EGU22-13431
https://doi.org/10.5194/egusphere-egu22-13431
EGU General Assembly 2022

Coupling between Southern Ocean Heat and Carbon: The role of atmospheric boundary conditions

Mark Hague, Matthias Münnich, and Nicolas Gruber
Environmental Physics Group, Institute of Biogeochemistry and Pollutant Dynamics, ETH Zürich

The Southern Ocean is well recognised as globally the most important region for the uptake and storage of excess heat (Q`) and carbon (C`) resulting from anthropogenic CO2 emissions. Although the processes governing the transport and storage of Q` and C` are tightly connected, the near surface boundary conditions of the two perturbation tracers are very different. That is, the spatial distribution of C` in the atmosphere is rather homogenous, while the uptake of Q` is characterised by strong horizontal gradients and temporal variability ranging from seasonal to interannual and decadal. The effect this difference has on the uptake and storage patterns of Q` and C` has received relatively little attention, especially when compared to the role of ocean circulation changes. In order to address this, we utilise a regional ocean biogeochemical model (ROMS-BEC) forced with an atmospheric reanalysis (ERA5) and perform a suite of model experiments. A first set of experiments quantifies changes in C` and Q` over the period 1979 -2019, comparing the model results with observation-based estimates. Here we find that the model is able to reproduce the main features of the observed Q` and C` storage patters: a region of enhanced heat storage at ~40^{o}S and down to 1200m, with carbon storage peaking in the surface layer (~200m) north of 40^{o}S and decreasing poleward and with depth. A second set of experiments aims to isolate the role of spatial and temporal variability of net surface heat flux (SHF) in driving changes in Q`, with the resulting storage patterns then compared to those derived for C`. We find that for C` the storage pattern is driven largely by the uptake of anthropogenic $CO_2$ , with a small contribution from circulation changes. In contrast, the storage pattern of Q` appears not to be strongly related to trends in SHF, suggesting that the mean SHF spatial distribution, as well as circulation changes may play a more prominent role. The SHF trends themselves are highly spatially heterogenous, and act to reduce the magnitude of the zonally integrated heat storage over the simulated period. However, we find that there are significant regional differences, with a modest increase in storage in the Pacific and Atlantic sectors being offset by a much stronger reduction in the Indian sector. Overall, we develop a conceptual framework for understanding the potential (de)coupling between oceanic uptake and storage of heat and carbon within the unique context of the Southern Ocean.