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The Southern Ocean carbon sink 1985-2018: first results of the RECCAP2 project

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The Southern Ocean is the main gateway for anthropogenic CO_2 into the ocean owing to the upwelling of old water masses with low anthropogenic CO_2 concentration, and the transport of the newly equilibrated surface waters into the ocean interior through intermediate, deep and bottom water formation. Here we present first results of the Southern Ocean chapter of RECCAP2, which is the Global Carbon Project's second systematic study on Regional Carbon Cycle Assessment and Processes. In the Southern Ocean chapter, we aim to assess the Southern Ocean carbon sink 1985-2018 from a wide range of available models and data sets, and to identify patterns of regional and temporal variability, model limitations and future challenges.

We gathered global and regional estimates of the air-sea CO_2 flux over the period 1985-2018 from global ocean biogeochemical models, surface pCO_2-based data products, and data-assimilated models. The analysis on the Southern Ocean quantified geographical patterns in the annual mean and seasonal amplitude of air-sea CO_2 flux, with results presented here aggregated to the level of large-scale ocean biomes.

Considering the suite of observed and modelled estimates, we found that the subtropical seasonally stratified (STSS) biome stands out with the largest air-sea CO_2 flux per area and a seasonal cycle with largest ocean uptake of CO_2 in winter, whereas the ice (ICE) biome is characterized by a large ensemble spread and a pronounced seasonal cycle with the largest ocean uptake of CO_2 in summer. Connecting these two, the subpolar seasonally stratified (SPSS) biome has intermediate flux densities (flux per area), and most models have difficulties simulating the seasonal cycle with strongest uptake during the summer months.

Our analysis also reveals distinct differences between the Atlantic, Pacific and Indian sectors of the aforementioned biomes. In the STSS, the Indian sector contributes most to the ocean carbon sink, followed by the Atlantic and then Pacific sectors. This hierarchy is less pronounced in the models than in the data-products. In the SPSS, only the Atlantic sector exhibits net CO_2 uptake in all years, likely linked to strong biological production. In the ICE biome, the Atlantic and Pacific sectors take up more CO_2 than the Indian sector, suggesting a potential role of the Weddell and Ross Gyres.

These first results confirm the global relevance of the Southern Ocean carbon sink and highlight the strong regional and interannual variability of the Southern Ocean carbon uptake in connection to physical and biogeochemical processes.