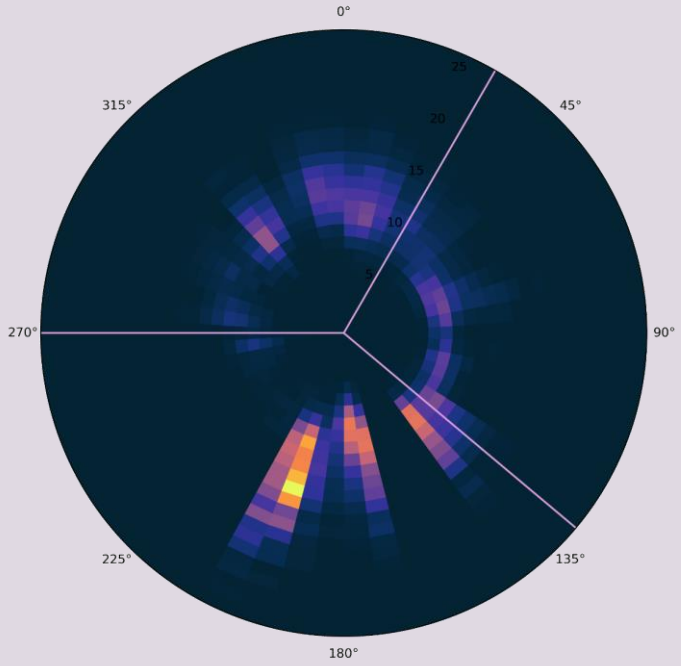
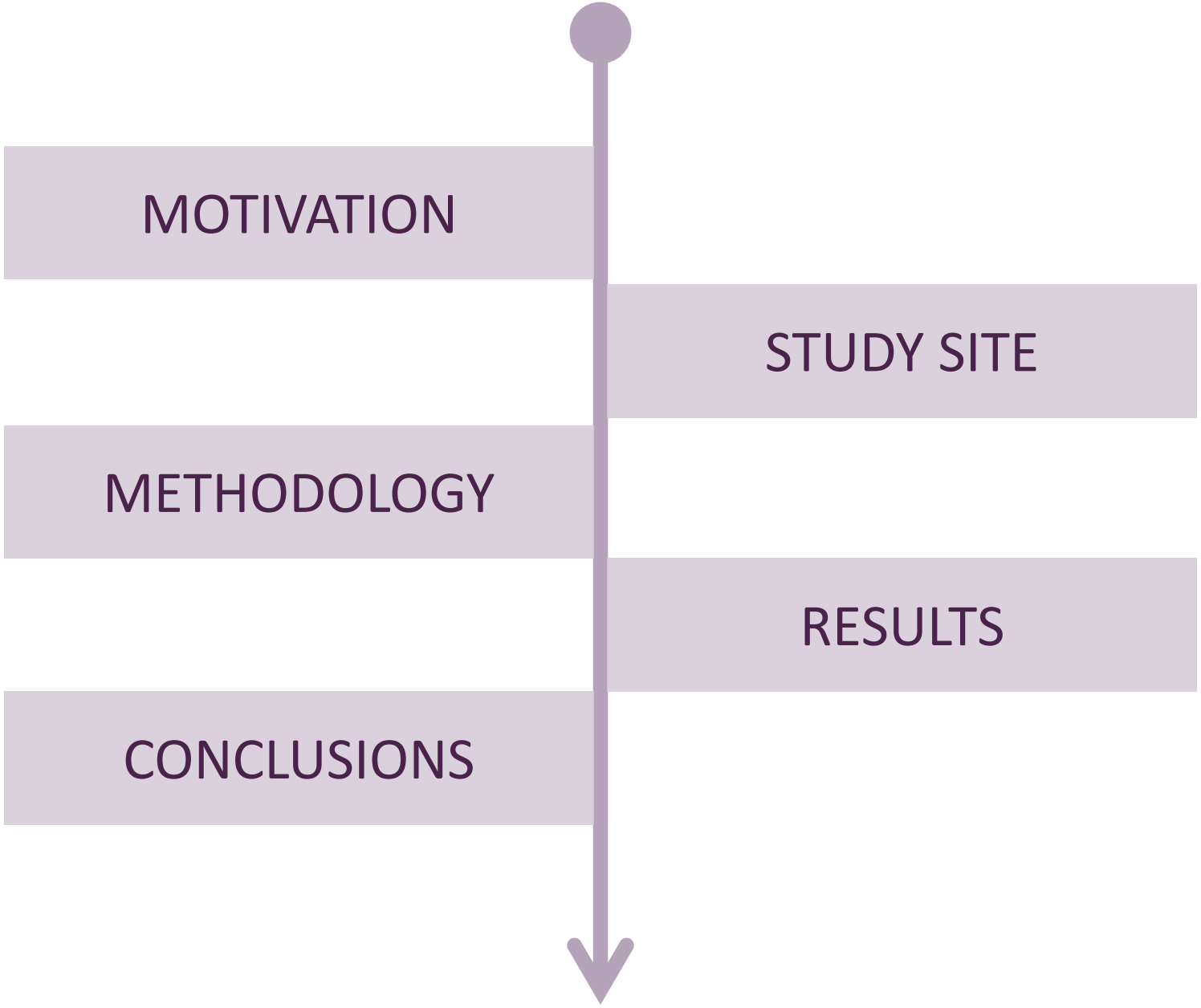
On the use of directional wave spectra to identify distant swells approaching a Pacific atoll



Laura Cagigal [a, b], Ana Rueda [b], Alba Ricondo [b], Giovanni Coco [a], Fernando Méndez [b]

[a.] University of Auckland, [b.] Universidad de Cantabria


MOTIVATION
STUDY SITE
METHODOLOGY
RESULTS
CONCLUSIONS

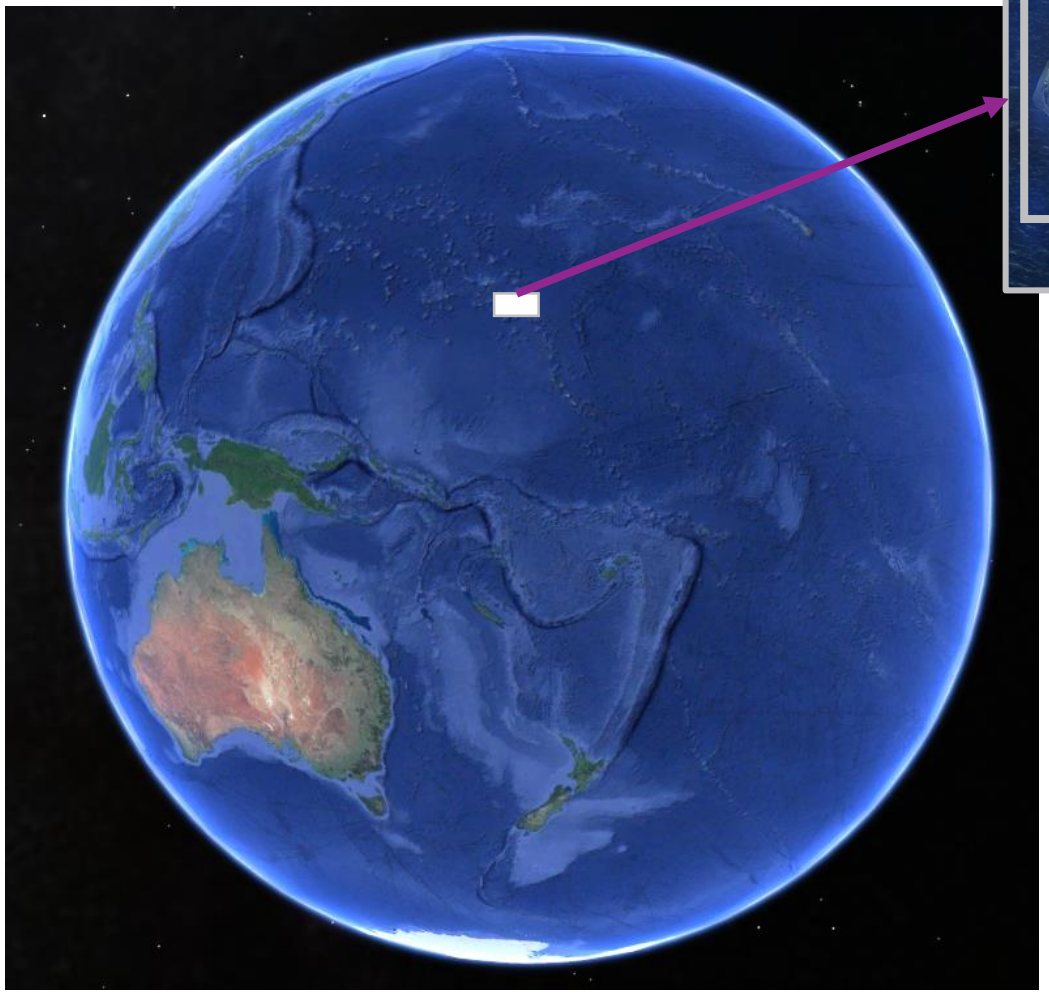
MOTIVATION: Inundation in the Pacific Islands

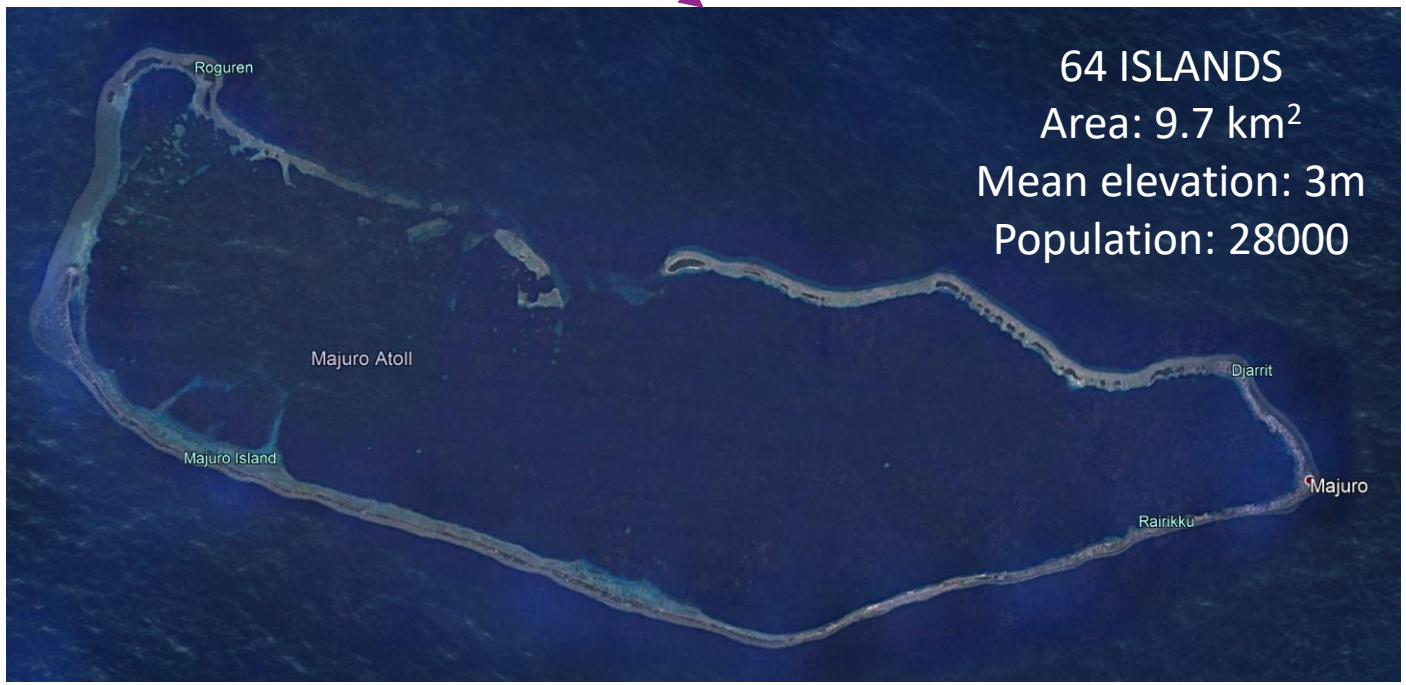
Source: Hoeke et al 2013

Atoll Islands are low-lying, with much of the land area < 3 m above mean sea level

Atoll Islands are vulnerable to a range of inundation hazards generated by atmospheric and oceanographic processes, including **typhoons and tropical storms** and **far-field generated swell**

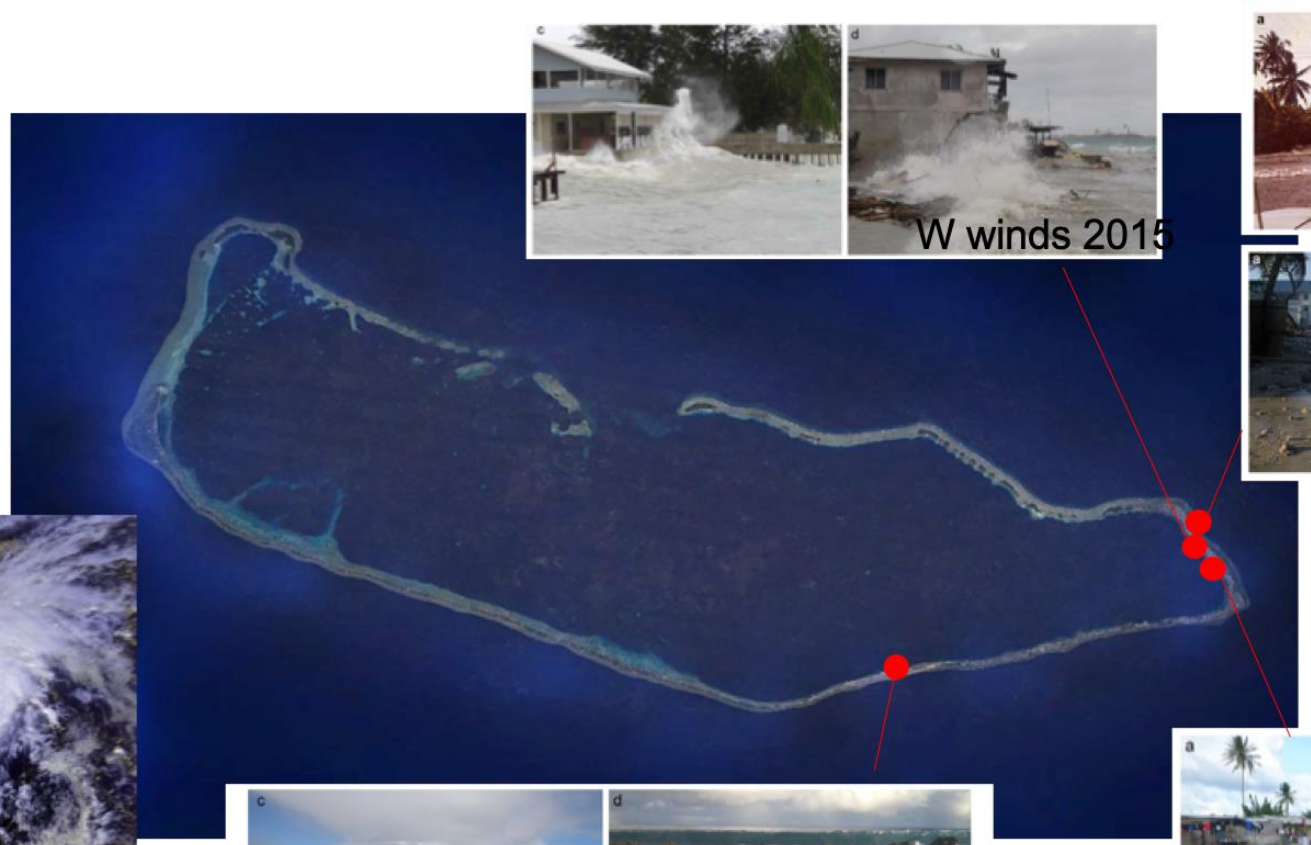
MAJURO ATOLL: Marshall Islands





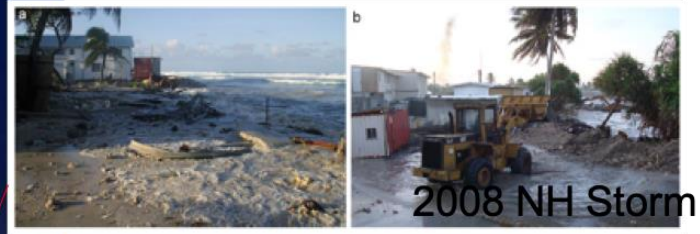
64 ISLANDS
Area: 9.7 km^2
Mean elevation: 3m
Population: 28000

FLOODING EVENTS

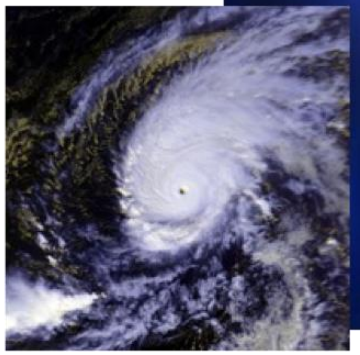


W winds 2015

1979 NH Storm



2008 NH Storm



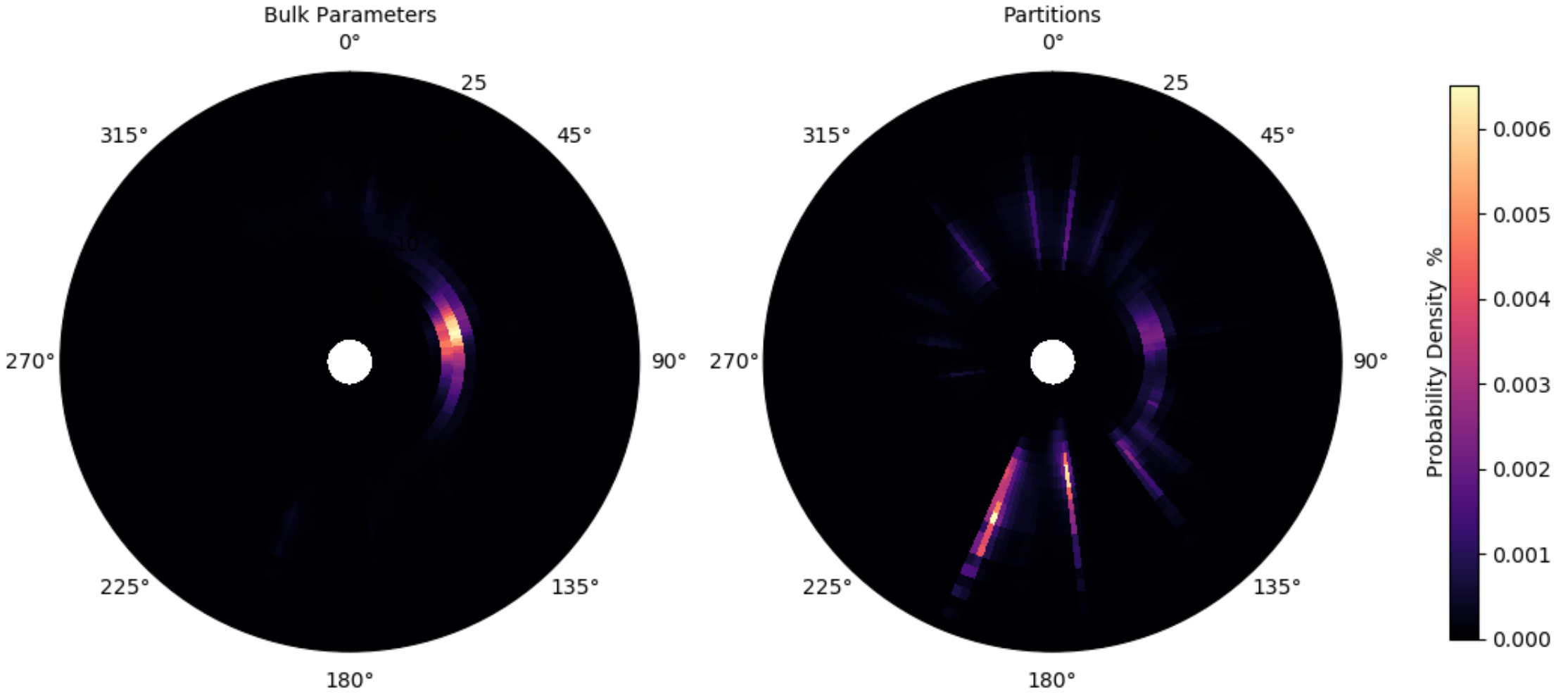
Super Typhon Paka 1997

2013 SH Storm

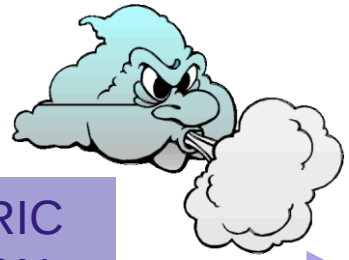
2011 La Niña

source: Ford et al. 2018 (Nat.H)

IMPORTANCE DIRECTIONAL SPECTRUM



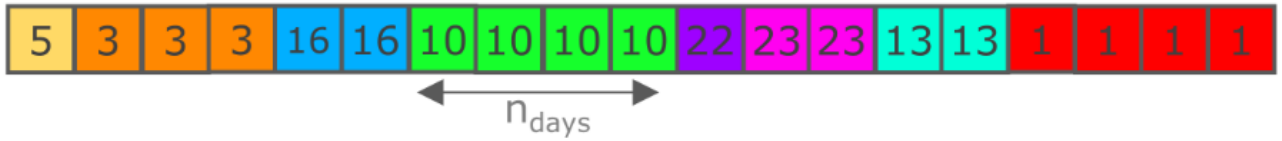
MOTIVATION: Probabilistic assessment of coastal flooding

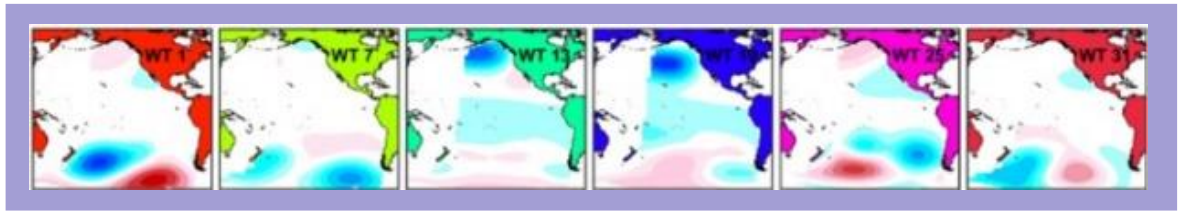


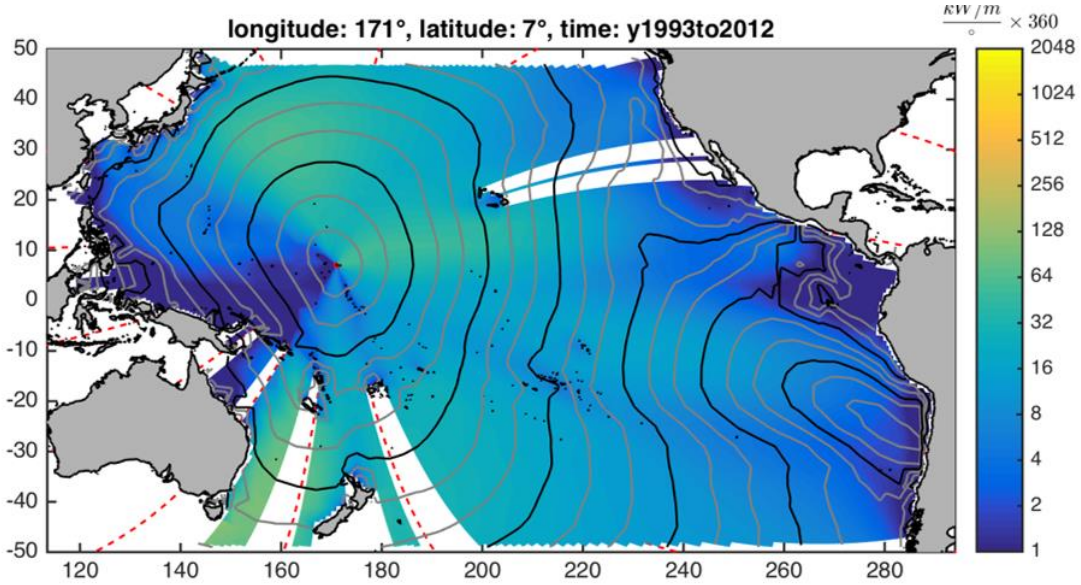
ATMOSPHERIC CIRCULATION (SLP)

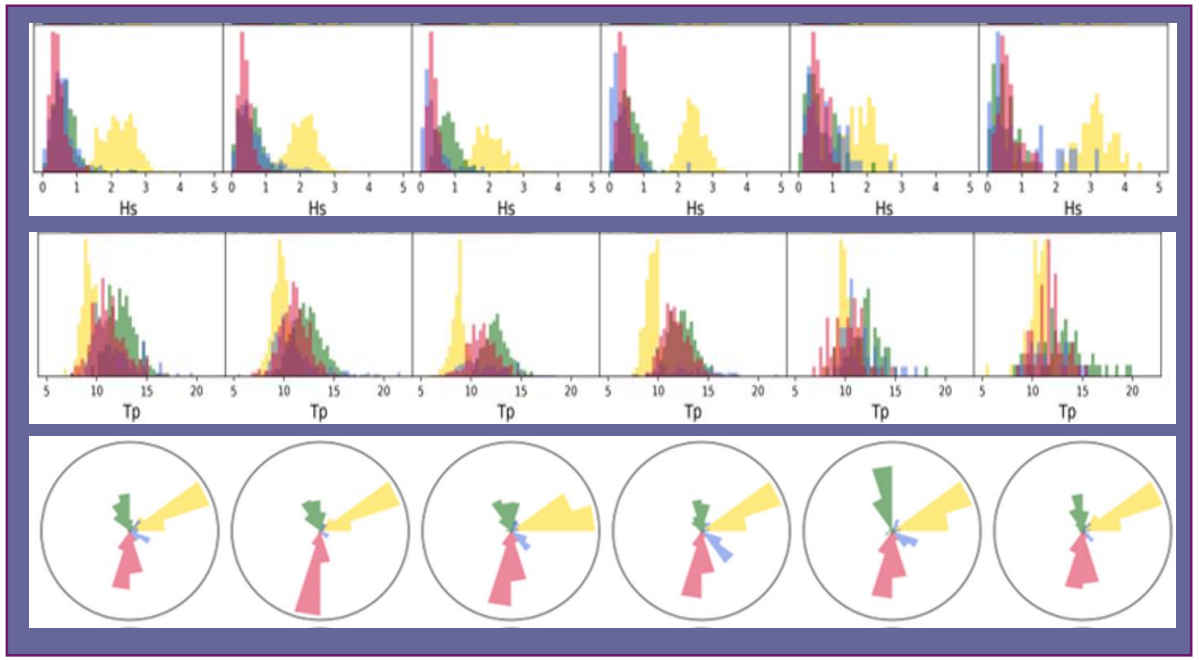
MULTIVARIATE WAVE CLIMATE

(H, T, Dir)

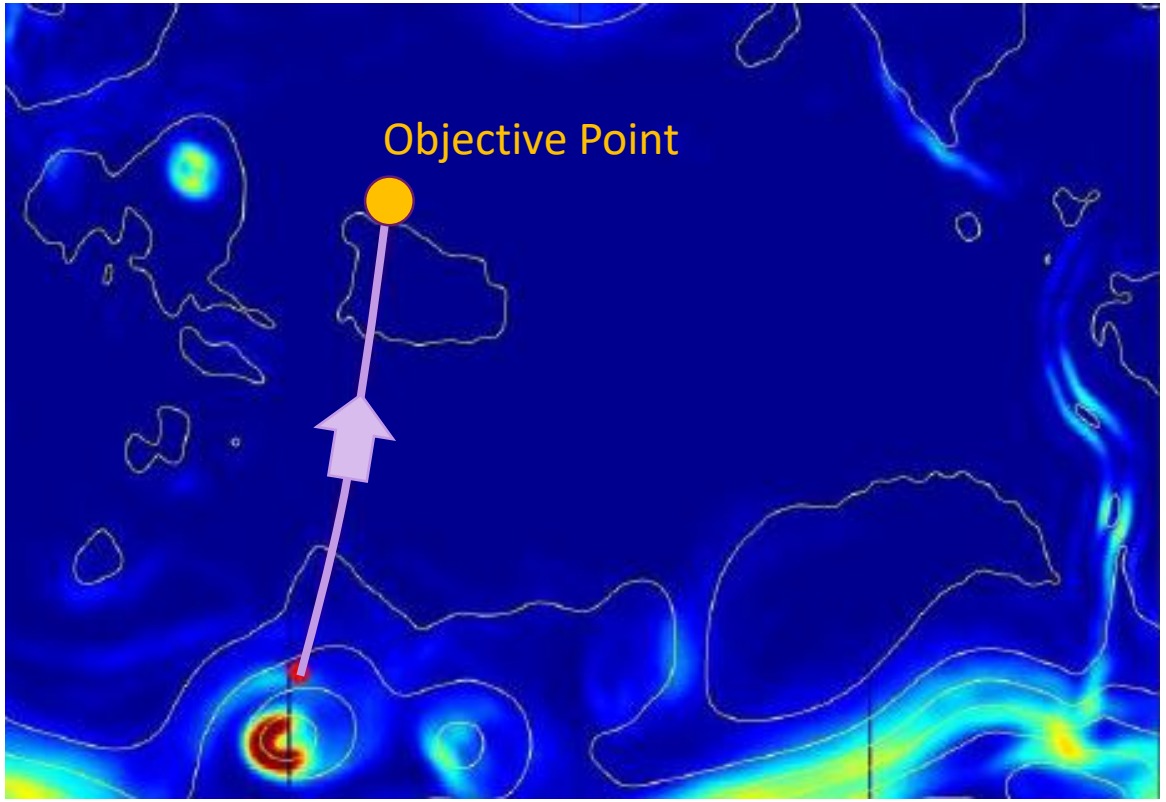


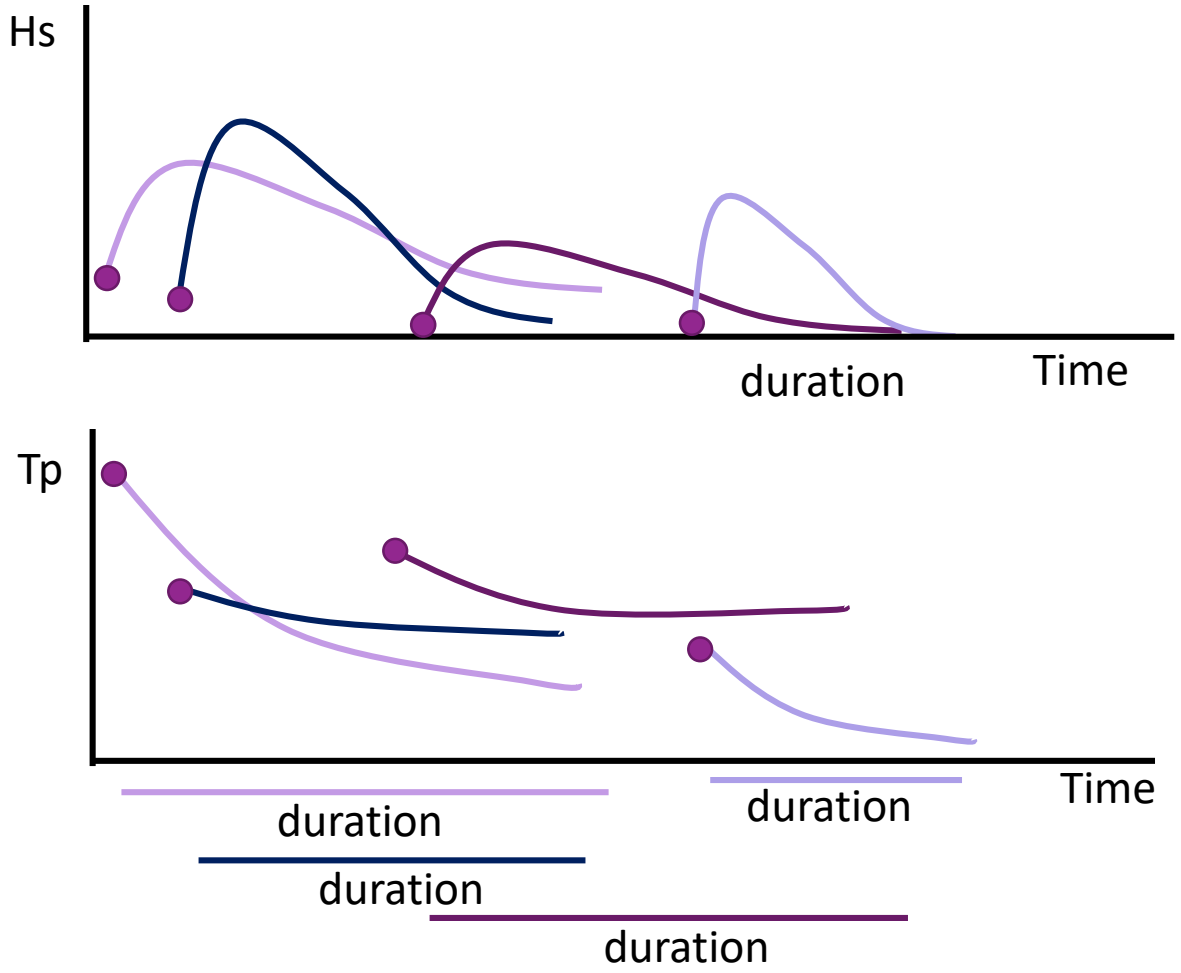




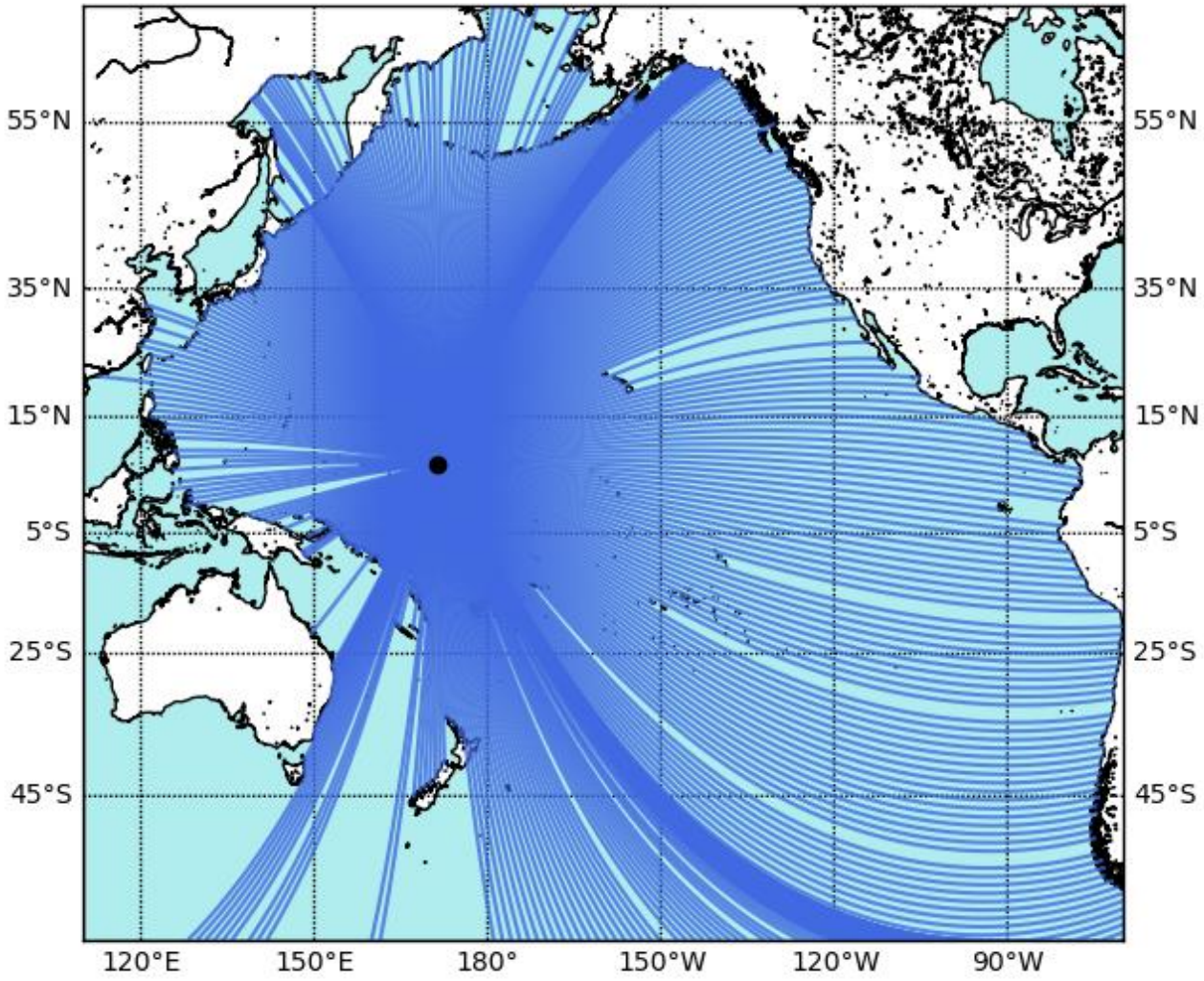


OBJECTIVE


Objective Point

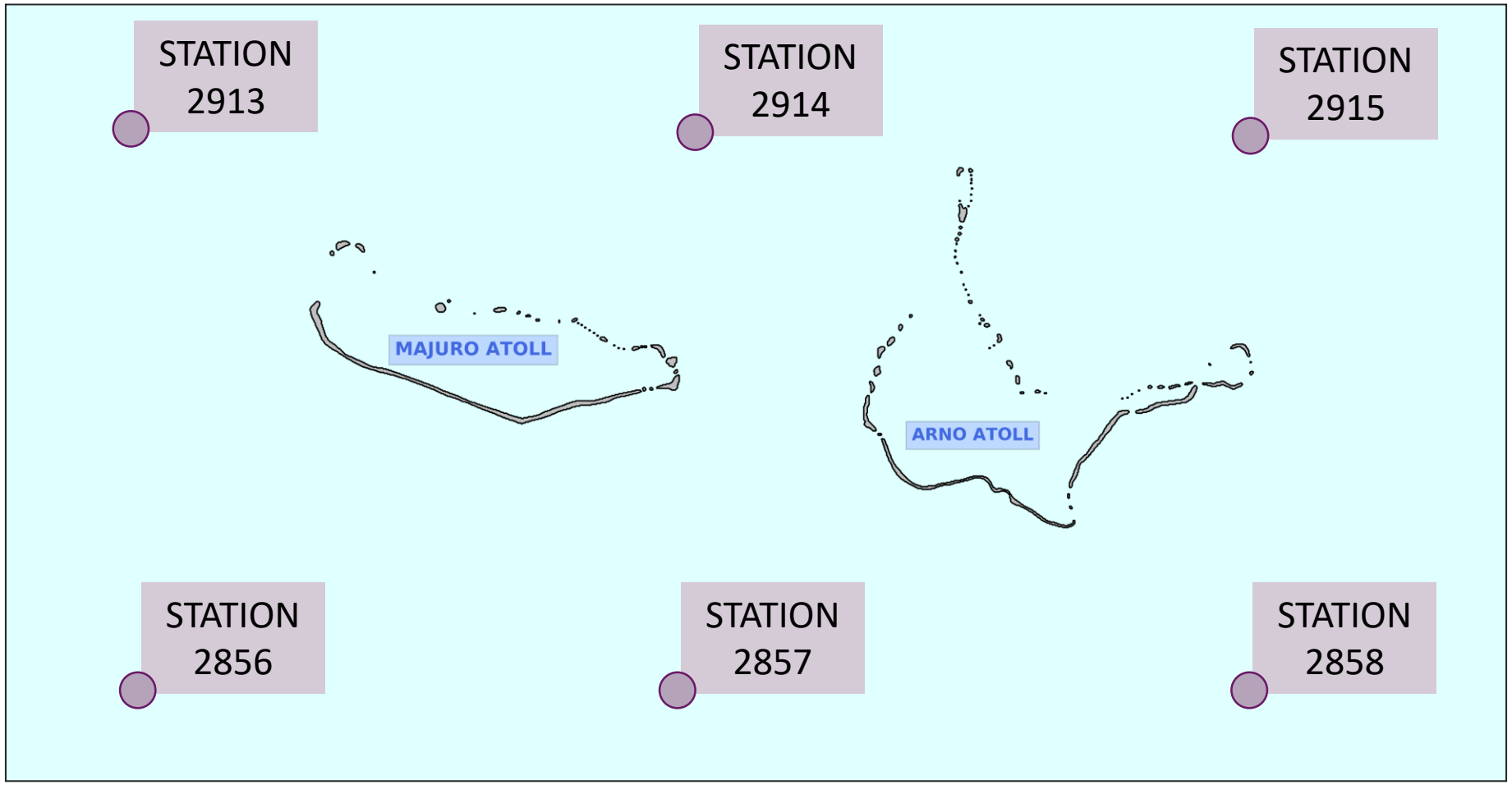

Hs
duration
Time
Tp
Time
duration
duration
duration
duration

STEPS

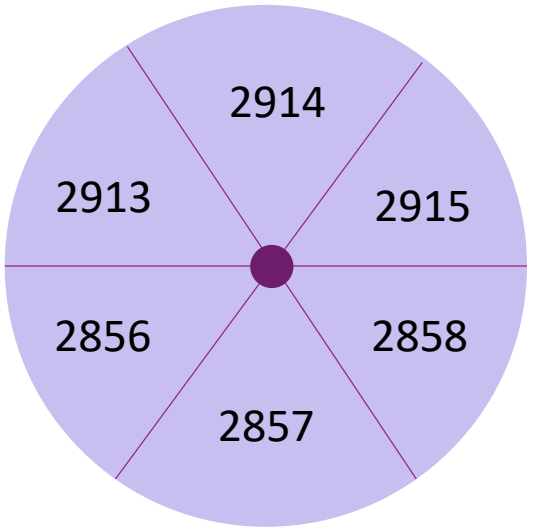


1. **CREATE A SUPER SPECTRA WITH ALL THE ENERGY APPROACHING THE ATOLL**
2. **OBTAIN THE SPECTRAL PARTITINONS**
3. **DEVELOP AN ALGORITHM TO AGREGATE SWELLS**
4. **PARAMETERIZE SWELLS**
5. **LINK SWELLS WITH WEATHER CONDITIONS**

1) SUPER-POINT

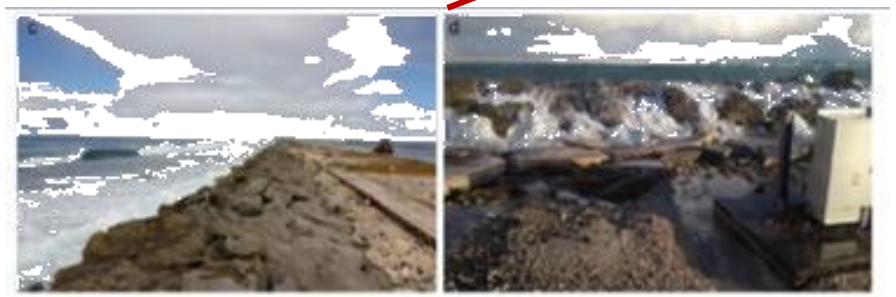


CSIRO – SPECTRAL INFORMATION



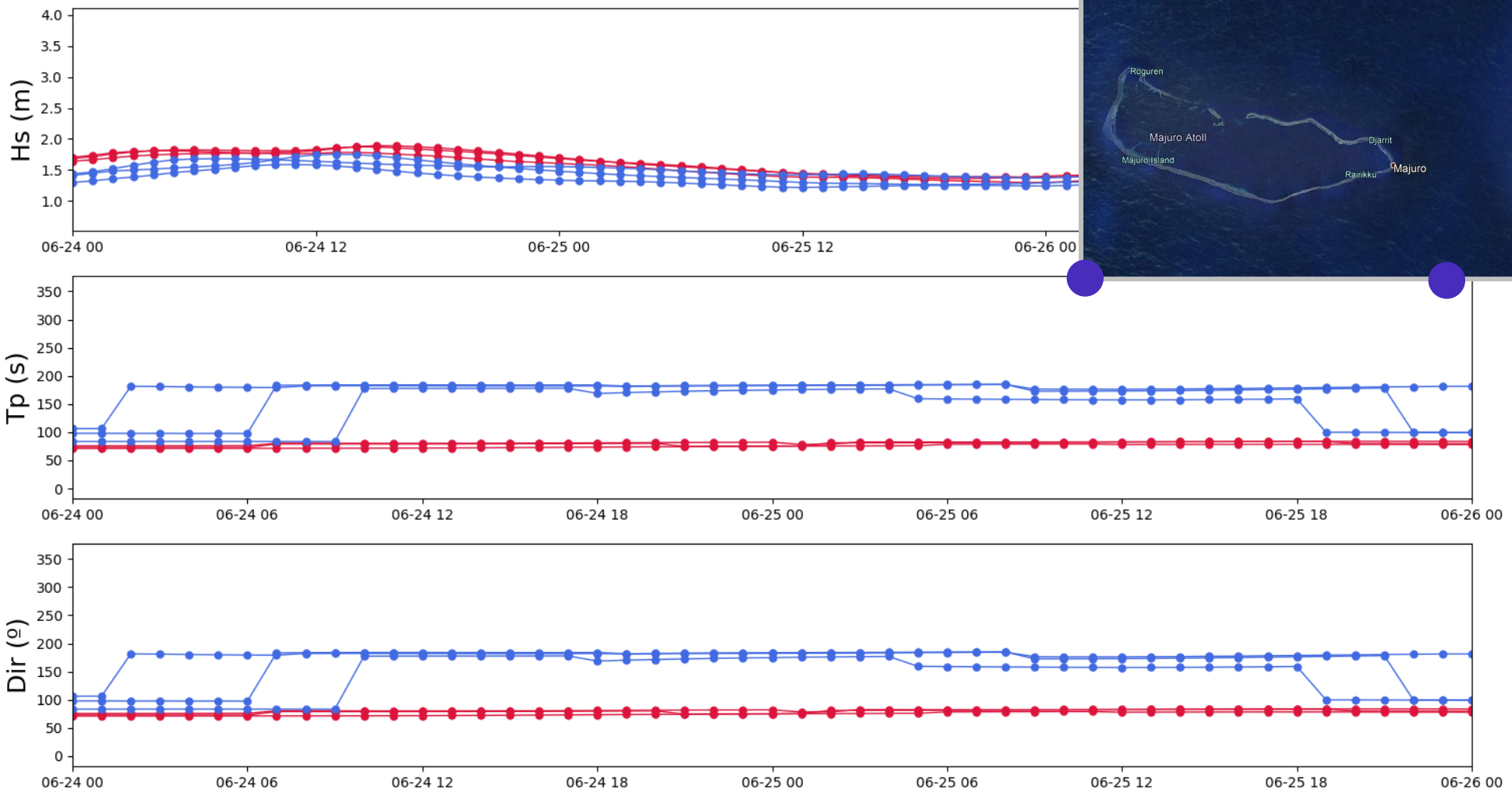
IMPORTANCE DIRECTIONAL SPECTRUM

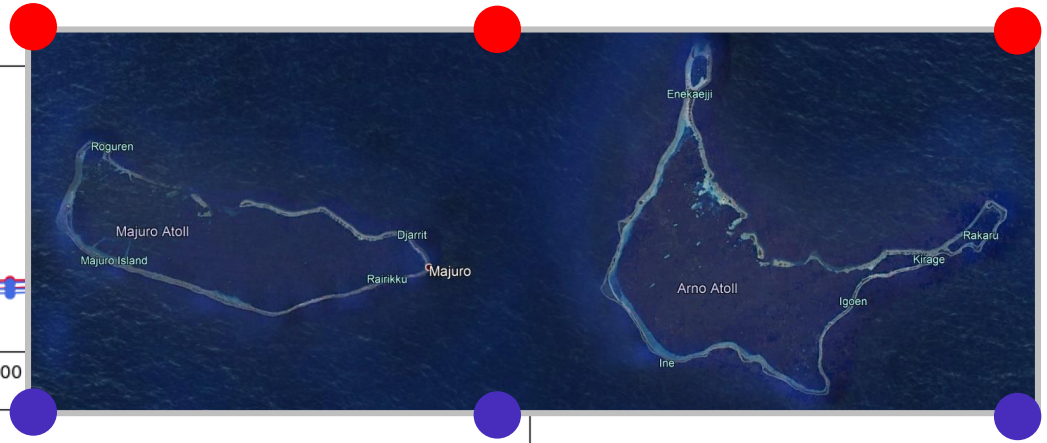
26 June 2013



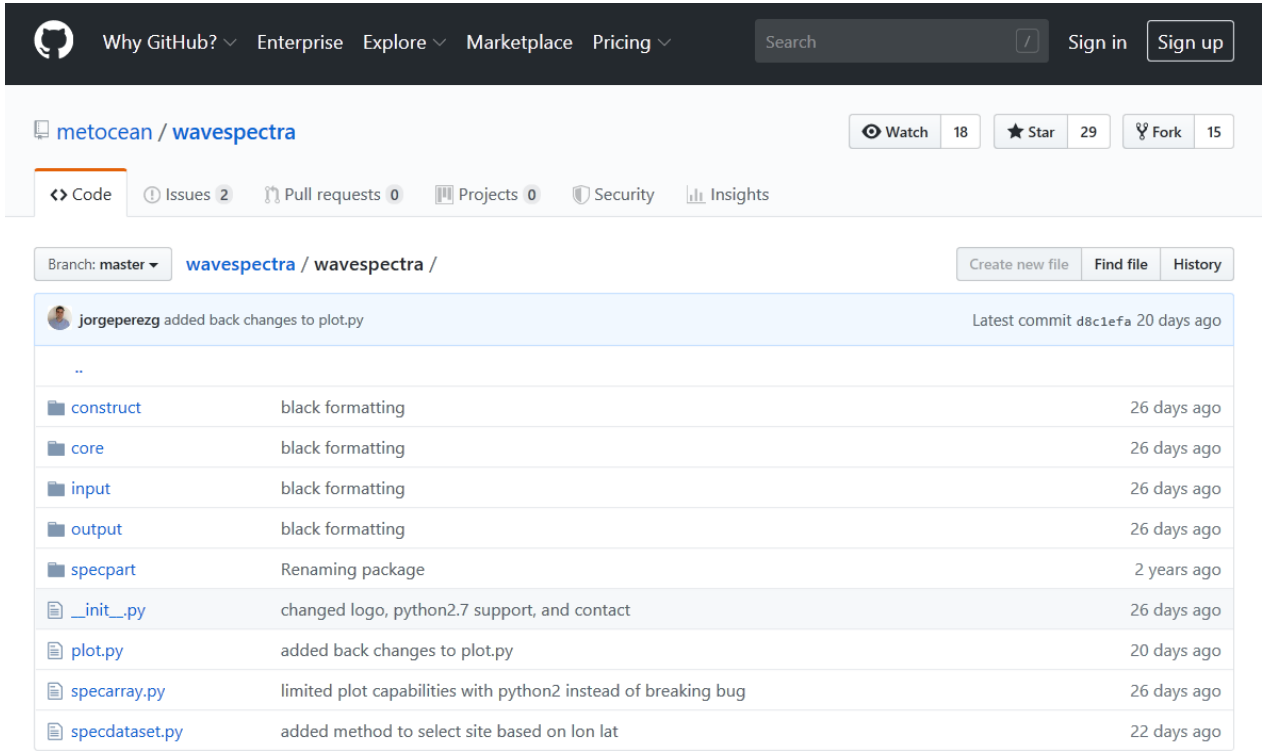
2013 SH Storn

IMPORTANCE SUPER POINT





2) SPECTRAL PARTITIONING

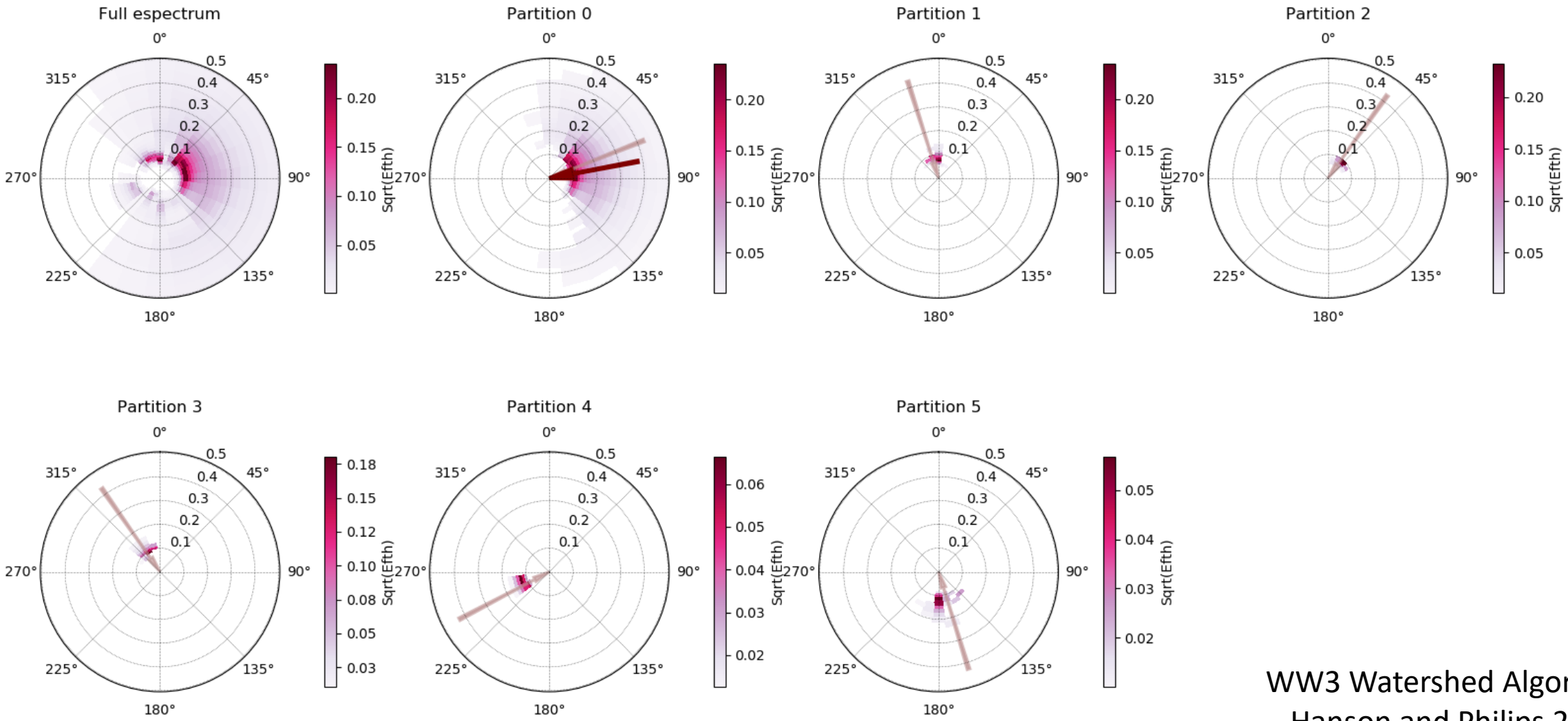


https://github.com/metocean/wavespectra/

WAVESPECTRA

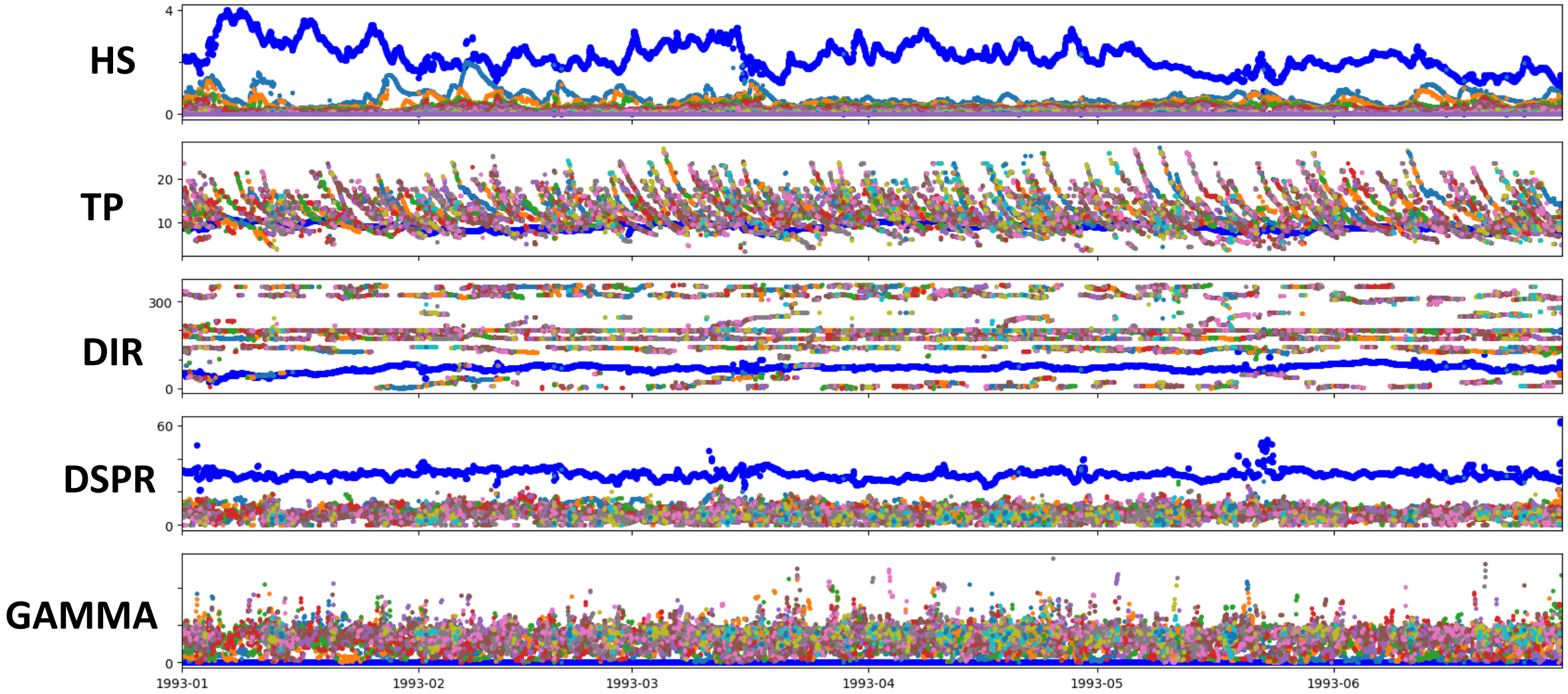
OPEN SOURCE LIBRARY FOR PROCESSING OCEAN WAVE SPECTRA ON PYTHON FROM METOCEAN SOLUTIONS (NZ)

2) SPECTRAL PARTITIONING

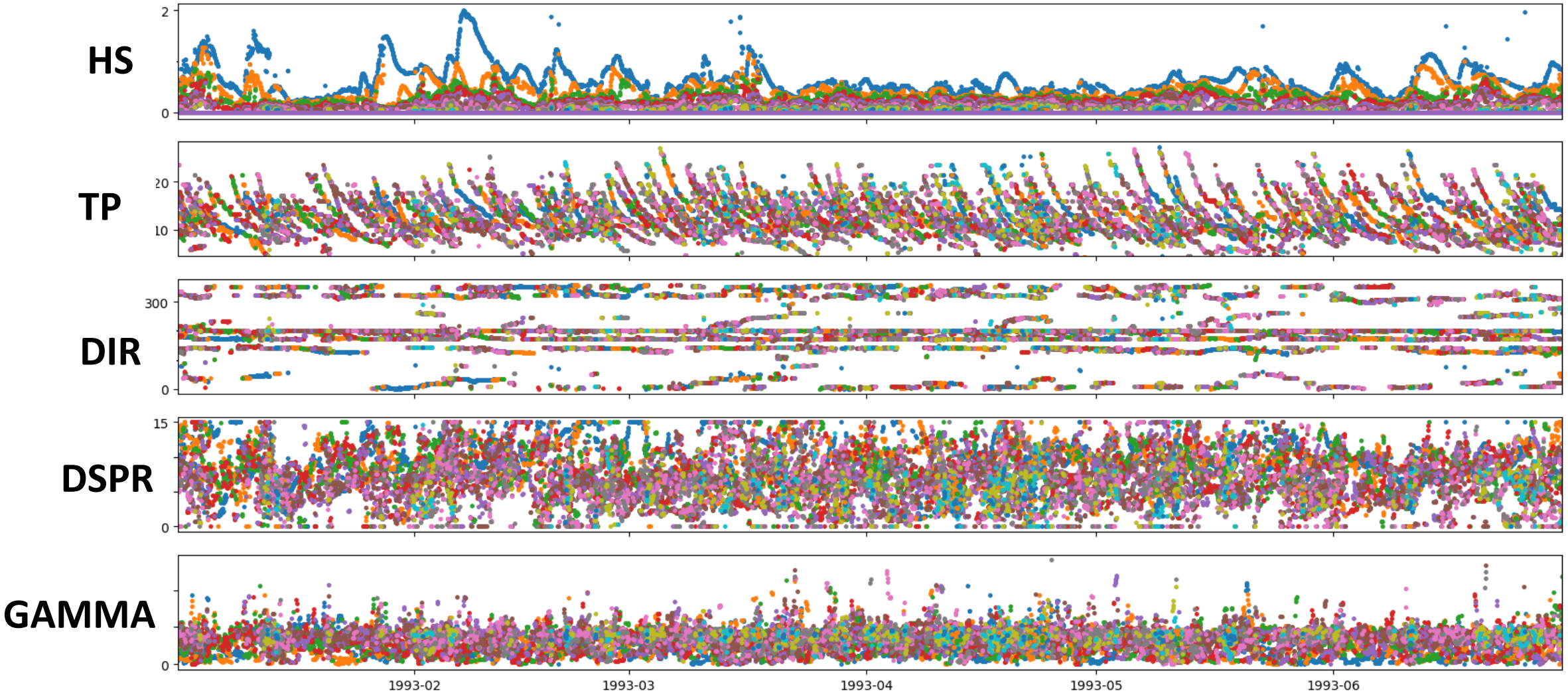


WW3 Watershed Algorithm,
Hanson and Philips 2009

2) SPECTRAL PARTITIONING: Sea + Swells



2) SPECTRAL PARTITIONING: Swells



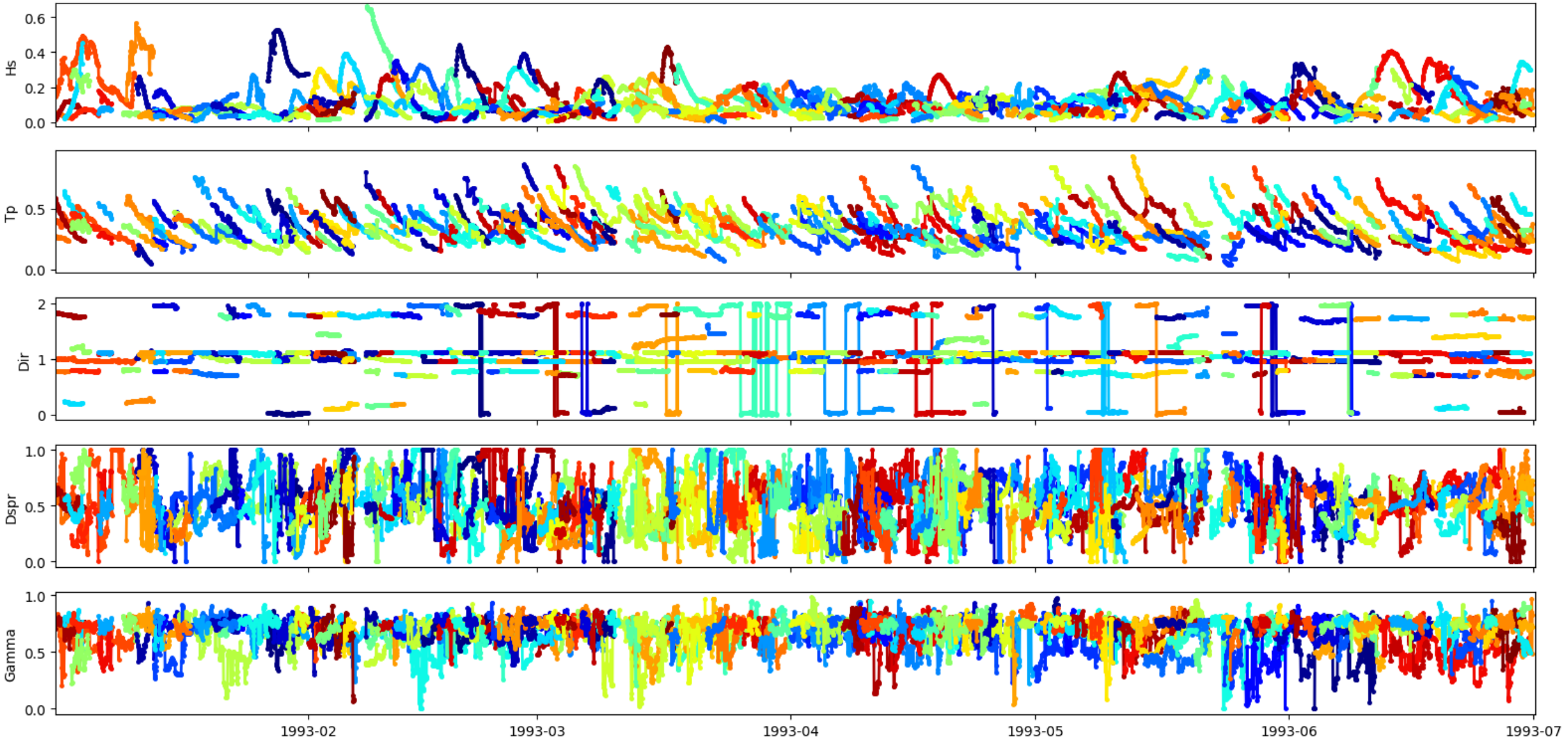
3) SWELL IDENTIFICATION

$\boldsymbol{Snakes\ search\ algorithm}$

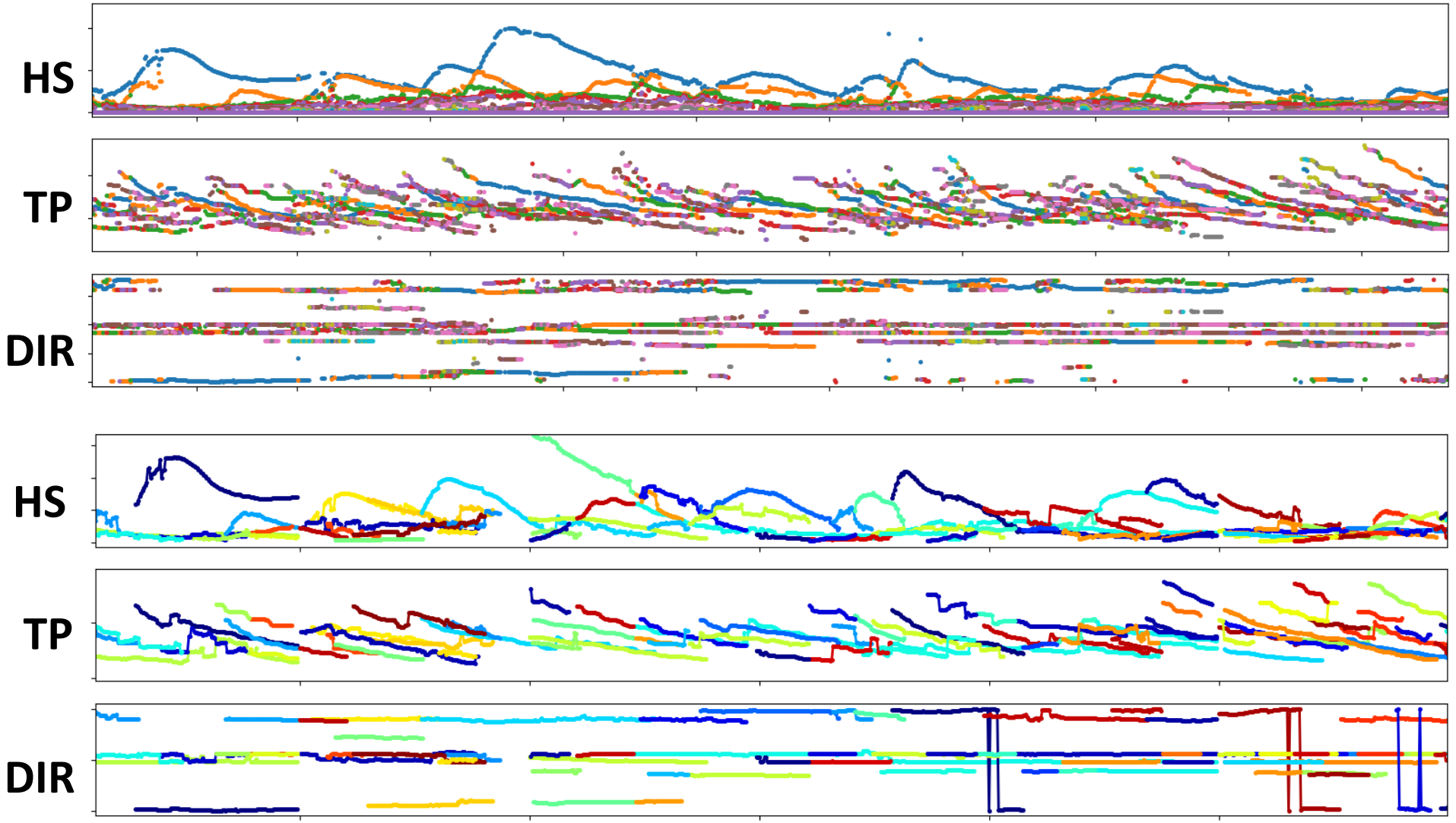
$$\boldsymbol{DISTANCE = f(\Delta Hs, \Delta Tp, \Delta Dir, \Delta Dspr, \Delta Gamma)}$$

$$\mathrm{D} = \sqrt{a * (H_t - H_{t-1})^2 + b * (Tp_t - Tp_{t-1})^2 + c * (Dir_t - Dir_{t-1})^2 + d * (\delta_t - \delta spr_{t-1})^2 + e * (\gamma_t - \gamma_{t-1})^2}$$

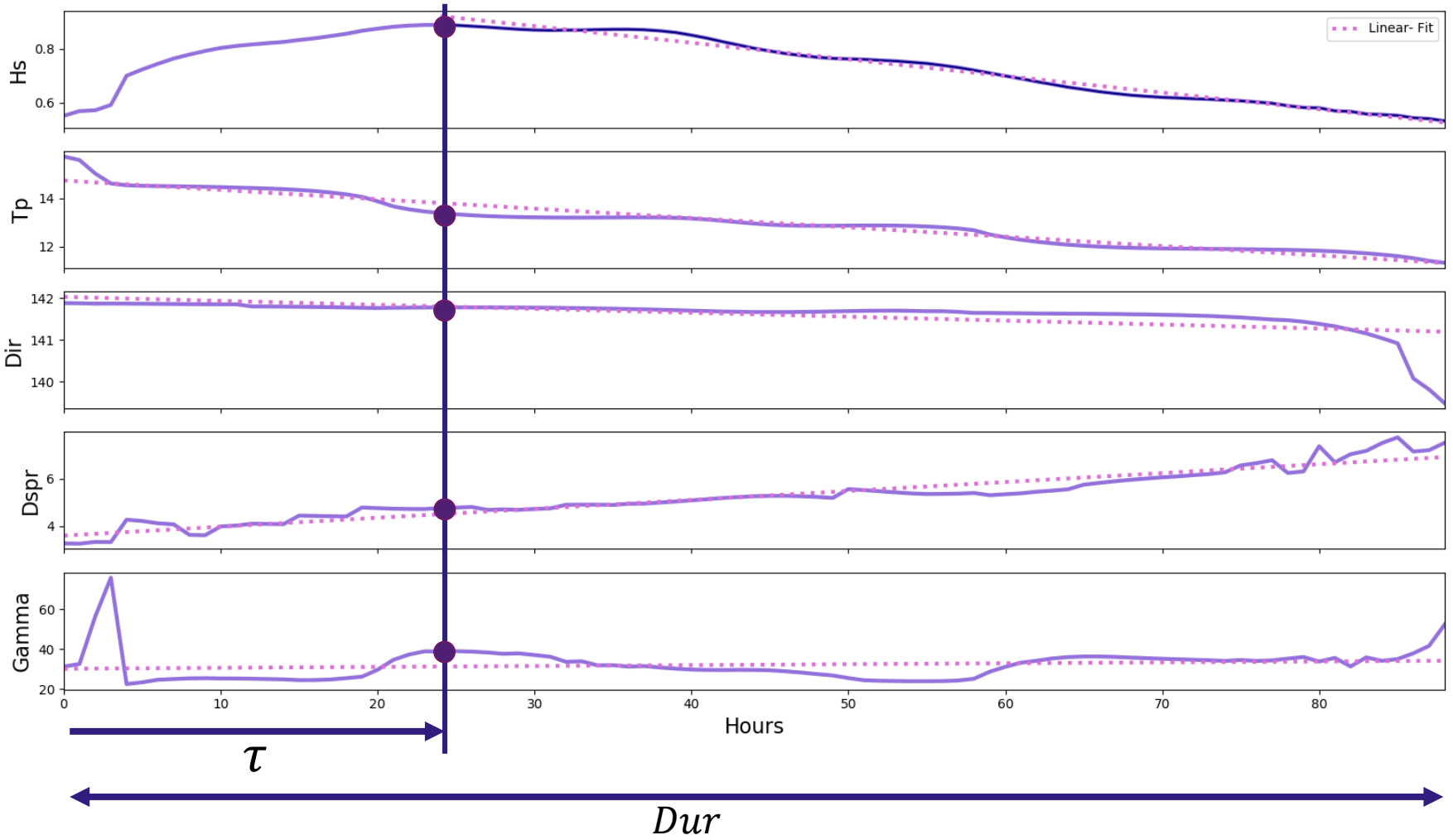
3) SNAKES


Hs
0.6
0.4
0.2
0.0
Tp
0.5
0.0
Dir
2
1
0
Dspr
1.0
0.5
0.0
Gamma
1.0
0.5
0.0
1993-02
1993-03
1993-04
1993-05
1993-06
1993-07

3) SNAKES



4) SNAKES PARAMETERIZATION



Parameters

Dur

τ

$H_s{}^*, s_{H_s}$

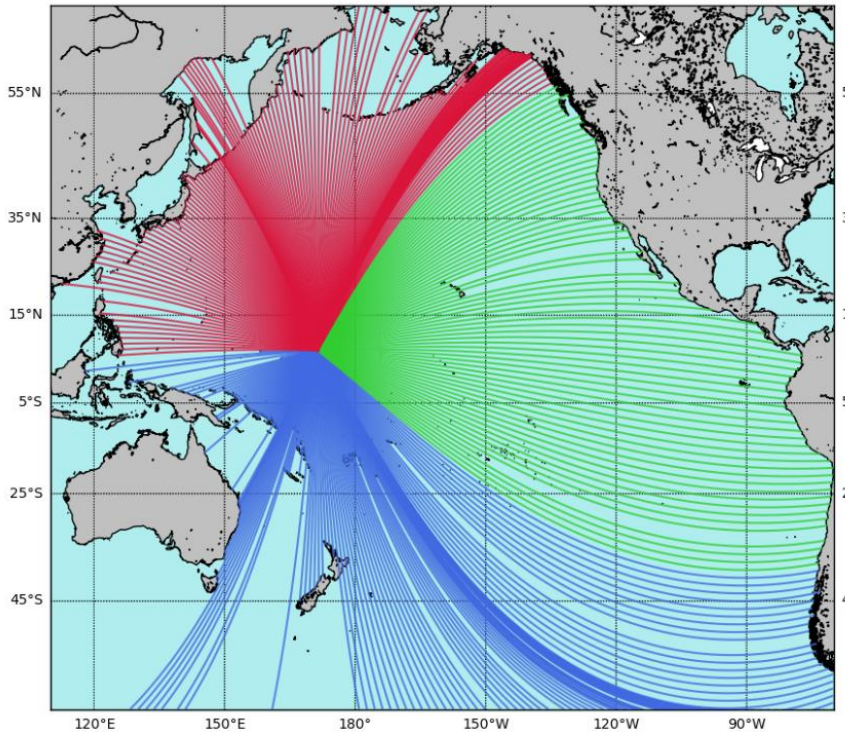
$T_p{}^*, s_{T_p}$

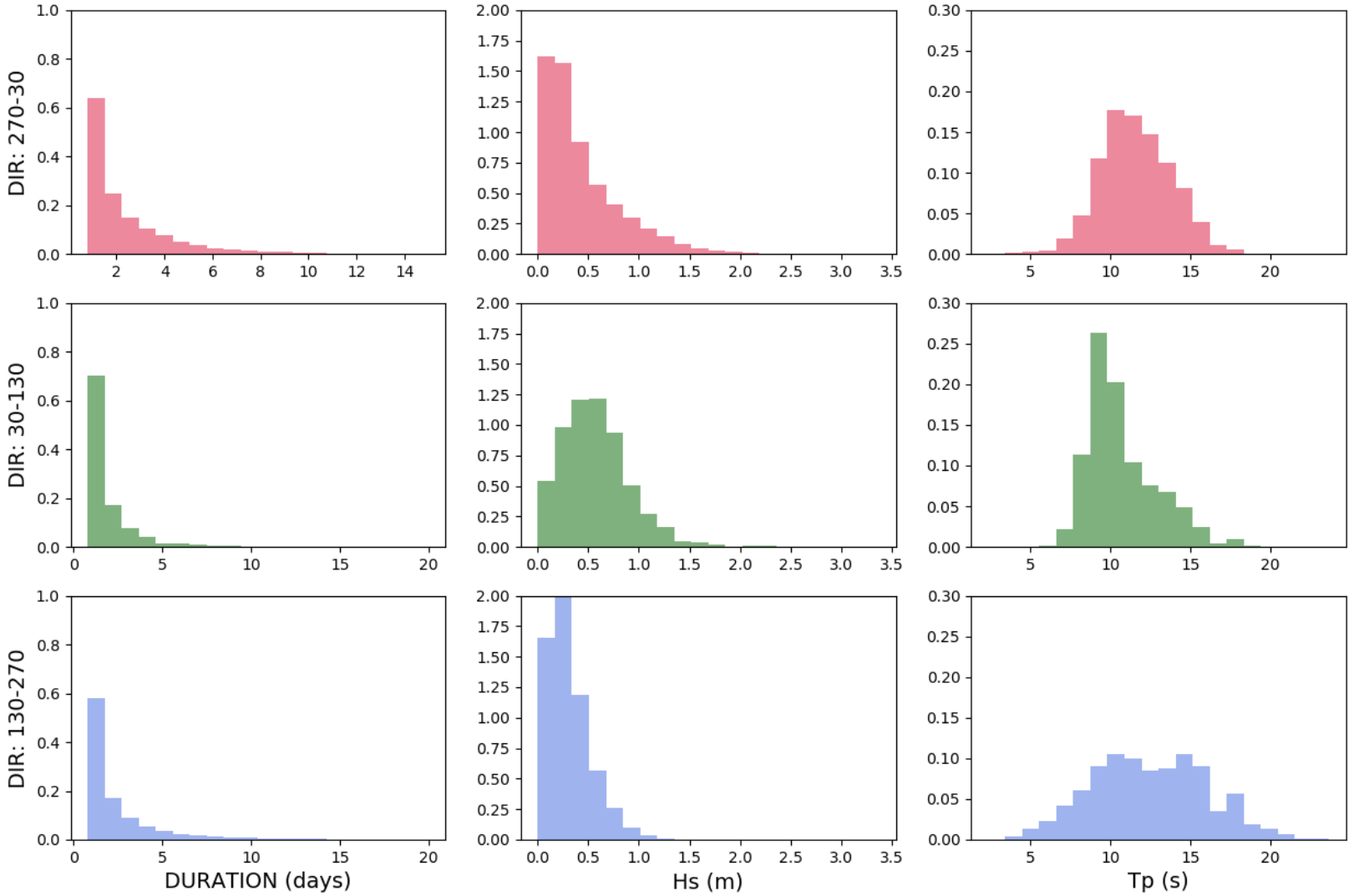
Dir^*, s_{Dir}

σ^*, s_σ

γ^*, s_γ

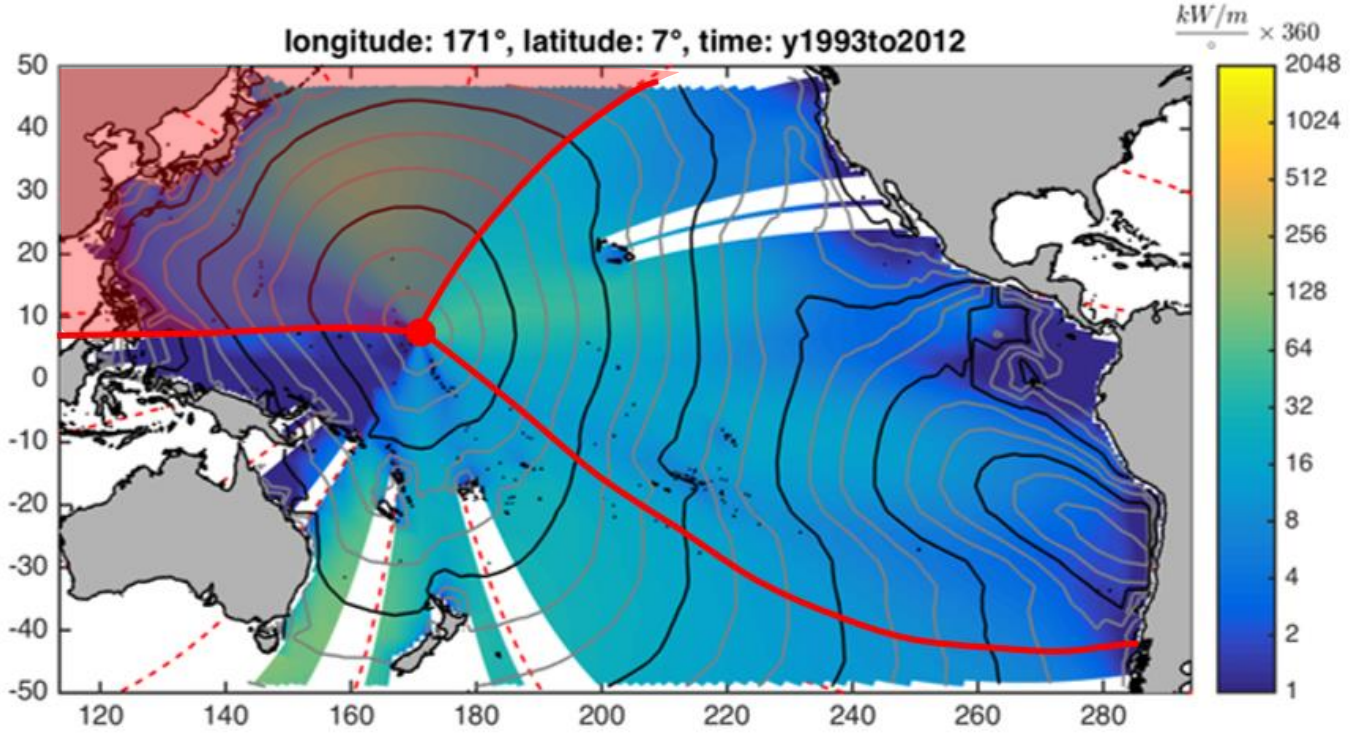
4) SNAKES PARAMETERIZATION



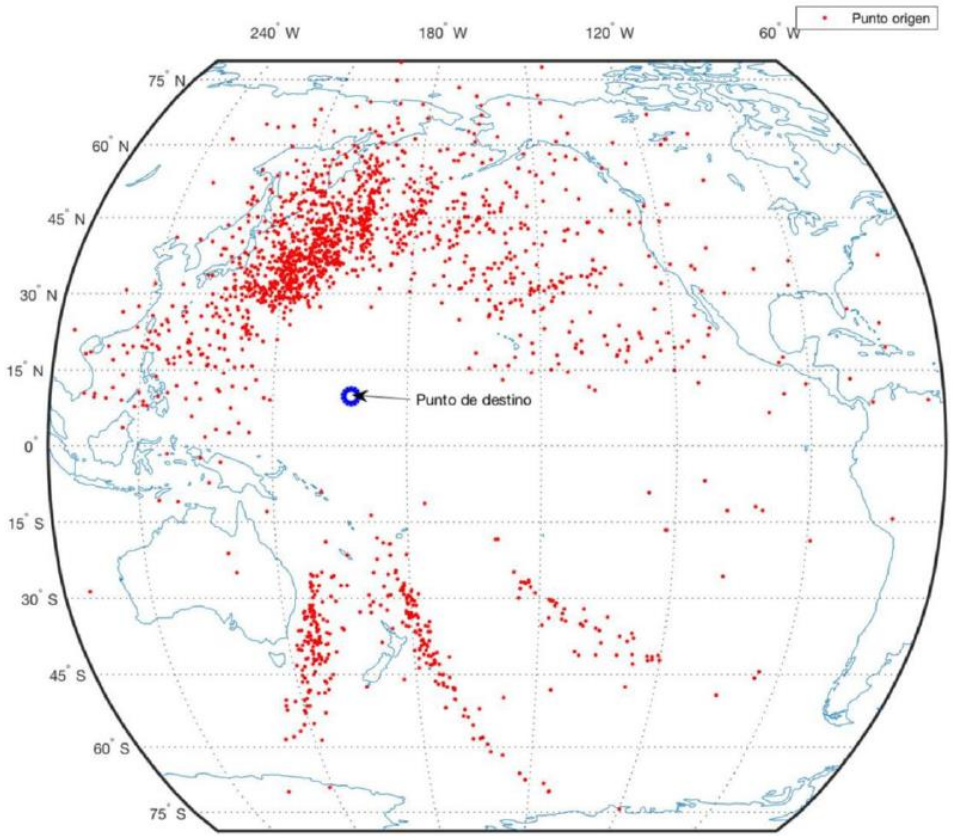


5) LINK TO WEATHER CONDITIONS

FINDING THE LINK BETWEEN PRESSURE CONDITIONS AND THE SWELL PARAMETERS FOR EACH WAVE FAMILY



PCs ⟷ 12 Swell Parameters



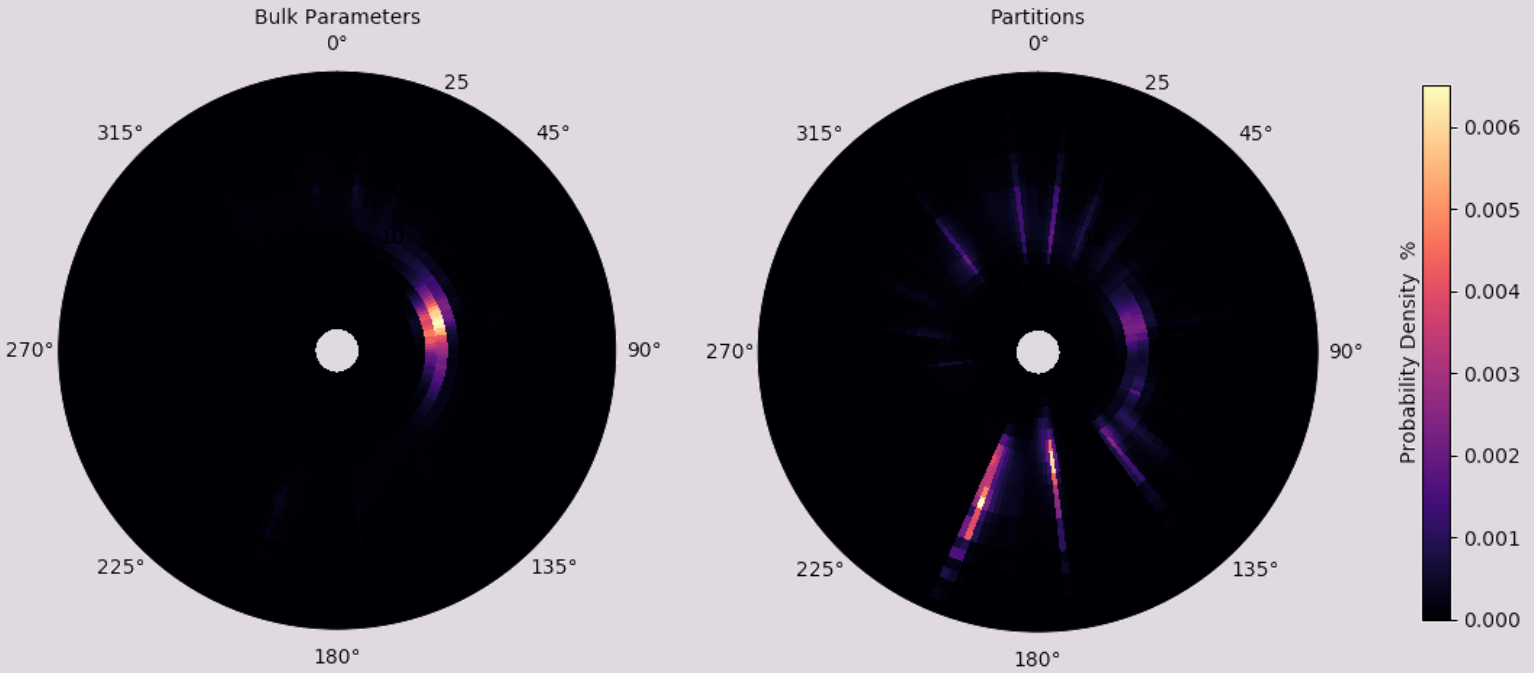
Algorithm from Portilla 2012

Storm-Source-Locating Algorithm Based on the Dispersive Nature of Ocean Swells

CONCLUSIONS

- IMPORTANCE OF AGGREGATING SPECTRAL INFORMATION AROUND THE STUDY ATOLL TO INCLUDE ALL SOURCES OF WAVE ENERGY
- NECESSITY TO CORRECTLY SIMULATE THE TIME EVOLUTION OF EVERY SWELL
- NEED OF EMULATE THE SWELL CHARACTERISTICS BASED ON THE ATMOSPHERIC SYSTEM THAT GENERATES THEM

Thanks



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