Contribution of Atmospheric forcing and chaotic ocean variability to global and regional sea level changes over 1993-2015

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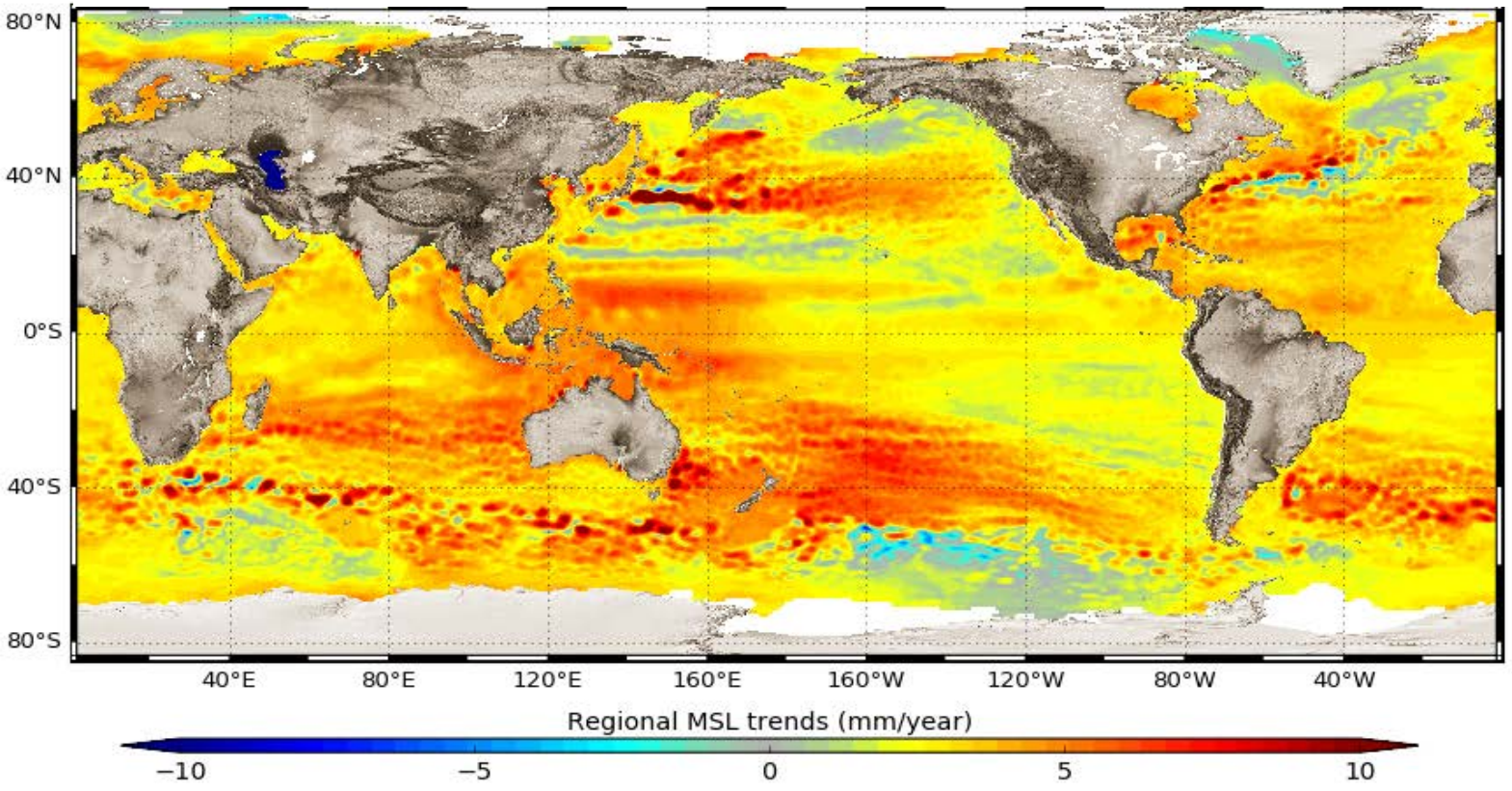
Projects :
ESA Living Planet Fellowship : OVALIE
OSTST-PIRATE (PI T. Penduff)

Motivations

Regional sea level trends over 1993-2017

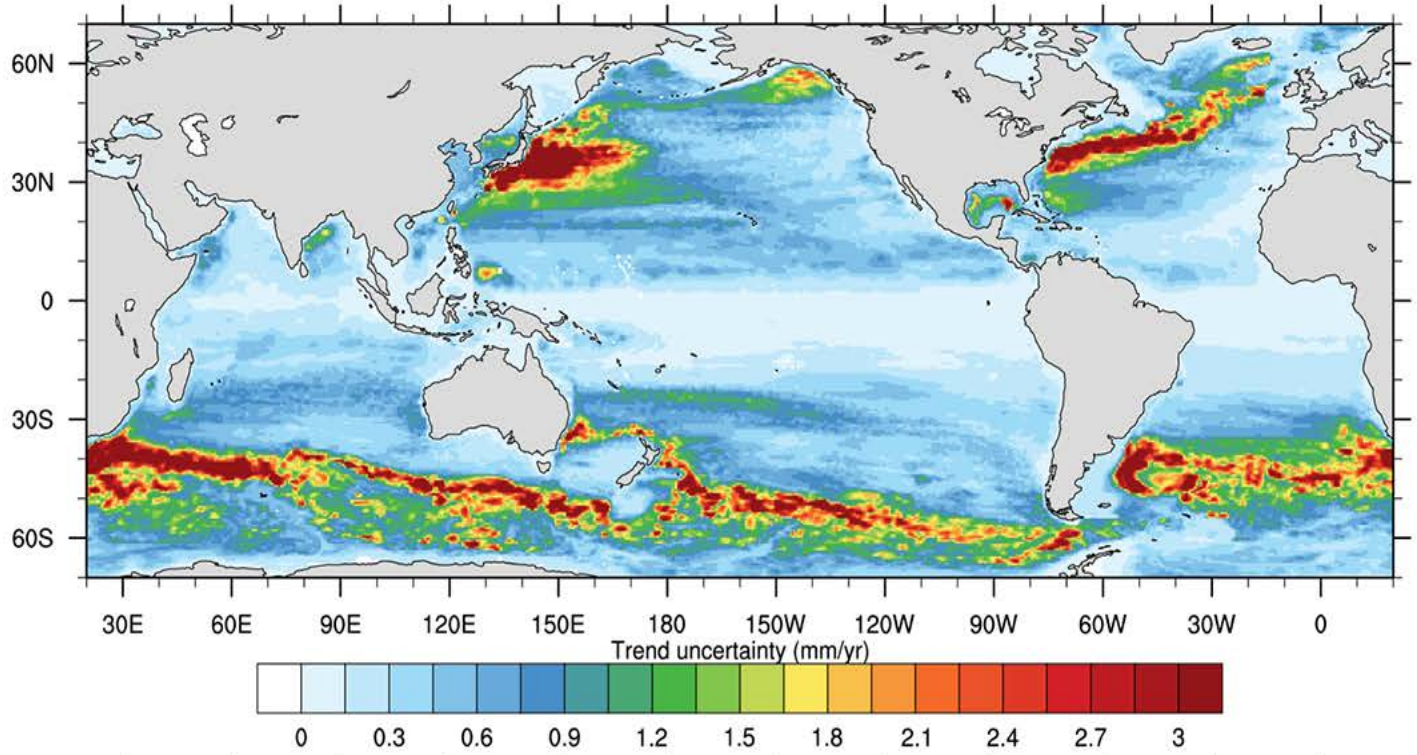


mm/yr

- **Large regional variability**
- **Odd structures for western boundary currents**

<u>Question</u> : Are these spatial patterns a response of atmospheric forcings?

Motivations



Sérazin et al. (2016)

- 20-year regional trend uncertainty (NEMO ¼°)
- Spread due to chaotic/intrinsic ocean variability
- Hot spots : western boundary currents and ACC

<u>Questions</u> :

How do the spatial patterns compare with the chaotic/intrinsic variability ?

Can we partition the atmospherically-forced and the chaotic/intrinsic sea level trends?

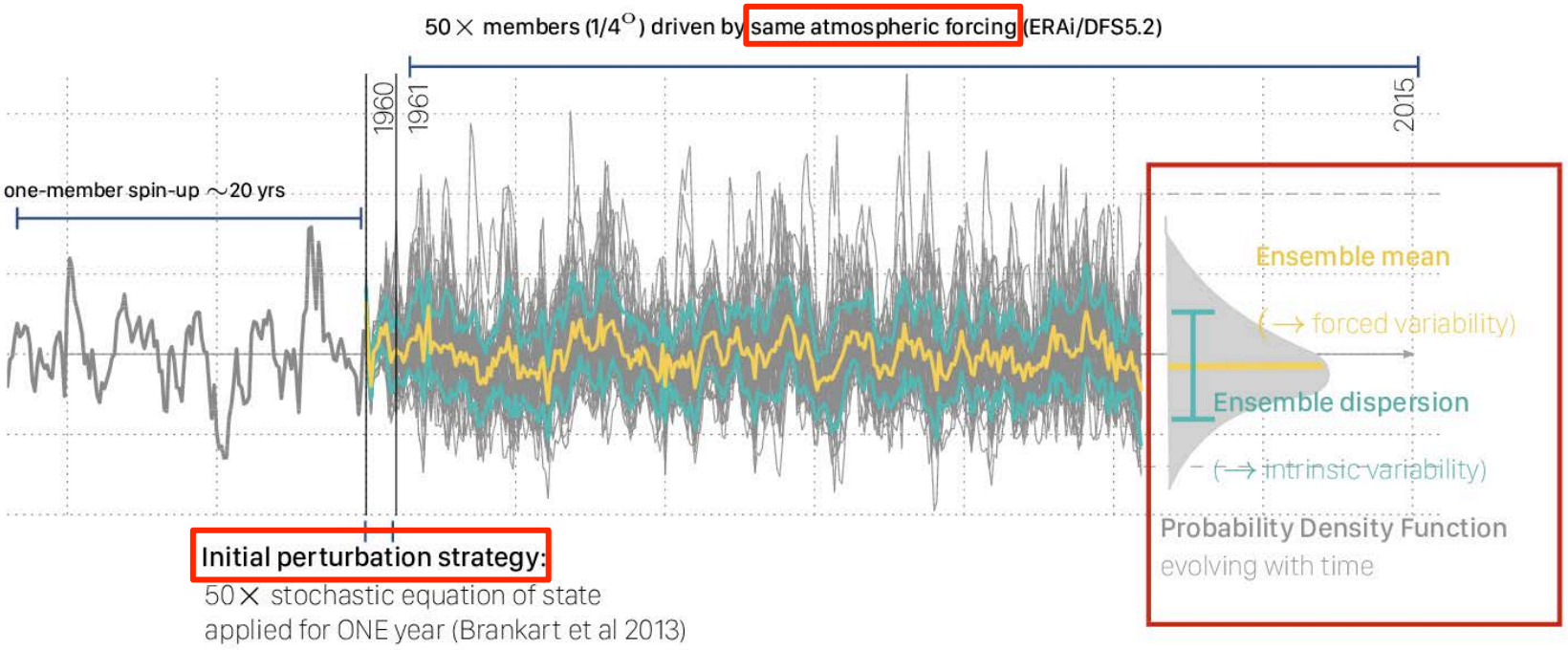
Outlines:

1- Regional sea level trends over 1993-2015

2- Regional thermosteric sea level trends over 2005-2015

Method (OCCIPUT and OSTST-PIRATE projects)

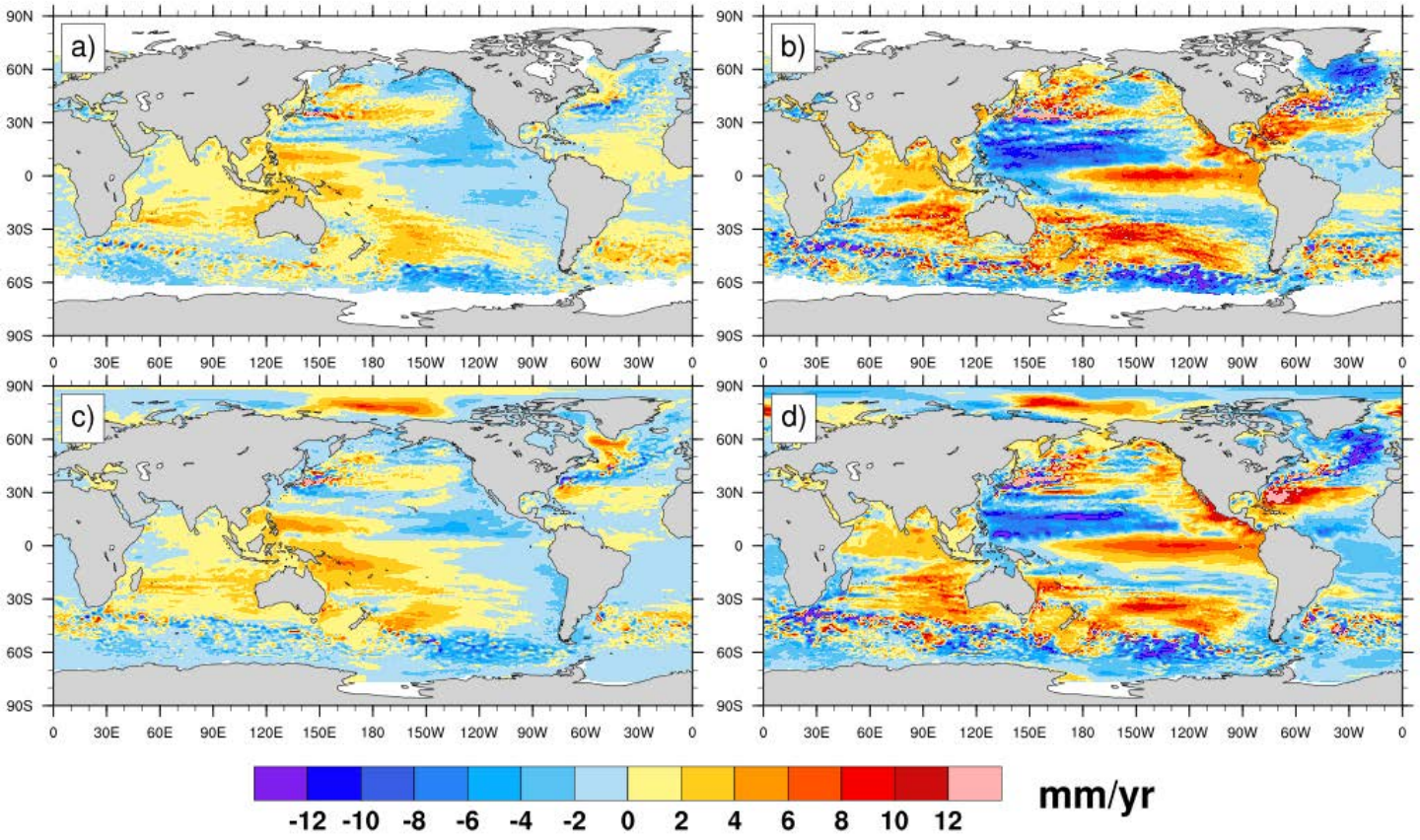
- Obs. = Atmospherically forced and **Chaotic/intrinsic variability**
- OCCIPUT Ensemble simulations (50 membres over 1960-2015, Bessières et al., 2016)
- **Ensemble Mean** = Atmospherically-forced response
- **Ensemble Spread** = Chaotic ocean variability



1 – Regional sea level trends over 1993-2015

Model validation

1993-2015 **2005-2015**

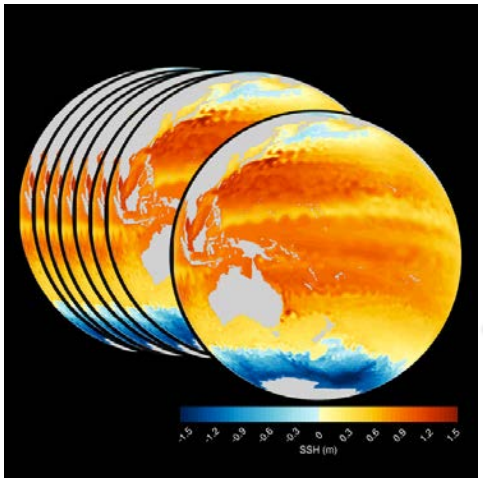


Satellite altimetry
(CCI data, Legeais et al., 2018)

NEMO ¼°(#1)

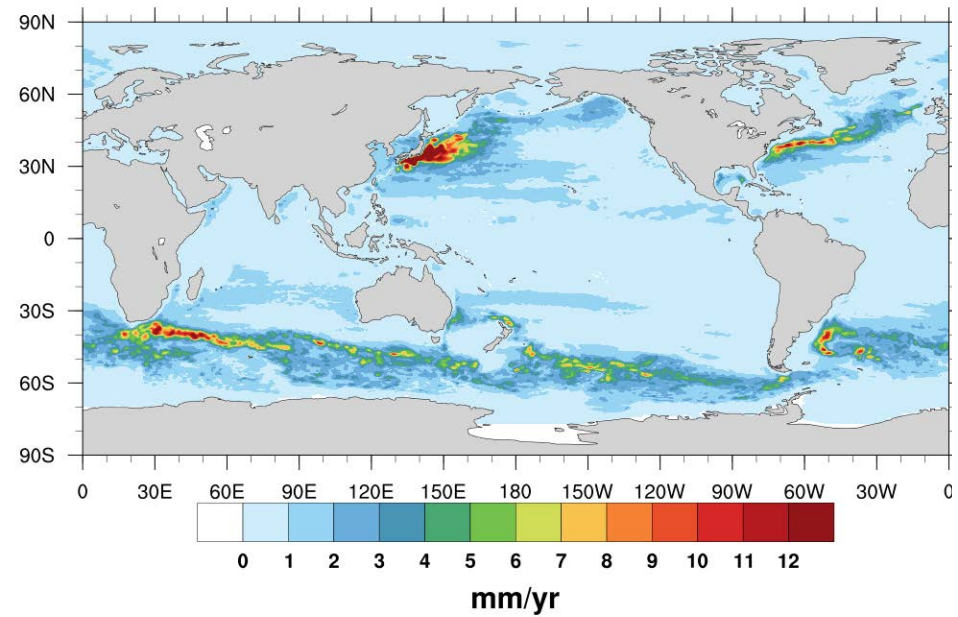
1 – Regional sea level trends over 1993-2015

Ensemble Spread

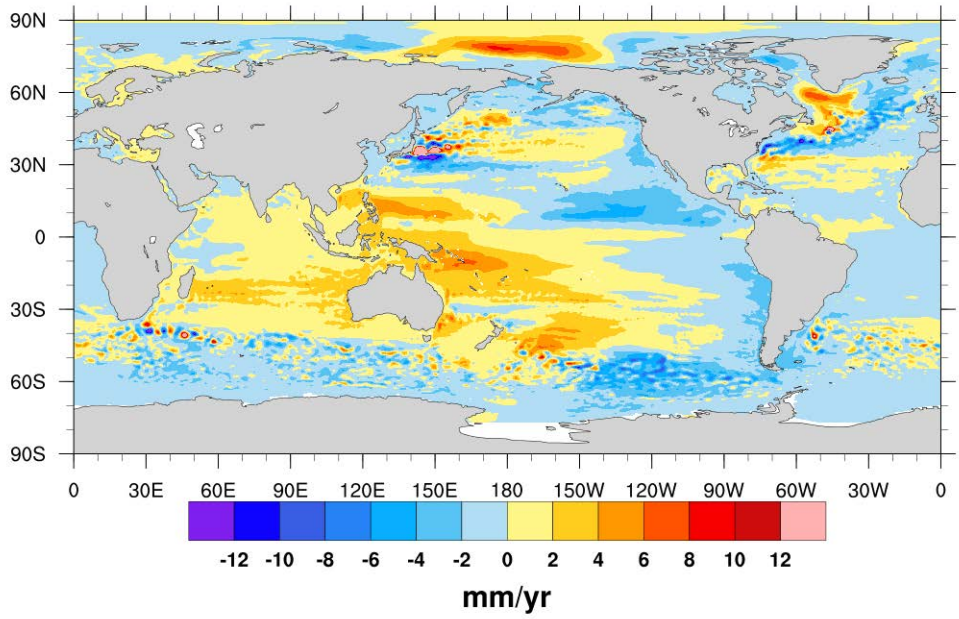


Ensemble Mean

Chaotic ocean variability (2*std)

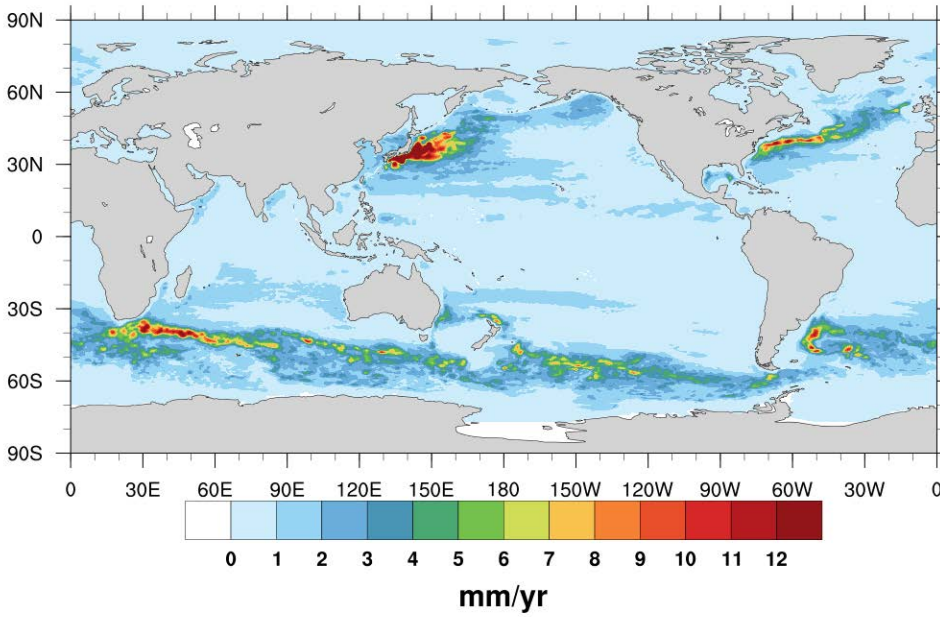


Atmospherically-forced response

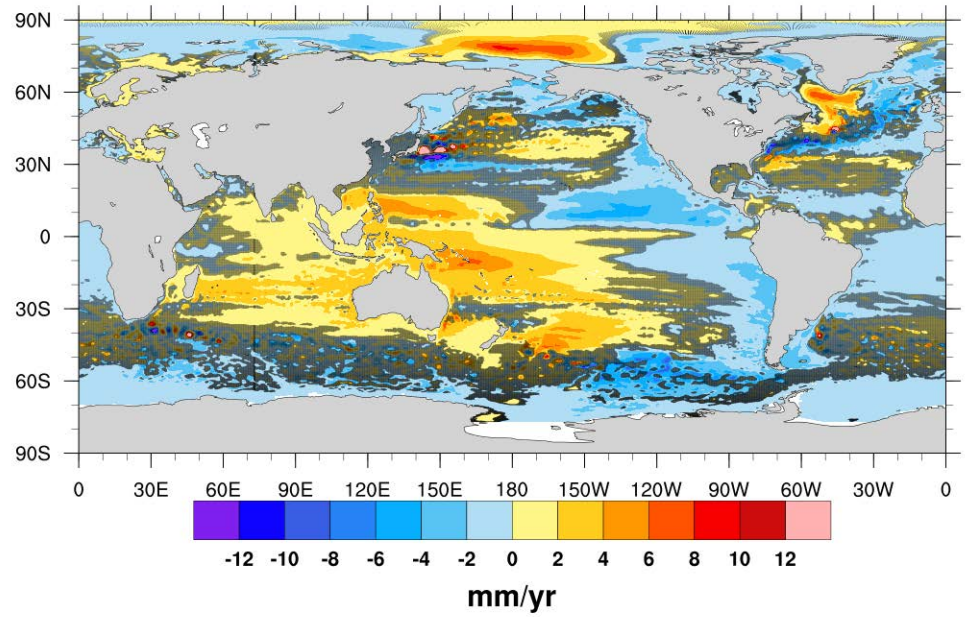


1 – Regional sea level trends

Chaotic ocean variability
(2*Ensemble Spread)



Atmospherically-forced response
(Ensemble Mean)



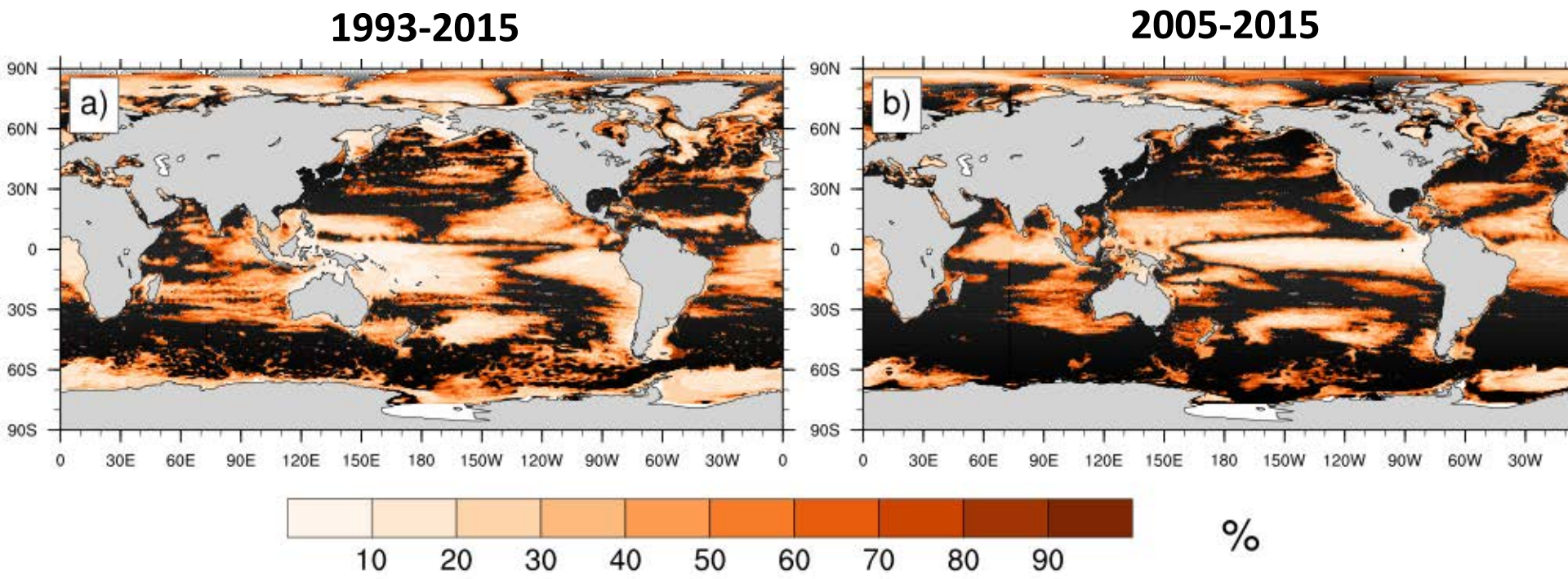
EMean/EStd > 2

Results :

-> 38% are masked by chaotic ocean variability over 1993-2015

-> 47% over 2005-2015

1 – Regional sea level trends



Estd / EMean < 1/2

Results :

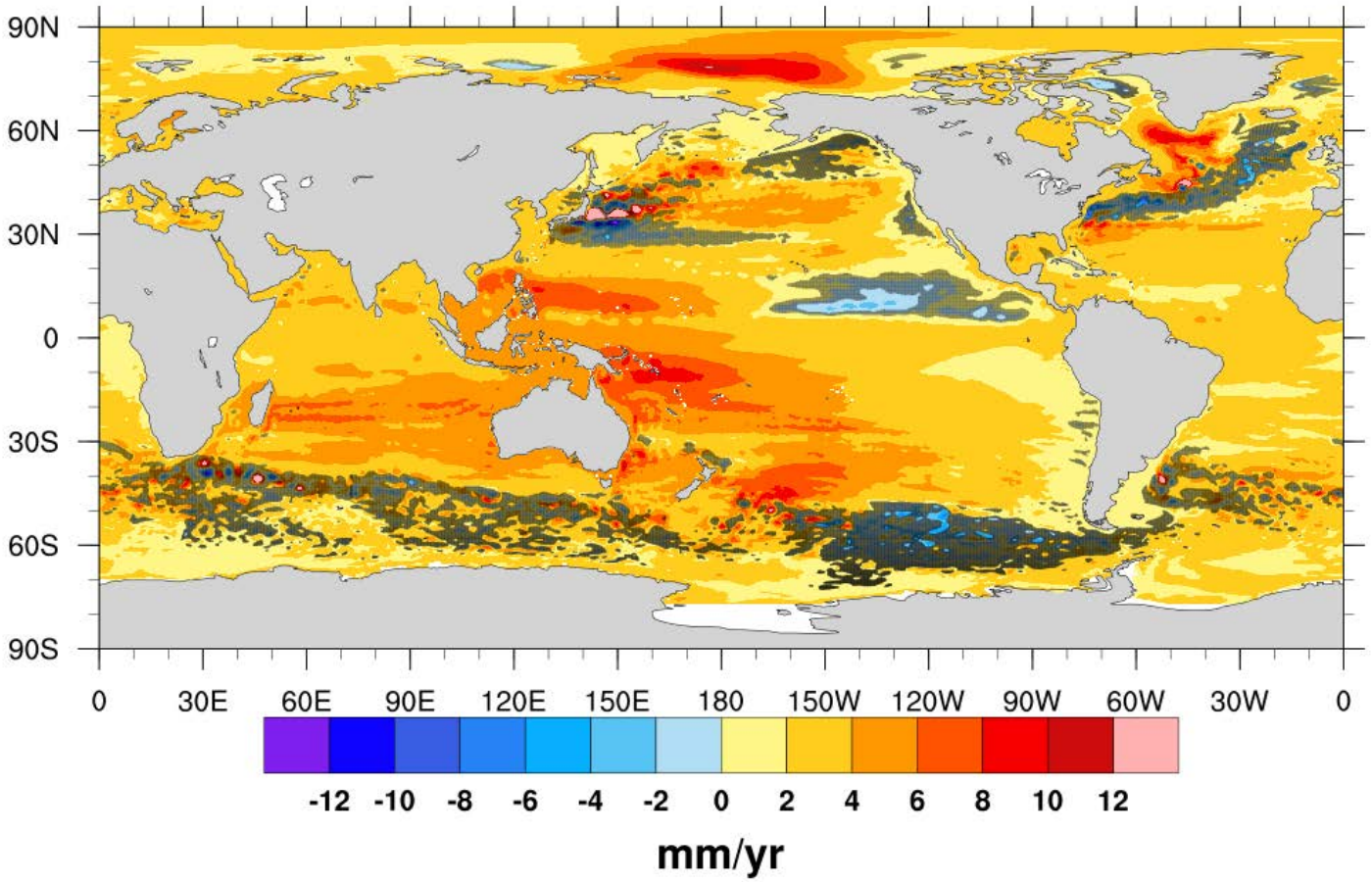
-> Tropical Pacific : ~10-20%

-> Indian Ocean : ~50-60%

-> Nord Atlantic : 60-70%

Paper : Llovel et al, GRL, 2018.

1 – Regional sea level trends



Results :

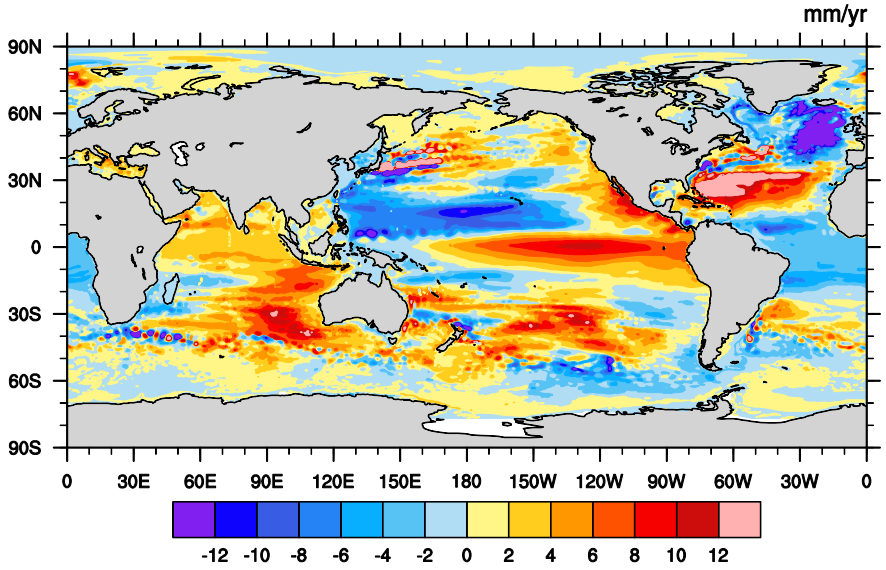
-> 12,5 % are masked by chaotic ocean variability over 1993-2015

-> 34% over 2005-2015

2 – Thermosteric sea level contribution

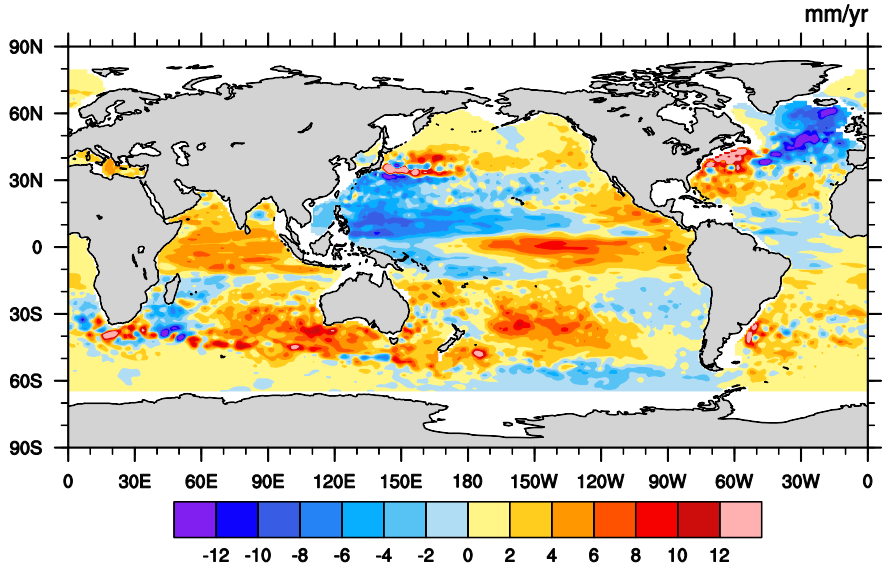
Regional thermosteric sea level trends over 2005-2015
Model validation

Ensemble Mean from OCCIPUT



mm/yr

Argo-based thermosteric sea level trends (Roemmich and Gilson, 2009)



mm/yr

Results :

-> spatial patterns are reproduced

-> Greater amplitudes for the model

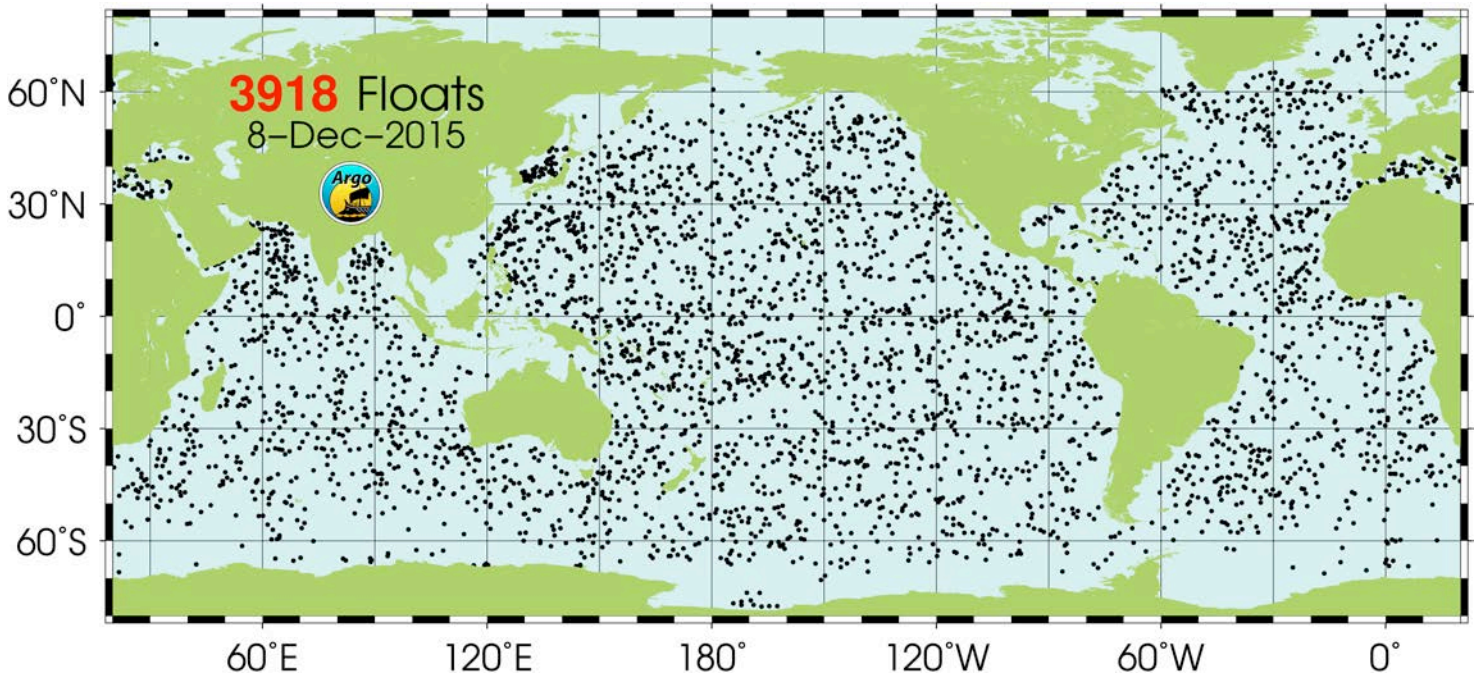
-> Argo sampling : 3°x3° : imprint of chaotic variability ?

2 – Thermosteric sea level contribution

<u>Question:</u> Does this chaotic/intrinsic variability have any imprint in Thermosteric sea level ?

<u>Method:</u>

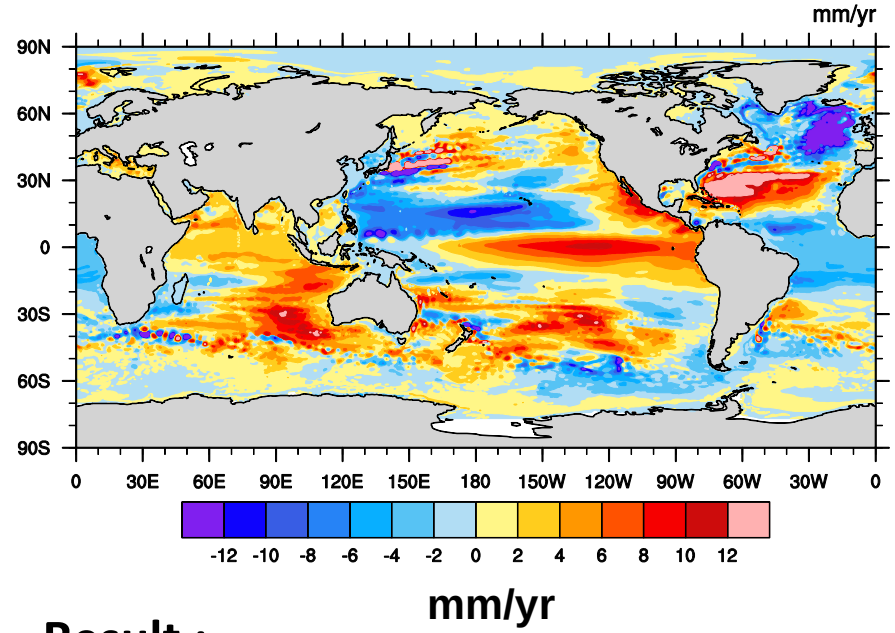
- Extraction of synthetic Argo floats from the OCCIPUT simulations
- ISAS (In Situ Analysis System) is an optimal interpolation tool developed to synthetize the Argo profiles (Gaillard et al., 2016)
- 43 members have been producted for T only



2 – Thermosteric sea level contribution

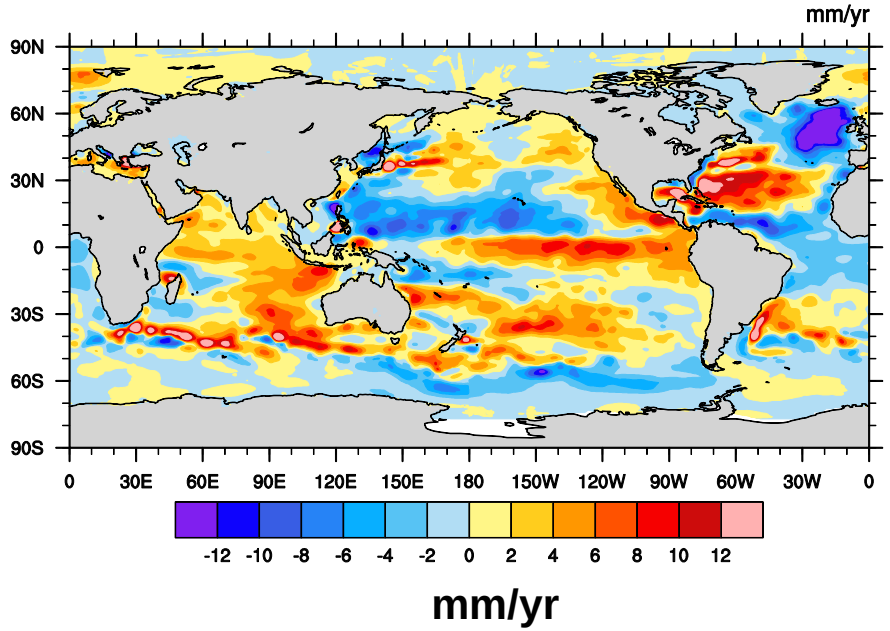
Regional thermosteric sea level trends over 2005-2015

Ensemble Mean from OCCIPUT



mm/yr

Ensemble Mean from synthetic ISAS (43 members)



mm/yr

Result :

-> spatial patterns are reproduced

-> Differences are also found

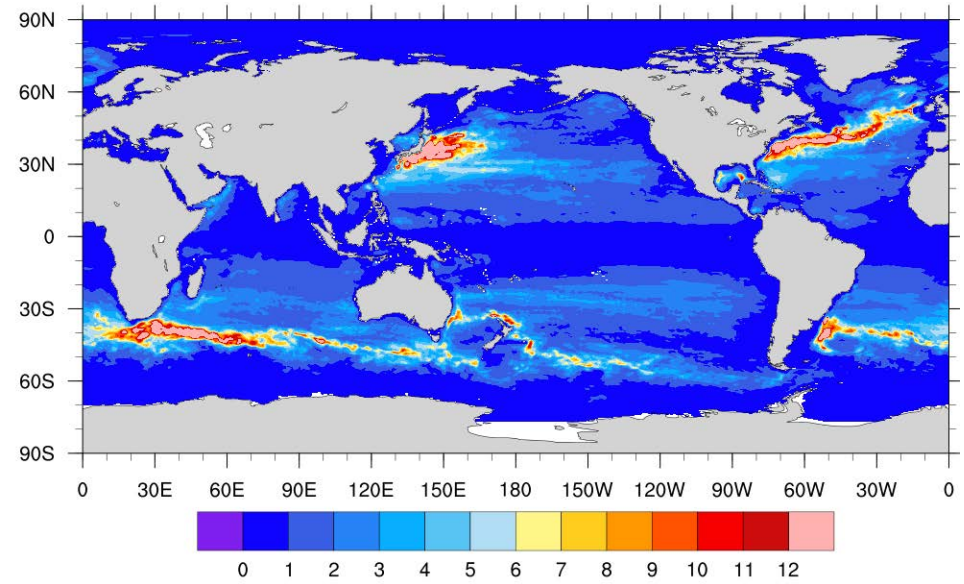
$$\Delta H_{ThermoSteric} = -\frac{1}{\rho_0}\int_{-H}^{0} \Delta\rho(T, S = 34.7, z)\, dz$$

2 – Thermosteric sea level contribution

Regional thermosteric sea level trends over 1993-2015

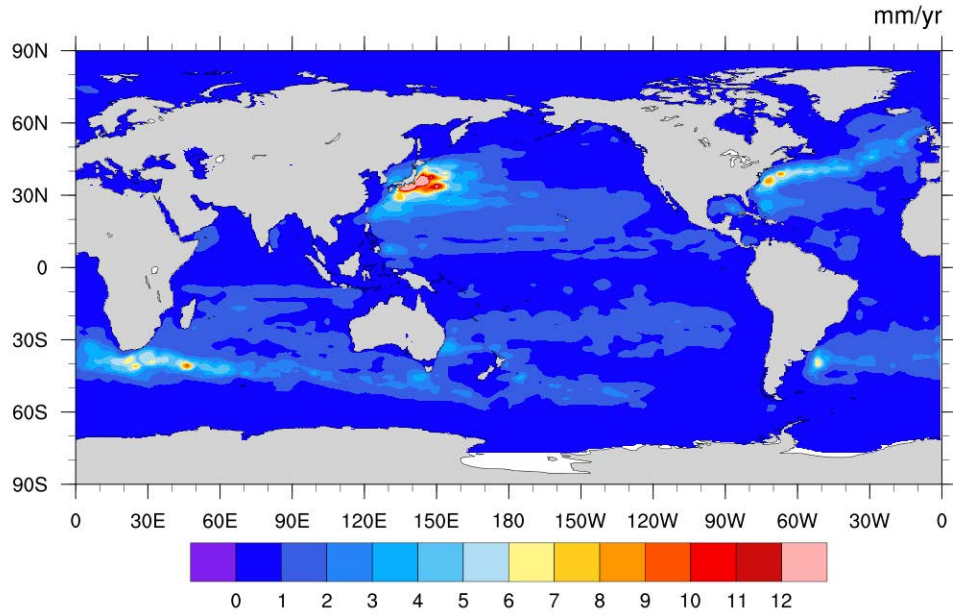
Chaotic ocean variability

Ensemble Spread from OCCIPUT



mm/yr

Ensemble Spread from ISAS (43 members)



mm/yr

Results :

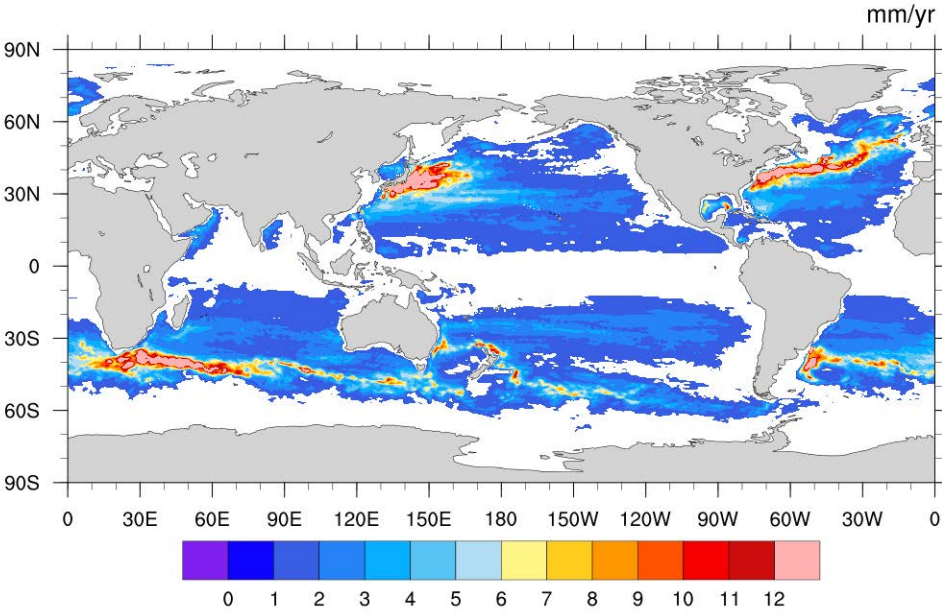
-> spread is reduced

-> large uncertainty for the western boundary currents

2 – Thermosteric sea level contribution

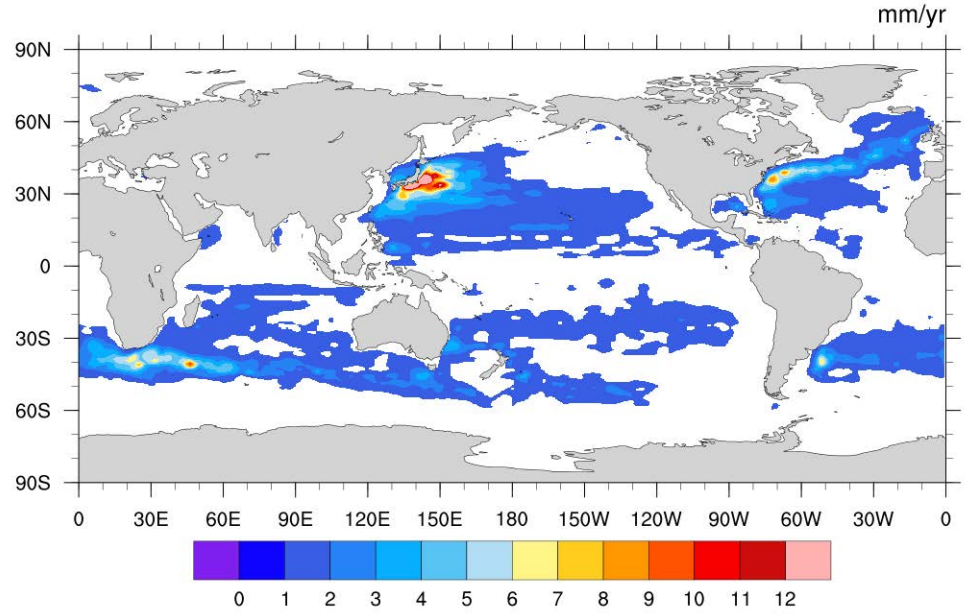
Regional thermosteric sea level trends over 1993-2015

Chaotic ocean variability
Ensemble Spread from OCCIPUT



mm/yr

Ensemble Spread from ISAS (43 members)



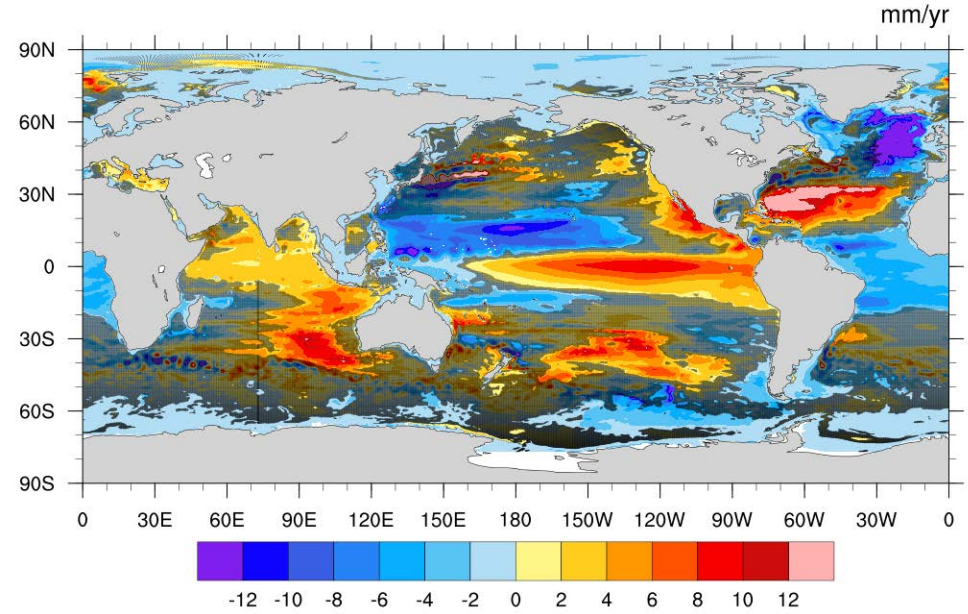
mm/yr

Results :

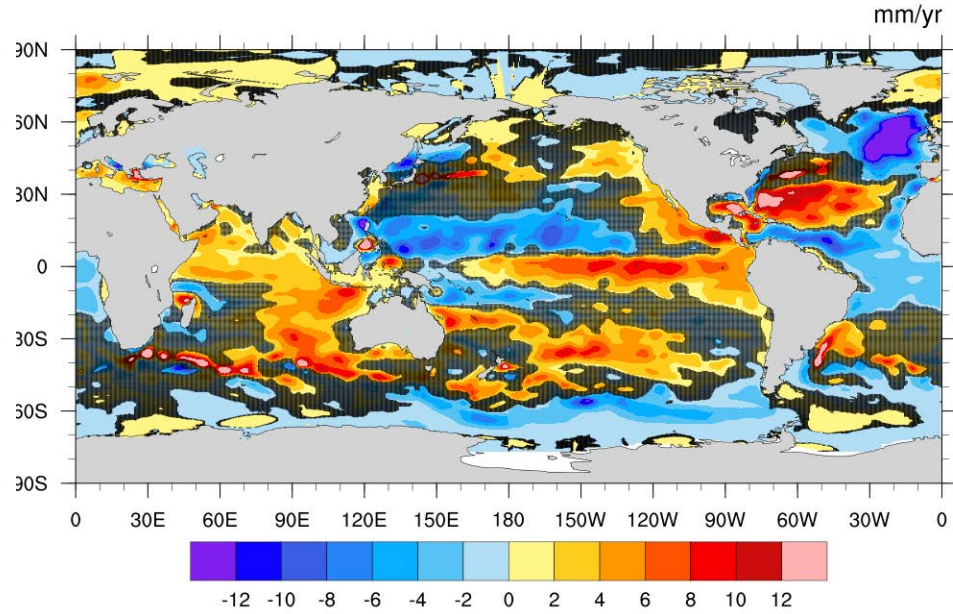
-> trend uncertainty > 1mm/yr

2 – Thermosteric sea level contribution

Chaotic ocean variability



synthetic ISAS (43 members)



EMean/EStd > 2

Results :

-> 49% are masked by chaotic ocean variability over 2005-2015

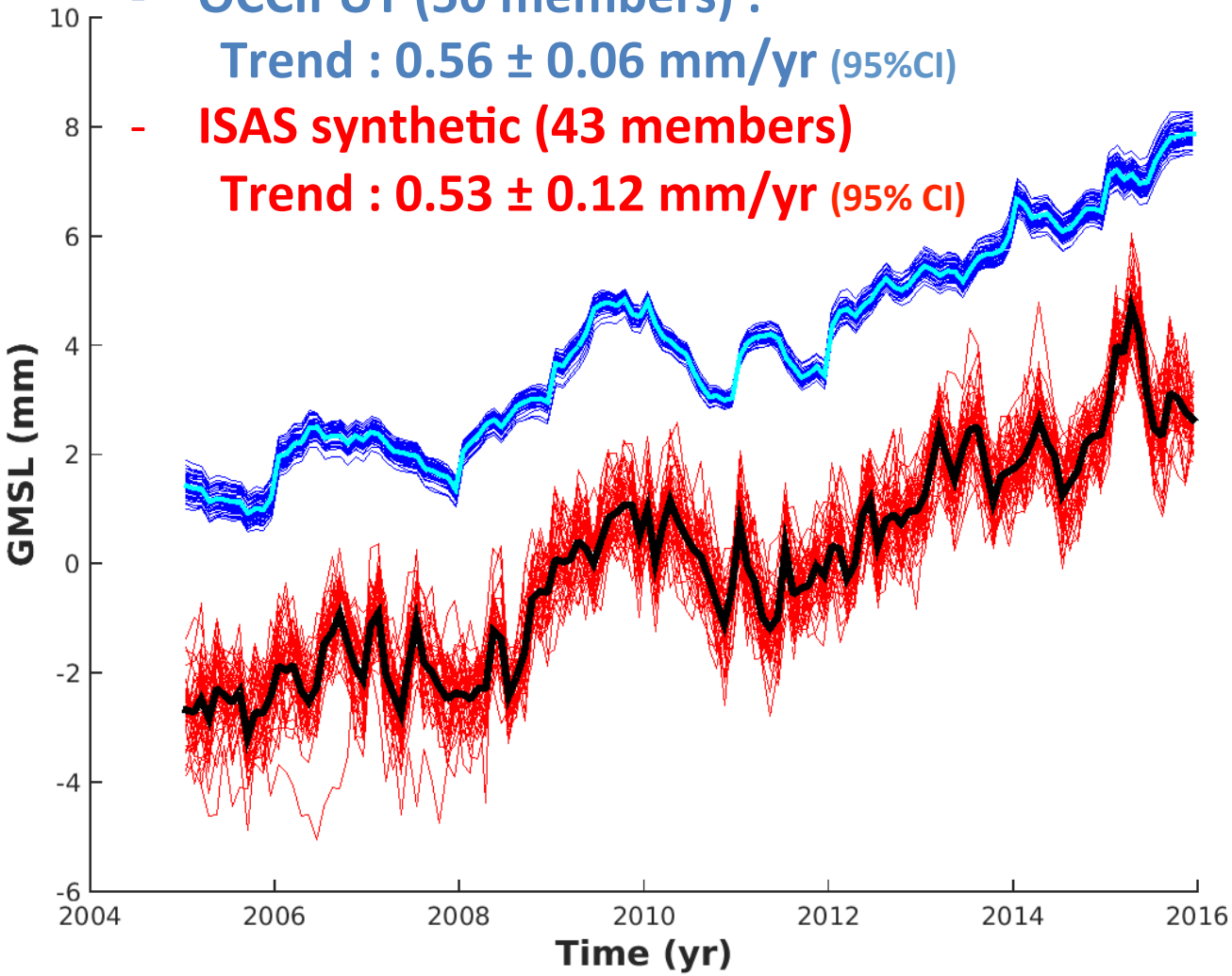
-> 37% after applying the ISAS interpolation

2 – Thermosteric sea level contribution

Impact on Global mean sea level budget over 2005-2015

GMThermoSteric Sea Level (60°N-60°S)

- **OCCIPUT (50 members) :**
  Trend : 0.56 ± 0.06 mm/yr (95%CI)
- **ISAS synthetic (43 members)**
  Trend : 0.53 ± 0.12 mm/yr (95% CI)



Conclusions :

1- Regional sea level trends

- **Hot spots : western boundary currents + ACC**
  - **RSL trend Spread > 12 mm/yr**
  - **Satellite altimetry : 2-3 mm/yr (decadal time scales, Ablain et al., 2017)**
- **Large inprint of Chaotic variabitity :**
  - **38% over 1993-2015**
  - **12.5% when considering the GMSL (3.2 mm/yr)**

2- Thermosteric sea level trends

- **Regional spread is reduced after the interpolation (ISAS)**
- **fraction of masked thermosteric sea level trends 37% instead of 49% as resolved by the model**
- **Global mean thermosteric over 2005-2015 : ± 0.12 mm/yr (95% CI)**