Low-frequency variability of Western Boundary Currents in the turbulent ocean: intrinsic modes and atmospheric forcing

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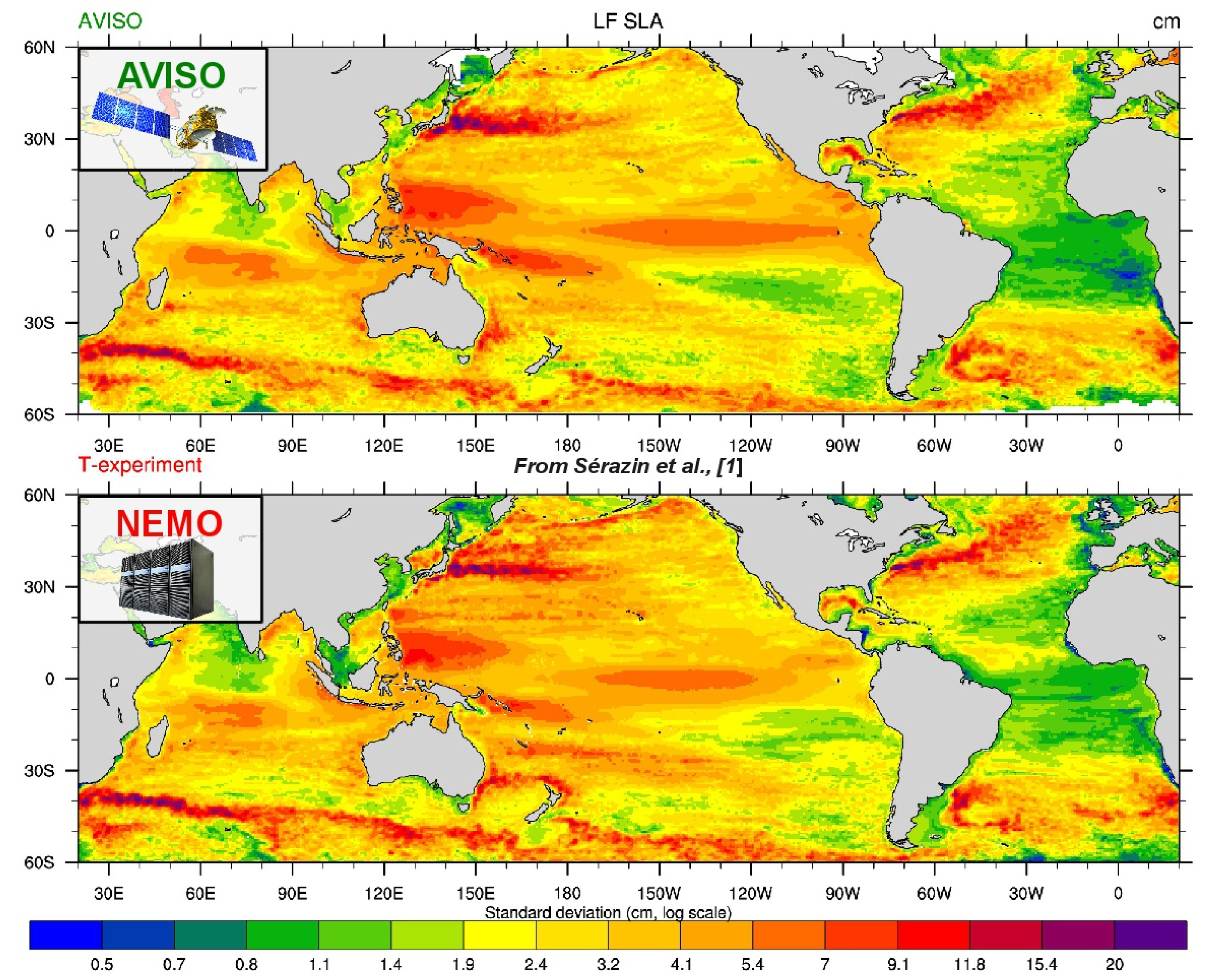
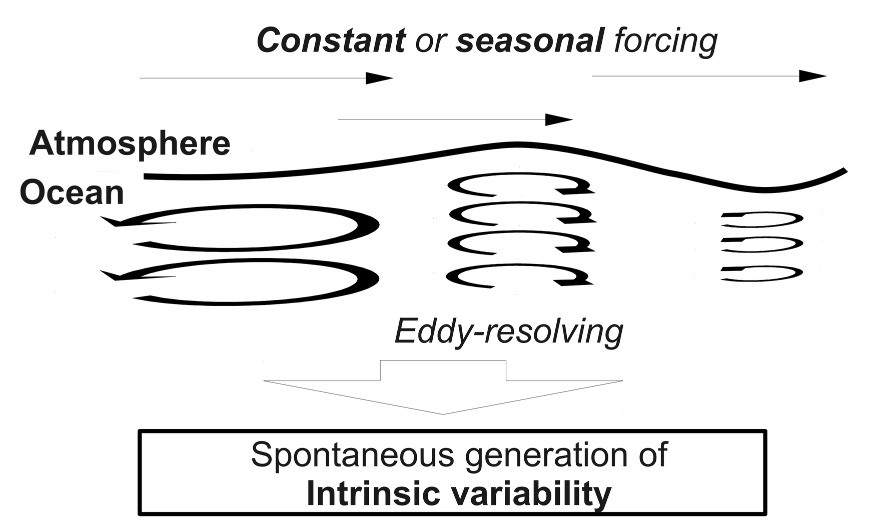
INTRODUCTION: OBSERVED AND SIMULATED LOW-FREQUENCY SEA-LEVEL VARIABILITY IN THE GLOBAL OCEAN

How accurate LF SLA variability is hindcasted by OGCMs ?

Ocean Global Circulation Models (OGCMs), as they get finer in resolution, get more realistic: they are able to reproduce with a remarkable accuracy the observed Low-Frequency (LF > 1 year) variability of Sea Level Anomaly (SLA) measured by satellite altimetry (AVISO) [1].

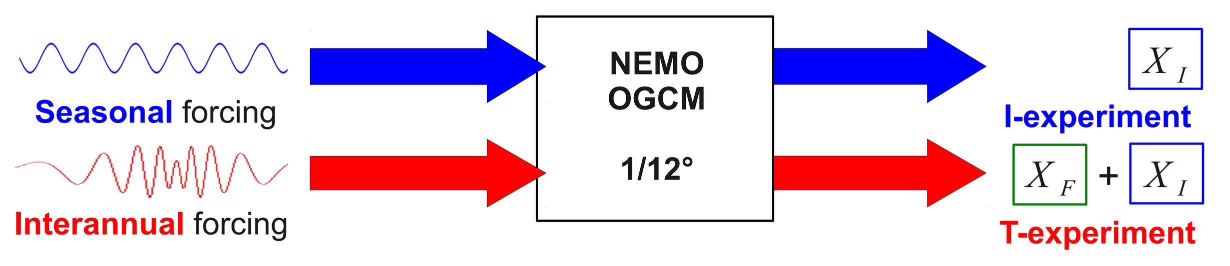


Intrinsic variability



Experimental strategy

Our turbulent laboratory: NEMO 1/12° (eddy-resolving OGCM)
Two types of simulations:
- The T-experiment simulates the total variability and it is used as a reference compared to the observed variability .
- The I-experiment aims at isolating the intrinsic variability.



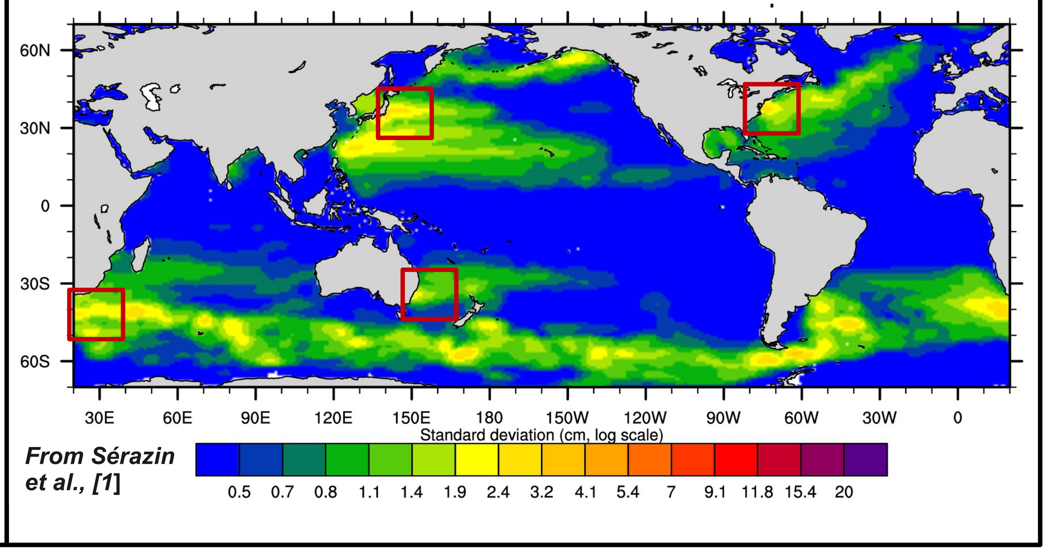
Why focusing on the Western Boundary Currents (WBC) ?

Usual paradigm (but NOT totally TRUE):
- Basin-scale wind stress curl variability via the linear oceanic Rossby wave adjustment drives WBC LF variability [2].

Lessons learned from OGCMS:
- WBC regions exhibit LF SLA **intrinsic** variability on a wide range of spatial scales in a realistic turbulent ocean [1].
- Intrinsic Kuroshio modes might be triggered by the atmospheric forcing via Rossby waves [3].

Lessons learned from idealized models:
- Oceanic **intrinsic** modes of WBCs derived in an idealized context may effectively coupled with the atmosphere [4].
- Jets might "coherently resonate" under an external forcing [5].

Low-frequency (<1 yr) Large-Scale (>12°) SLA STD in the I-experiment

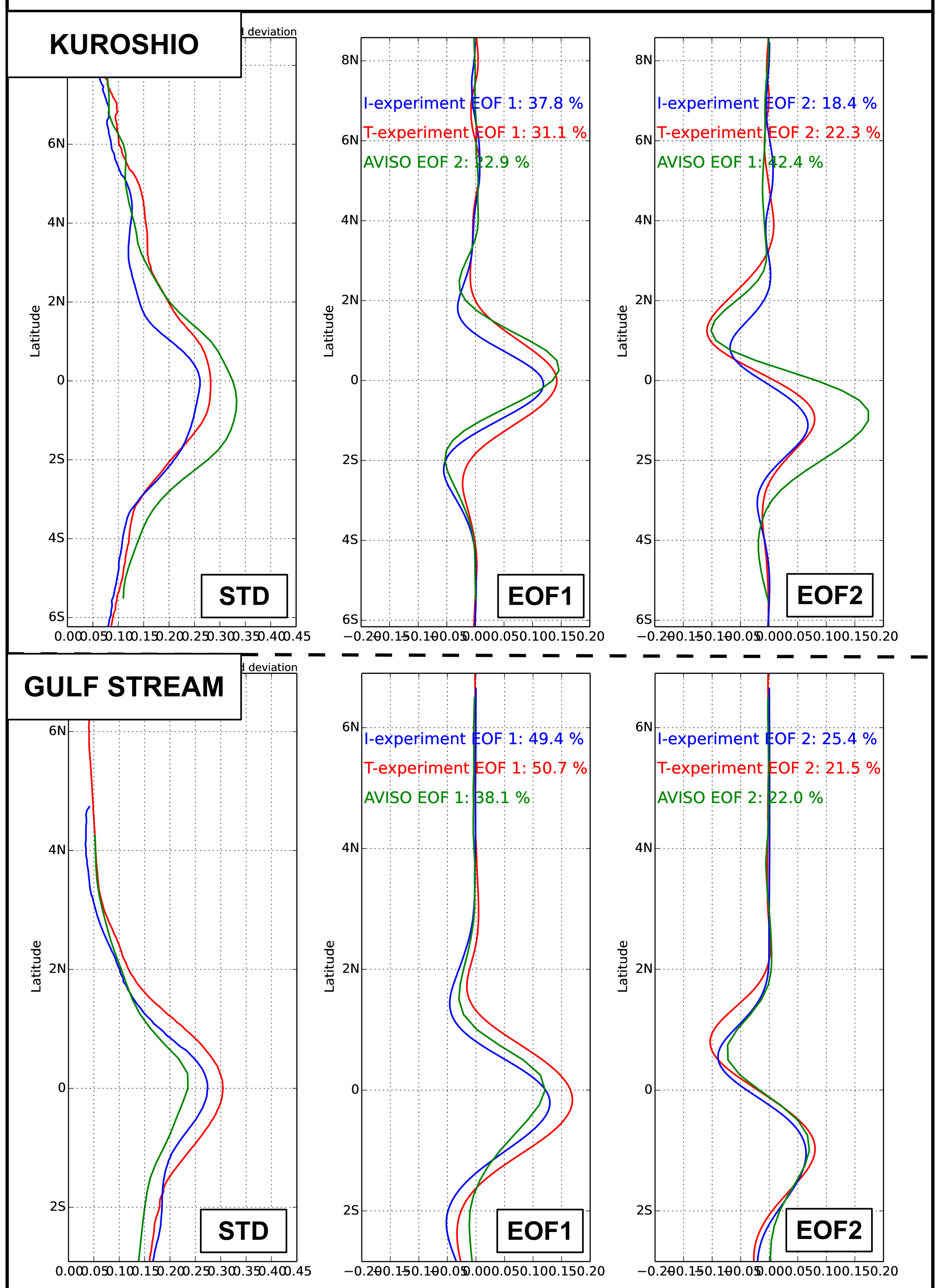


INTRINSIC MODES OF VARIABILITY IN THE KUROSHIO AND THE GULF STREAM

Spatial structure of jet modes

EOF decomposition of the zonal jets into 2 modes (10°x10° box):

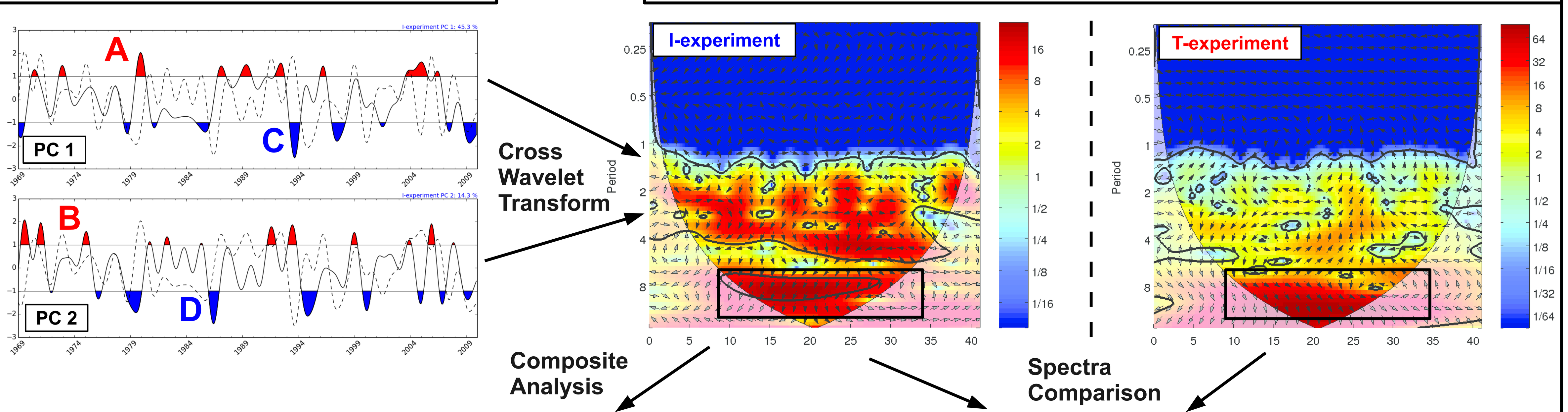
- **Kuroshio ↔ Gulf Stream:**
  → Mode 1: Displacement of the SSH gradient ↔ Jet displacement
  → Mode 2: Increase/decrease of the SSH gradient ↔ Jet intensification/weakening
- **AVISO ↔ T-experiment:**
  → NEMO 1/12° is able to reproduce the main jet meridional modes
- **T-experiment ↔ I-experiment:**
  → Jet meridional modes of variability are shaped by oceanic processes



A focus on the Kuroshio: application of the turbulent oscillator [6]

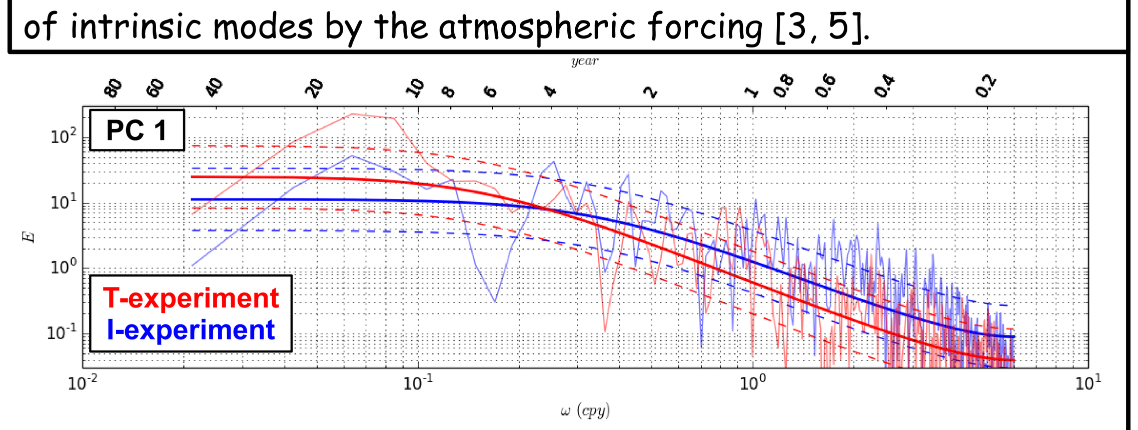
Key state decomposition:
A) Migration of the jet to the North
B) Intensification of the jet
C) Migration of the jet to the South
D) Weakening of the jet

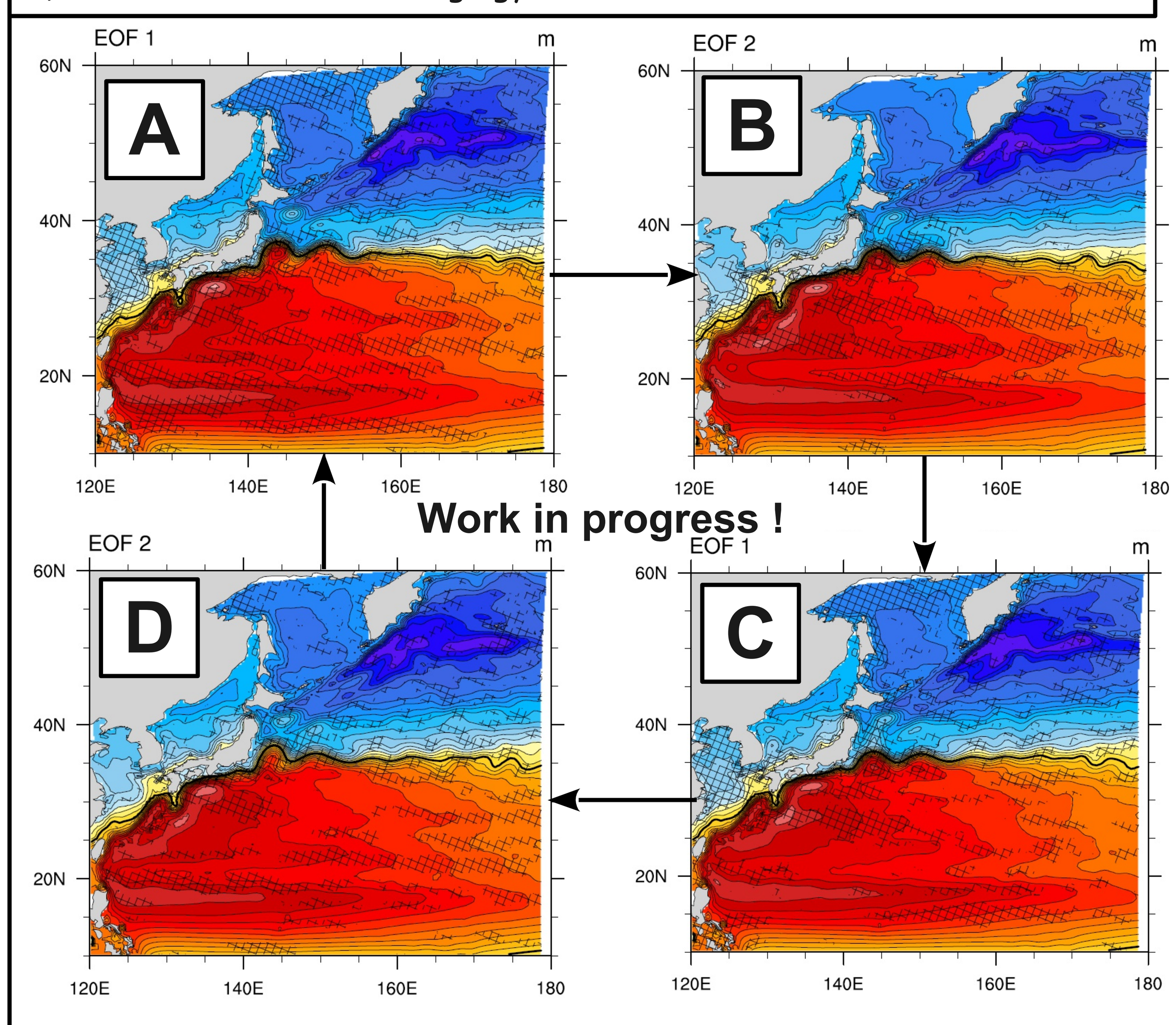
Cross-wavelet analysis:
- In the I-experiment, PC1 is in positive quadrature phase with PC2 in the band 8-10 year, consistent with the turbulent oscillator paradigm [6].
- Similar result in the T-experiment: the intrinsic coupling between PC1 and PC2 in this frequency band might be robust to the atmospheric forcing.



The turbulent oscillator theory [6]:
A)Strong Eastward Jet / Large gyre / Strong PV barrier
B)Strong Eastward Jet / Small gyre / Strong PV barrier
C)Weak Eastward Jet / Small gyre / Weak PV barrier
D)Weak Eastward Jet / Large gyre / Weak PV barrier

Spectral analysis:
The PCs low-frequency content is more energetic in the T-experiment than in the I-experiment: consistent with a triggering of intrinsic modes by the atmospheric forcing [3, 5].





MESSAGE OF THIS POSTER

- NEMO 1/12° is able to reproduce the global SLA LF variability as well as the Kuroshio and Gulf Stream modes of variability with a good accuracy.
- Turbulent oceanic processes are able to shape the spatial structure of LF modes in the Gulf Stream and in the Kuroshio.
- In the Kuroshio, the two main modes of variability are in quadrature phase in the frequency band 8-10 year for both simulations. These modes might be triggered by the atmospheric forcing [3, 5].
- Whether or not the turbulent oscillator [6] intrinsically occurs in a realistic ocean is currently studied.

References:
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