PSMSL 80th Anniversary

Workshop on Sea Level Science

Exploring extreme sea level events

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October 29th 2013, Liverpool

Exploring extreme sea level events

Exploring **Climate** variability of **Extreme Sea level** events by using **Non-stationary** Extreme **Statistical** models

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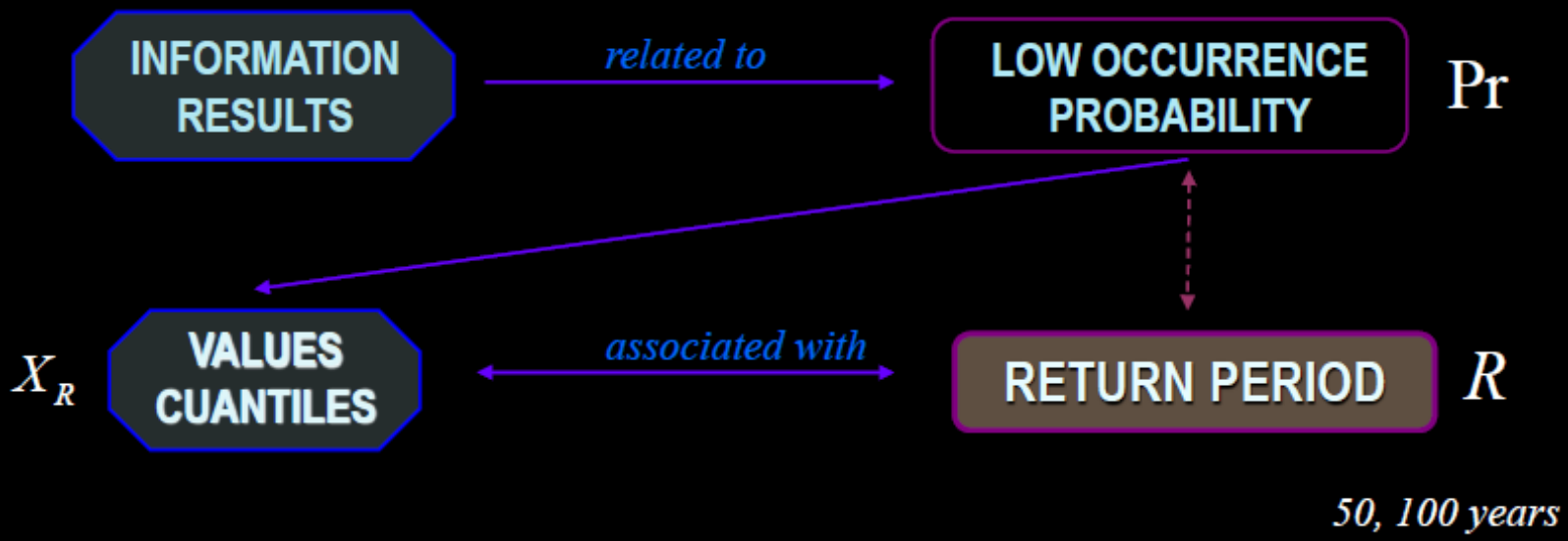
EXTREME VALUE THEORY

Statistical discipline that develops a set of techniques and methods to quantify and model the stochastic behavior of extreme events, either in magnitude or frequency.



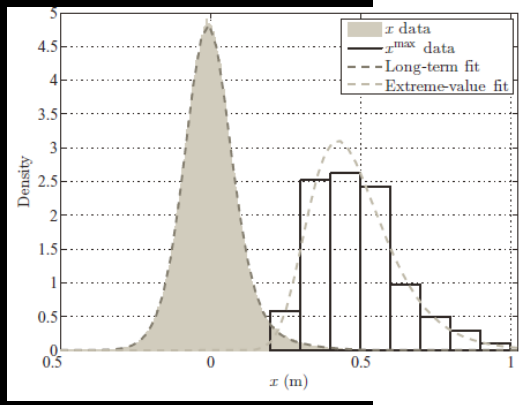
~~*percentile time series*~~

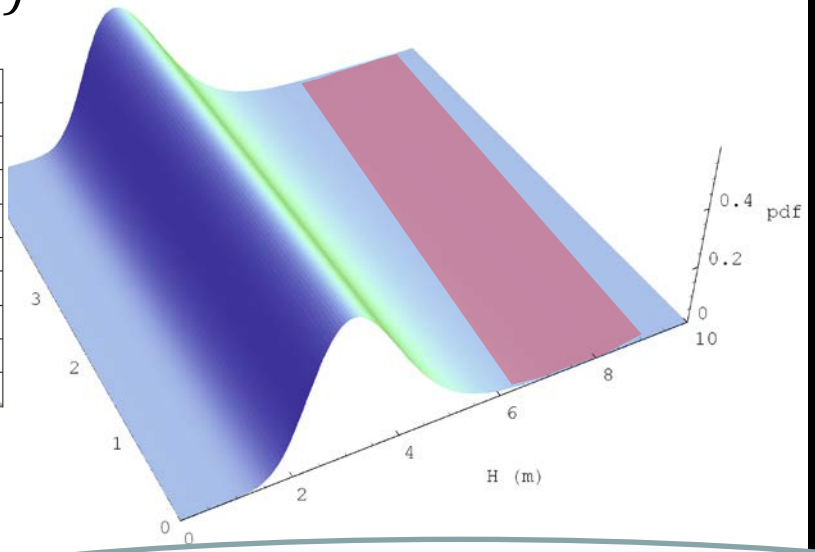
[..the most important statistical discipline for the applied sciences over the last 50 years…]

[..unique as a statistical discipline for describing the unusual rather than usual…]

Coles, 2001

$F(x;\theta)$



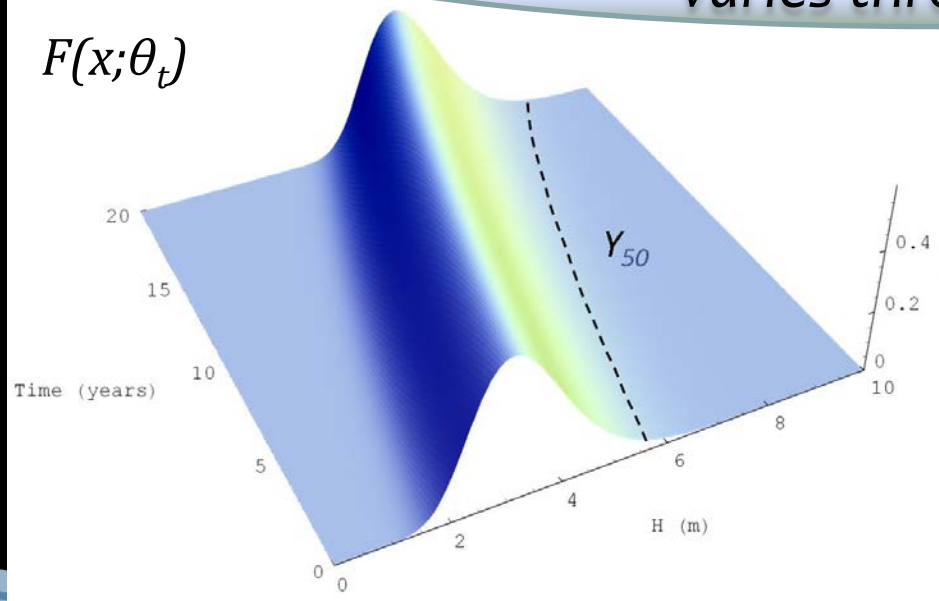


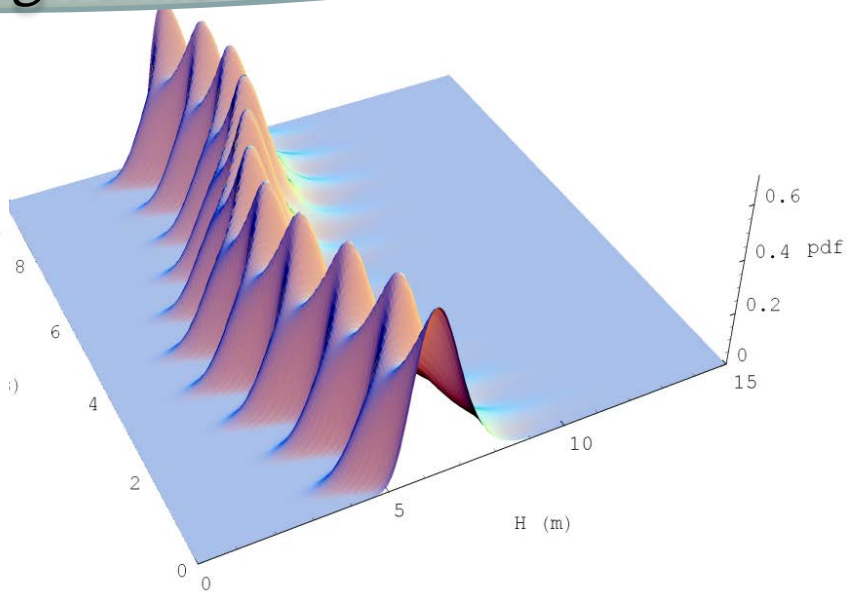
R = Return Period → Y_R

$$\text{Prob} = 1 - \frac{1}{R}$$

The probability of an extreme sea level varies through time

$F(x;\theta_t)$

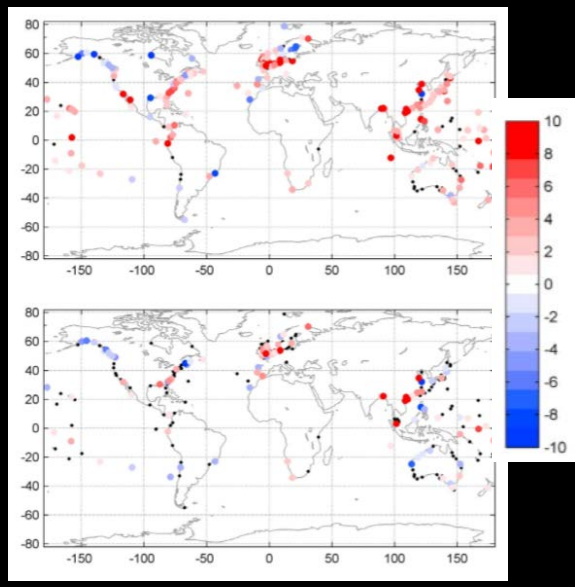




Focusing on extreme sea levels..

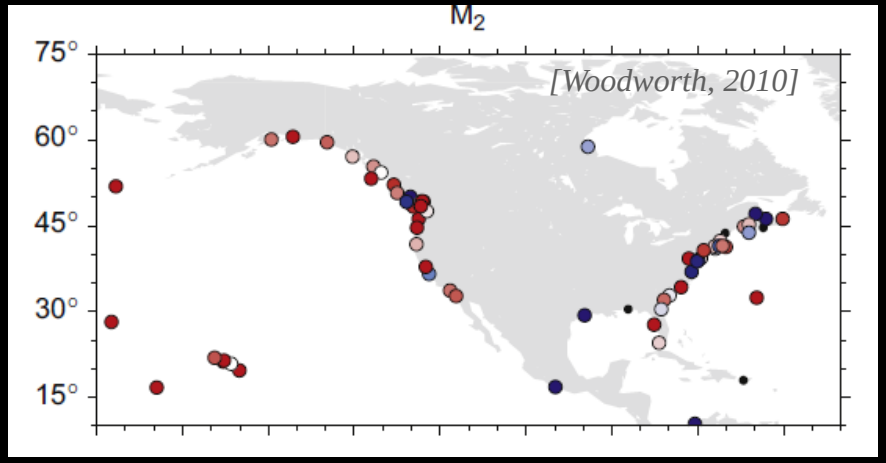
Contribution to Changes on Extremes?

[Woodworth and Blackman, 2004]
[Menendez & Woodworth, 2010]
…



MEAN SEA LEVEL

TIDE



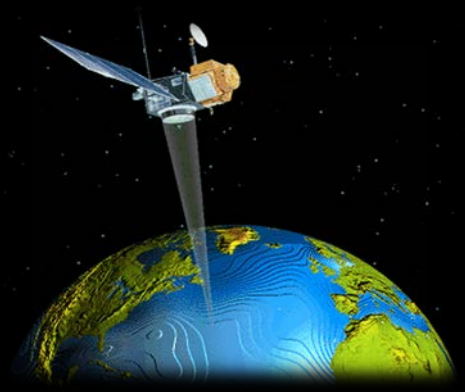
STORMINESS

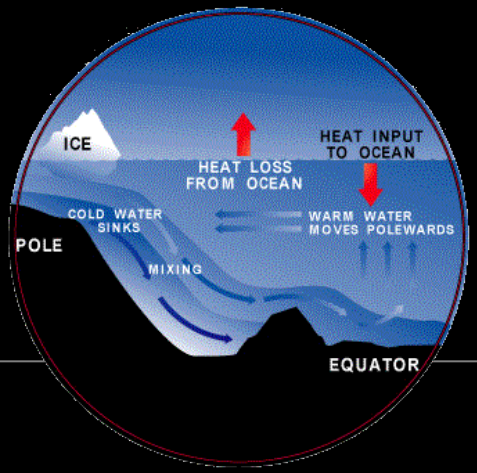
- Storm SURGE
- WAVES-Setup

[Marcos et al., 2009]
[Bromisrki et al., 2003]
[Bernier & Thompson, 2006]
…

EXTREME SEA LEVEL DATA SOURCES:

- **IN-SITU**
  Tide-Gauges..
- **REMOTE**
  Satellite altimeter..
- **MODELS**
  Ocean models..





TIME SCALES:

- **Short-term;** *seasonality (within a year)*
- **Mid-term;** *inter-annual (irregular fluctuations, modulations)*
- **Long-term;** *decadal to secular changes → TRENDS*

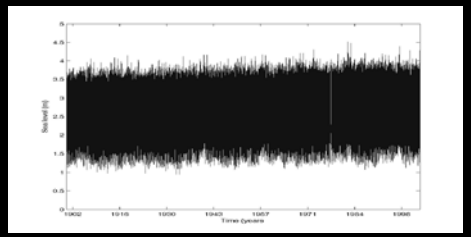
SPATIAL SCALES:

- **Local**
- **Regional**
- **Global**

SOME APPLICATIONS..

Including Mean Sea level Uncertainty

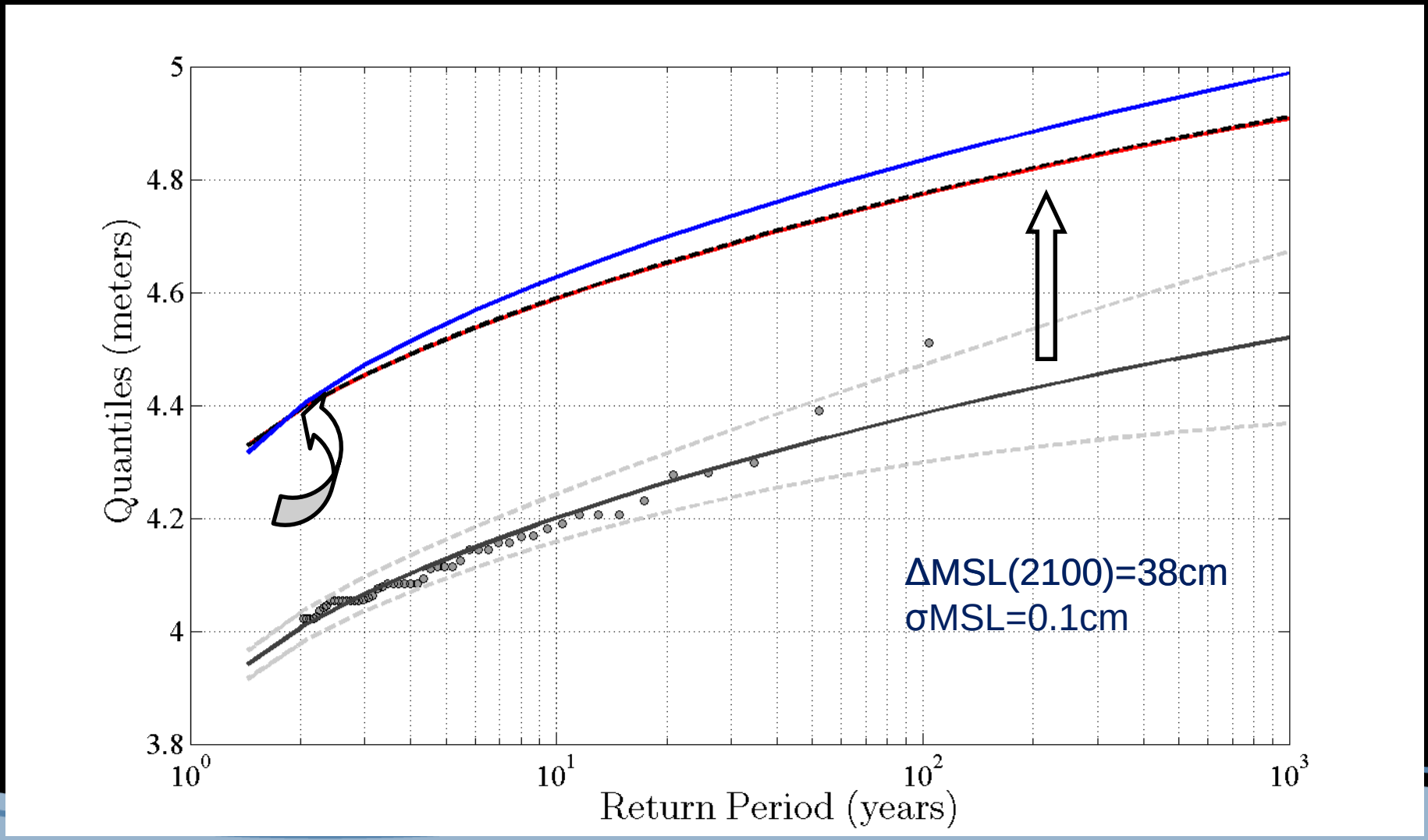
Local / TG



Data: San Francisco Tide-gauge record (Noaa)

1900-present hourly time series

Joint Probability Method: F(extreme SL / MSL rise)

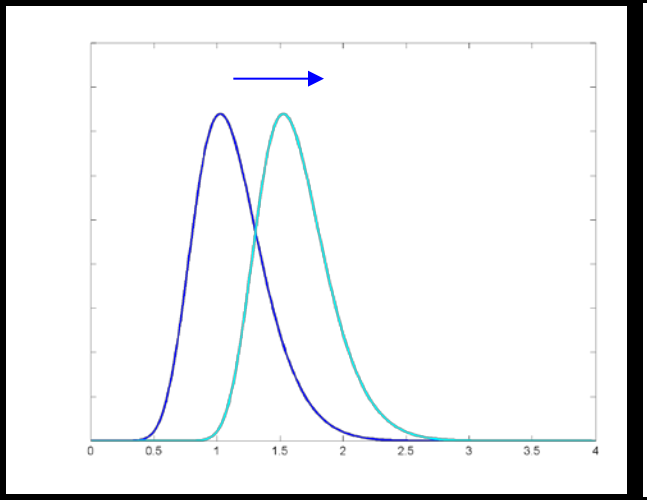


Influence of different Climate variability time scales

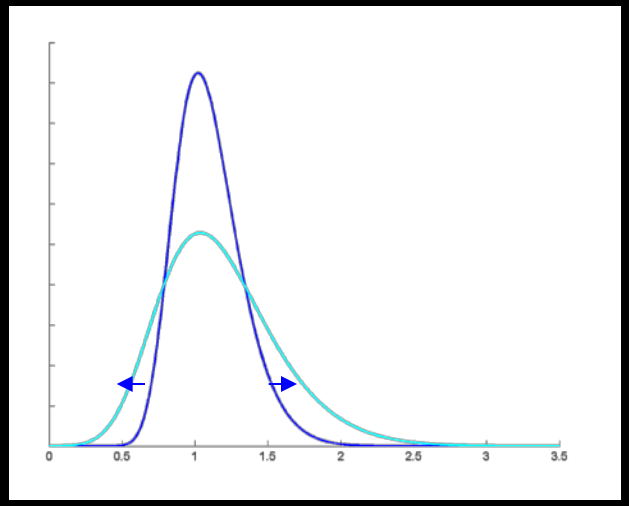
Time-dependent Generalized Extreme Value distribution (GEV)

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

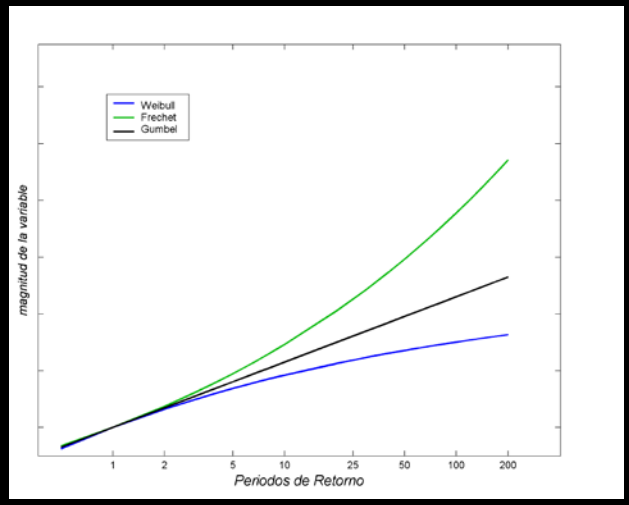
$\mu \rightarrow$ *location*



$\psi \rightarrow$ *scale*



$\xi \rightarrow$ *shape*



San Francisco Tide-gauge record

Hourly time series from 1900

[Méndez et al., 2007]

Newlyn Tide-gauge record

Hourly time series from 1915

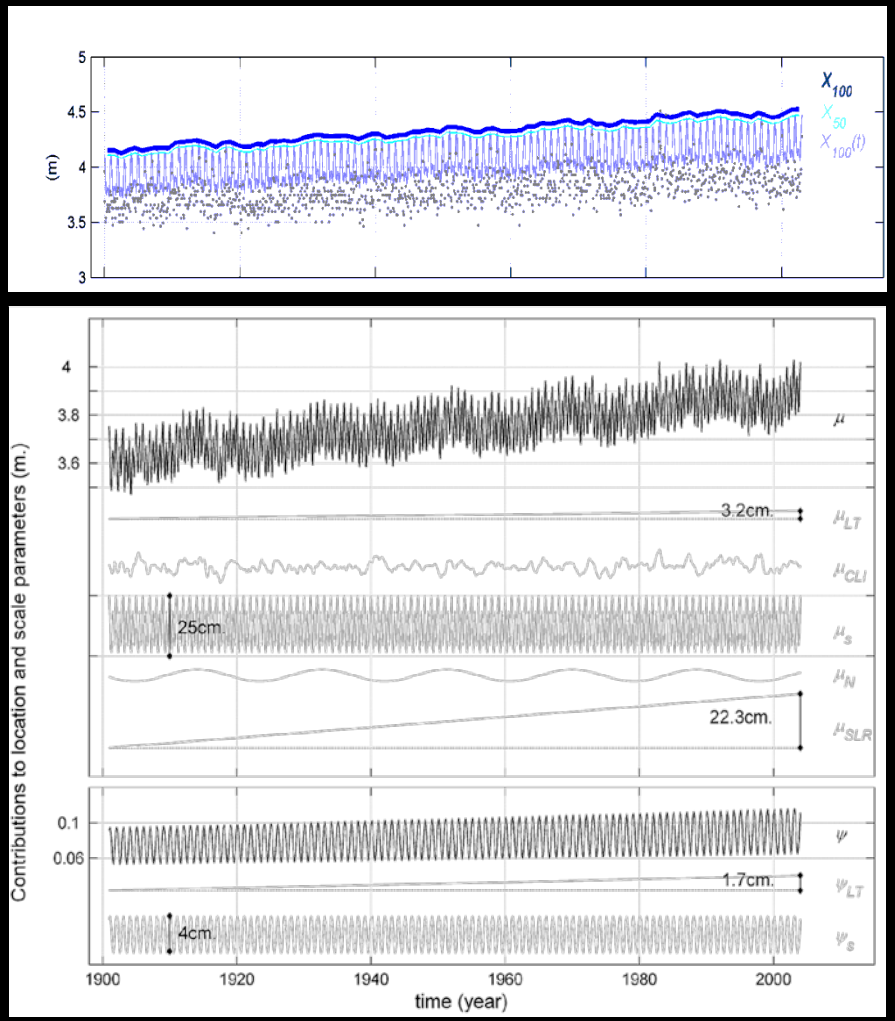
[Menendez et al., 2009]

Influence of different Climate variability time scales

Local / TG

San Francisco Tide-gauge record

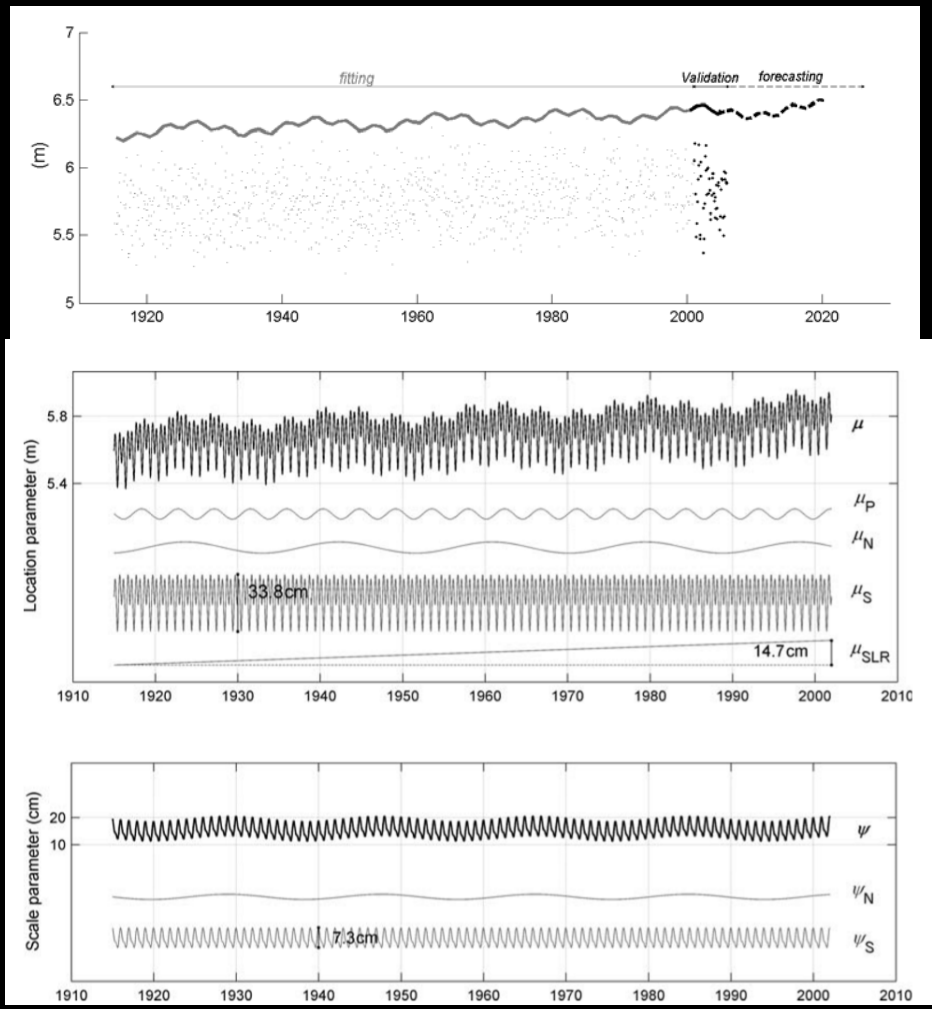
Hourly time series from 1900



[Méndez et al., 2007]

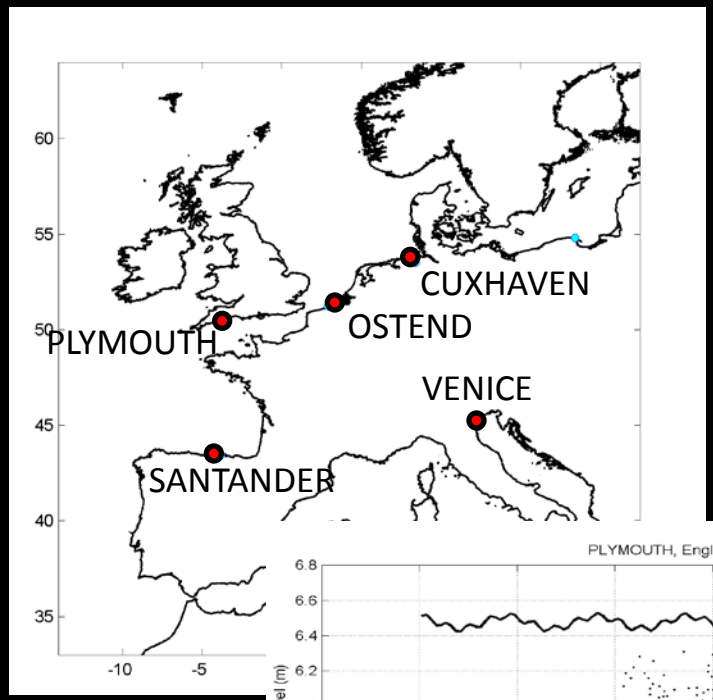
Newlyn Tide-gauge record

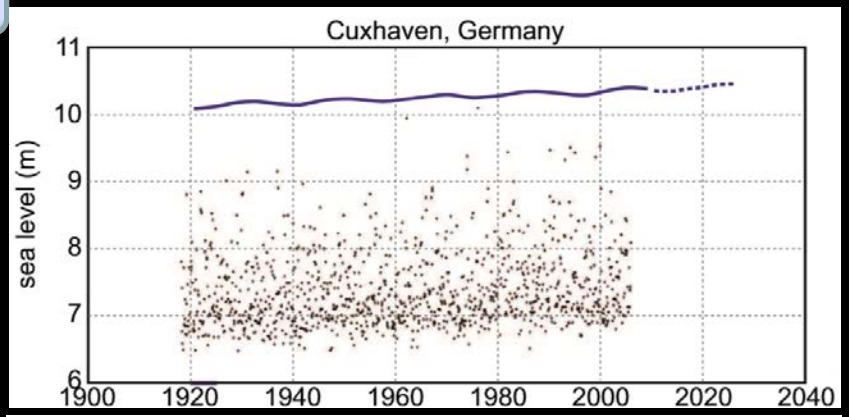
Hourly time series from 1915

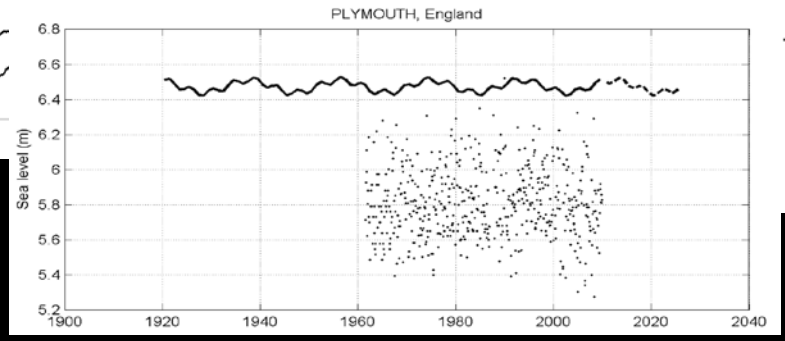


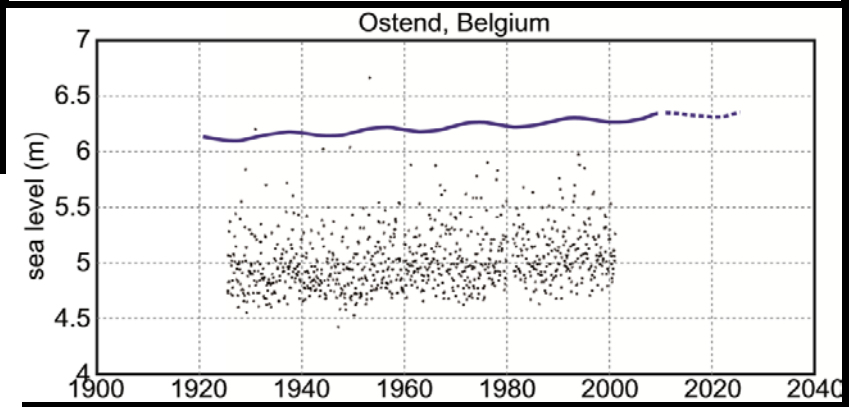
[Menendez et al., 2009]

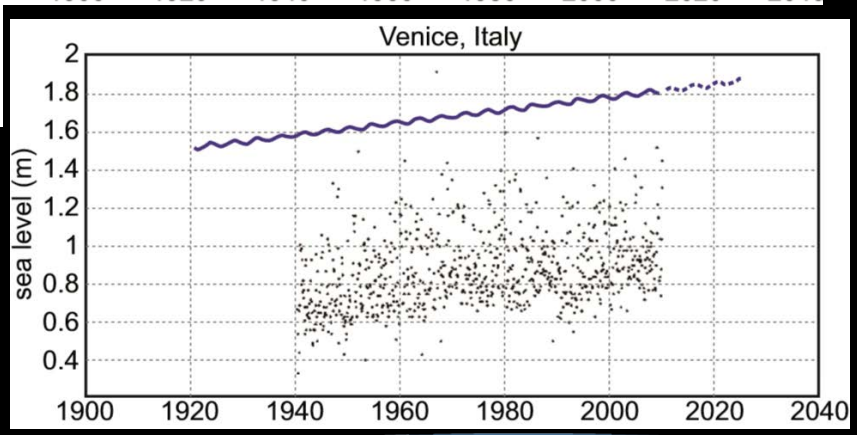
Analyzing Astronomical modulations

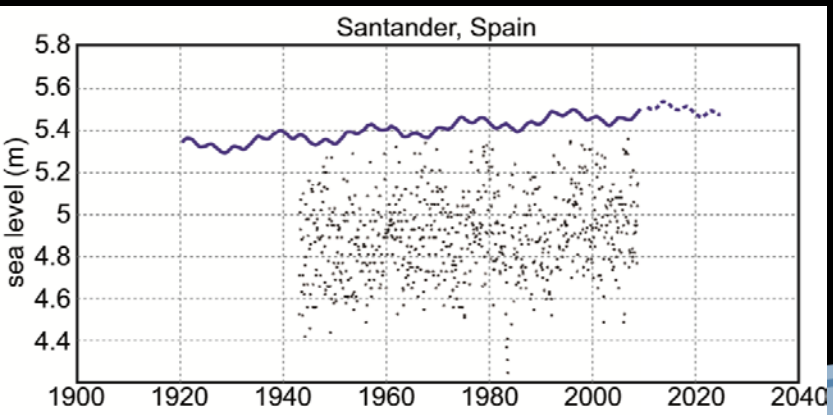












Analyzing Trends on extremes

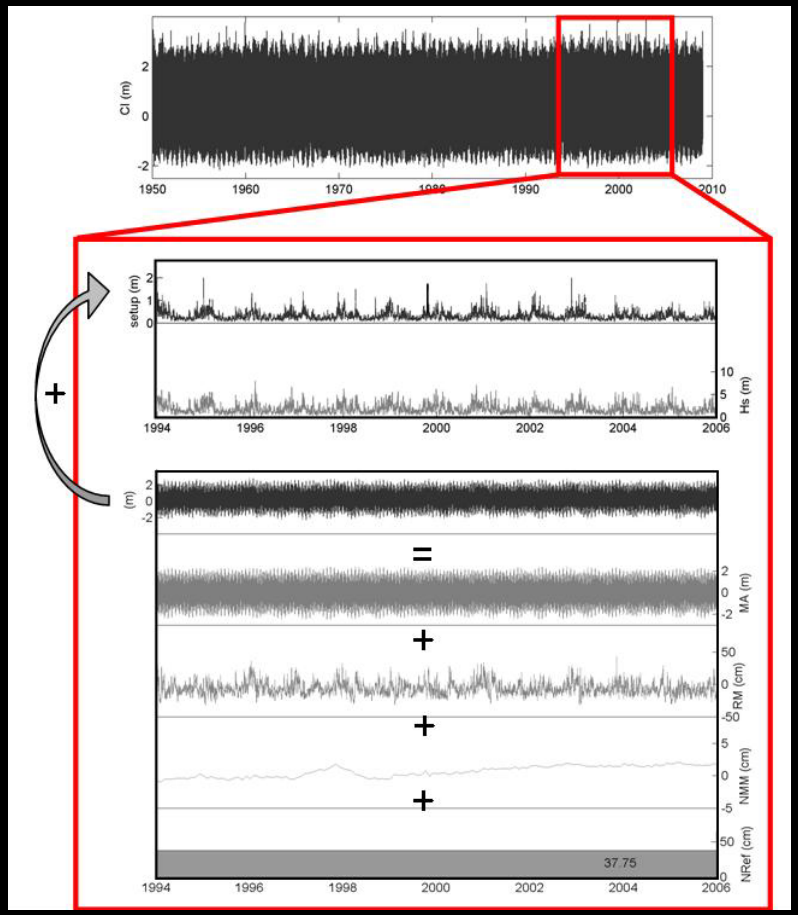
Pareto-Poisson extreme model (exceedances over a threshold)

Setup

Flood Level = Sea Level + Waves

Nref + MSL + Tide + Surge

60 yr hourly reconstruction of flooding level time series



RUN-UP

Waves

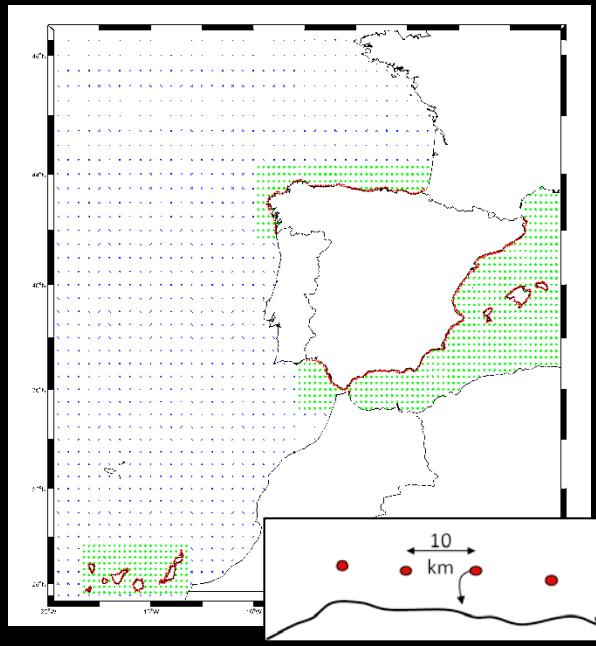
SEA LEVEL

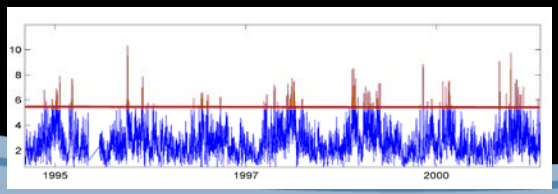
Tide

Storm Surge

Regional MSL

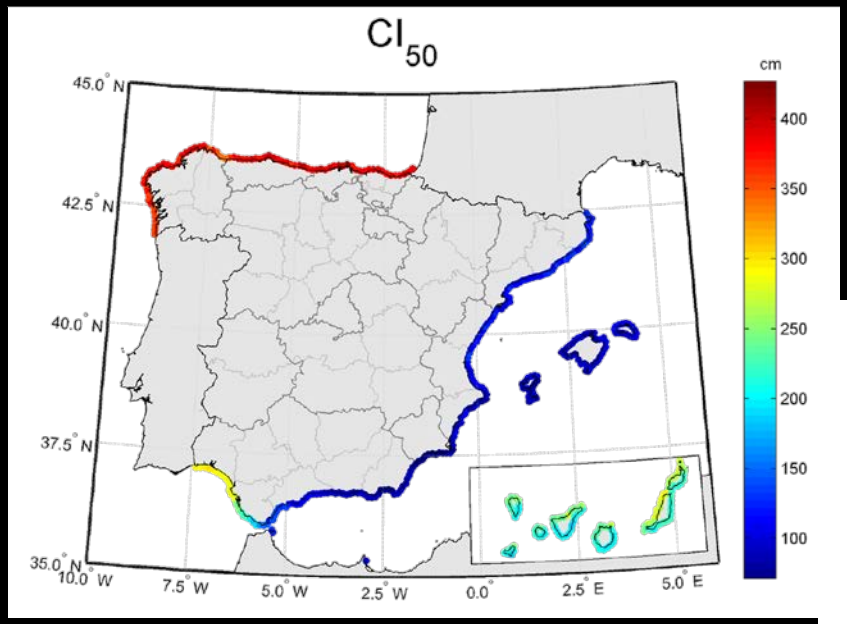
423 analyzed Nearshore sites

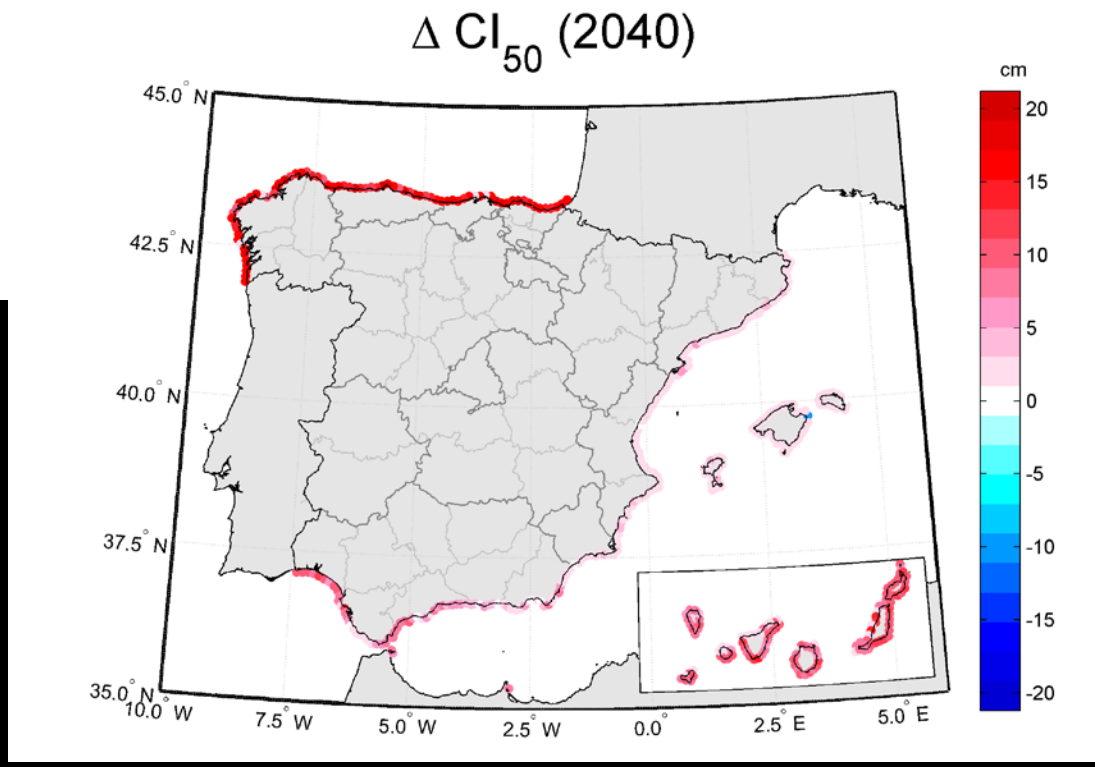




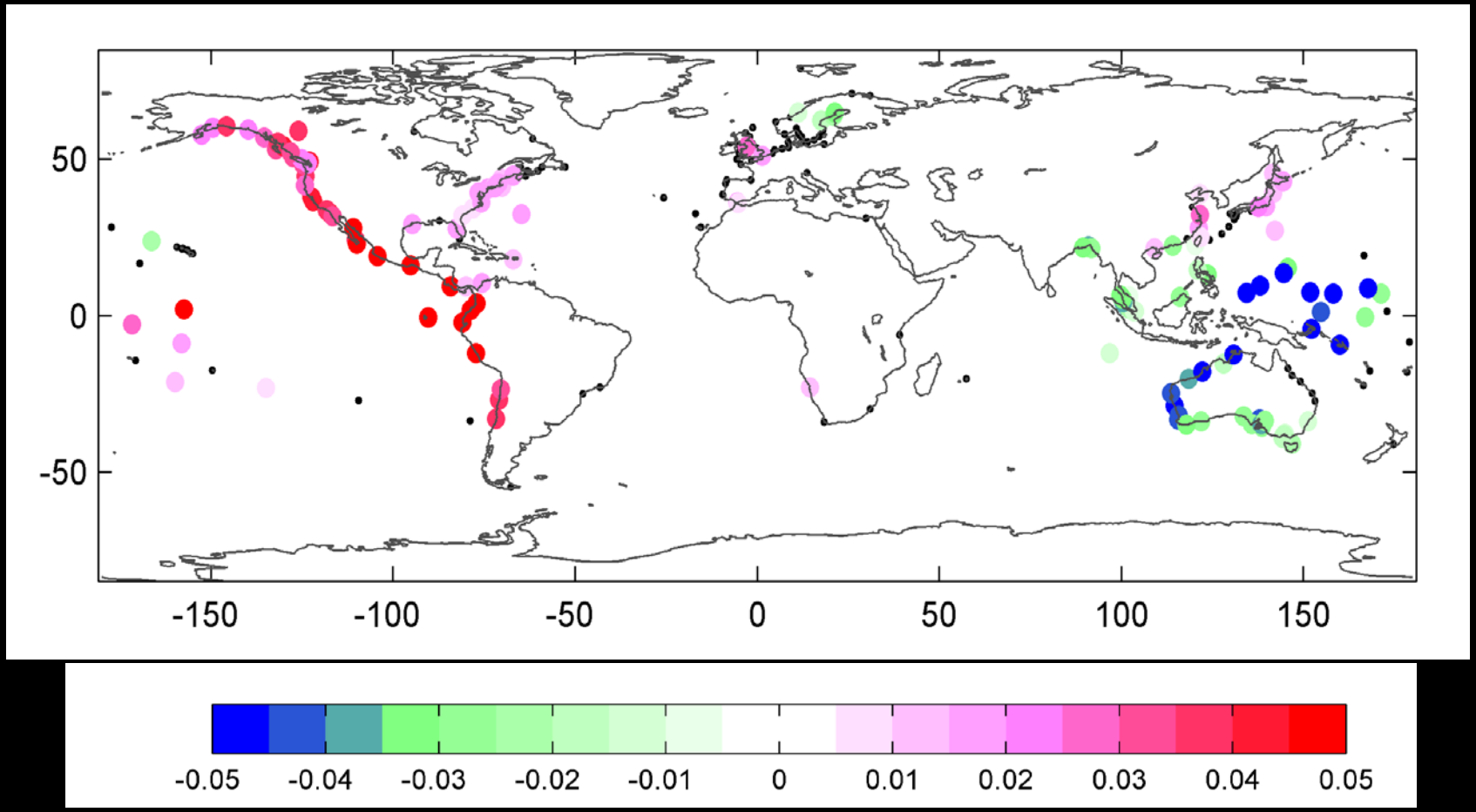
99.5%

Analyzing Trends on extremes



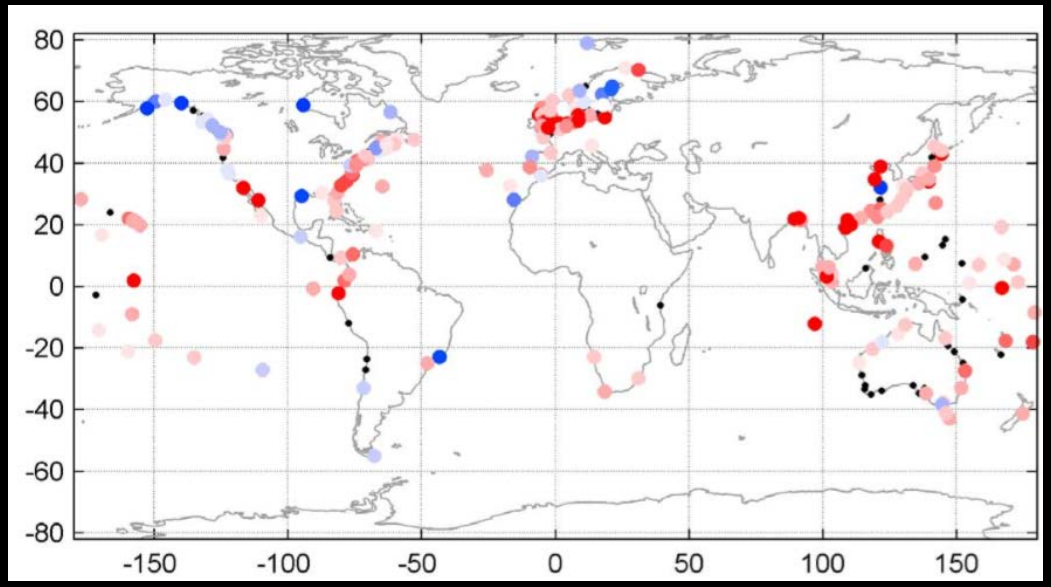


Analyzing ENSO phenomena influence

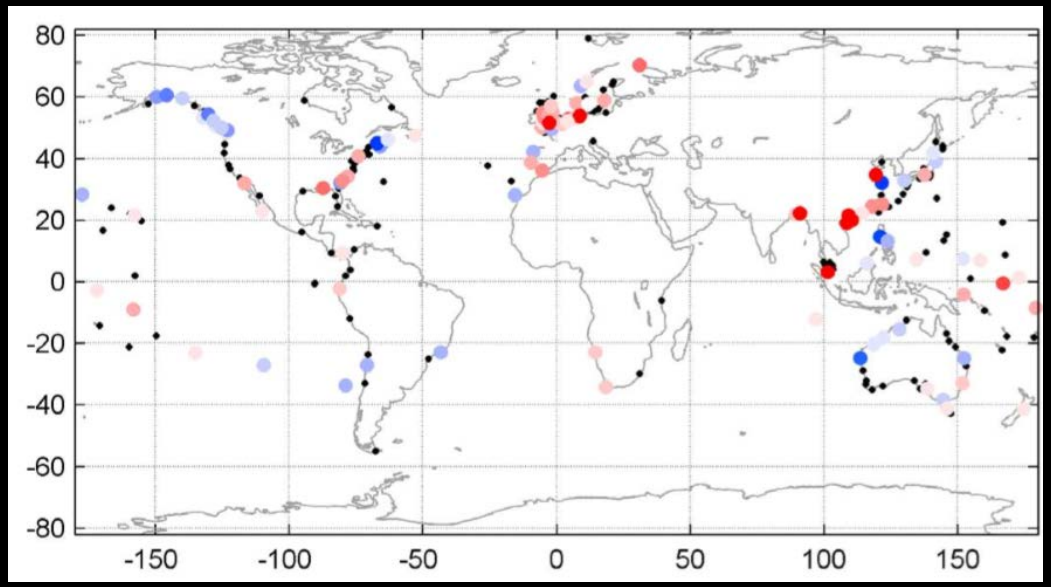


[Menendez & Woodworth, 2010]

Analyzing Trends on extremes



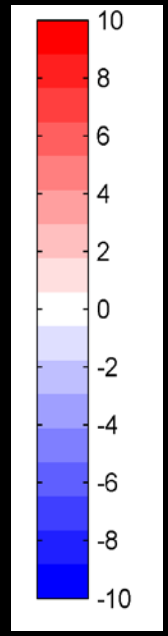
total elevation



total elevation after removal of annual medians

Y50 trends

(cm/10yr)



[Menendez & Woodworth, 2010]

- Main critical factors for an adequate analysis of extreme sea level changes :
  - Long & high quality records
  - Choose the best statistical method for each goal
  - Understanding shorter time-scales for a good evaluation of trends

- The time-dependent extreme analysis is valid for different sea level variables and data-sets

- The time-dependent model provides climate information about the behavior of extreme sea levels.

Thanks for your attention!

Comments? Questions?