Multiple Equilibria and Low-Frequency Variability in the Adiabatic Overturning Circulation

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Our project is concerned with the Atlantic Meridional Overturning Circulation (AMOC), its stability, variability, and sensitivity to atmospheric forcing, both mechanical (wind-stress) and thermodynamical (heat and freshwater surface fluxes). The focus is the interhemispheric cell in the largely adiabatic regime, where the flow is characterized by a descending branch in the high latitudes of the North Atlantic and the upwelling branch in the Antarctic Circumpolar Current (ACC) region of the Southern Ocean. These two end points are connected by shared isopycnals along which the flow takes place.

The approach is to systematically study the amplitude and frequency of the AMOC's response to localized buoyancy with a coarse-resolution ocean-only model in a domain of simple geometry: a single semi-enclosed basin spanning two hemispheres of equal extent, with the southernmost eighth of the domain consisting of a reentrant channel periodic in longitude. We analyze the model using innovative diagnostics, focused on the residual overturning circulation (ROC), which is the proper measure of the transport of heat and other tracers.

Recent results

- In the limit of weak interior mixing, the ocean can support a pole-to-pole overturning circulation on isopycnals that outcrop in both the Northern Hemisphere and a high-latitude southern circumpolar channel. This overturning cell participates in a salt feedback, which counteracts the precipitation-induced surface freshening of the northern high latitudes without substantially affecting the southern high-latitude salinity. The net result is an increase in the range of isopycnals shared between the two hemispheres, which strengthen the overturning circulation. This process results in a positive salt feedback.
- If precipitation in the Northern Hemisphere sufficiently exceeds that in the Southern Hemisphere, the overturning cell reverses and its southern end-point moves equatorward of the channel. The reversed overturning circulation is shallower and weaker than its forward counterpart and is maintained diffusively. In a limited range of parameters, multiple equilibria are found for the same forcing configuration.
- For weak diapycnal diffusivity, the multiple equilibria are unstable to time-dependent oscillations around each of the fixed points. The oscillations around the forward cell peak at a decadal timescale with a mode expressed in the Northern Hemisphere subpolar gyre, modulated by a multi-centennial oscillation occupying both hemispheres. These oscillations mediate transitions between the multiple regimes.

Bibliography

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