Defining Coastal Hazards and Design Criteria in Tropical Environments

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The Challenge

- Often need to provide metocean design criteria conditions and inundation extents for coastal hazards.

- Results have implications for construction costs.

- In the tropics we need to consider tropical cyclones.

- Today, we will talk about how cyclones can be addressed in coastal hazard studies.
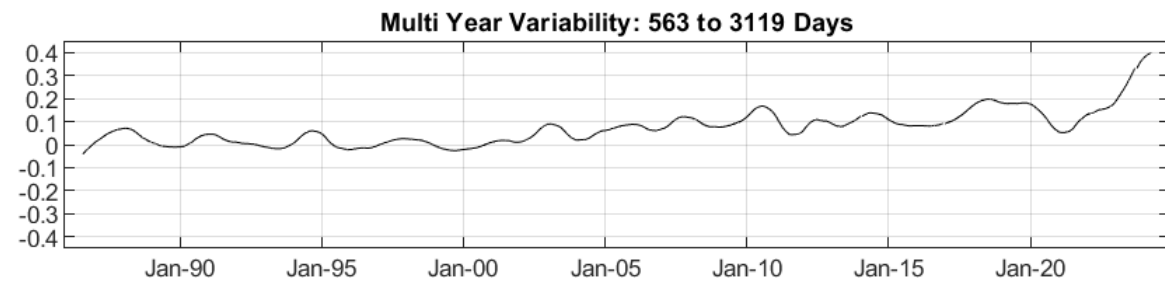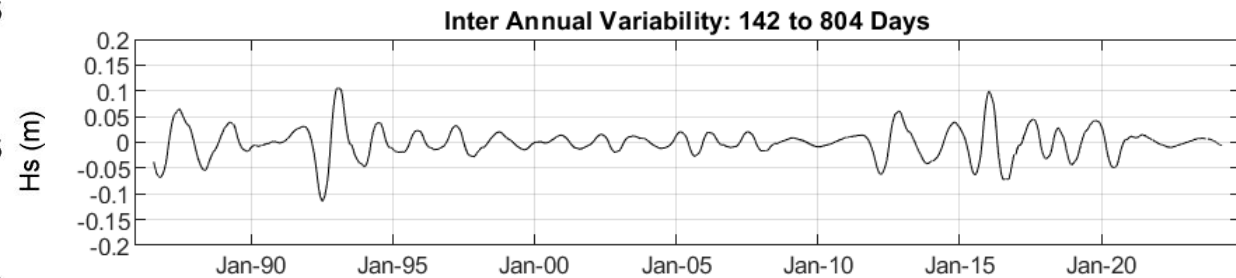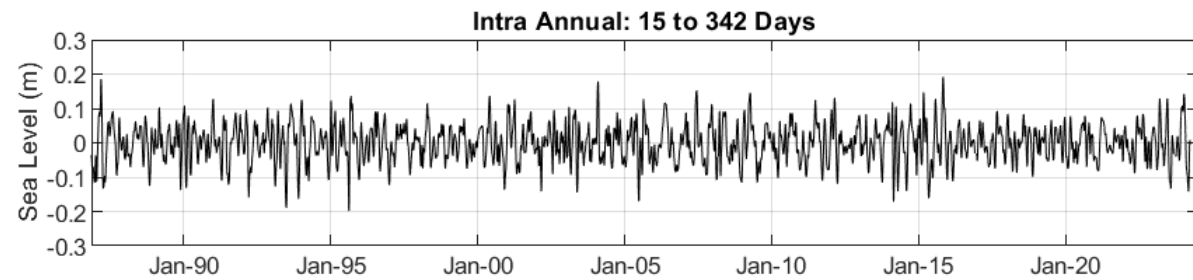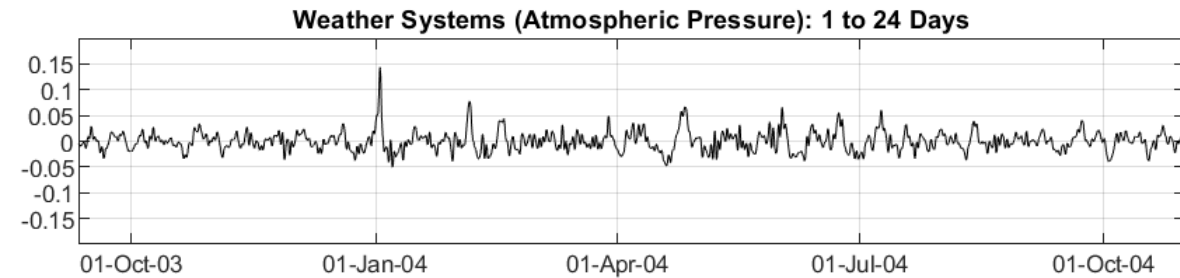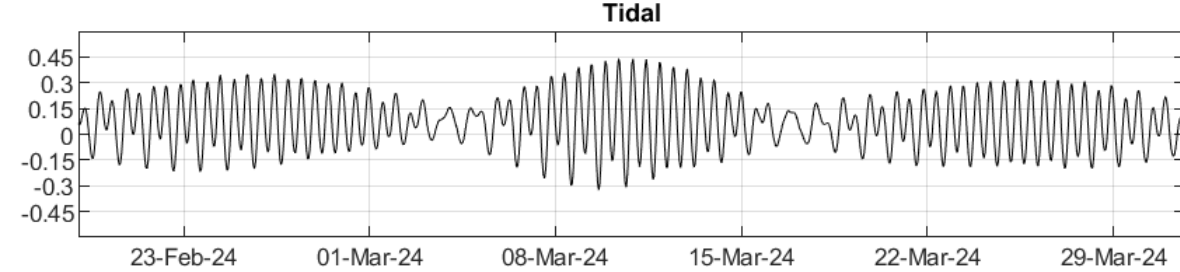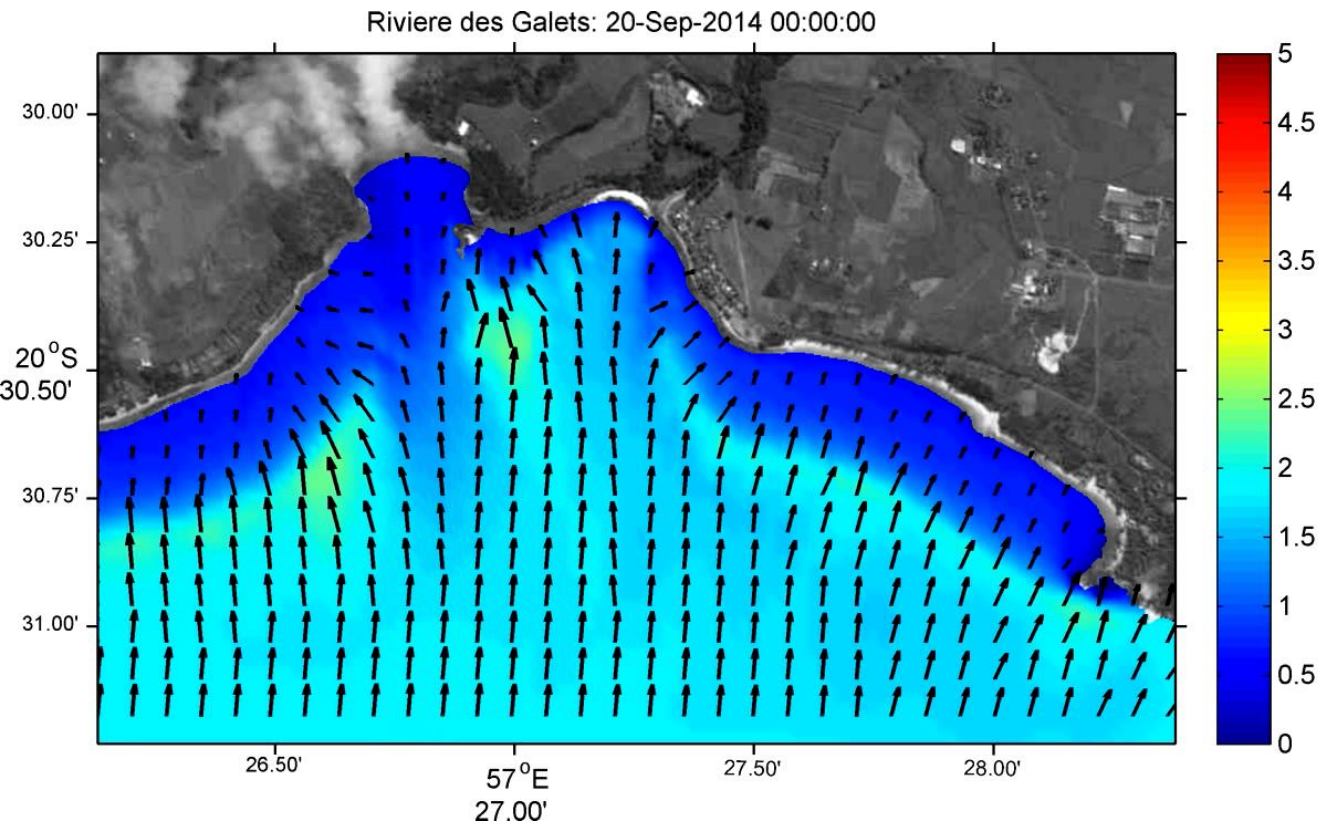
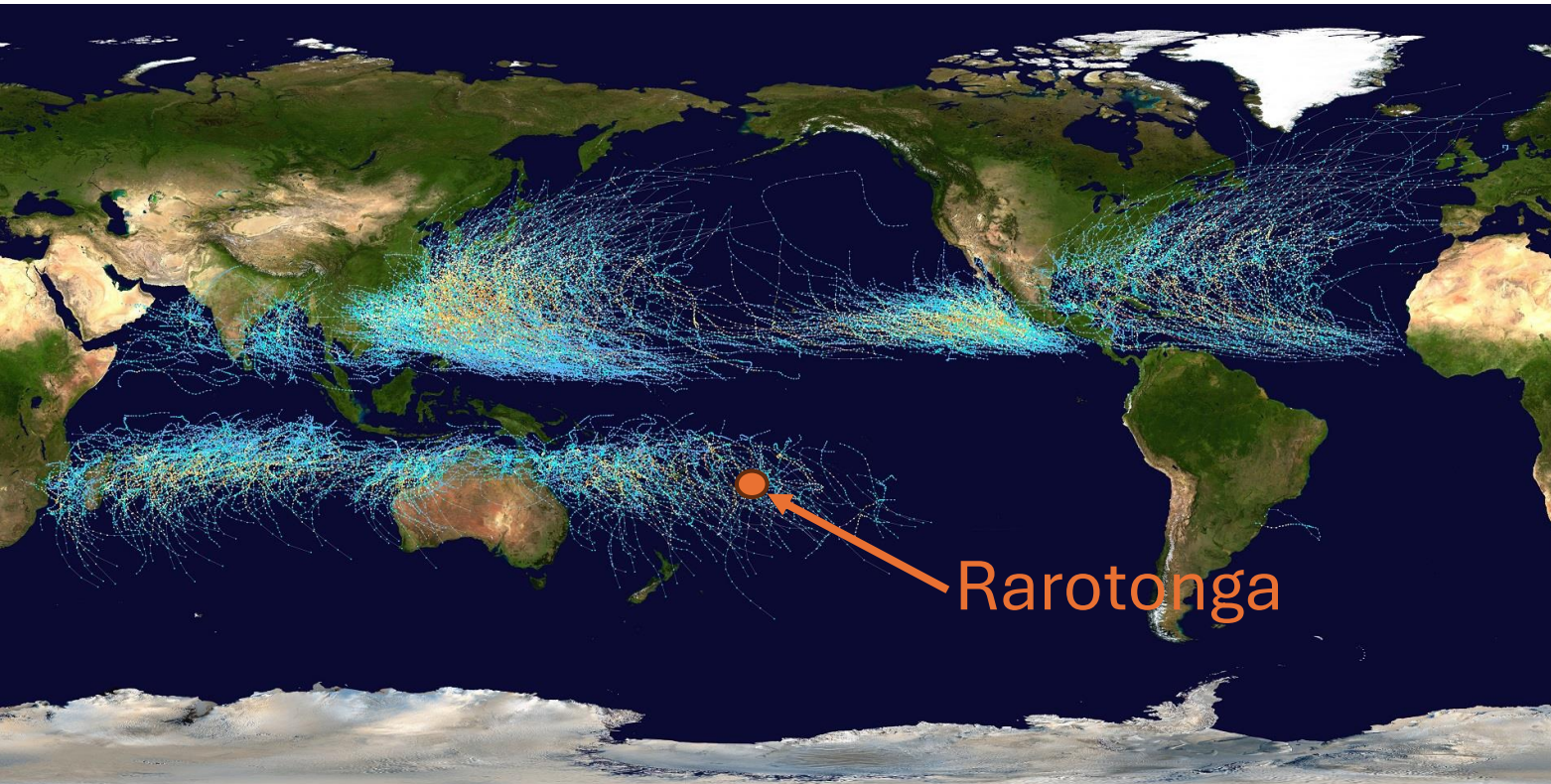# Case Studies
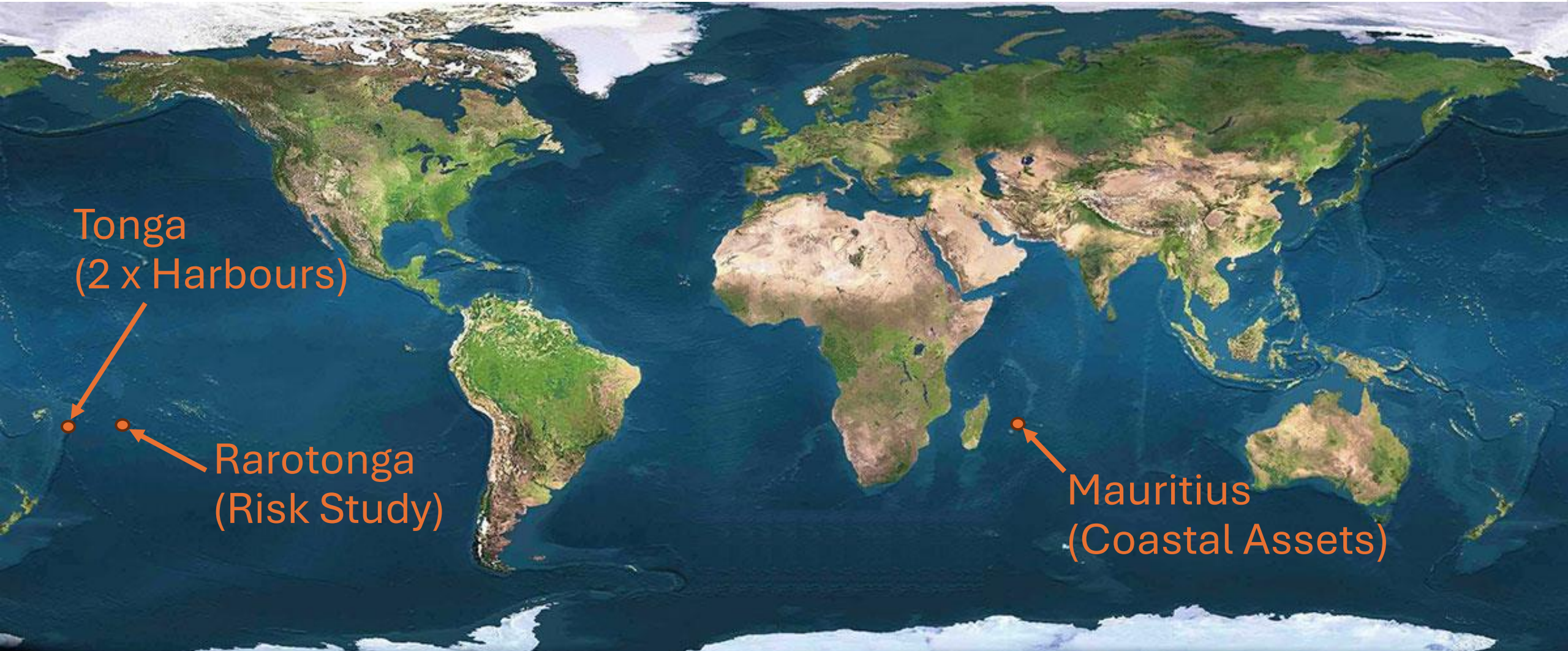
Tonga
(2 x Harbours)

Rarotonga
(Risk Study)

Mauritius
(Coastal Assets)

Coastal Hazards in Temperate Zones

Usual method is to:

- Create a 45-year wave hindcast
- Nest to our location of interest

Riviere des Galets: 20-Sep-2014 00:00:00

Tidal

Weather Systems (Atmospheric Pressure): 1 to 24 Days

Intra Annual: 15 to 342 Days

Inter Annual Variability: 142 to 804 Days

Multi Year Variability: 563 to 3119 Days

Cyclones are a different beast…

Rarotonga

- About 85 cyclones per year worldwide.

- Occur in the tropics between 5 and 30 degrees in Summer months

- Require a delicate balance of forces to form

- Notice no cyclones in the eastern Pacific
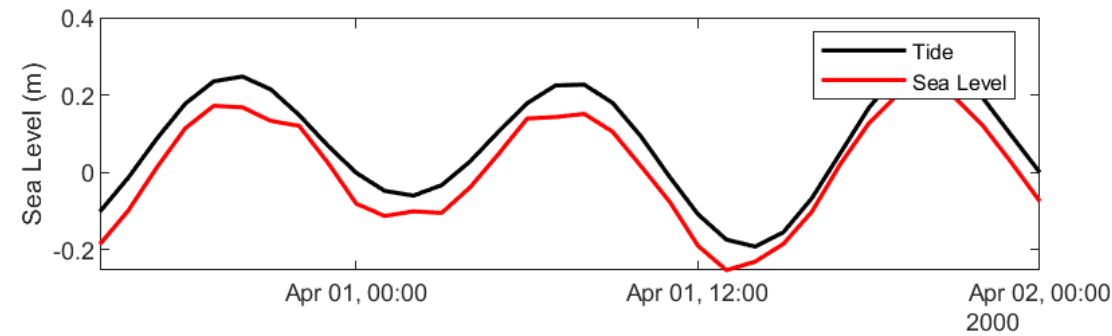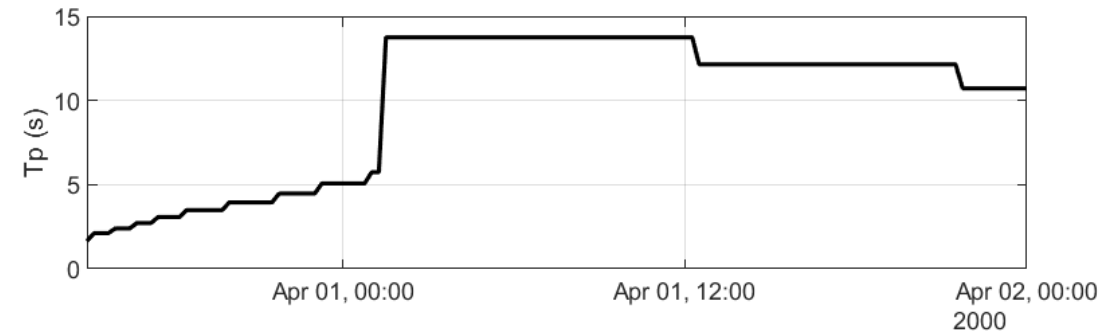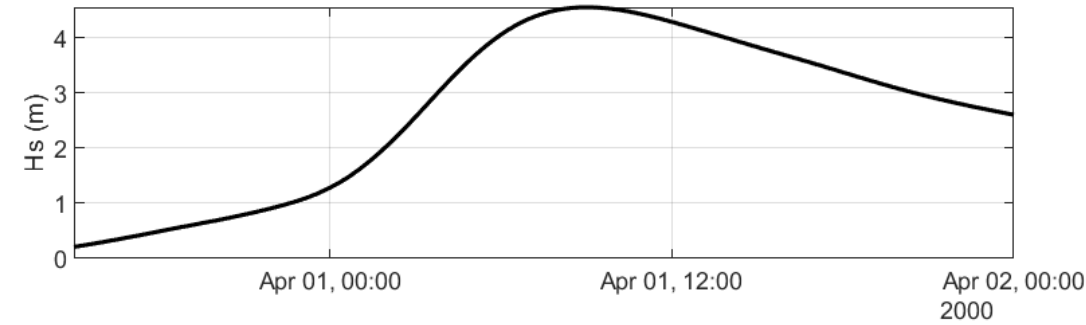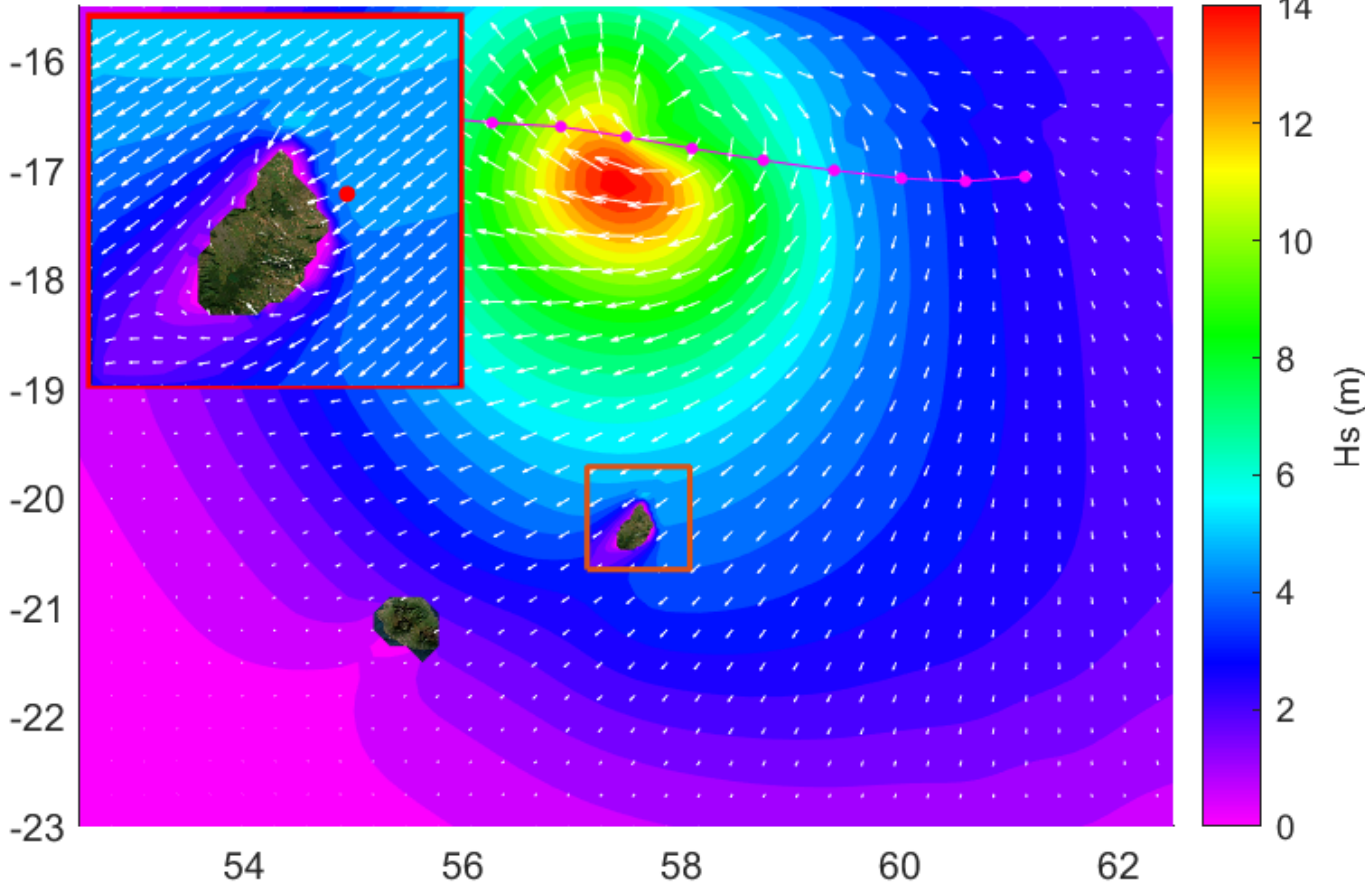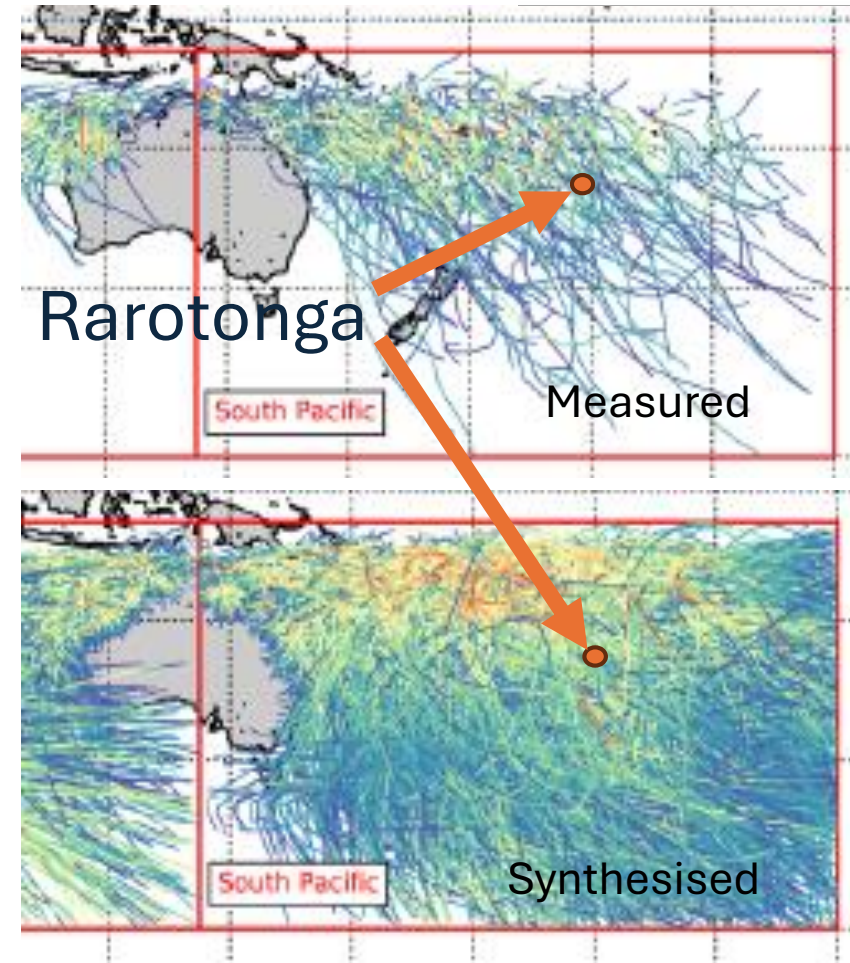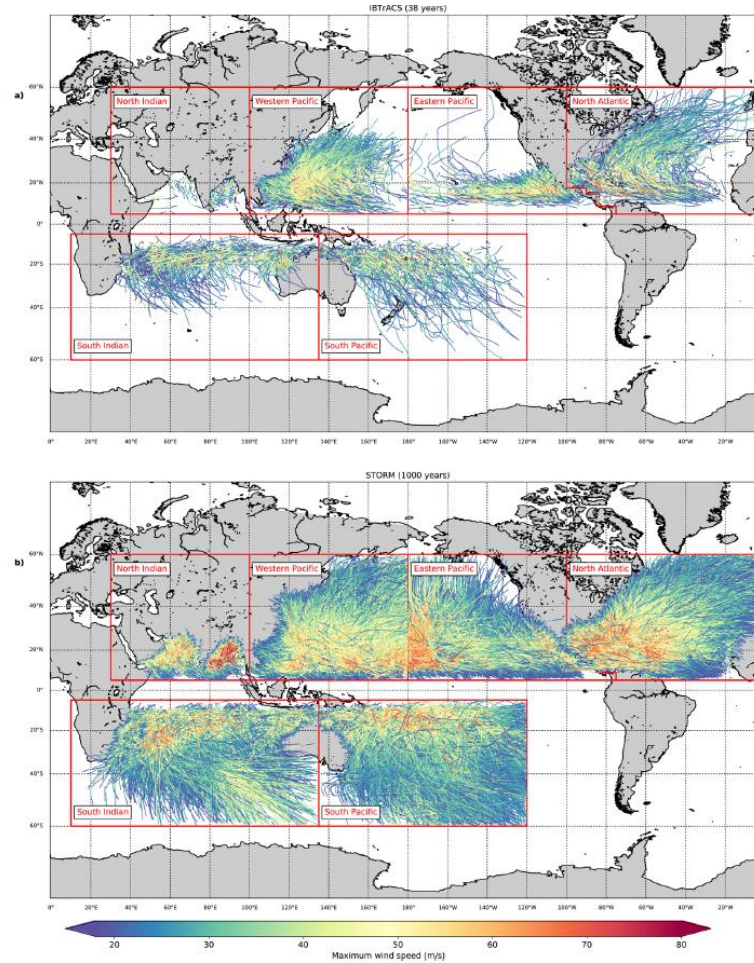
- Good historical records date back to 1980
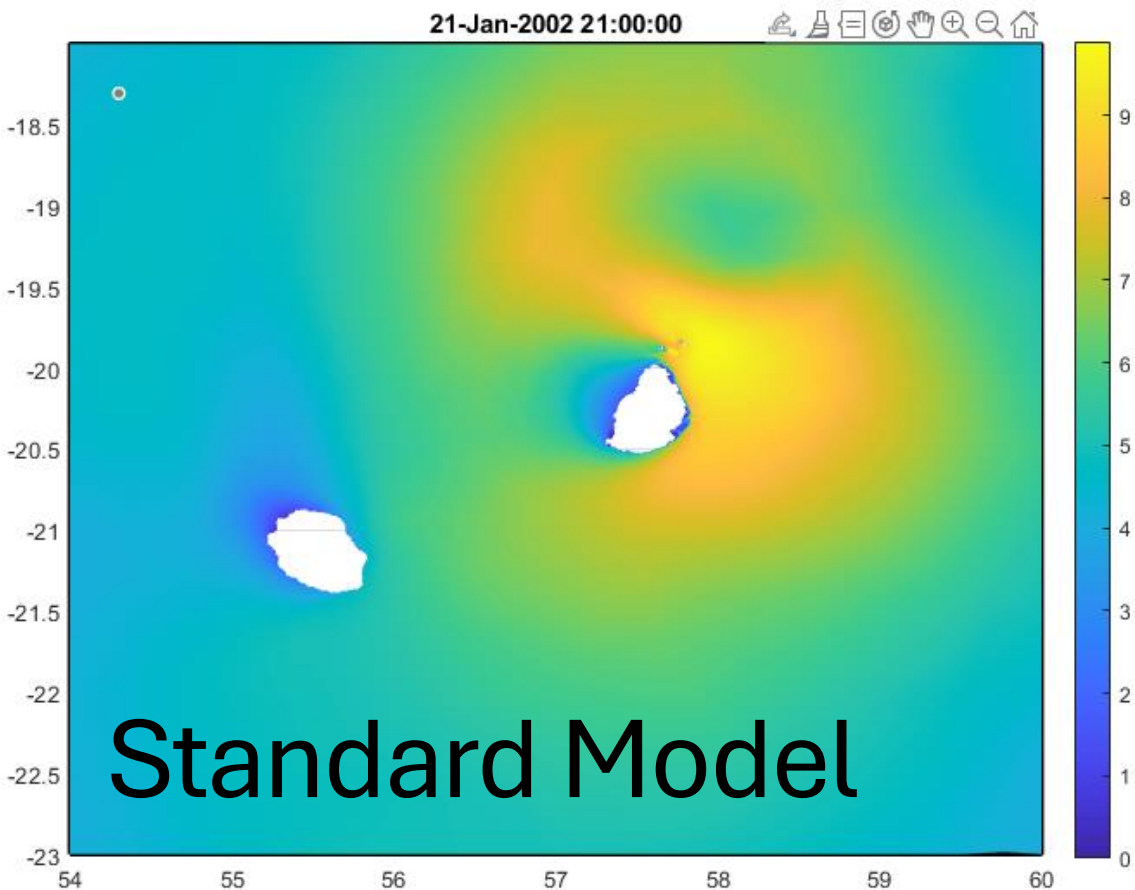
Cyclones

Small changes in tracks matter!

Cyclone sparsity

- Rely on Monte Carlo models of cyclone tracks

- Used the STORM database

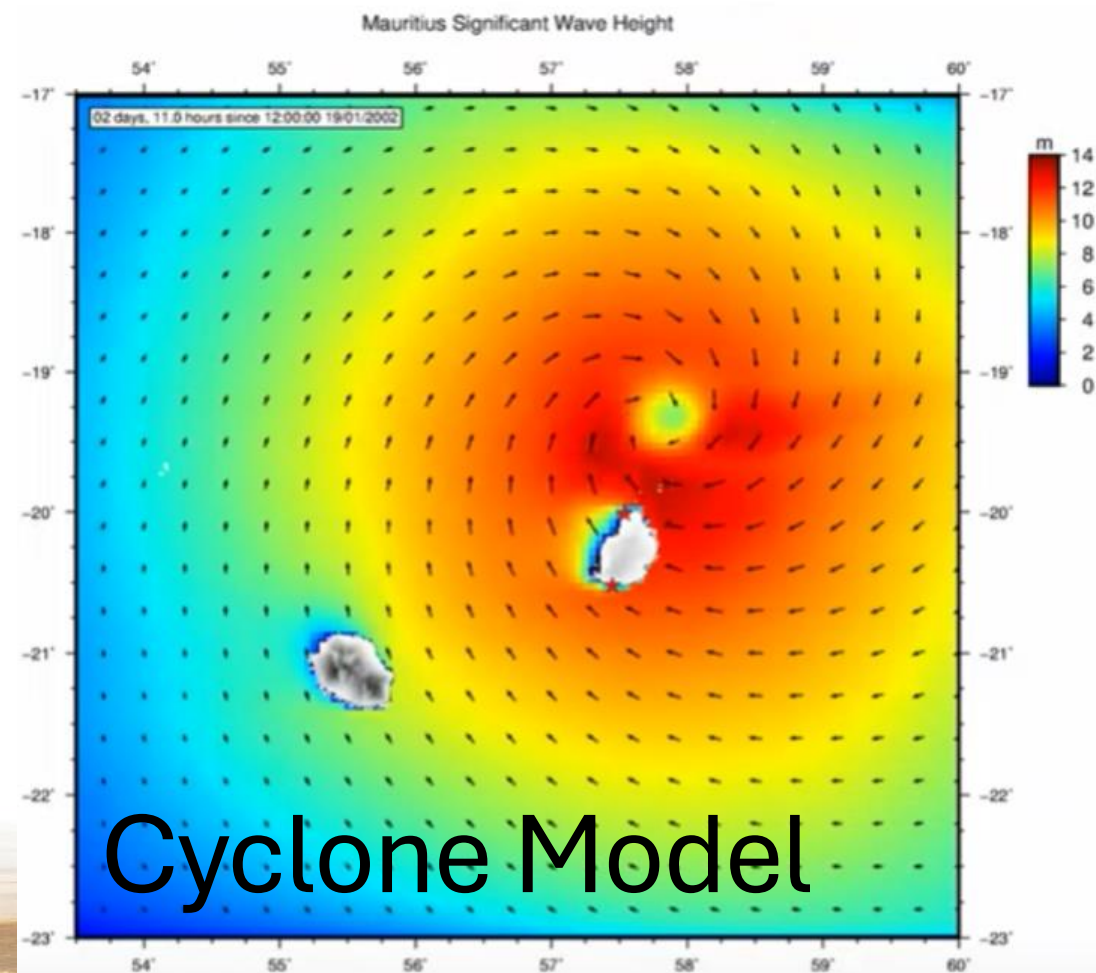- Gives 10,000 years of cyclone tracks

- Especially useful for Rarotonga

Modelling Cyclones

Global wind fields are coarse (often 0.25 to 0.5 degree) and so are resultant wave fields.

Standard Model

Use sensitivity analysis to optimise model grid resolution model timestep

Cyclone Model

- In Tonga we modelled cyclones tracks (approximately 8000 cyclones) using SWAN, with a small timestep.
- Need to balance computational demands with grid resolution for resolving wind field and bathymetric/topographic features.
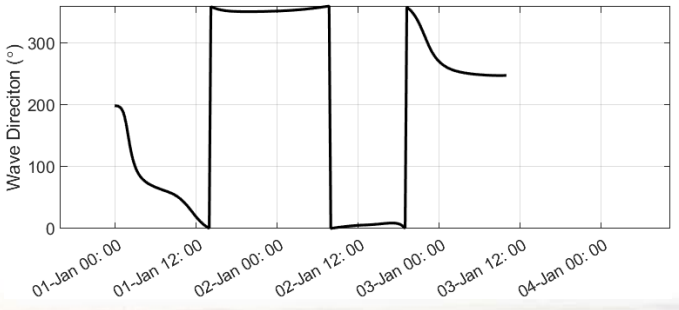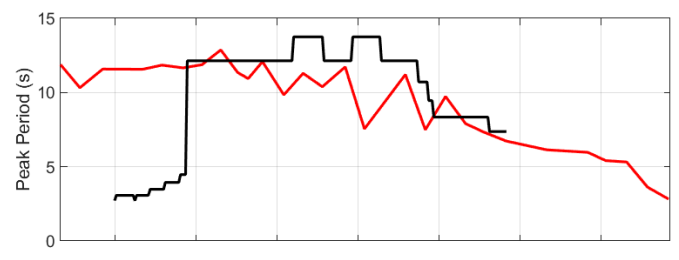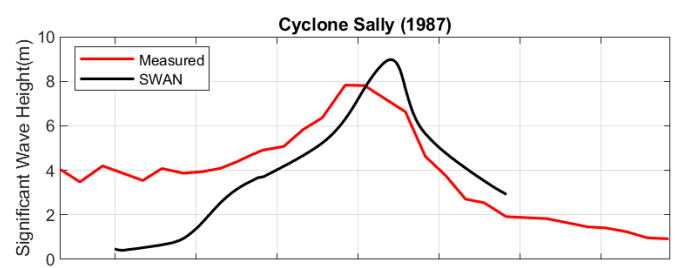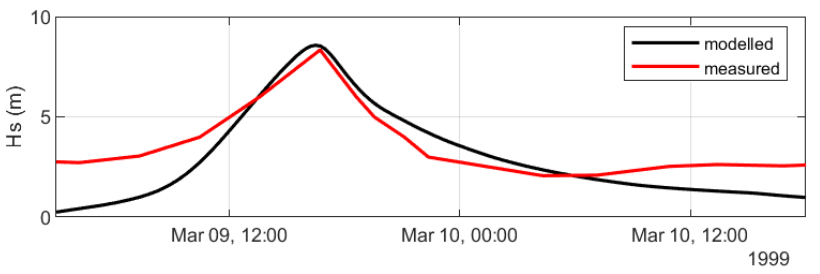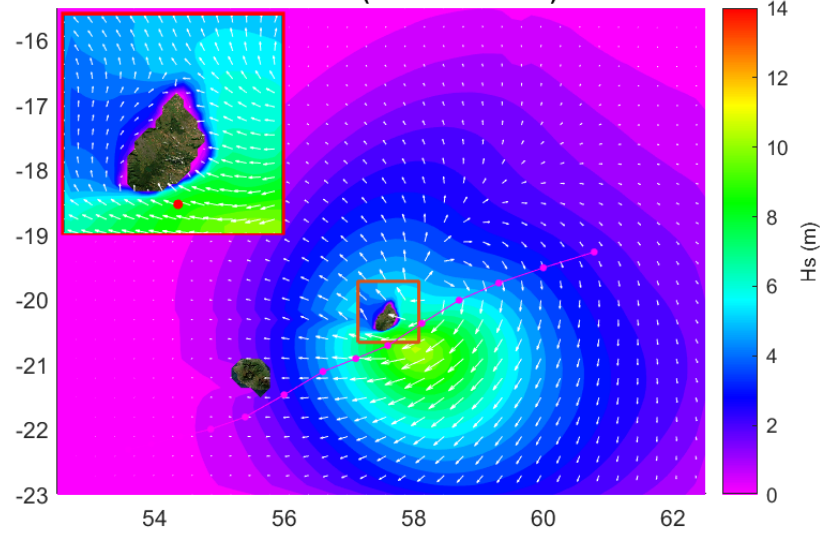- The result is timeseries of waves, wind, pressure and rainfall for each event.
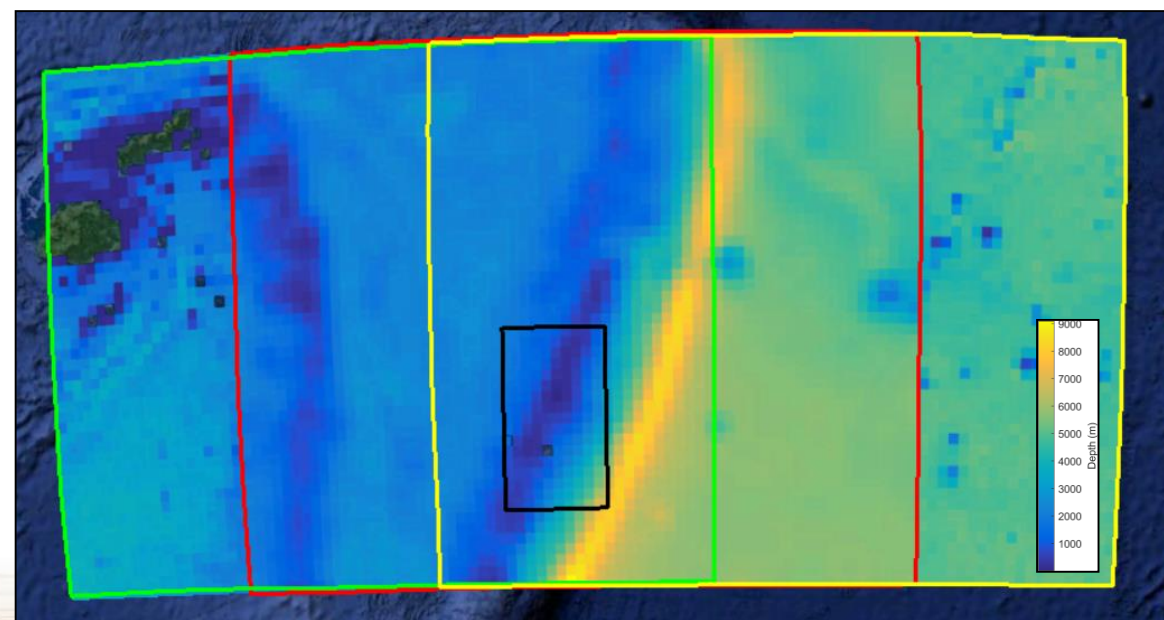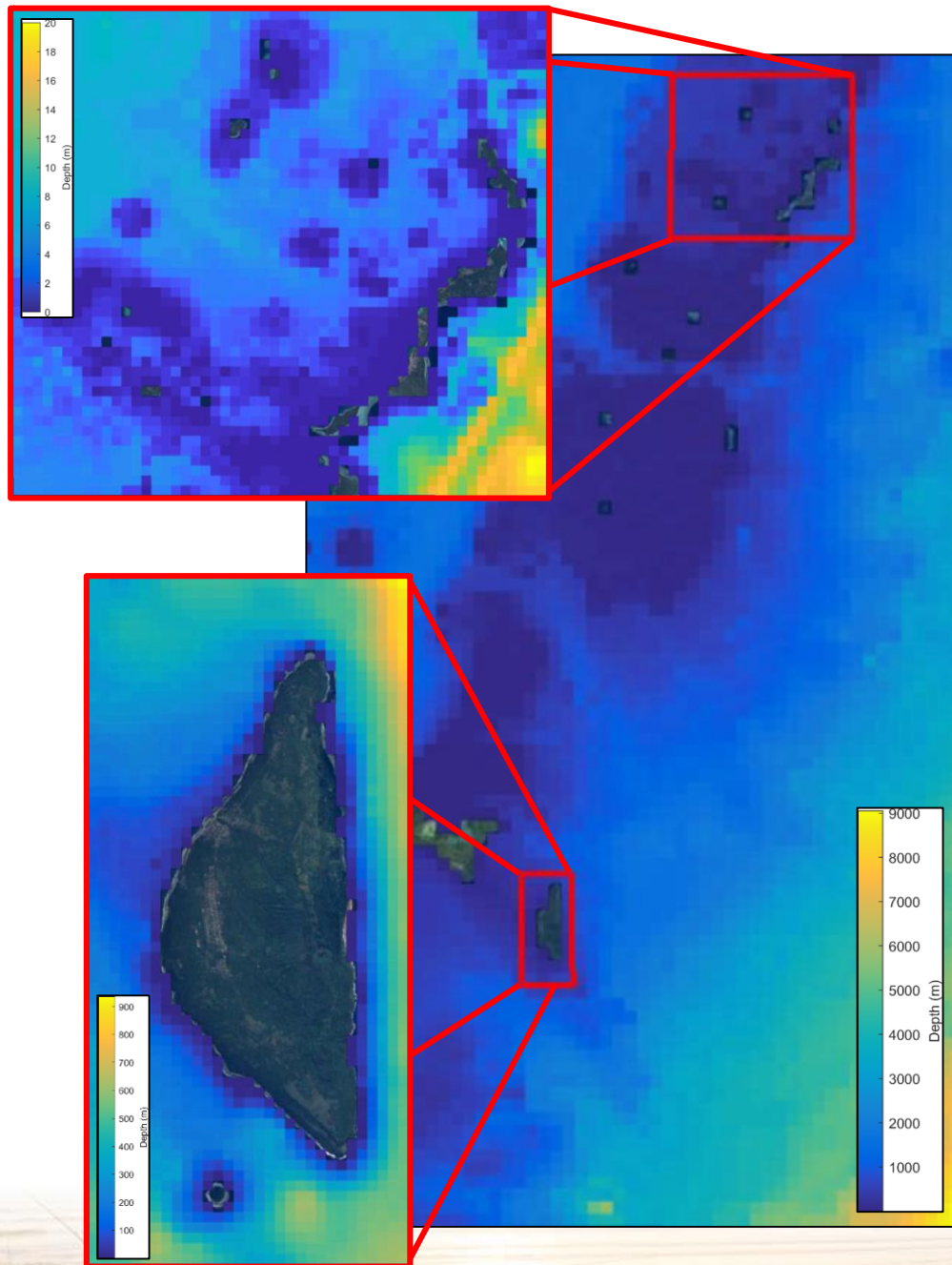
Cook Islands:

Cyclone Sally (direct hit) followed by Cyclone Olaf
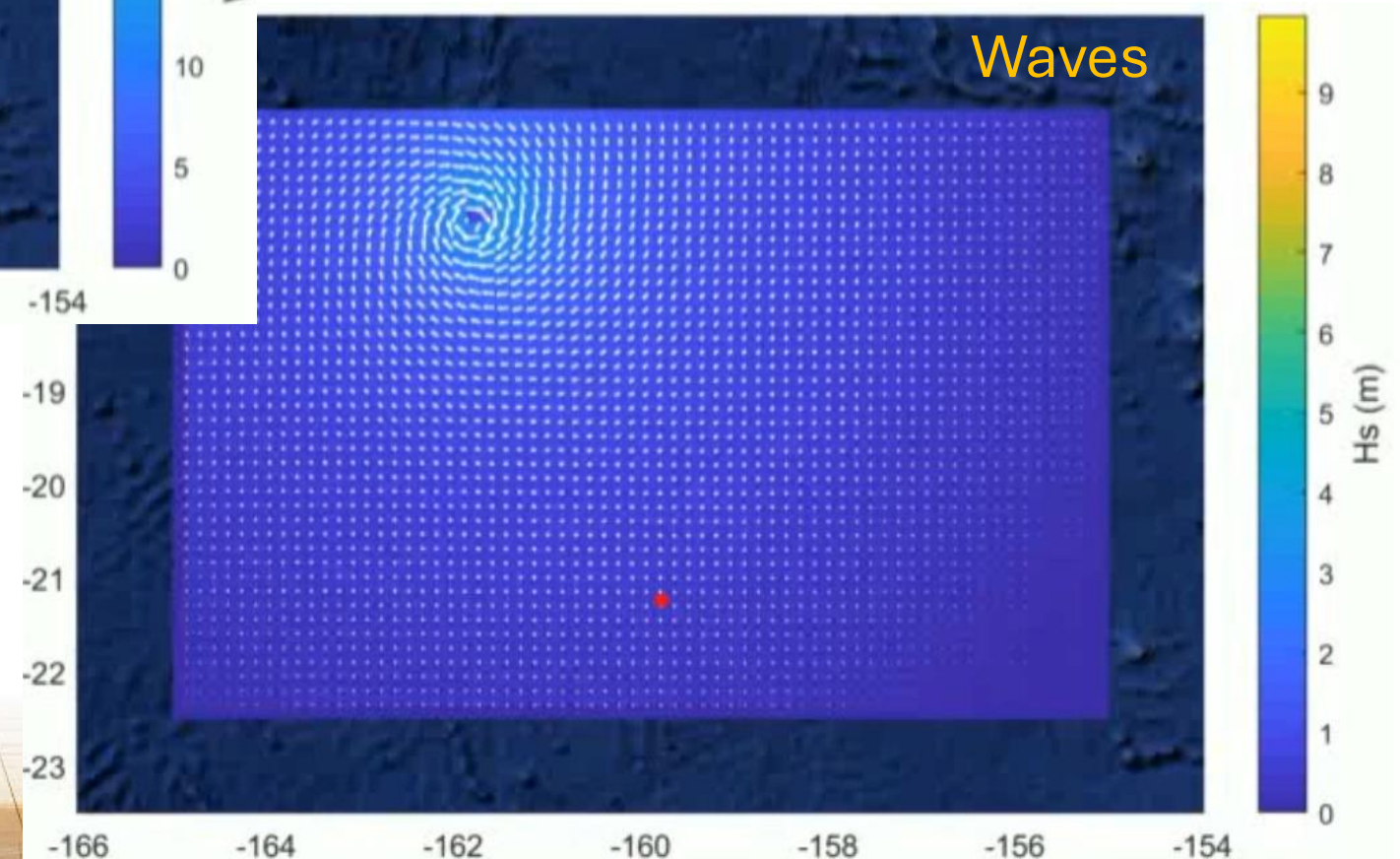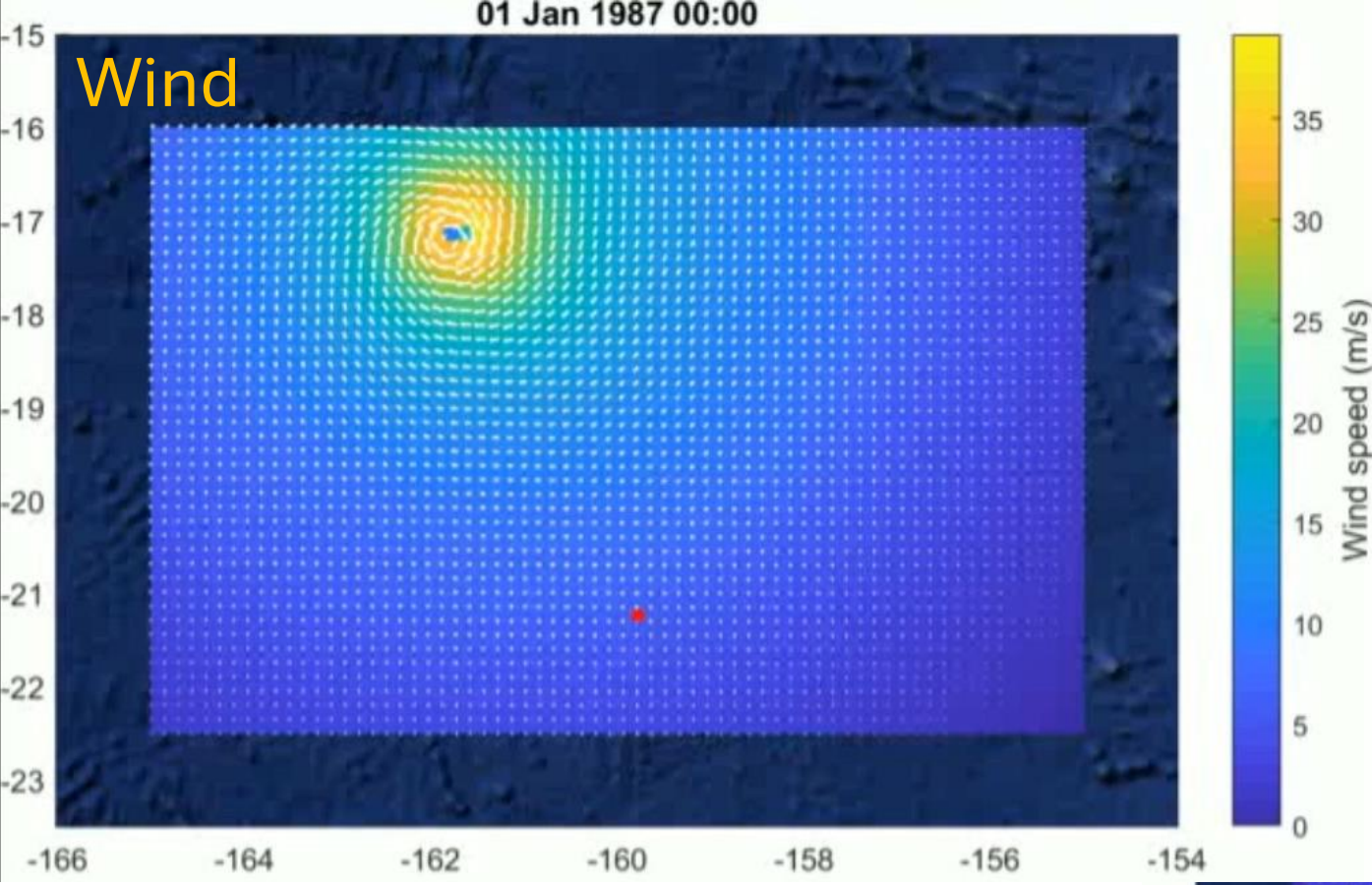
Cyclone Model Calibration

Calibrated against observed measured waves …

Measured Atmospheric Pressure

Climate Change

- Likely more intense
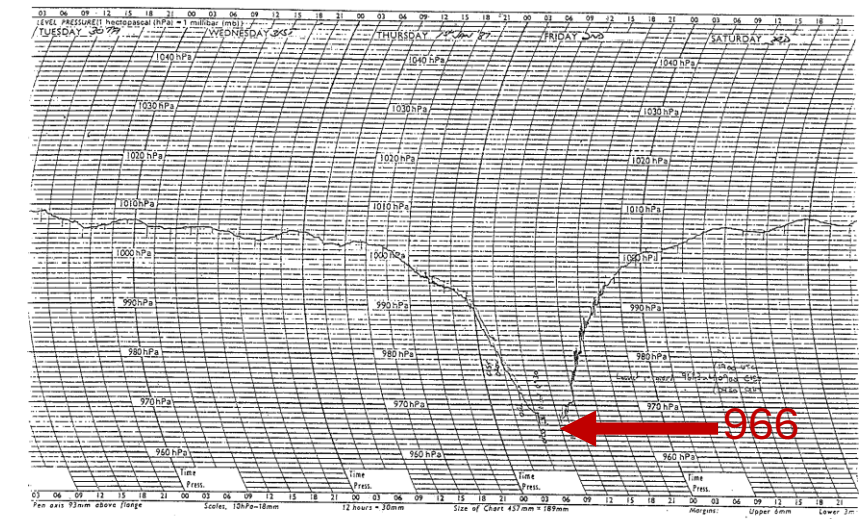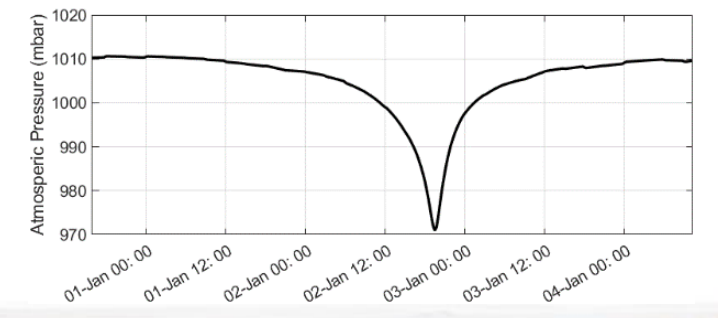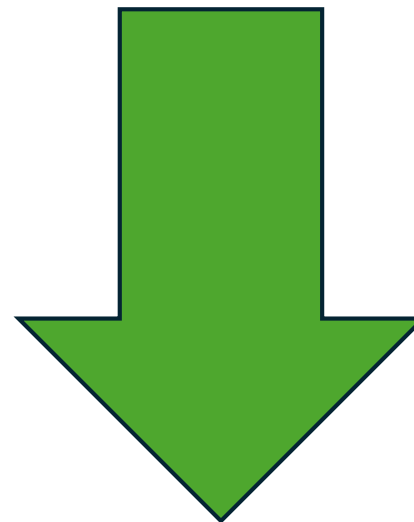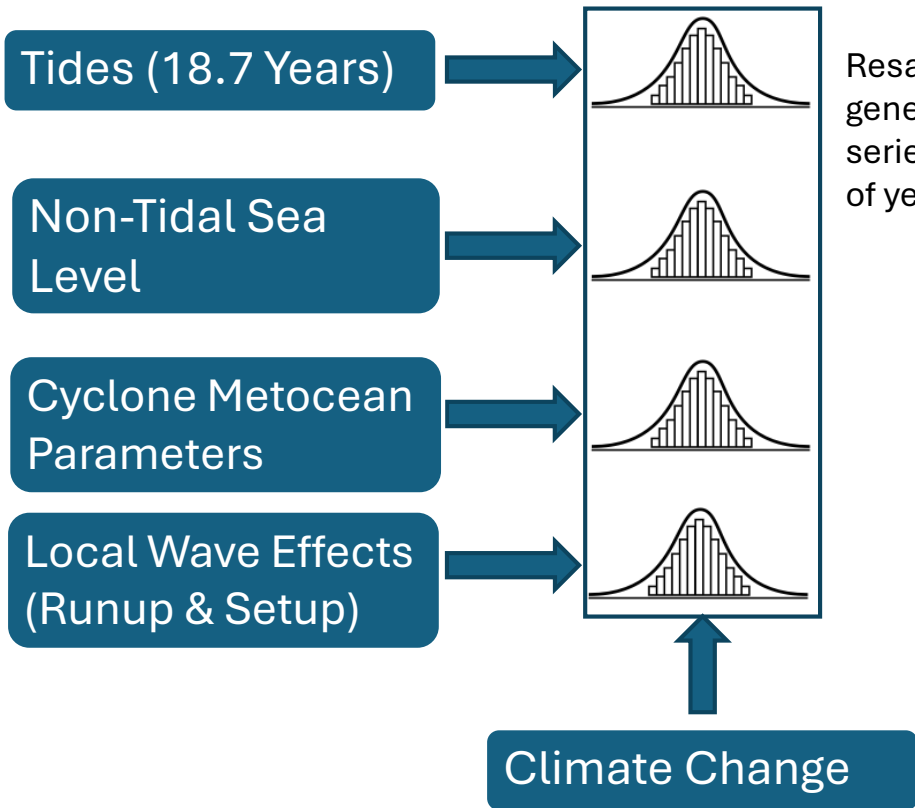- Stronger winds
- Lengthened season
- Increased range
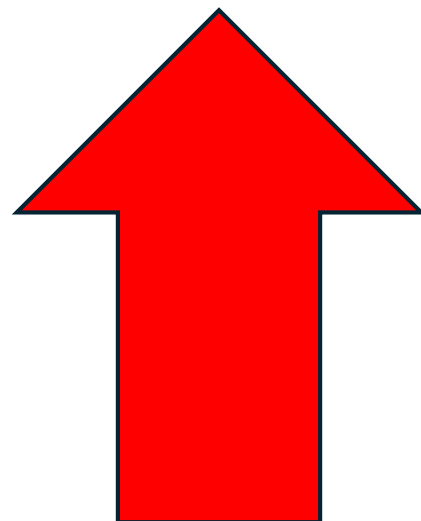
...but fewer of them.

Not yet a convincing method to accurately quantify the change in frequency and increased intensity in models.
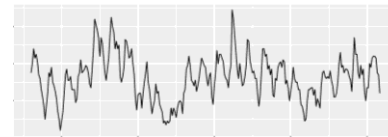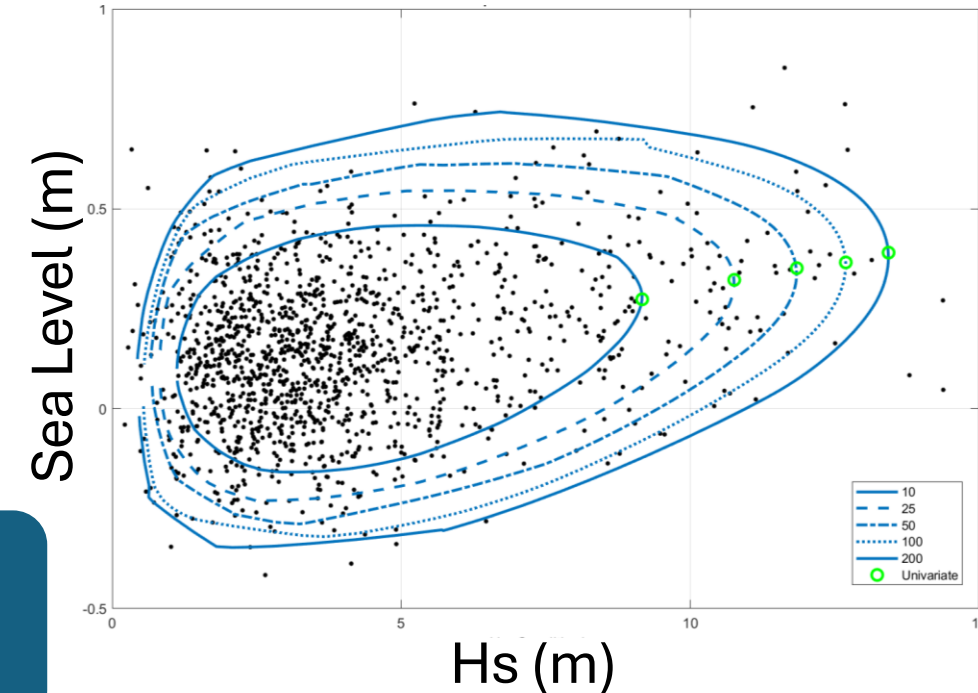
Combining processes: Monte Carlo

Create Distributions

Tides (18.7 Years)

Non-Tidal Sea Level

Cyclone Metocean Parameters

Local Wave Effects (Runup & Setup)

Climate Change

Resample to generate long time series (thousands of years).

Analyse and Create Extreme Conditions for Coastal Inundation Modelling

Sea Level (m)
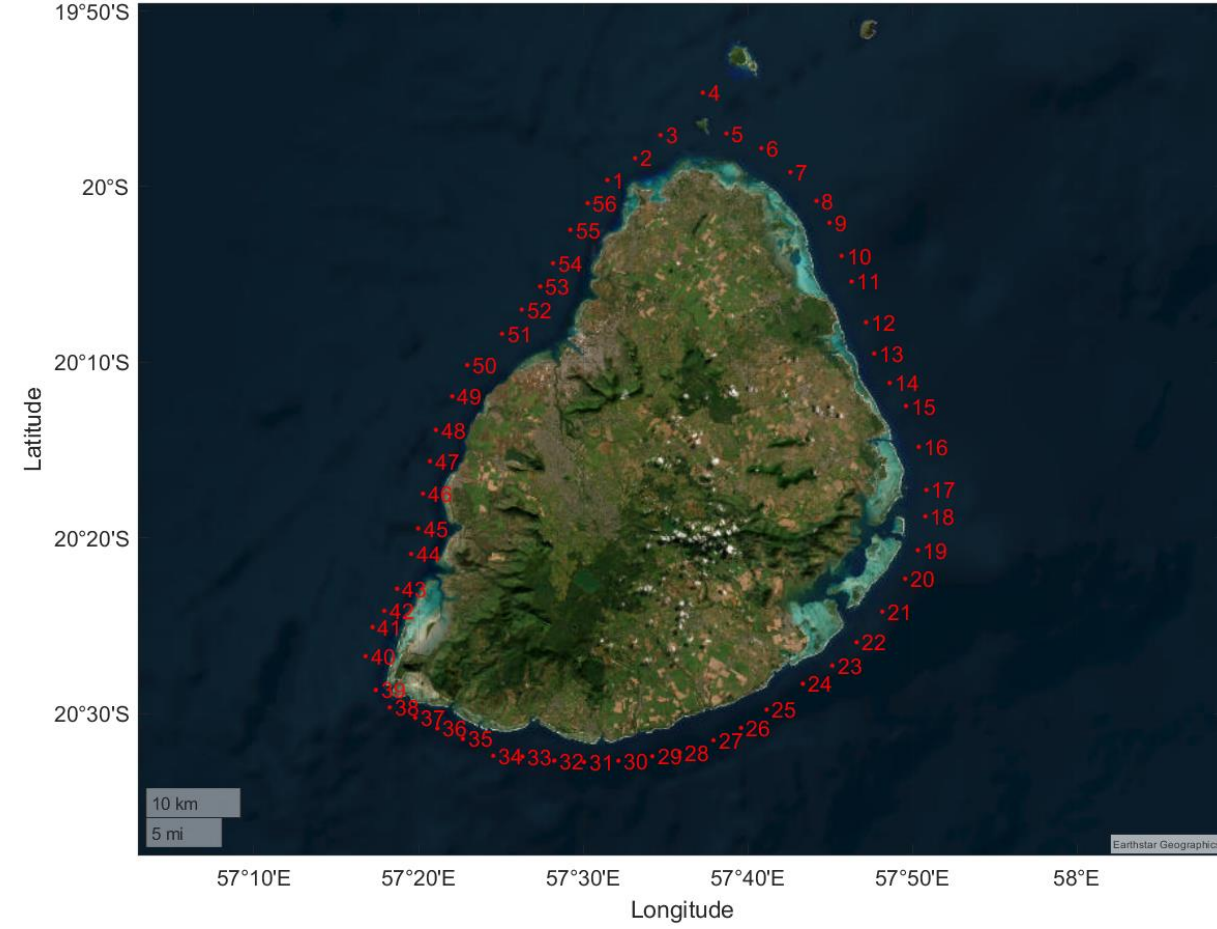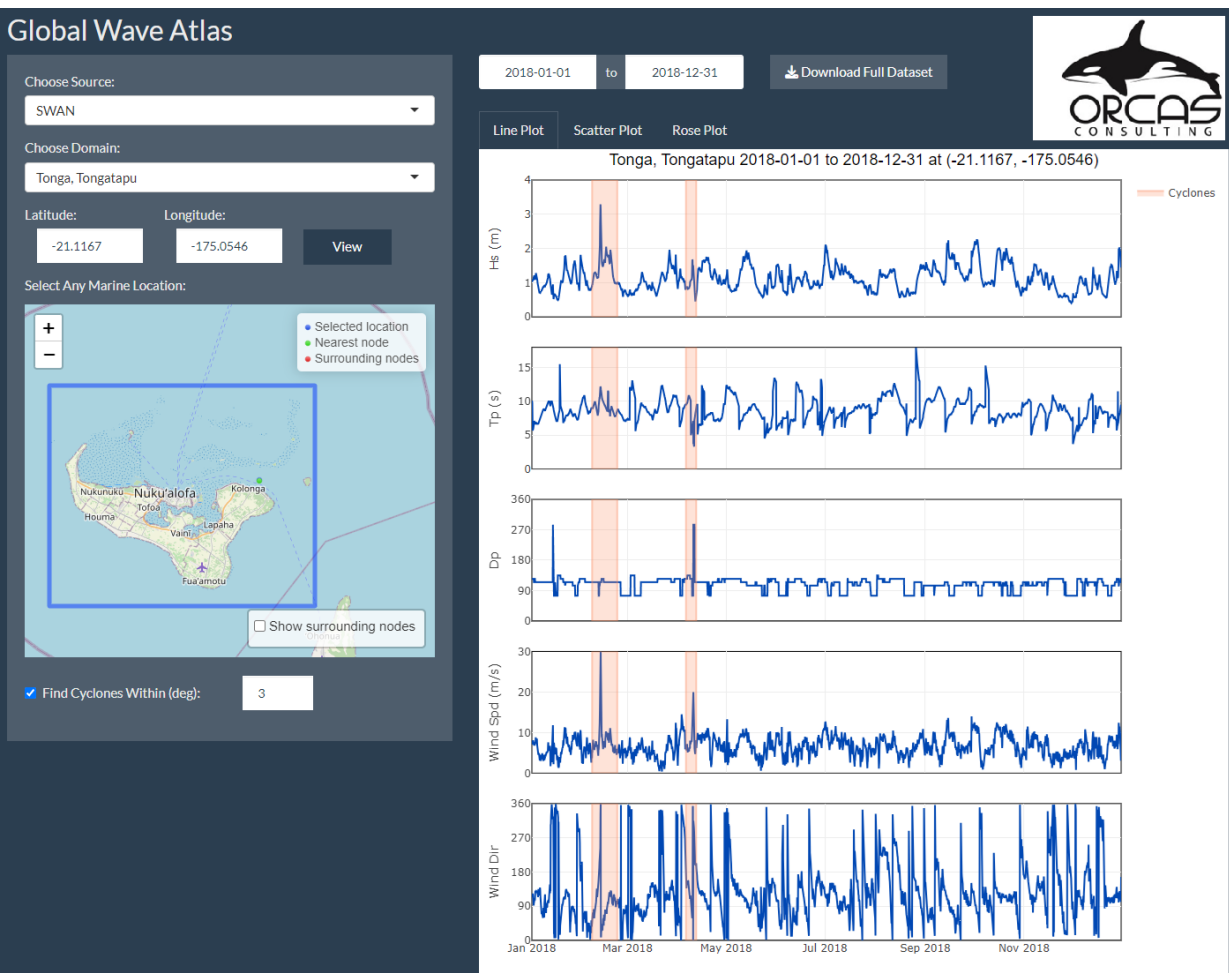
Hs (m)

10
25
50
100
200
Univariate

Nearshore modelling

- Used XBeach GPU
- Grid: 3m x 3m (1088 x 2720)
- Calibrated against observations
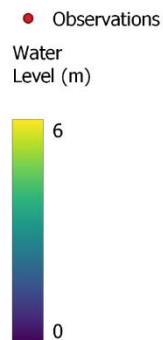
- Final product: countrywide cyclone models.
- Integrated into our Metocean data interface.

- Once run, it does not need to be run again.
- Developing these products for each country that we work in.

Questions