Climate Variability of Extremes of Wave Height Using a Time-Dependent GEV Model

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Motivation

- Extreme sea states are critical for design and safety of coastal and offshore infrastructure
- **Significant wave height** (Hs) allows to characterize these conditions
- Climate change, seasonal variability and long-terms trends influence the extremes

Limitations:

- Classical Generalized Extreme Value distribution assumes stationarity

Objectives:

- Apply time-dependent GEV in **5-Day Maxima**
- Gain insights about climate variability of extreme events

Methodology

Time-dependent Generalized Extreme Value distribution:

$$G(x;\mu_t,\psi_t,\xi_t)=\begin{cases}\exp\left\{-\left[1+\xi_t\frac{x-\mu_t}{\psi_t}\right]^{-1/\xi_t}\right\}, & \xi_t\neq 0,\\ \exp\left\{-\exp\left[-\frac{x-\mu_t}{\psi_t}\right]\right\}, & \xi_t=0,\end{cases}$$

where

$$\mu_t=\beta_0+\sum_{i=1}^{P_\mu}\left[\beta_{2i-1}^{harm}\cos(2\pi it)+\beta_{2i}^{harm}\sin(2\pi it)\right]+\beta_{LT}t+\sum_{k=1}^{Q_\mu}\beta_k^{co}n_{k,t}$$

$$\log(\psi_t)=\alpha_0+\sum_{i=1}^{P_\psi}\left[\alpha_{2i-1}^{harm}\cos(2\pi it)+\alpha_{2i}^{harm}\sin(2\pi it)\right]+\alpha_{LT}t+\sum_{k=1}^{Q_\psi}\alpha_k^{co}n_{k,t}$$

$$\xi_t=\gamma_0+\sum_{i=1}^{P_\xi}\left[\gamma_{2i-1}^{harm}\cos(2\pi it)+\gamma_{2i}^{harm}\sin(2\pi it)\right]+\gamma_{LT}t+\sum_{k=1}^{Q_\xi}\gamma_k^{co}n_{k,t}$$

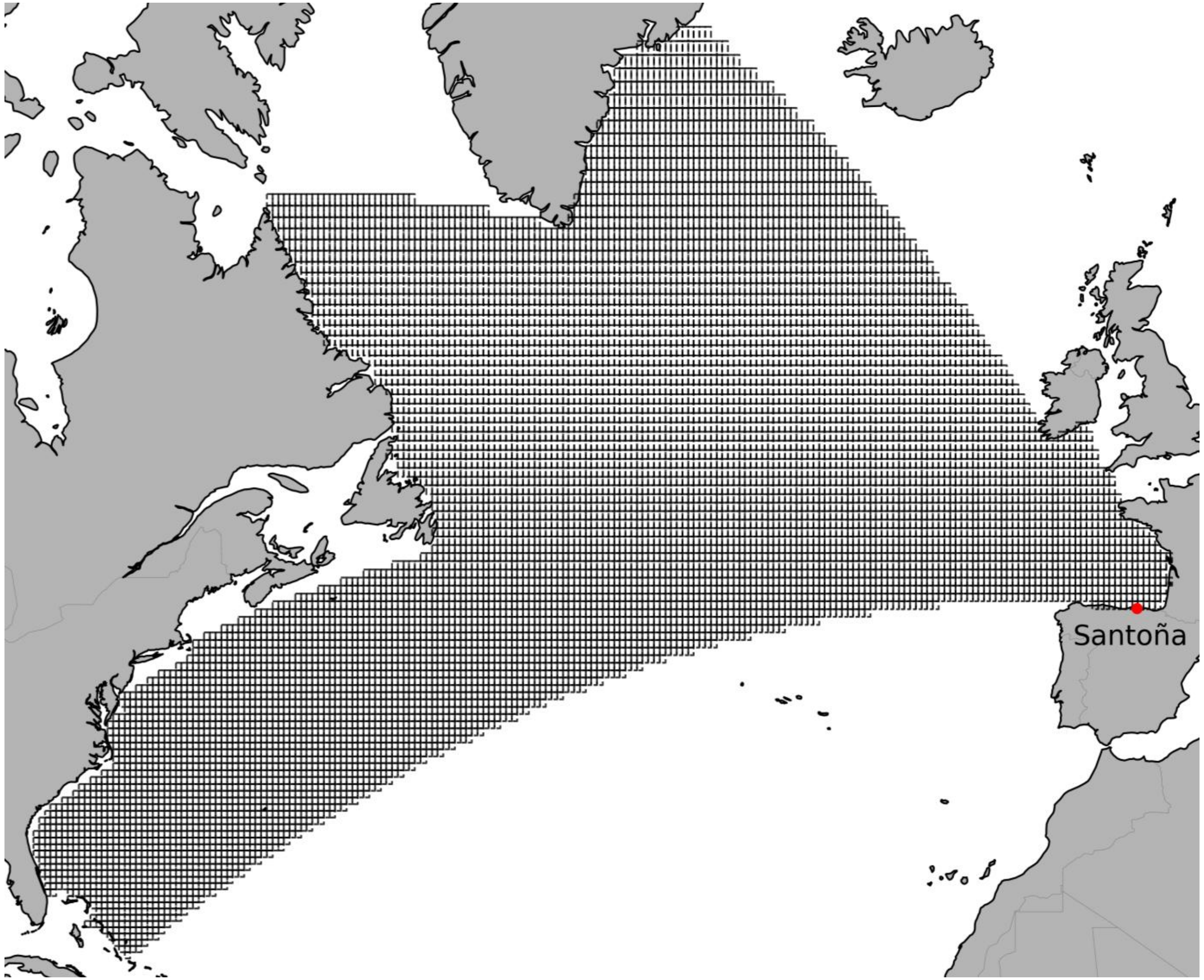
Data

Covariates:

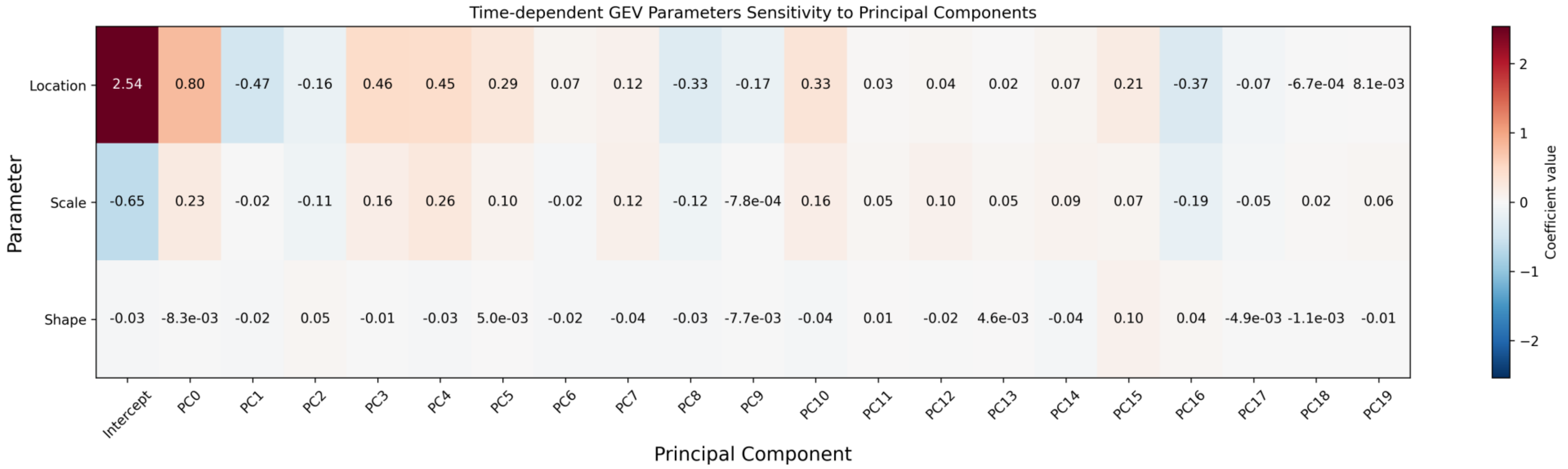
- MSLP
- Gradient of MSLP

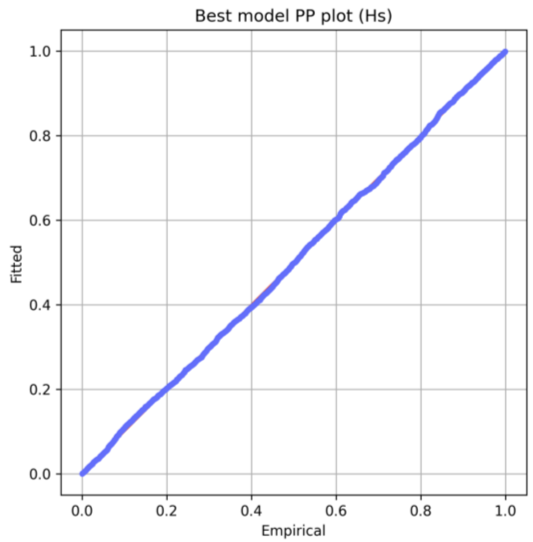
Pre-process:

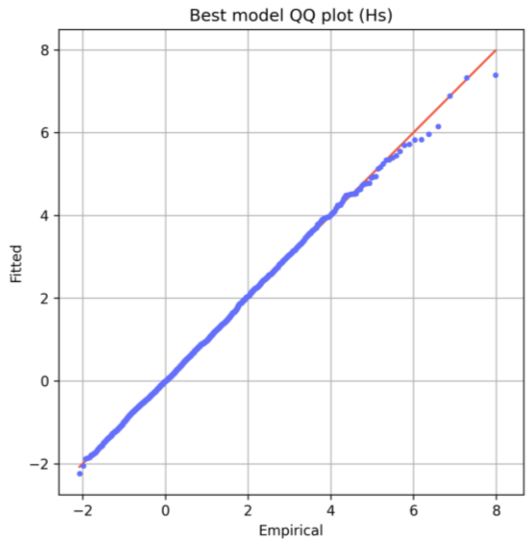
- PCA
- Scale



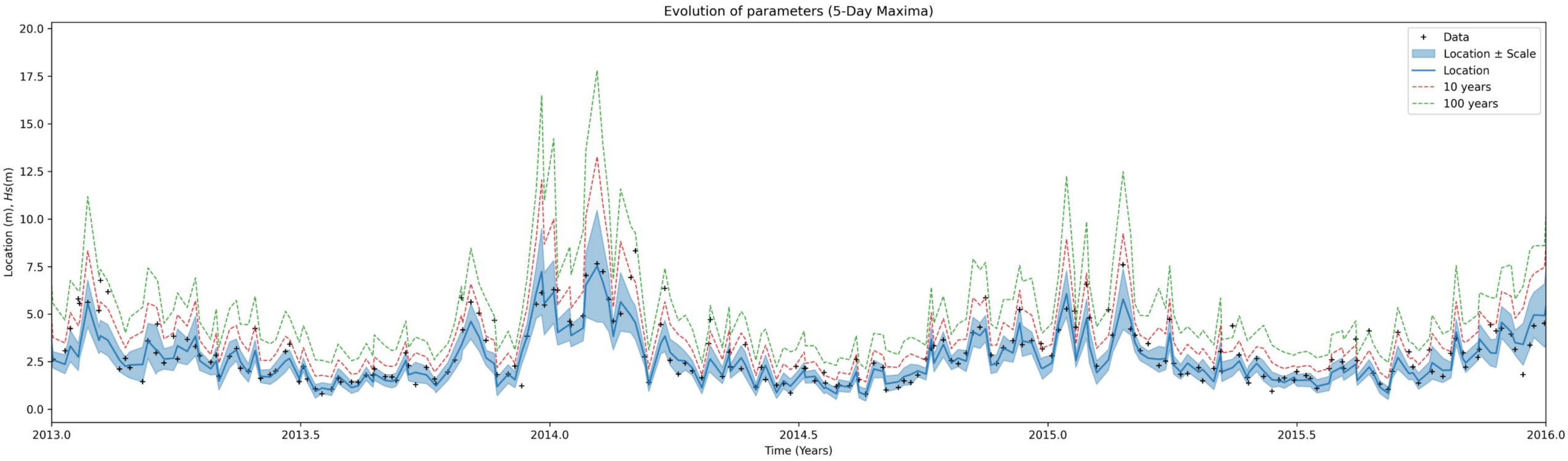
Results


Time-dependent GEV Parameters Sensitivity to Principal Components
Parameter
Location 2.54 0.80 -0.47 -0.16 0.46 0.45 0.29 0.07 0.12 -0.33 -0.17 0.33 0.03 0.04 0.02 0.07 0.21 -0.37 -0.07 -6.7e-04 8.1e-03
Scale -0.65 0.23 -0.02 -0.11 0.16 0.26 0.10 -0.02 0.12 -0.12 -7.8e-04 0.16 0.05 0.10 0.05 0.09 0.07 -0.19 -0.05 0.02 0.06
Shape -0.03 -8.3e-03 -0.02 0.05 -0.01 -0.03 5.0e-03 -0.02 -0.04 -0.03 -7.7e-03 -0.04 0.01 -0.02 4.6e-03 -0.04 0.10 0.04 -4.9e-03 -1.1e-03 -0.01
Intercept PC0 PC1 PC2 PC3 PC4 PC5 PC6 PC7 PC8 PC9 PC10 PC11 PC12 PC13 PC14 PC15 PC16 PC17 PC18 PC19
Principal Component
Coefficient value
2 1 0 −1 −2


Best model PP plot (Hs)
Fitted
Empirical
0.0 0.2 0.4 0.6 0.8 1.0

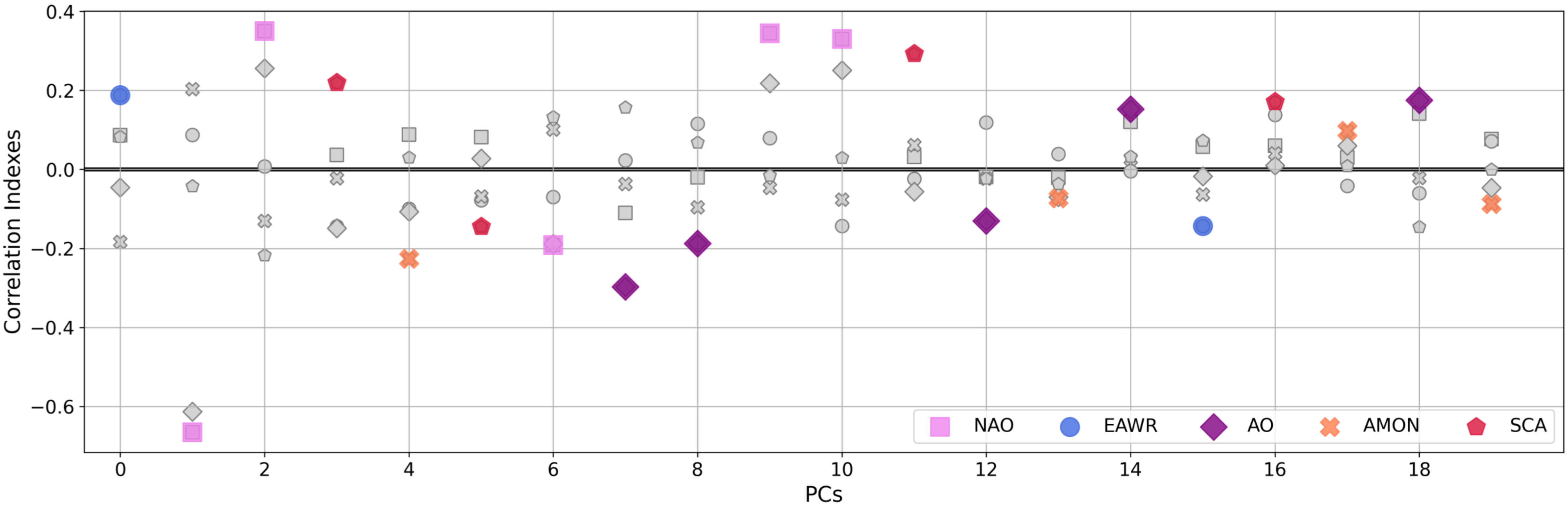

Best model QQ plot (Hs)
Fitted
Empirical
−2 0 2 4 6 8

Results



Evolution of parameters (5-Day Maxima)
Data
Location ± Scale
Location
10 years
100 years
Location (m), Hs(m)
Time (Years)
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
2013.0
2013.5
2014.0
2014.5
2015.0
2015.5
2016.0

Results



0.4
0.2
0.0
−0.2
−0.4
−0.6
Correlation Indexes
0
2
4
6
8
10
12
14
16
18
PCs
NAO
EAWR
AO
AMON
SCA

Conclusions and Future Work

- Climate variability enables the modelling of 5-Day Maxima of significant wave height using a time-dependent GEV model

- Future work: Condition the time-dependent GEV model to Weather Types to obtain physical interpretation of extremes under different climate patterns

- Code available in BlueMath

Thank you!

Poster Room: PA14

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