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INSTITUTO DE HIDRÁULICA AMBIENTAL
UNIVERSIDAD DE CANTABRIA

Looking for Local Monthly Wave Climate Indices

Paula Camus, Fernando Méndez, Iñigo Losada, Melisa Menéndez, Antonio Espejo, Jorge Pérez, Ana Rueda, Yanira Guanche

Wave Climate and Climate Change Group
Environmental Hydraulics Institute "IHCantabria"

13TH INTERNATIONAL WORKSHOP ON WAVE HINDCASTING AND 4th COASTAL HAZARDS SYMPOSIUM
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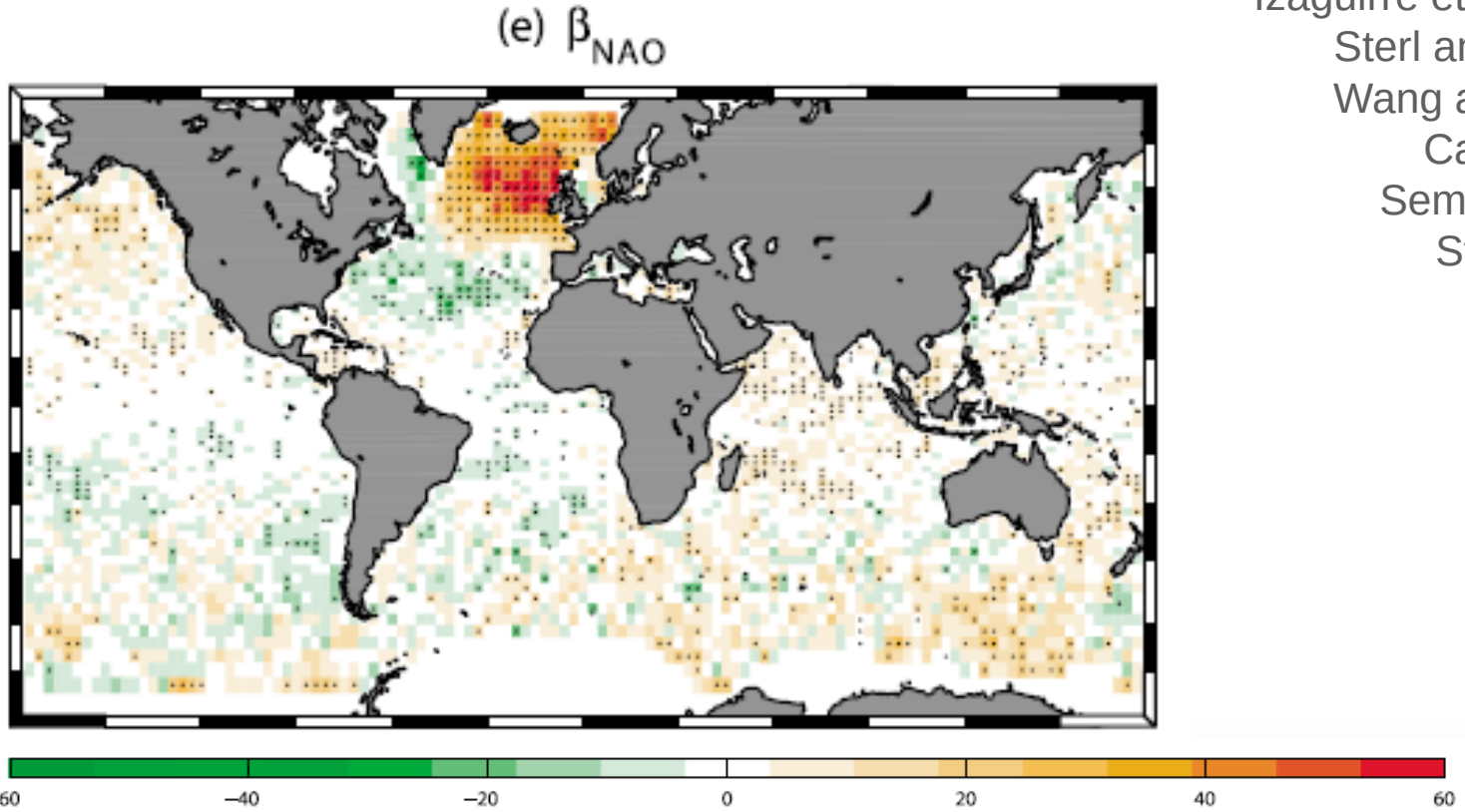
Well-known climate indices (PNA, SOI, Niño3, NAO, AO, SAM,..) have been used to explain wave climate variability

Gulev and Griegorieva (2006)
Hemer (2010)
Izaguirre et al. (2010, 2011)
Sterl and Caires (2005)
Wang and Swail (2001)
Caires et al.(2006)
Semedo et al. (2011)
Stopa et al.(2012)

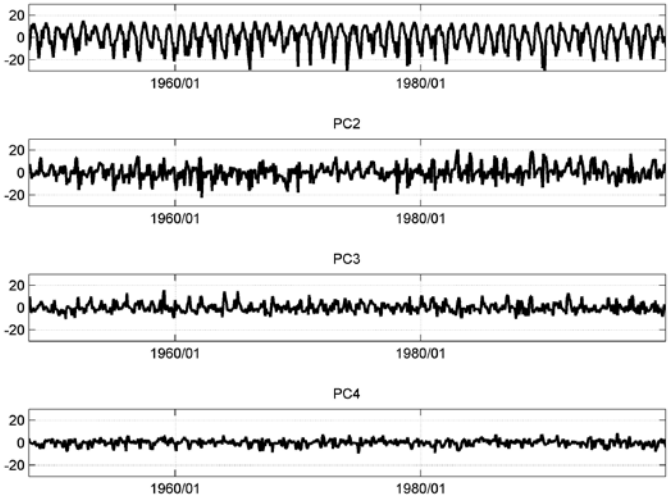


Spatial variability of the influence of climate indices in the location parameter of the wave extreme model (Izaguirre et al., 2011)

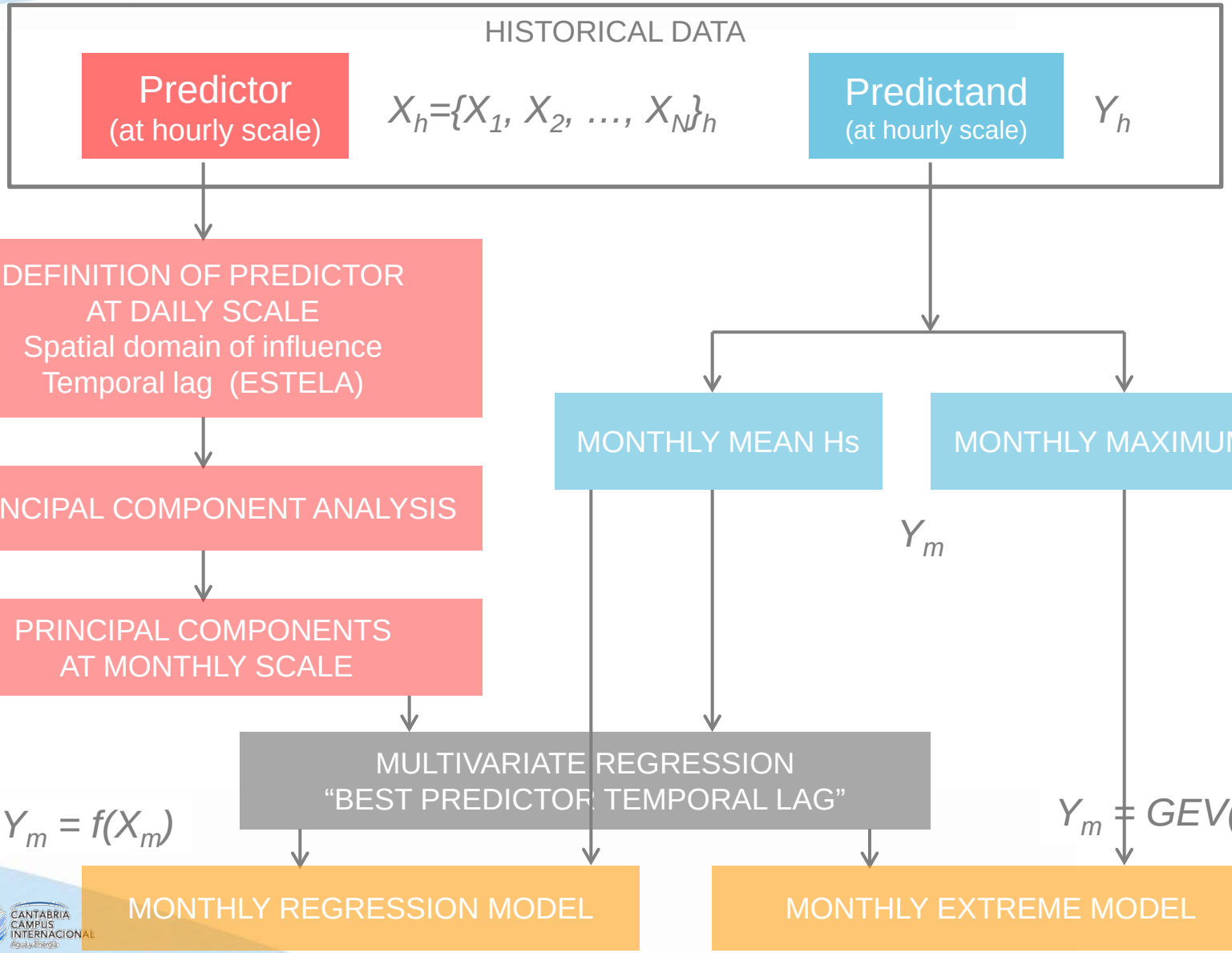
To find temporal coefficients of modes of atmospheric varibility strongly linked to wave climate at particular location

$X_m = \{X_1, X_2, \ldots, X_N\}_m$

Y_m



$$Y_m = f(X_m)$$

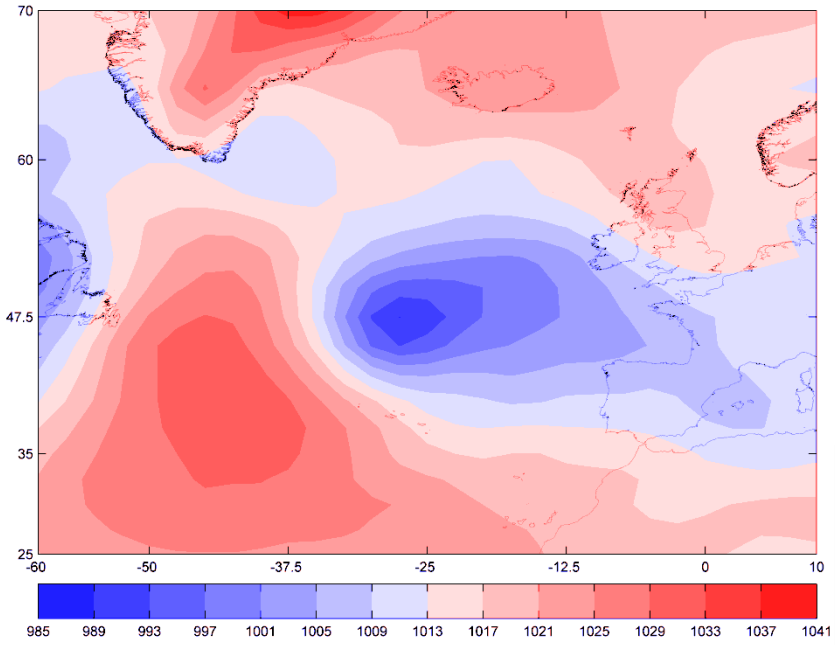

HISTORICAL DATA
Predictor
(at hourly scale)
$X_h=\{X_1, X_2, \ldots, X_N\}_h$
Predictand
(at hourly scale)
Y_h
DEFINITION OF PREDICTOR
AT DAILY SCALE
Spatial domain of influence
Temporal lag (ESTELA)
X_d
PRINCIPAL COMPONENT ANALYSIS
PRINCIPAL COMPONENTS
AT MONTHLY SCALE
X_m
MONTHLY MEAN Hs
MONTHLY MAXIMUM Hs
Y_m
MULTIVARIATE REGRESSION
"BEST PREDICTOR TEMPORAL LAG"
$Y_m = f(X_m)$
$Y_m = GEV(X_m)$
MONTHLY REGRESSION MODEL
MONTHLY EXTREME MODEL

HISTORICAL DATA

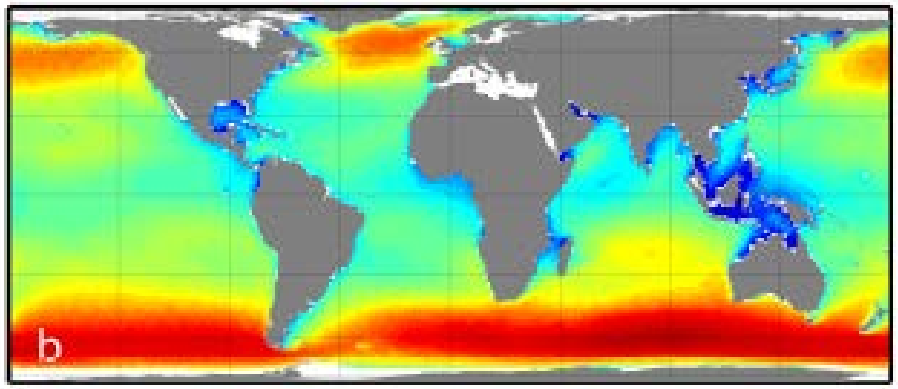
Predictor

Predictand

NCEP reanalysis (SLP), 1948-2010
Time resolution: 6 h
Spatial resolution: 2.5º
Kalnay et al., 1996

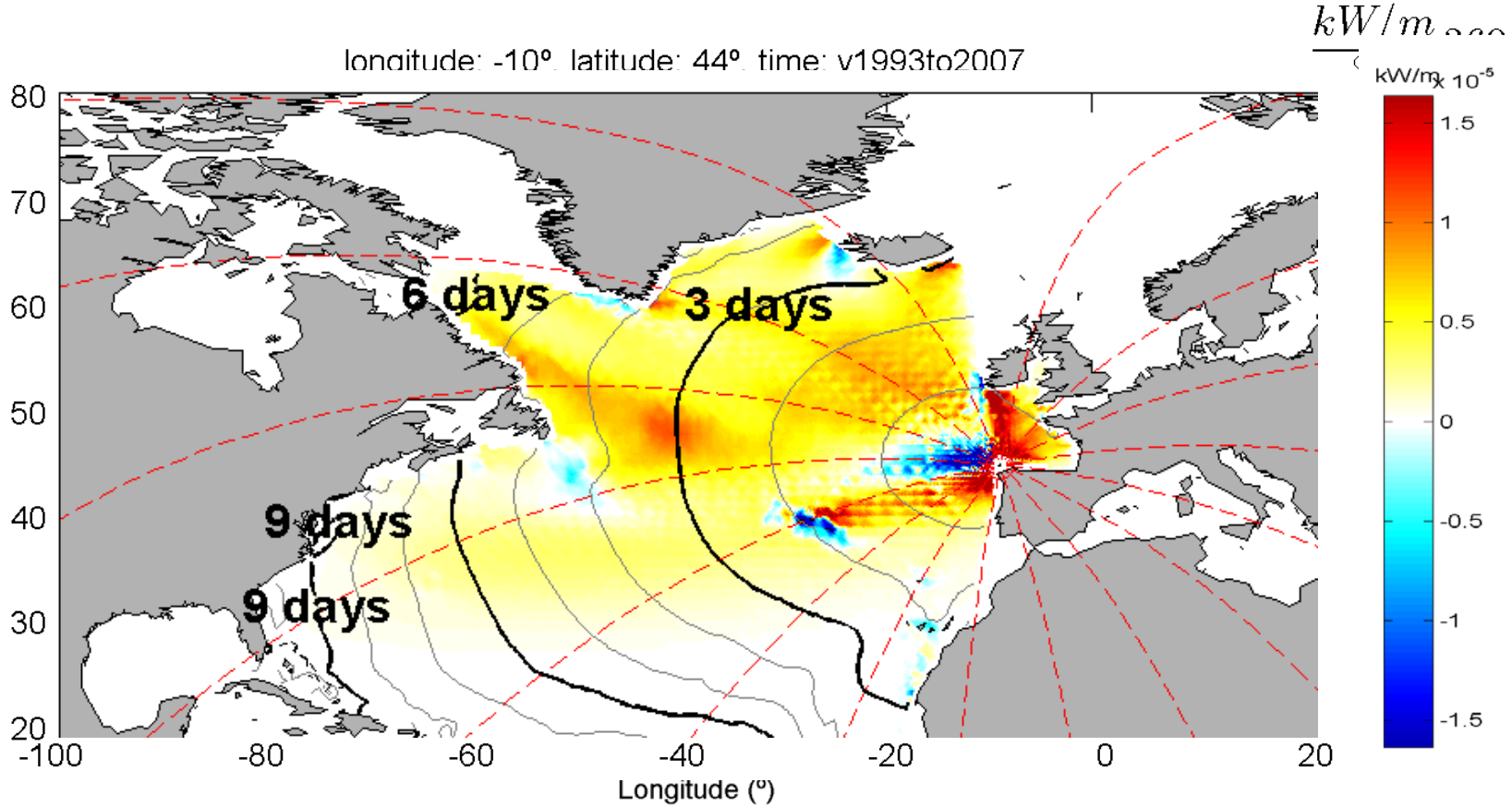


GOW reanalysis, 1948-2010
Time resolution: hourly
Spatial resolution: 1.5º in longitude and 1.0º in latitude
Reguero et al., 2012



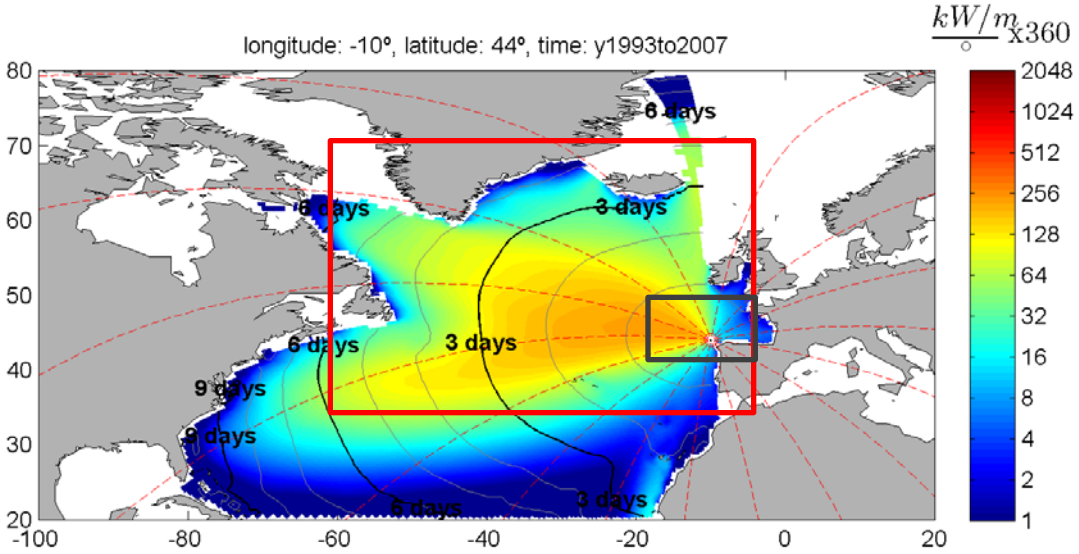
DEFINITION OF PREDICTOR AT DAILY SCALE: Spatial domain and temporal lag

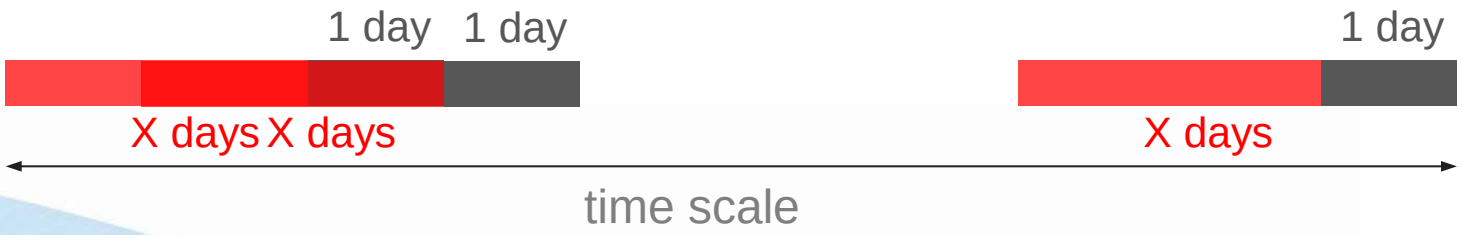
ESTELA (Pérez et al., 2013)



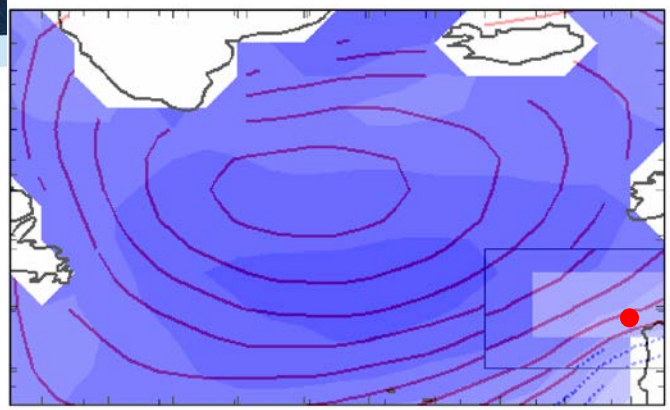
DEFINITION OF PREDICTOR AT DAILY SCALE:

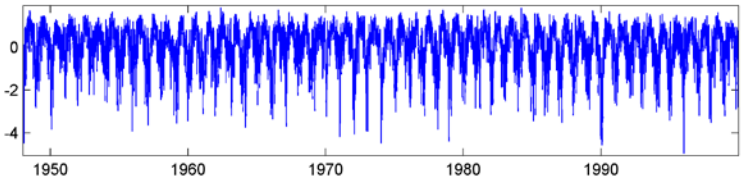
Spatial domain and temporal lag ESTELA (Pérez et al., 2013)

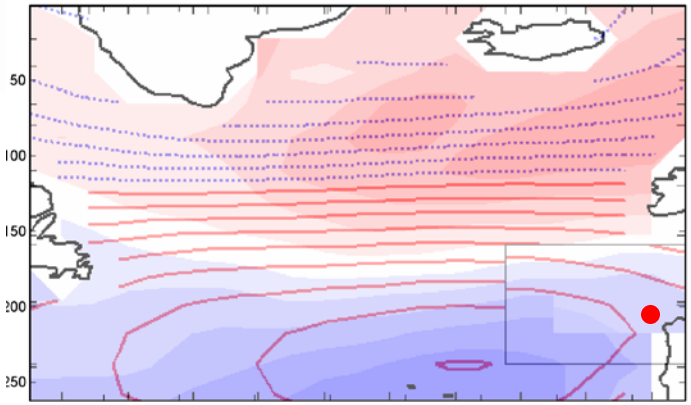


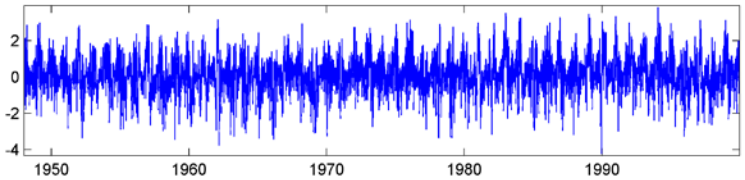


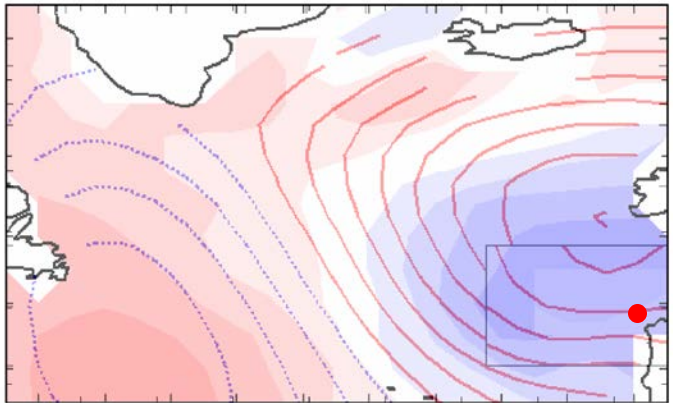
PRINCIPAL COMPONENT ANALYSIS

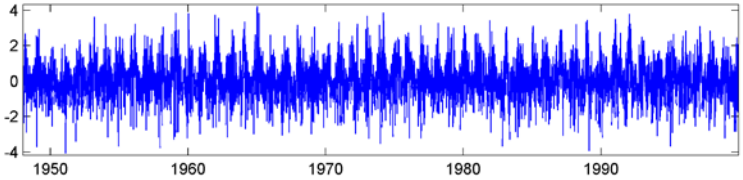


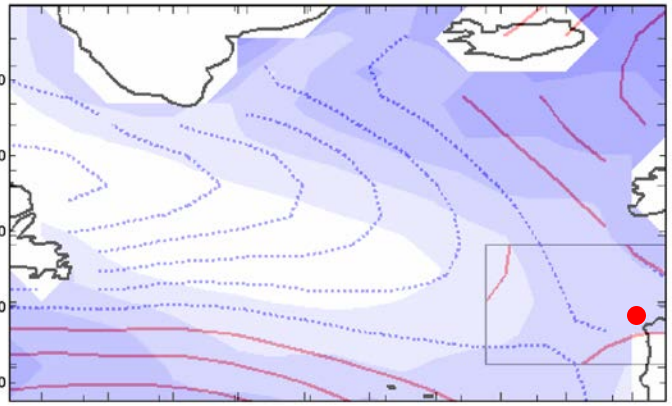


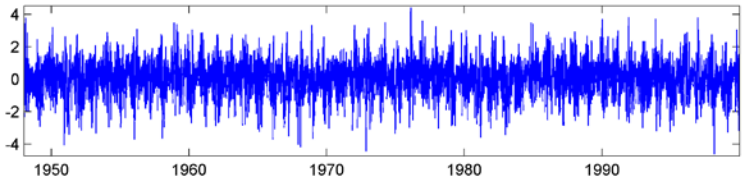






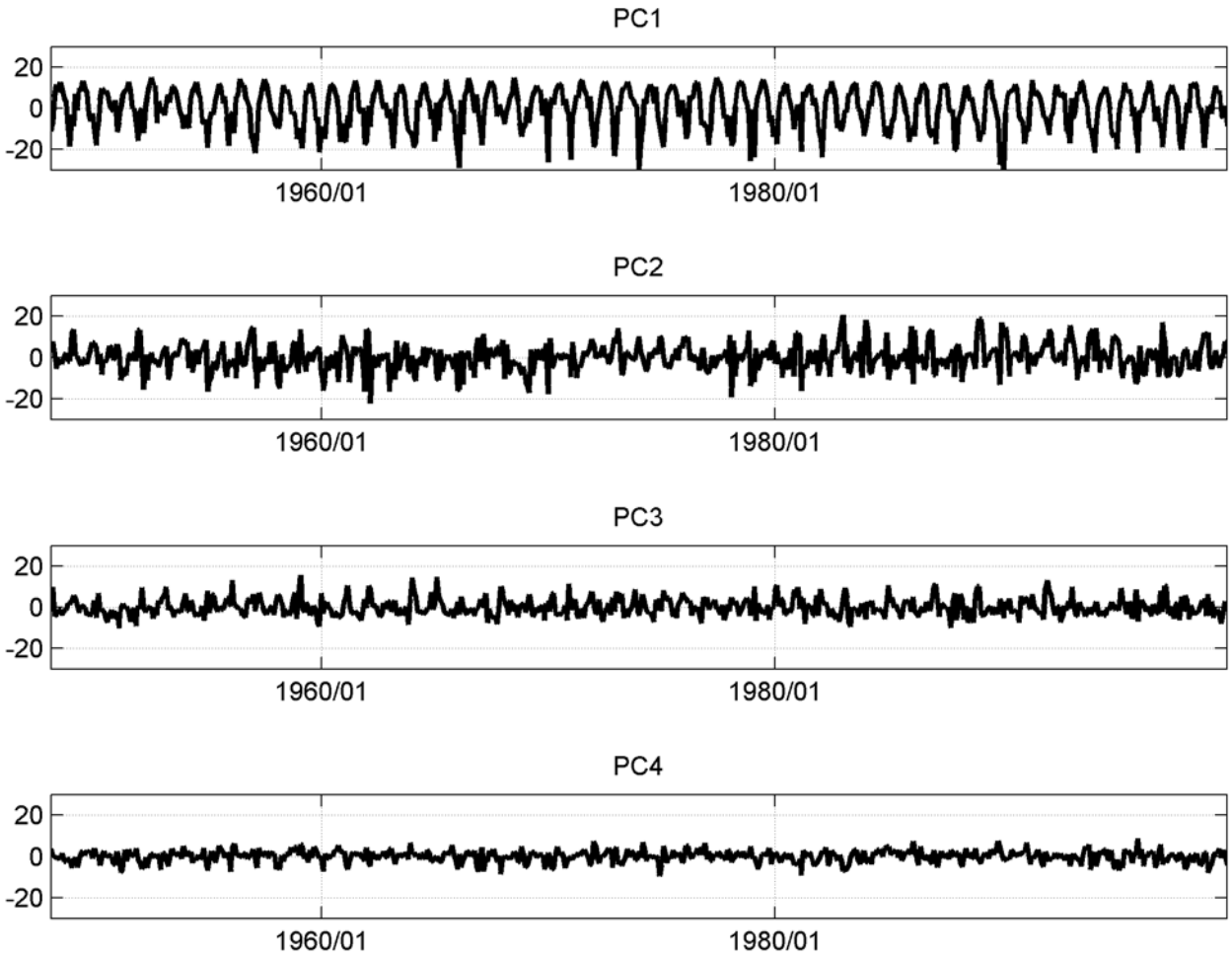


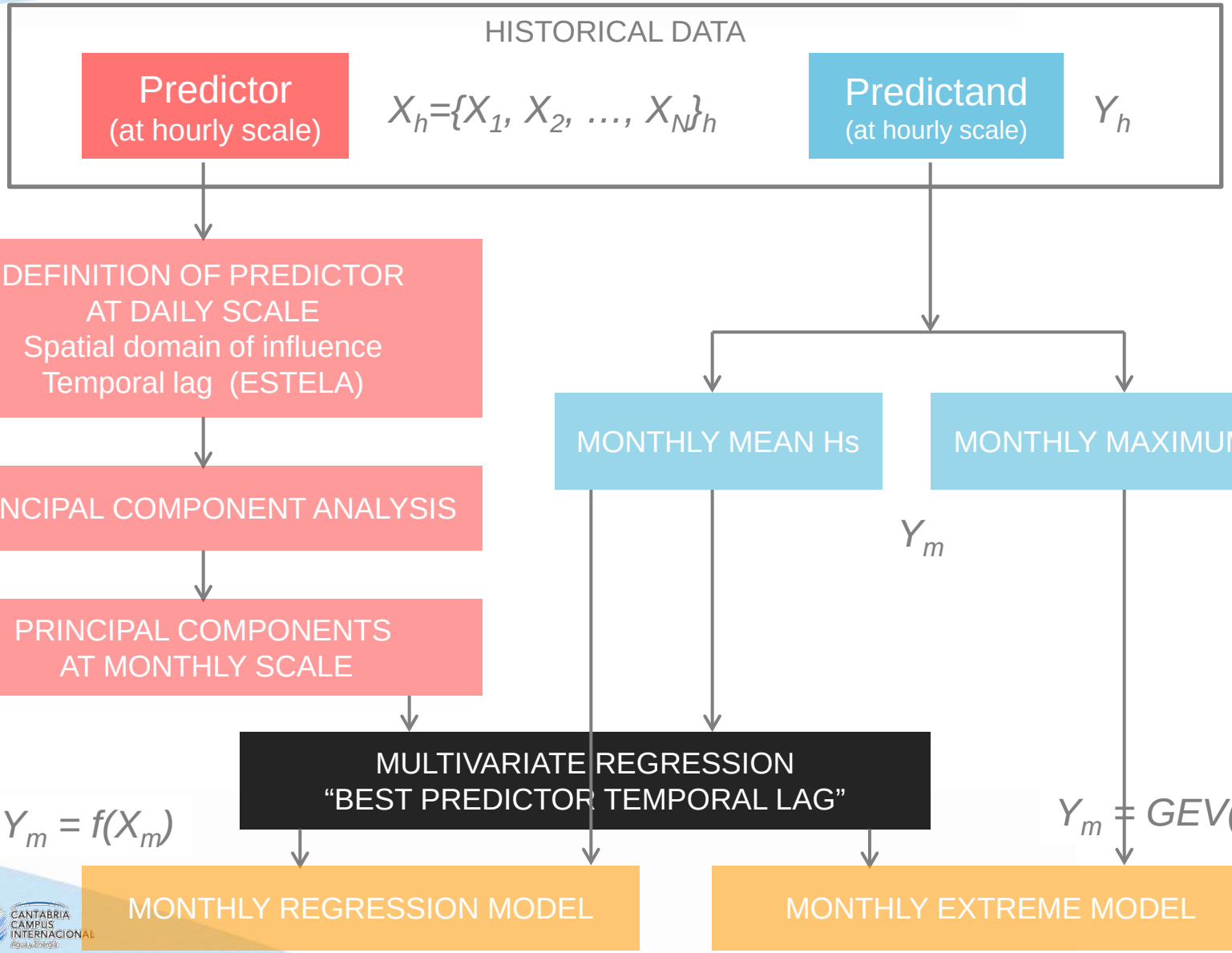




PRINCIPAL COMPONENTS AT MONTHLY SCALE

$$X_m = \{ PC1_m, PC2_m , \ldots, PCN_m \}$$

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MONTHLY EXTREME MODEL

MULTIVARIATE LINEAR REGRESSION

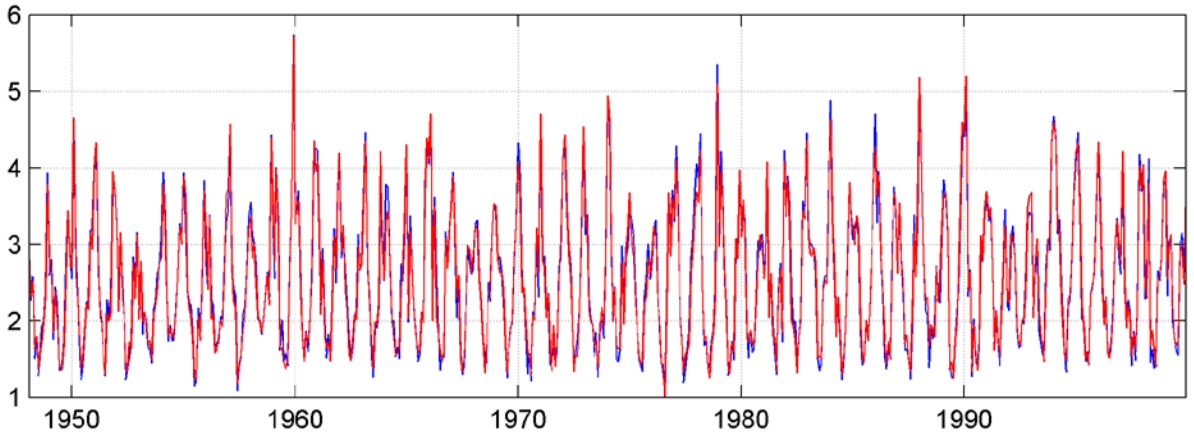
Predictors are selected in a forward procedure (Wang et al., 2010) $Y_m = f(X_m)$
Calibration period: 1948 - 1999

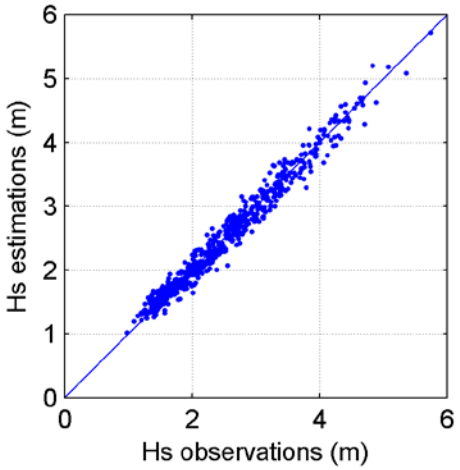
$$M_1 : Y_m(t) = a + b_1 PC_m^1(t)$$

$$M_2 : Y_m(t) = a + b_1 PC_m^1(t) + b_2 PC_m^2(t)$$

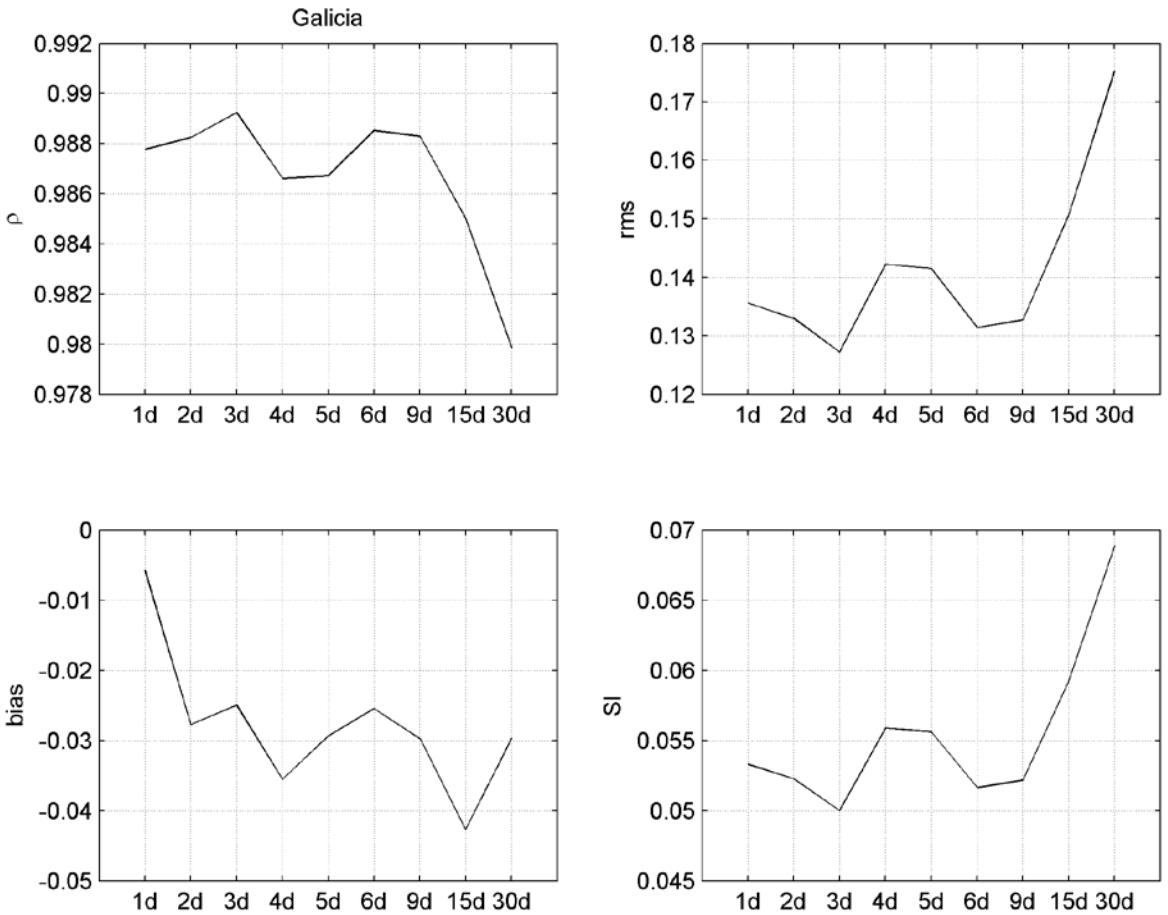
...

$$M_i : Y_m(t) = a + \sum_1^i b_i PC_m^i(t)$$





Sensitivity analysis - BEST TEMPORAL LAG

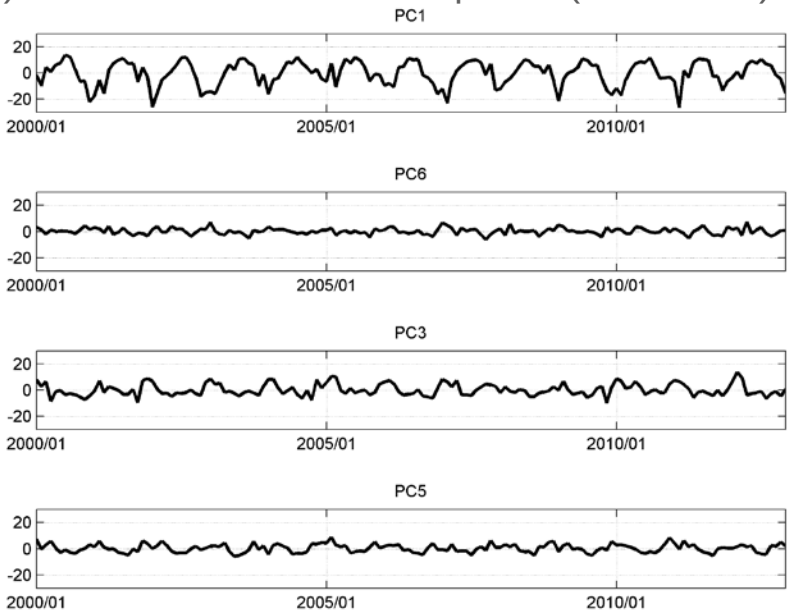


MONTHLY REGRESSION MODEL

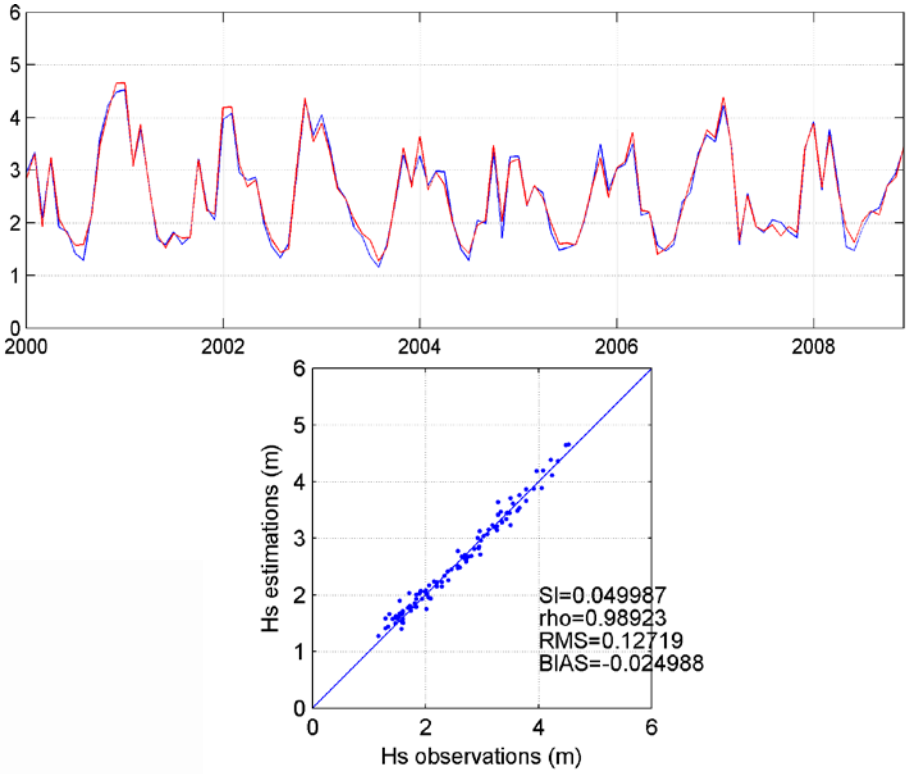
Validation of the regression model with the “best predictor”

$$Y_m(t) = 2.8424 - 0.8462 * PC1_m(t) + 0.2666 * PC6_m - 0.2343 * PC3_m + 0.1830 * PC5_m + \ldots$$

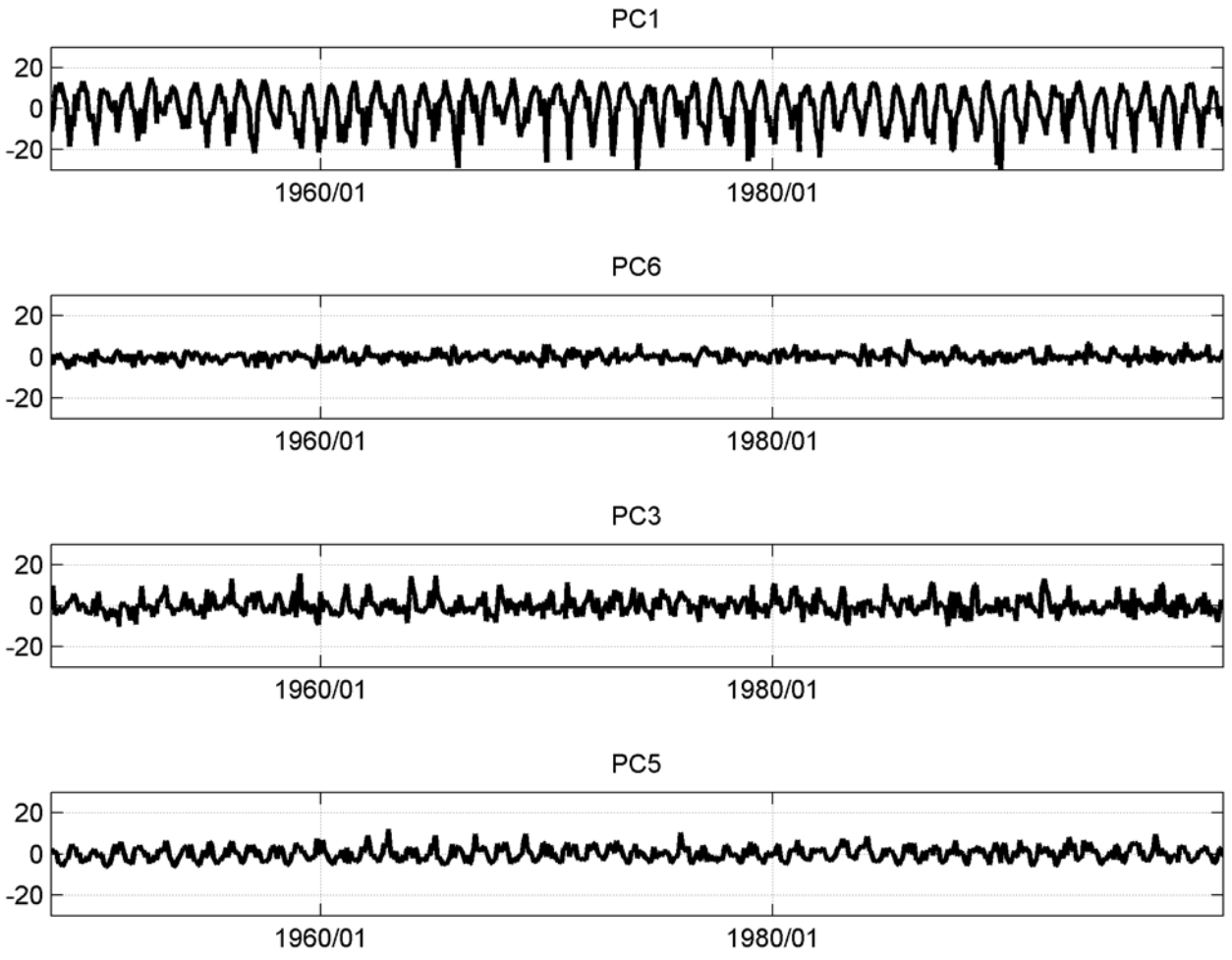
a) Predictor in the validation period (2000-2010)



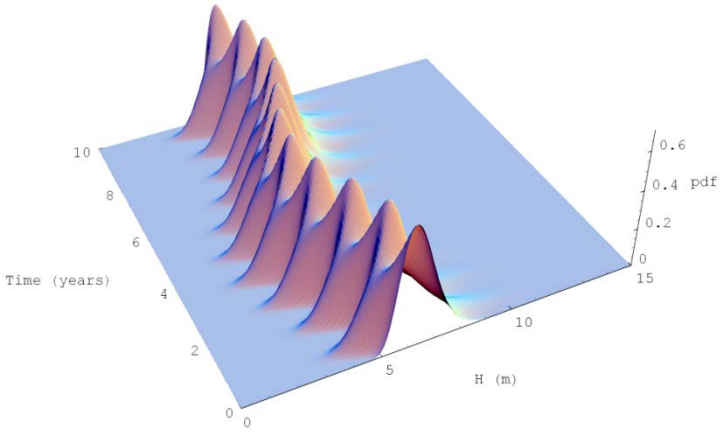
b) Results in the validation period (2000-2010)



MONTHLY REGRESSION MODEL - LOCAL MONTHLY WAVE CLIMATE INDICES



MONTHLY EXTREME MODEL



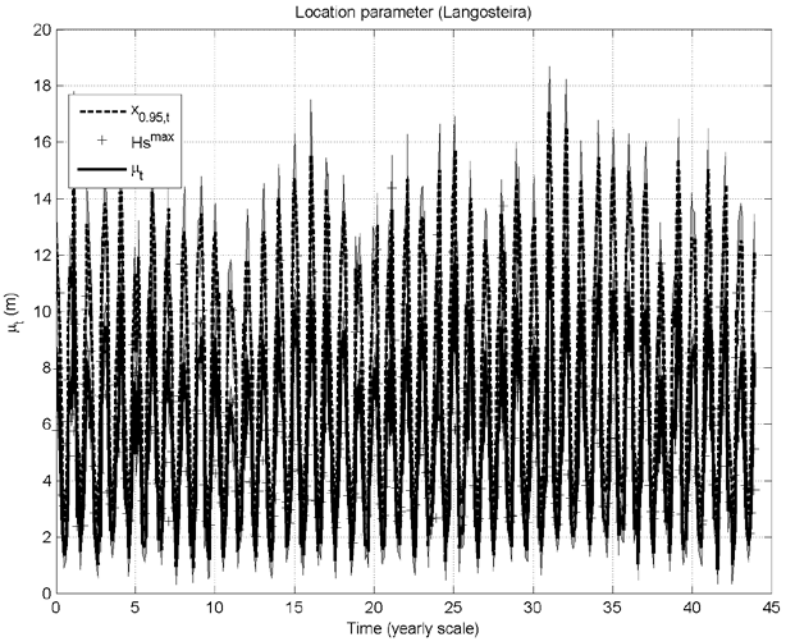
$$F(x;\theta) = \exp\left\{-\left[1+\xi\left(\frac{x-\mu}{\psi}\right)\right]^{-1/\xi}\right\}$$

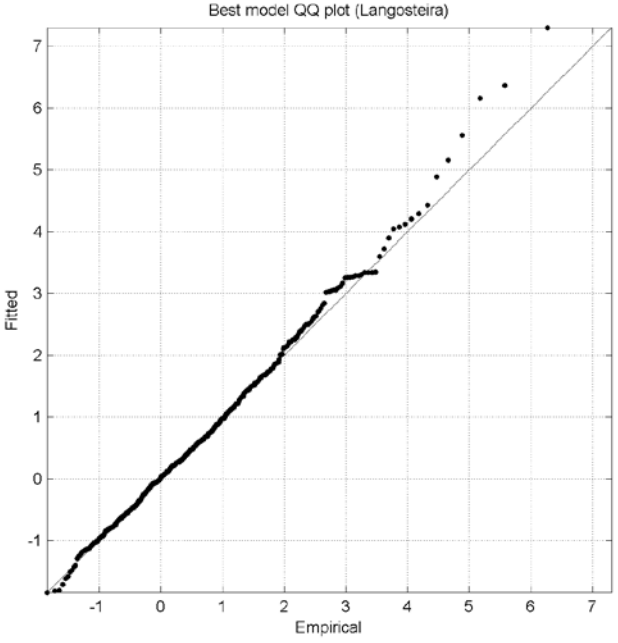
Mínguez et al., 2010

$\mu(t) = \beta_0 + \beta_1 * PC1_m + \beta_2 * PC2_m + \ldots$

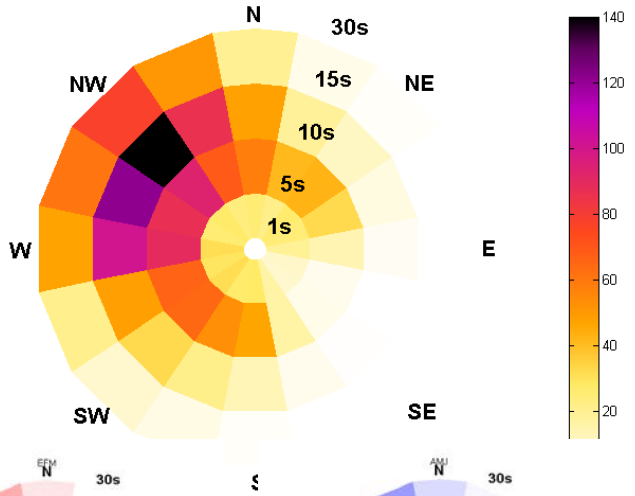
$\psi(t) = \alpha_0 + \alpha_1 * PC1_m + \alpha_2 * PC2_m + \ldots$

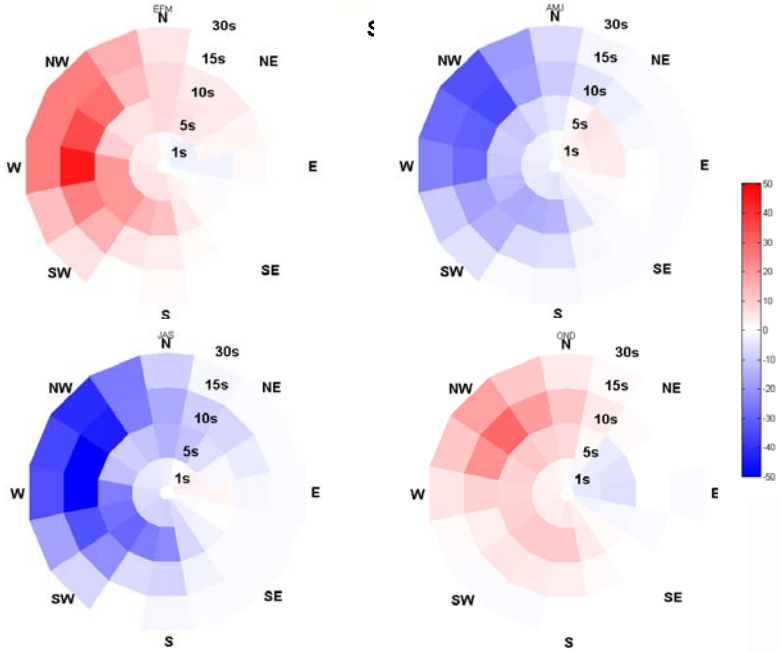
$\xi(t) = \gamma_0 + \gamma_1 * PC1_m + \gamma_2 * PC2_m + \ldots$

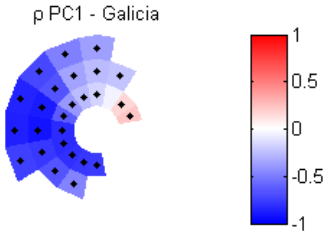


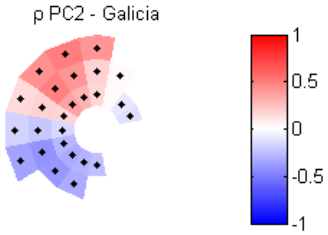


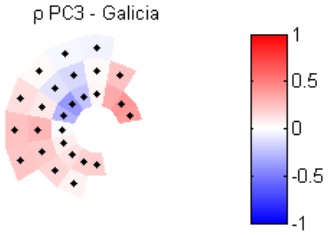
CORRELATION OF LOCAL MONTHLY INDICES WITH LOCAL WAVE CLIMATE

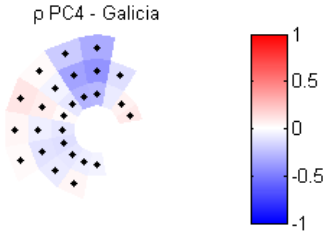


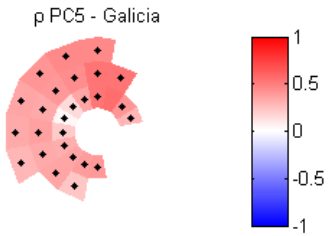


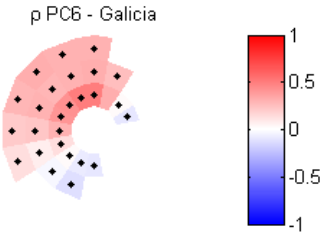




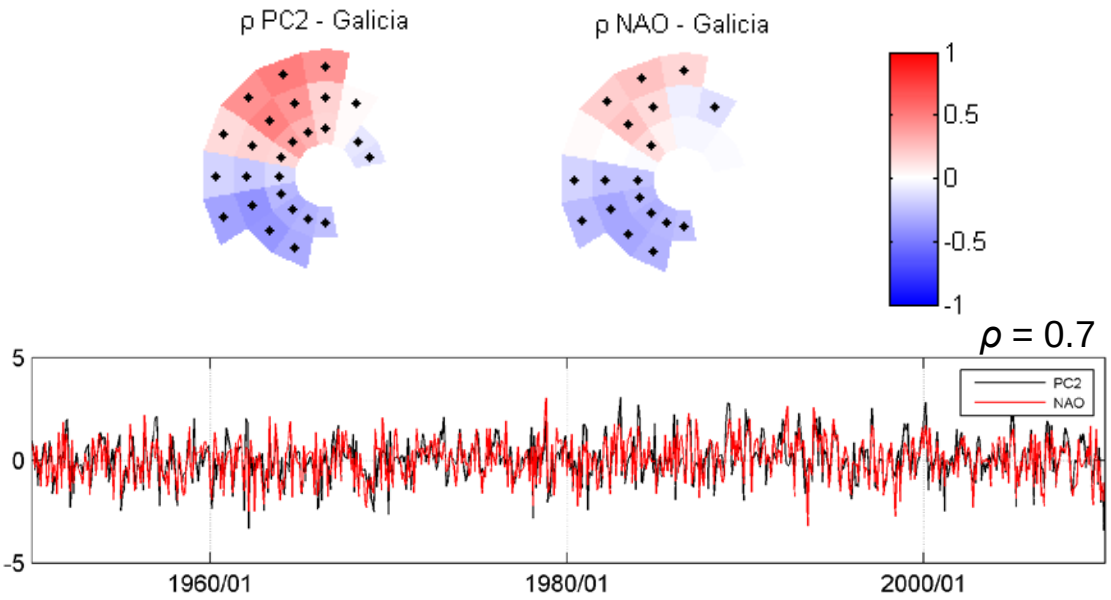


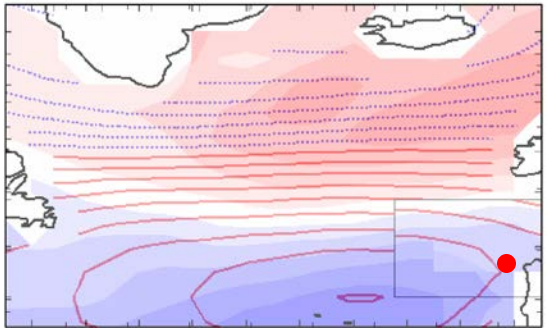


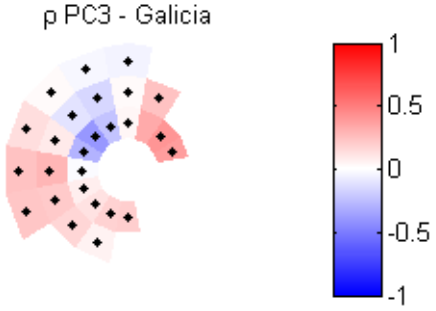


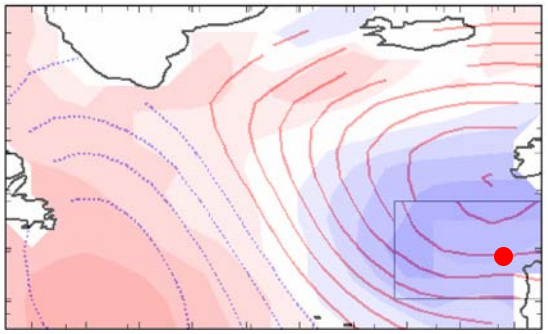


CORRELATION OF LOCAL MONTHLY INDICES WITH LOCAL WAVE CLIMATE

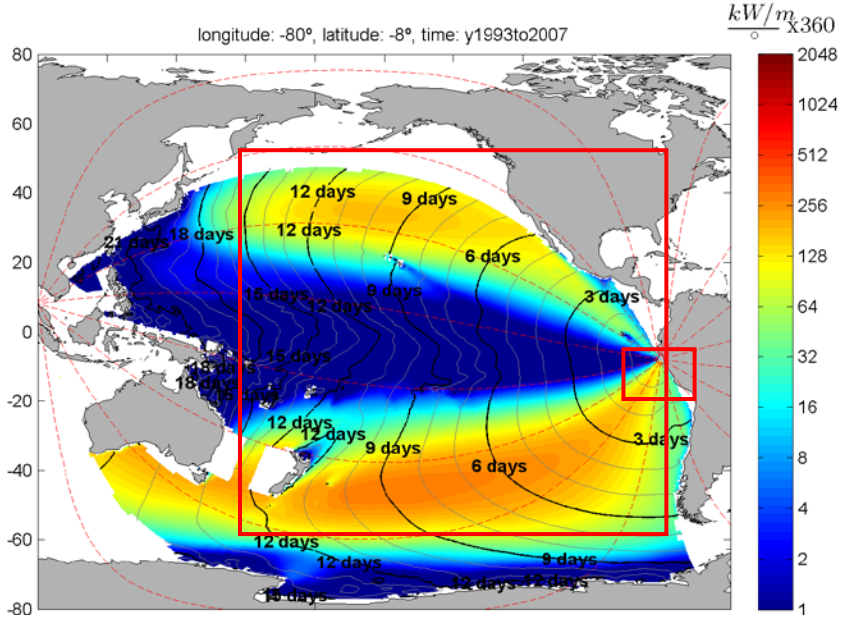


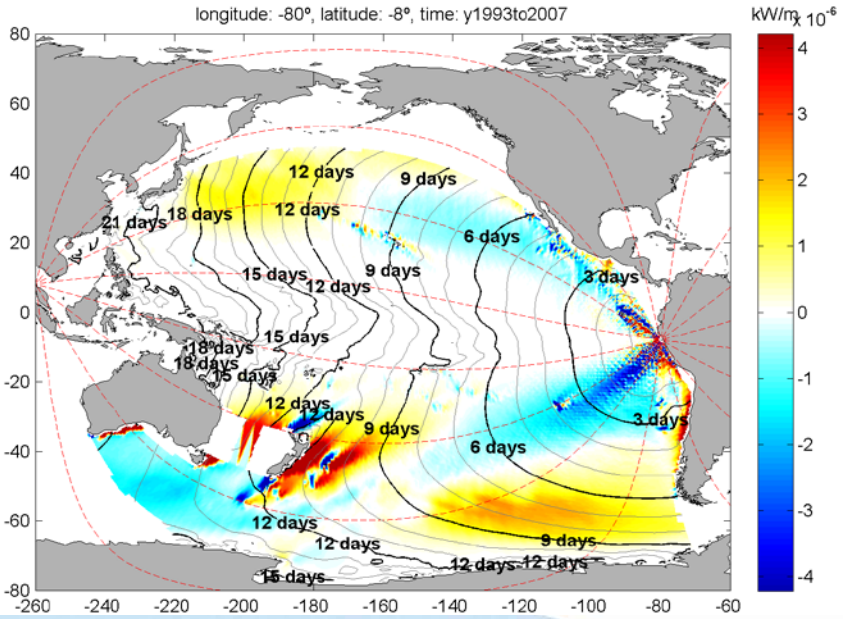






TRUJILLO (PERÚ)





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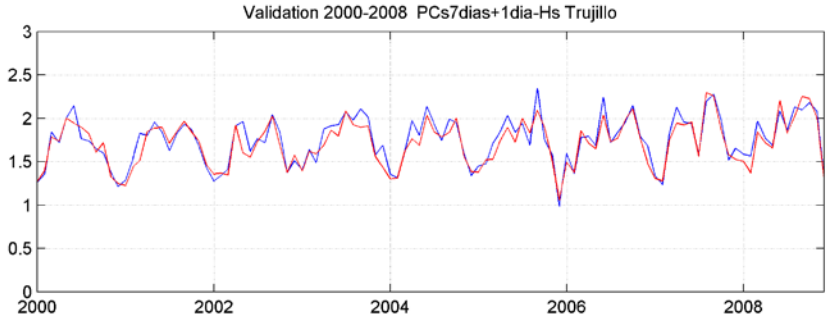
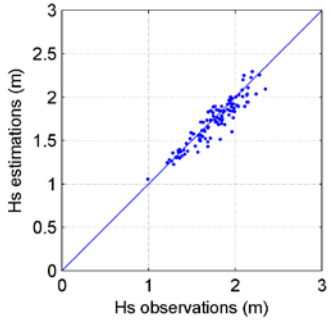




SI=0.06109

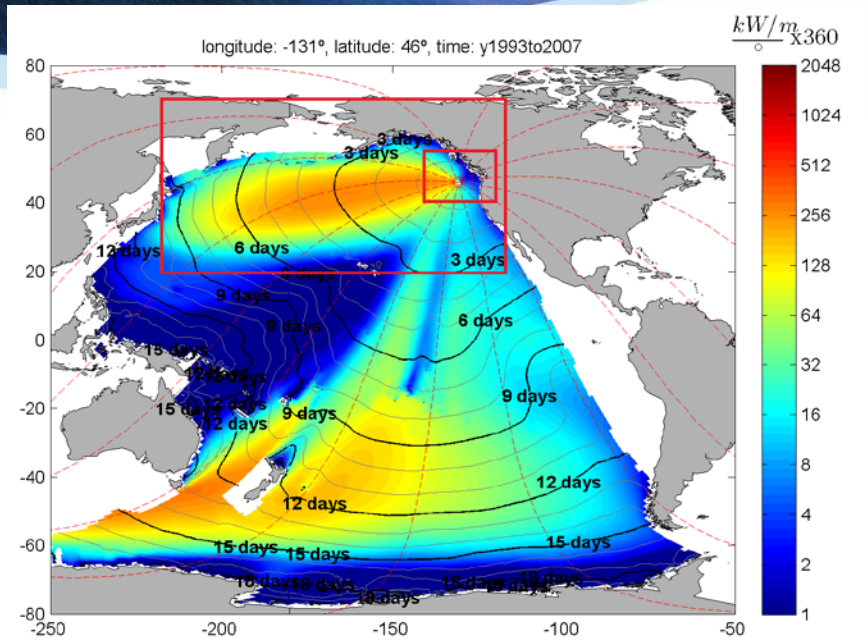
rho=0.93343

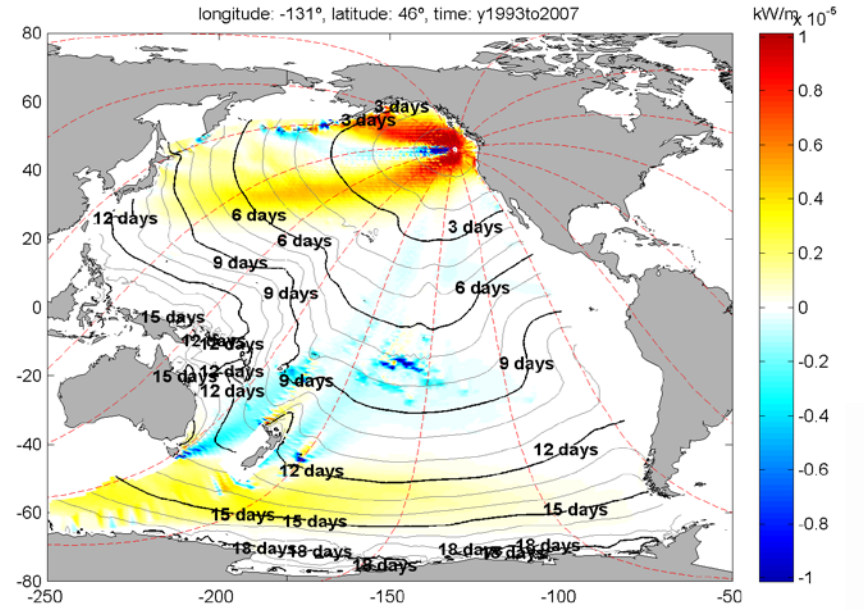
RMS=0.10673

BIAS=0.036409

Other applications

OREGON (USA)





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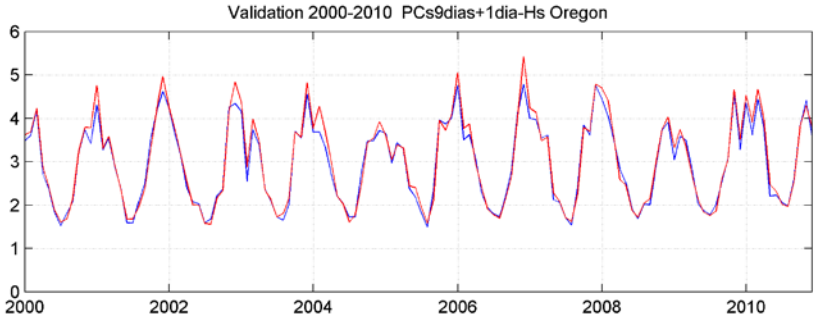

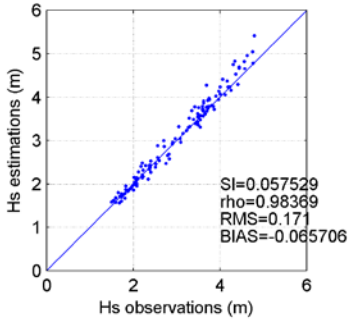

Conclusions

- A methodology to obtain local monthly wave climate indices has been proposed

- The methodology is based on the statistical relation between the atmospheric predictor (sea level pressure) and the local wave climate at a monthly scale

- The spatial domain and the temporal lag are the key properties of the wave predictor. The ESTELA method (Pérez et al., 2013) has been implemented to characterize the footprint of the wave climate at the particular location of interest and to automate the definition of the predictor spatial domain.

- The optimal temporal lag of the predictor in the area of influence of the local wave climate at particular location is obtained as the best solution of a multivariate regression model

- The monthly values of the principal components of predictor at a daily scale are the local indices.

- The local monthly indices obtained with this methodology improve the statiscal model fitting, both the monthly mean wave height and the monthly maximum wave height.

- This statistical downscaling approach can be used to project, for different CMIP5 climate models and in extratropical areas, monthly wave climate (long-term distributions, long-term extreme value distributions)

- Further research is needed to extend this methodology to tropical regions (tropical cyclones...)

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Wave Climate and Climate Change Group
Environmental Hydraulics Institute "IHCantabria"

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