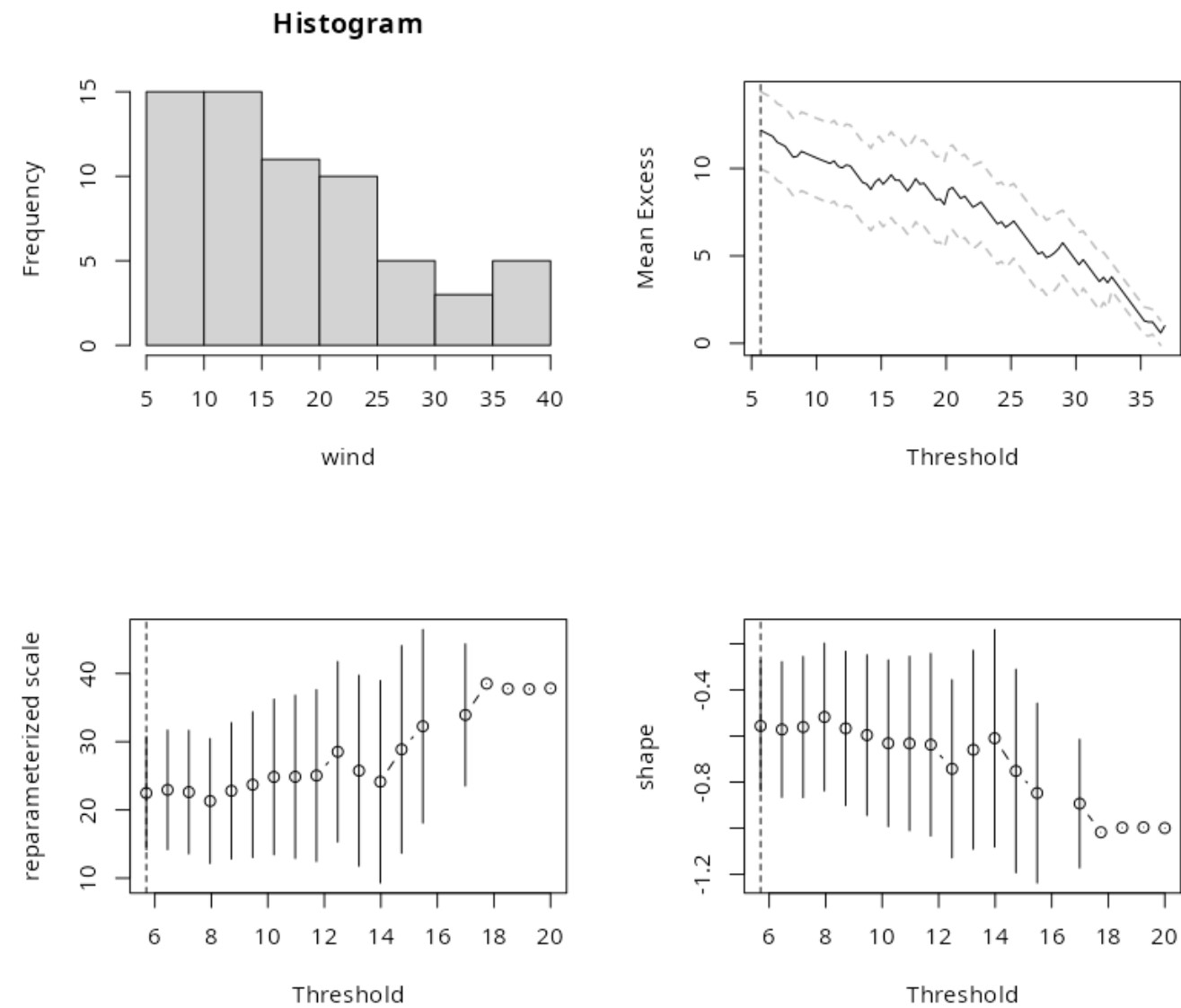
## Historical wind without direct measurements :

- Parametric wind model to estimate wind speed from TC parameters
- Model of Vinour et al, 2025
- 6 parameters needed



## Classical GPD Approach

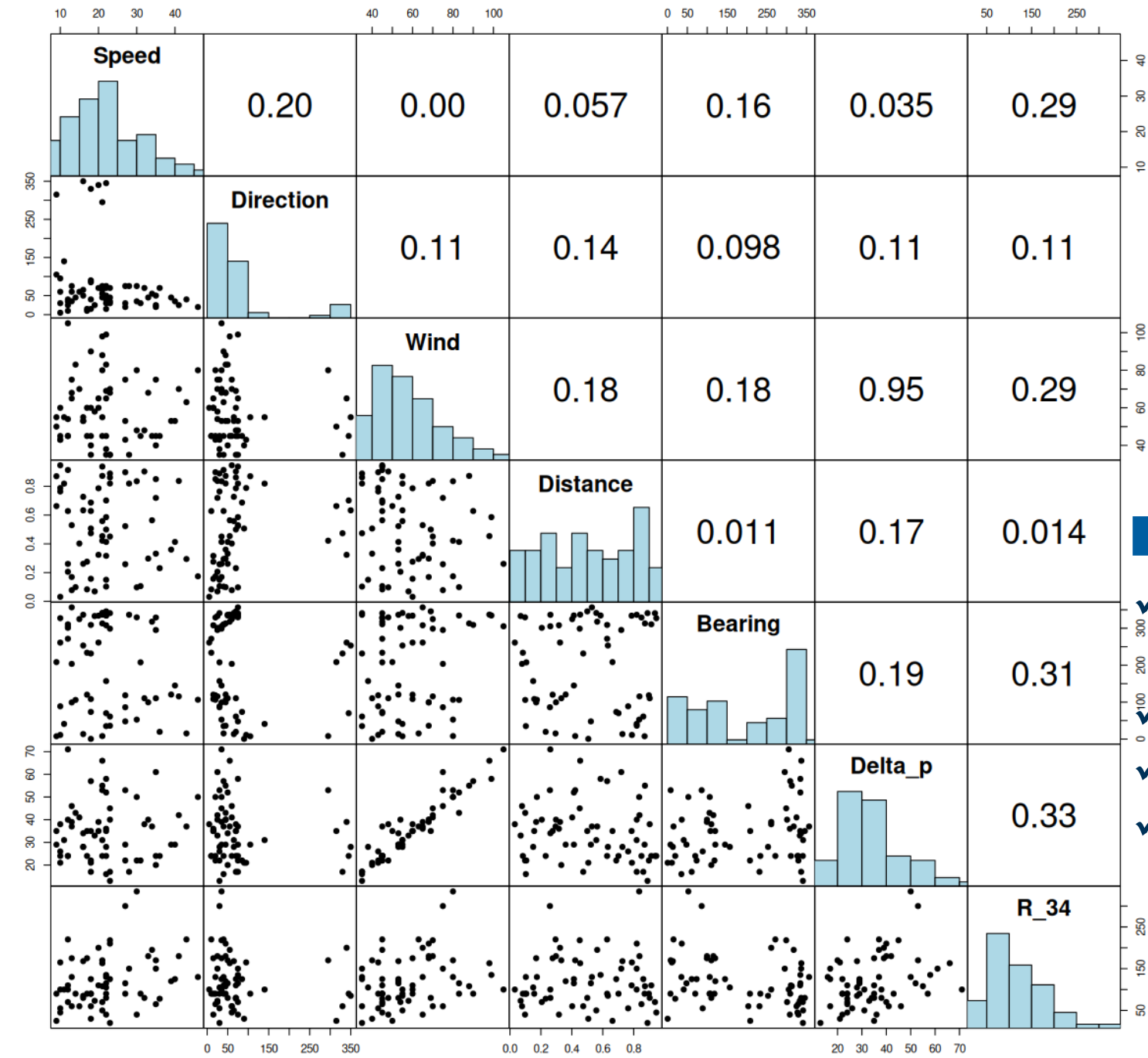
- Fit a GPD/POT to the data (threshold selection, parameters estimation...)
- Estimated the Return levels from TC using the fitted model
- **Large uncertainties** linked to the paucity of data



Alternative : **augment** the database using **Stochastic Weather Generators**

- Accurate description of the past events ;
- **Cheap to simulate** a large number ;
- So-called Monte Carlo Approach ;
- Two elements : **marginal distributions** of parameters and **joint distribution**.

## Distribution of TCs parameters from IBTrACS data



For each variable



- ✓ Several models and mixtures thereof;
- ✓ Estimation : ML/EM ;
- ✓ Selection : **AIC**
- ✓ Specific models for directions

Table 2: Distributions used to model positive variables.

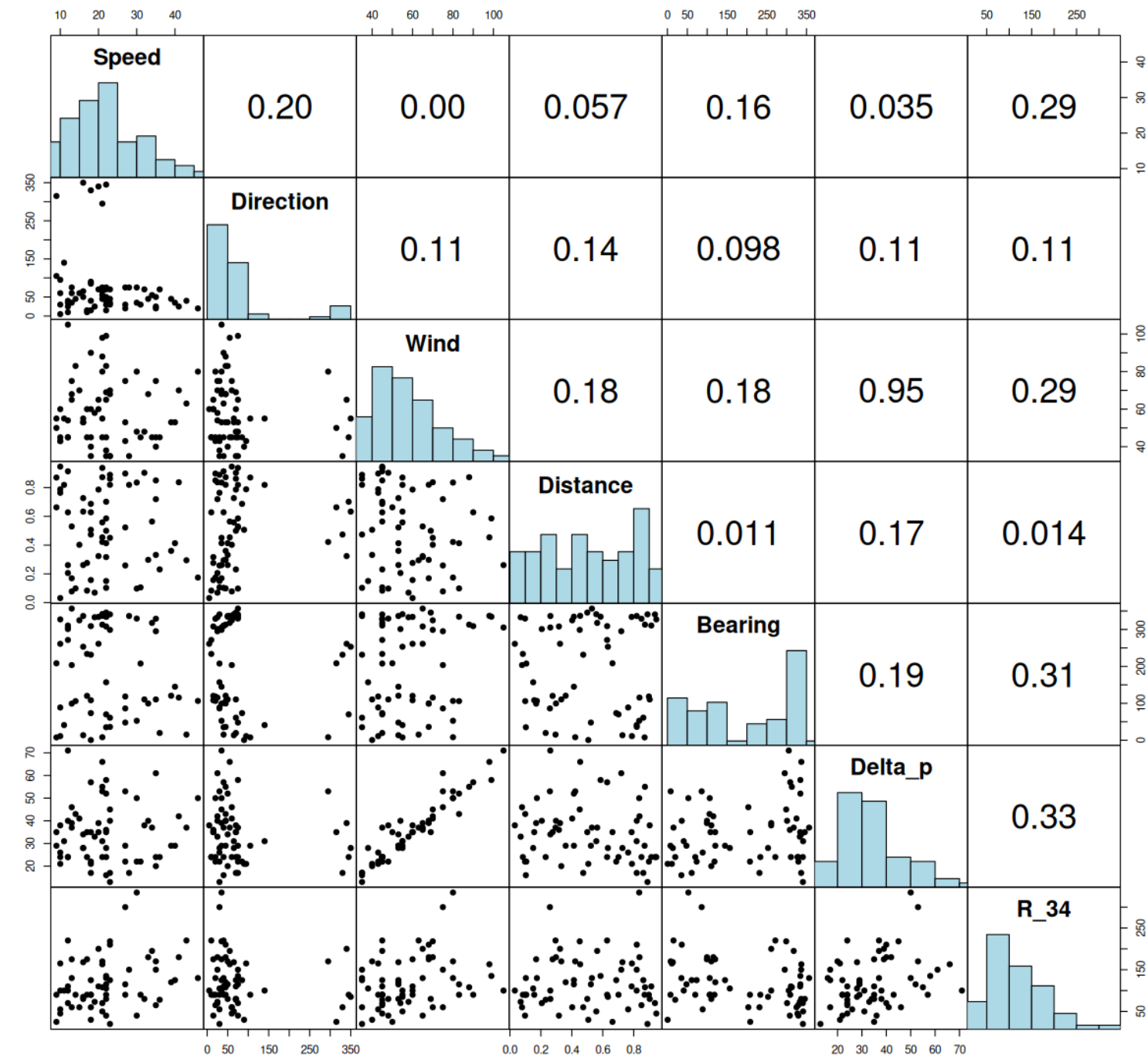
Name	Parameters
Exponential	1
Pareto	1
Inverse Gaussian	2
Log-Normal	2
Gamma	2
Inverse Gamma	2
Weibull	2
Generalized Pareto	2
Extended GPD <sup>1</sup>	3
Generalized Beta of second kind <sup>2</sup>	4
Two Log-Normal	5
Log-Normal and Gamma	5
Log-Normal and Generalized Pareto	5
Log-Normal and Weibull	5
Two Inverse Gaussian	5
Log-Normal and Inverse Gaussian	5

Table 3: Distributions used to model positive variables.

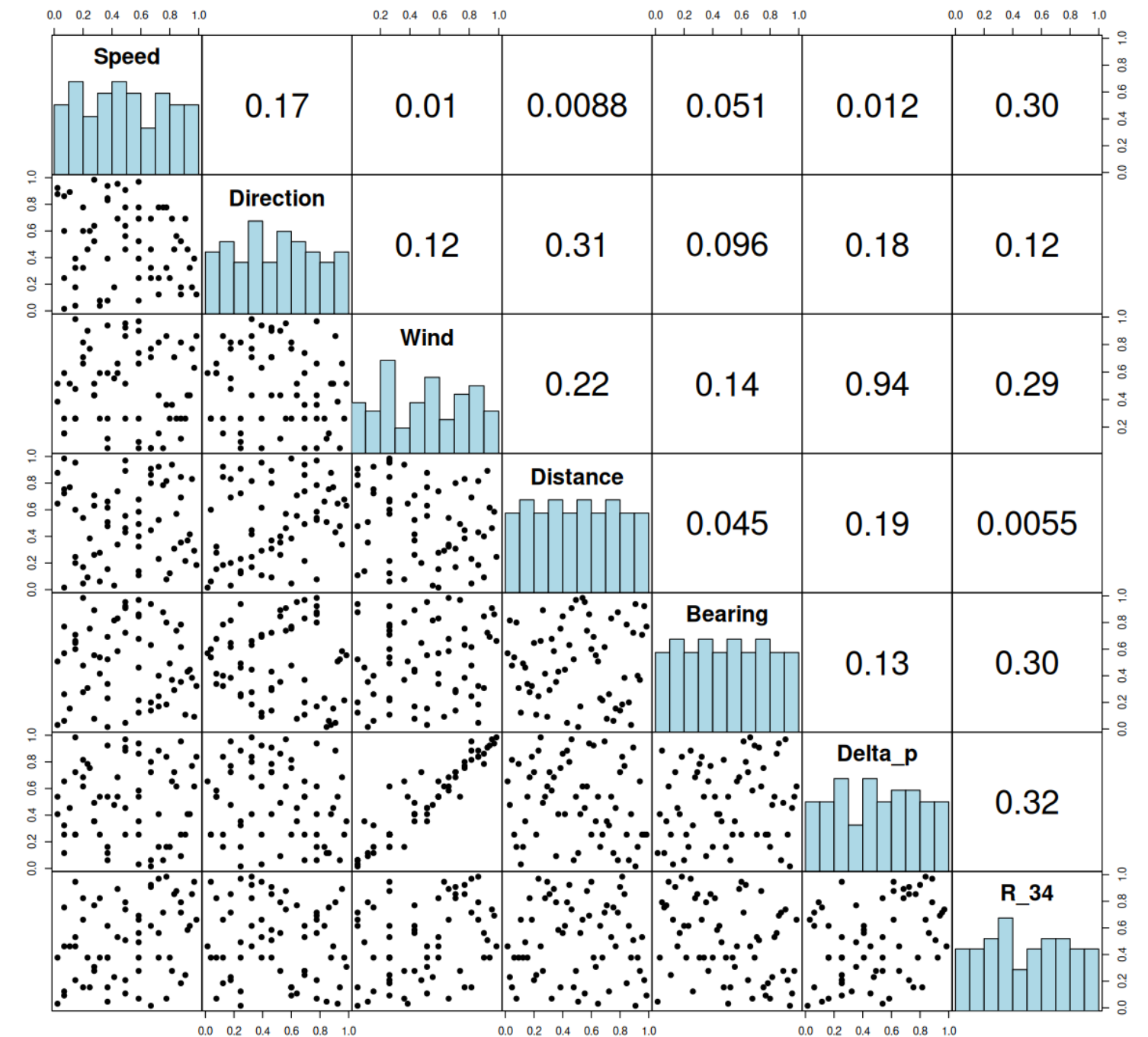
Name	Parameters
Normal <sup>1</sup>	2
Generalized Beta of 1 <sup>st</sup> kind	4
Beta	2
Logit Normal	2
Beta Inflated at 0	3
Beta Inflated at 1	3
Beta Inflated at 0 and 1	4
Two Log-Normal <sup>1</sup>	5
Two Beta	5
Two Logit-Normal	5

# P3 - Improved Monte-Carlo Simulation Method

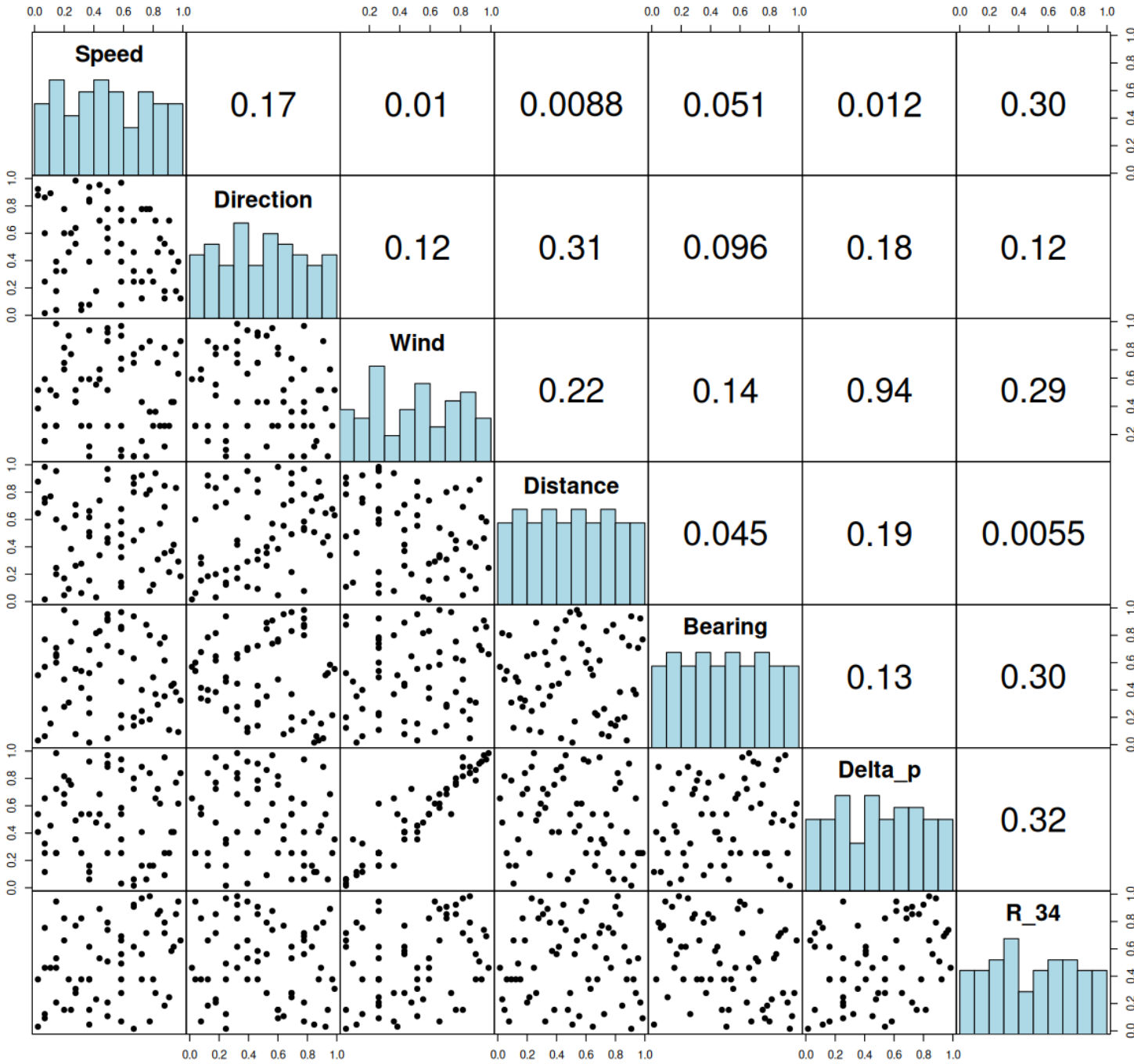
Distribution of TCs parameters from IBTrACS data



Transform to uniform margins



Distribution of TCs parameters from IBTrACS data



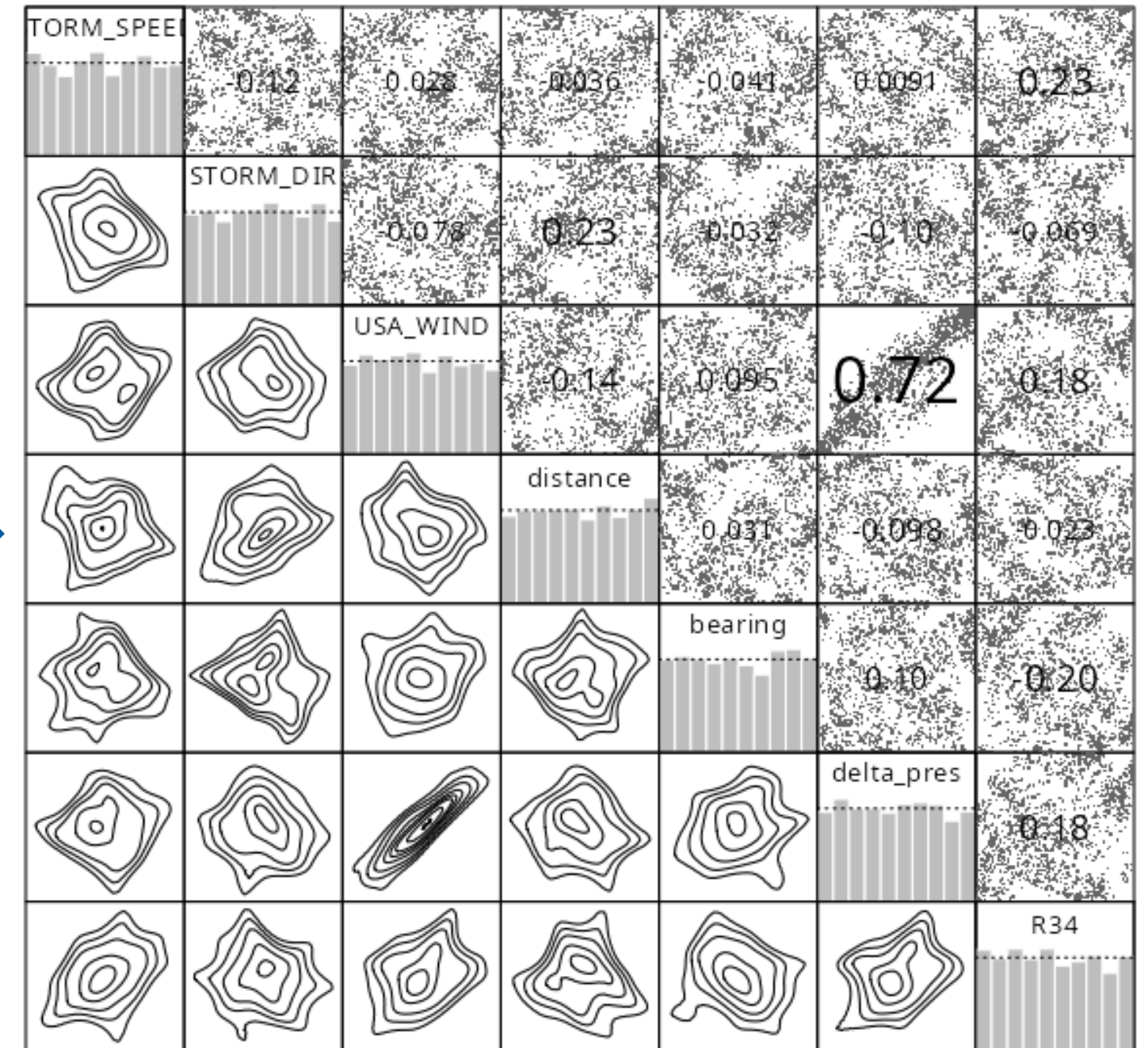
Fit a **Copula** model



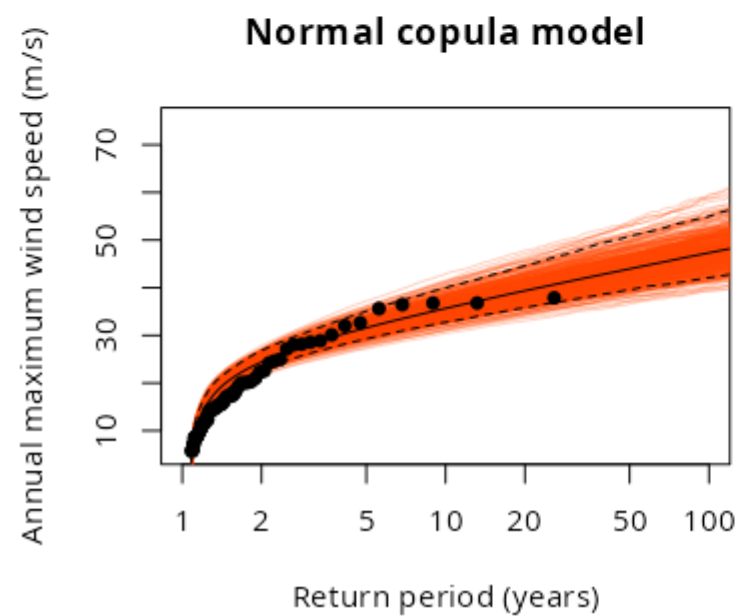
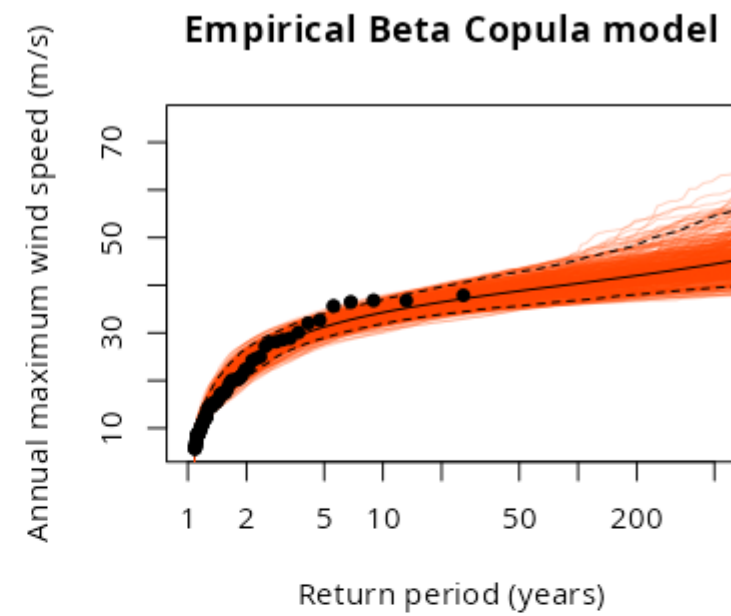
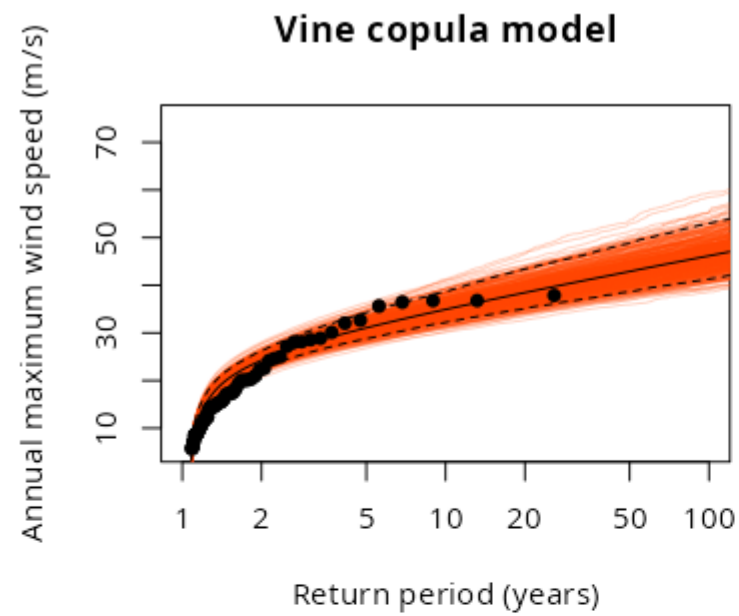
3 models studied :

- Normal copula
- Beta empirical
- Regular Vine copula

Very cheap to simulate

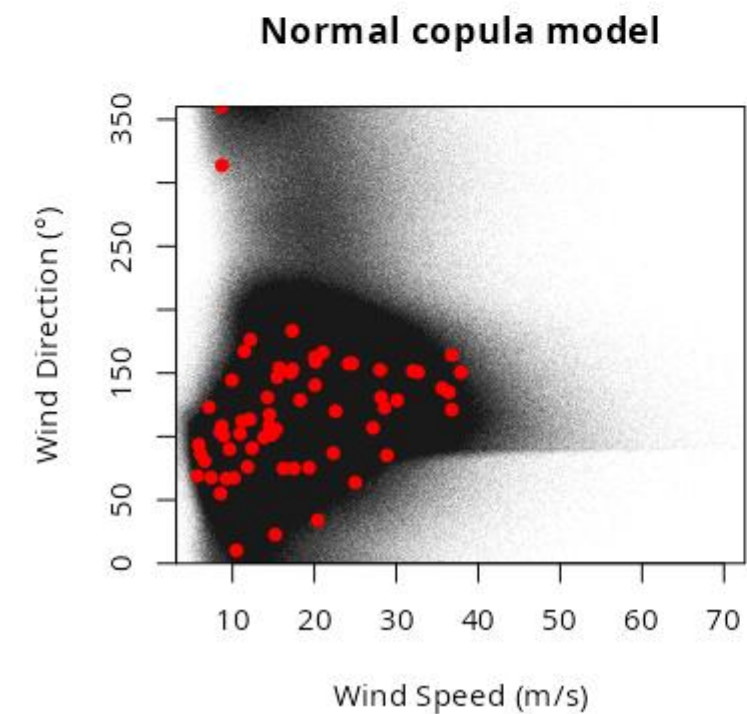
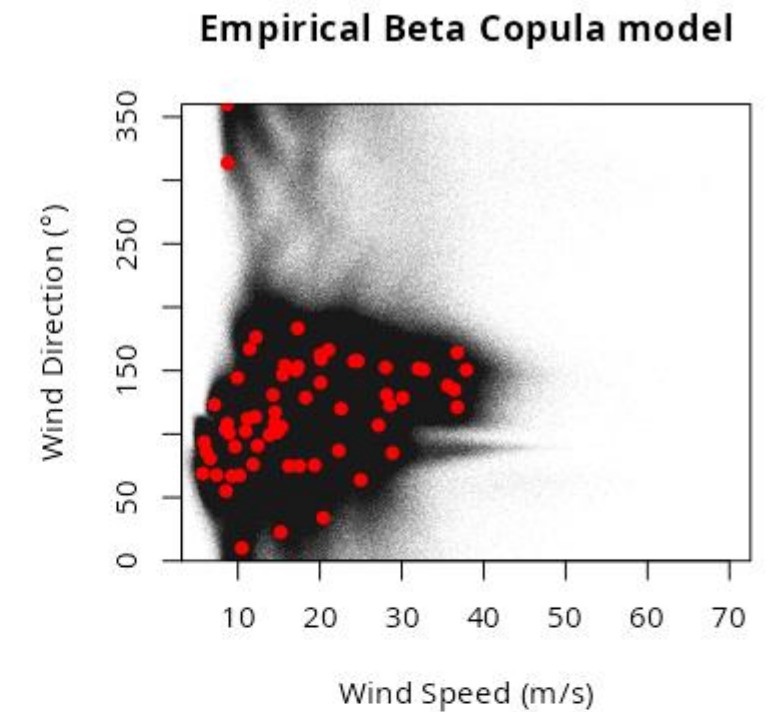
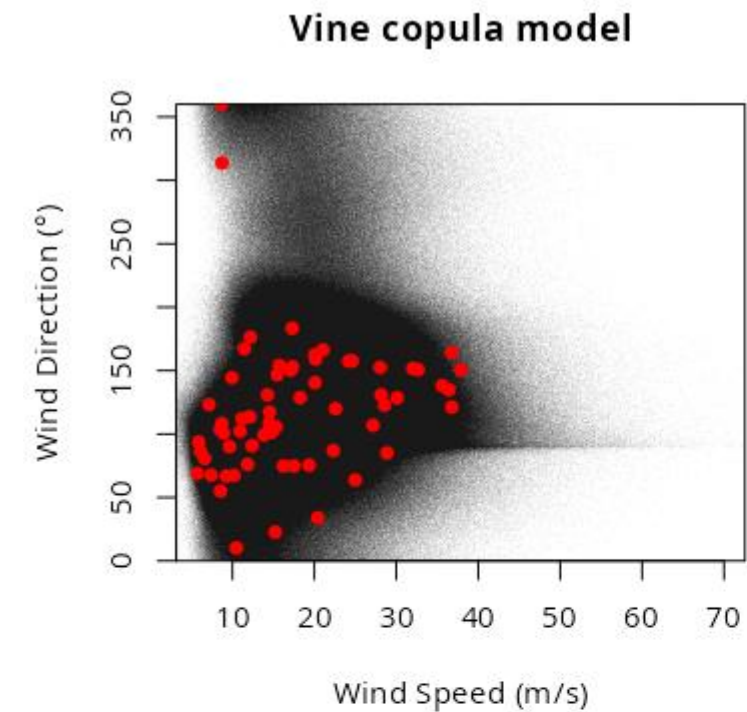


## Monte Carlo approach : results



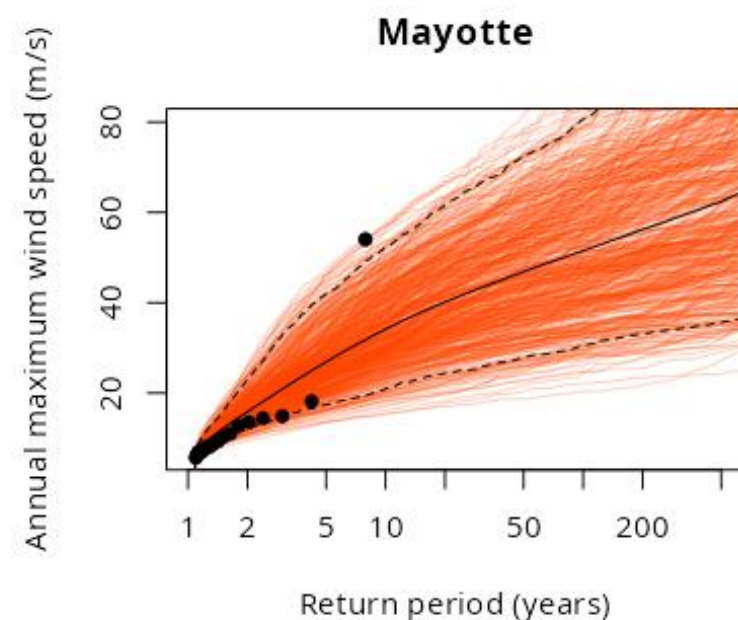
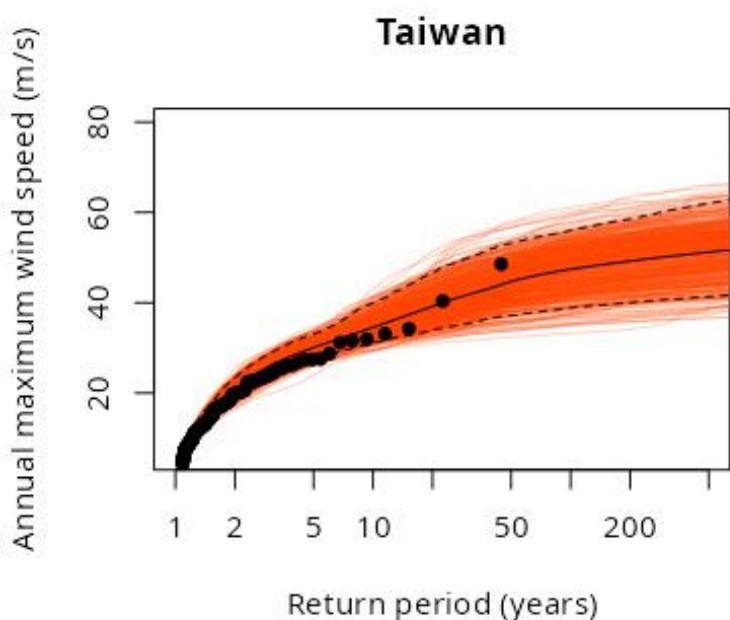
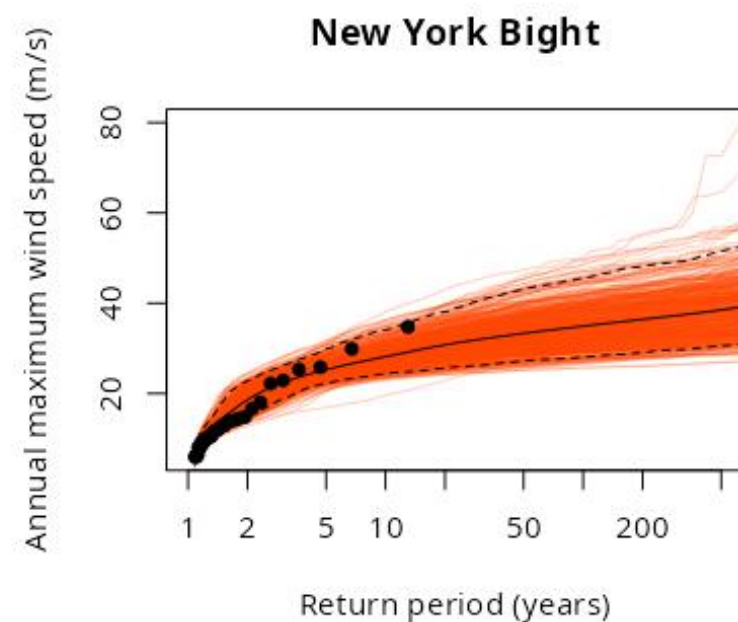
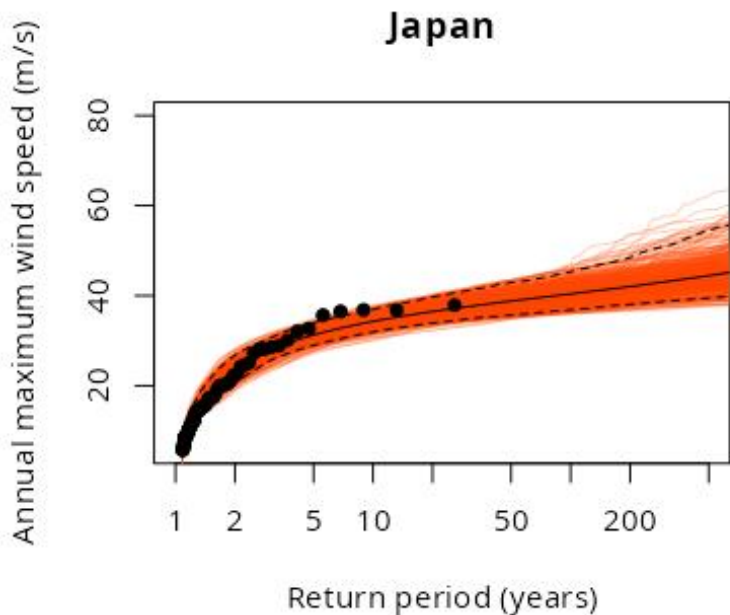
Figures from Raillard et al, 2026. *In prep.*

- Replicates the **historical winds** ;
- Provides estimates for **any return period** ;
- Uncertainties estimated using parametric bootstrap ;
- Provides the **joint distribution** of wind speed and direction



## Conclusion

- Implemented into a Web Application using {shiny}
- Versatile and robust method ;



OROWSHI Project - Tropical Cyclone parameter modelling

- Description
- Location Selection
- User inputs
- Data exploration
  - Table
  - Maps
  - Pairs plot
- Marginal models
  - Available models
  - Pressure difference
  - Radius of maximum wind speed (from IBTrACS)
  - Radius of 34-kt wind
  - Maximum wind speed
  - Storm translation speed
  - Storm direction
  - Distance to location
  - Bearing to location
- Joint Models
  - Empirical copula
  - Normal copula
  - Empirical Beta copula
  - Vine copula
- Wind Estimation
  - Ishihara & Yamaguchi (2015) Gradient wind model
  - Ishihara & Yamaguchi (2015) Vertical wind model
  - Ishihara & Yamaguchi (2015) - 10-min time series
  - OROWSHI Surface wind model
  - OROWSHI Vertical wind model
  - OROWSHI - 10-min time series
  - Monte-Carlo simulation
  - Historical Wind
- Ongoing work
  - To Do List

### Improved IMCS method application

#### Application functionalities

- Select a location
- Fit marginal distributions
- Fit a global dependence structure
- Simulate from the fitted model
- Estimate the wind from an asymmetric hurricane model.

#### Source code

The source code and installation procedure of the application, using **Docker** is available on IFREMER gitlab, [here](#)

#### Contributing

This application is still under development, and any contribution is welcomed. If you have something you would like to contribute, but you are not sure how, please don't hesitate to reach out by sending me an [email](#) or by opening an issue. It currently depends on a registration on the IFREMER Gitlab, which can be done by sending me an email.

#### Know bugs or caveats

- from times to times, the fitting procedure fails, which kills the app.

#### Acknowledgements

This work is part of the OROWSHI project which receive funding from France Energies Marines and its members and partners, as well as French State funding managed by the French National Research Agency under the France 2030 Investment Plan (ANR-10-IEED-0006-34).

Thank you for your attention!

