EGU23-17328, updated on 20 Apr 2024
https://doi.org/10.5194/egusphere-egu23-17328
EGU General Assembly 2023

RECCAP2 – Southern Ocean carbon fluxes and storage

Lavinia Patara[1], Judith Hauck[2], Luke Gregor[3], and the RECCAP2 Southern Ocean team[*]
[1]GEOMAR Helmholtz Centre for Ocean Research Kiel, Kiel, Germany
[2]Alfred-Wegener-Institut, Helmholtz-Zentrum für Polar- und Meeresforschung
[3]Environmental Physics, Institute of Biogeochemistry and Pollutant Dynamics, ETH Zurich, Zürich, Switzerland
[*]A full list of authors appears at the end of the abstract

Cool temperatures, vigorous overturning circulation, and high biological productivity make the Southern Ocean a key region for the air-sea CO_2 exchanges. It is also 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. Here we present results from the Southern Ocean chapter of RECCAP2, which is the Global Carbon Project's second systematic study on Regional Carbon Cycle Assessment and Processes. We analyse Southern Ocean contemporary carbon fluxes and anthropogenic carbon accumulation in 1985-2018 from a wide range of global ocean biogeochemical models (GOBMs), surface ocean pCO_2-based data products (pCO_2-products), and data-assimilated models, with the aim of identifying patterns of regional and temporal variability, model limitations and future challenges. Our results highlight agreement of GOBMs and pCO_2-products on the mean Southern Ocean contemporary CO_2 uptake (0.75 ± 0.28 PgC yr^{-1} and 0.74 ± 0.07 PgC yr^{-1} respectively). Compared with RECCAP1 (where the database of model- and observation-based estimates was significantly smaller), the new estimates suggest a weaker sink, possibly due to better representation of winter outgassing. Strong discrepancies exist between GOBMs and pCO_2-products in seasonality and trend estimates between 1985-2018. The pCO_2-products show the presence of a stagnation in uptake through the 1990's followed by a rapid increase in uptake, while GOBMs show consistent uptake throughout the 1985-2018 period. On a regional level, the subtropical seasonally stratified (STSS) biome has the largest air-sea CO_2 flux with uptake of CO_2 peaking in winter, whereas the ice (ICE) biome is characterised by a generally small magnitude of fluxes into and out of the ocean 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 magnitude, with GOBMs showing spread in the strength of winter outgassing and difficulties in simulating the strongest CO_2 uptake in summer. The biases in GOBMs originate mainly from the non-thermal component of air-sea CO_2 flux, and in particular from the difficulty in simulating the competing effects of circulation and biology on carbon draw-down in summer. Our analysis reveals a distinct zonal asymmetry (secondary to the latitudinal gradient) between the Atlantic, Pacific and Indian sectors. The zonal asymmetry is observed in the mean uptake and amplitude of the seasonal cycle rather than the phasing of the seasonal cycle. GOBMs show a 20% spread and an overall underestimate of their simulated anthropogenic carbon accumulation,

pointing to insufficient water mass formation and interior ventilation. 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.

RECCAP2 Southern Ocean team: Cara Nissen, Mark Hague, N. Precious Mongwe, Seth Bushinsky, Scott C. Doney, Nicolas Gruber, Corinne Le Quéré, Manfredi Manizza, Matthew Mazloff, Pedro M. S. Monteiro, Jens Terhaar