Relationship between Air-Sea Density Flux and Isopycnal Meridional Overturning Circulation

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This study aims to explore the relationship between air-sea density flux and isopycnal AMOC, using the IPCC AR4 model projections of the 21st century climate.

The semi- adiabatic component of AMOC beneath the mixed layer is described using the concept of the "**push-pull mode**" (PP mode; *Radko et al.* 2008), which represents the combined effects of the **adiabatic push into the deep ocean in the Northern Hemisphere and pull out of the deep ocean in the Southern Hemisphere**:

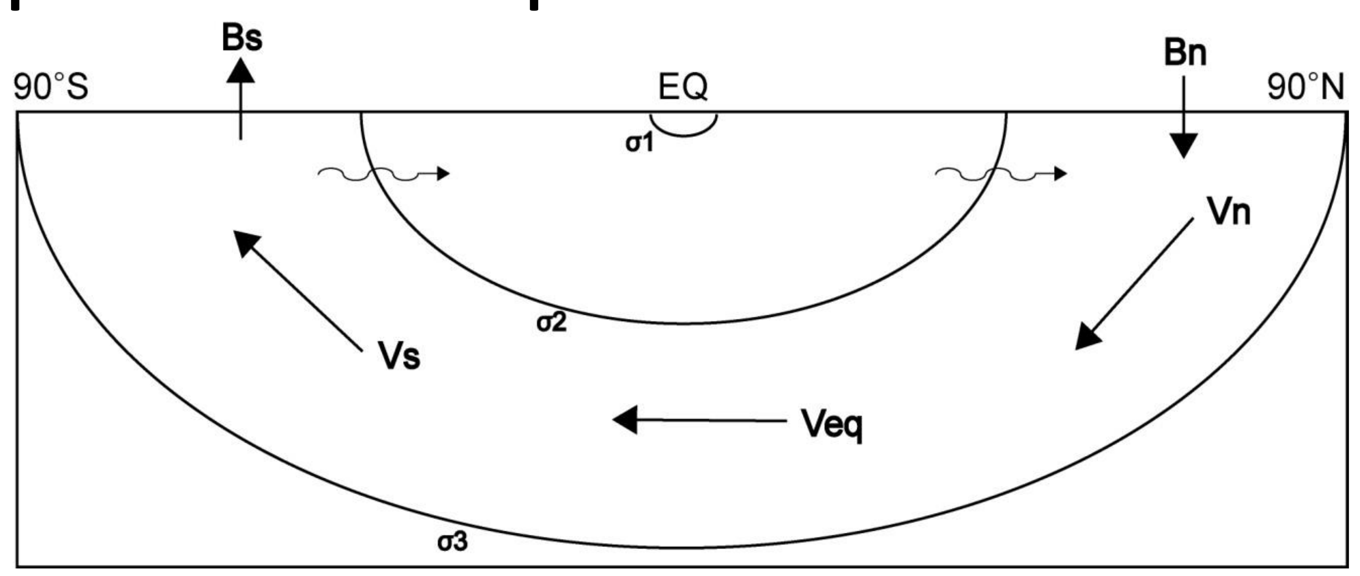

Figure 1: Push-Pull mode

$$PP(\sigma)=\frac{1}{2}[B_s-B_n]^{\sigma}_{\sigma_{max}}+\frac{1}{2}(\Psi_a^{30S}+\Psi_a^{65N})$$

where Ψ_a^{LAT} is the isopycnal AMOC streamfunction at latitude LAT, and $B_{s,n}$ is the water mass transformation function calculated from the surface density flux *D* (*Walin* 1982):

$$B_{s,n}(\sigma)=\lim_{\Delta\sigma\to 0}\frac{1}{\Delta\sigma}\iint_{\Delta\sigma} D(x,y)\,dxdy$$

PP = Ψ_a if the diapycnal mixing is negligible and stratification is steady.

To explore how PP evolves in changing climate, we analyzed IPCC AR4 global-change simulation with the (GFDL) Climate Model version 2.1 (CM2.1).

Ψ_a weakens in response to warming and freshening of the North Atlantic:

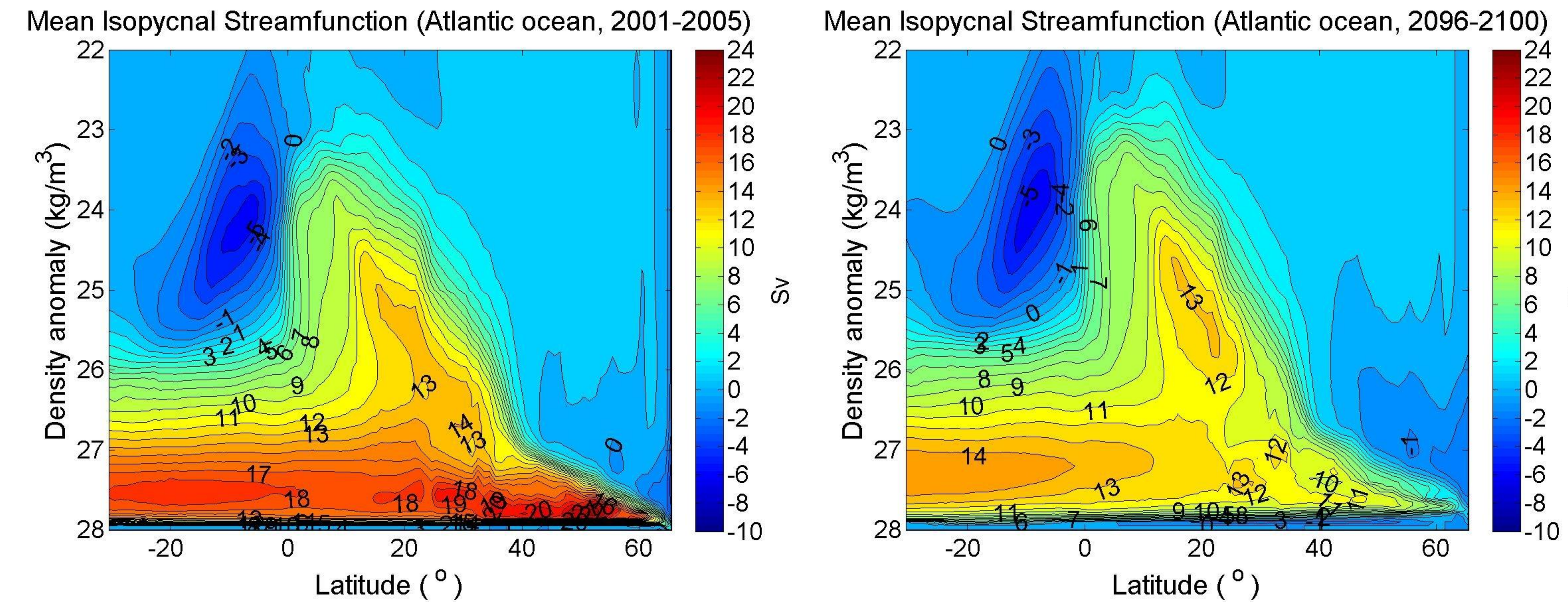

Figure 2: Isopycnal AMOC Ψ_a in GFDL CM2.1 simulation averaged over 2001-2005 (left panel) and 2096-2100 (right panel). Units are Sv.

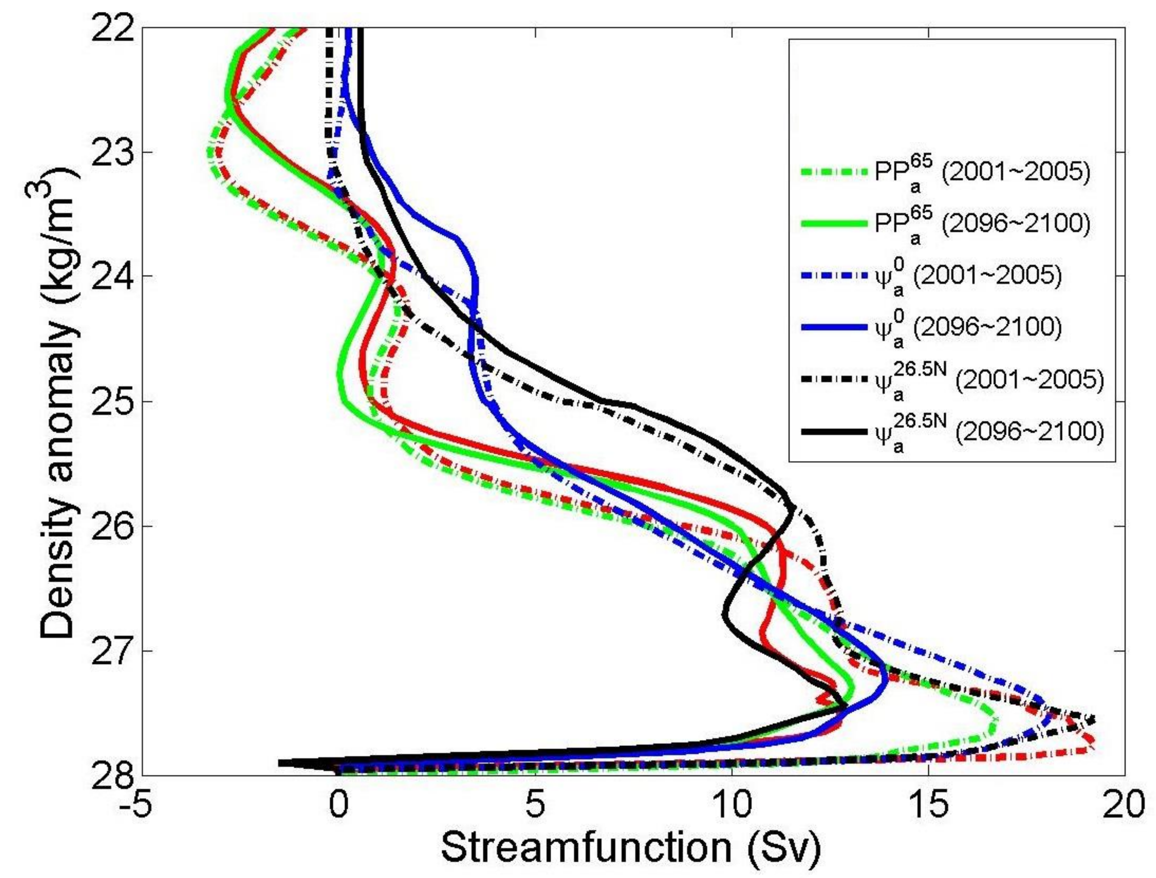

Figure 2: Isopycnal AMOC Ψ_a GFDL CM2.1 simulation averaged over years: 2001-2005 (left) and 2096-2100 (right).

Main Results

- PP and AMOC at the equator (Ψ_a^0) are similar in the deep density layers;
- the linear trends in the maximum PP and Ψ_a^0 are similar as well (0.04-0.05 Sv yr^{-1});
- contribution of the surface heat flux to PP is greater than the contribution of the freshwater flux;
- exchanges with the Southern Ocean play a large role in variability of the PP mode

The overall agreement between the push–pull mode and actual isopycnal AMOC suggests a largely adiabatic, pole-to-pole response of the AMOC to the global warming.

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References

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