How Diabatic Processes Impact the Growth of Long Baroclinic Oceanic Waves?

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Interests

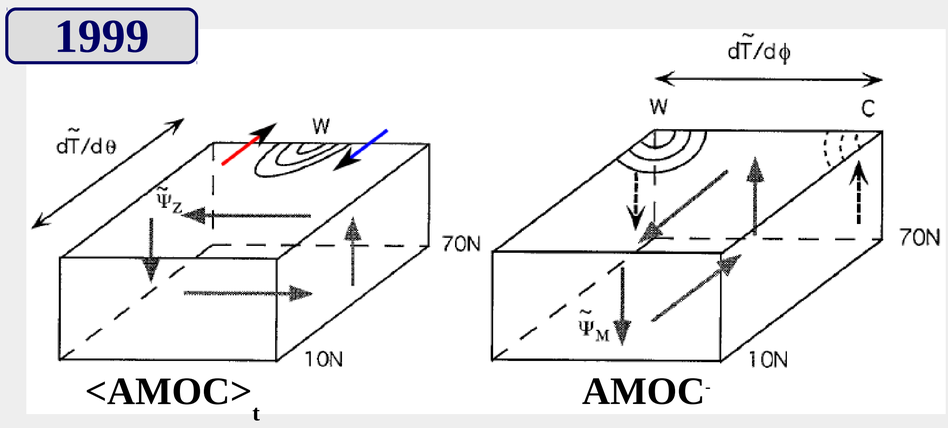
Intrinsically-driven oceanic mode of low frequency AMOC variability associated with long baroclinic waves

Background

- Idealized studies[1,2]: Large scale baroclinic instability of the oceanic mean flow
- Observations[3]: Evidences of long oceanic waves in the North Atlantic
- Stability analyses[4]: Least damped Atlantic MOC basin eigenmode

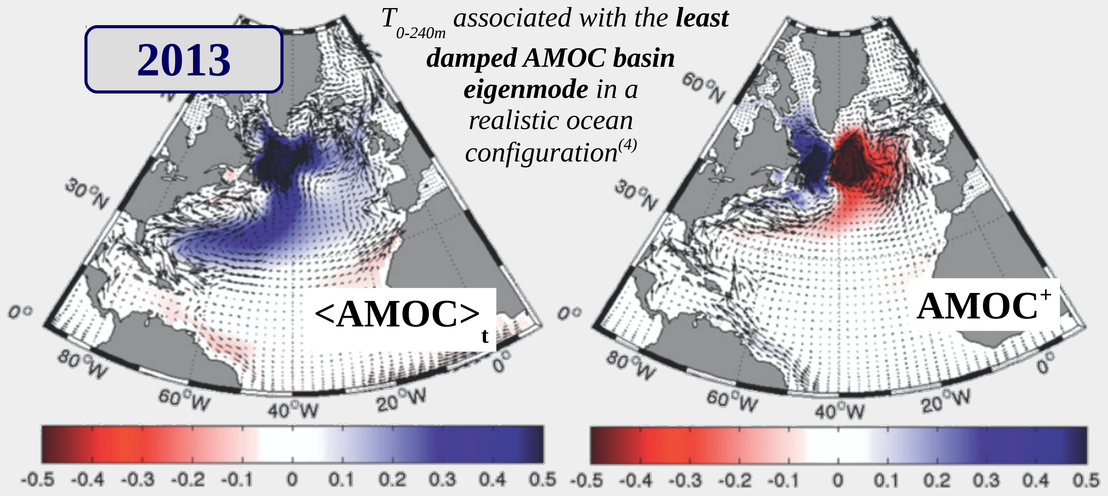
➔ **Q1: Why climate models fail in systematically reproducing this mode[5] ?**

1999



*Schematic diagram of the interaction between **long baroclinic oceanic waves** and **AMOC low frequency variability**[2]*

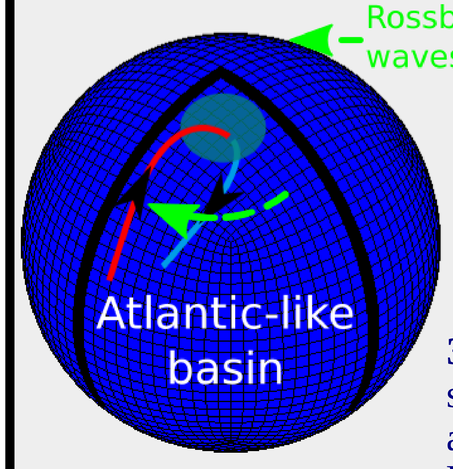
2013

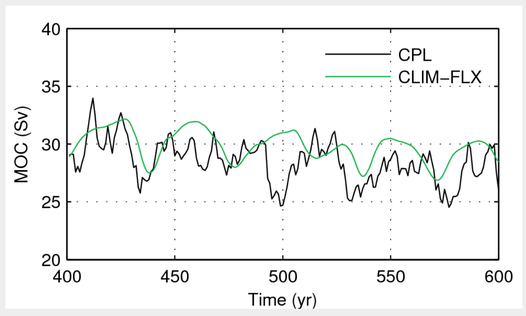


$T_{0\text{-}240m}$ *associated with the **least damped AMOC basin eigenmode** in a realistic ocean configuration*[4]

Strategy and results

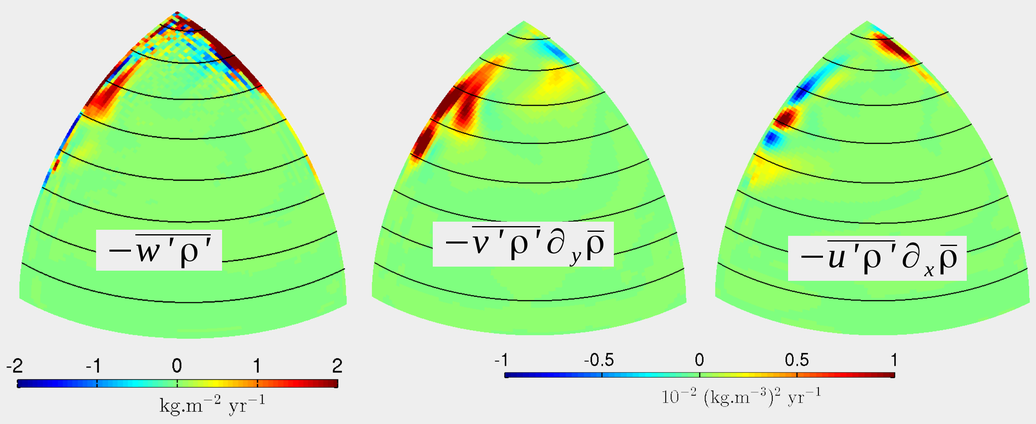
The model – Double Drake[6,8], MITgcm[7]





30-40 years Atlantic-like MOC variability simulated by the Double Drake configuration, associated with westward propagating long oceanic waves

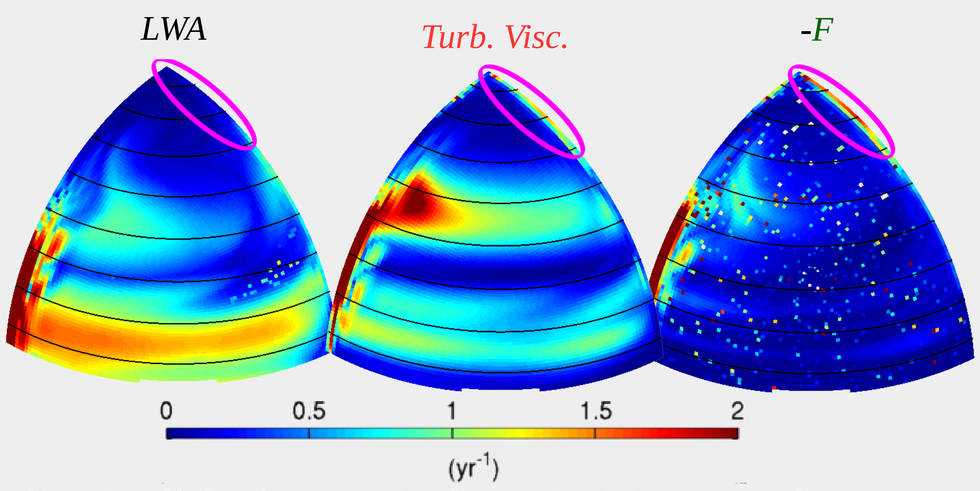
Diagnostic – Eddy fluxes



The **western** and **eastern** boundaries are barolinically unstable at **high latitudes**

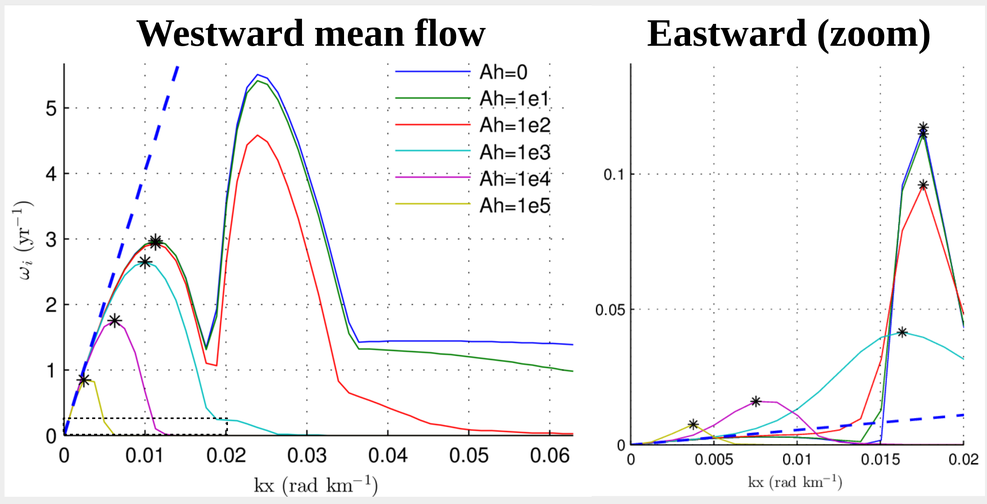
Prognostic – Local linear QG stability analysis

$$(\partial_t + \boldsymbol{u_g}.\nabla_h)\,q = A_h\nabla^2\tilde{q} - F$$



Including the **diabatic terms** in the analysis increases the consistency with diagnostics of the non-linear solution

The turbulent viscosity: an analytical approach



The turbulent viscosity has the ability to **excite unstable modes.** The **vertical structure** of the most unstable modes might change accordingly (not shown)

- **Q1: Aside from the oceanic mean state, parametrizations of sub-grid scale diabatic processes matter**

➔ **Support the ongoing effort for developing dynamically based parametrizations for climate models**

(1) Colin de Verdière A, Huck T (**JPO 1999**) Baroclinic instability : An oceanic wavemaker for interdecadal variability
(2) Te Raa LA, Dijkstra HA (**JPO 2002**) Instability of the thermohaline ocean circulation on interdecadal timescales
(3) Frankcombe, L., Dijkstra, H., Von der Heydt, A., (**GRL 2008**) Sub-surface signatures of the Atlantic Multidecadal Oscillation
(4) Sévellec F, Fedorov AV (**JC 2013**) The leading, interdecadal eigenmode of the Atlantic meridional overturning circulation in a realistic ocean model
(5) Muir LC, Fedorov AV (**CD 2015**) Evidence of the AMOC interdecadal mode related to westward propagation of temperature anomalies in CMIP5 models
(6) Ferreira, D., J. Marshall, and J.-M. Campin, (**JC 2010**) Localization of deep water formation: Role of atmospheric moisture transport and geometrical constraints on ocean circulation
(7)Marshall, J., A. Adcroft, C. Hill, L. Perelman, and C. Heisey, (**JGR 1997**) A finite-volume, incompressible Navier Stokes model for studies of the ocean on parallel computers
(8) Jamet, Q., T. Huck, O. Arzel, J.-M. Campin, and A. Colin de Verdière, (**CD 2016**) Oceanic control of multidecadal variability in an idealized coupled gcm