The drivers and the extent of the meridional coherence of the AMOC remain unclear in high-resolution MPI-ESM model simulations

María Jesús Rapanague (maria-jesus.rapanague@mpimet.mpg.de), Dian Putrasahan, and Jochem Marotzke. Max Planck Institute for Meteorology, Hamburg, Germany.

Sharing is encouraged

Introduction

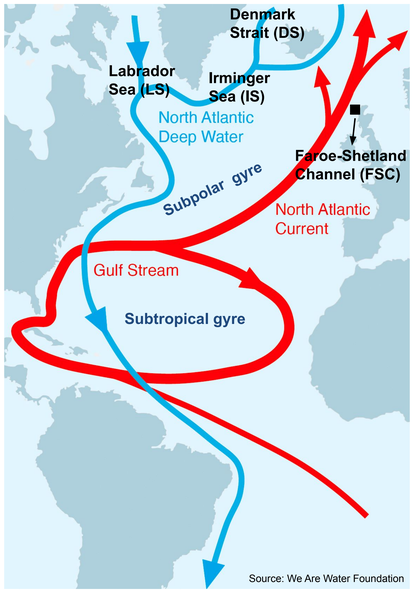

Figure 1: scheme of the AMOC and location of regions of interest.

The **Atlantic Meridional Overturning Circulation (AMOC)** as usually depicted in Figure 1, tacitly assumes to have **meridional coherence** across the Atlantic, connecting the subtropical and subpolar gyres. However, the validity of this assumption has been questioned several times (see e.g. [1, 2]) and remains unclear. Therefore, the use of new **high- and very-high-resolution model simulations to assess the meridional coherence of the AMOC** is important to improve our understanding of the AMOC variability and its drivers.

Methods

We analyzed 3 control simulations of the **coupled model MPI-ESM1.2**, with different ocean resolutions:

- **NR, 1º** (eddy-parameterising)
- **HR, 0.4º** (eddy-permitting)
- **ER, 0.1º** (eddy-resolving).

For each simulation, we calculated the **squared spectral coherence** of the AMOC strength in depth coordinates with:

- Subpolar AMOC (average from 50°N to 60°N)
- Mixed layer depth in the Labrador Sea and the Irminger Sea
- Overflow transport in the Denmark Strait and in the Faroe-Shetland Channel.

The coherence is similar to the standard correlation coefficient but in the frequency domain, allowing the **assessment of the meridional coherence of the AMOC and its potential drivers on several timescales simultaneously.**

Is the AMOC connected across all latitudes? Spectral coherence analysis conducted on 3 model simulations with increasing resolution (1º, 0.4º and 0.1º) shows that the meridional coherence of the AMOC on decadal-to-bidecadal timescales decreases with higher resolutions, and potential drivers of its variability differ between simulations.

Results and discussion

- More detailed flow fields are captured with increasing resolution (Figure 2), with a narrower and stronger Gulf Stream and less zonal bias in the North Atlantic current.
- Connectivity of the AMOC between the subpolar and subtropical gyres is observed on decadal timescales for the coarse resolution (NR), like in [3], but it decreases with higher resolutions. On interannual scales it is confined to the subpolar gyre.
- Coherence with other variables is observed mostly on decadal and longer timescales. While NR is connected only to the Denmark Strait, HR is connected with all of them.
- Surprisingly, high connection of AMOC across almost all latitudes with the Labrador Sea variability is seen on bidecadal timescales in ER.
- A deeper analysis, taking a closer look at more possible drivers of AMOC variability, with other very-high-resolution models and observations is necessary to conclude if the long-held notion of meridional coherence of the AMOC is valid or not.

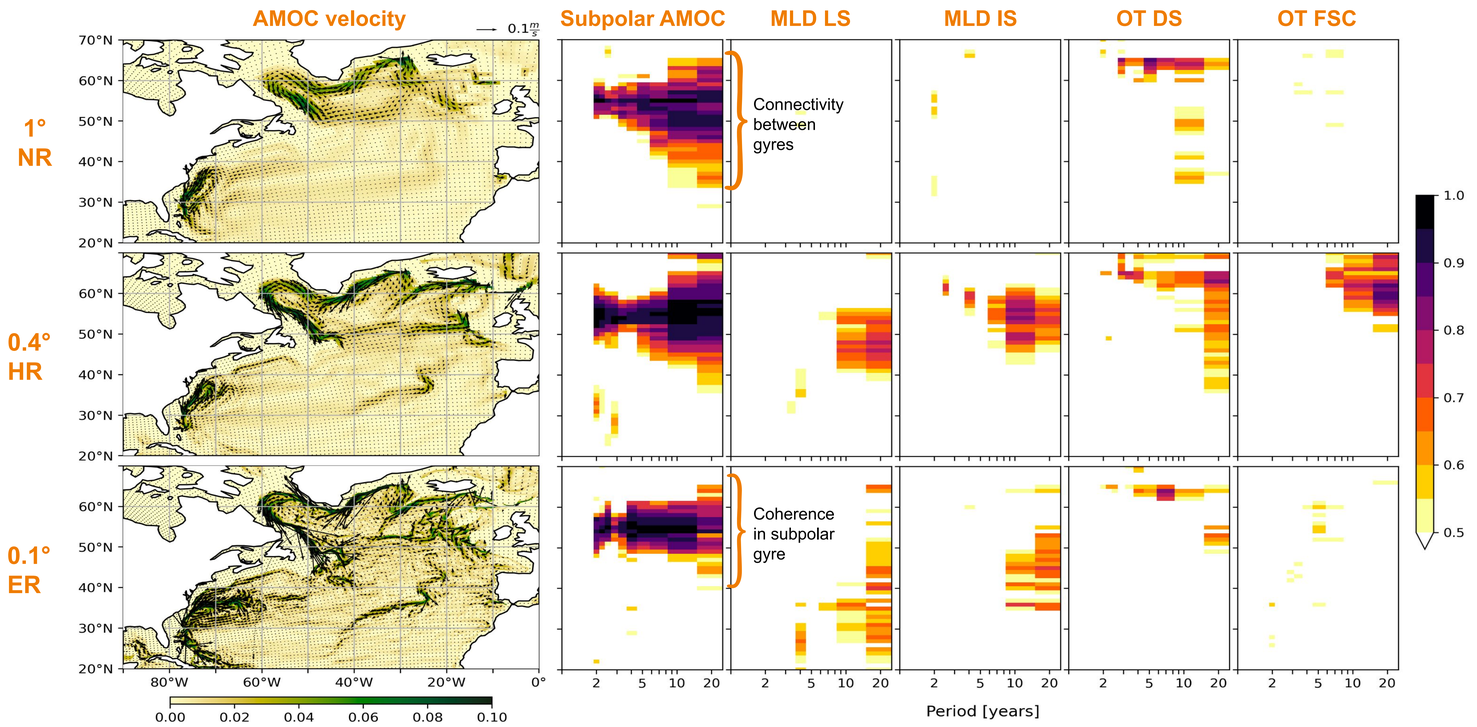

*Figure 2: **Flow velocity at 1000 m depth (left)** and **squared coherence (right)** for the 3 simulations (NR, HR and ER) from 20ºN to 70ºN, between the AMOC strength and: the subpolar AMOC (50 - 60 °N average), the mixed layer depth in the Labrador Sea (MLD LS) and the Irminger Sea (MLD IS), and the overflow transport in the Denmark Strait (OT DS) and the Faroe-Shetland Channel (OT FSC). Shown values are significant with a 95% confidence level.*

References
[1] Bingham et al. (2007). Meridional coherence of the AMOC.
[2] Zou et al. (2018). How Is Meridional Coherence Maintained in the Lower Limb of the AMOC?
[3] Gu et al. (2020). Time scale dependence of the meridional coherence of the AMOC.

MAX-PLANCK-INSTITUT FÜR METEOROLOGIE

IMPRS on Earth System Modelling
INTERNATIONAL MAX PLANCK RESEARCH SCHOOL