2018 International AMOC Science Meeting | US CLIVAR

Decomposing the Variability in the North Atlantic Meridional Overturning Circulation

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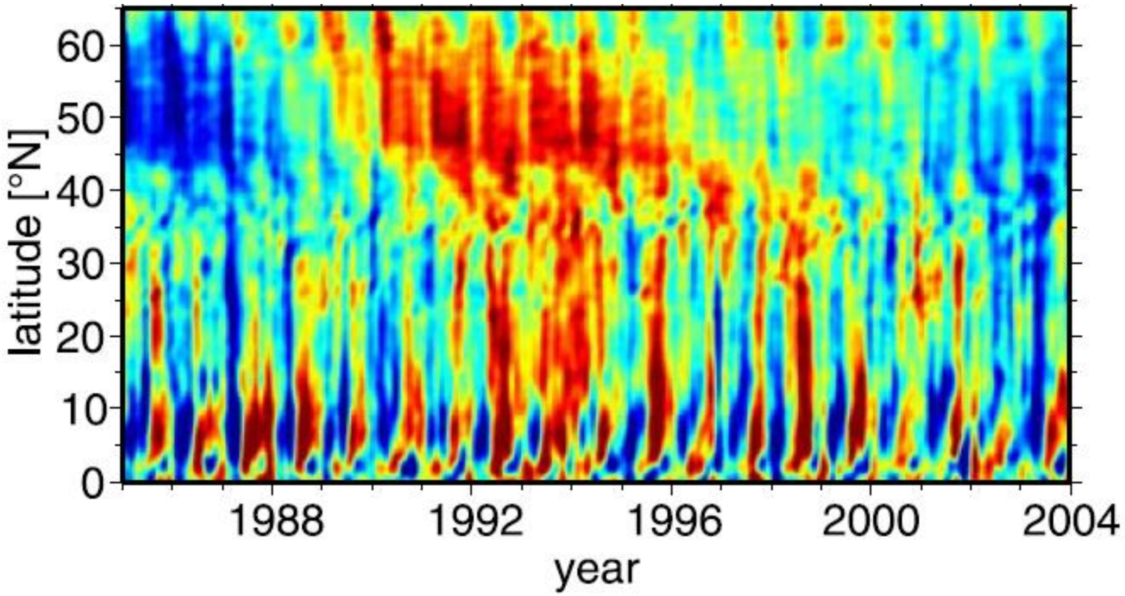
NICHOLAS SCHOOL OF THE ENVIRONMENT

OVERTURNING IN THE SUBPOLAR NORTH ATLANTIC PROGRAM

Motivation – Lack of meridional MOC coherence

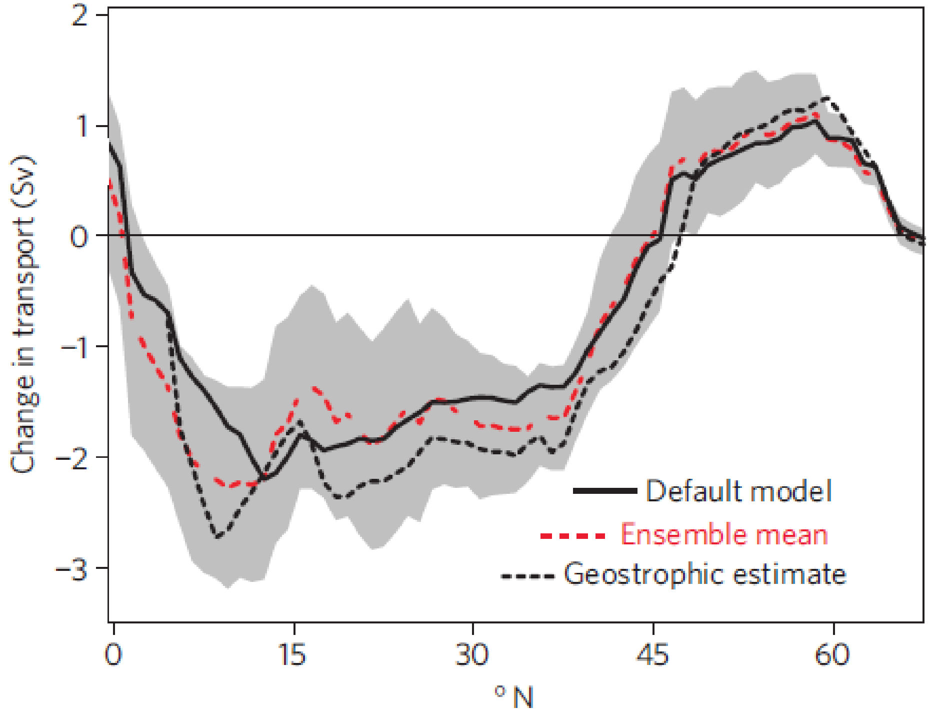
- Different MOC variability between the subpolar and the subtropical gyre.

Hovmöller diagram of upper transport anomalies



(Bingham et al., 2007)

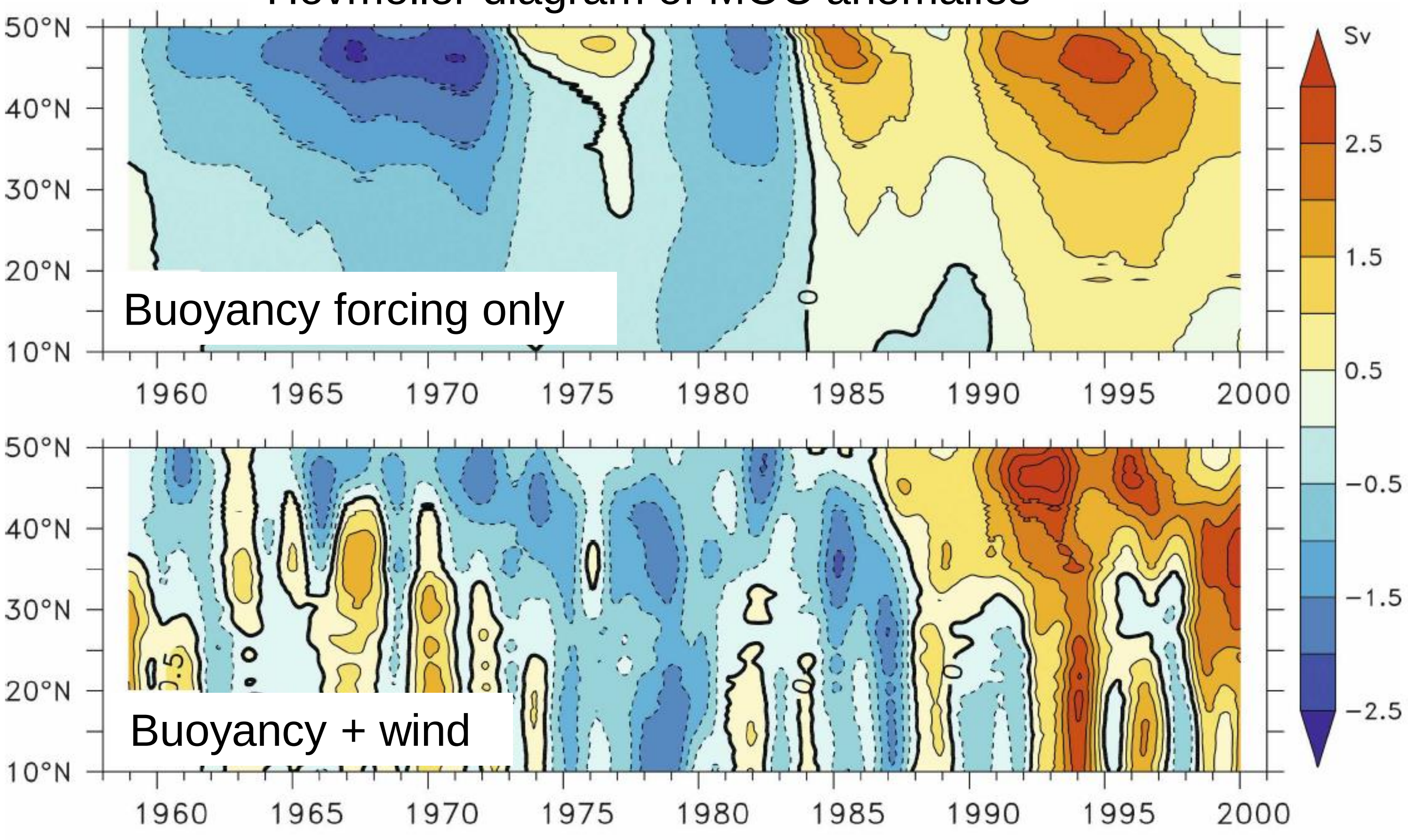
Upper transport difference between 1950-1970 and 1980-2000



(Lozier et al., 2010)

Motivation – Attribution of lack of meridional MOC coherence

Hovmöller diagram of MOC anomalies



- Meridional coherence is masked by high frequency wind-forced variability.

(Biastoch et al., 2008)

Goals

- To quantify the meridionally coherent component and gyre-specific component of MOC variability.
- To determine the contribution of the two components to total MOC in the subpolar and the subtropical gyre.

Data

- Reanalysis: **SODA**3.4.2, GFDL MOM5/SIS model base, 1/4°, 1980-2015;
- OGCM: **FLAME**, 1/12°, 1990-2004;

  ORCA025, 1/4°, 1961-2004.

  HYCOM, 1/12°, 1978-2015

Methods

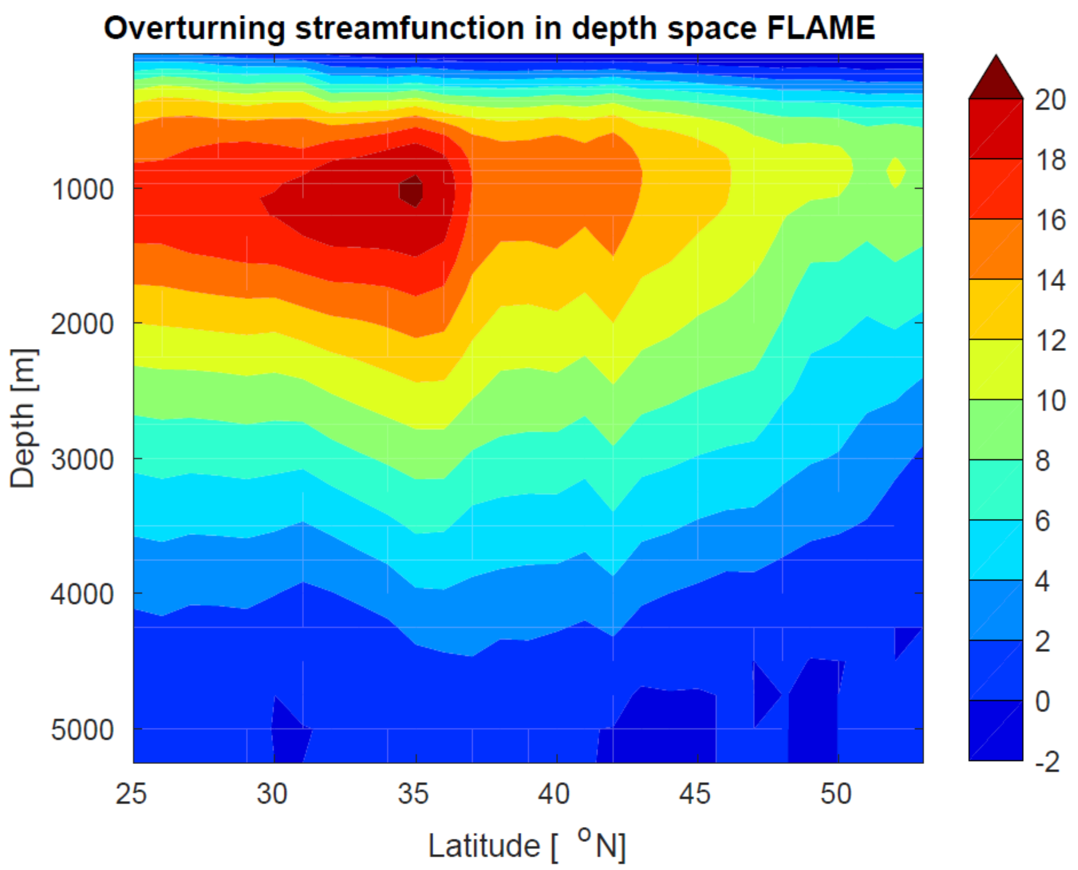
- MOC calculation in σ_2 space:

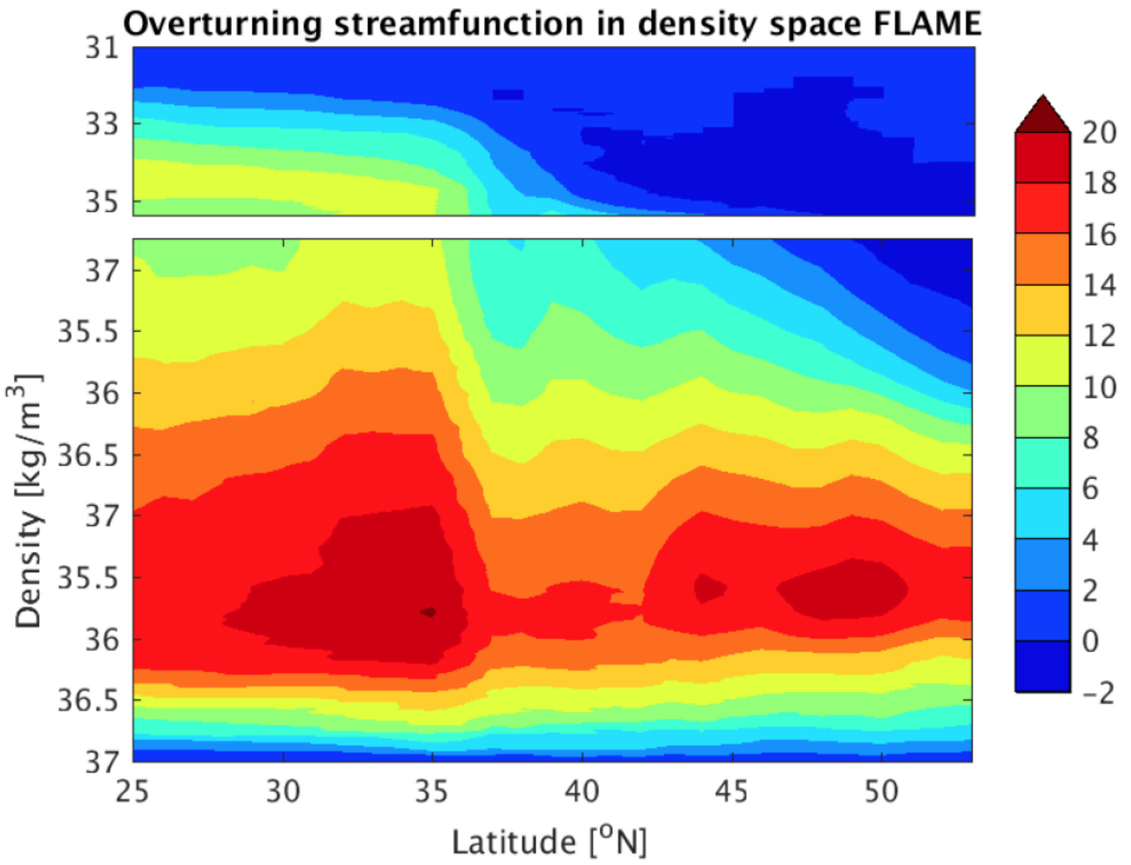
$$\mathrm{AMOC}(\varphi, \mathrm{t}) = \max \Psi(\varphi, \sigma_2, \mathrm{t}) = \max \left[\int_{\sigma_2}^{\sigma_2\, surface} \int_{x_w}^{x_e} v(\mathrm{x}, \varphi, \sigma_2, t)\, dx\, d\sigma_2 \right].$$

Latitude — Time — Overturning Streamfunction

- Calculated with monthly data, and then averaged annually before a trend is removed.
- Empirical Orthogonal Function (EOF) Analysis.

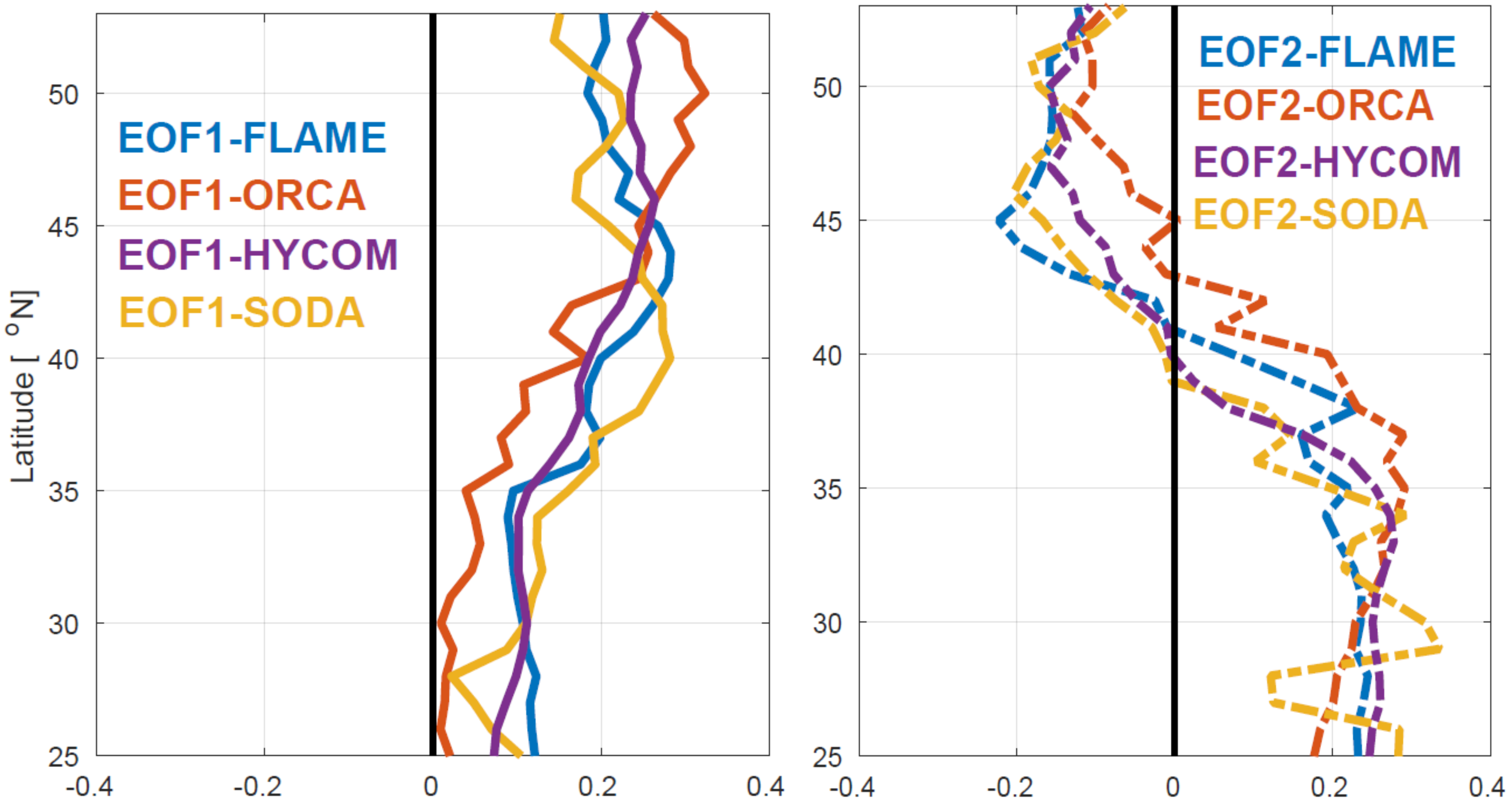
Overturning streamfunction in z/σ space



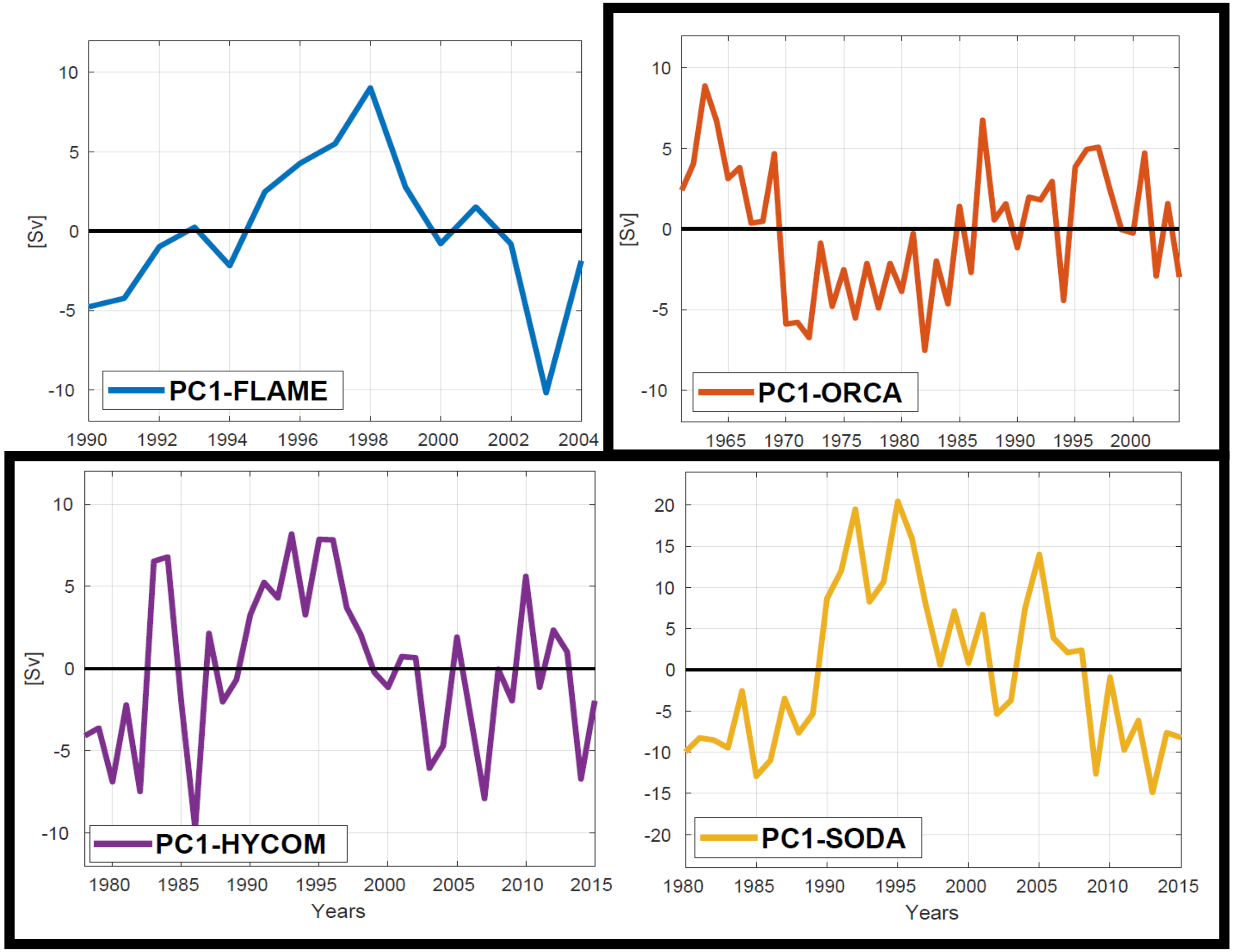


Decomposing MOC variability with EOF

- EOF1: Meridional coherent mode (model range: 46%-60%);
- EOF2: Gyre-specific mode (model range: 16%-30%).



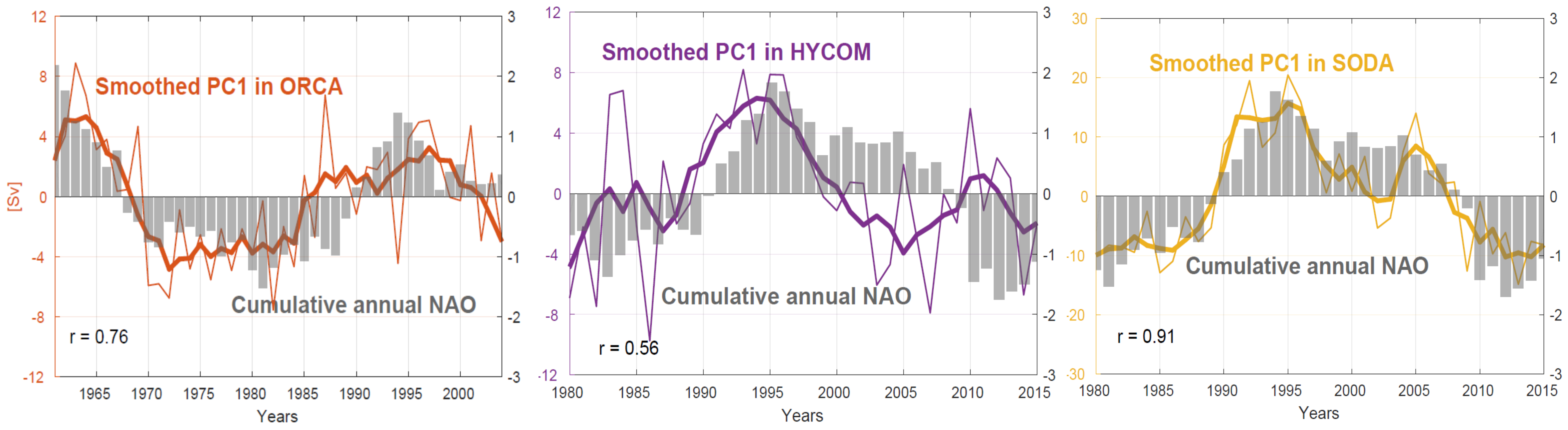
Decomposing MOC variability with EOF



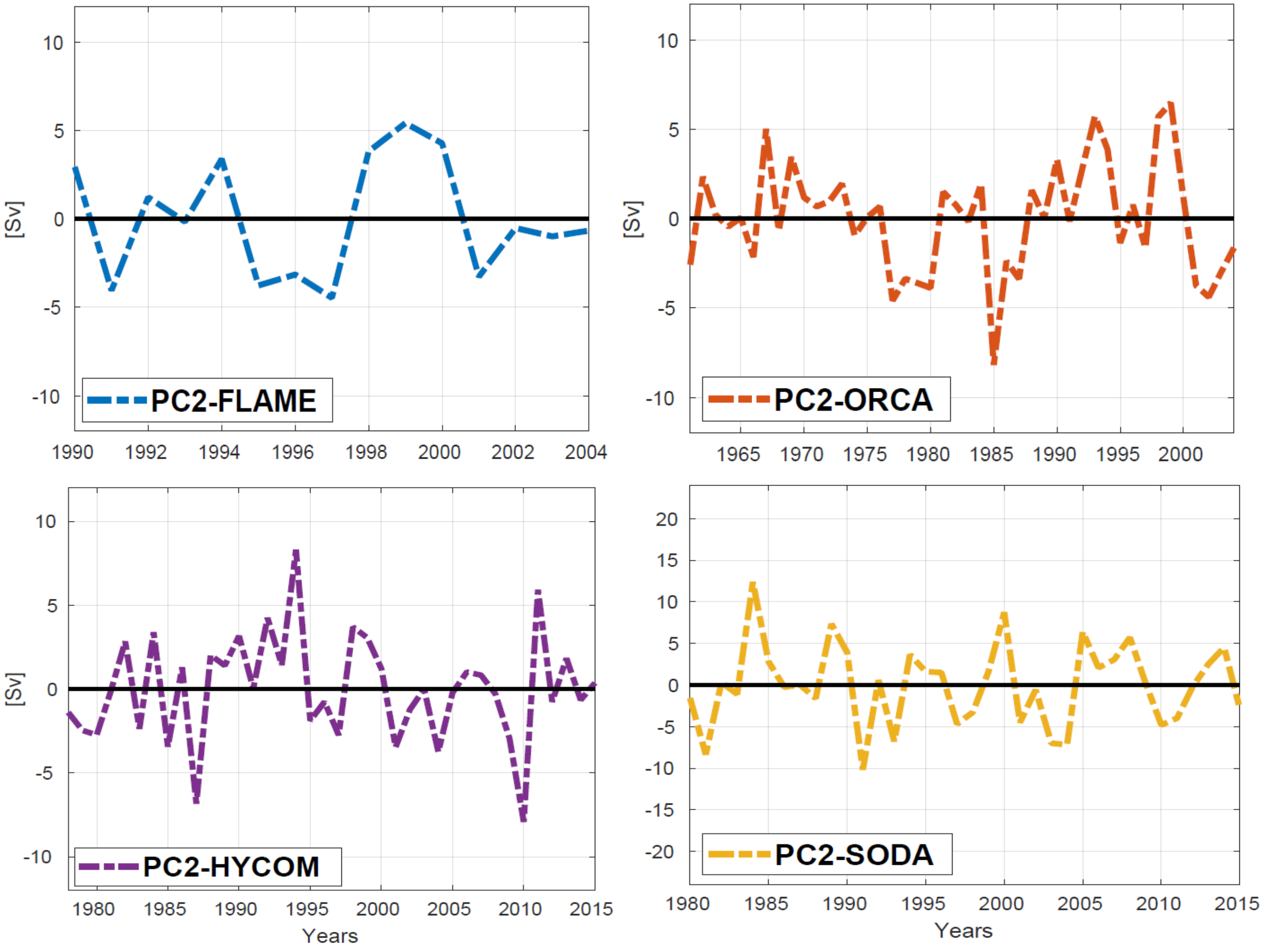
- Principal Component (PC) for EOF1 contain both interannual and decadal variabilities.

Coherent MOC variability is linked to cumulative NAO

- Coherent MOC is more related to persistent NAO situations, rather than individual events.

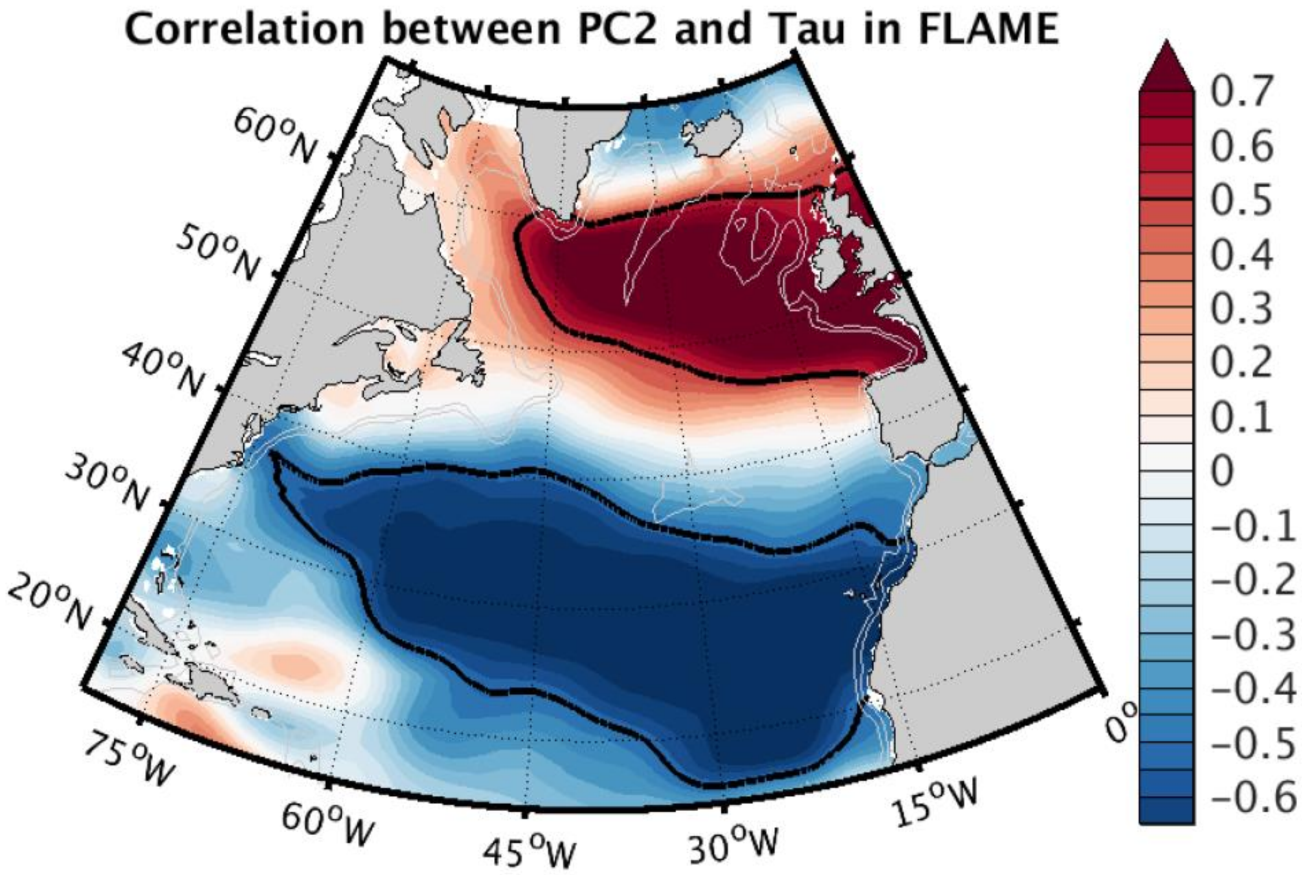


Decomposing MOC variability with EOF



- PC for gyre-specific mode (EOF2) varies on interannual time scales.

Gyre-specific MOC variability is linked to wind stress



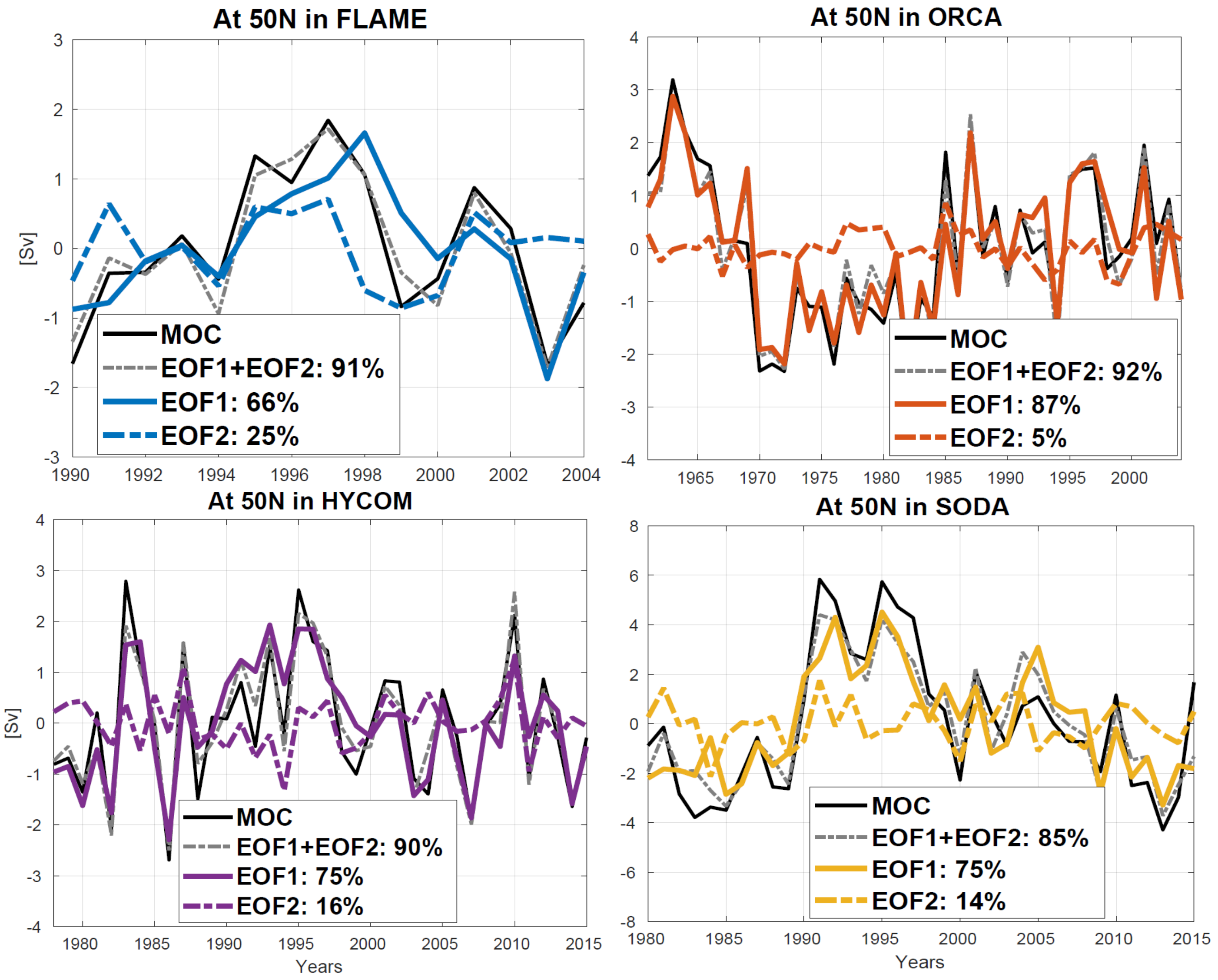
- Subpolar: stronger westerlies ➔ weaker MOC
  - Ekman transport
  - Geostrophic transport?
- Subtropics: stronger easterlies ➔ stronger MOC
  - Ekman transport
  - Mid-ocean transport with Rossby wave adjustment

(Zhao and Johns, 2014)

Goals

- To quantify the meridional coherent component and gyre-specific component of MOC variability.
- **To determine the contribution of the two components to total MOC in the subpolar and the subtropical gyre.**

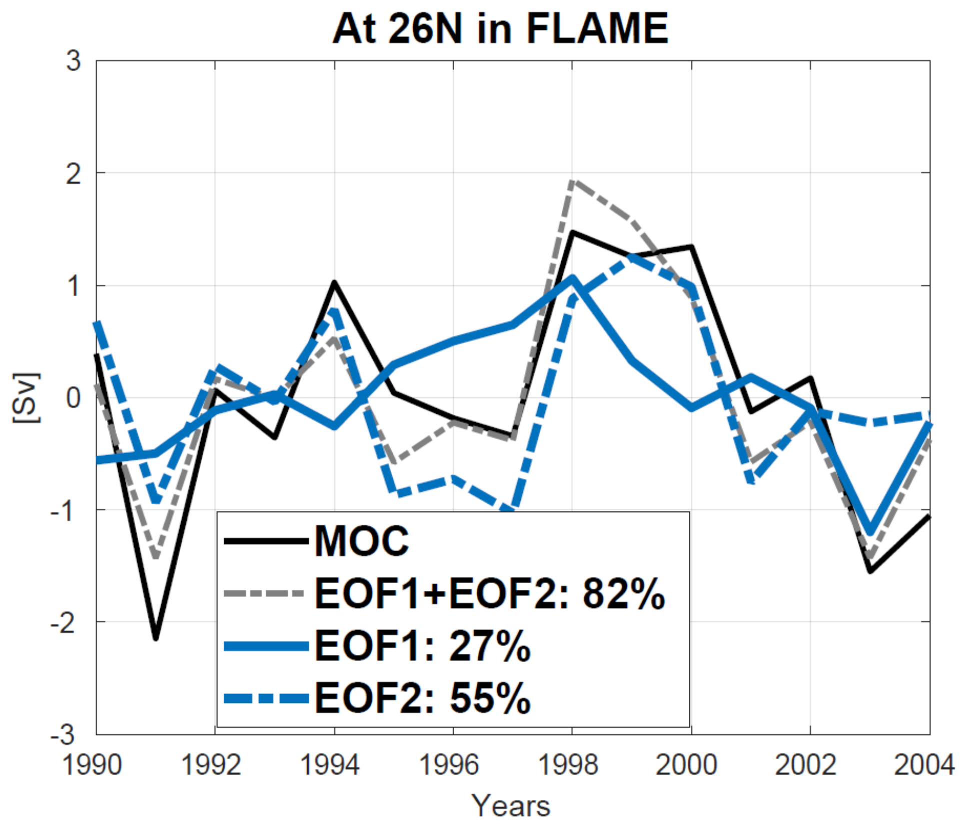
Decomposing MOC variability at 50°N

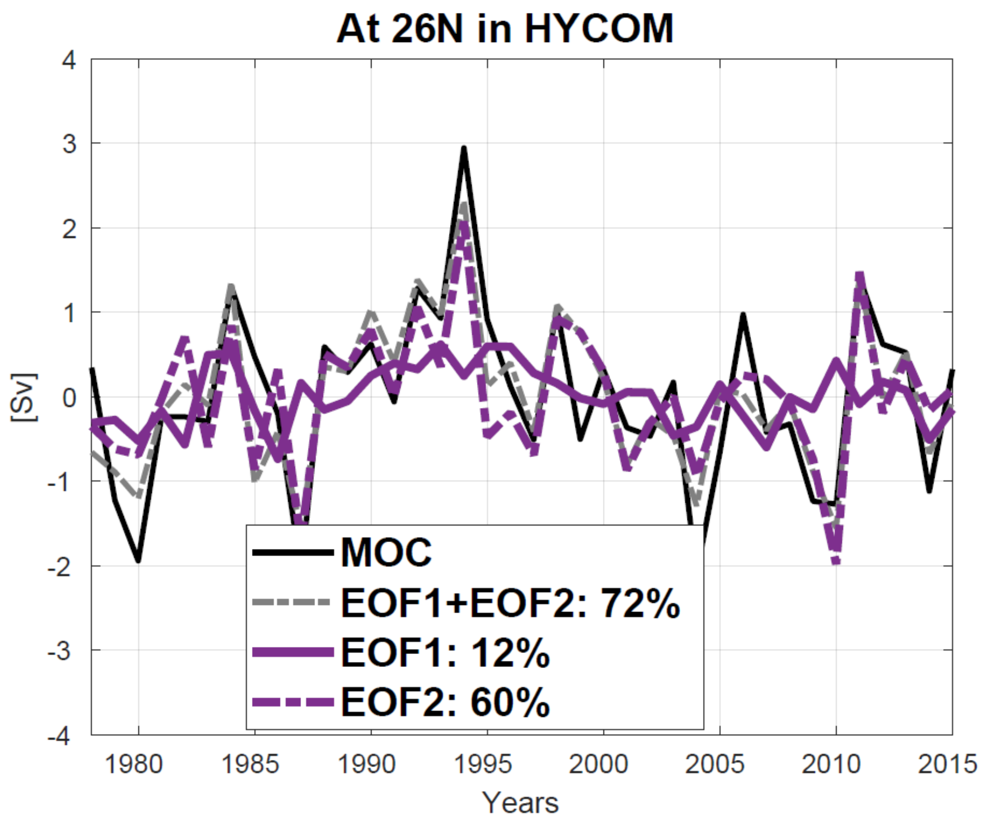


- EOF1+EOF2: 85-92% of total MOC variance
- **EOF1: 66-87%**
- EOF2: 5-25%

Decomposing MOC variability at 26°N

- EOF1+EOF2: 72-82%
- EOF1: 12-27%
- **EOF2: 55-60%**

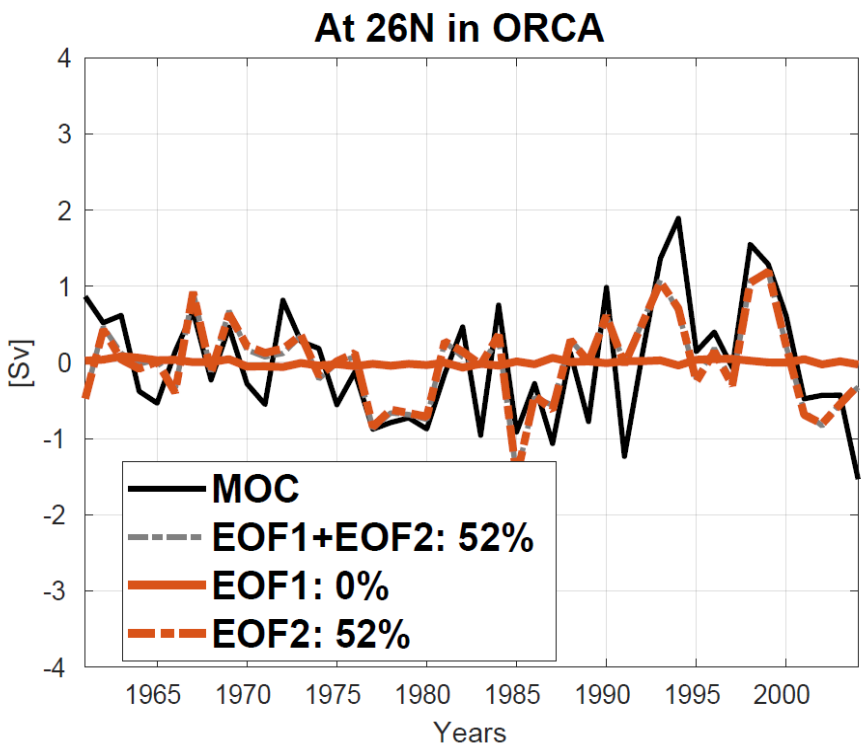


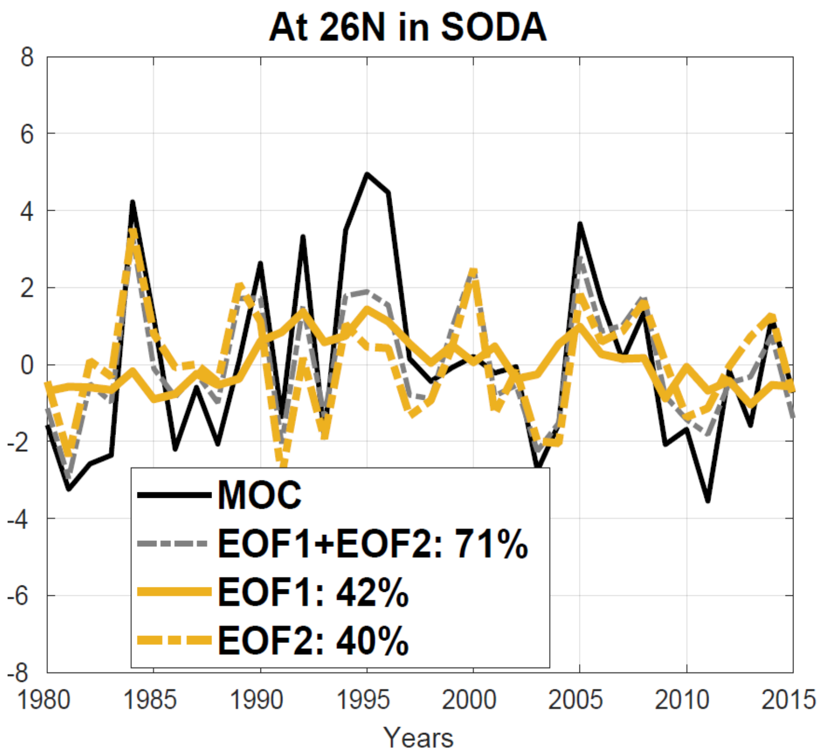


Decomposing MOC variability at 26°N

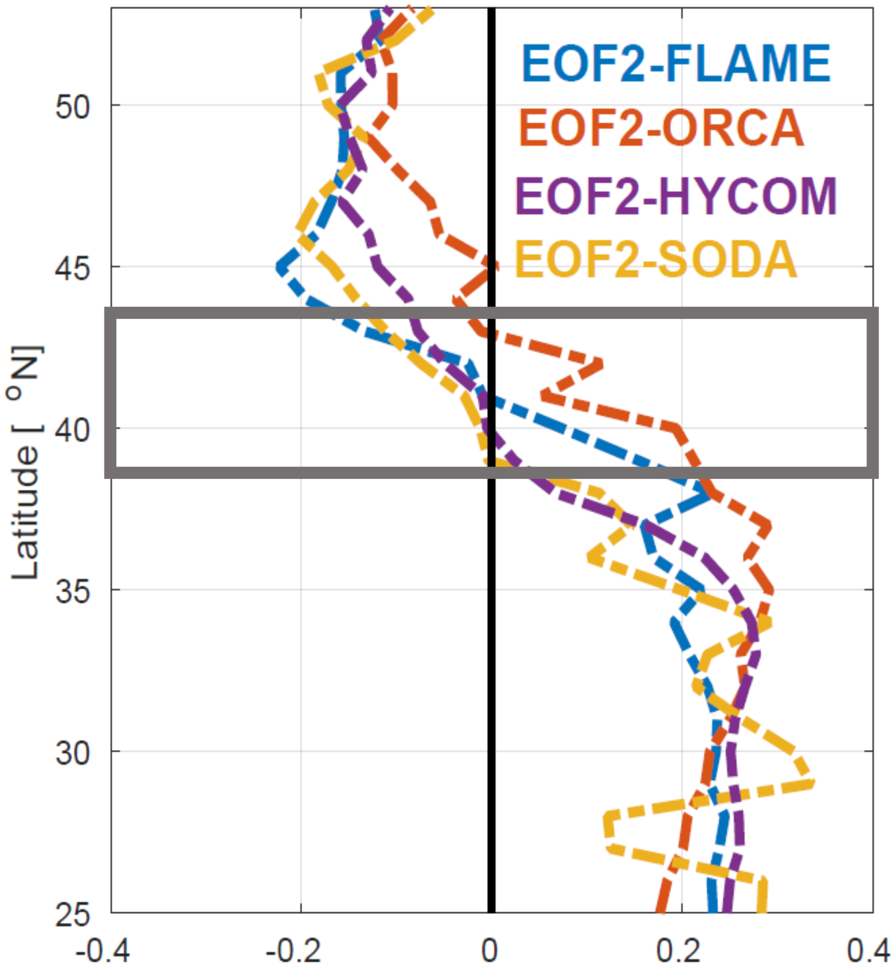
- EOF1+EOF2: 52%
- EOF1: 0%
- **EOF2: 52%**

- EOF1+EOF2: 71%
- **EOF1: 42%**
- **EOF2: 40%**



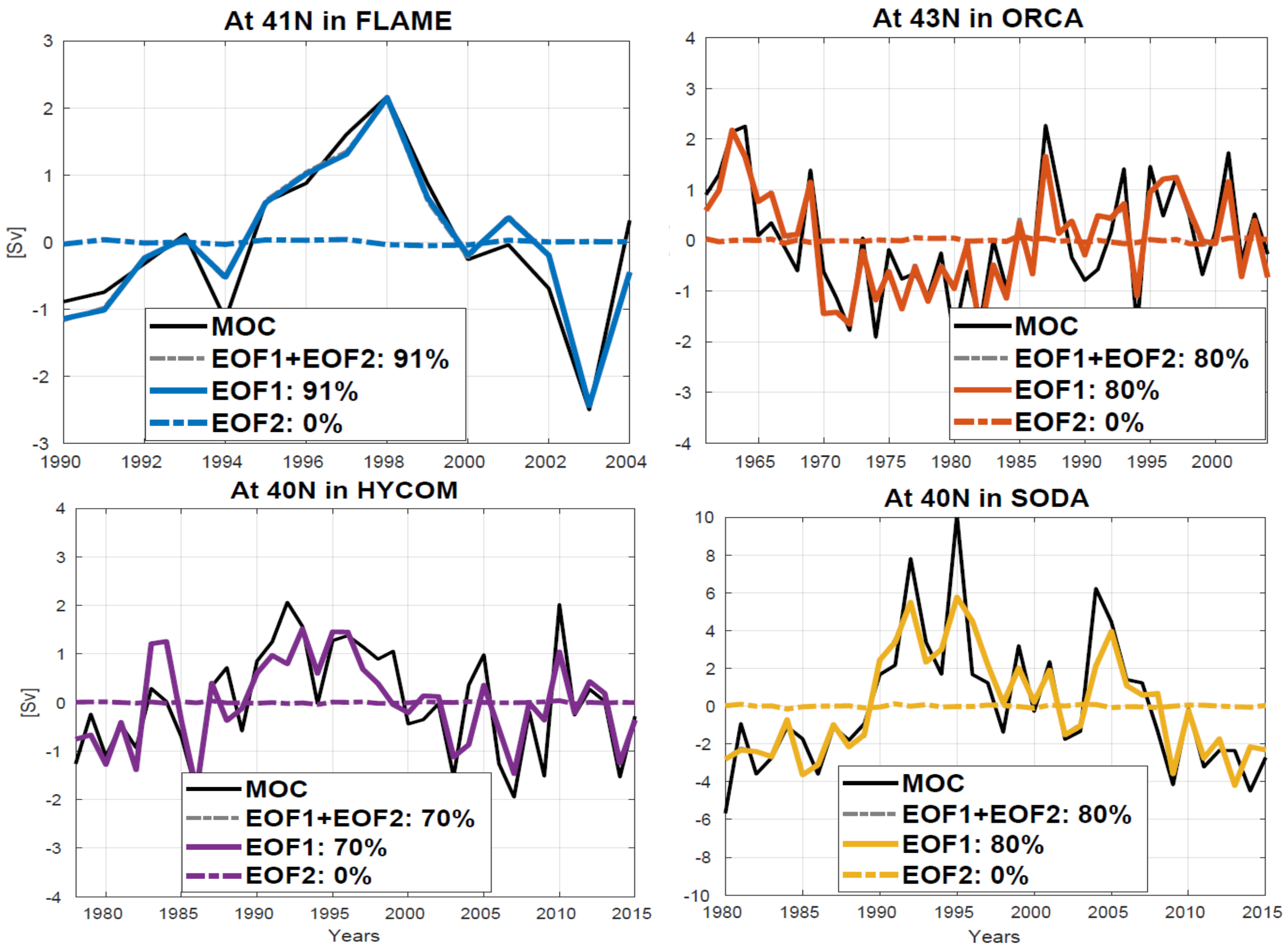


Gyre-gyre boundary as the key region to detect coherent MOC variability



- At 40-43°N, EOF2 = 0.

Gyre-gyre boundary as the key region to detect coherent MOC variability



- **EOF1: 70-91%** of total MOC variance
- EOF2: 0%

Conclusions I

- MOC is decomposed into a **meridionally coherent mode** and a **gyre-specific mode**.
- The coherent mode is linked to **persistent NAO**.
- The gyre-specific mode is linked to **local wind stress**.

- **Ongoing study – Diagnosing mechanism:**
    - How does NAO impact the meridional coherent mode? Heat flux?
    - How does wind stress drive the gyre-specific mode?

Conclusions II

- The **subpolar MOC** (50°N) is dominated by coherent mode (66-87%), with a relatively small contribution from gyre-specific mode (5-25%).
- The **subtropical MOC** (26°N) is dominated by gyre-specific mode (~50%), with an overall significant contribution from coherent mode (27-42%).
- The meridionally coherent mode can be detected at the **gyre-gyre boundary**.

- **Ongoing Study– Application on observations:**
  - Can we reconstruct subpolar MOC with observations at 41°N and 26°N?