Extreme coastal wave energy fluxes: projected global changes

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Extreme waves at coasts

- Stress on coastal structures
- Sediment transport and erosion
- Coastal inundation (together with storm surges)

What is the impact of climate changes on extreme waves?

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In this study we focus on **Extreme Wave Energy Flux**

$$\mathrm{WEF} = E \cdot c_g = \frac{1}{64\pi}\rho g^2 T_{-10} H_s^2$$

In the scenario **RCP8.5** (the most extreme of the Representative Concentration Pathways)

- Ensemble of 6 CMIP5 models
- Wave modelling with WavewatchIII v4.18 on global scale
- We performed a non-stationary Extreme Value Analysis on WEF along the coasts

Ensamble models
ACCESS1-0
ACCESS1-3
EC-EARTH
CSIRO-Mk3.6.0
GFDL-ESM2M
GFDL-ESM2G

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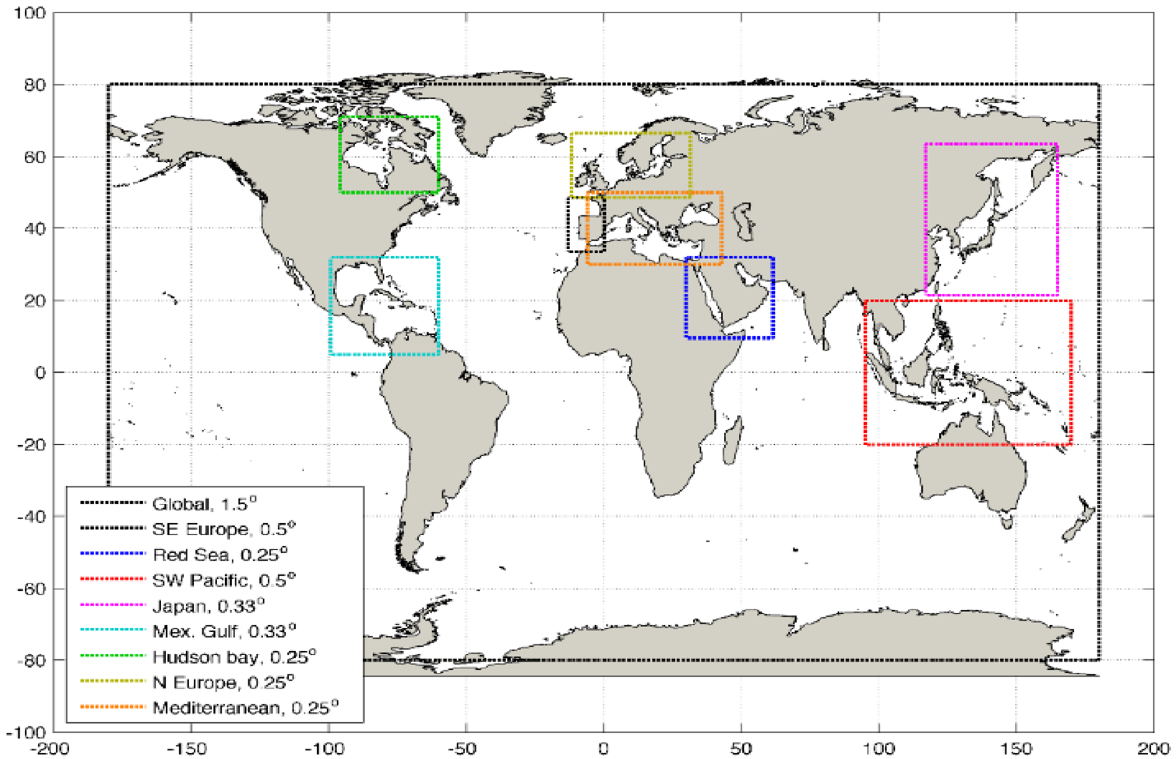
Model setup

Model: WavewatchIII v4.18

Growth/dissipation source term: ST4 (Ardhuin et al. 2010)

Grids: global regular grid (1.5 deg resolution) with nests

Output saved at points along the coast

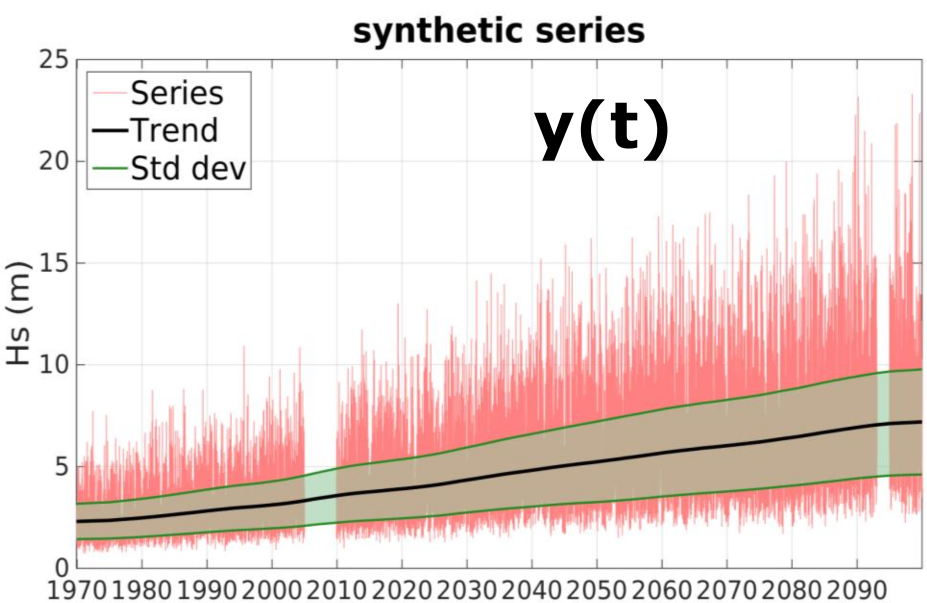


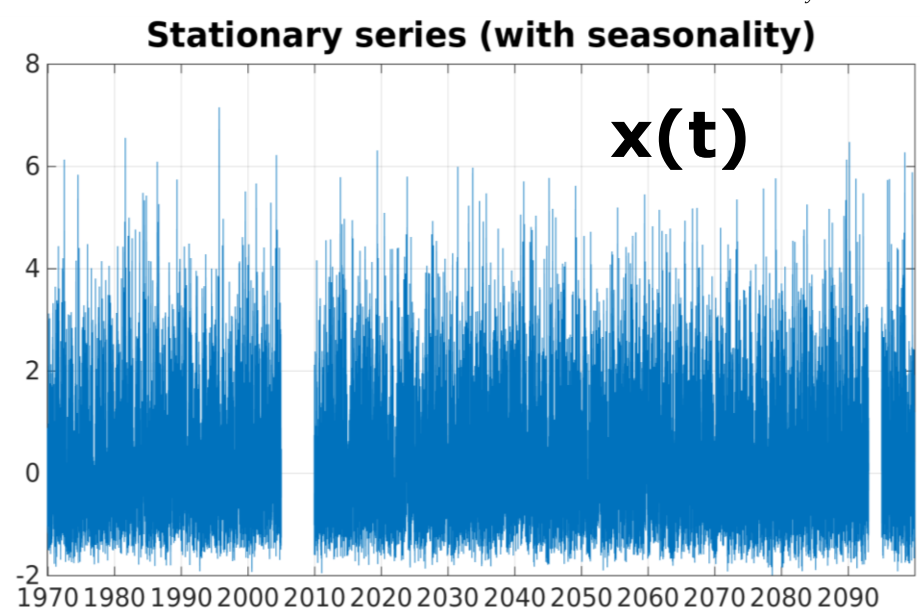
The extremes were studied using a **simplified non-stationary Extreme Value Analysis** techinque: the Transformed Stationary methodology (Mentaschi et al. 2016)

Basic concept

- transform the non stationary time series into a stationary one (through a local normalization)
- execute a stationary EVA on the transformed series
- back-transform the stationary EVA into a non stationary one

$$x(t) = \frac{y(t) - tr_y(t)}{std_y(t)}$$





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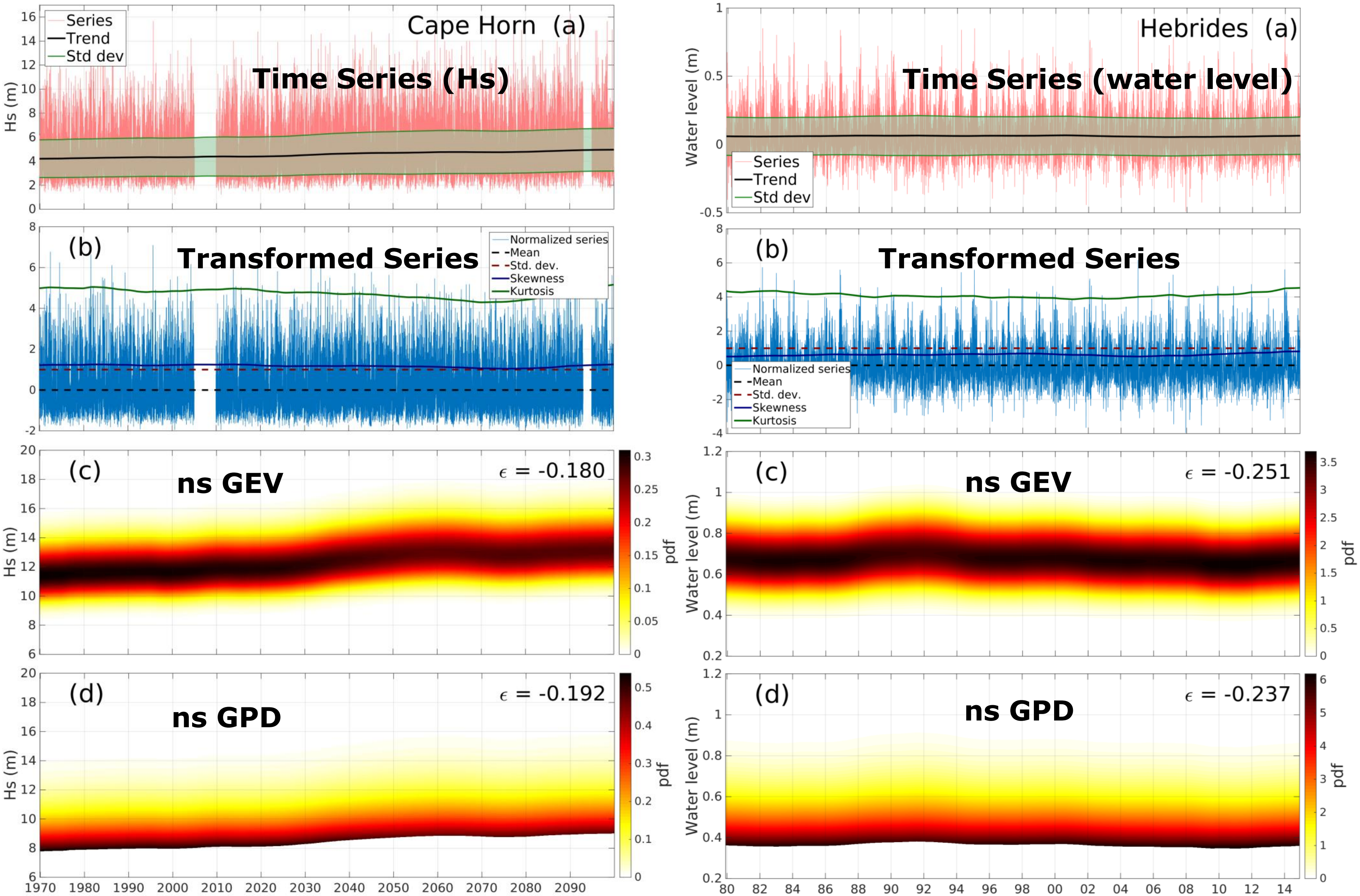
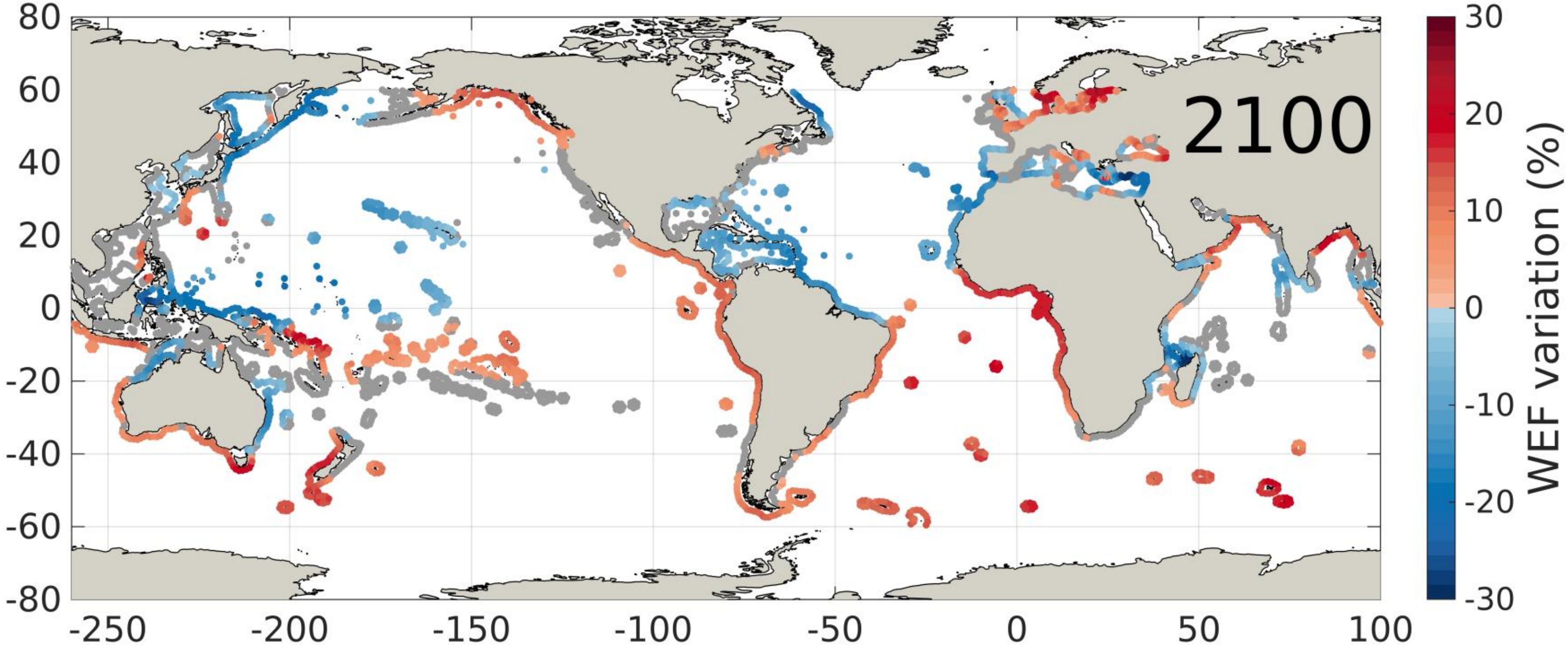


Advantages of this approach

- simple to implement and fast to run
- all you need is the series itself
- the transformation of the series to stationary makes it possible to diagnose easily the applicability of EVA and MLE

All the theory beyond this methodology is explained in **Mentaschi et al. 2016**, The transformed-stationary approach: a generic and simplified methodology for non-stationary extreme value analysis

A MATLAB toolbox with an implementation of this approach is available open-source on gitHub, at https://github.com/menta78/tsEva



Long term projection of extreme Wave Energy Flux

% change of the 100 year return level

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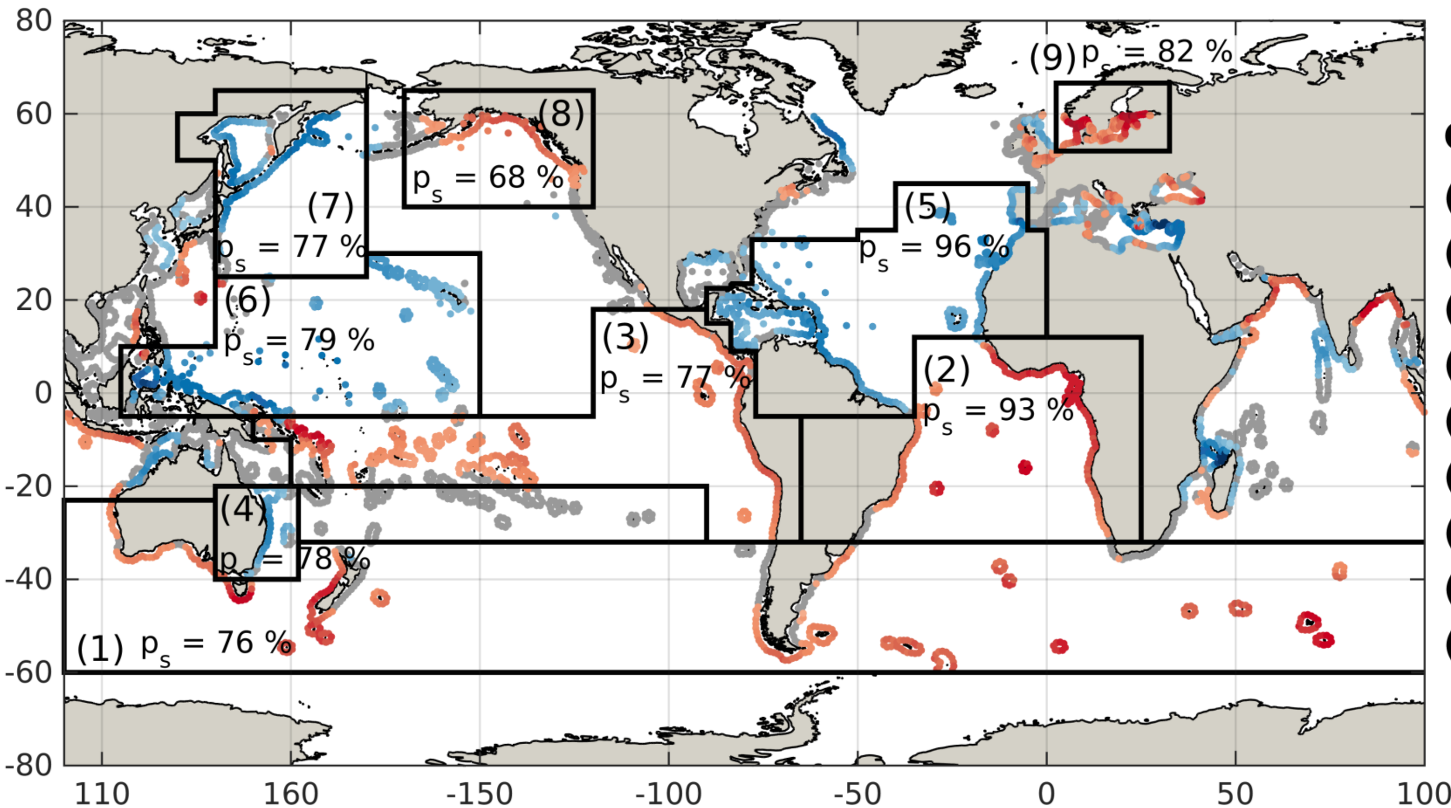
Vast coastal areas display consistent tendencies to increase or decrease



Considered areas:

(1) S. Temp. Zone

(2) S. Atlantic

(3) Subeq.-Trp. E. Pac.

(4) E. Australia

(5) N. Tropical Atlantic

(6) NW. Trop. Pacific

(7) NW. Pacific

(8) NE. Pacific

(9) Baltic Sea

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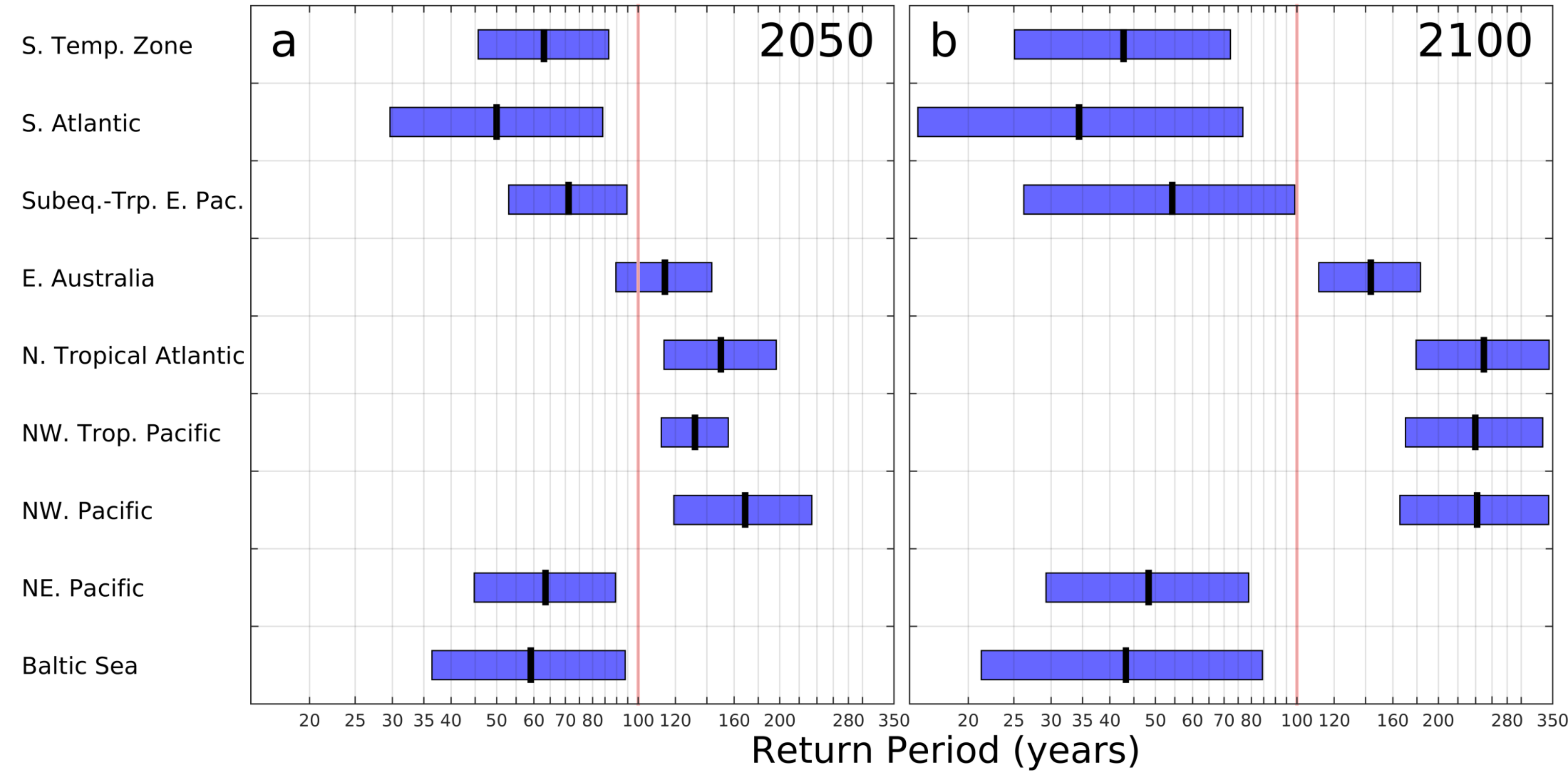
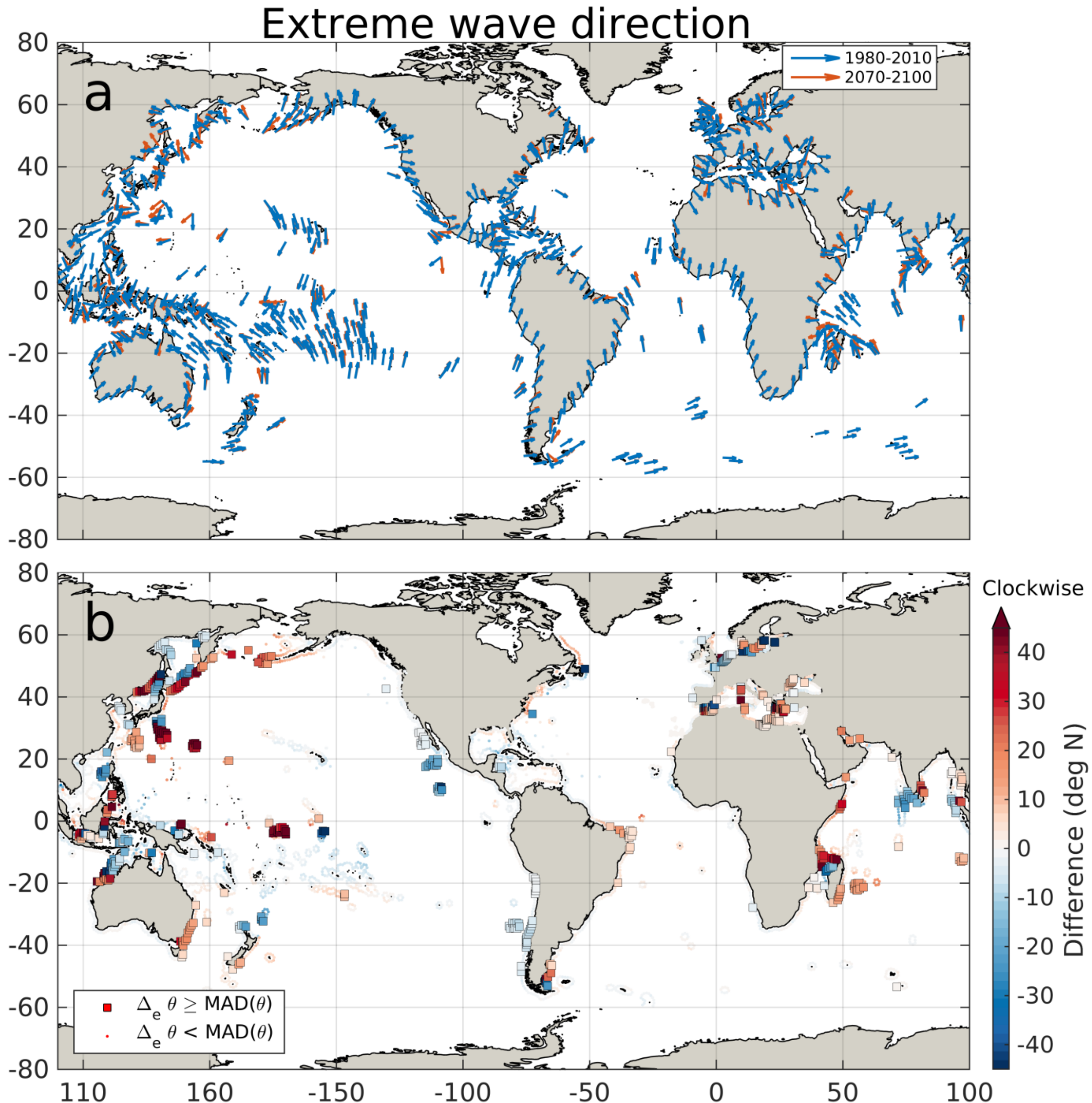
… and changes of frequency



Extreme wave direction is projected to change slightly worldwide.

In the Southern Hemisphere the rotation is usually northward.

In the Northern Hemisphere the rotation is prevalently eastward



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Why does WEF change in this way (in projections)?

We can explain these changes in terms of projected intensification of teleconnection patterns such as AAO, ENSO and NAO

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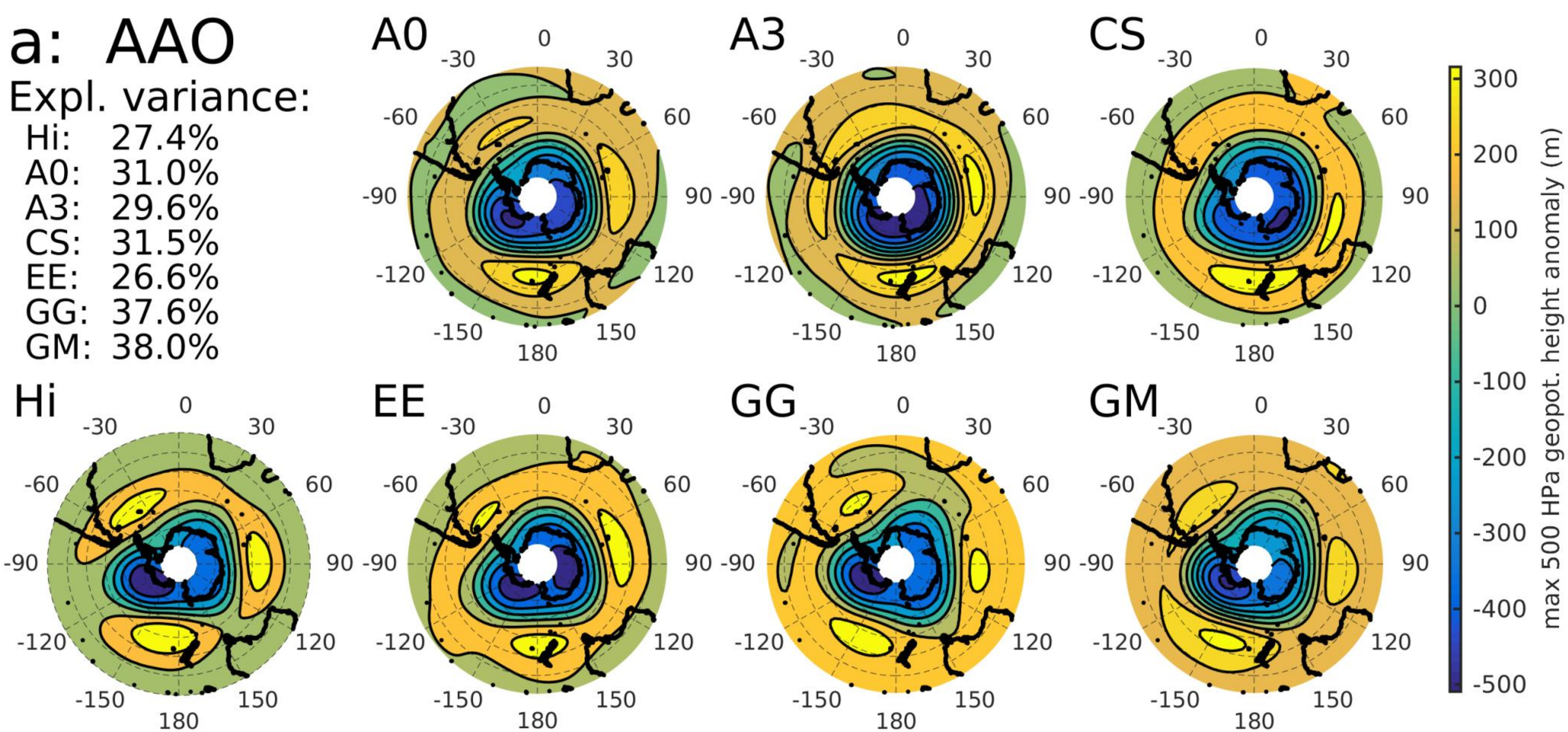
a: AAO

Expl. variance:

Hi: 27.4%
A0: 31.0%
A3: 29.6%
CS: 31.5%
EE: 26.6%
GG: 37.6%
GM: 38.0%



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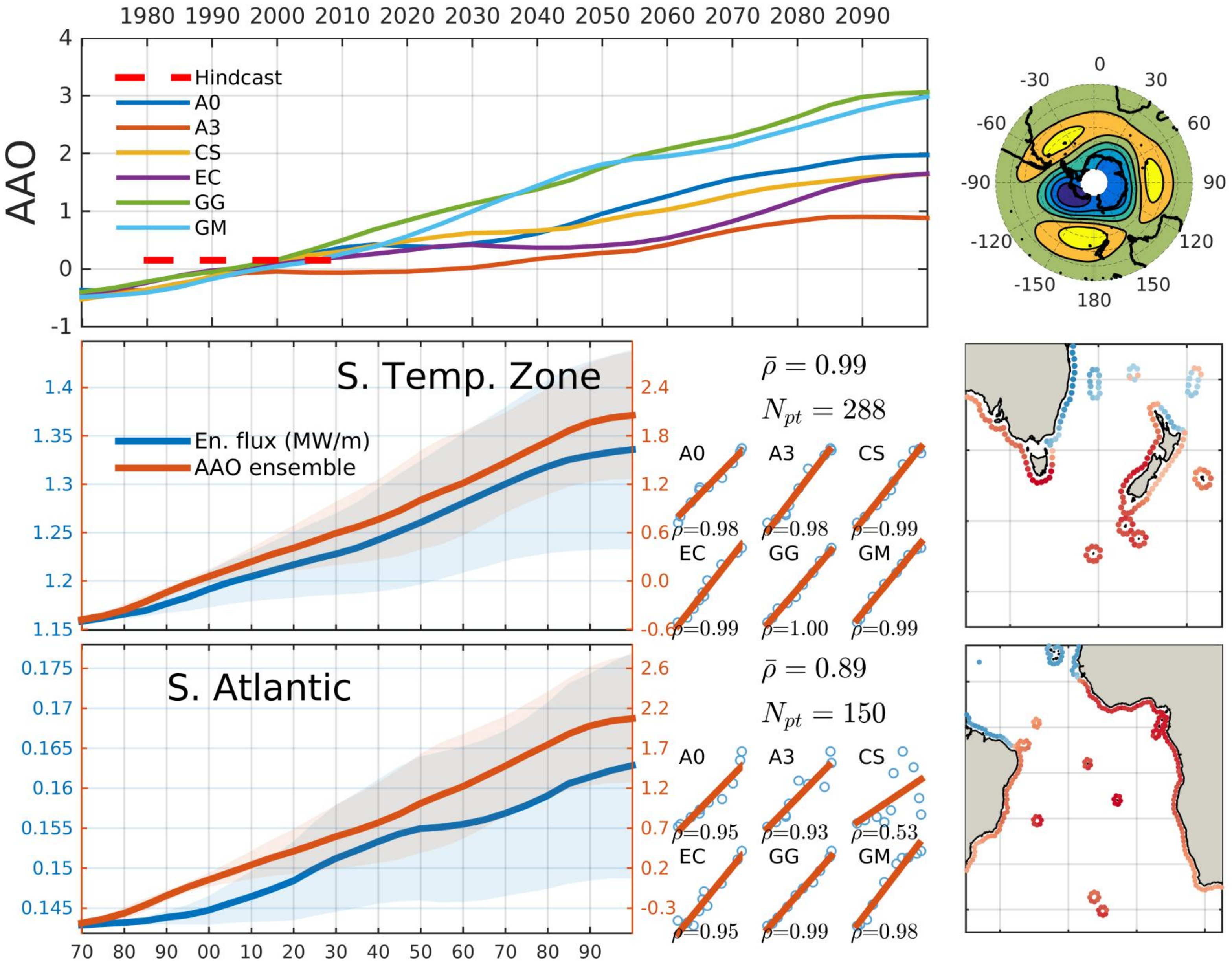
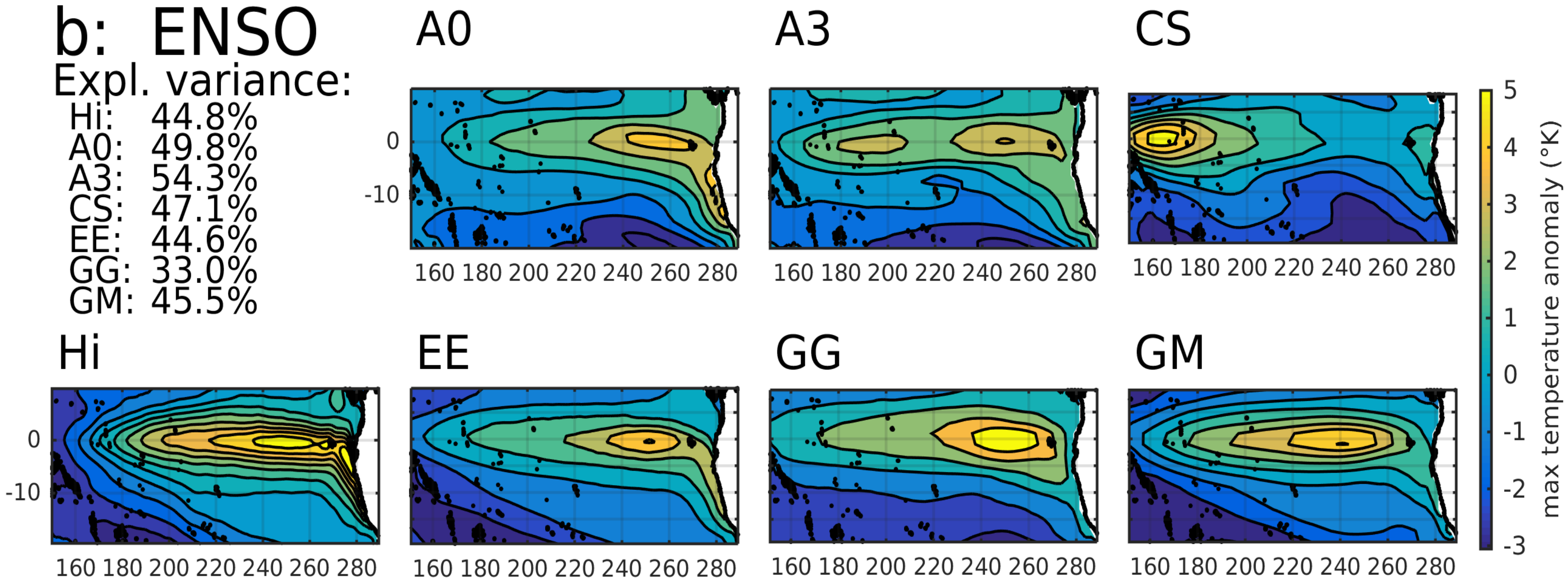


b: ENSO

Expl. variance:

Hi: 44.8%
A0: 49.8%
A3: 54.3%
CS: 47.1%
EE: 44.6%
GG: 33.0%
GM: 45.5%



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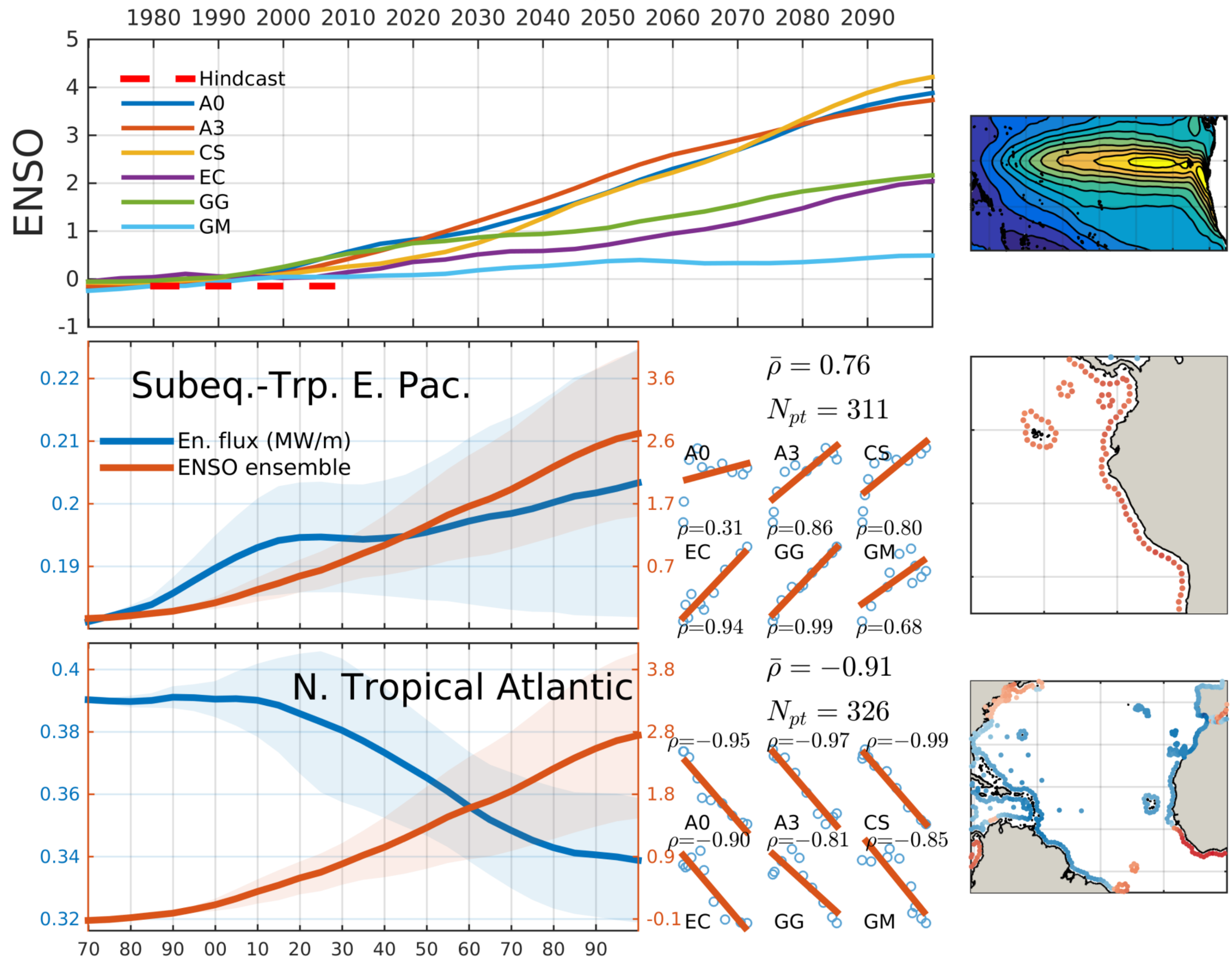

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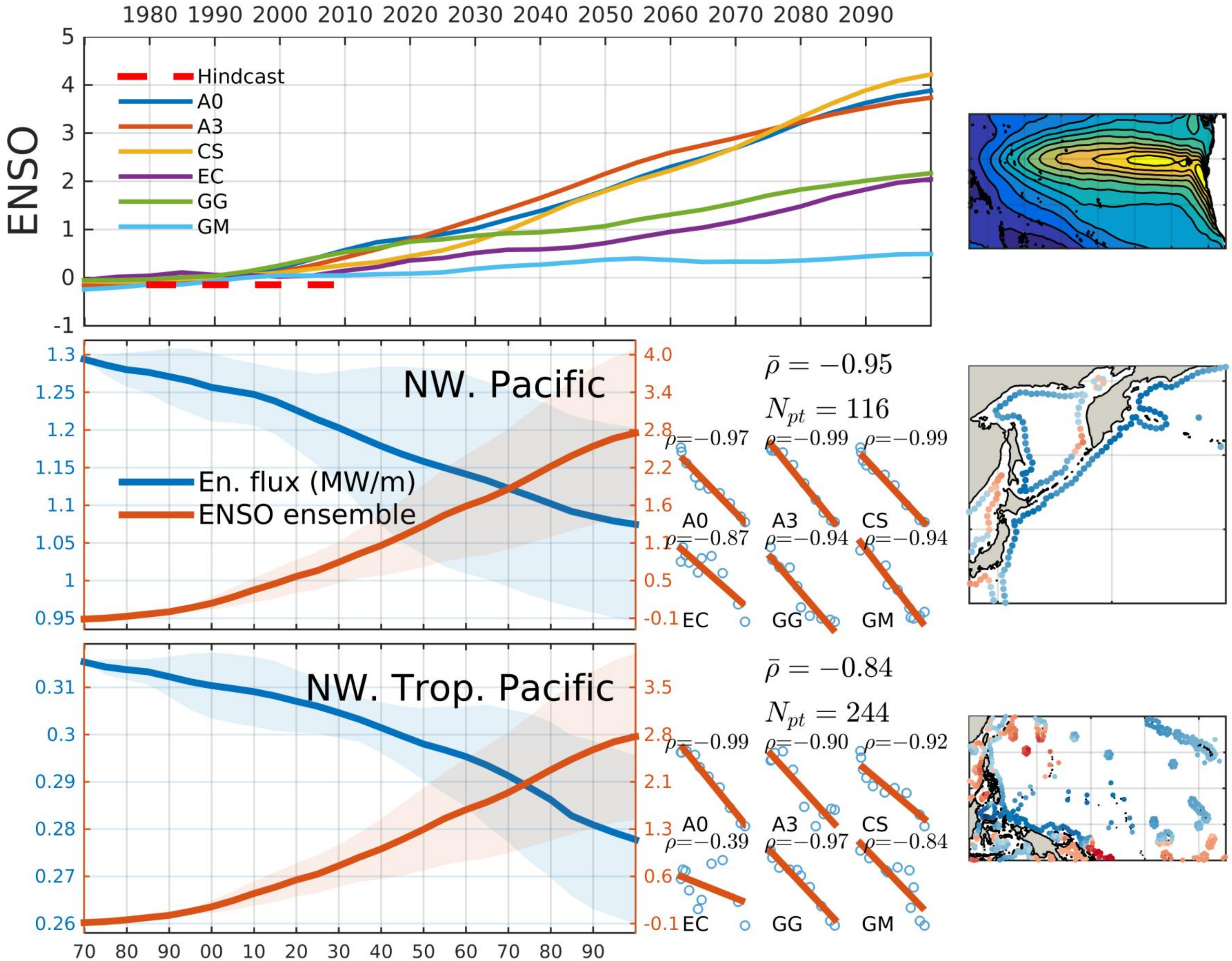

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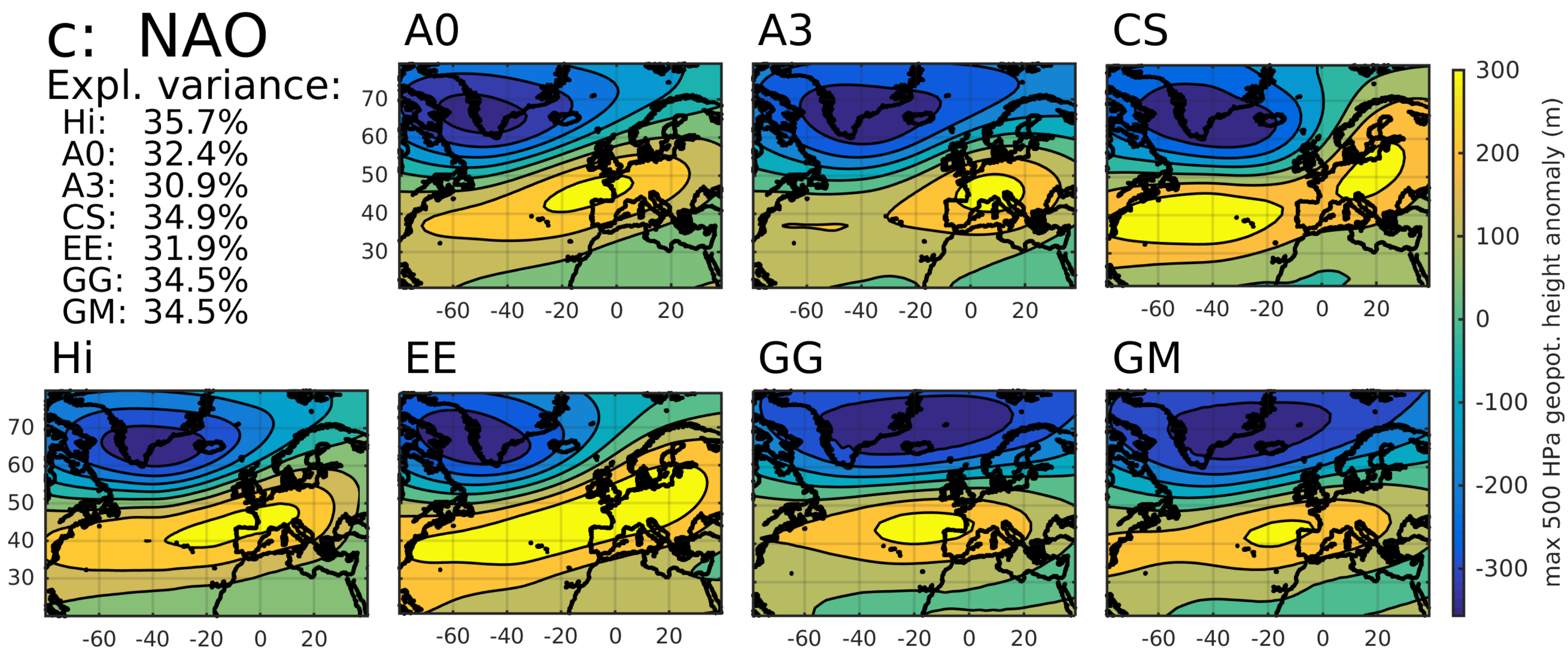
c: NAO

Expl. variance:

Hi: 35.7%
A0: 32.4%
A3: 30.9%
CS: 34.9%
EE: 31.9%
GG: 34.5%
GM: 34.5%



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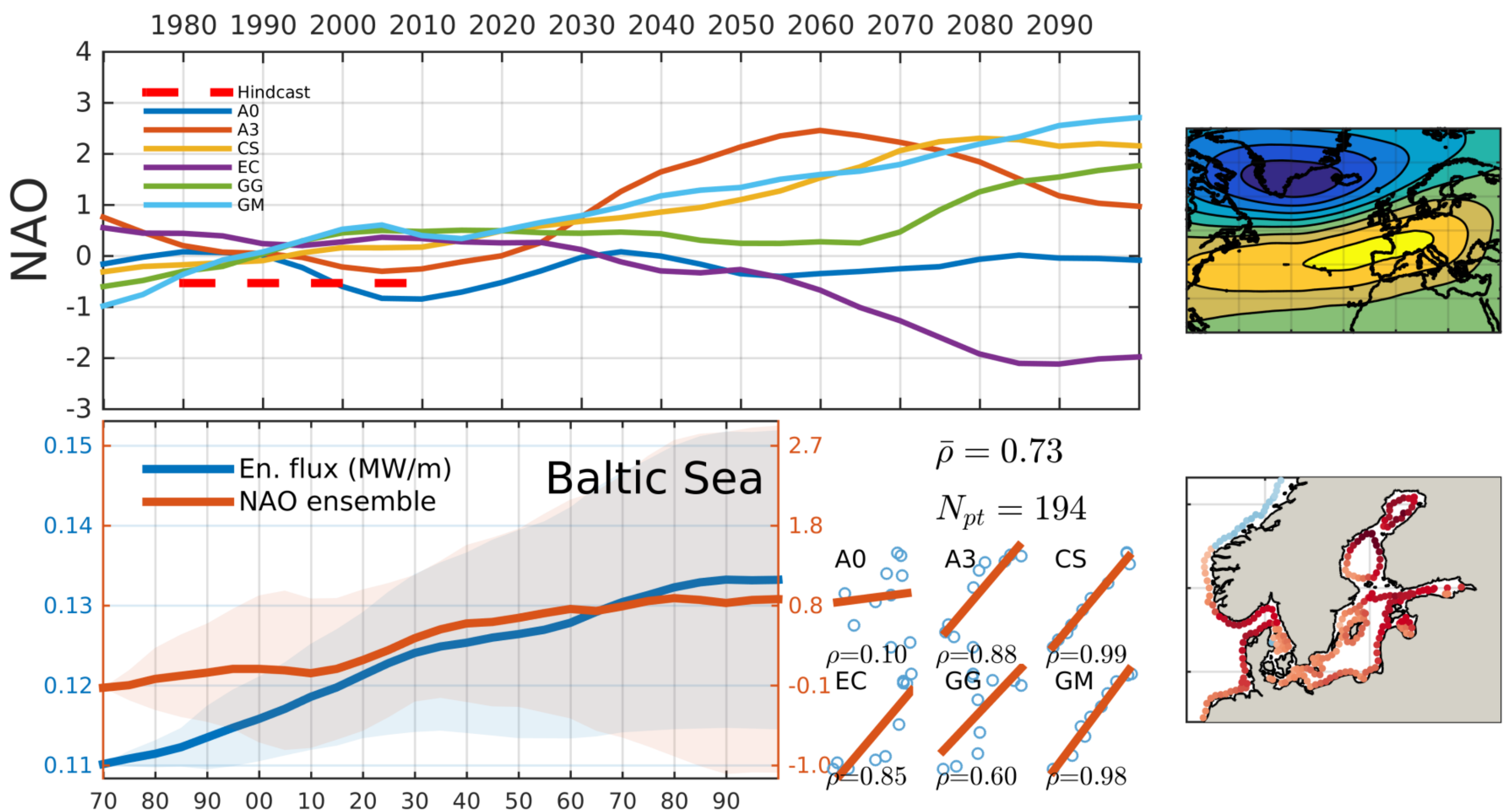

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Mentaschi et al. 2017, Global changes of extreme coastal wave energy fluxes triggered by intensified teleconnection patterns. Geophysical Research Letters

Thank you!

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