Can a barotropic vorticity budget help us understand the drivers of the variability of the Weddell Gyre?

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Method

The barotropic vorticity equation can be obtained by taking the curl of the *depth-integrated* momentum equation:

$$\underbrace{\beta V}_{1} = \underbrace{\frac{J(p_b, H)}{\rho_0}}_{2} - \underbrace{f\frac{Q_m}{\rho_0}}_{3} + \underbrace{f\partial_t\eta}_{4} - \underbrace{\nabla\times\mathcal{U}_t}_{5} + \underbrace{\frac{\nabla\times\tau_s}{\rho_0}}_{6} - \underbrace{\frac{\nabla\times\tau_b}{\rho_0}}_{7} + \underbrace{\nabla\times\mathcal{A}}_{8} + \underbrace{\nabla\times\mathcal{B}}_{9}$$

1. Advection of planetary vorticity
2. Bottom pressure torque (BPT)
3. Mass flux term
4. Sea level changes
5. Curl of the depth-integrated acc.
6. Curl of surface stress
7. Curl of bottom drag
8. Curl of non-linear terms
9. Curl of horizontal viscosity

Model

We are using MOM6 coupled with SIS2 at 0.1° resolution, with the RYF PanAntarctic configuration.

- **CTRL**: 34-year spin-up until stabilization of the gyre's circulation
- **Perturbation experiments:** branched off after spin-up

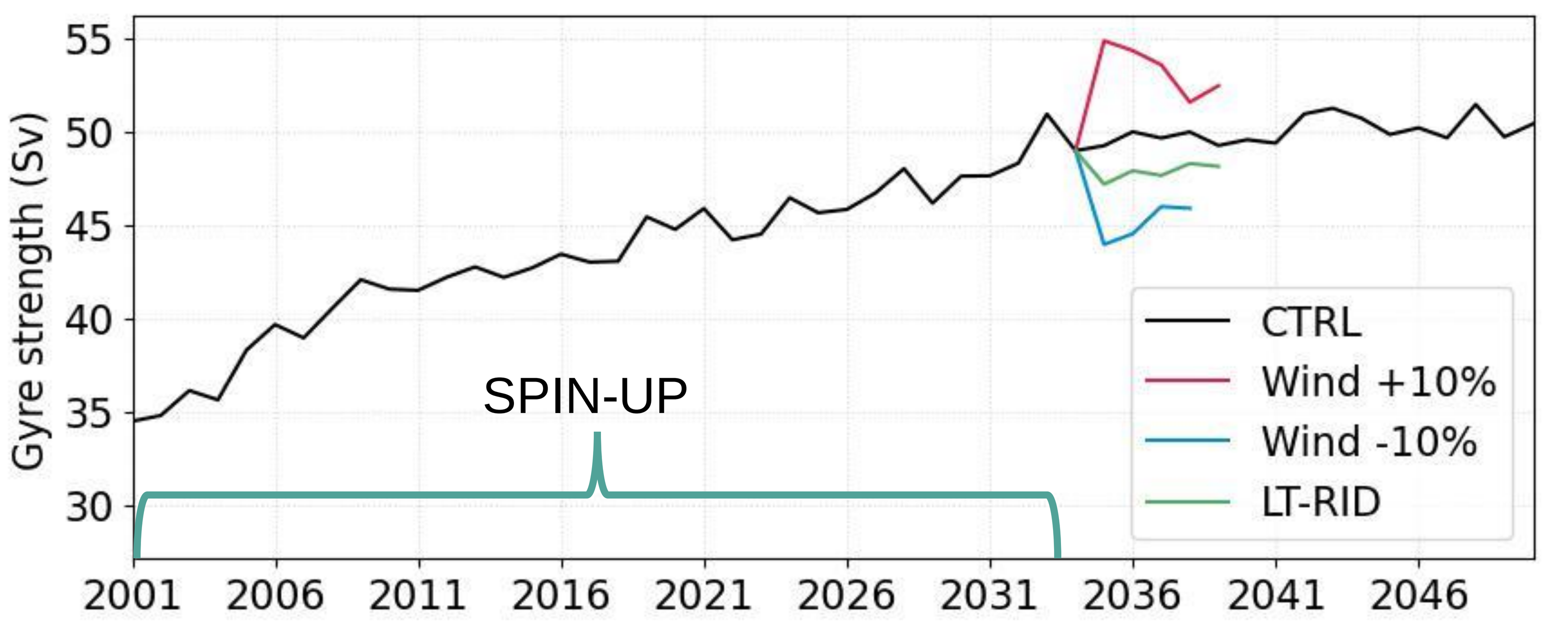
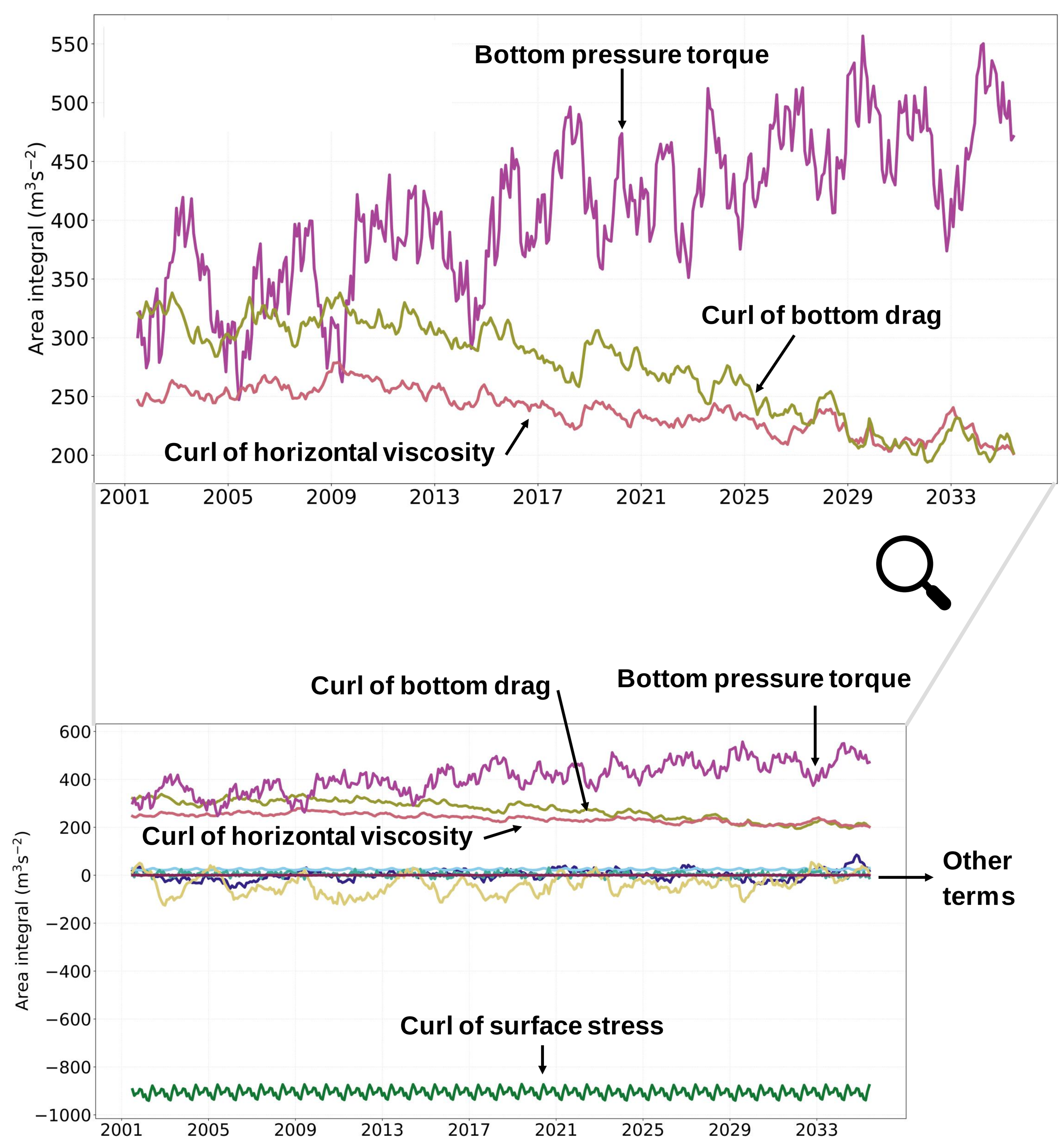


Figure: Weddepll Gyre strength for the CTRL simulation and perturbation experiments.

What is happening during the spin-up period?

Only three of the terms of the budget display trends (bottom pressure torque, bottom drag and horizontal viscosity):



Production of Dense Shelf Water is decreasing, making the bottom layer of the gyre lighter and reducing abyssal transport:

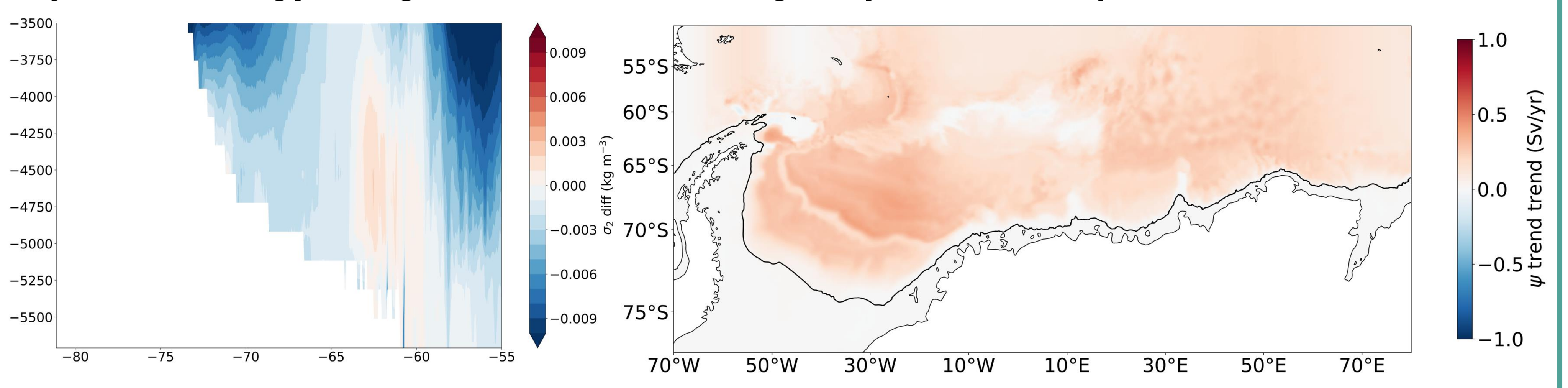


Figure: 2034 – 2001 difference of the CTRL spin-up for σ_1 averaged within the lower layer of the gyre (left), and the trend in the lower layer barotropic streamfunction (right).

Reduced stratification at the surface, increasing the transport by thermal wind balance:

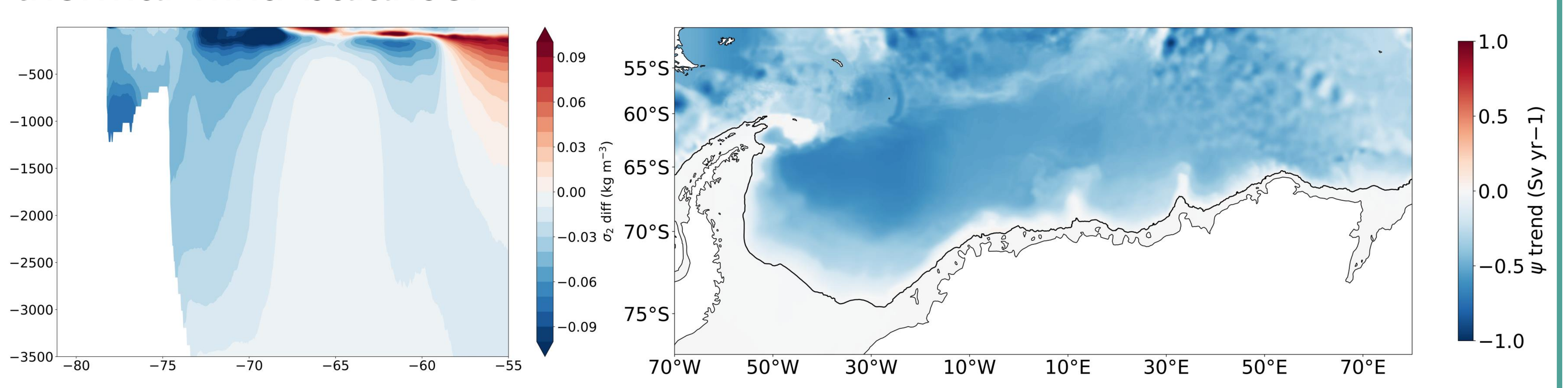


Figure: 2034 – 2001 difference of the CTRL spin-up for σ_1 averaged within the upper layer of the gyre (left), and the trend in the lower upper barotropic streamfunction (right).

Hypothesis

- The bottom layer weakening reduces the bottom drag curl
- The surface layer intensifies at a higher rate than the bottom layer weakens, resulting in an increased gyre strength.
- The overall intensification is balanced by an increasingly dominant BPT

Future work

Look at the response in the perturbation experiments, and the reaction of the barotropic vorticity budget.