Mechanisms of interannual to decadal sea level variability along the European coasts

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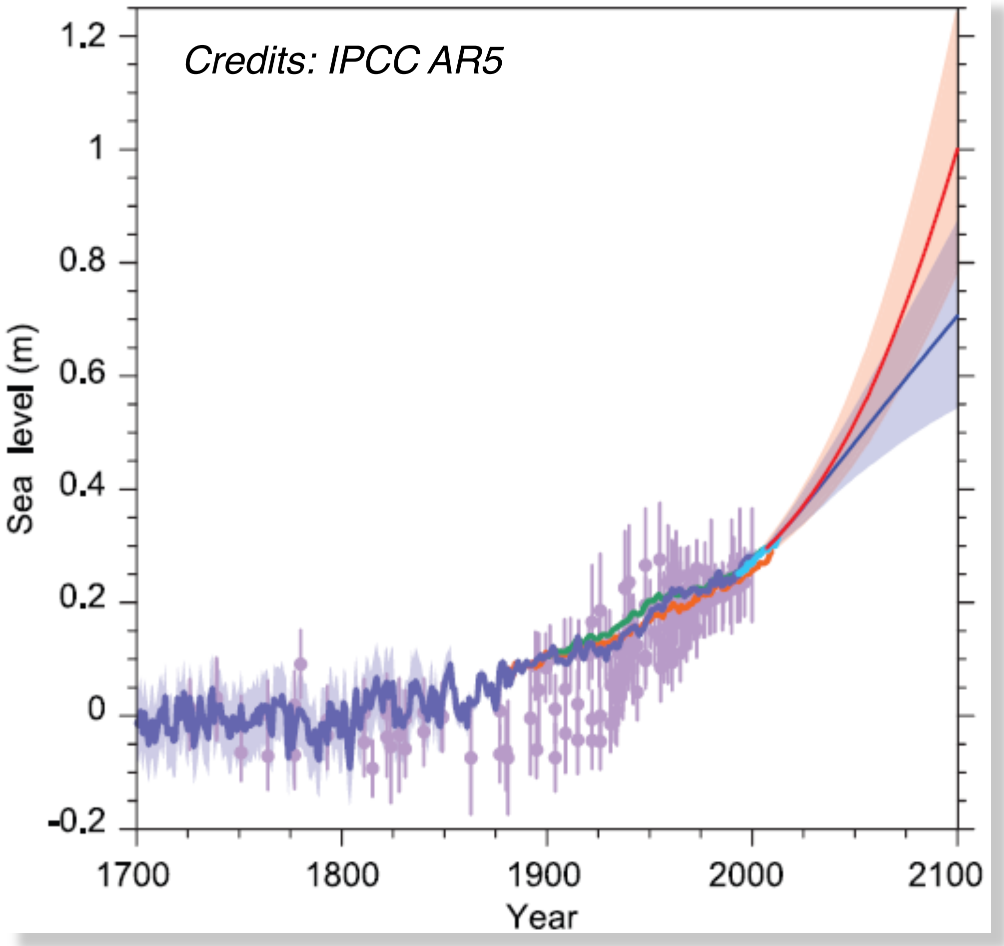
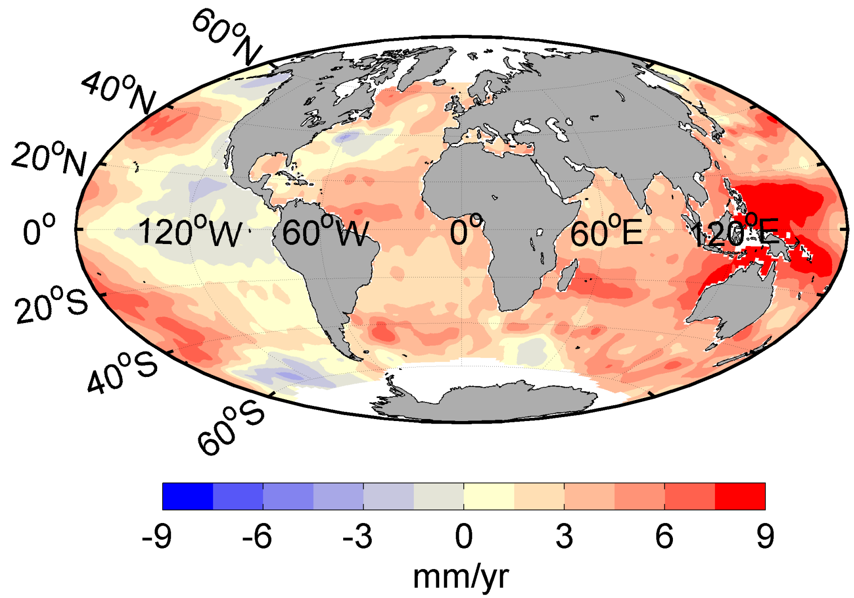
Motivation

Global mean sea level is projected to rise **~53 cm** over 21st century



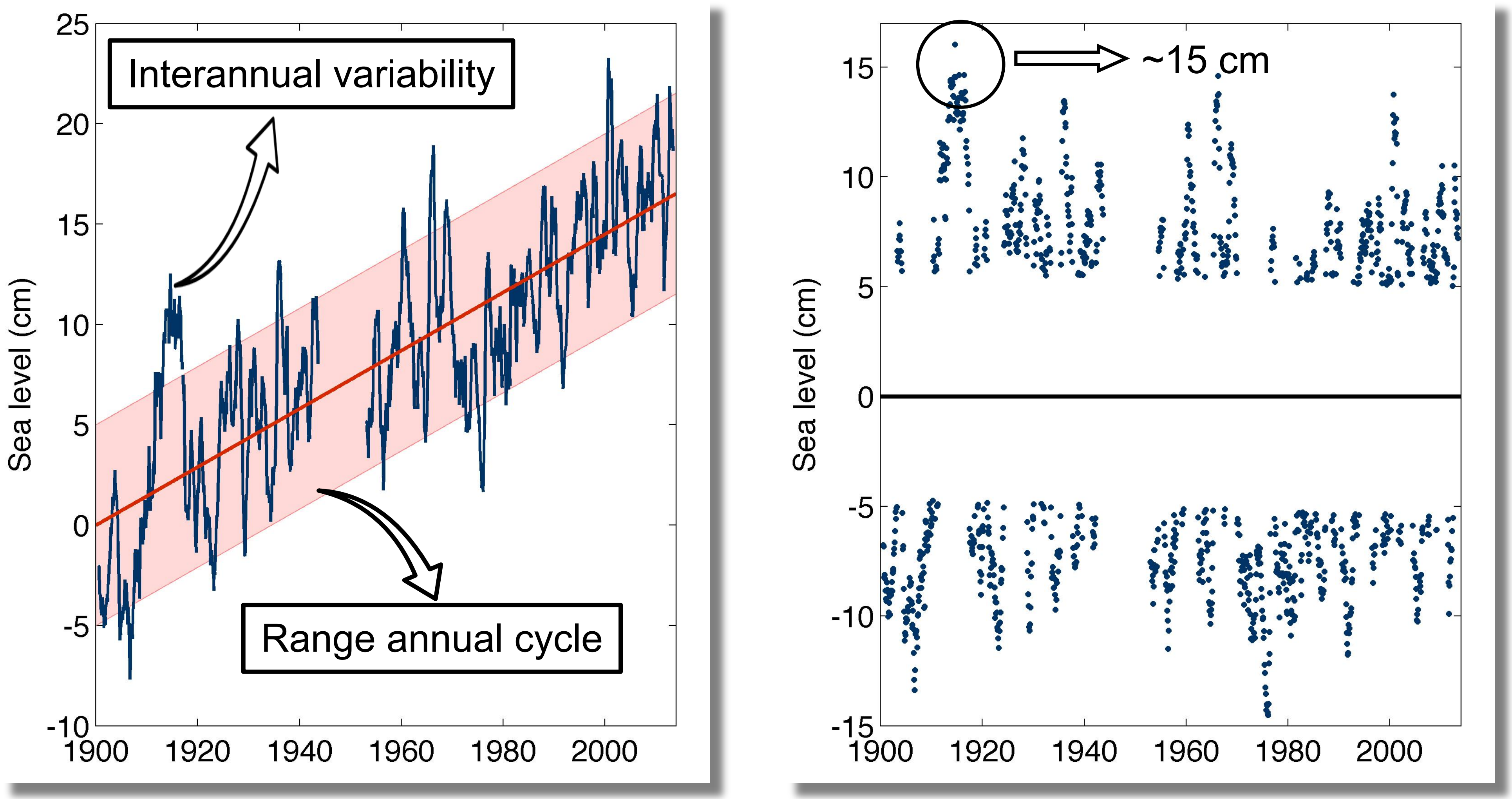
However…

Sea level rise is highly **non-uniform**



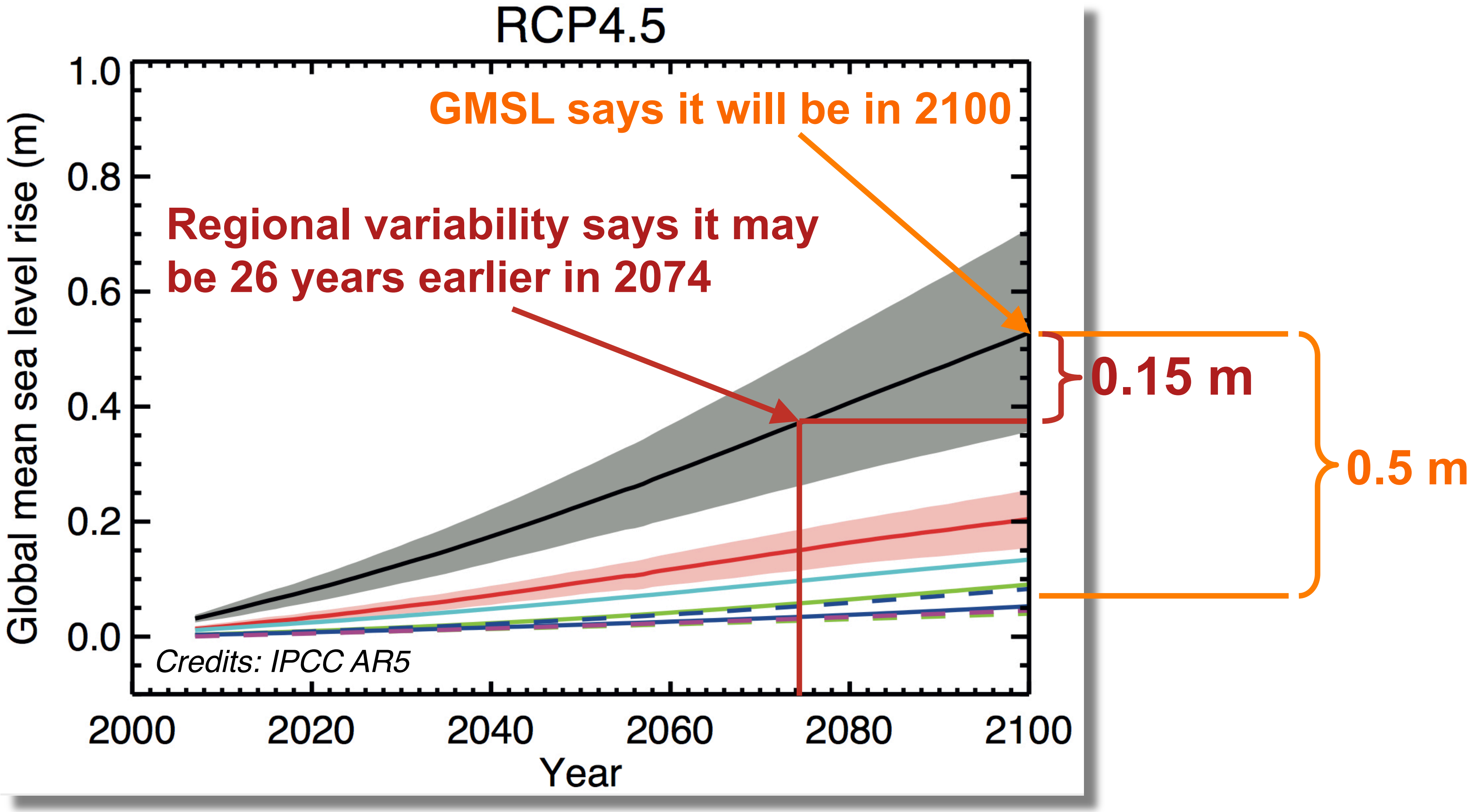
Motivation

Moreover, **sea level** varies also on a wide range of **temporal scales**



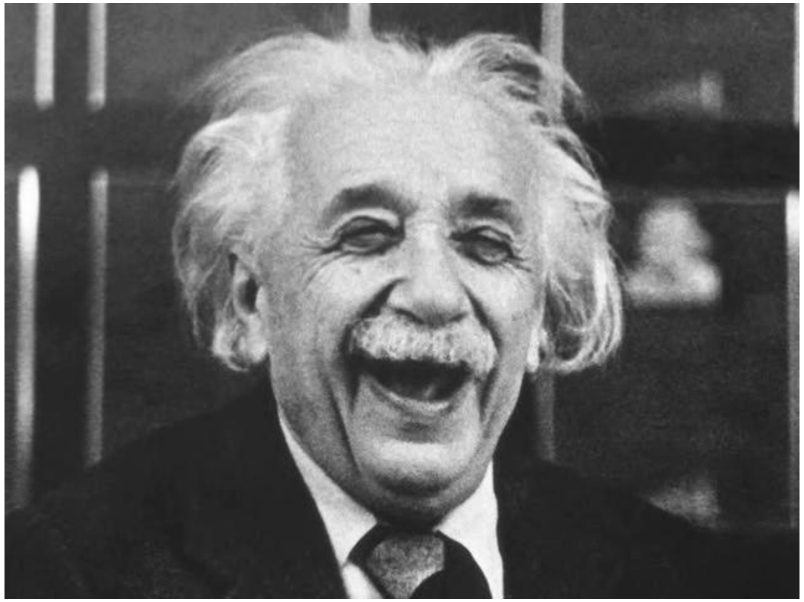
Motivation

Let's do a little exercise: when will the **0.5 m threshold** be crossed?



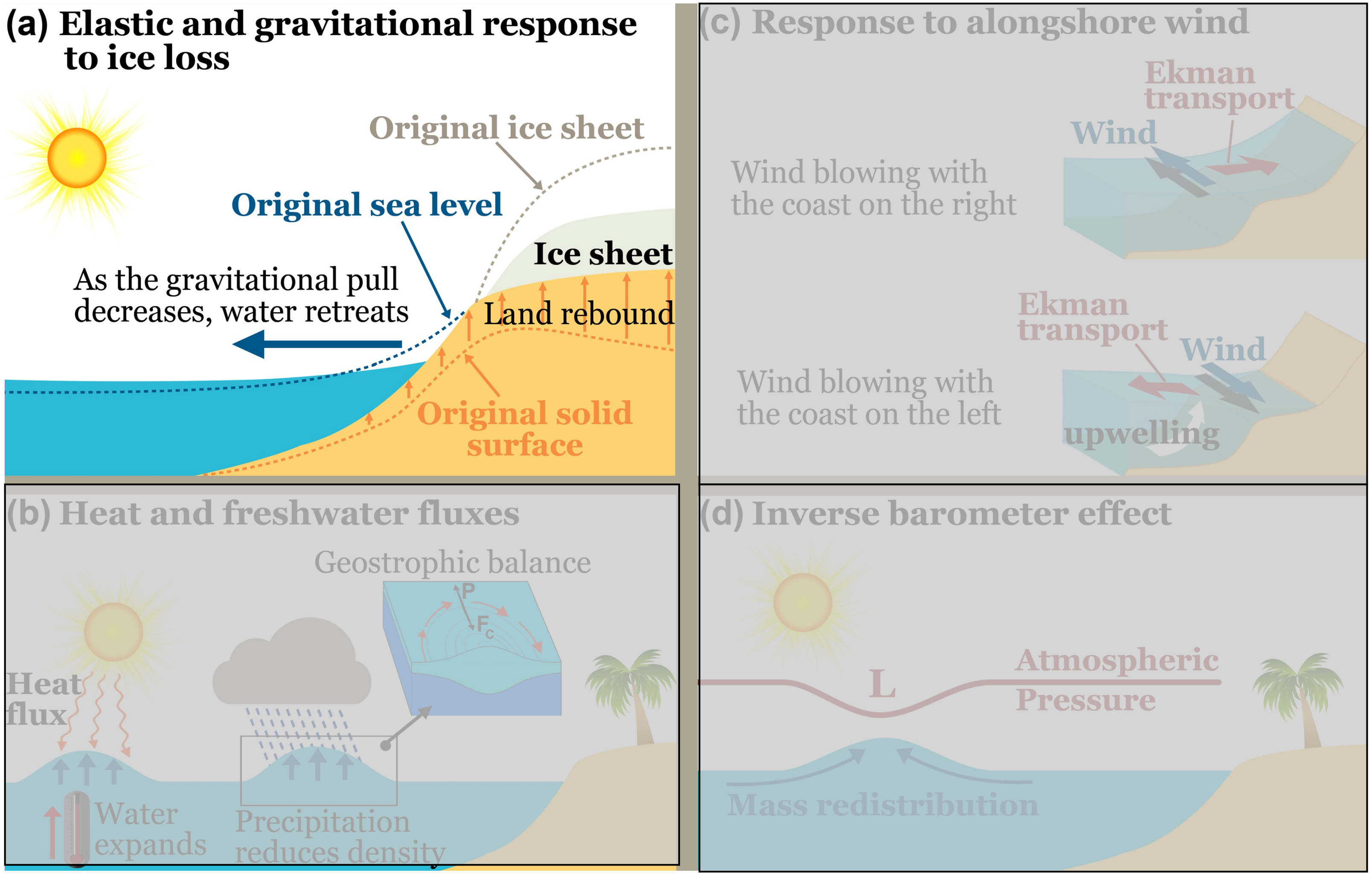
Goal

Improve our understanding of the interannual to decadal sea level variability along the European coasts so that we can produce better regional projections



"Everything should be made as simple as possible, but not simpler"

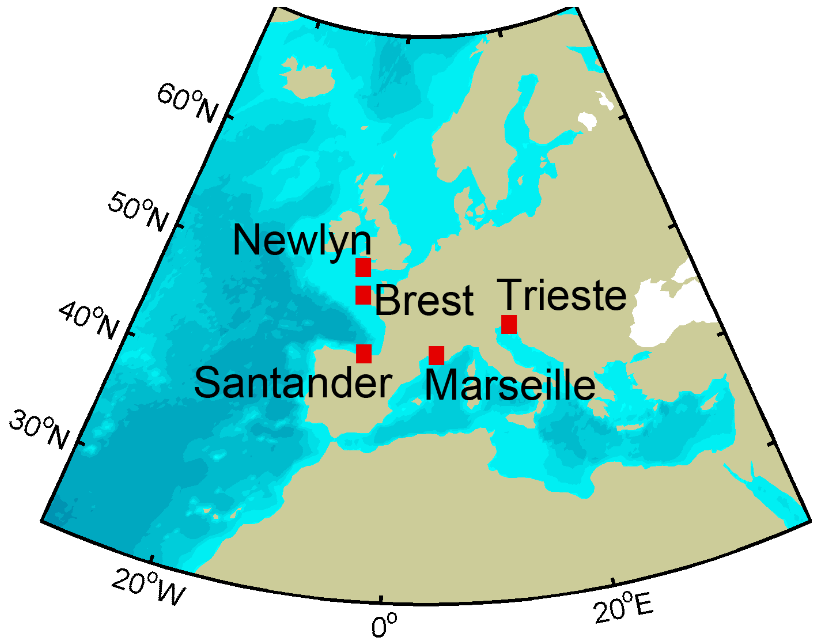
What causes the sea level to change?



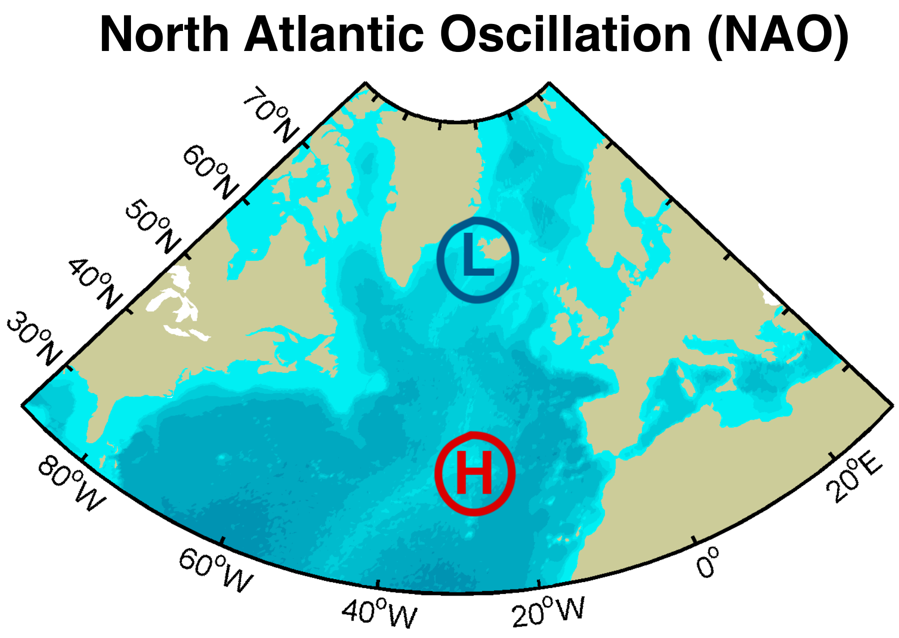
Data sets

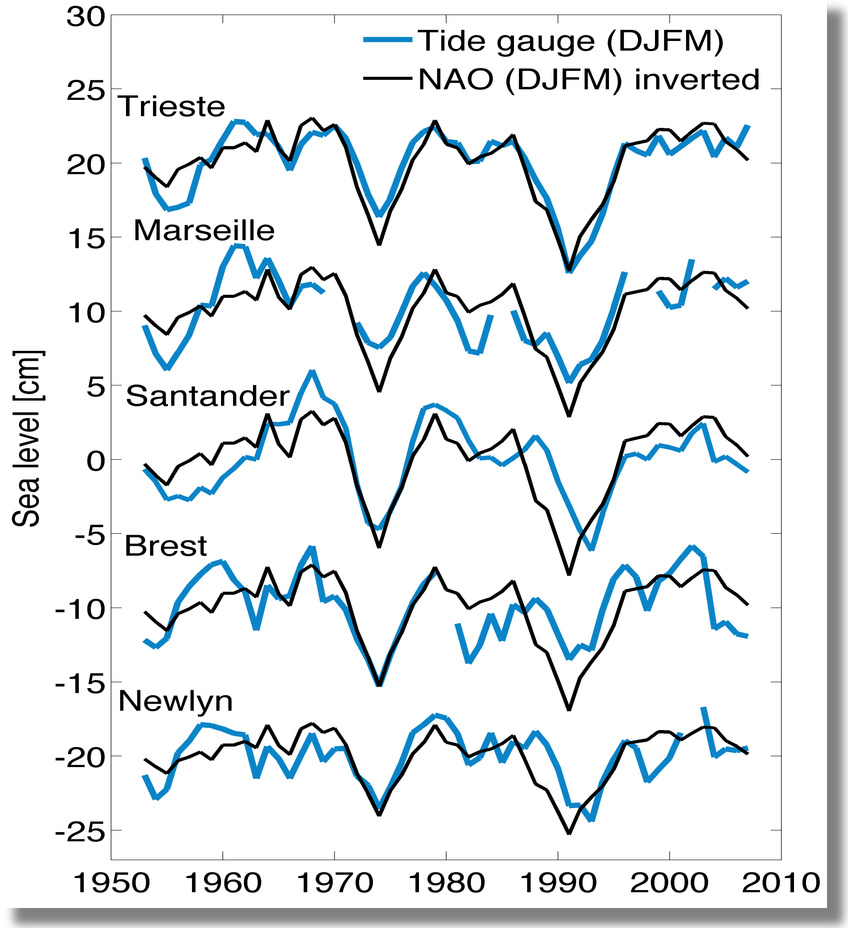
We explore decadal fluctuations from long **tide gauge records** using a combination of:

- **Atmospheric observations**: sea level pressure and wind
- A **barotropic model**: a 2D version of the HAMSOM model forced with only wind (1958-2008) (*Jordá et al., 2012)*
- A **baroclinic model**: the 3D GECCO global ocean synthesis (1952-2001) (*Kohl and Stammer, 2008*)



Sea level and the North Atlantic Oscillation





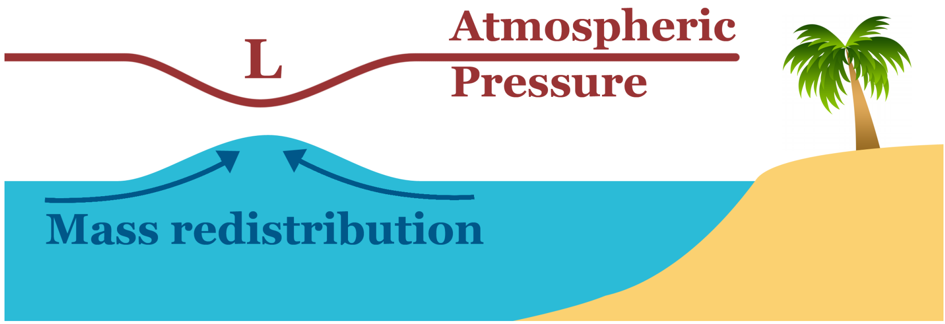
Calafat et al 2012

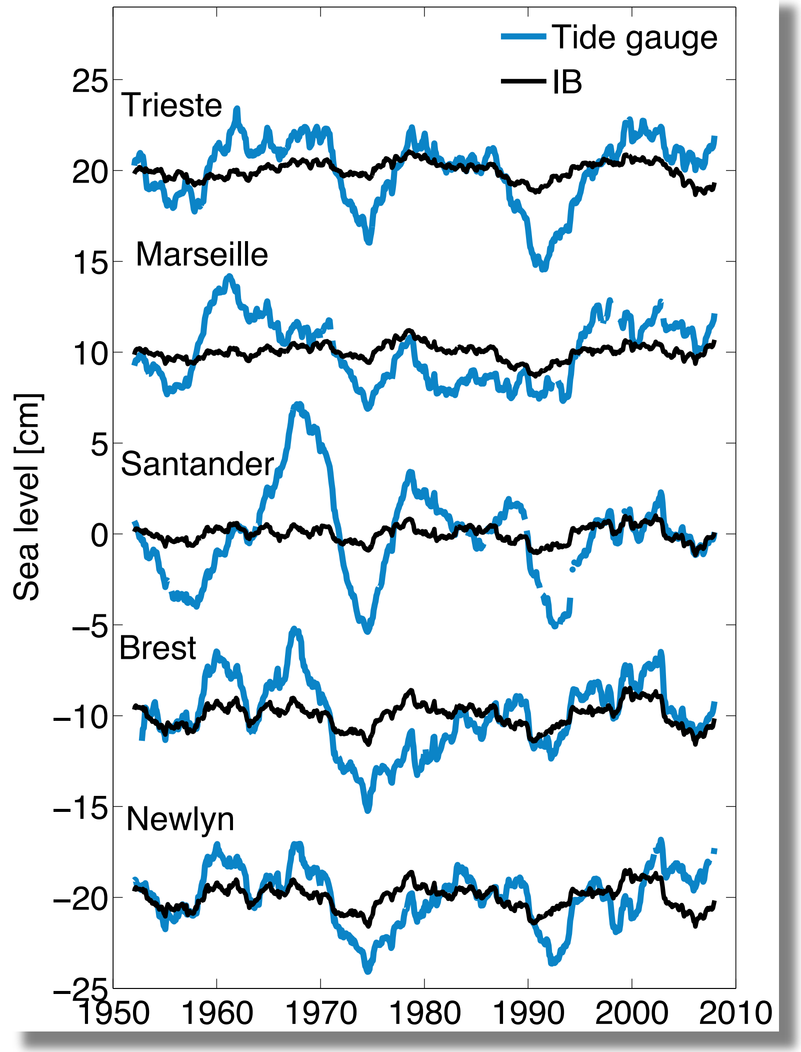
High **correlation** with NAO and **coherency** between tide gauges

The contribution of atmospheric pressure

Inverse barometer

$$SL_{IB} = \frac{1}{g\rho_0}\left(\overline{P}_a - P_a\right)$$





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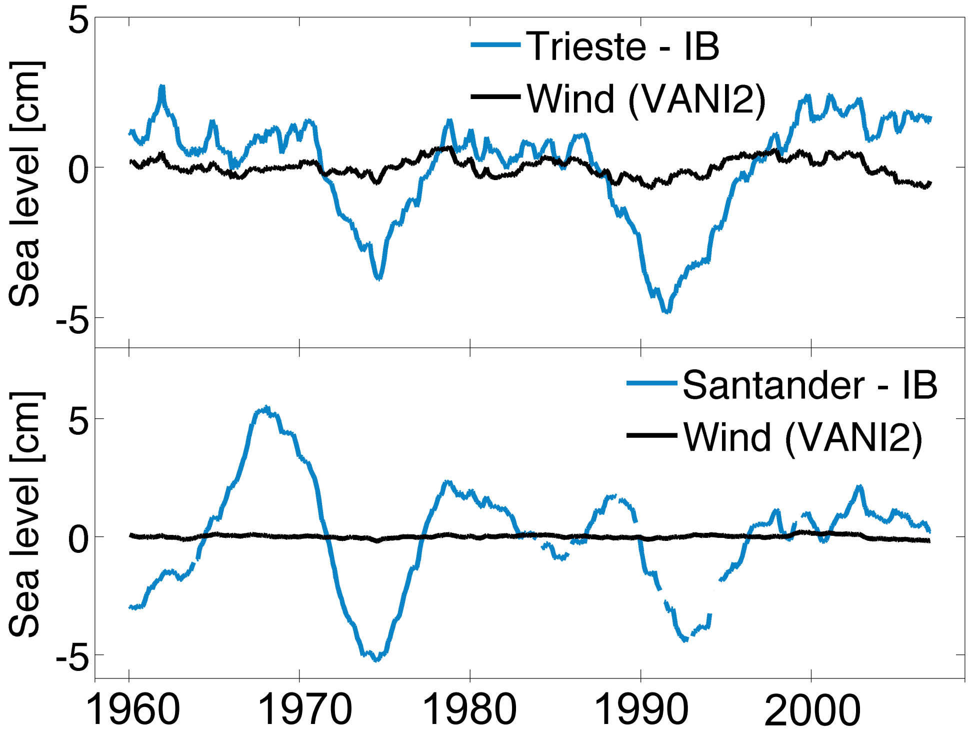
The barotropic response to the wind

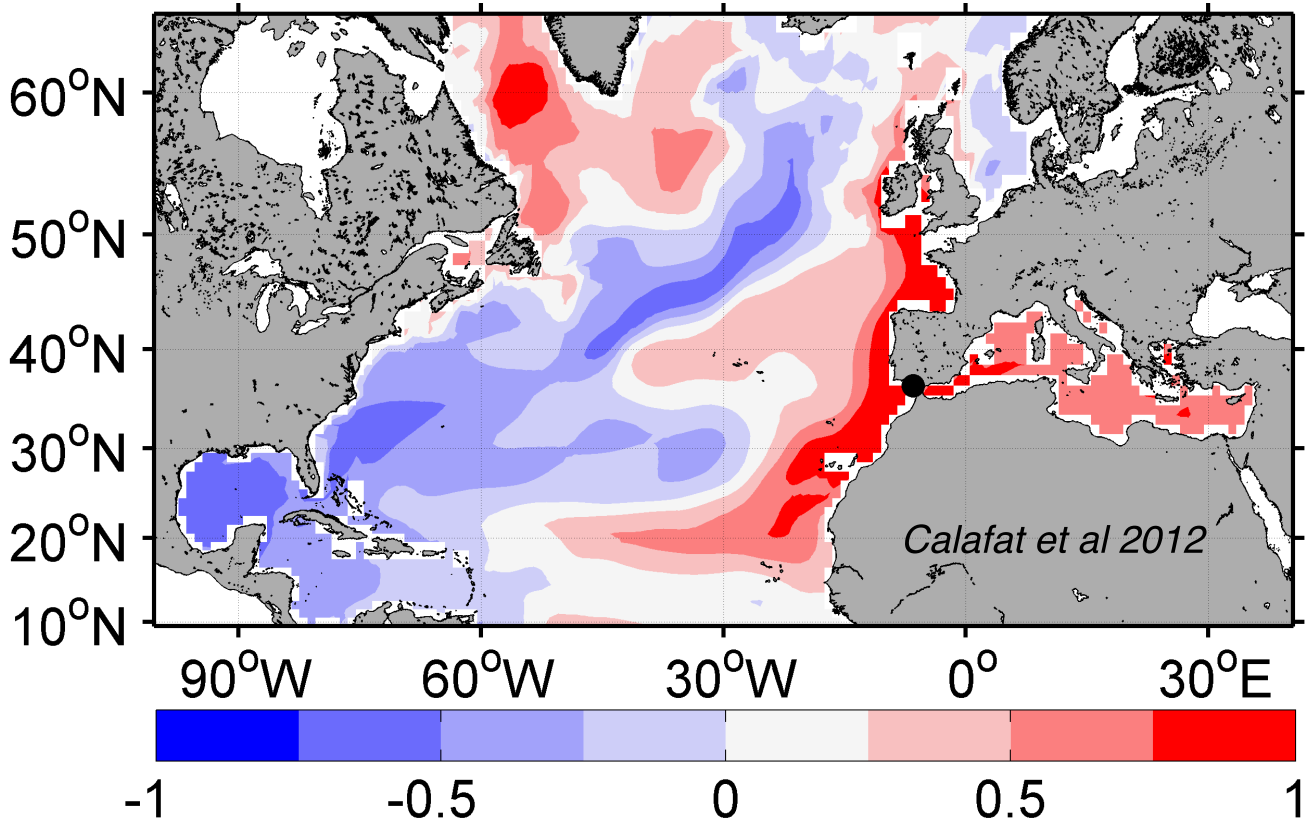
Sea level from the HAMSOM model



The barotropic response to wind explains a very small fraction of the variability

Calafat et al 2012

A coherent sea level signal along the coast



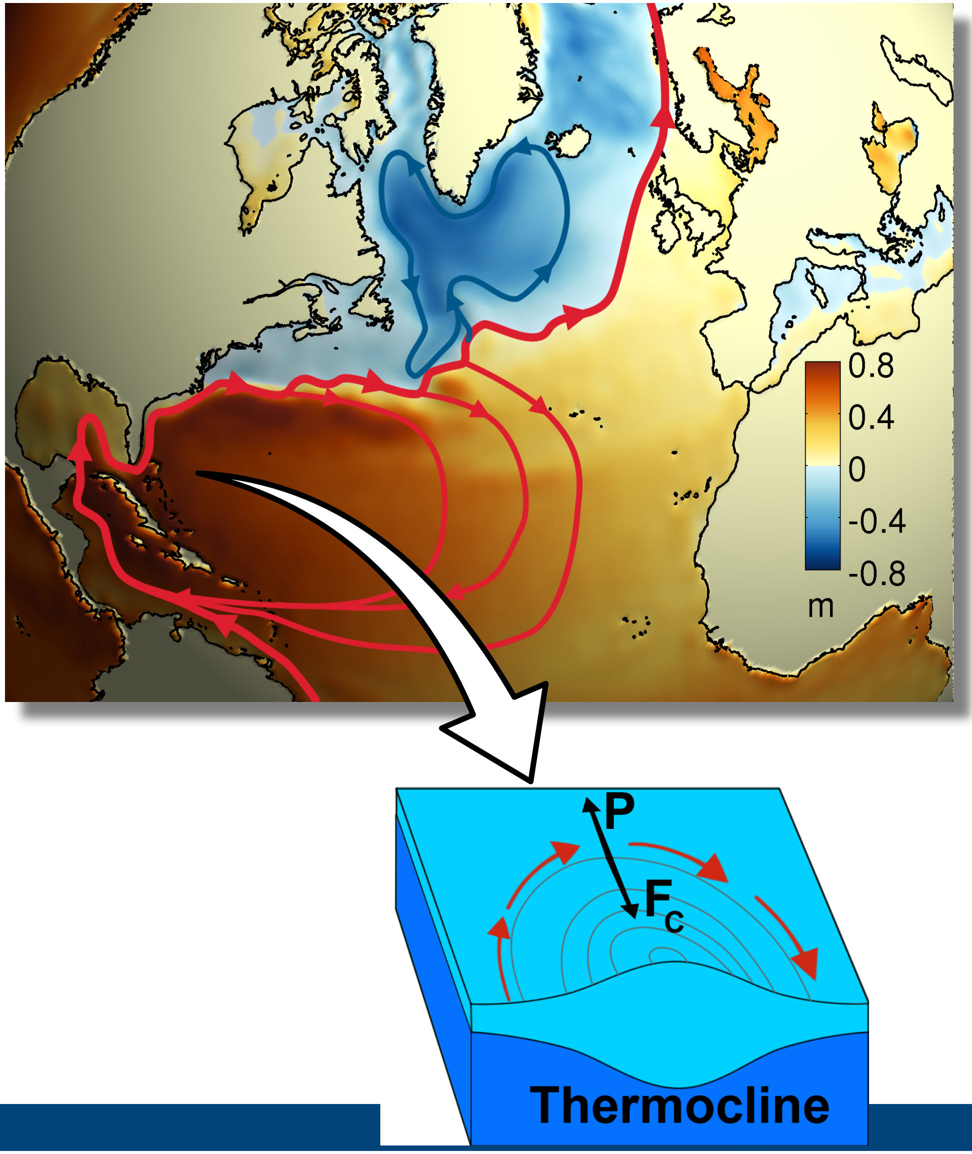
The **coherent signal** is limited to a narrow band along the coast

⇨

Subtropical gyre fluctuations or wave propagation?

Contribution from the subtropical gyre

North Atlantic large-scale circulation



Barotropic streamfunction

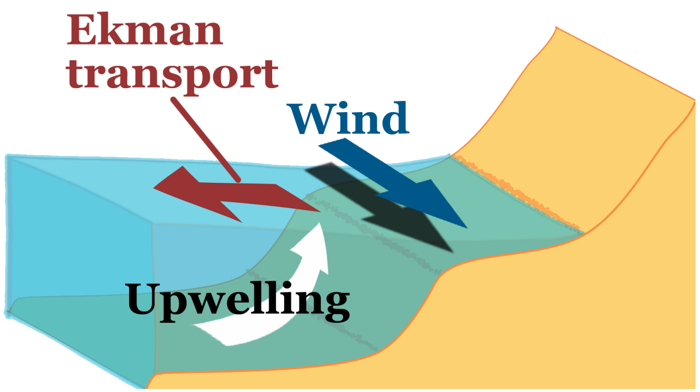
$$\psi(x,y,t) = \int_{-H}^{0}\int_{x_E}^{x} v(x',y,z,t)\,dx'\,dz$$

⇩

Transport of the subtropical gyre

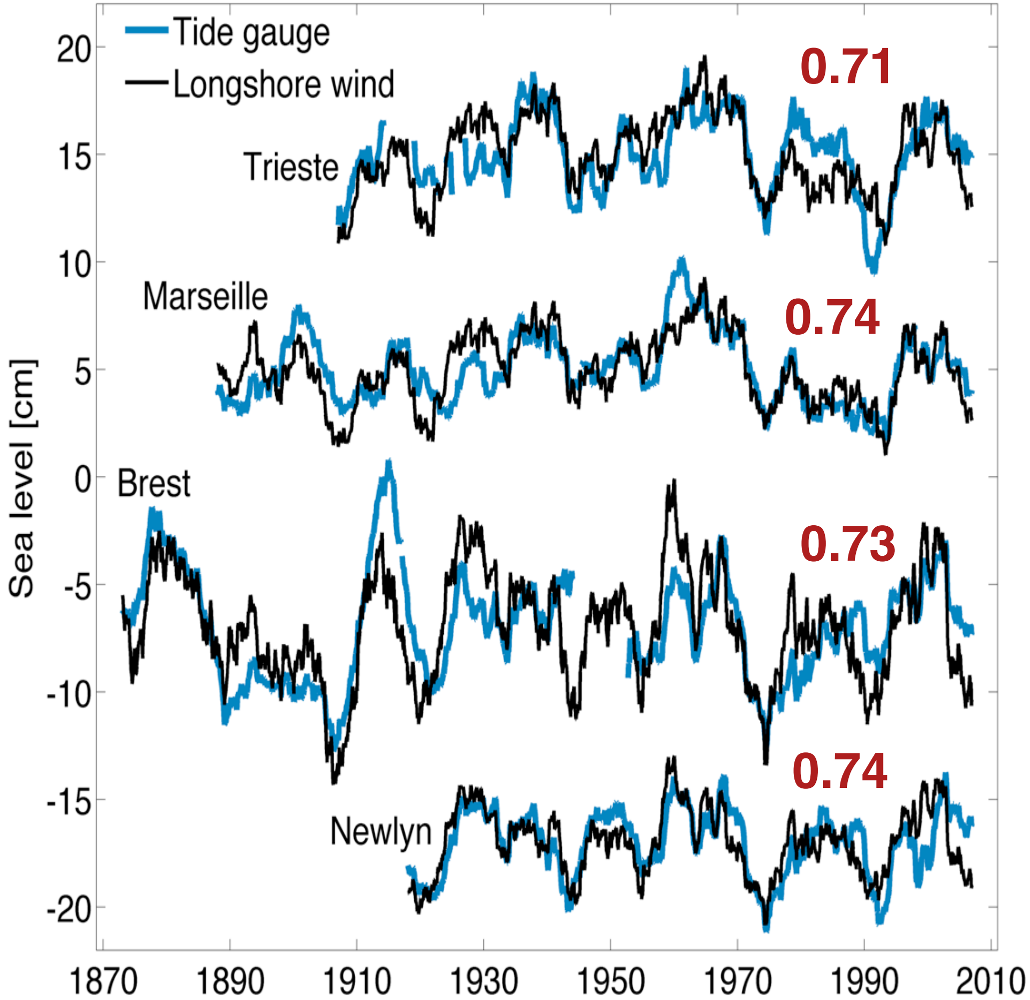
We found **no correlation** between the strength of the subtropical gyre and the sea level along the eastern boundary

The baroclinic response to the longshore wind



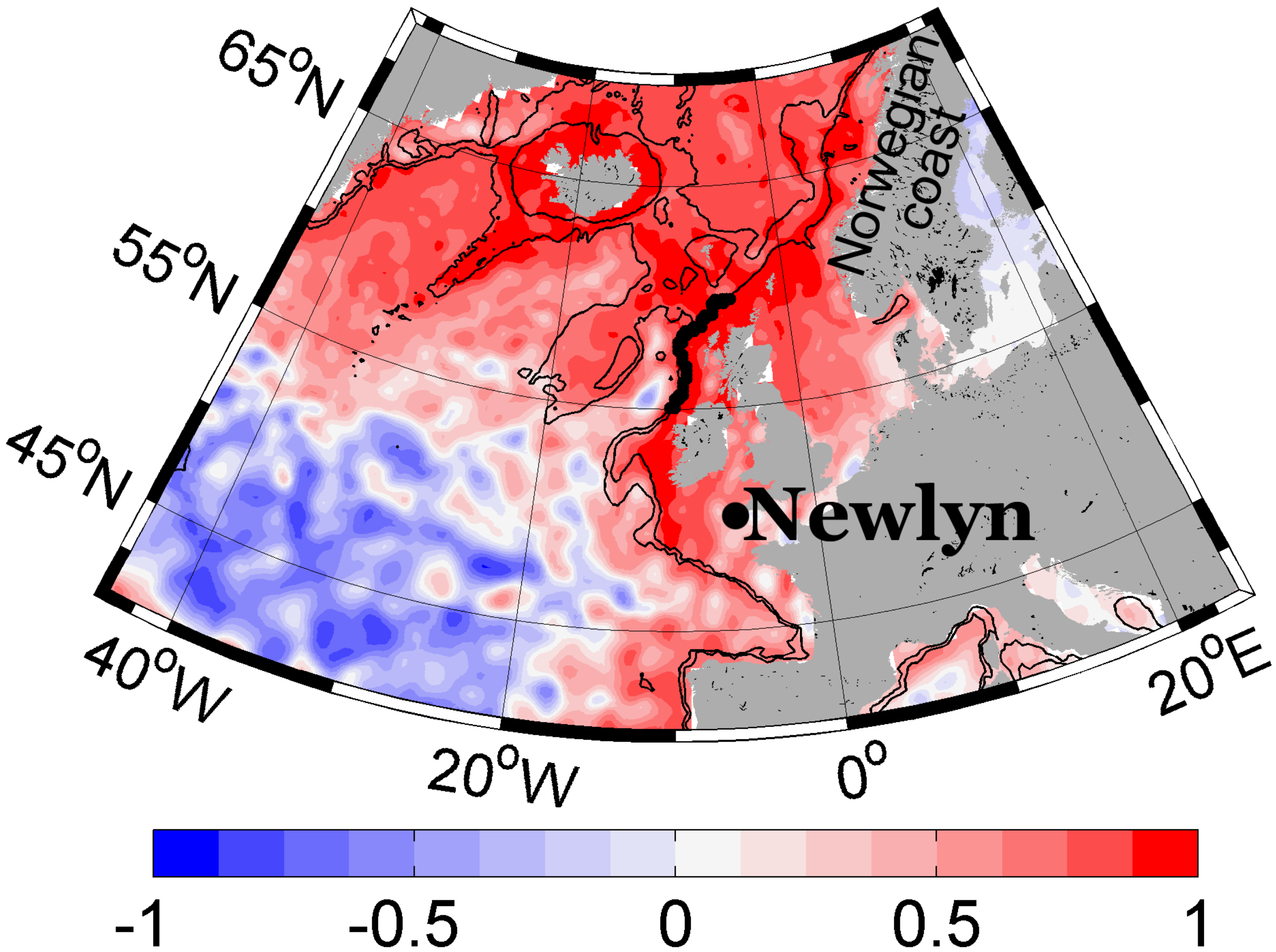
The response is **not local**. It can be expressed as a sum of modes (waves) with amplitudes given by:

$$A(y,t) = \int_{y_0}^{y} B\tau^s\left(y', t - \frac{y - y'}{c}\right) dy'$$



Calafat et al 2012

What is the extension of this signal?



Calafat et al 2013

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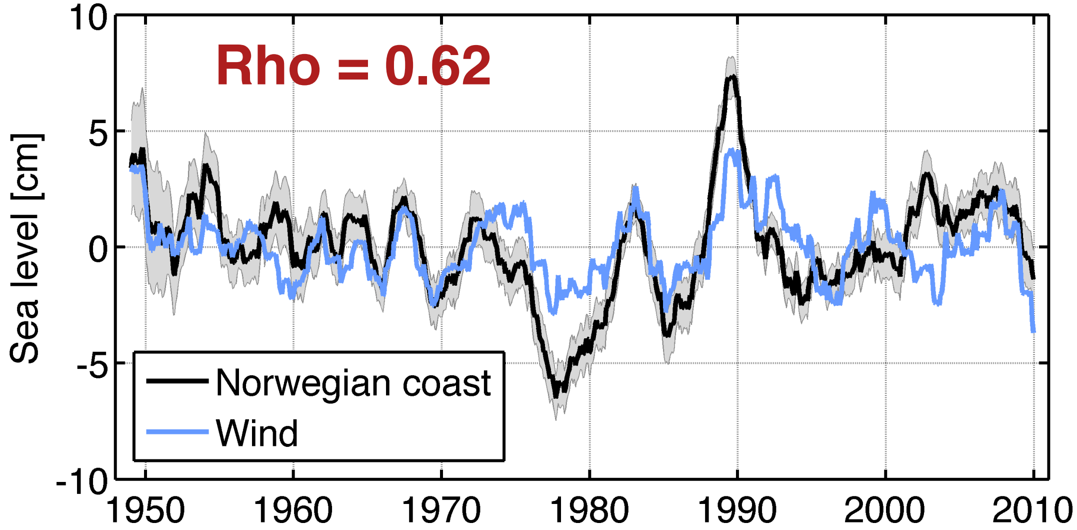

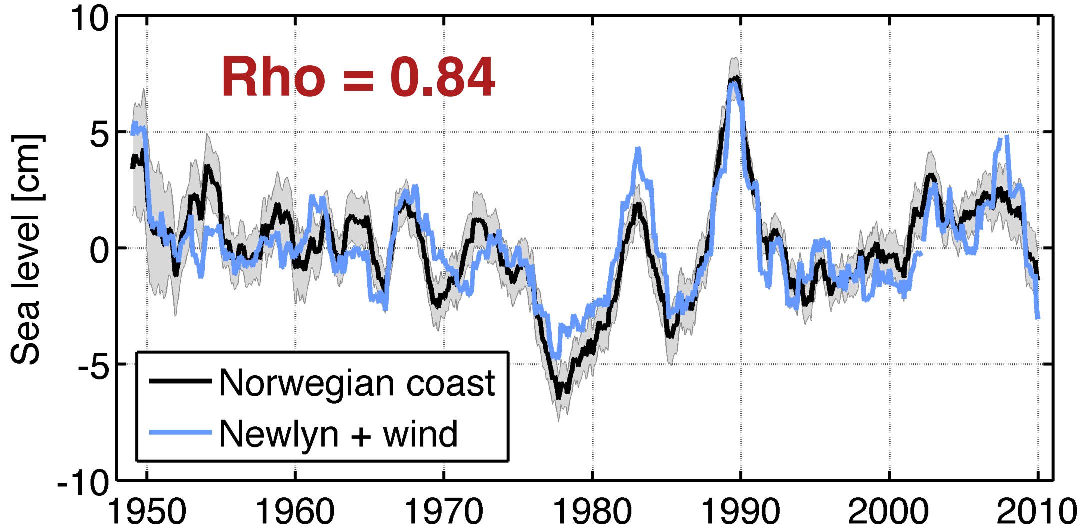

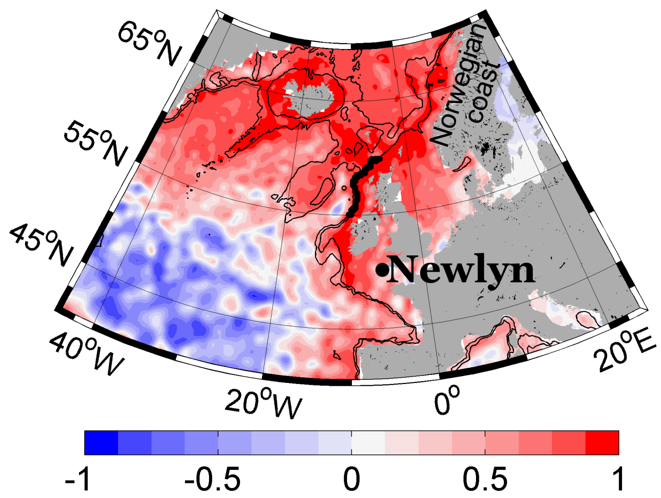

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Conclusions

- There is **significant decadal-scale variability** in the coastal zone
- Such variability can be explained as a response to changes in **longshore wind forcing** and **boundary waves propagation**
- Variations are highly **coherent** along the coast from the Canary Islands up to the Norwegian coast
- Open-ocean and coastal sea level are **decoupled**, hence the need for improved altimetry data at the coast that help us understand the transmission of oceanic signal across the shelf to the coast