Ensembles of eddying ocean simulations for climate. The OCCIPUT prototype.

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Thanks to
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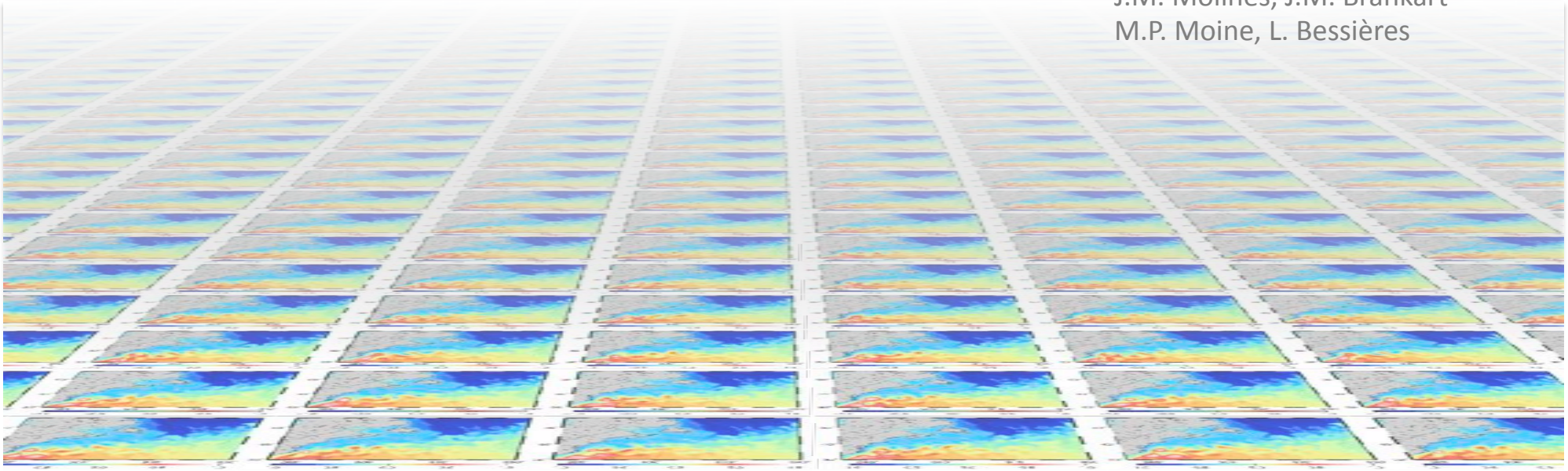
M.P. Moine, L. Bessières

OceaniC Chaos – ImPacts, StrUcture, predicTability



Outline

- **Why run *ensembles* of multi-decadal eddying ocean hindcasts ?**
  - ✓ The LF oceanic variability has a chaotic character
  - ✓ Simulate the envelope of possible 50-year ocean trajectories
- **The OCCIPUT project** (ANR 2014-2017, LGGE/CERFACS)
  - ✓ Main objectives
  - ✓ Integration/initialization strategy
- **Conclusions and perspectives**

Shallow-water models: LF intrinsic variability (pure)

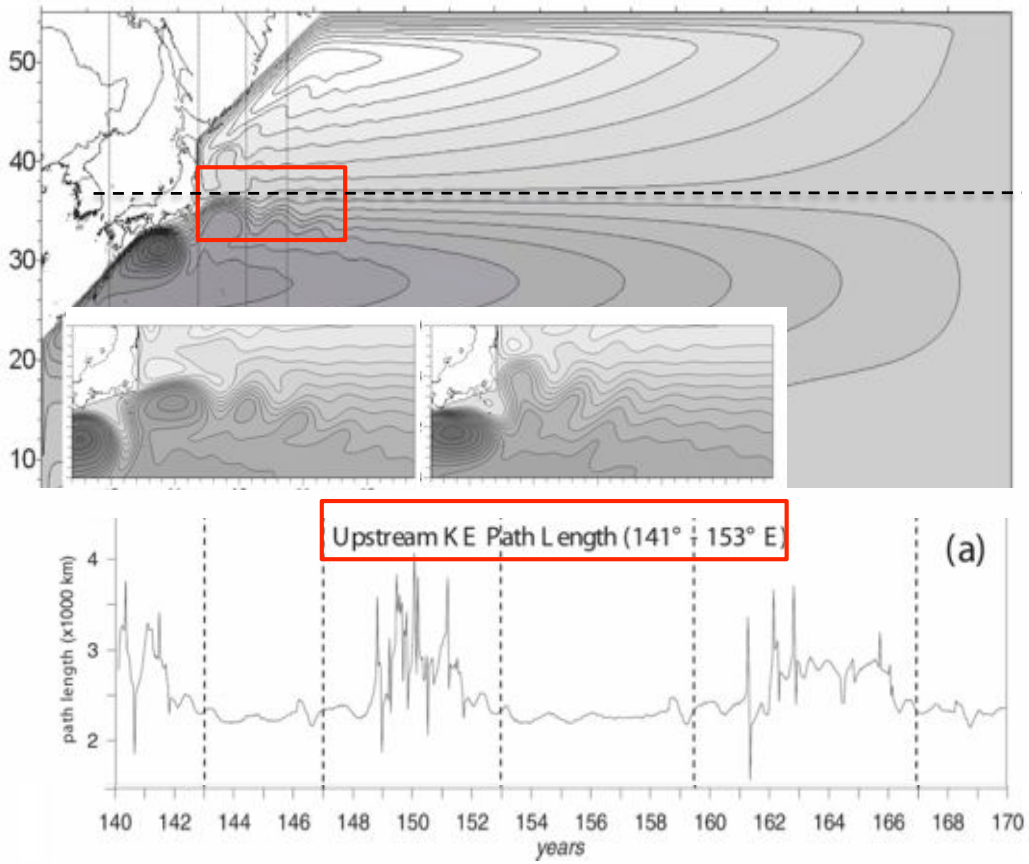
North Pacific @High *Re* $(\overline{u'.\nabla u'})$

+ Constant or seasonal wind forcing

➔ **« Pure » intrinsic 1-10 year chaotic variability**

Dijkstra & Ghil 2005; Pierini 2006; Sushama et al 2007

Relaxation oscillation (Pierini 2006)



Shallow-water models: LF intrinsic variability (forced)

North Pacific @High *Re* $(\overline{u'.\nabla u'})$

+ Constant or seasonal wind forcing

➔ **« Pure » intrinsic 1-10 year chaotic variability**

Dijkstra & Ghil 2005; Pierini 2006; Sushama et al 2007

+ Low-frequency wind forcing (NPO-like)

➔ **Forced intrinsic 1-10 year chaotic variability**

(partly paced by the external forcing)

« Relaxation oscillation », Pierini 2013; Crucifix 2012; Taguchi 2007

Low-frequency WBC variability :

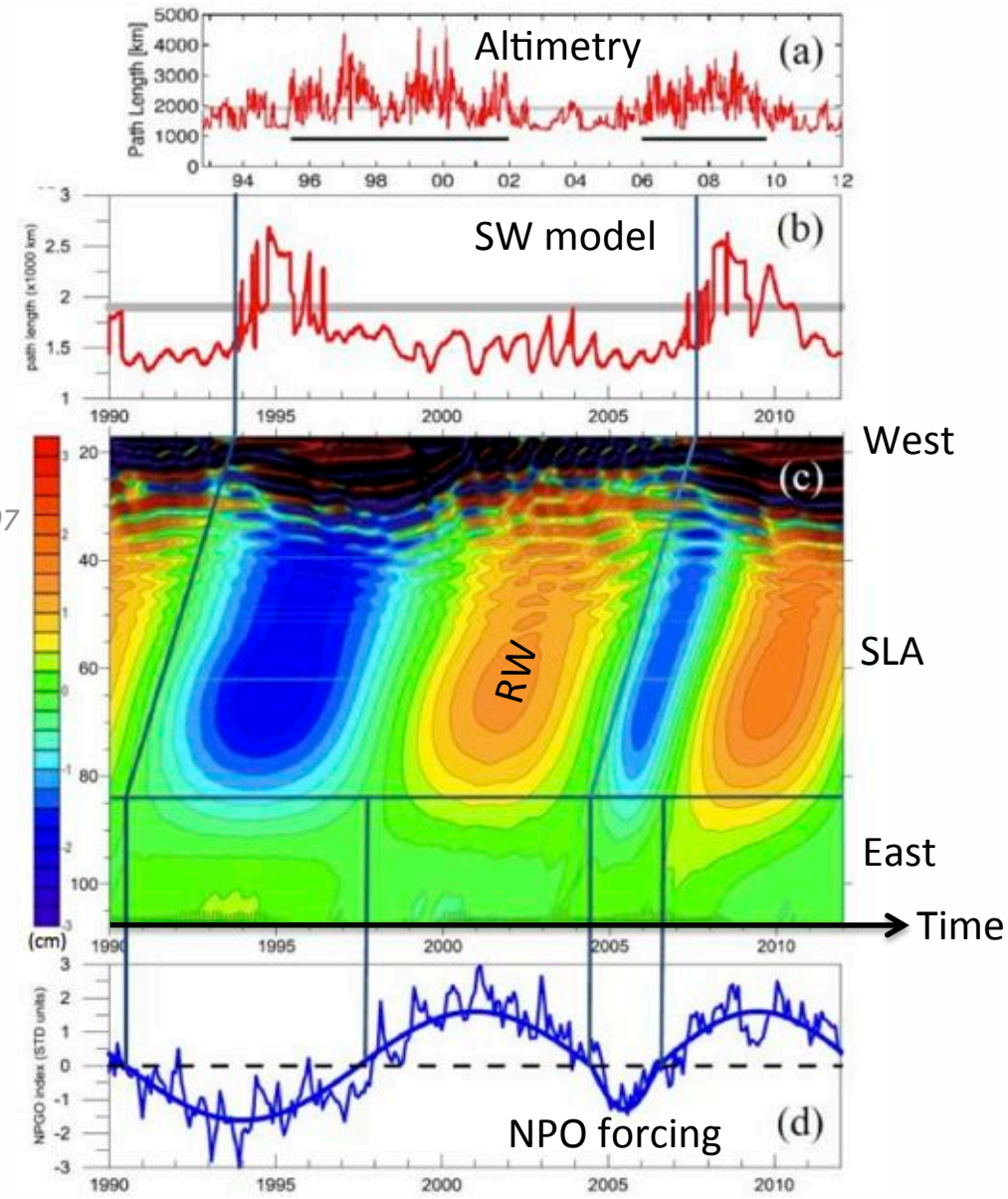
- spatial patterns : set by intrinsic modes
- temporal evolution : partly controlled by forcing

Realistic context :

Amplitude ? Other imprints ?

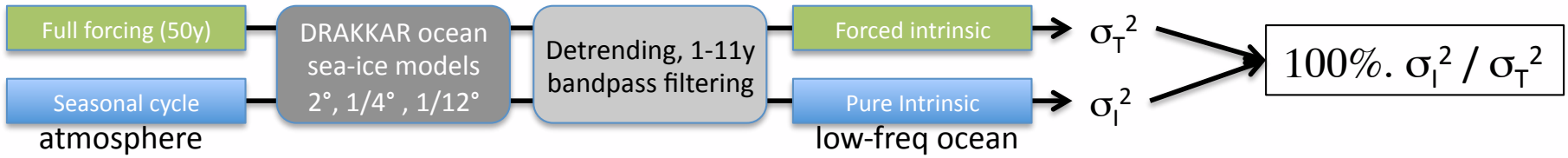
→ Eddying OGCMs

Paced Relaxation oscillations (Pierini 2013)



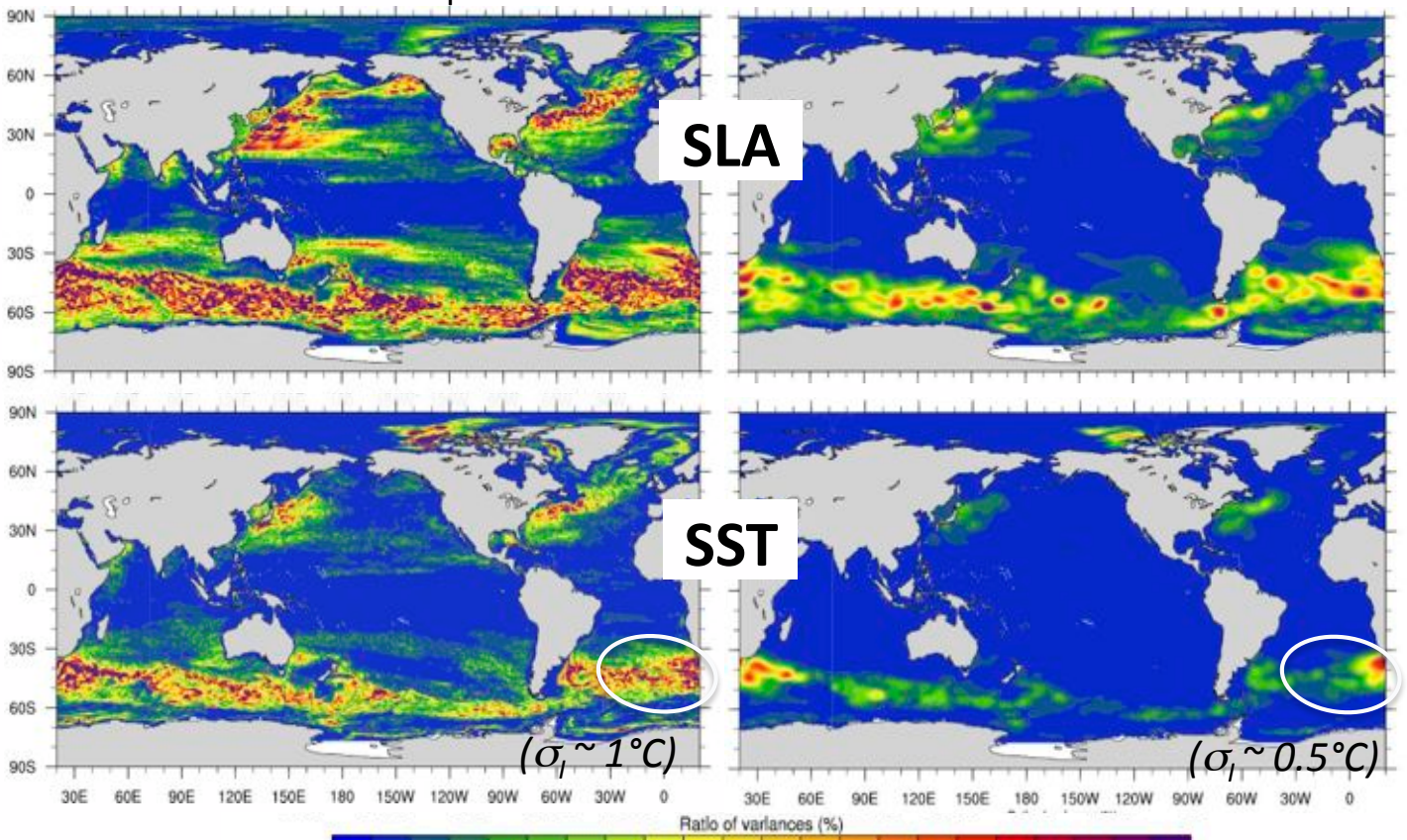
OGCMs: LF intrinsic variability **amplitudes, imprints** (pure)

As in Penduff et al 2011

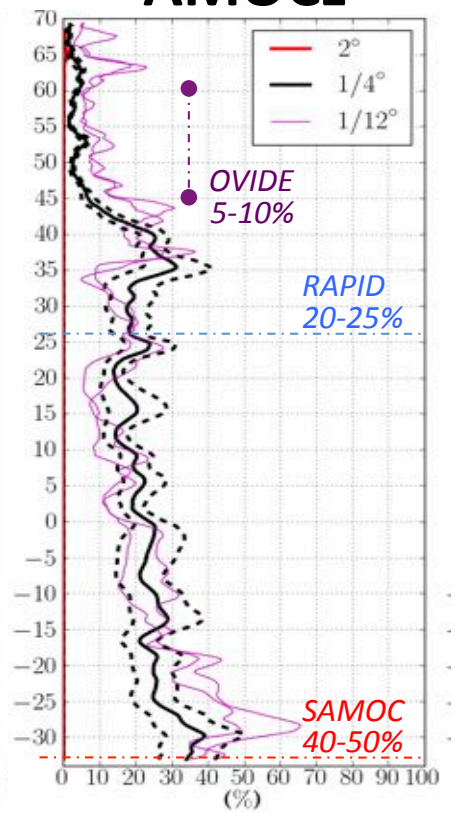


T > 18 months — all spatial scales

T > 18 months — L > 12°



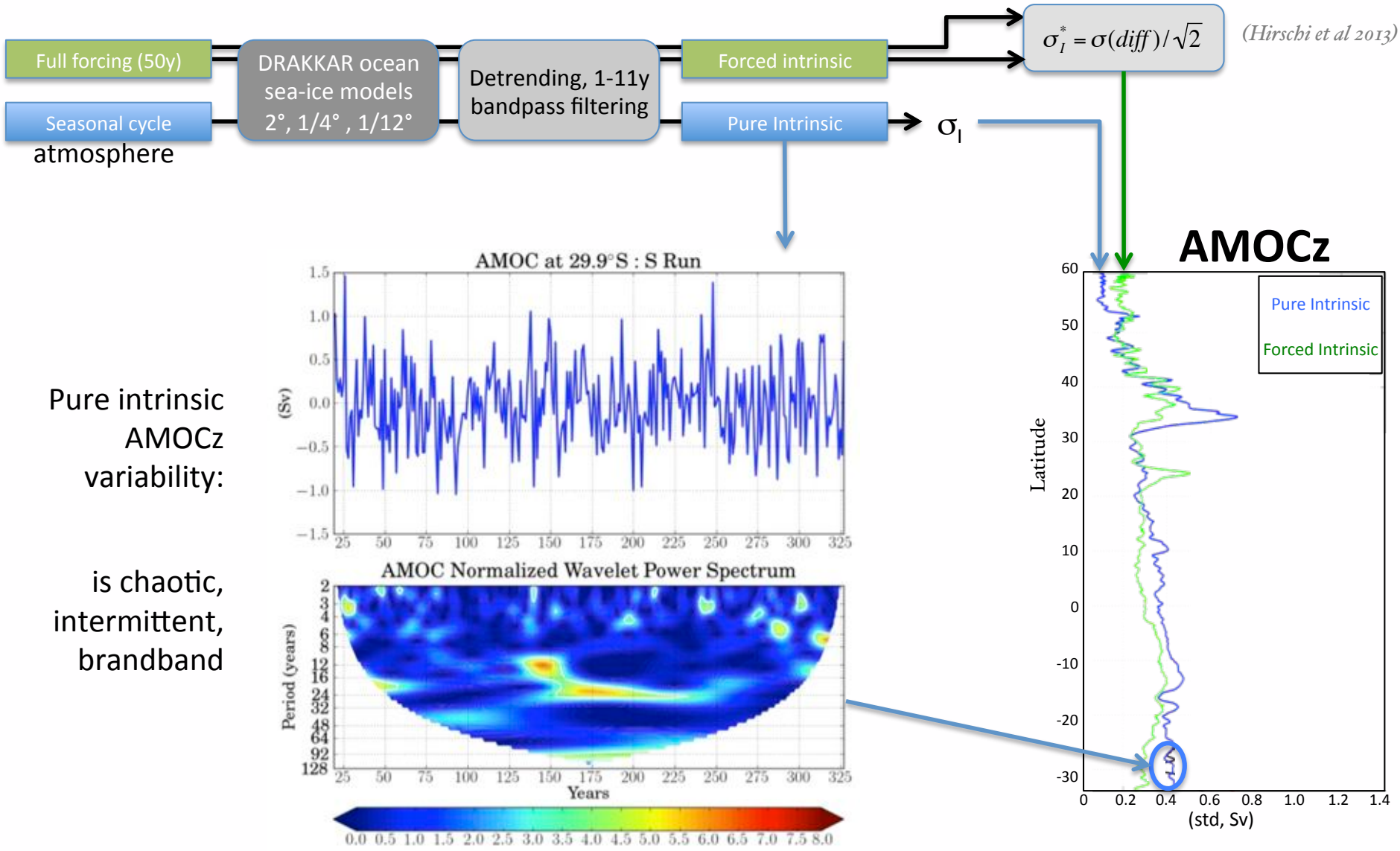
AMOCz



Serazin et al (in prep)

Grégorio et al (in prep)

OGCMs: LF intrinsic variability **amplitude** (pure vs forced) AMOCz



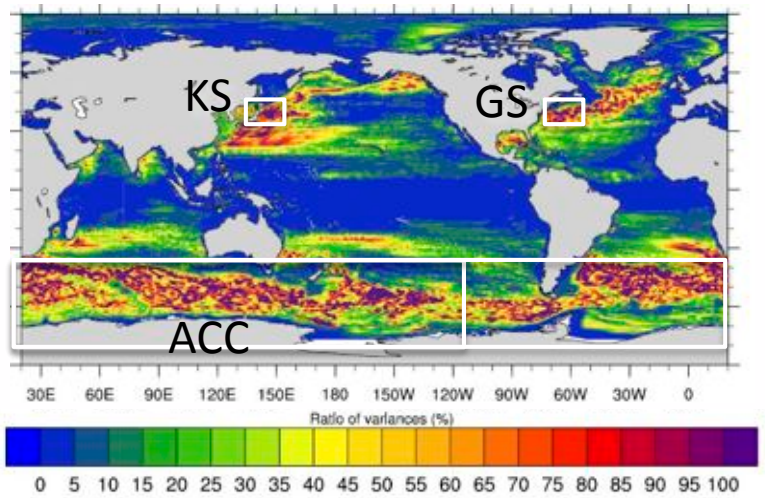
Pure intrinsic AMOCz variability:

is chaotic, intermittent, brandband

Grégorio et al (in prep)

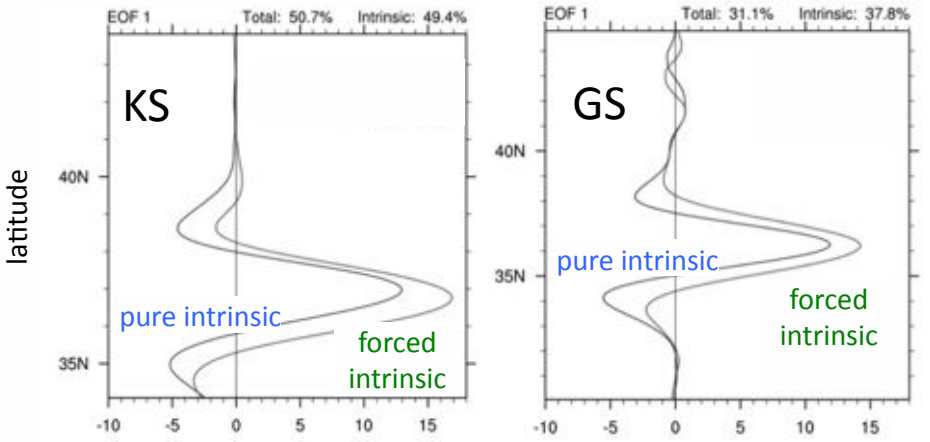
OGCMs: pure and forced intrinsic variabilities have common **spatial patterns** in eddying regions

SLA : σ_I^2 / σ_T^2



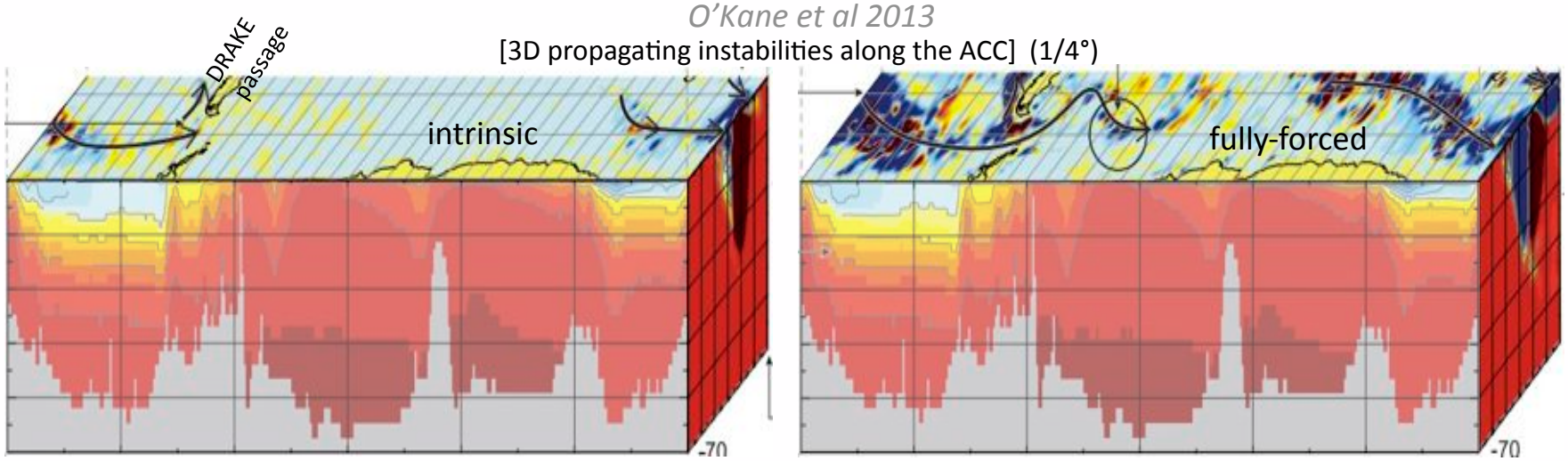
Sérazin et al, in prep (also see Taguchi et al 2007)

[1D SLA EOFs in the Gulf Stream and Kuroshio] DRAKKAR 1/12°



O'Kane et al 2013

[3D propagating instabilities along the ACC] (1/4°)



OCCIPUT objectives

In the eddying regime

Pure intrinsic LF variability :
chaotic, intermittent, brandband
large-scale SST & AMOC signature
up to 50-100% of the full variance

Forced intrinsic LF variability
locally shaped by pure intrinsic
sensitive to initial conditions
partly paced by forcing

→ **Chaotic LF variability**
→ **Probabilistic eddying hindcasts**

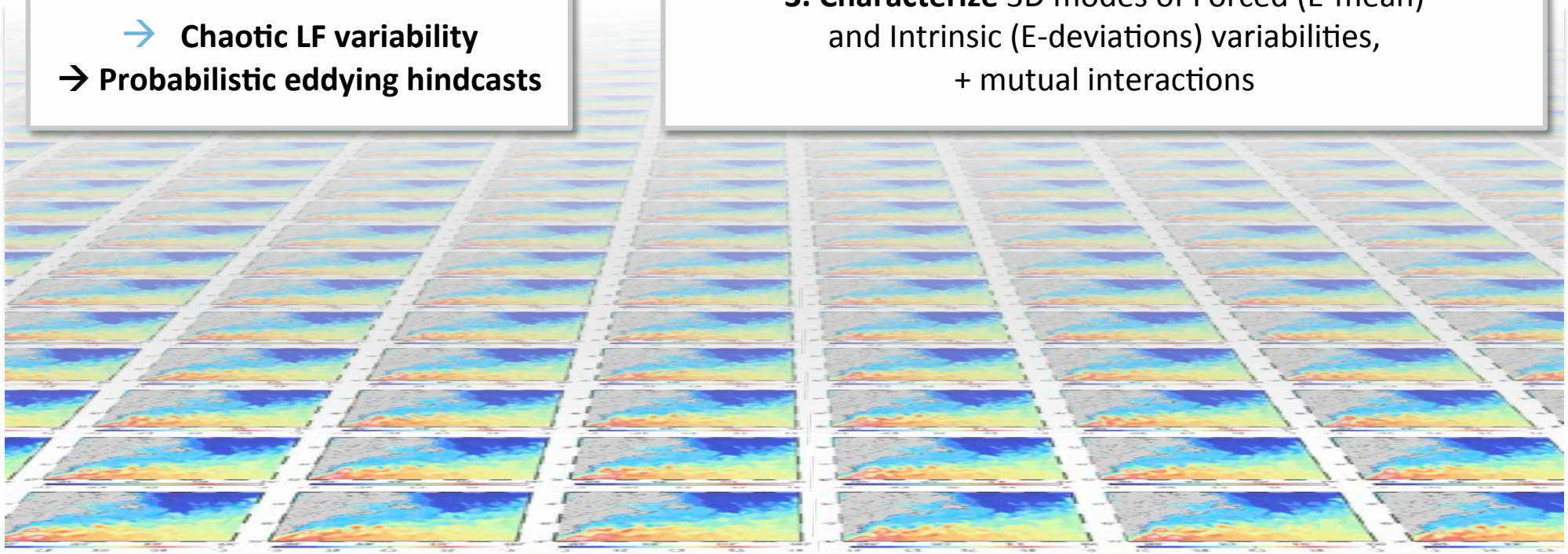
OCCIPUT objectives :

Simulate ~50-year envelope of possible ocean trajectories
Study the forced & intrinsic 1-10yr ocean variability

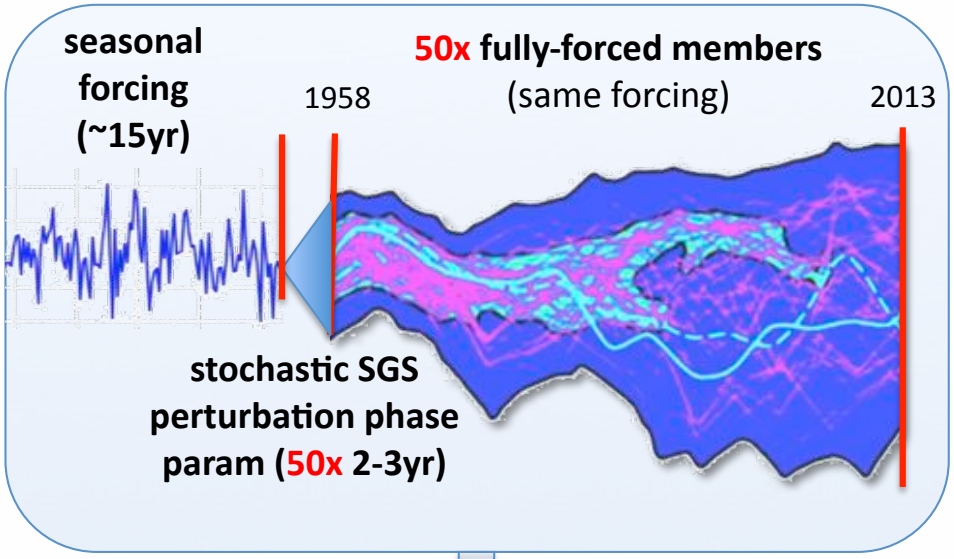
1. Perform a 50-member global 1/4° ocean/sea-ice
ensemble hindcast (1958-present).
Same forcing / perturbed initial conditions

2. Probabilistic assessment/analysis of key variables' **PDFs**

3. Characterize 3D modes of Forced (E-mean)
and Intrinsic (E-deviations) variabilities,
+ mutual interactions



Integration strategy — Numerical setup



50x Monthly 3D outputs

50x 5d 2D fields (SST, UVTS@RAPID, OVIDE)

50x Synthetic obs (altimeters, in-situ T/S)

50x 1d fields (Transports, MHT(y), etc)

Online ensemble diags (e.g. deciles of SST at timestep)

Timestep ensemble Reynolds Statistics (eddy MHT)

Global ORCA025-L75 (1/4°) NEMO config.

DFS5.2 ERA40/ERA-I/satellite forcing (Absolute wind)

Setup close to AR6 ocean components (besides forcing)

Strong interaction with DRAKKAR

Bullx CURIE through PRACE (8000 procs)

NEMO3.5-xIOS — One exec: 50 members

50x [160 procs per member]

about 6x ORCA12

CPU ~15 Million hours (to be requested)

OUTPUT ~100-120 TB (to be shared)

Production planned in 2015

Initialization strategy

Our focus: 1-10yr intrinsic variability ➔ Nonlinearly saturated spread

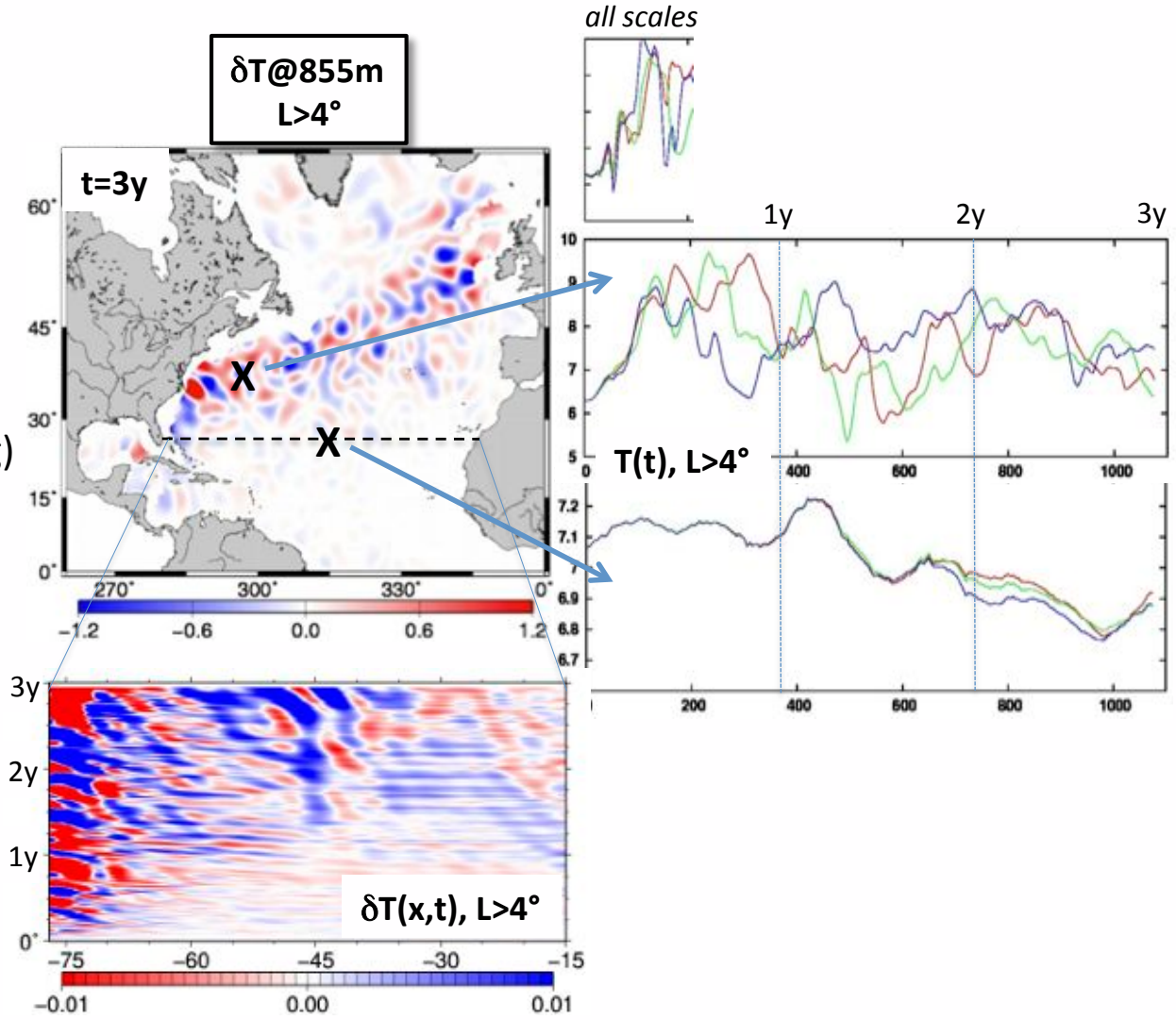
Spinup➔ 50x [2-3y stochastic EOS] ➔ resume ensemble (same physics)

(Brankart OM 2013)

3x NATL025 over 3 years

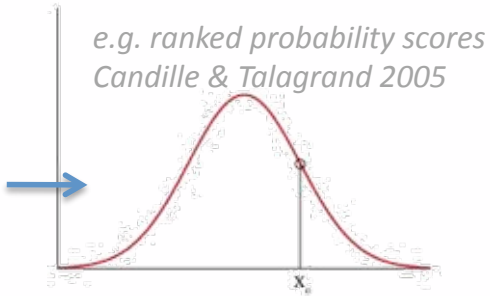
- Fast mesoscale decorrelation in GS ; then spread ➔ **LFLS** *(inv. cascade?)*
- Slower STG (but 15°/1y RW emerging)

- Stochastic perturbation might be extended to TKE



Conclusions - Perspectives

- **Probabilistic ocean hindcasts**
  - ✓ LF variability has a chaotic character (MOC, SST, etc)
  - ✓ Ensembles for other uncertainty studies
  - ✓ Ensembles scale perfectly on massively // machines
  - ✓ Ensemble/obs interface: representativeness, validation



- **How relevant to actual (coupled) climate ?**
  - ✓ Not clear, but ocean-only might be a usual step toward the answer
  - ✓ Are intrinsic SST modes present/modified with coupling ? LF «noise» source ?
  - ✓ Eddies → more extratrop. SST var. → more SST impact on atm. *Kirtman et al 2012'*

Collaborative analyses of OCCIPUT data