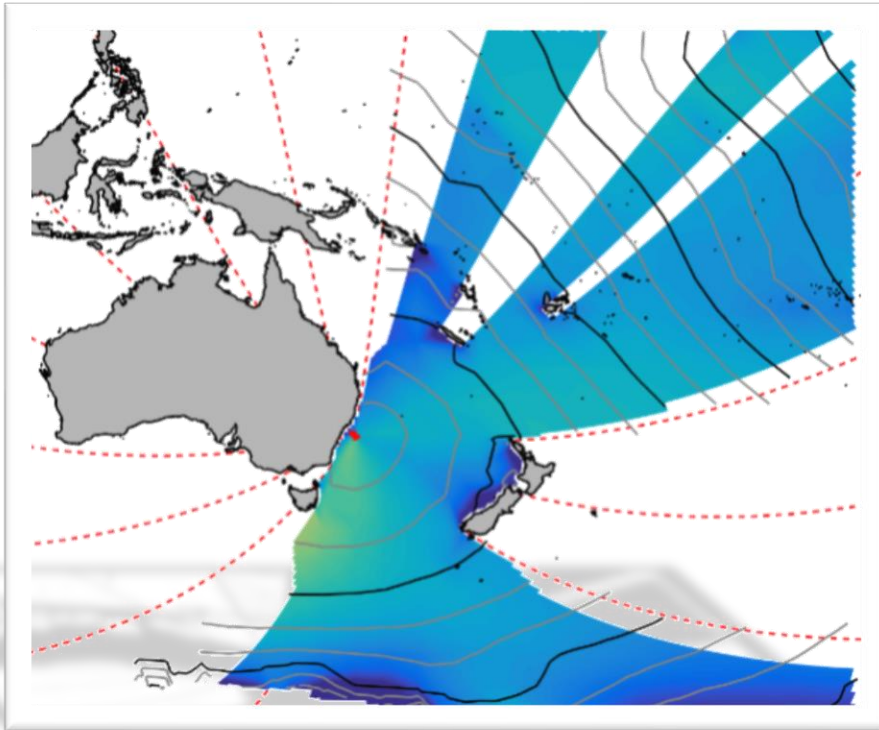# EXTRACTING MORPHODYNAMICS TIME-SCALES FROM DRIVERS AND SHORELINE RESPONSE

Jennifer Montaño *(jmon177@aucklanduni.ac.nz)*

Giovanni Coco

Laura Cagigal

Karin Bryan

Fernando Mendez

Ana Rueda

THE UNIVERSITY OF AUCKLAND
Te Whare Wānanga o Tāmaki Makaurau
NEW ZEALAND

SCIENCE
SCHOOL OF ENVIRONMENT

Coast and Ocean Collective

What do you want to predict?

Short-term

Hours/days

Storm events
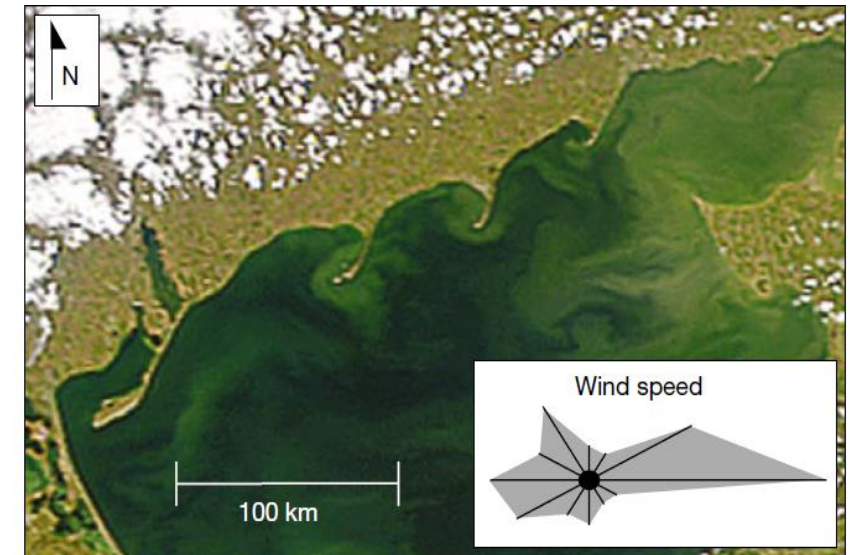
Medium-term

Seasonal/inter-annual

Wave-climate

Long-term

Decadal/centennial

Sea Level Rise

Cross-shore sediment transport

Longshore sediment transport

What do you want to predict?

Short-term

Hours/days

Storm events

Medium-term

Seasonal/inter-annual
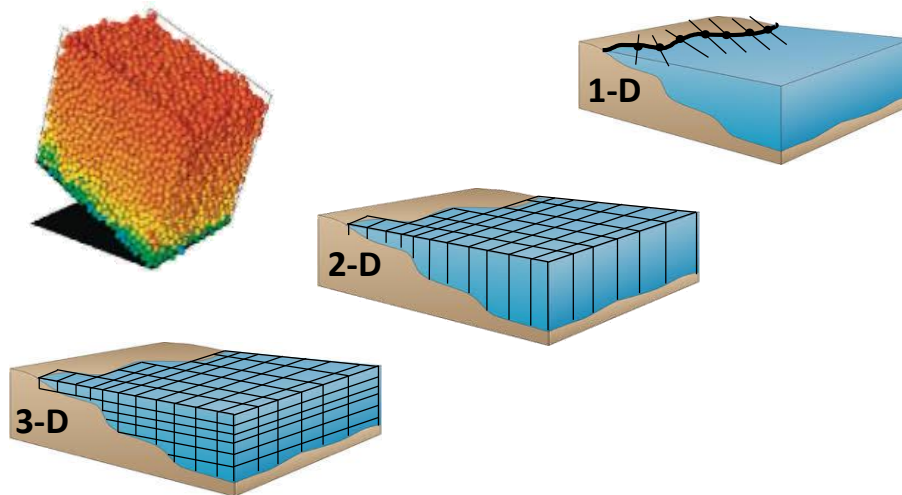
Wave-climate

Long-term
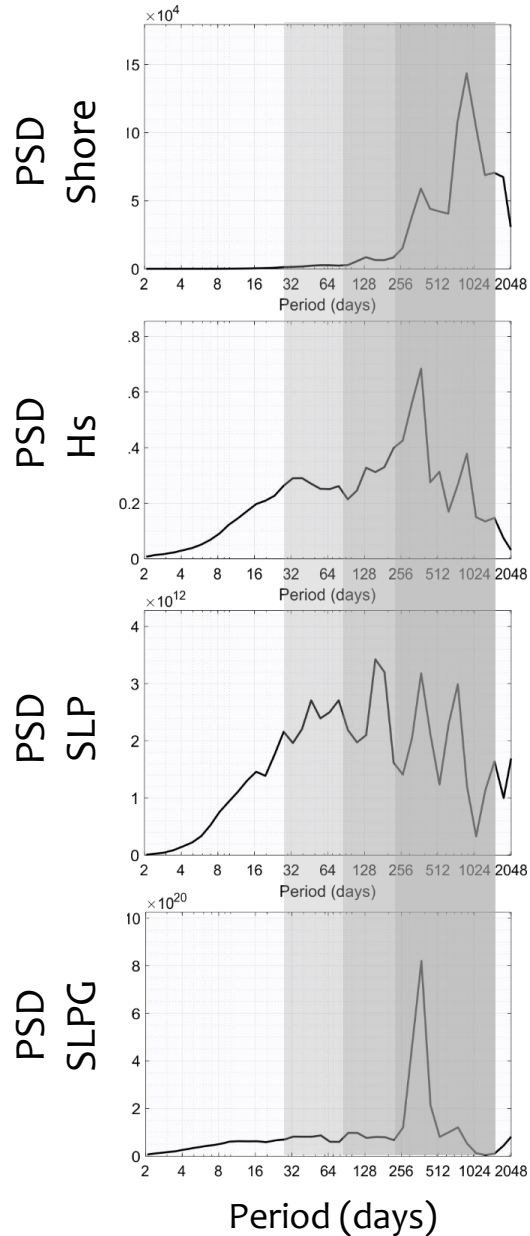
Decadal/centennial

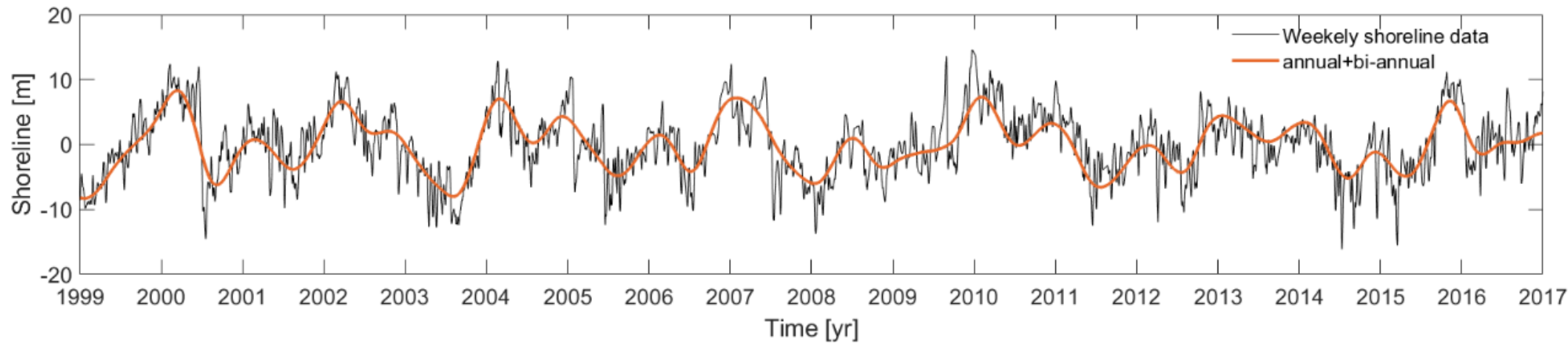Sea Level Rise

Cross-shore sediment transport

Longshore sediment transport
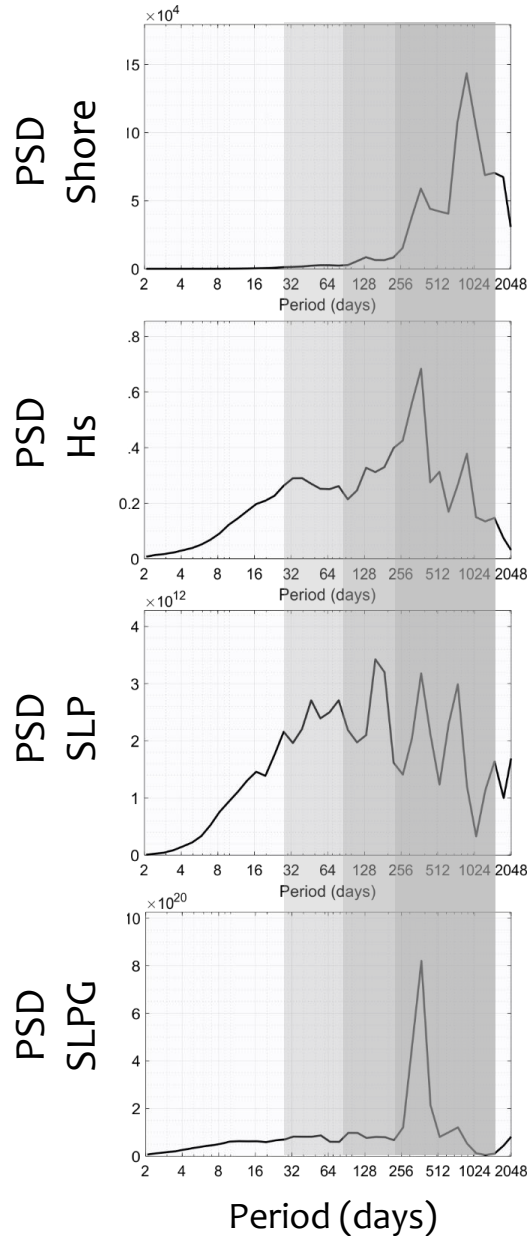
What (scales) are the models predicting?

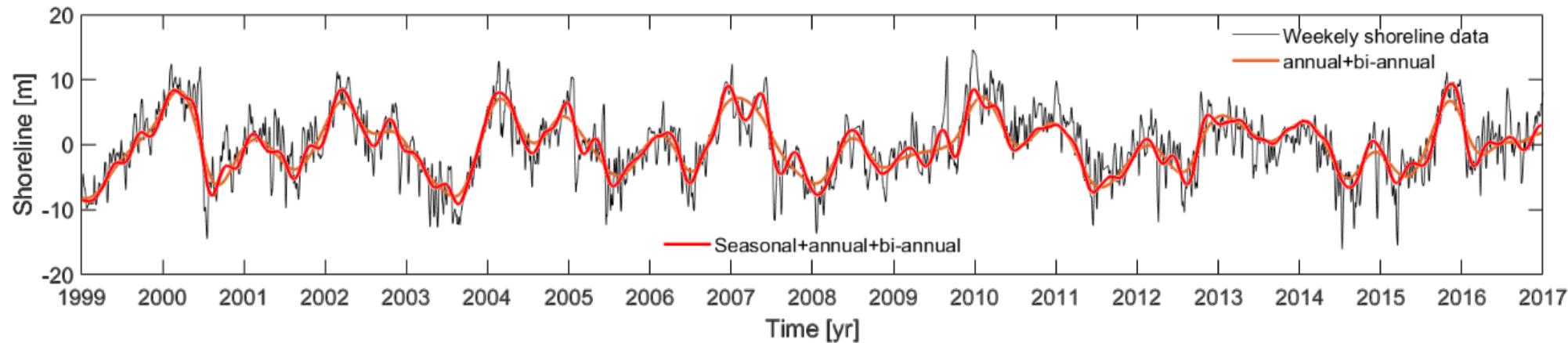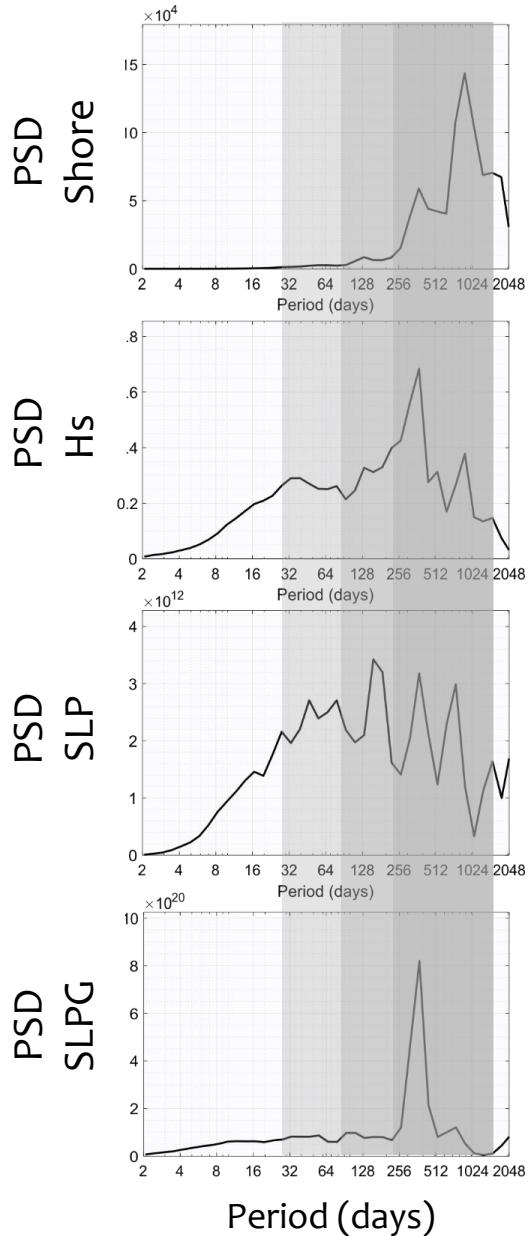annual – bi-annual can explain about **60%** of the shoreline variance

> Monthly can explain **85%** of the shoreline variance

What (scales) are the models predicting?

PSD Shore

PSD Hs

PSD SLP

PSD SLPG

Period (days)

annual – bi-annual can explain about **60%** of the shoreline variance
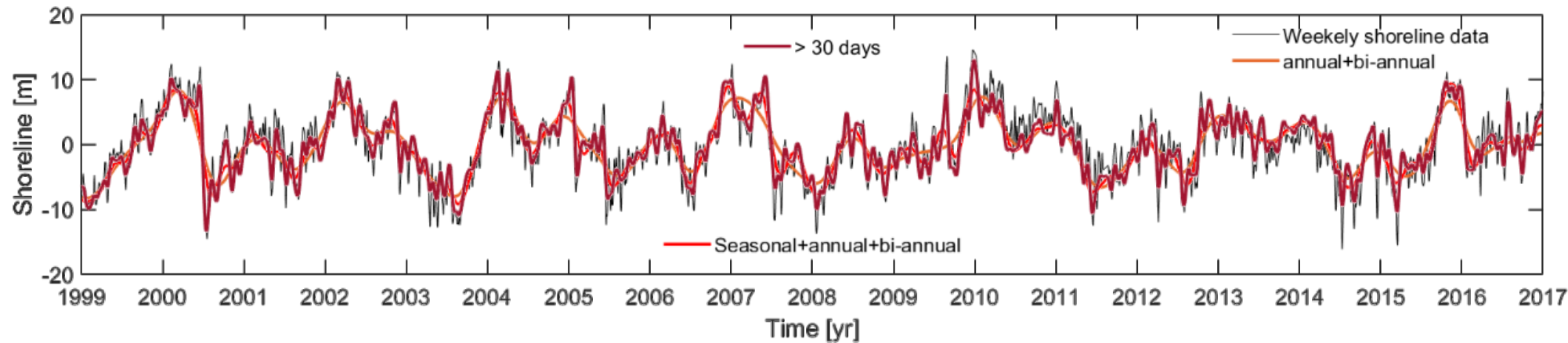
> Monthly can explain **85%** of the shoreline variance

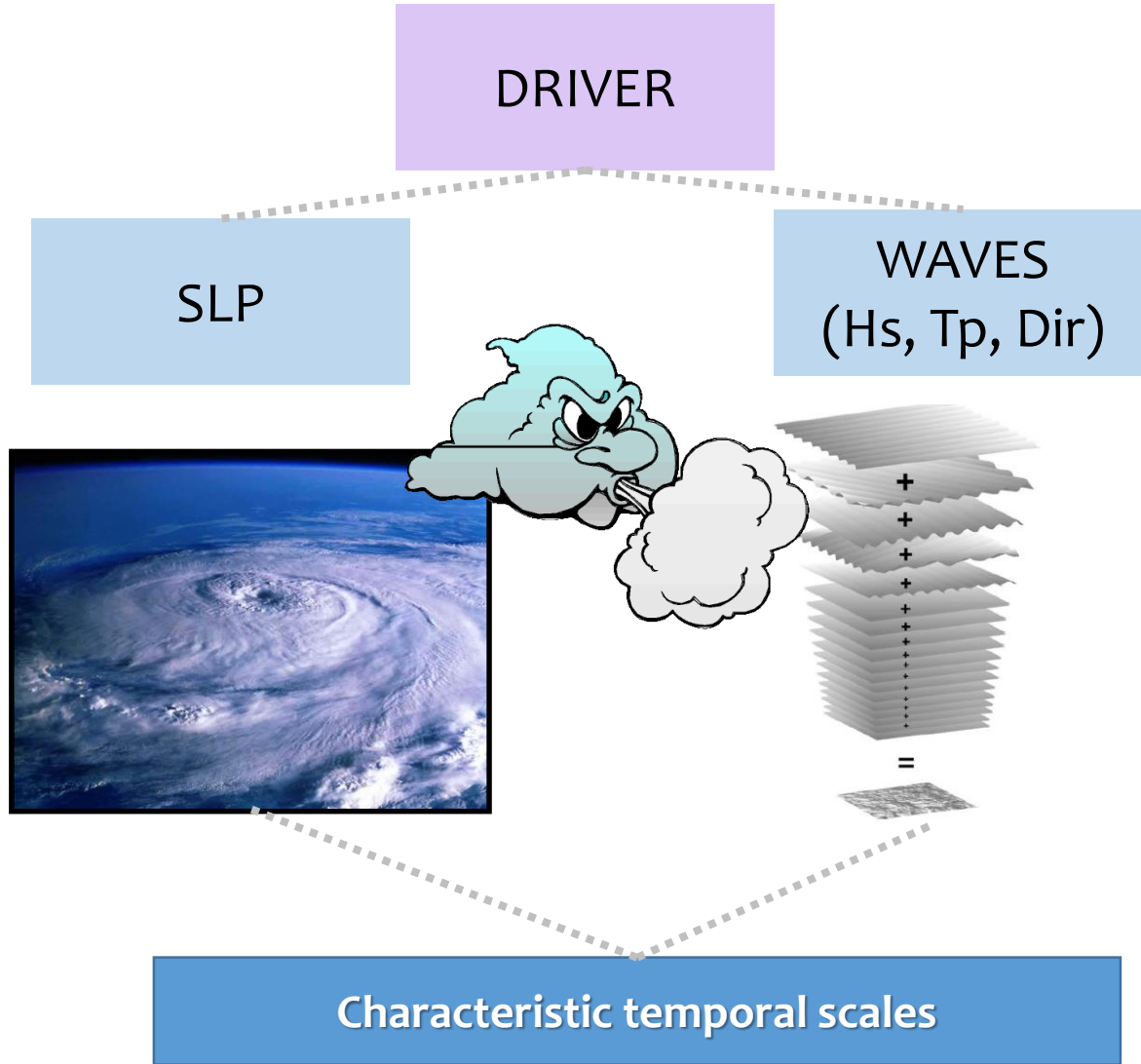# *What (scales) are the models predicting?*

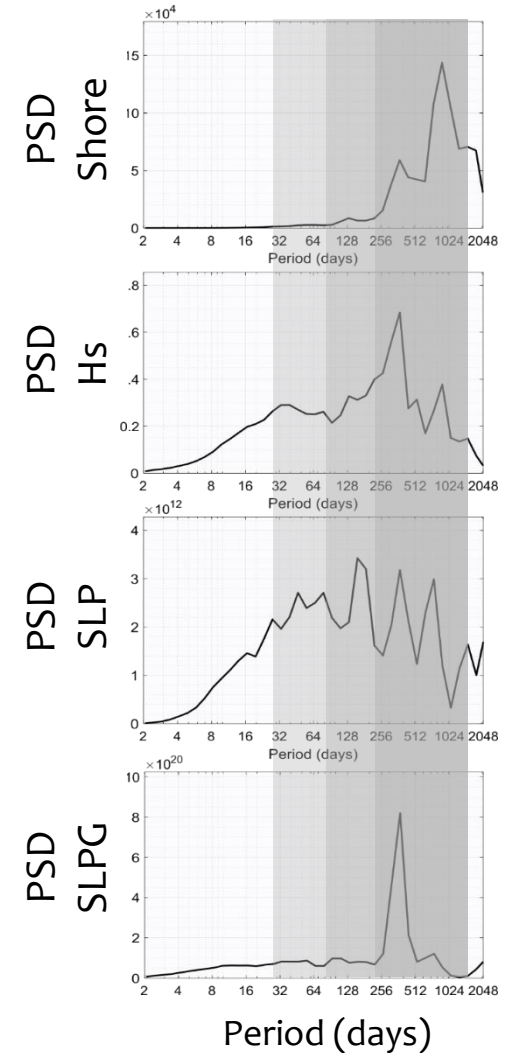annual – bi-annual can explain about **60%** of the shoreline variance

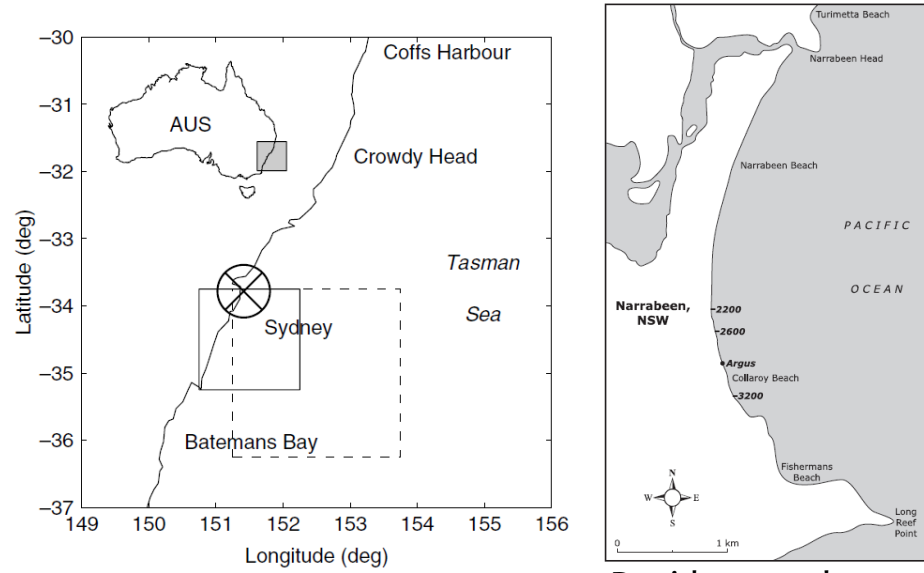> Monthly can explain **85%** of the shoreline variance

Isolating time-scales

DRIVER

SLP

WAVES
(Hs, Tp, Dir)

Shoreline response

Isolating time-scales from drivers and shoreline response

Characteristic temporal scales

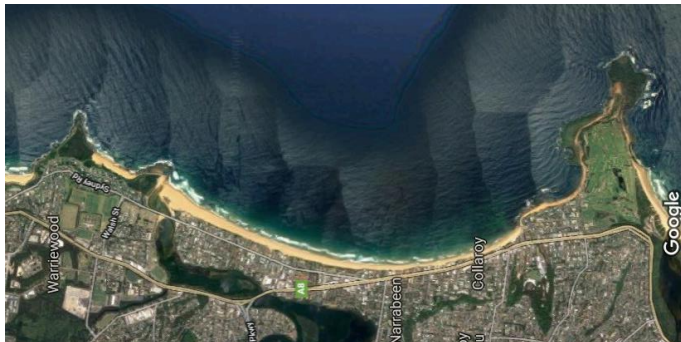PSD Shore

PSD Hs

PSD SLP

PSD SLPG

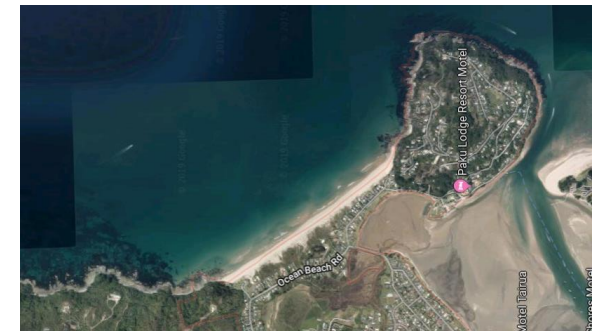Period (days)

STUDY SITES

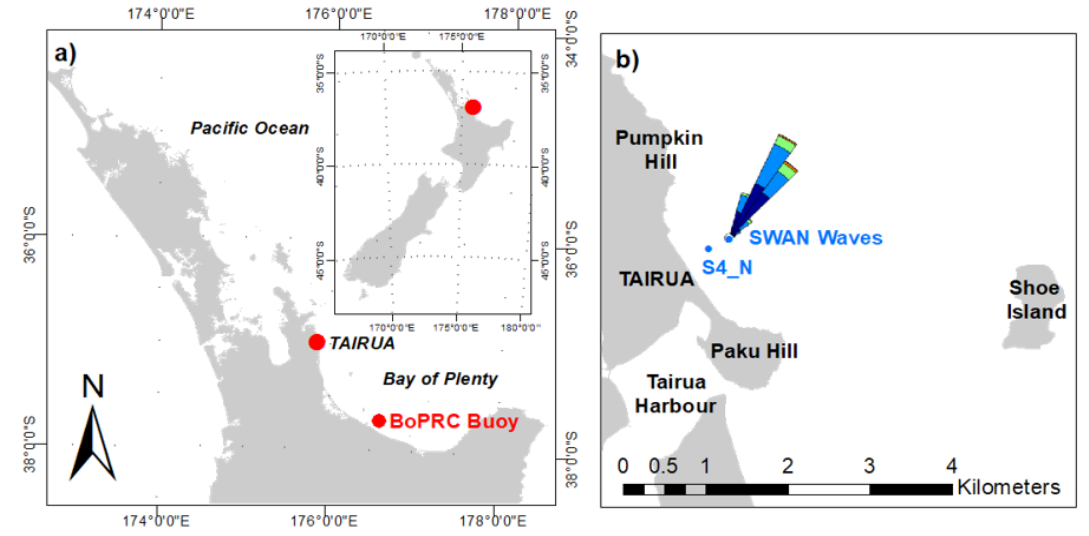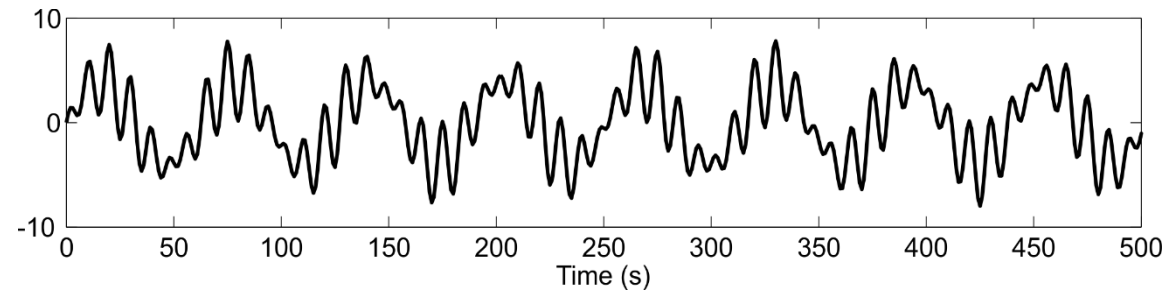## NARRABEEN, AUSTRALIA

Harley et al., 2010
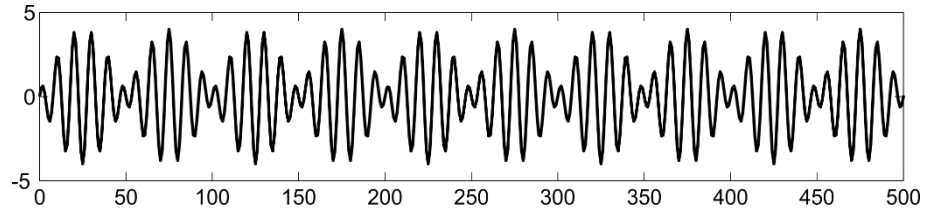

Davidson et al., 2010

TAIRUA BEACH, NEW ZEALAND

CamEra System

CEEMD Method

Complete Ensemble Empirical Mode Decomposition

$$a_2 = 4 \, ; \quad \Delta a_2 = 0.5 \, ; \quad f_2 = \frac{1}{10}$$
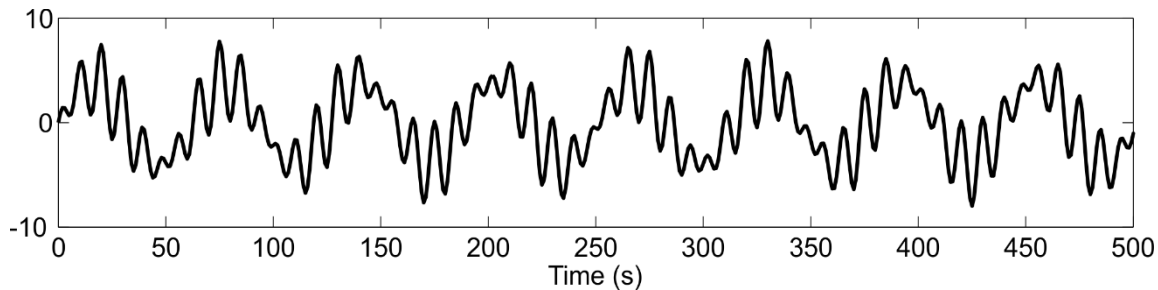
amplitude-modulated signal

$+$
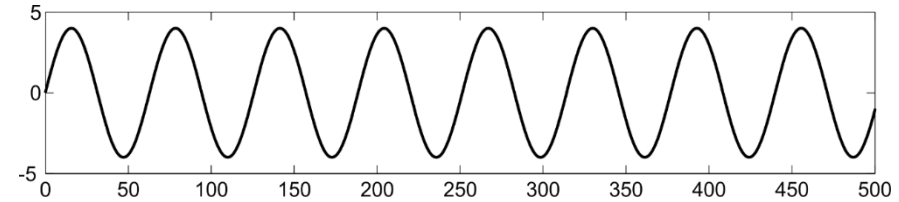
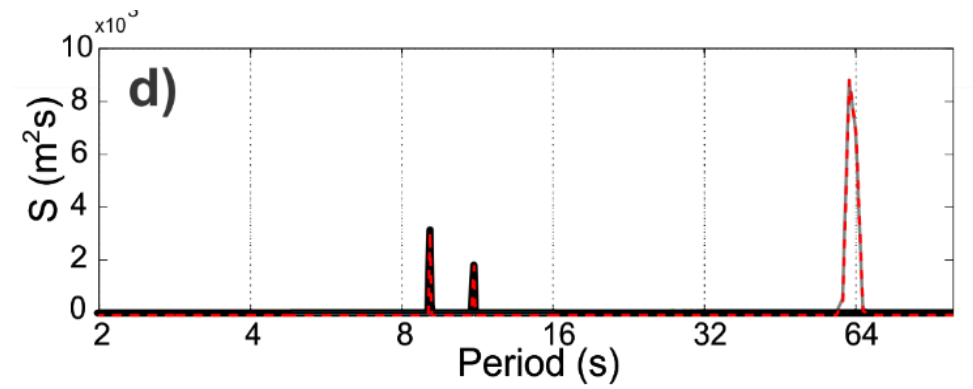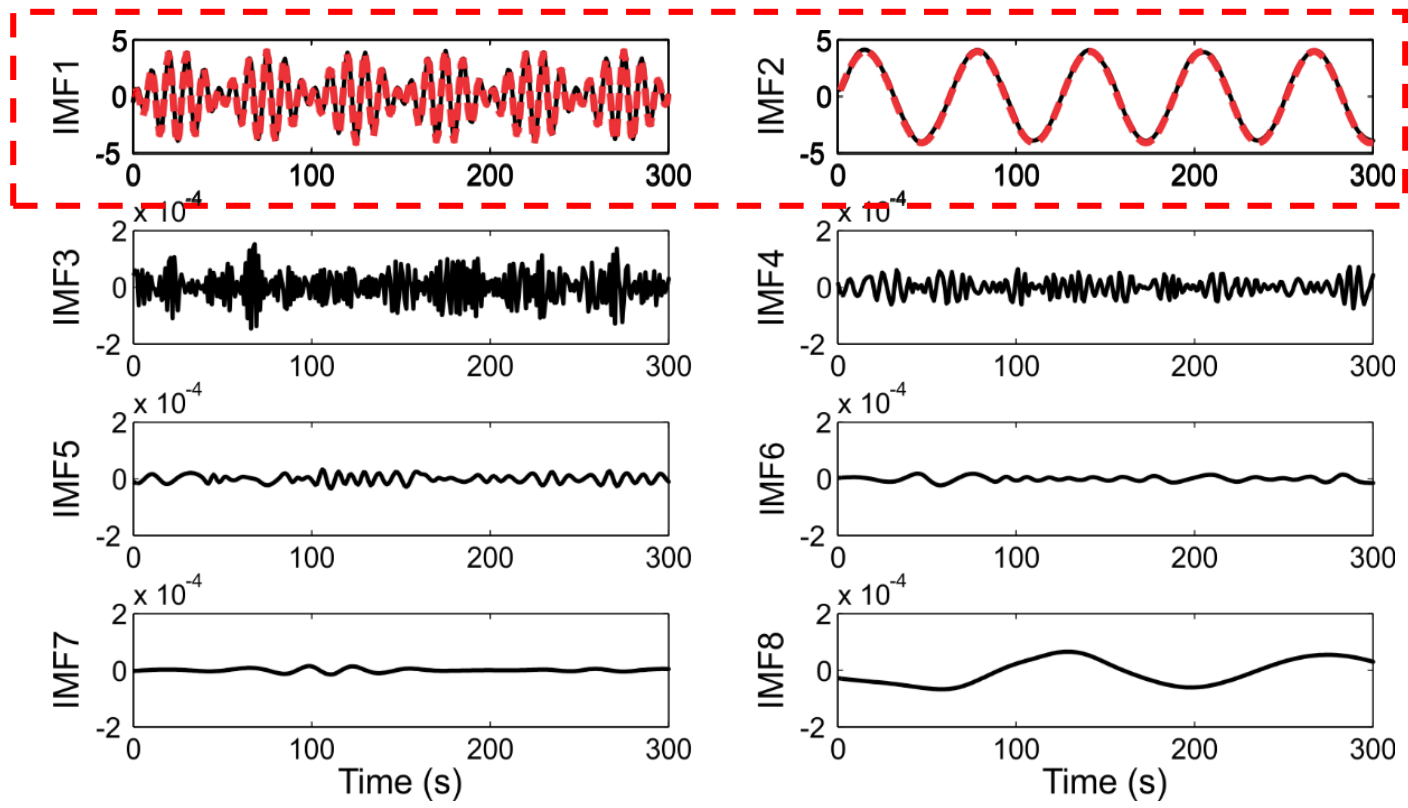$$a_1 = 4 \, ; \quad f_1 = \frac{1}{50}$$

Carrier wave
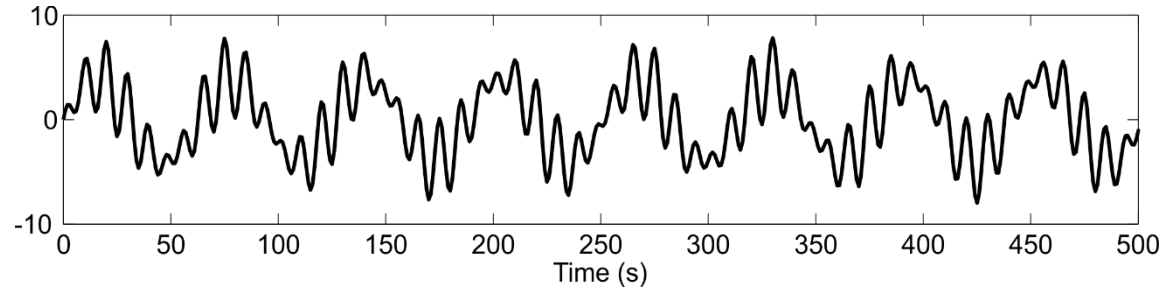
CEEMD Method
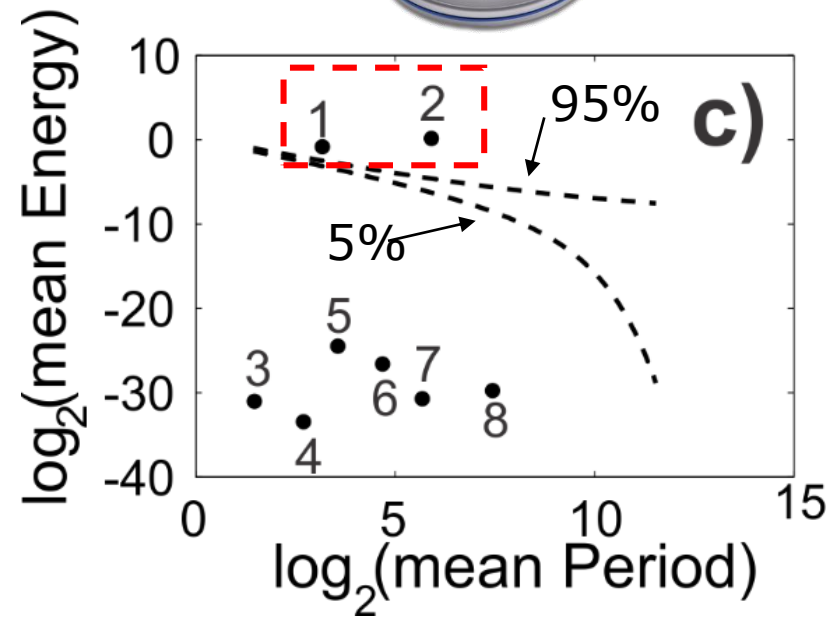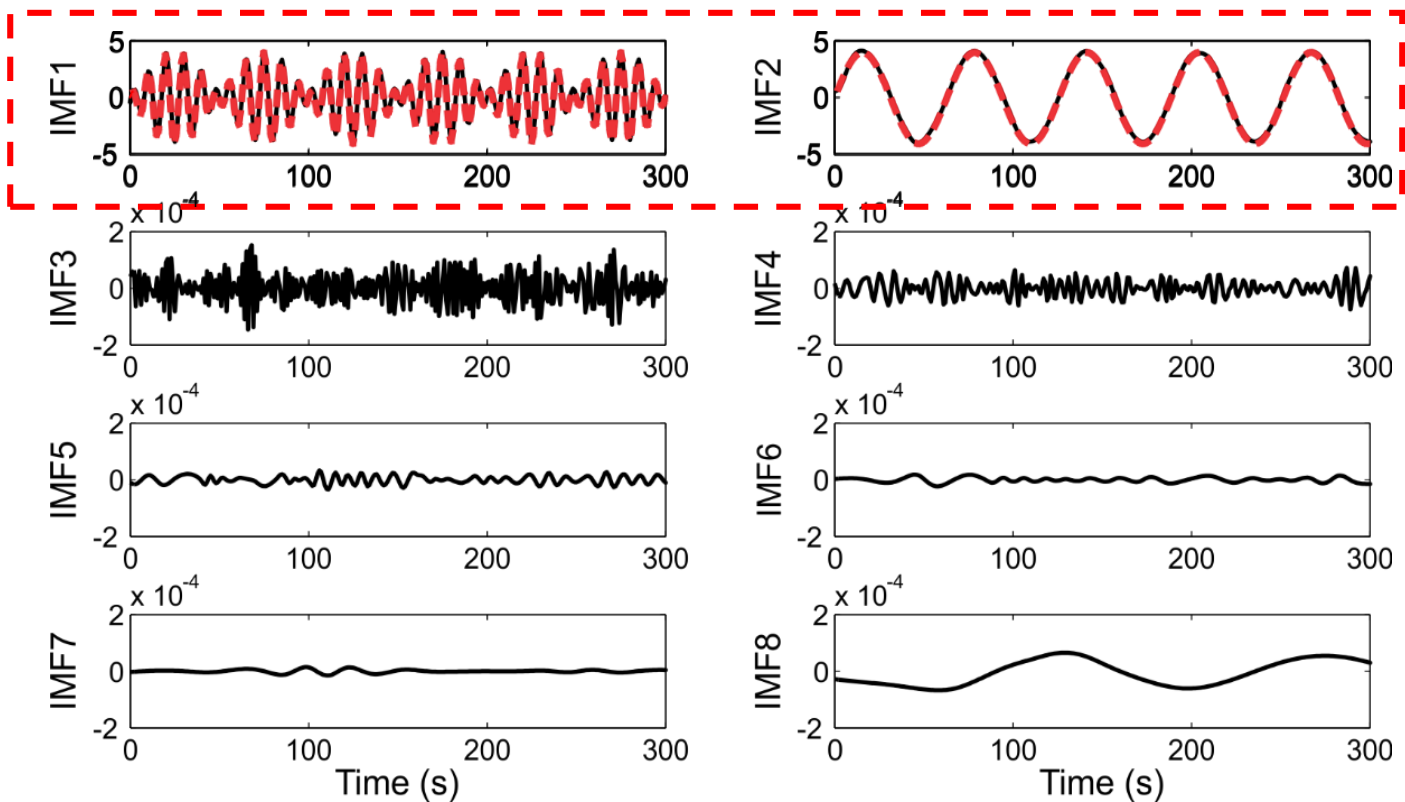
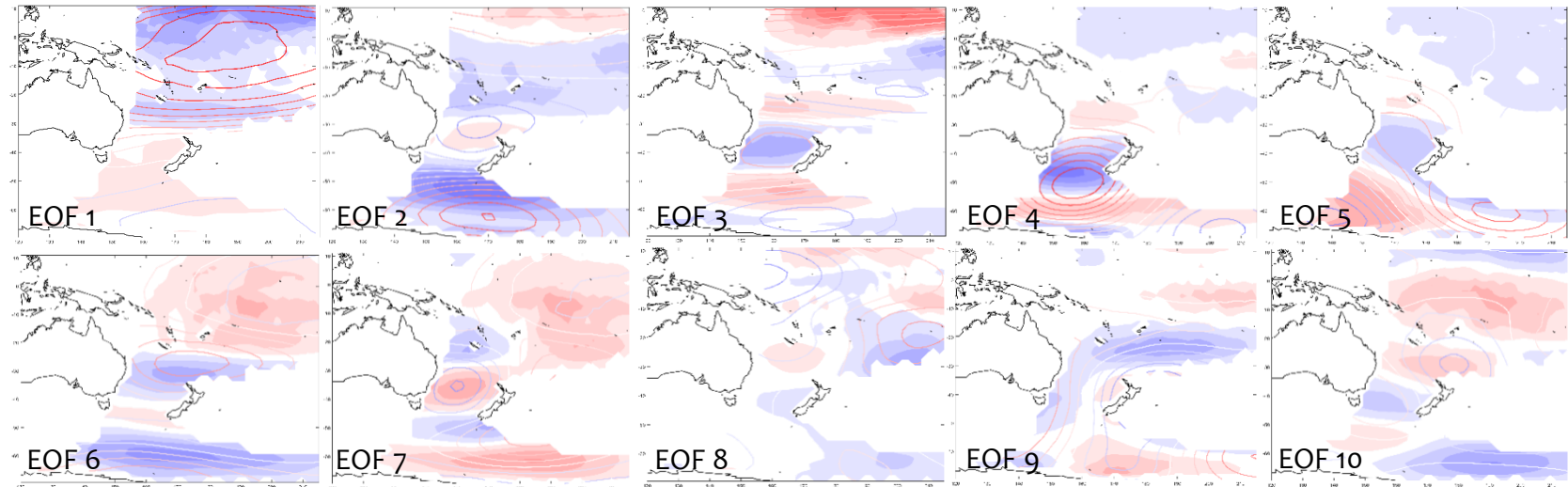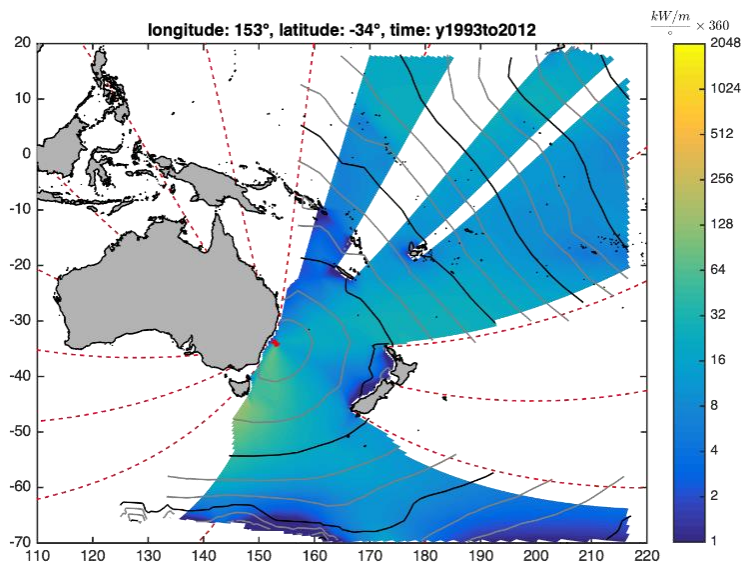*Wu and Huang, 2004*

CEEMD Method

DRIVERS

SLP & SLPG

- SLP & SPLG from CFSR reanalysis
- ESTELA informs of the average effective energy flux towards a target point and the average travel time

PCA

- The EOFs are ranked in increasing order of explained variance.
- We used the first 10 PCs(EOFs)

WAVES

- Wave Height (Hs)
- Wave Period (Tp)
- Wave Direction

ISOLATING TIME-SCALES

CEEMD

- Decompose Shoreline signal and Drivers (SLP or Waves) in different temporal scales (IMFs).
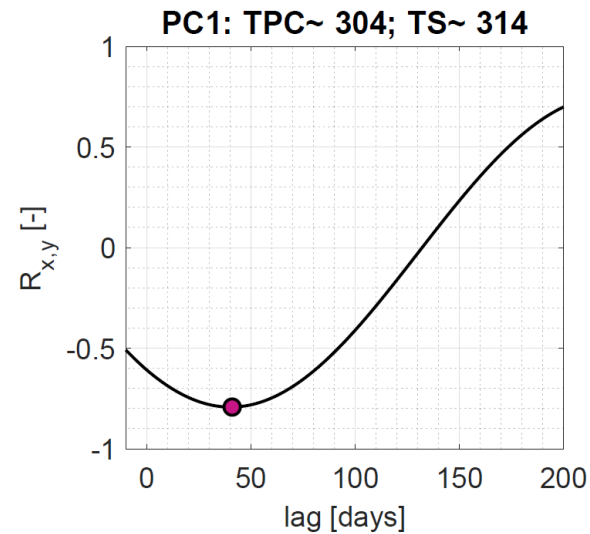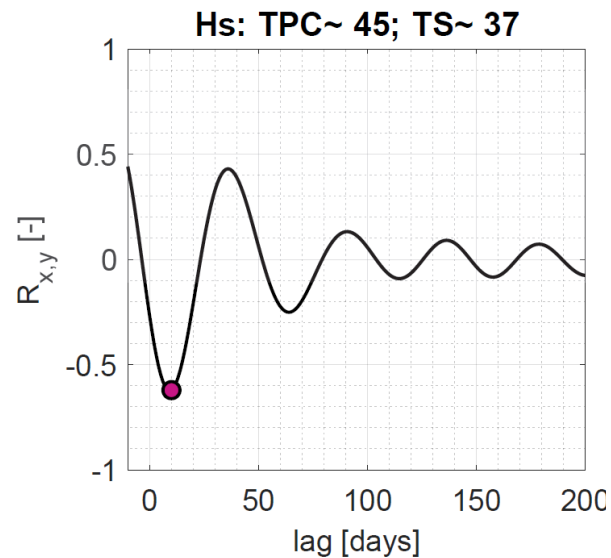- Each IMF has a characteristic period and explained variance

Cross-correlation (R_{xy})

- Finding the max/min cross-correlation and time-lag between driver(x) and shoreline(y) for each IMF (i.e. each temporal scale)

Optimization (IMFs)

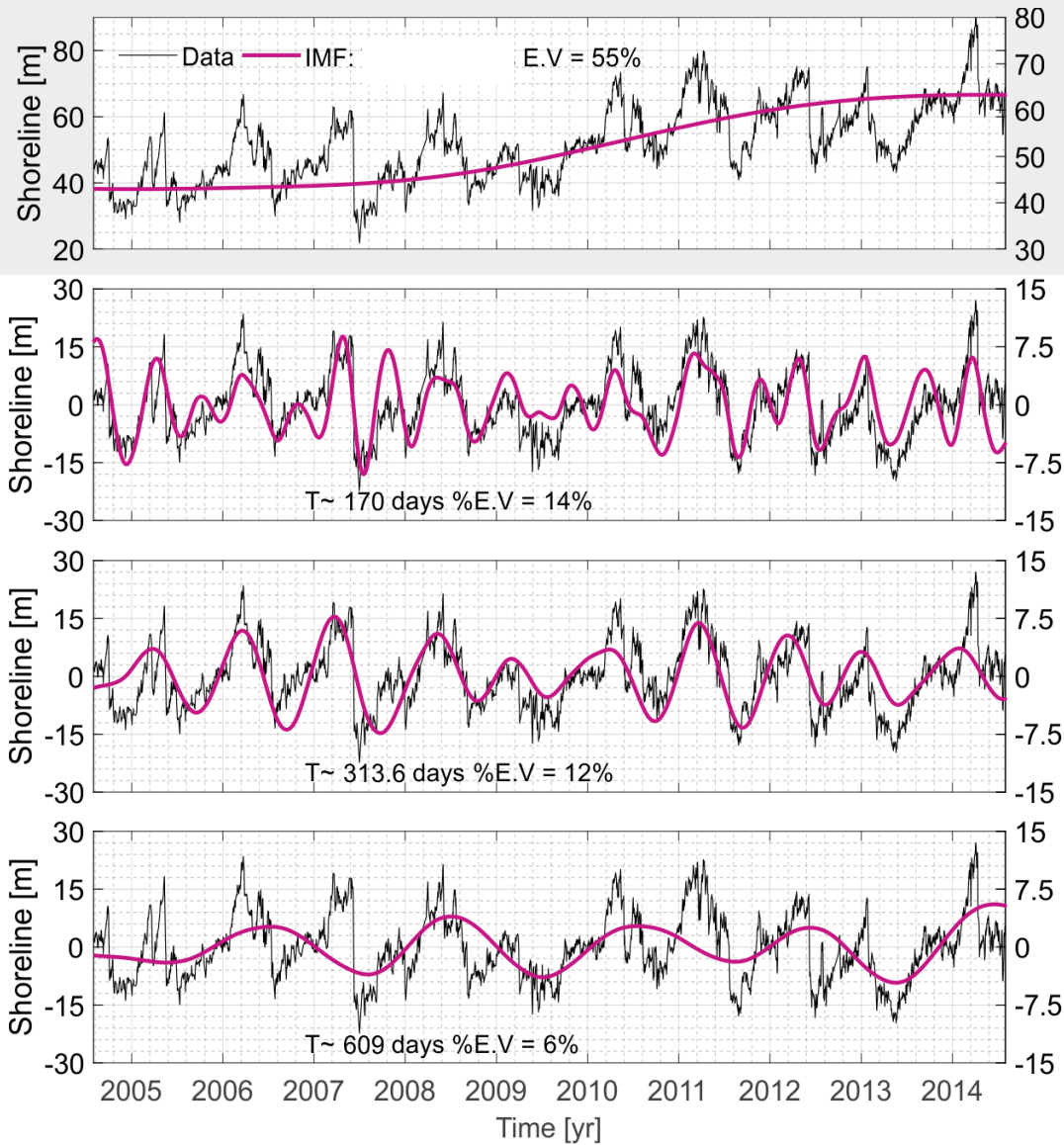- A threshold between the cross-correlations (PCs -Shoreline) are selected to predict the shoreline at the specific temporal scale (IMF).

$$R_{xy}(\tau) = \frac{\langle x(t)y(t+\tau)\rangle}{\sigma_x \sigma_y} \rightarrow -1 \leq R_{xy} \leq 1$$

$$S_{IMF} = \sum_i^N c_i Y_i$$

Hs: TPC~ 45; TS~ 37

PC1: TPC~ 304; TS~ 314

Isolating time-scales

Narrabeen, Australia
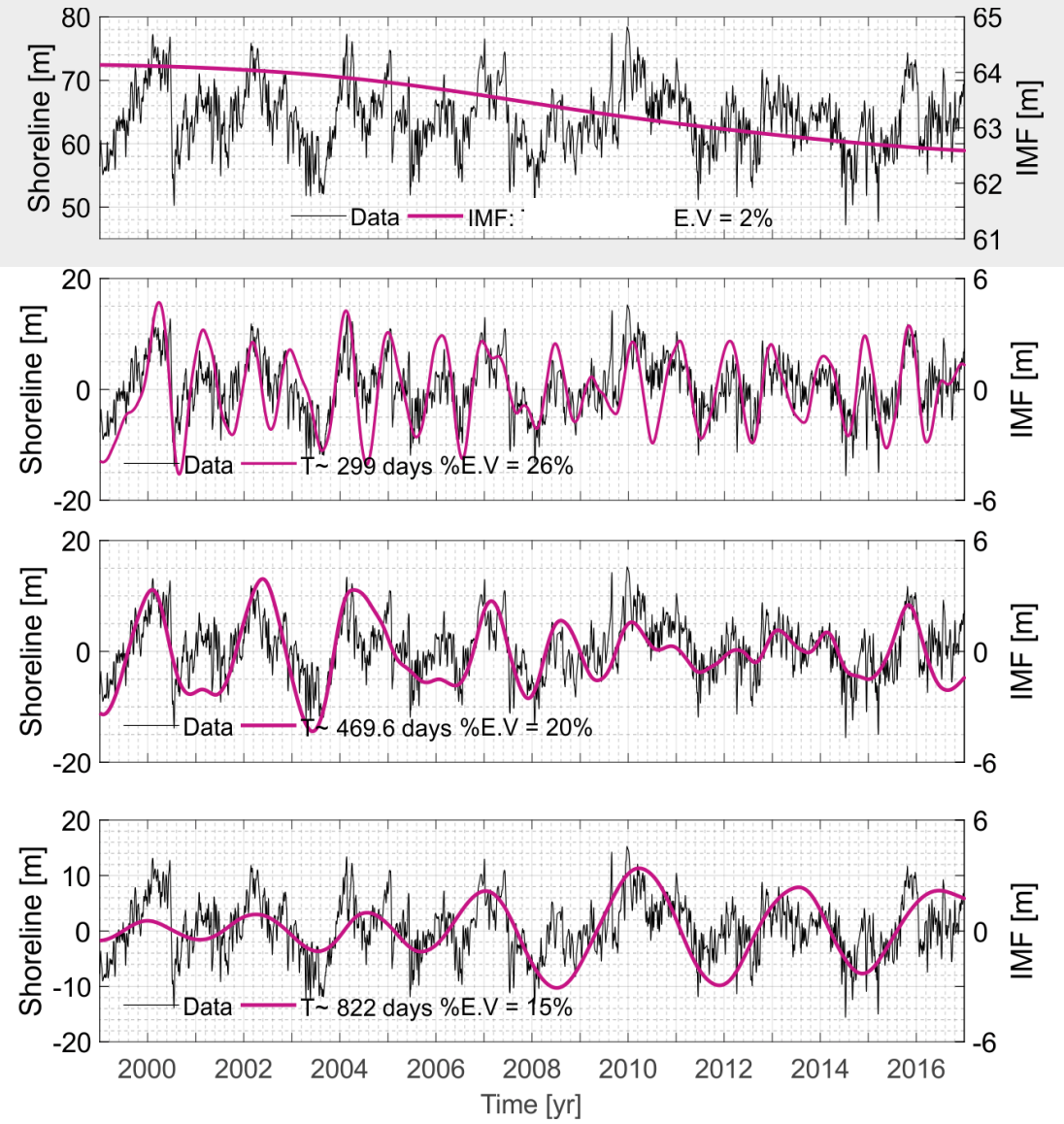
Tairua, New Zealand

Correlating time-scales (Shoreline & Drivers)
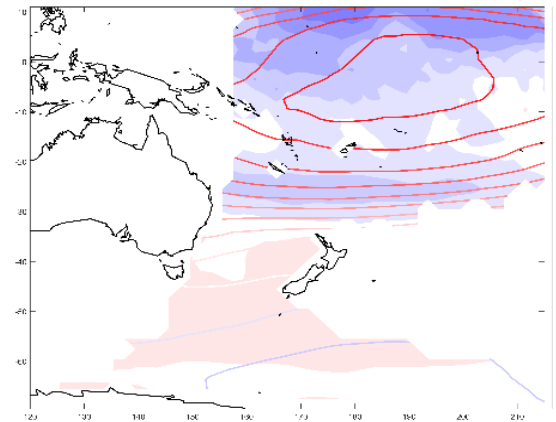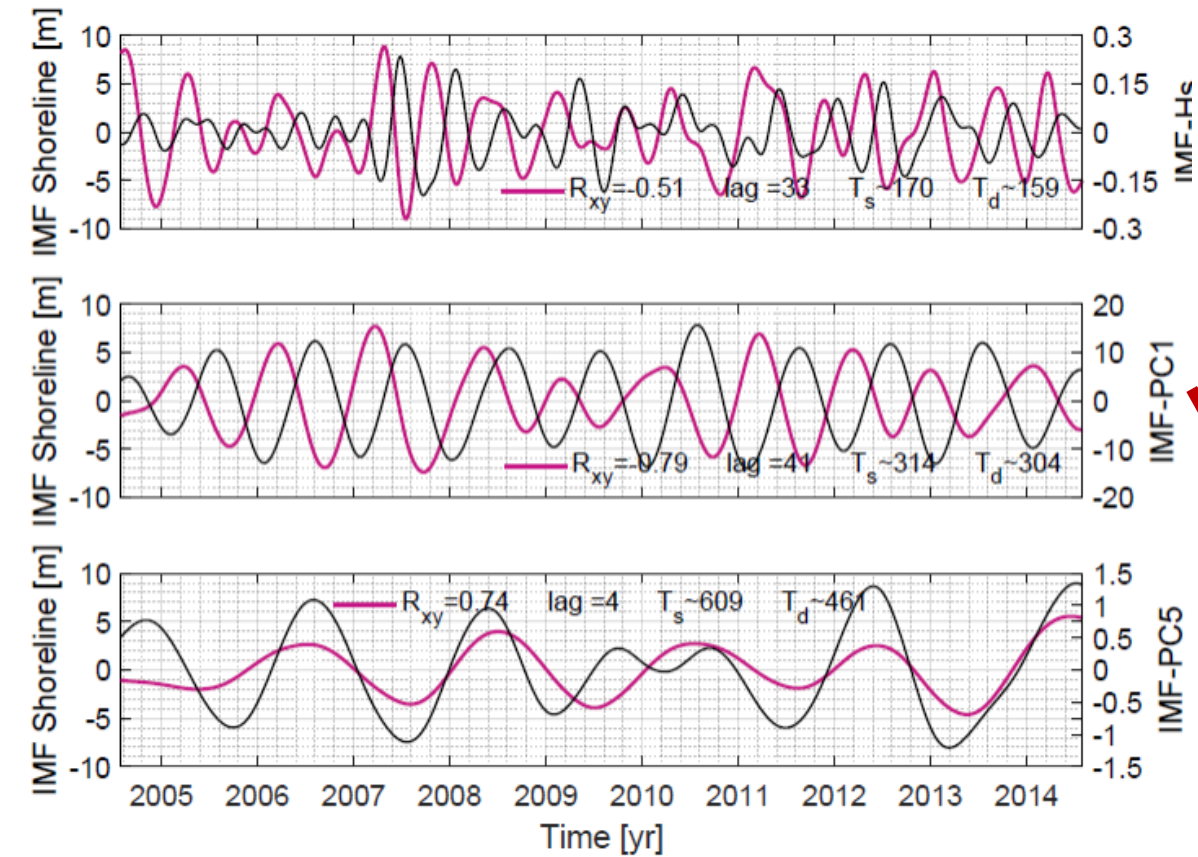
Narrabeen, Australia

Correlating time-scales (Shoreline & Drivers)
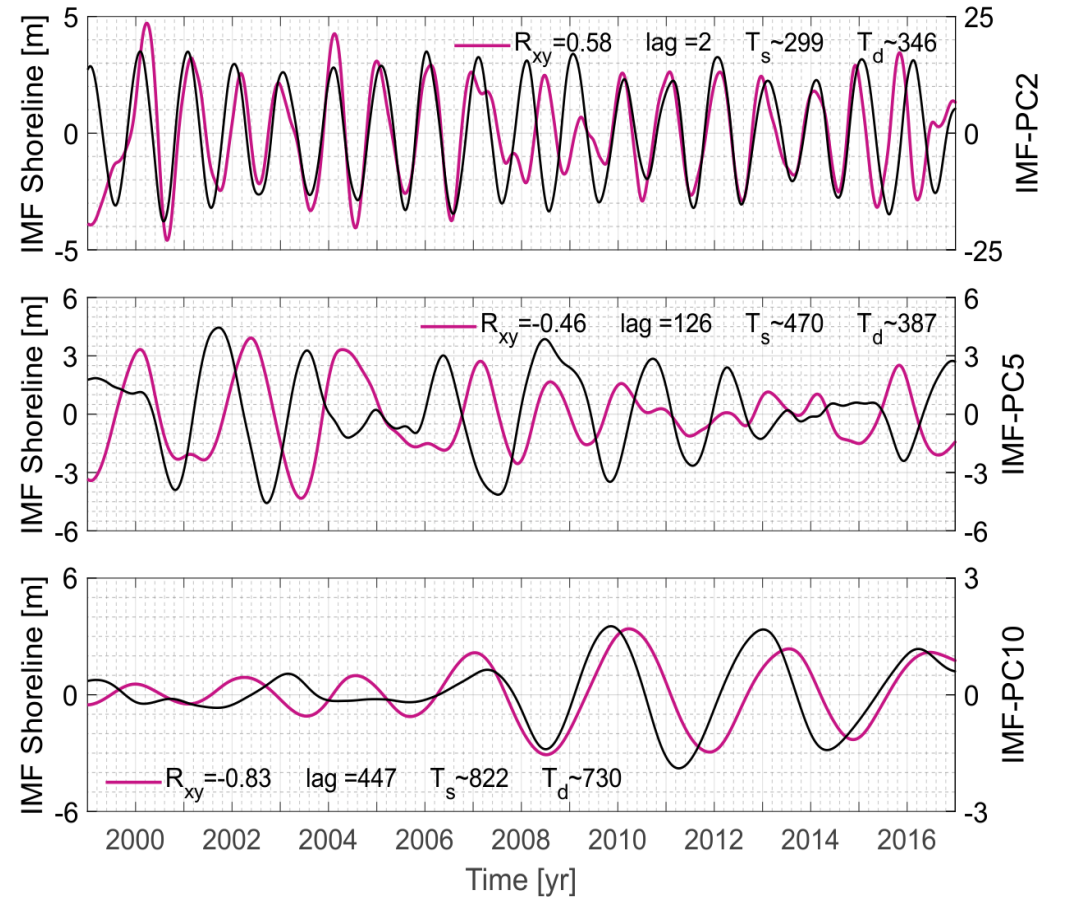
Tairua, New Zealand

Reconstructing shoreline time-scales
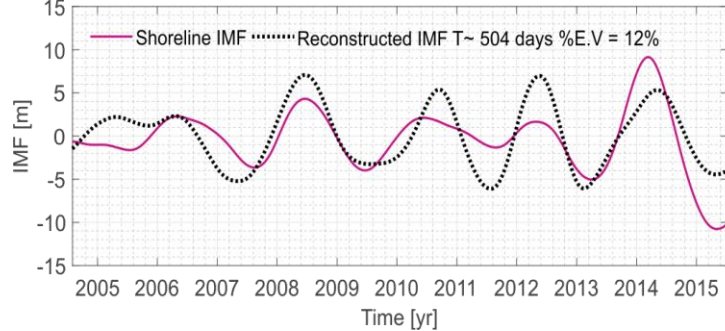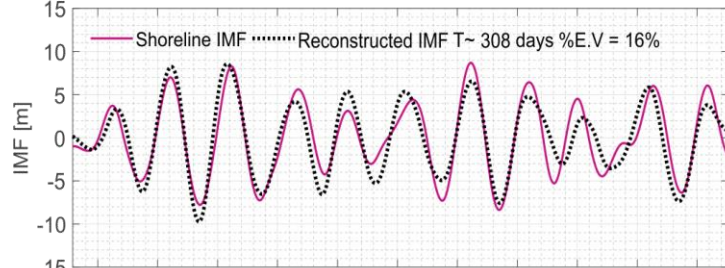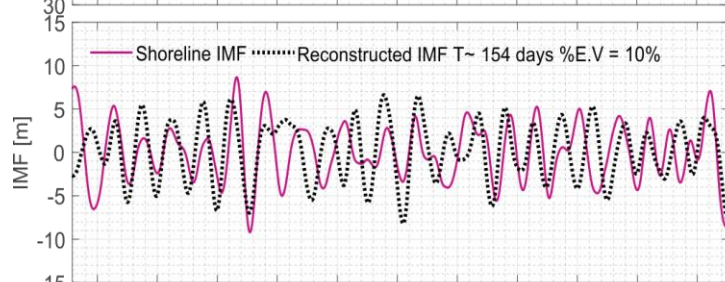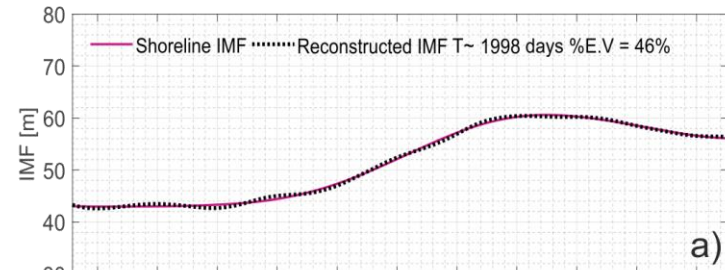
$$S_{IMF} = \sum_{i}^{N} c_i Y_i$$

Narrabeen, Australia
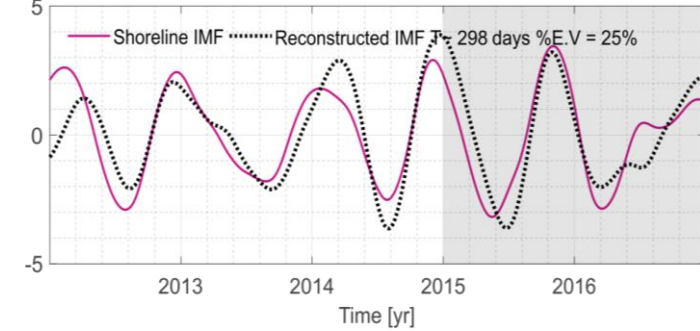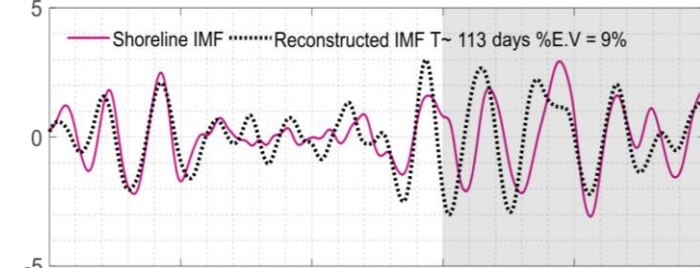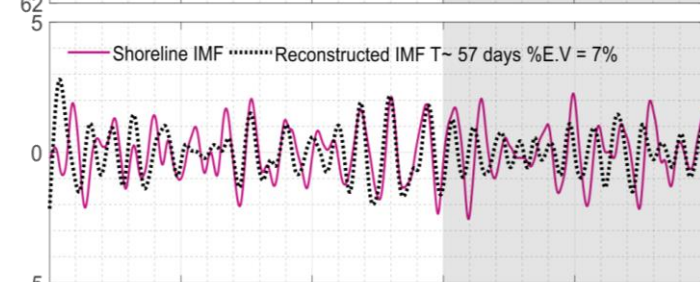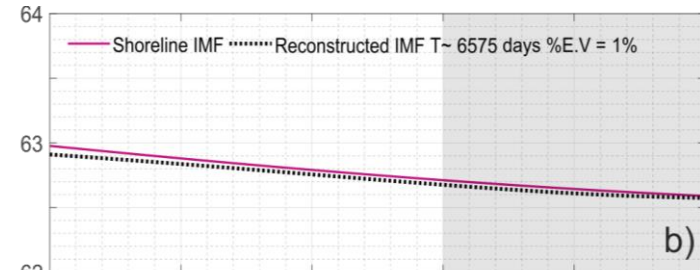
Tairua, New Zealand

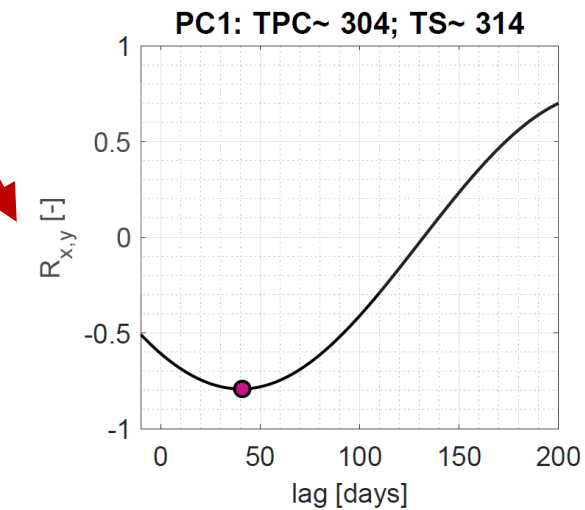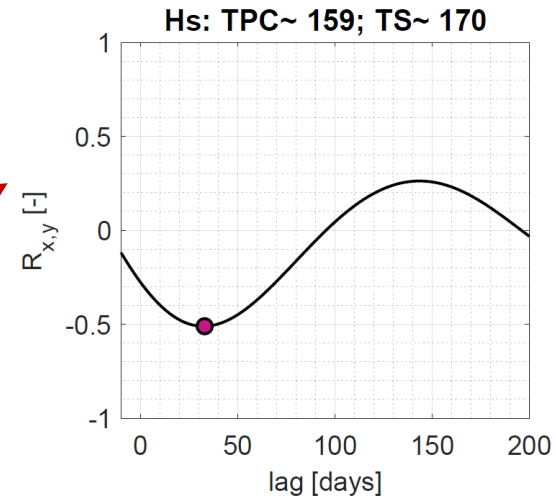# *Predicting the shoreline position*
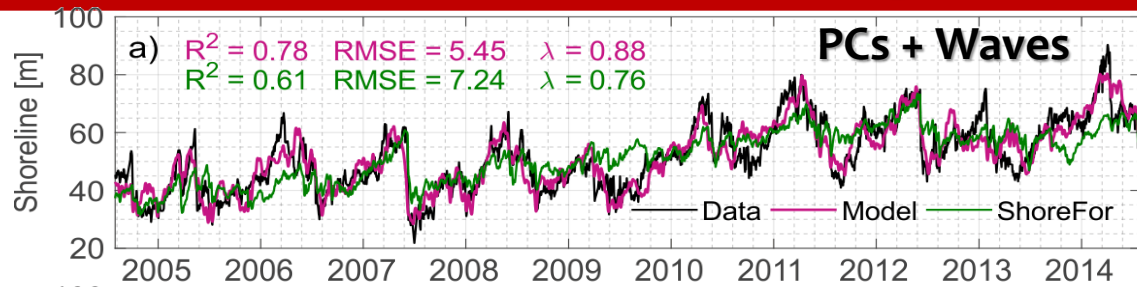
PCs + Waves

a) $R^2 = 0.78$ RMSE = 5.45 $\lambda = 0.88$
$R^2 = 0.61$ RMSE = 7.24 $\lambda = 0.76$

Data — Model — ShoreFor

Narrabeen, Australia

Predicting the shoreline position

a) PCs + Waves

$R^2 = 0.78$ RMSE = 5.45 $\lambda = 0.88$
$R^2 = 0.61$ RMSE = 7.24 $\lambda = 0.76$

Data — Model — ShoreFor

PCs

$R^2 = 0.69$ RMSE = 6.53 $\lambda = 0.83$

Narrabeen, Australia

Predicting the shoreline position

a) $R^2 = 0.78$ RMSE = 5.45 $\lambda = 0.88$
$R^2 = 0.61$ RMSE = 7.24 $\lambda = 0.76$

PCs + Waves

Data   Model   ShoreFor

$R^2 = 0.69$ RMSE = 6.53 $\lambda = 0.83$

PCs

$R^2 = 0.51$ RMSE = 8.3 $\lambda = 0.7$

Waves

Narrabeen, Australia

Predicting the shoreline position

a) PCs + Waves
$R^2 = 0.78$ RMSE = 5.45 $\lambda = 0.88$
$R^2 = 0.61$ RMSE = 7.24 $\lambda = 0.76$

Data   Model   ShoreFor

PCs
$R^2 = 0.69$ RMSE = 6.53 $\lambda = 0.83$

Waves
$R^2 = 0.51$ RMSE = 8.3 $\lambda = 0.7$

PCs + Waves
$R^2 = 0.19$ RMSE = 8.35 $\lambda = 0.41$
$R^2 = 0.04$ RMSE = 16.77 $\lambda = 0.08$
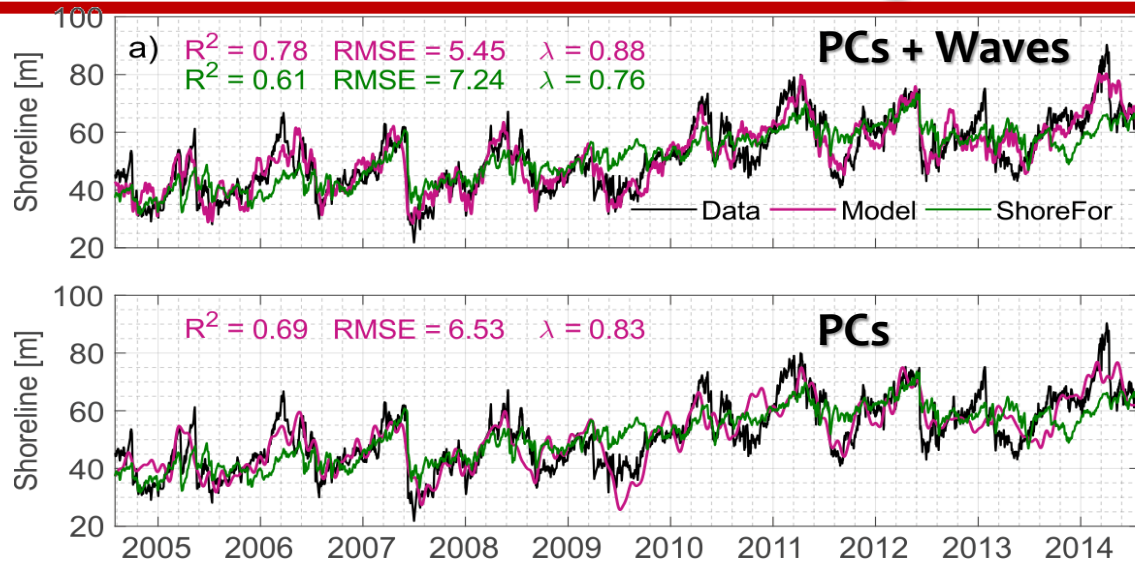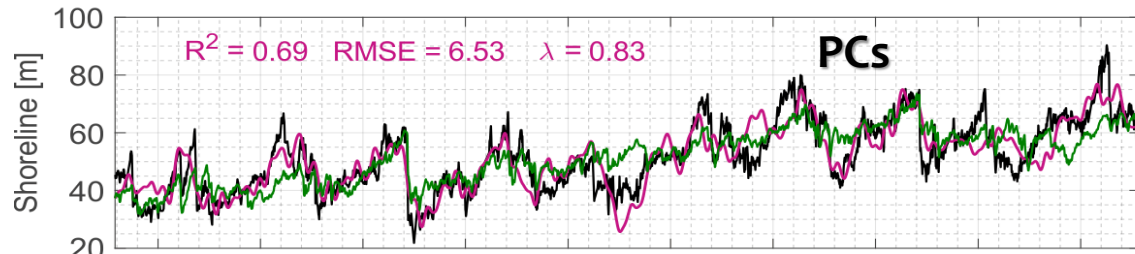
Narrabeen, Australia

Predicting the shoreline position

Tairua, New Zealand
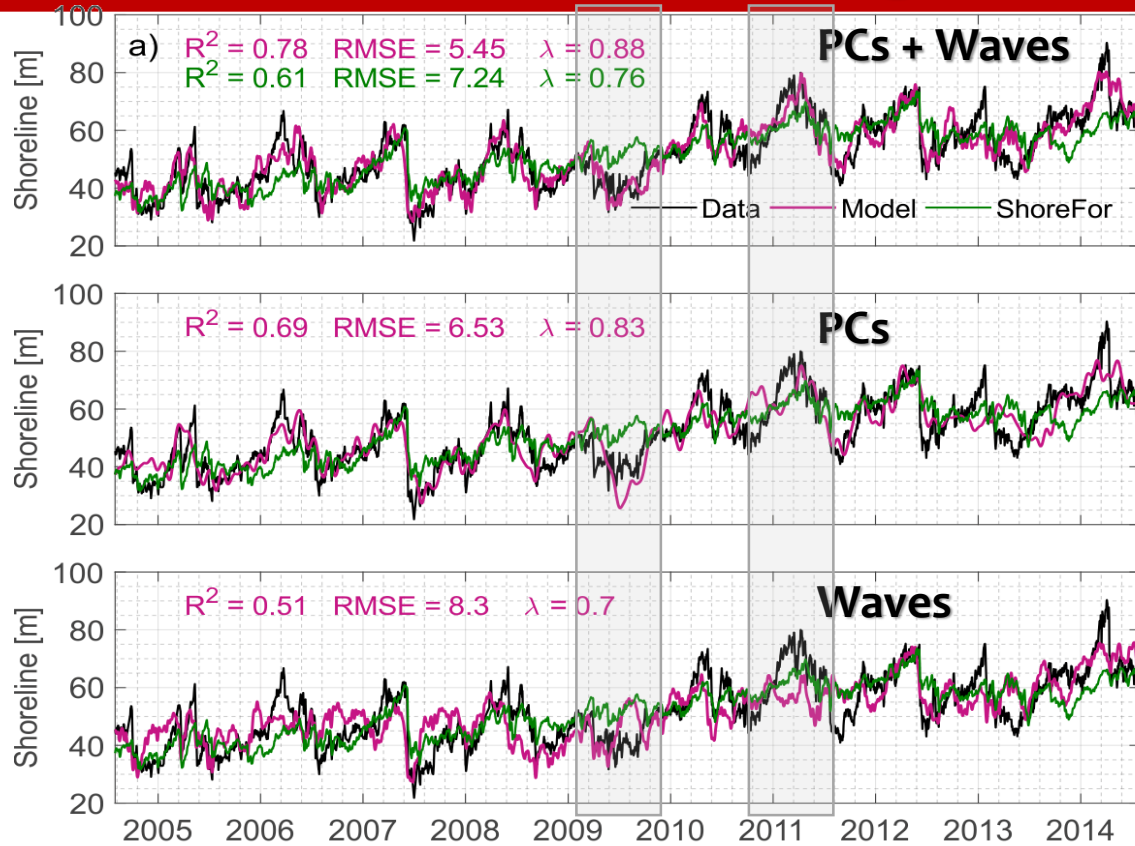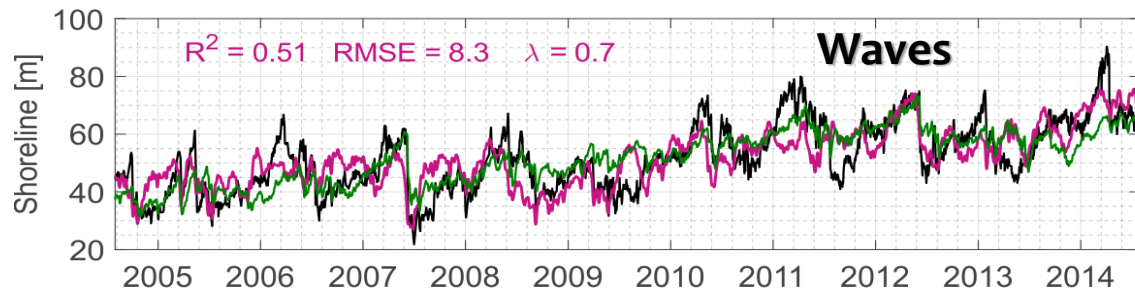
Extracting Information from the time-scales

Tairua, New Zealand

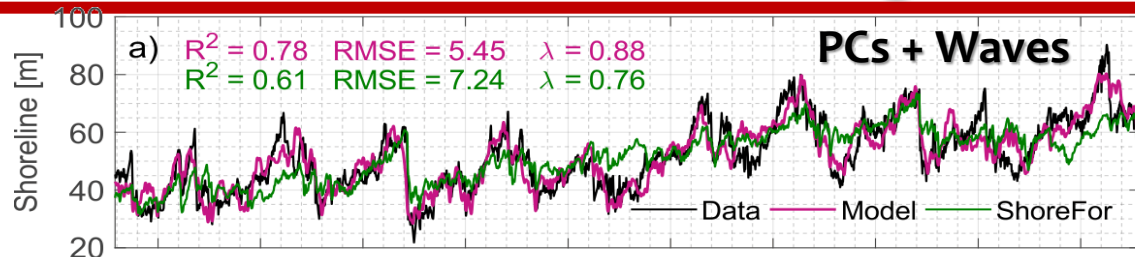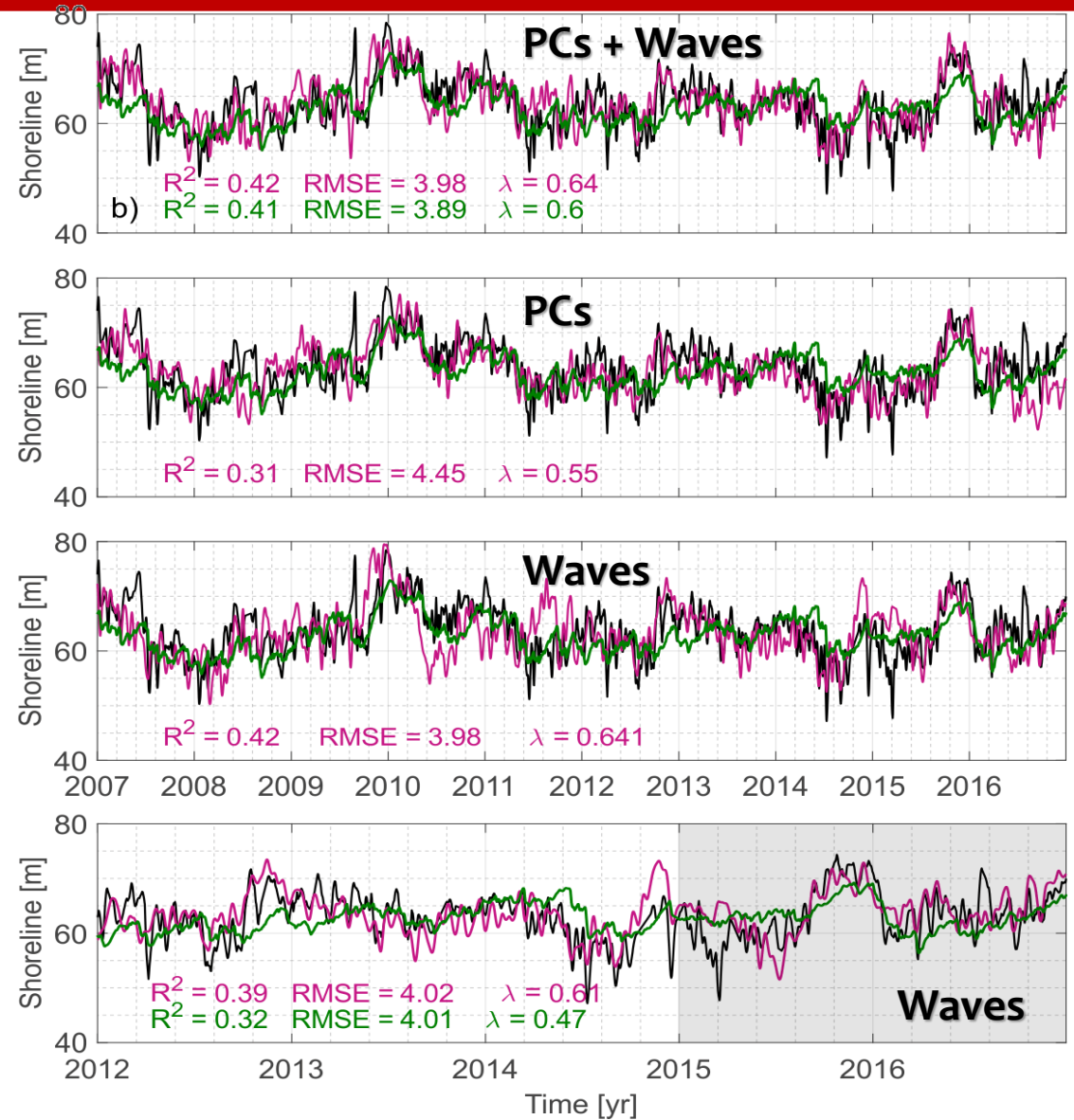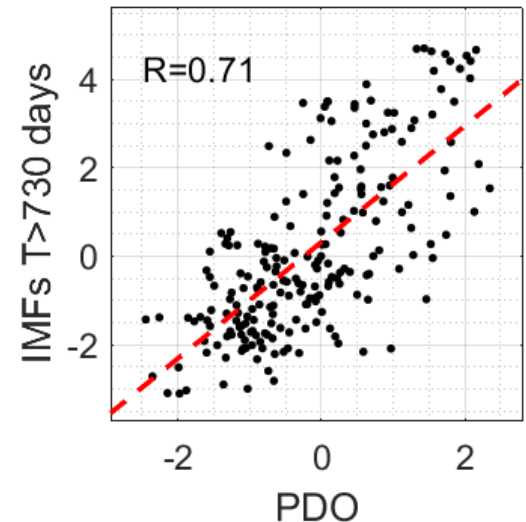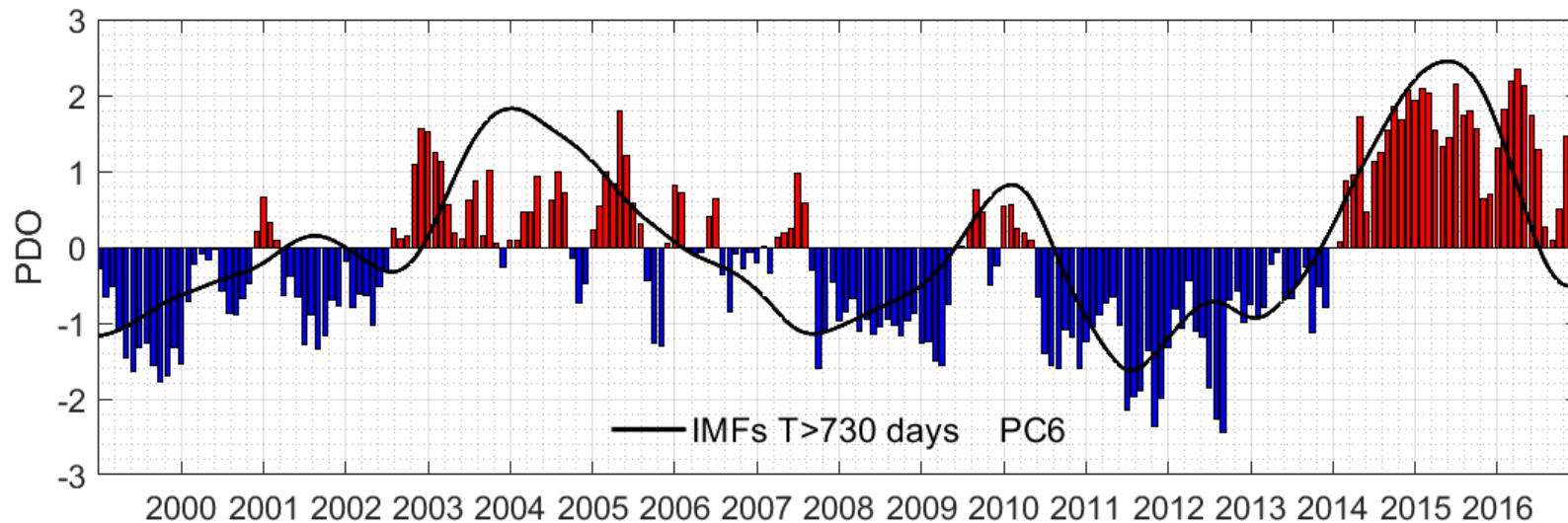| Shoreline		Driver		Coefficient	Rxy
Period	**E. V (%)**	ST	5	-4.5	-0.44
30	8.0	8	18	-1.6	-0.23
		1	10	2.6	0.22
		3	22	3.3	0.22

Shoreline		Driver	Coefficient	Rxy	SOI	PDO
Period	**E. V (%)**	1	0.35	-0.84	**0.61**	**-0.62**
821.88	15.17	10	3.69	0.80	0.35	*0.50*
		7	2.52	-0.76	**0.43**	**-0.65**
		ST	-3.44	-0.76	**0.46**	**-0.47**
		3	-1.13	0.72	0.21	0.13
		5	-1.00	0.61	0.36	**-0.55**
		6	-1.52	0.42	*-0.51*	*0.71*

Summary and *future* work

- The shoreline position can be **decomposed** and **predicted** using an approach that **isolates** the main **temporal-scales.**

- During the **calibration** period the model **skillfully** reproduce the shoreline changes. However, model skill are reduced during the **forecast** period, although, it displays a better performance that ShoreFor Model.

- Shoreline position at **Narrabeen** is better predicted when **SLP** and **SLPG** principal components (PCs) are used.

- Shoreline position at **Tairua** is well predicted when only **wave characteristics** are used (Wave steepness and direction).
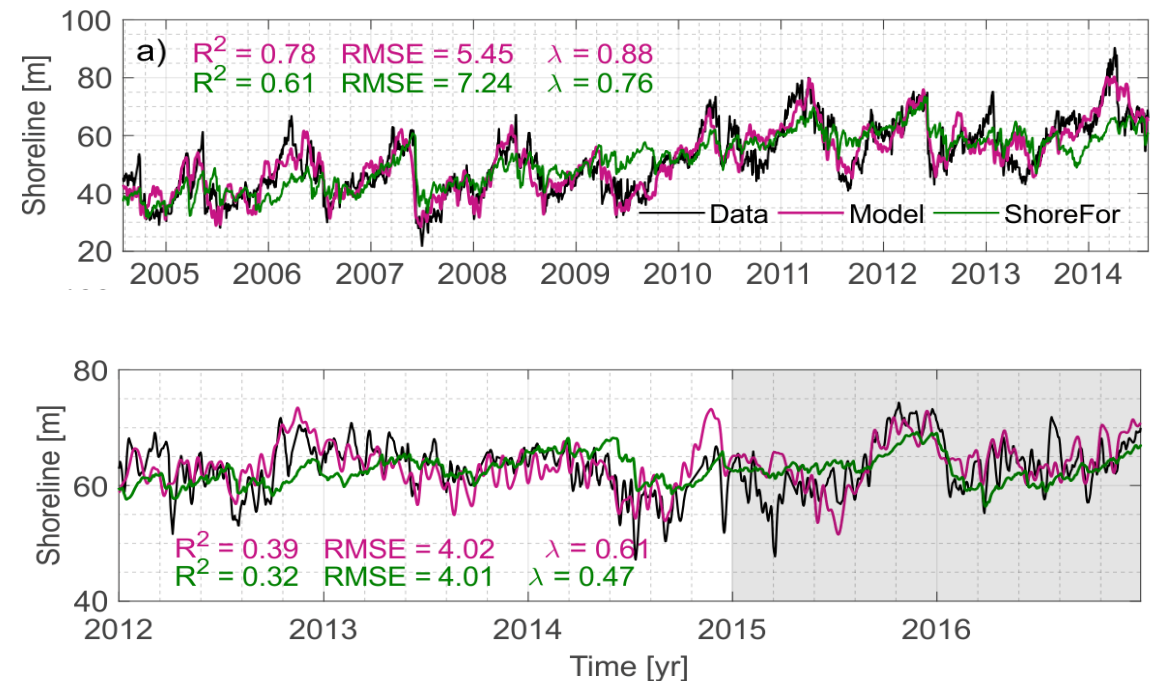
Summary and *future work*

- Longer time-scales (T > 550 days) in the **SLP** and **SLPG** principal components at **Narrabeen** were **related** with **SOI** and **PDO** index, weaker correlations were found with wave characteristics.

- Good correlations at longer time-scales (T >730 days) at **Tairua** were found with **wave** characteristics and **SLP** and **SLPG** and SOI and PDO index.

- Better correlations were found with **PDO** than **SOI**
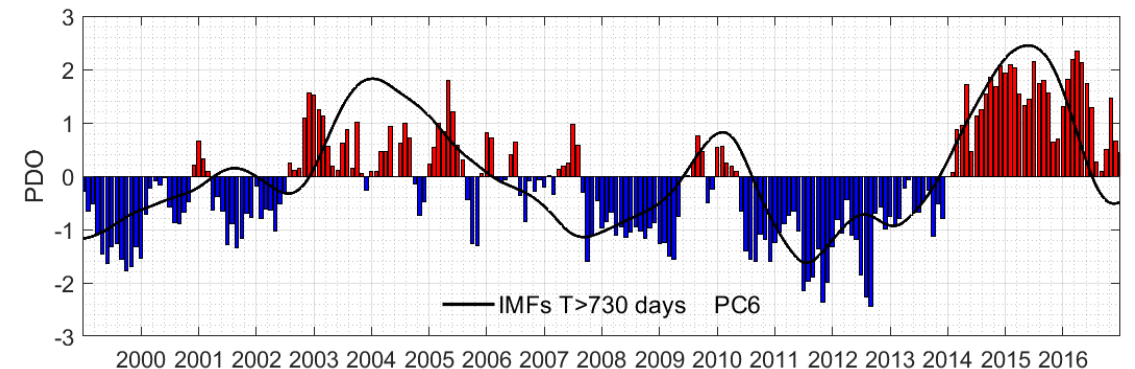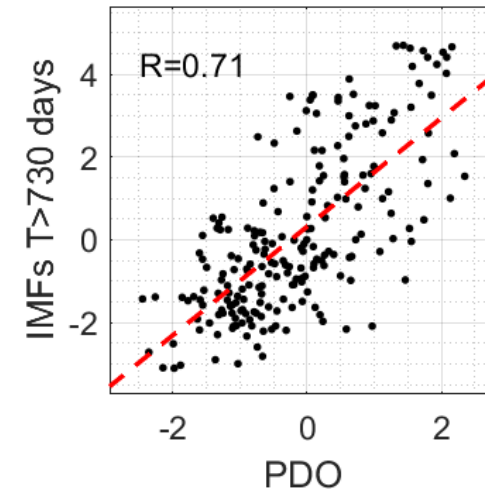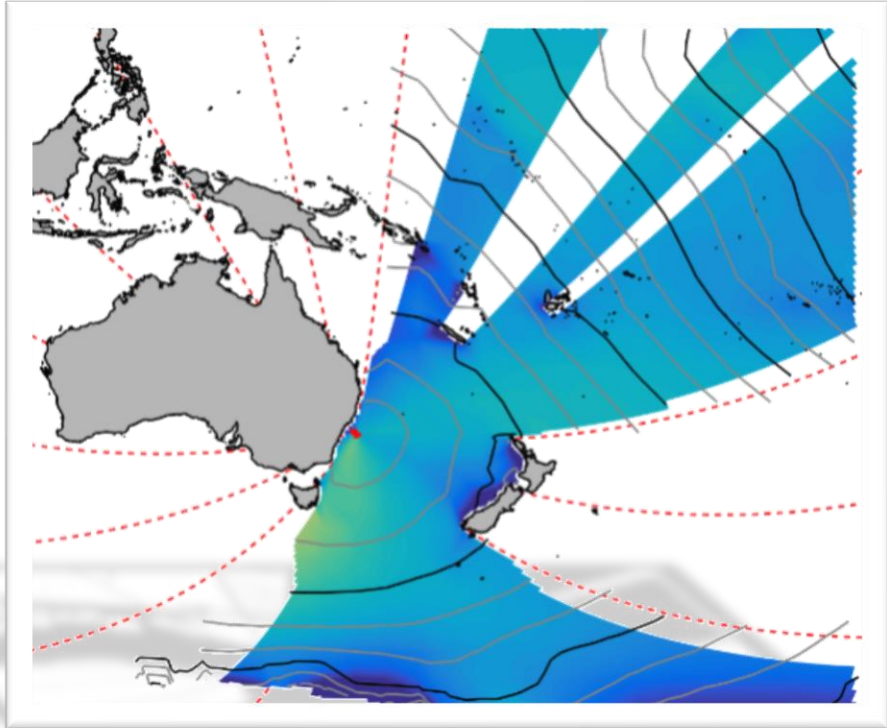
MERCI!!
THANKS!!!

Jennifer Montaño
jmon177@aucklanduni.ac.nz