



HAL
open science

Climate-relevant imprints and observational implications of the oceanic intrinsic variability: lessons from the OCCIPUT Large Ensemble

Thierry Penduff, Sally Close, Stephanie Leroux, Serazin Guillaume, W. Llovel,
Jean-Marc Molines, Laurent Terray, Laurent Bessières,, Bernard Barnier

► To cite this version:

Thierry Penduff, Sally Close, Stephanie Leroux, Serazin Guillaume, W. Llovel, et al.. Climate-relevant imprints and observational implications of the oceanic intrinsic variability: lessons from the OCCIPUT Large Ensemble. The Large Ensembles Workshop, Jul 2019, Boulder, United States. hal-03000802

HAL Id: hal-03000802

<https://hal.science/hal-03000802>

Submitted on 12 Nov 2020

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Climate-relevant imprints and observational implications of the **chaotic/intrinsic ocean variability**: lessons from the OCCIPUT oceanic Ensemble.

T. Penduff⁽¹⁾, S. Close⁽¹⁾, S. Leroux⁽²⁾, G. Sérazin⁽³⁾, W. Llovel⁽³⁾, J.-M. Molines⁽¹⁾, L. Terray⁽⁴⁾, L. Bessières⁽⁴⁾, B. Barnier⁽¹⁾

⁽¹⁾IGE, Grenoble, France. ⁽²⁾Ocean Next, Grenoble, France. ⁽³⁾LEGOS, Toulouse, France. ⁽⁴⁾CERFACS, Toulouse, France

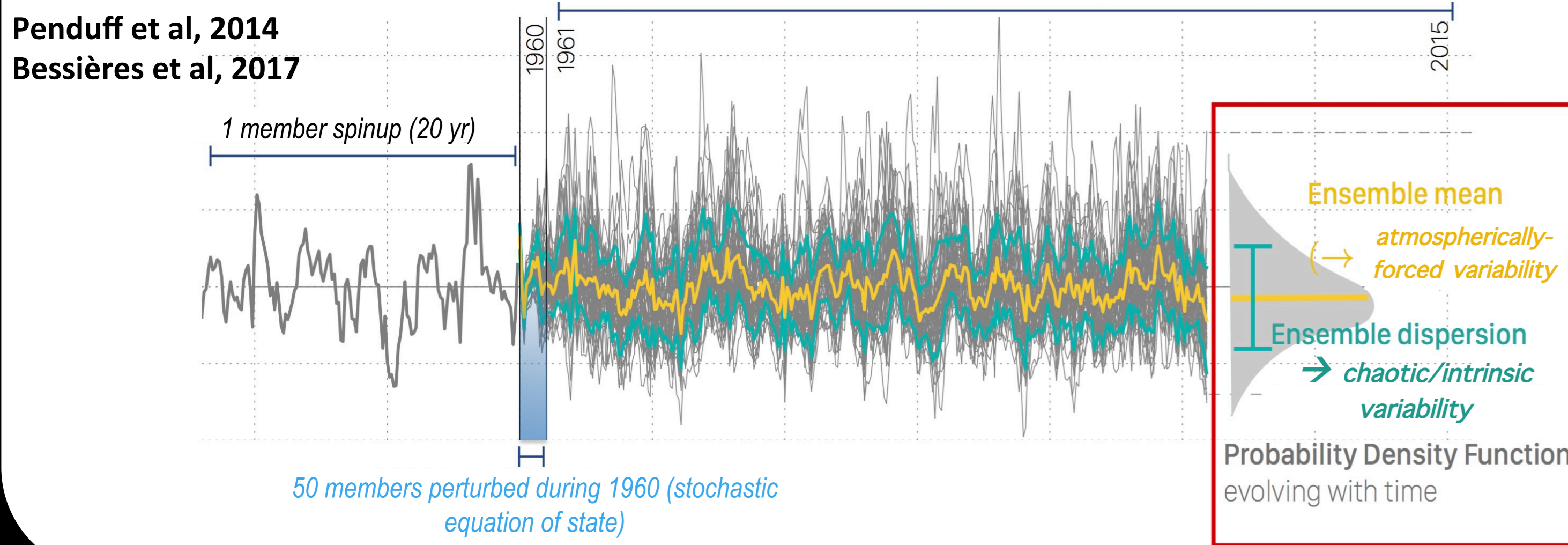
Contact: Thierry.Penduff@cnrs.fr

The OCCIPUT Ensemble: 50 turbulent ocean hindcasts

- NEMO global ocean model
- Resolution 1/4° — 1960-2015
- 50 members with:
 - Same ERA-Interim atm. forcing
 - Slight initial perturbations

Estimate the oceanic:

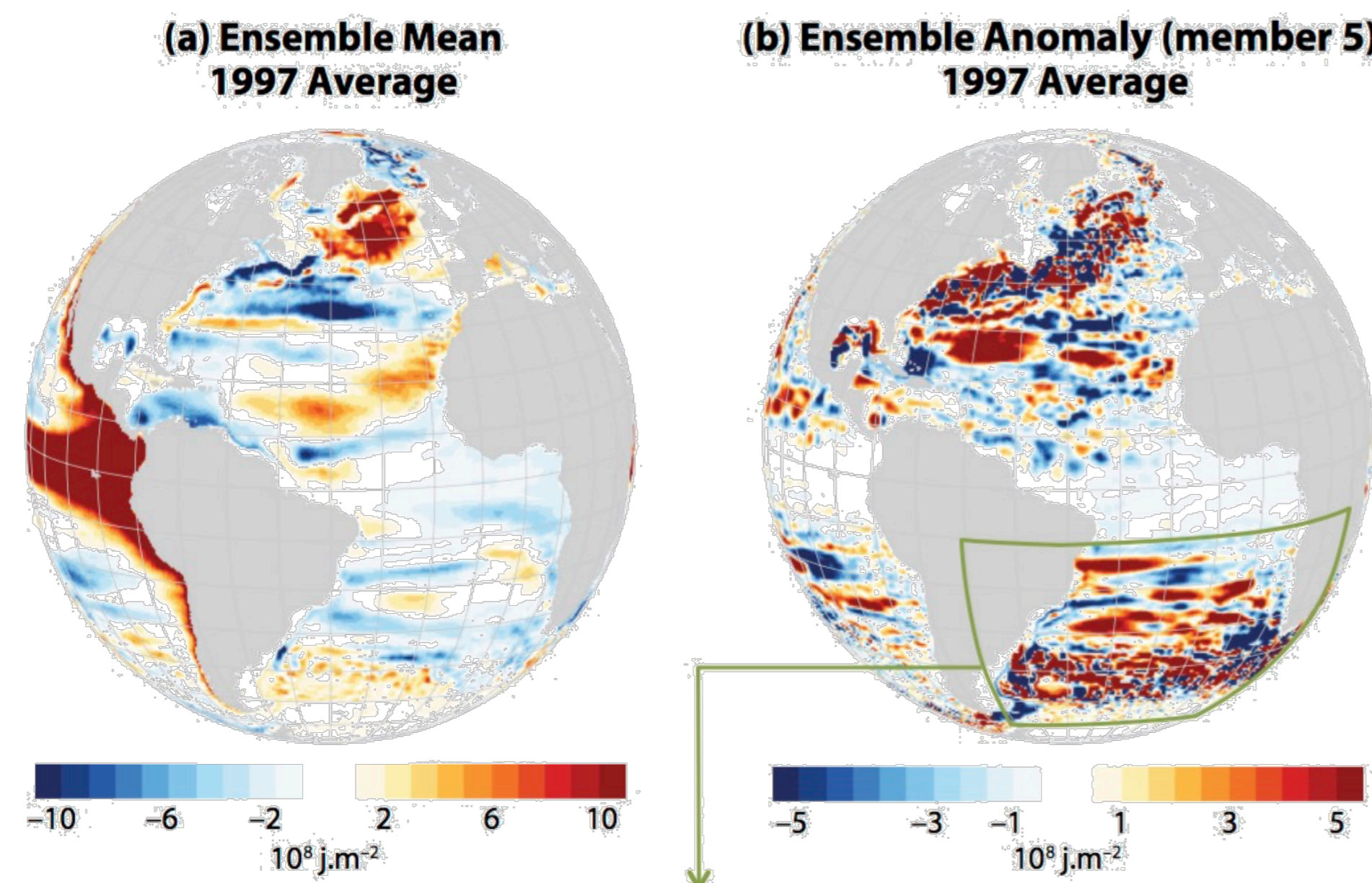
- **Atmospherically-forced variability** ($\sigma_F = \text{STD of ensemble mean}$)
- **Chaotic/intrinsic variability** ($\sigma_C = \text{mean of ensemble STD}$)



Take-home messages

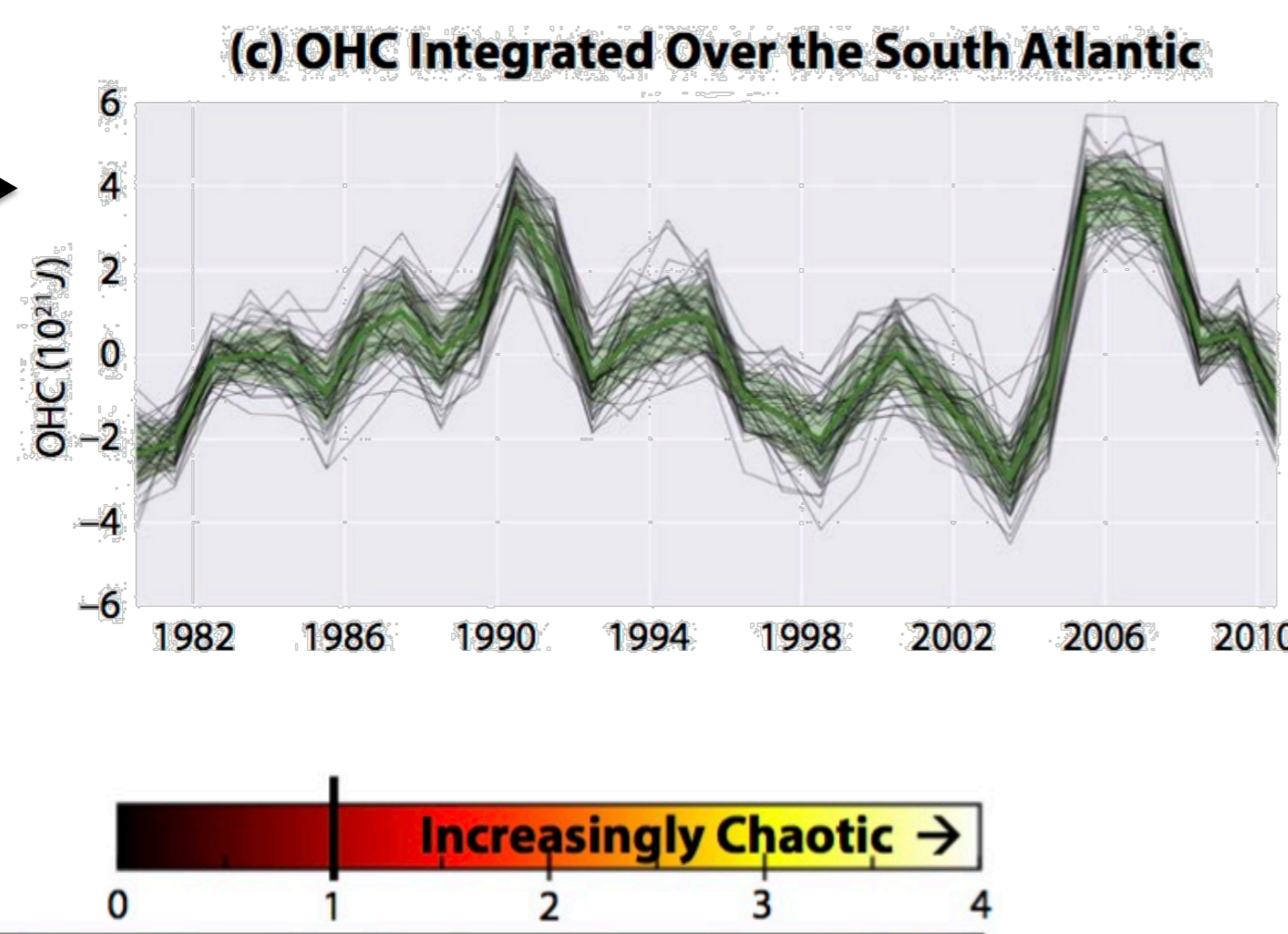
- In the presence of mesoscale, the ocean spontaneously generates a strong **low-frequency chaotic/intrinsic variability (LFCIV)**. It locally competes with the **atmospheric forcing** in driving the interannual-to-multidecadal variability of key ocean climate indices (OHC_{0-700m}, AMOC, MHT, etc).
- Much weaker or absent in coarse-resolution ocean models used in most IPCC-class climate simulators, **this strong LFCIV, might impact the atmosphere in coupled models with turbulent oceans.**
- Over large regions, the **LFCIV adds a random component** to local 20/30-year trends of OHC and sea level, hindering their unambiguous attribution to **[atmospheric+anthropogenic] drivers.**
- Ensemble model statistics can be used to **attenuate the signature of LFCIV in observational datasets** (via filters or Machine Learning), and **unveil the deterministic response of the real ocean to the atmosphere.**

Interannual variability of Ocean Heat Content (0-700m)

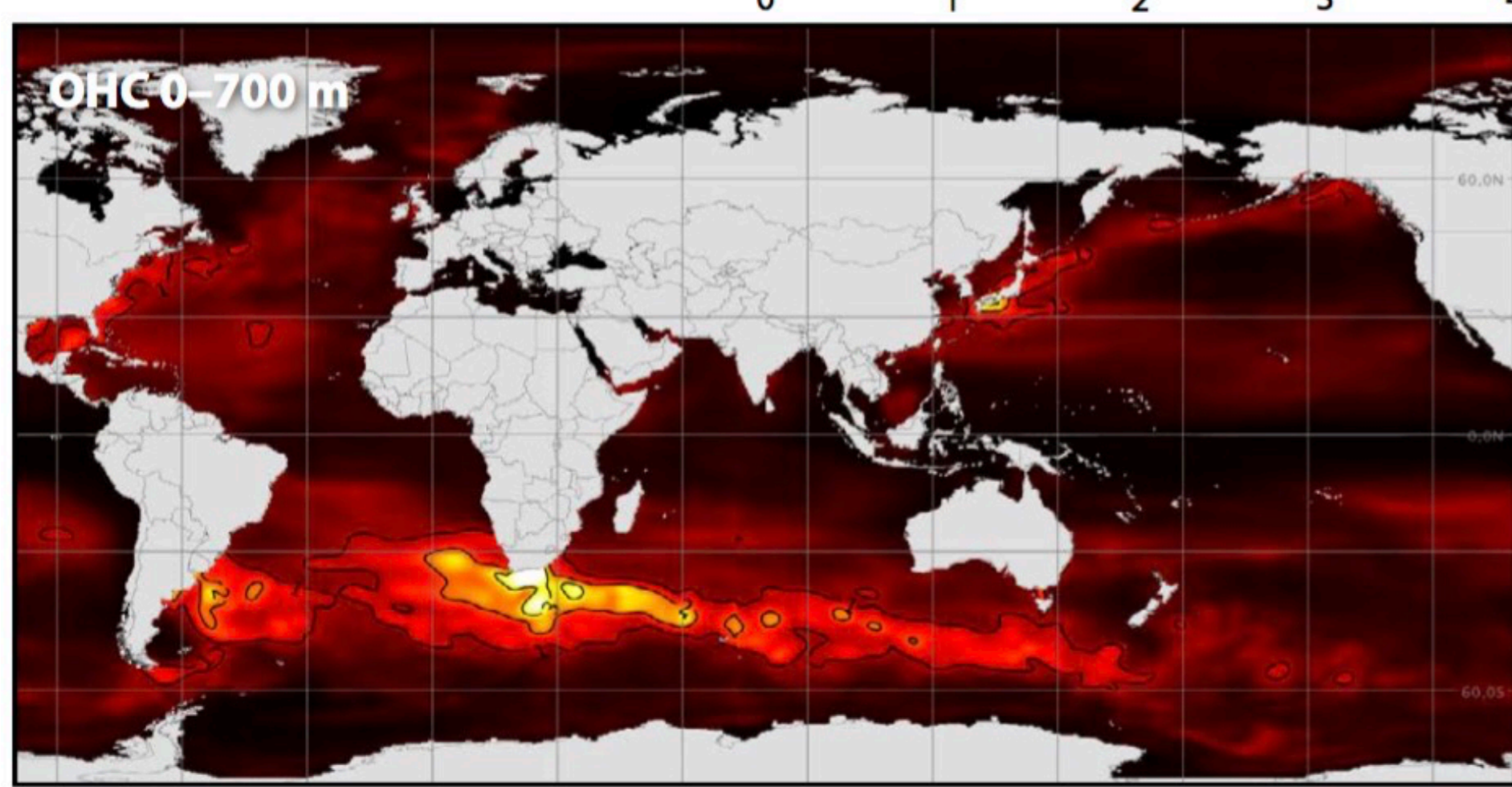


LFCIV imprint on OHC₀₋₇₀₀:

- up to basin scales (and multiple decades)
- dominates **Forced variability** in regions within contours



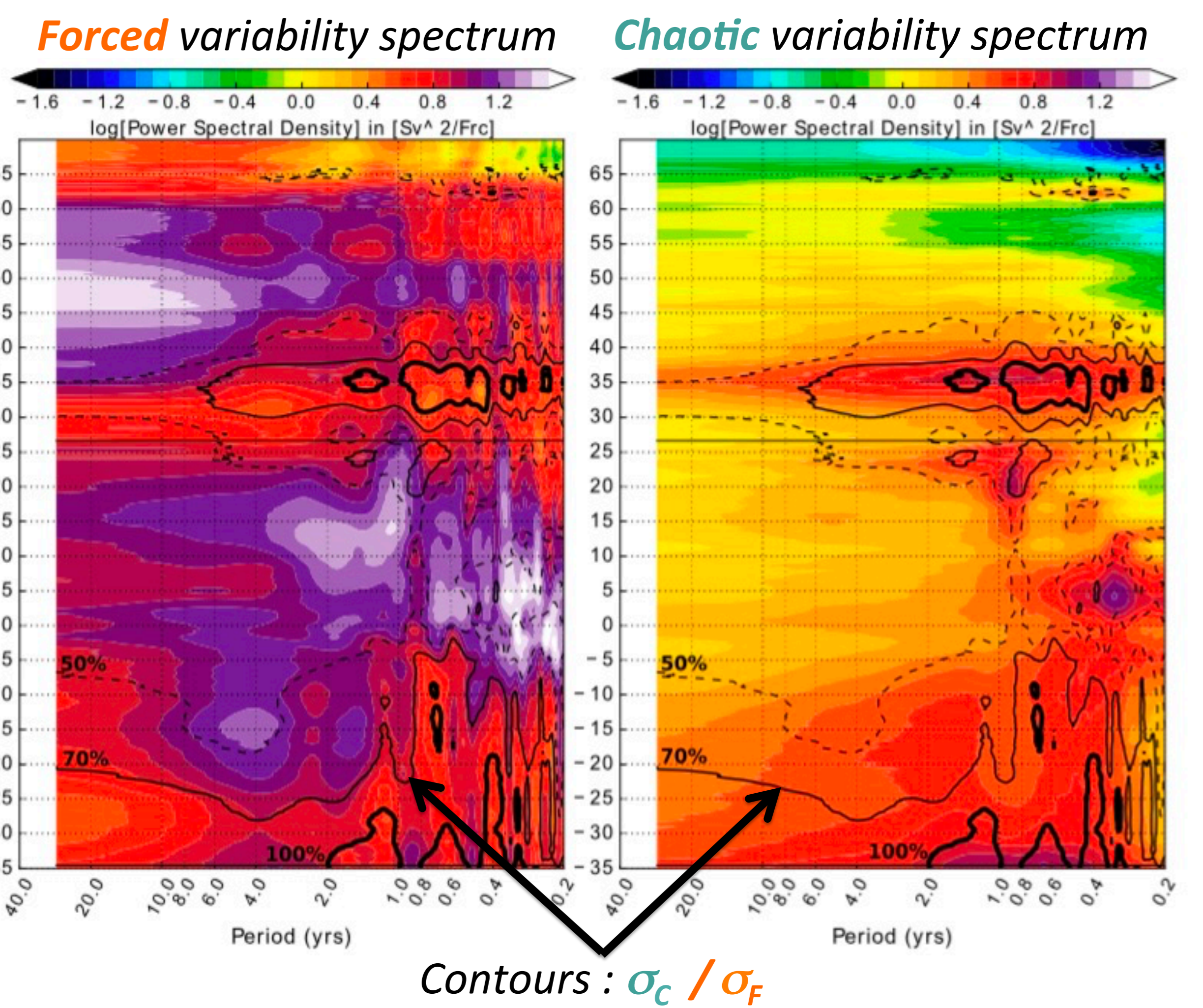
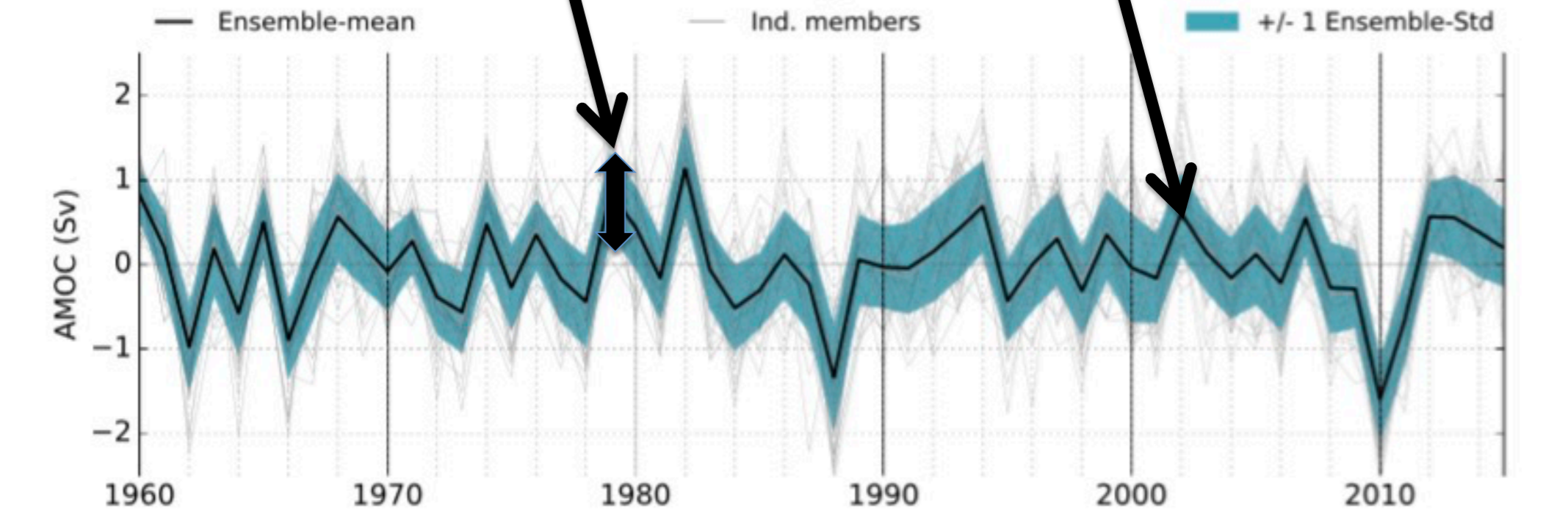
This strong 1-30yr chaotic variability of OHC & AMOC (almost absent without eddies) is expected to impact the atmosphere in coupled models with eddying oceans



Sérazin et al, 2017
Penduff et al, 2018

Interannual variability of the Atlantic Meridional Overturning Circulation

AMOC at 34°S: **chaotic** as strong as **forced** variability

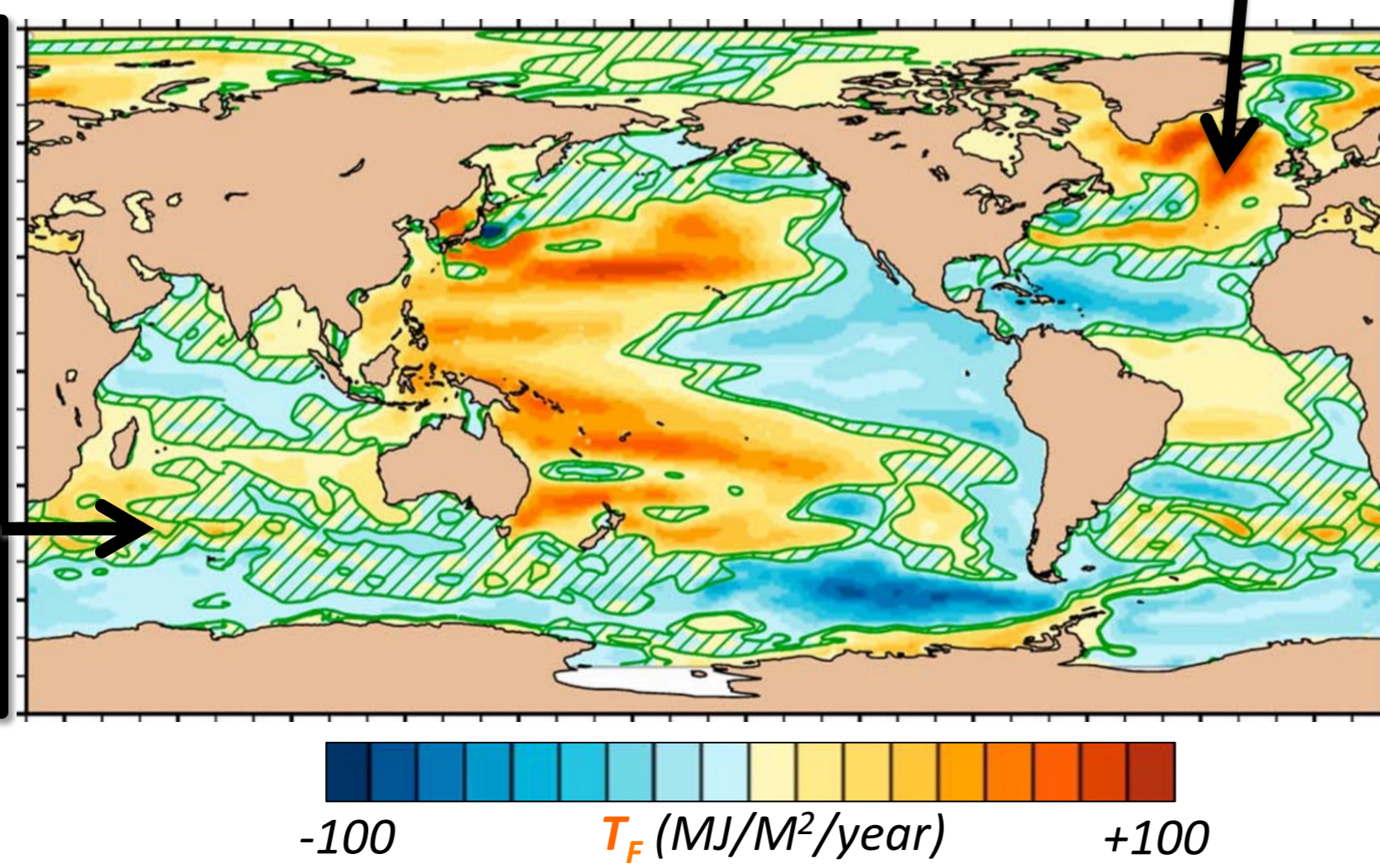


Leroux et al, 2018

21-year trends* (1980-2010) of Ocean Heat Content

- **[atmospheric + anthropogenic drivers]** → **Forced** OHC trends T_F (colors)
- **LFCIV** → **Random** OHC trends T_R

In regions where $|T_F| < 2 \cdot T_R$ (green shading) OHC trends can NOT be surely attributed (95% confidence) to **[atmospheric + anthropogenic drivers]**



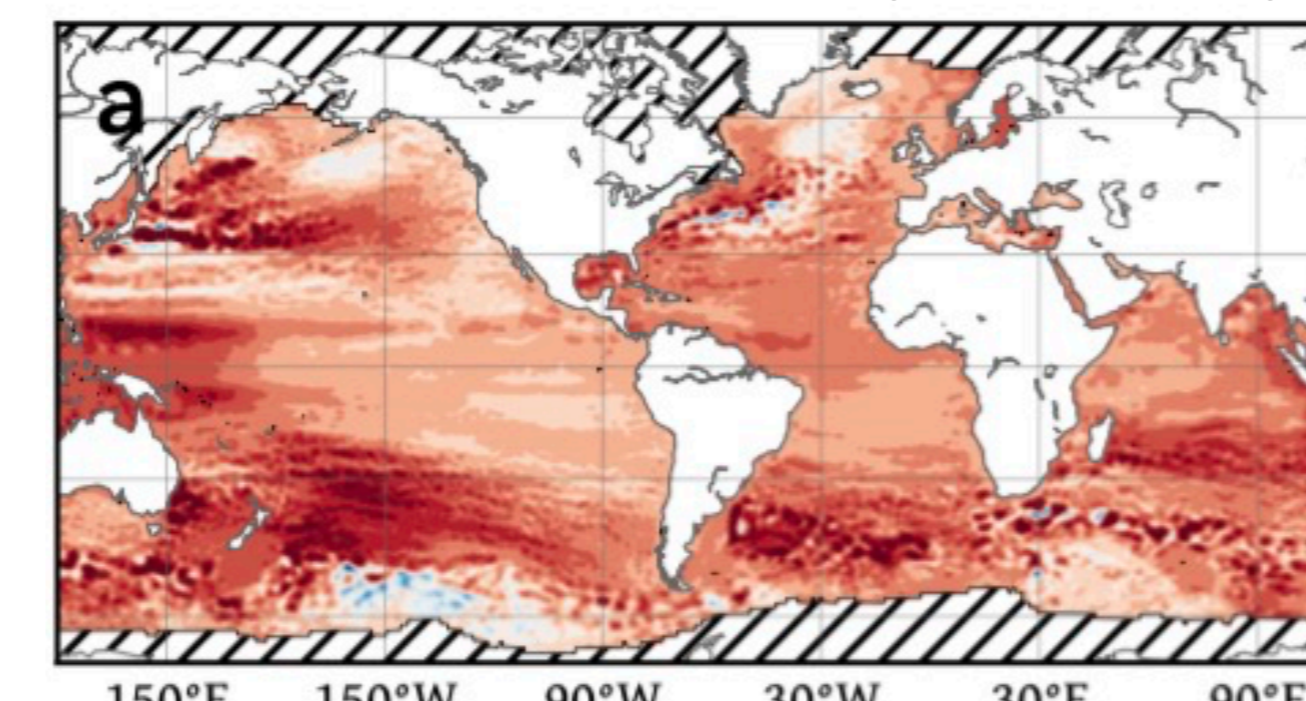
(* corrected for model drift & global mean trend removed)

Sérazin et al, 2017

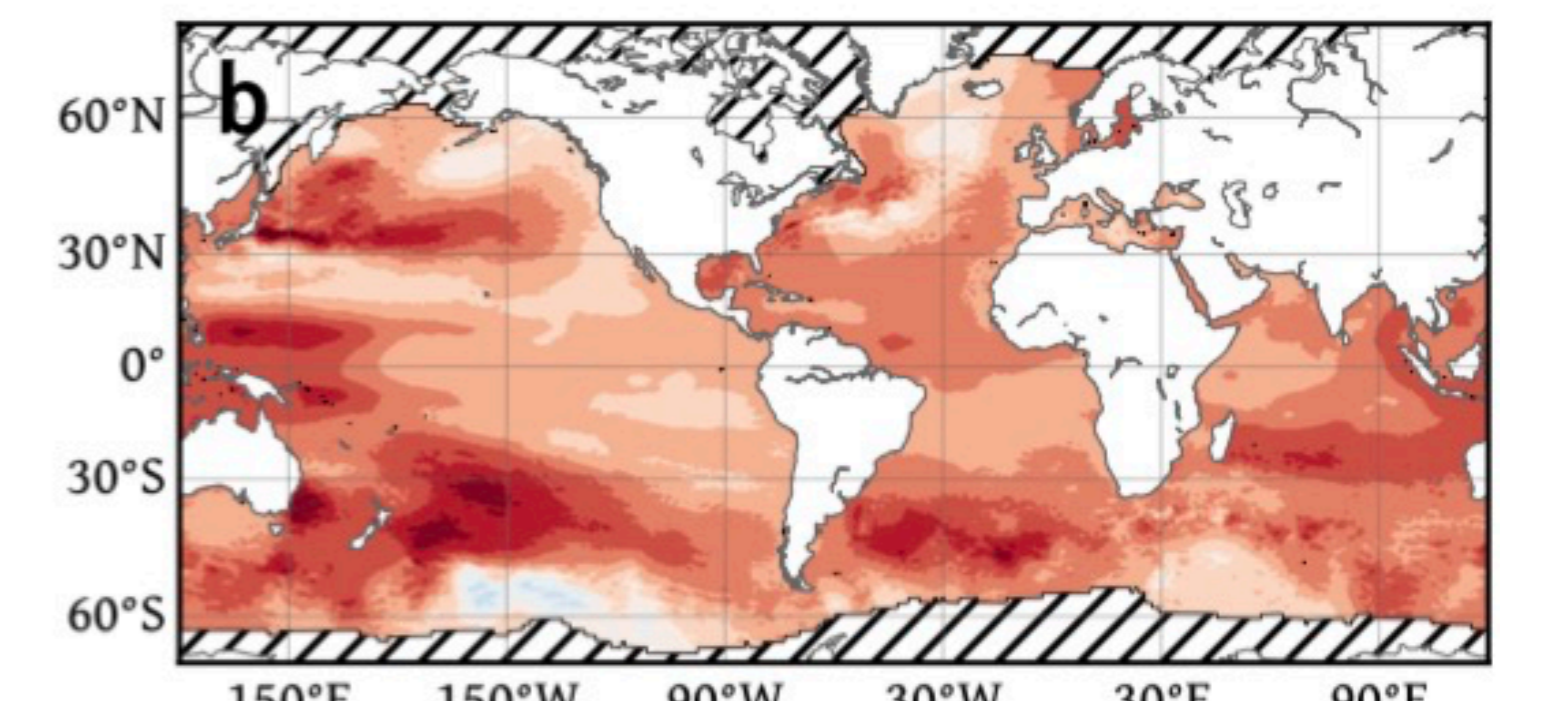
23-year trends (1993-2015) of Observed Sea Level

- In many regions, $\sigma_C > \sigma_F$ on space scales [110-800km], over *all* time scales
- Filtering out scales [110-800km] → **estimation of Forced observed trends**
- Currently developing an estimator based on Machine Learning (CNN)

SL trend observed by altimetry



Estimation: **Forced** observed SL trend



Close et al, in rev

References

Bessières et al., 2017: Development of a probabilistic ocean modelling system based on NEMO 3.5: application at eddying resolution, Geosci. Model Dev., 10, 1091-1106, doi:10.5194/gmd-10-1091-2017.
 Close et al.: A means of estimating the intrinsic and atmospherically-forced contributions to sea surface height variability applied to altimetric observations. In revision, Progress in Oceanography.
 Leroux et al, 2018: Intrinsic and Atmospherically Forced Variability of the AMOC: Insights from a Large-Ensemble Ocean Hindcast. J. Climate, 31, 1183-1203, https://doi.org/10.1175/JCLI-D-17-0168.1
 Penduff et al, 2014: Ensembles of eddying ocean simulations for climate. CLIVAR Exchanges, Special Issue on High Resolution Ocean Climate Modelling, 65, Vol 19 No.2, July 2014.
 Penduff et al, 2018: Chaotic variability of ocean heat content: Climate-relevant features and observational implications. Oceanography 31(2).
 Sérazin et al, 2017: A global probabilistic study of the ocean heat content low-frequency variability: Atmospheric forcing versus oceanic chaos, Geophys. Res. Lett., 44, 5580-5589, doi:10.1002/2017GL073026.