OVALIE PROJECT

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LIVING PLANET FELLOWSHIP

HYDROSPHERE

Atmospherically-forced and chaotic interannual variability of regional sea level and its components over 1993-2015

Institut
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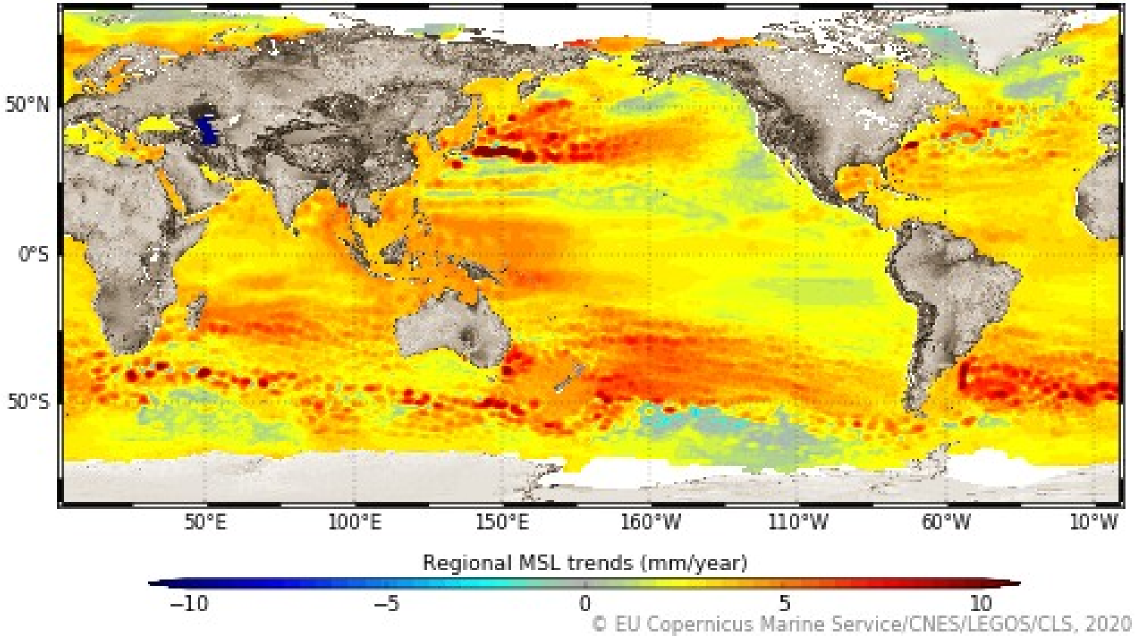
de l'environnement

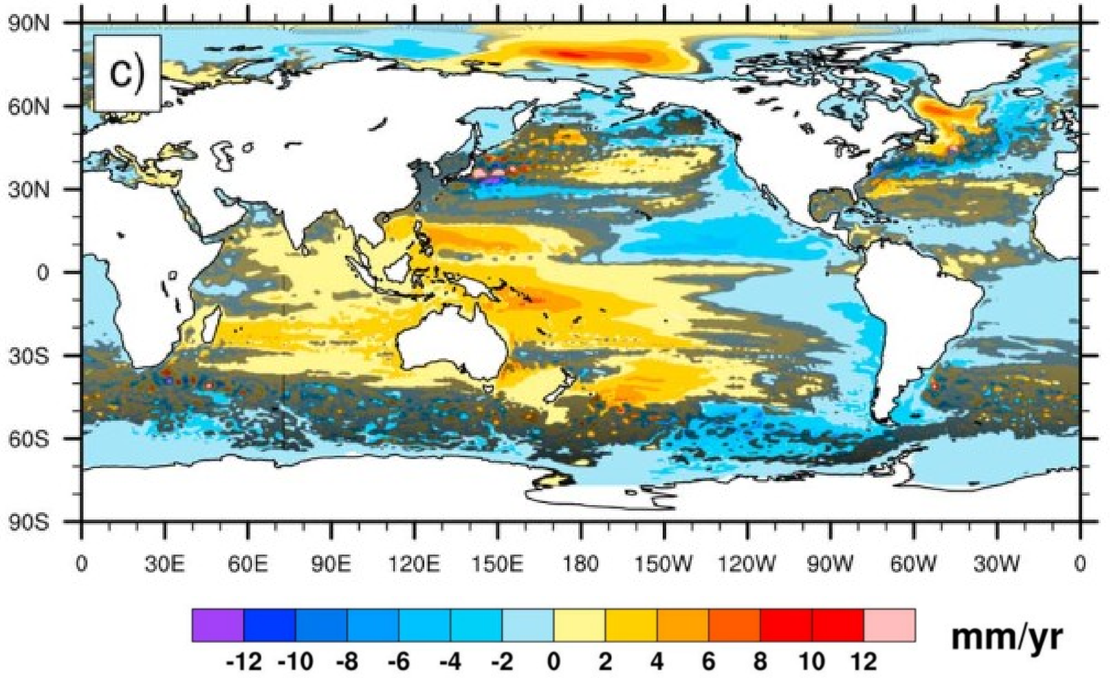
Context

- Global mean sea level rise of 3.1 mm/year (WCRP Global Sea Level Budget Group, 2018) with large regional variability
- Chaotic ocean variability may mask atmospherically-forced regional sea level trends over 38% of the global ocean area (black dots) from 1993 to 2015 (*Llovel et al., 2018, Penduff et al., 2019*)

Regional mean sea level trends (mm/yr)



Ensemble mean of sea level trends from the 50 members over 1993–2015



Objectives

- To disentangle the regional sea level (Δh) forced and chaotic variability at interannual time scales over 1993-2015

- To investigate the steric and manometric (the measurement of pressure) components

$$\Delta h = \Delta h_{steric} + \Delta h_{manometric}$$

- To analyse the response of the different oceans to the chaotic and atmospherically-forced sea level interannual variability

- To compare our methodology to previous studies on the subject (*Forget and Ponte 2015, Penduff et al., 2011*)

DATA

The OCCIPUT ensemble simulation

- Based on NEMO 3.5 model
- 50 member ensemble simulation
- Curvilinear grid : 1/4° resolution
- Period of the simulation : 1960 – 2015
- 20-year spin-up
- Monthly temporal resolution
- Same atmospheric forcings
- Initial perturbations x 50

Satellite altimetry data: the CCI product

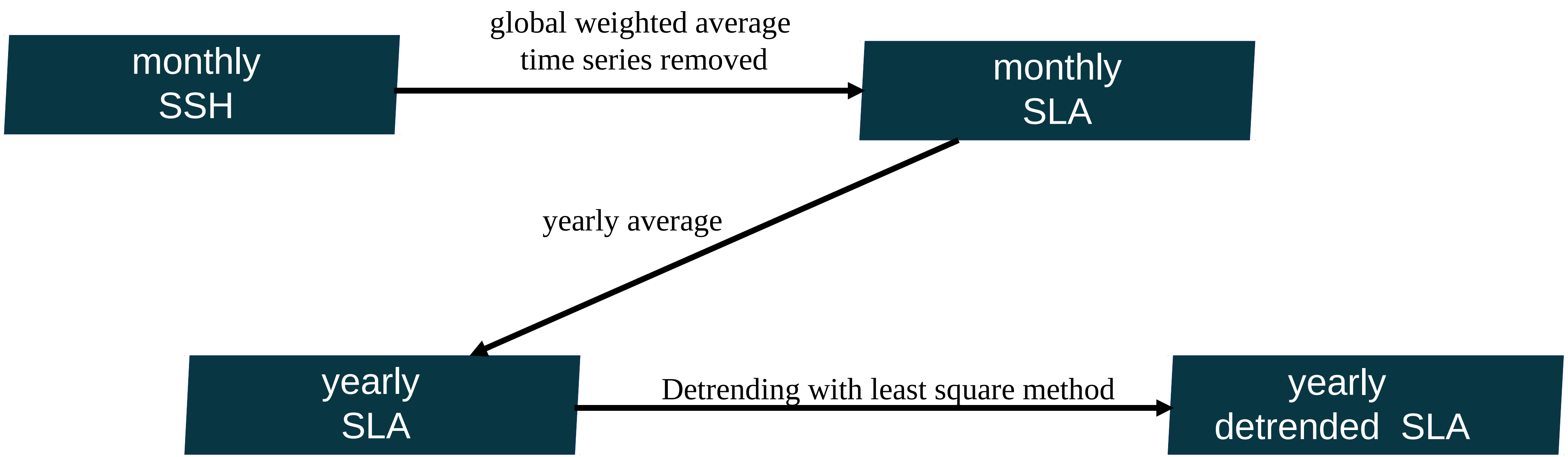
- 1/4° resolution
- Period : 1993-2015
- Monthly temporal resolution
- All available satellite altimetry missions

Steric sea level data: the ISAS product

- 1/2° resolution
- Period : 2002-2015
- Monthly temporal resolution
- In situ measurements (Argo profiles,..)

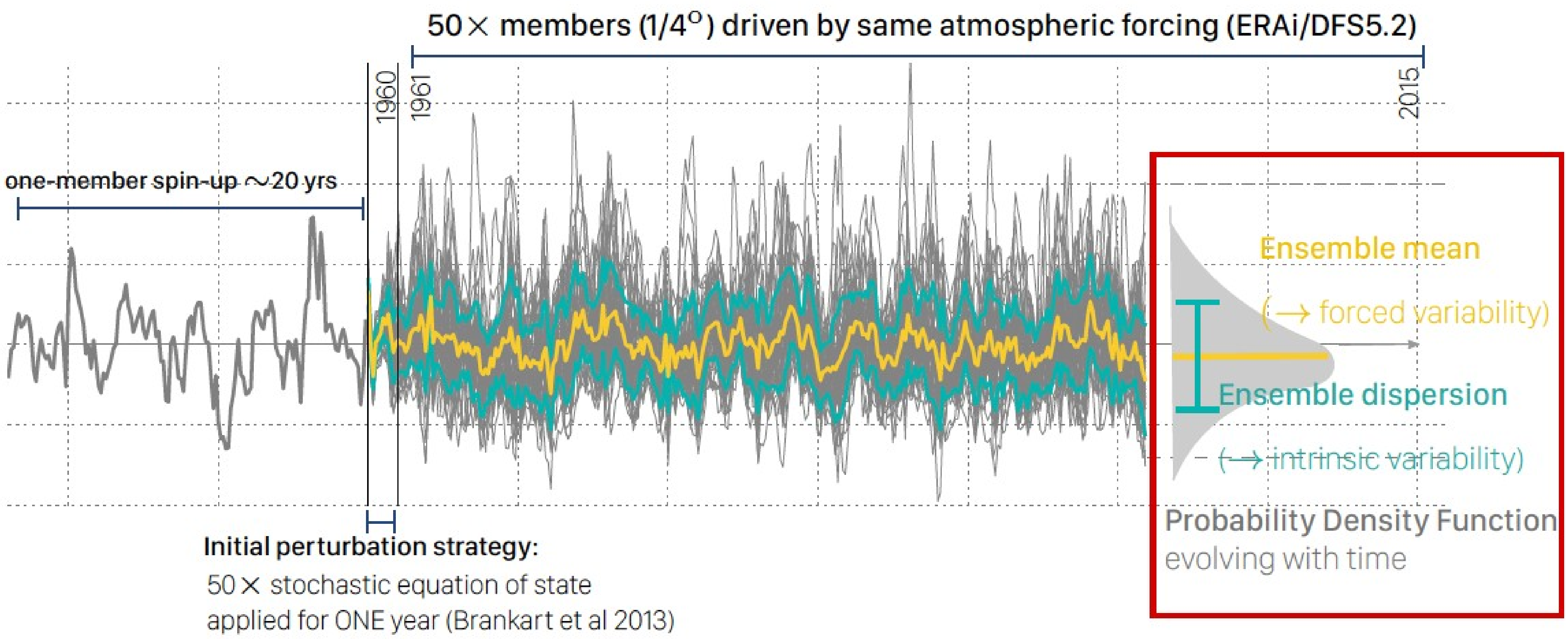
Methodology

- From the simulated sea surface height (SSH) to an adequate dataset to investigate sea level interannual variability



- Period considered : 1993-2015
- The same processes are applied to the steric sea level and the manometric sea level

Methodology

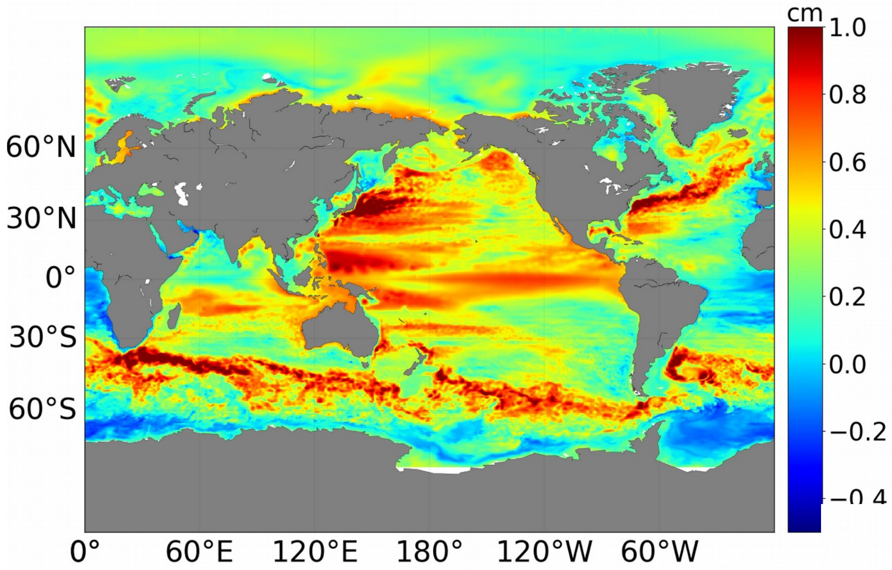


σ_{forced} = ensemble mean standard deviation

$\sigma_{chaotic}$ = ensemble dispersion time mean

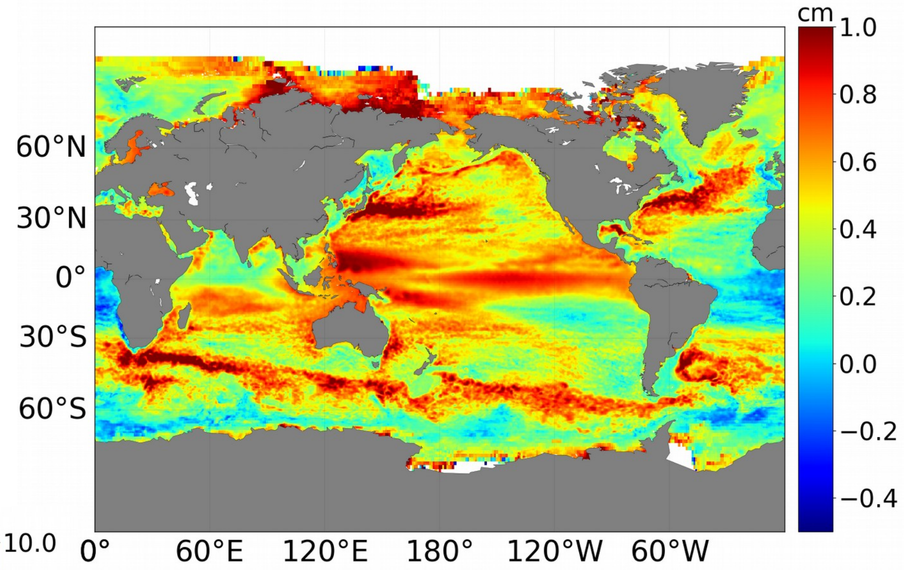
Model assessment vs the CCI product

1993-2015



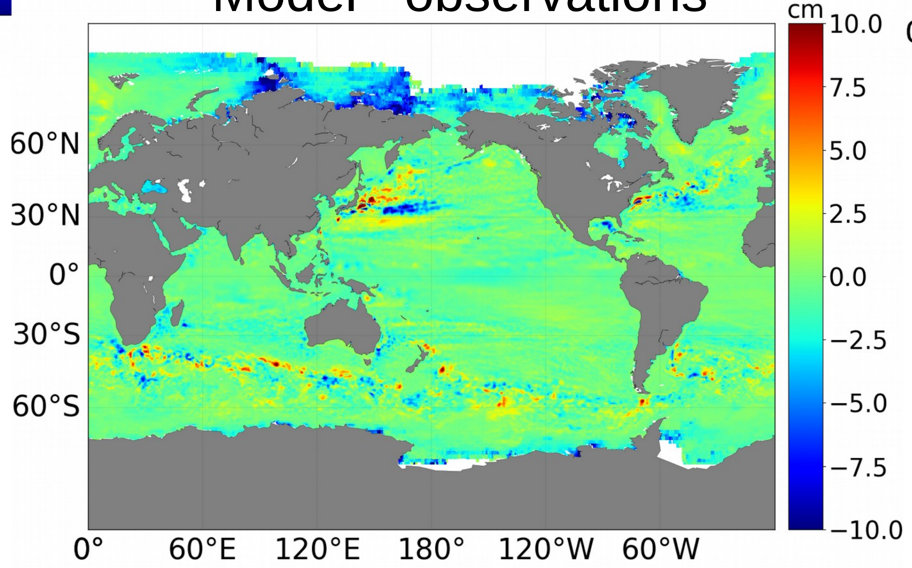
Model

⚠ Logarithmic scale



Observations

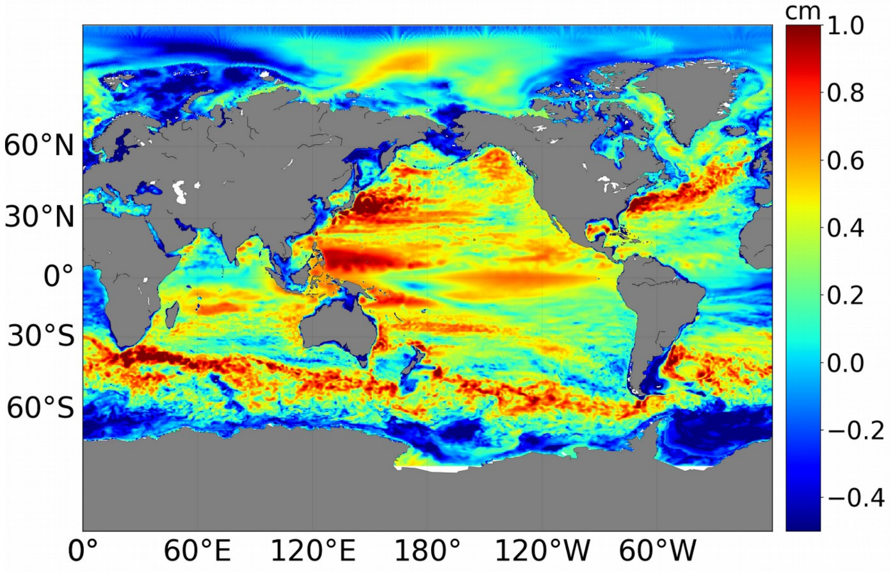
Model - observations



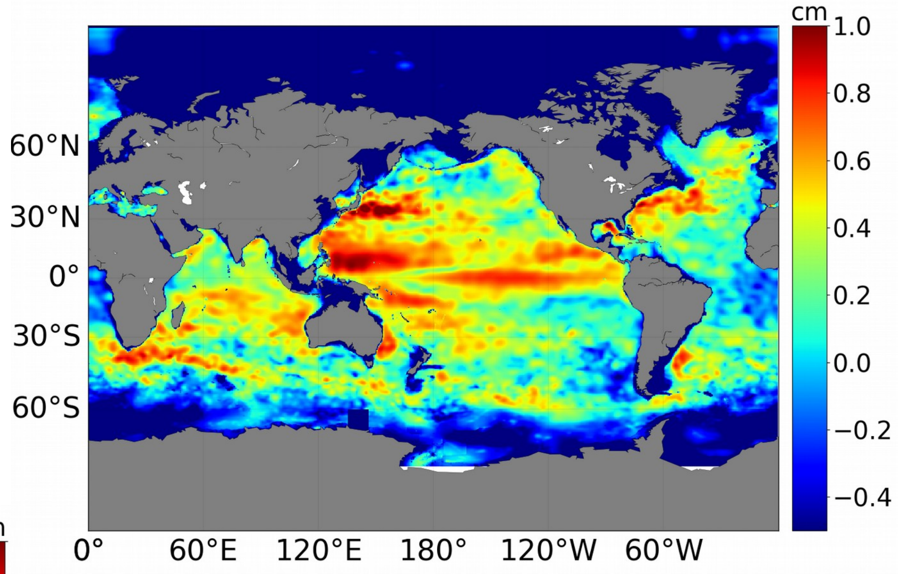
Model assessment vs the ISAS product

2005-2015

← Logarithmic scale →

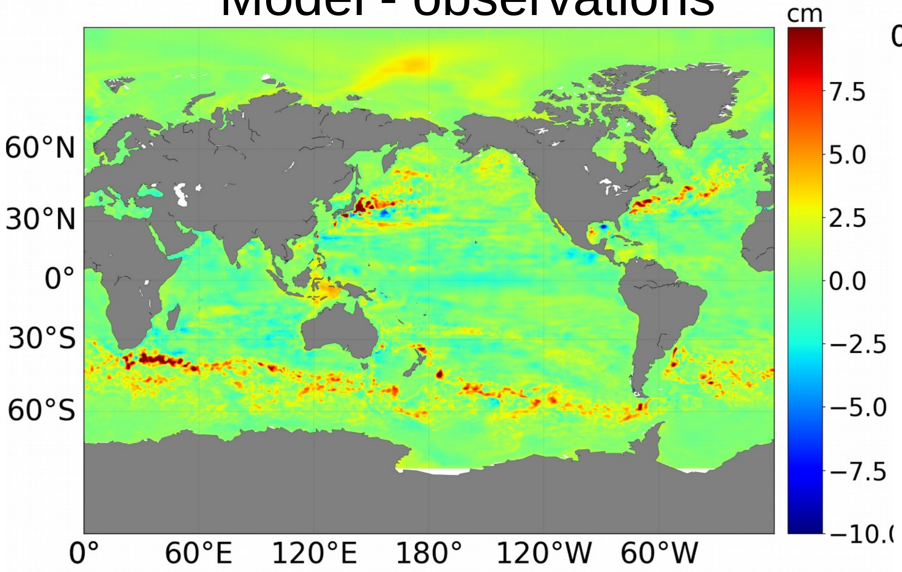


Model

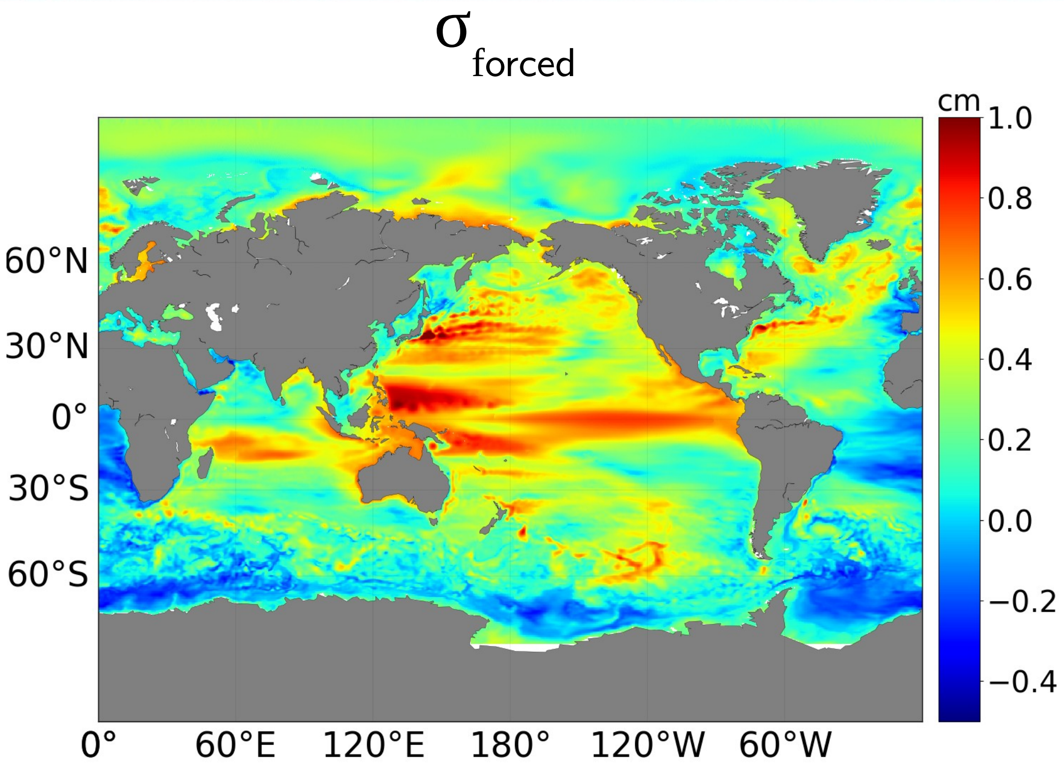


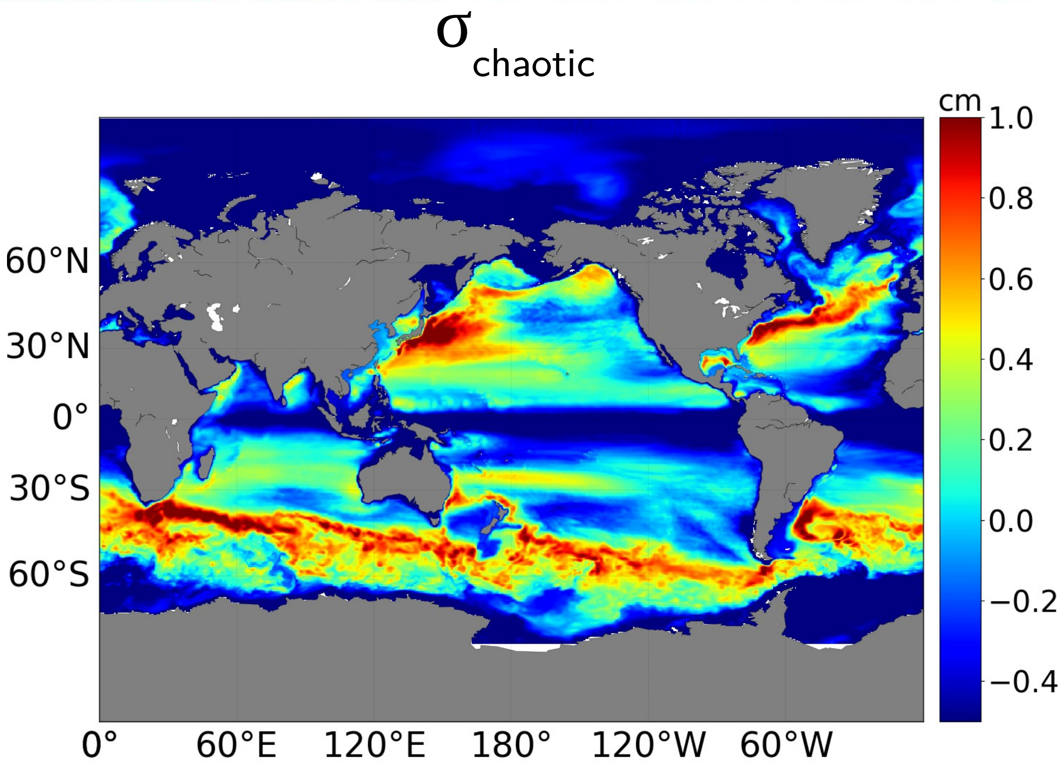
Observations

Model - observations



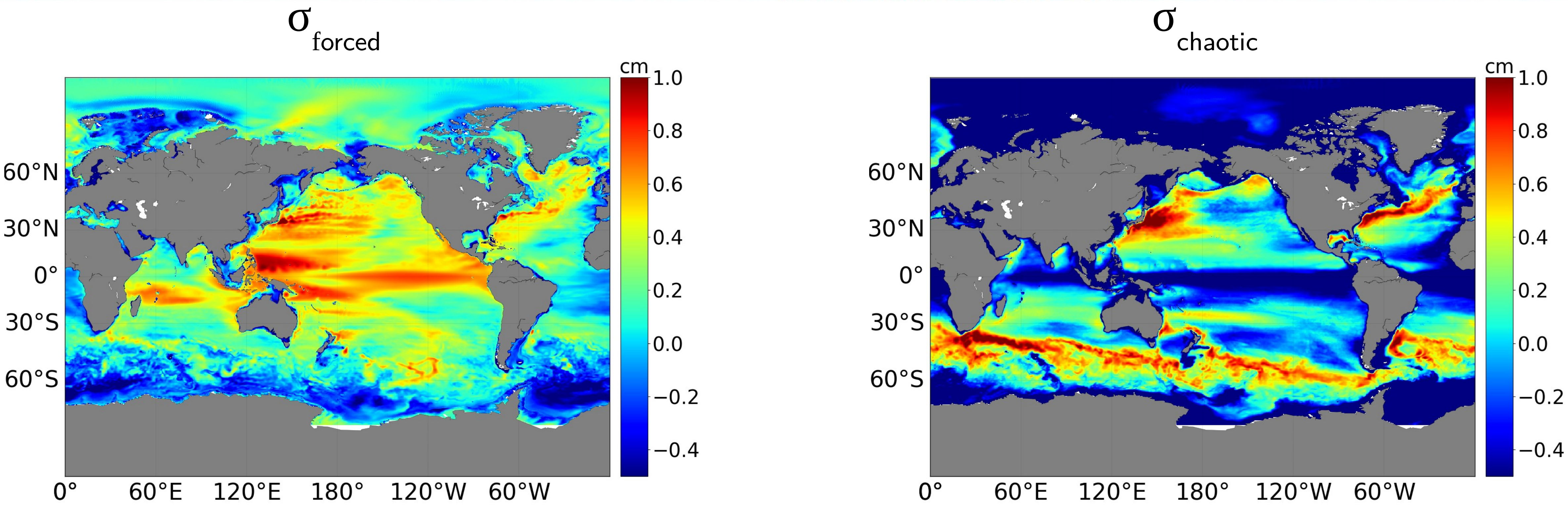
Atmospherically-forced and chaotic variabilities : SLA





- σ_{forced} strong at low latitudes and near the coasts and weak in the South Atlantic Ocean
- $\sigma_{chaotic}$ strong in the ACC, along the western boundary currents (Kuroshio, Gulf Stream) and weak in the equatorial band
- The energetic system (western boundary currents) also have a forced component

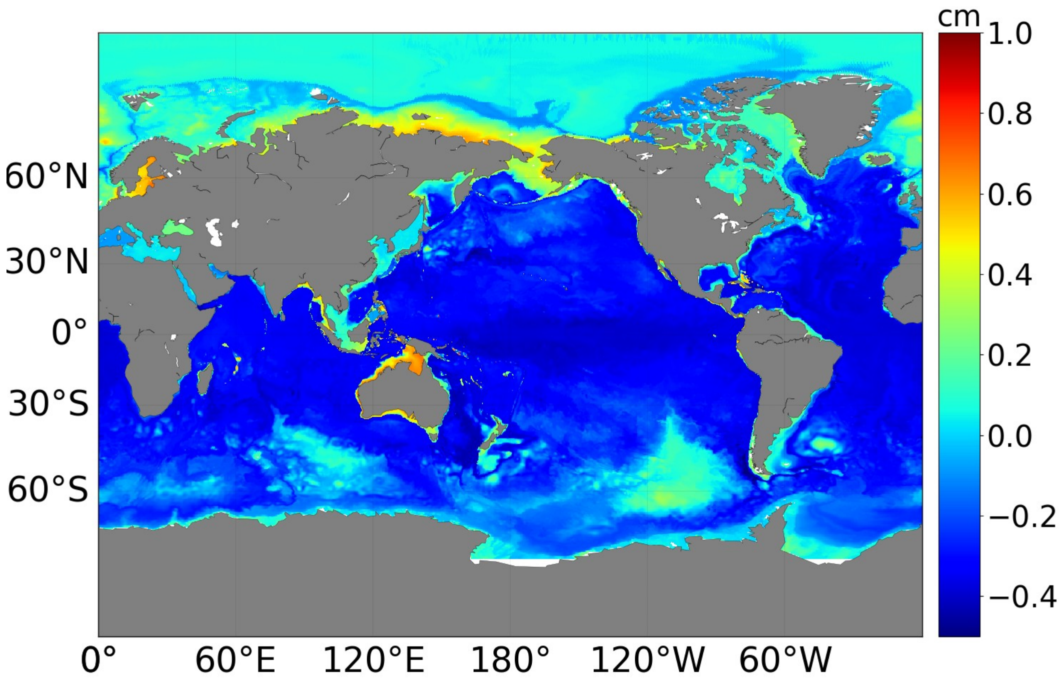
ATMOSPHERICALLY-FORCED AND CHAOTIC VARIABILITIES : STERIC COMPONENT



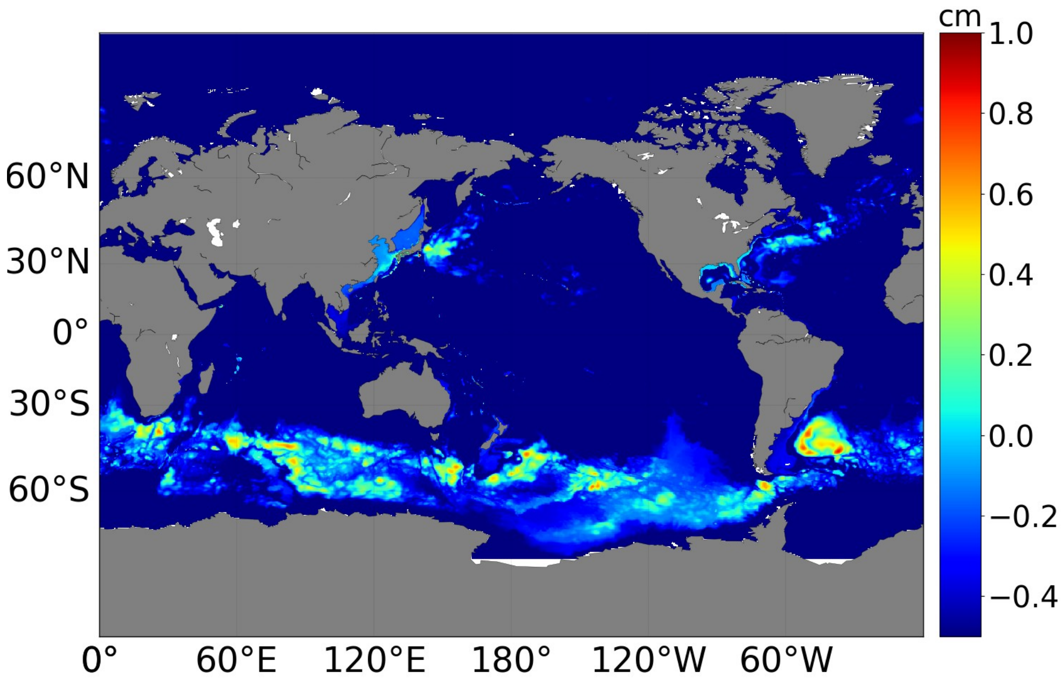
- Steric σ_{forced} is high at low latitudes and steric $\sigma_{chaotic}$ is high in the ACC and along western boundary currents.
- σ_{forced} and $\sigma_{chaotic}$ spatial patterns are mainly explained by the steric variability spatial patterns
- Differences mainly in the coastal regions

Atmospherically-forced and chaotic variabilities : manometric component

σ_{forced}



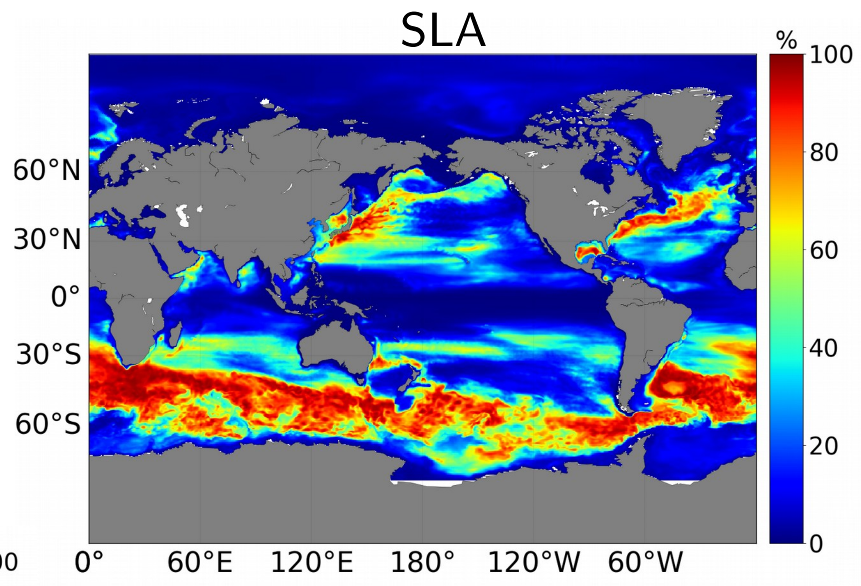
$\sigma_{chaotic}$

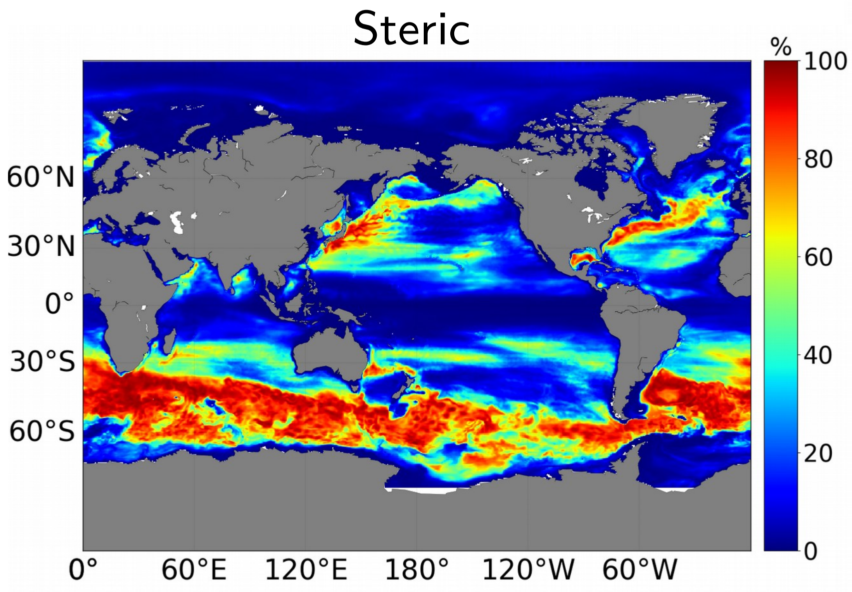


- Manometric σ_{forced} explains the high σ_{forced} along the coasts and above 65°N
- Manometric $\sigma_{chaotic}$ strong in the ACC, the western boundary currents and near the Chinese coast

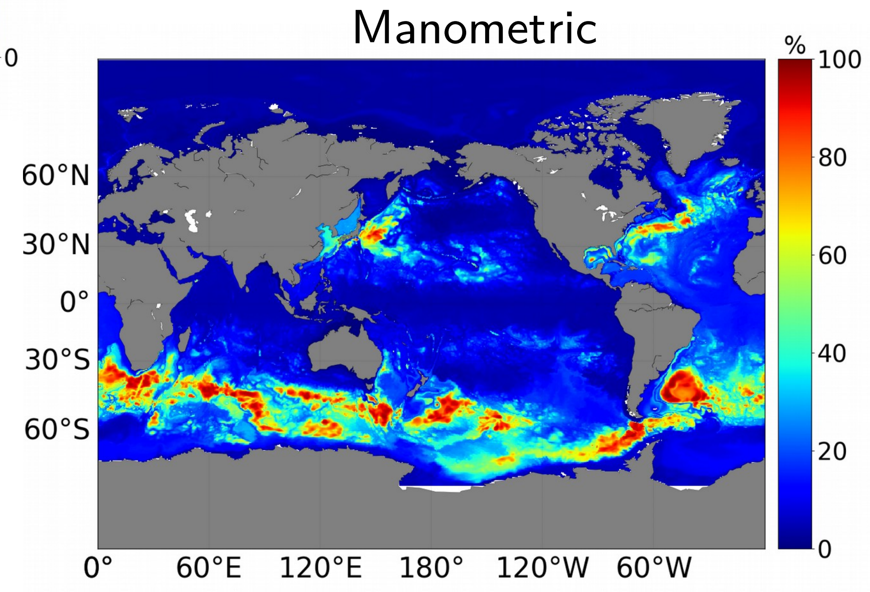
Identification of interannual chaotic hotspots

$$R = \frac{\sigma^2_{chaotic}}{\sigma^2_{chaotic} + \sigma^2_{forced}}$$

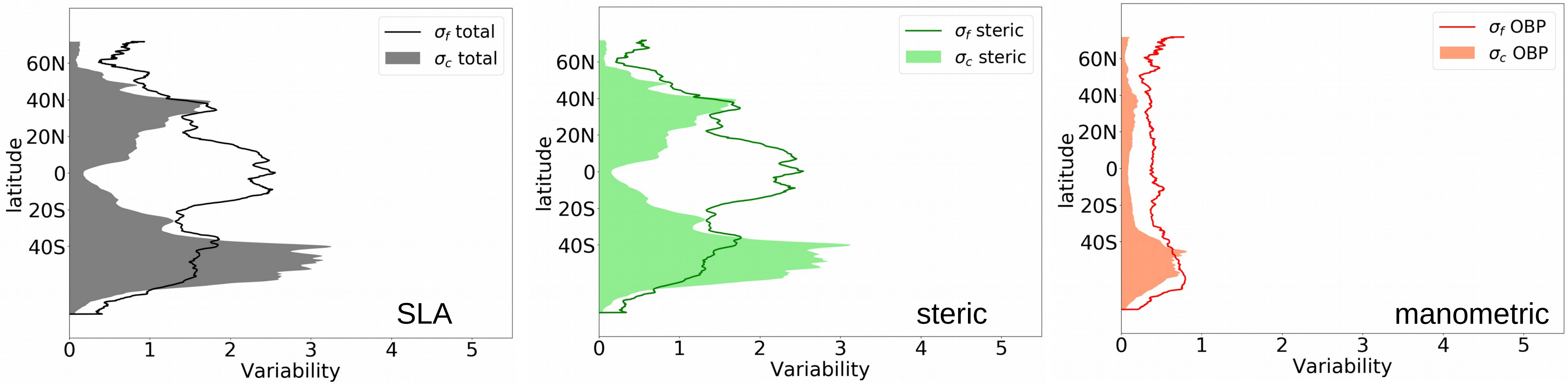




- R > 20 % over 48 %, 48 %, 26 % for the SLA, steric and manometric sea level

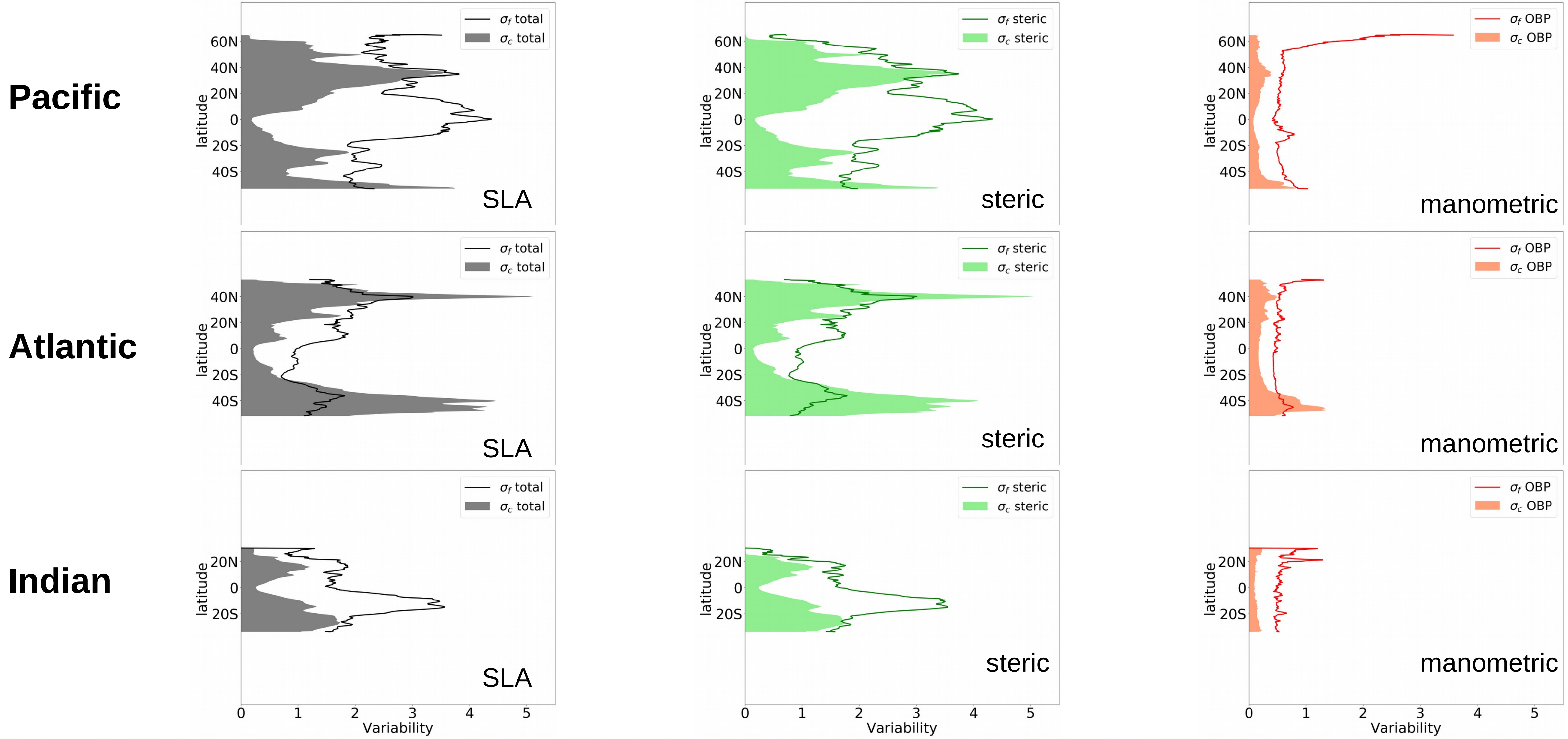


Zonally averaged forced and chaotic sea level interannual variability



- σ_c equivalent to σ_f in western boundary currents and σ_c stronger than σ_f in the ACC for the sea level and its steric component
- Strong σ_c within the ACC for the manometric sea level

Zonally averaged forced and chaotic sea level interannual variability



Conclusions

- The NEMO simulation skillfully represents the observed interannual variability of regional sea level and its steric component
- The atmospherically-forced variability strong patterns are located at low latitudes and in the western boundary currents whereas the chaotic interannual variability reaches its maxima in the western boundary currents and in the ACC
- The atmospherically-forced and chaotic sea level interannual variability mostly have a steric origin except in coastal water
- The chaotic variability explains more than 20 % of the total interannual variability over 48 %, 48 % and 26 % of the global ocean for the sea level and its steric and manometric components
- A paper will be submitted very soon on these results

Perspectives

- To investigate if the chaotic variability is more important as a function of depth or closer to the coast
- To investigate if these values depend on the period considered
- To apply a spectral analysis to the chaotic and forced contributions of the sea level and its components for different time resolution to quantify the energy spectra of chaotic variability
- To analyze other ensemble simulations with different forcing sets, with a higher spatial resolution and/or including other drivers of regional sea level changes. This could be done at regional scale

Thanks for your attention

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