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The role of internal variability for decadal carbon uptake anomalies in the Southern Ocean

Aaron Spring, Hongmei Li, Tatiana Ilyina

Max Planck Institute for Meteorology, Bundesstraße 53, 20146 Hamburg, Germany

The oceans, especially the Southern Ocean, act as a major sink for anthropogenic CO_2 emissions and play an essential role in modulating global carbon cycle and climate change. Previous studies based on observations (e.g., Landschützer et al. 2015) show pronounced decadal variations of carbon uptake in the Southern Ocean in recent decades and that this variability is largely driven by internal climate variability. However, due to limited ensemble size of simulations, the variability of this important ocean sink is still poorly assessed by the state-of-the-art earth system models (ESMs).

To assess variability, we generate a large ensemble of historical simulations via perturbed initial conditions in the ocean and atmosphere. Based on the Max Planck Institute-ESM (MPI-ESM), we simulate 100 historical simulations from 1850 to 2005.

To investigate the internal variability of the air-sea carbon fluxes in the Southern Ocean, we analyze the variability of the underlying processes; such as sea level pressure and wind in the atmosphere, sea surface temperature or mixing of the ocean and primary production in biogeochemistry.

We identify individual ensemble members that show decadal anomalous outgassing trends in the carbon sink similar to observations. Preliminary results indicate two main drivers for these carbon flux trends: i) intensified winds enhance upwelling of carbon-rich waters ii) primary production is reduced at 50-60°S by reduced euphotic water column stability; and enhanced at 40-50°S by increased phytoplankton growth rate due to temperature increase.

We conclude that large ensemble simulations are able to reproduce decadal trends of carbon sink variability of the Southern Ocean.