Variability of the ocean carbon sink

Interannual variability of air-sea CO_2 exchange: high-resolution ocean biogeochemical simulations

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In Short

- Discrepancy between models and observations of the ocean carbon sink
- Discrepancy explained by lack of internal variability
- We will test the impact of high-resolution on the simulated ocean carbon sink

Carbon dioxide (CO_2) emissions from fossil fuels and land-use change amounted to 11.2 PgC yr^{-1} in 2016 [**??**] and force anthropogenic climate change. Ocean and land sinks provide an extremely valuable service to humankind by each drawing down about 25% of anthropogenic CO_2 emissions [**??**], thereby slowing the rate of anthropogenic climate change. On time-scales longer than a century the ocean will be the main repository for anthropogenic CO_2 emissions and the Southern Ocean is the main conduit by which this CO_2 enters the ocean.

The Global Carbon Project (www.globalcarbonproject.org) publishes a Global Carbon Budget (GCB) once a year [**??**]. This is a state-of-the-art estimate of CO_2 emissions from fossil fuel combustion and land-use change, rate of growth of atmospheric CO_2 concentration and ocean and land CO_2 sinks. The ocean CO_2 sink is estimated from selected ocean biogeochemical models that produce a mean oceanic CO_2 sink over the 1990s consistent with observations within 90% confidence intervals. The results of the ocean biogeochemical models are compared to an independent estimate of two pCO$_2$-based flux products, which apply different interpolation methods to fill gaps in the sea-surface pCO$_2$ observational product (SOCAT, surface ocean CO_2 Atlas).

In the Global Carbon Budget 2018 [**??**], a model evaluation metric was introduced that illustrates the mismatch between modelled and observed surface ocean pCO$_2$. One important outcome of this evaluation is that the models underestimate the interannual to decadal variability that is seen in the pCO$_2$-based flux products, especially in the temperate and high-latitudes. Multiple studies based on observations have shown variability in the ocean CO_2 sink larger than estimated by the models, particularly related to representing the effects of variable ocean circulation in models. This may be due to the absence of internal variability which is not captured by single realizations of coarse resolution model simulations.

We performed an initial Arctic high-resolution simulation [**??**] and there was a significant difference in the CO_2 fluxes between the low- and high-resolution simulations. The Arctic contribution to the total ocean carbon sink is relatively small, yet this illustrates that the resolution can have an important impact on the CO_2 flux estimate. This motivates our proposed simulations with a set-up applying also higher-resolution in larger regions globally, especially including the North Atlantic and Southern Oceans as critical regions for CO_2 uptake. Underlying physical processes that are resolved in the high-resolution set-up are currently being investigated.

For the work proposed here we apply a global version of FESOM, coupled with the biogeochemistry and ecosystem model REcoM2 [**??**] [**??**]. When used at coarse resolution, the AWI-CM (with FESOM at its ocean component) is comparable to other CMIP5 models in terms of its representation of the mean climate and climate variability. The biogeochemistry and ecosystem model REcoM2 coupled to the MITgcm ocean circulation model has been successfully used for studies on recent and future changes in the carbon cycle and for the Global Carbon Budget [**????**]. FESOM runs with REcoM2 have proven to be well suited for studies on the global and regional scale [**??**].

WWW

https://www.awi.de/en/science/biosciences/marine-biogeoscience/main-research-focus/mathematical-modelling.html

More Information

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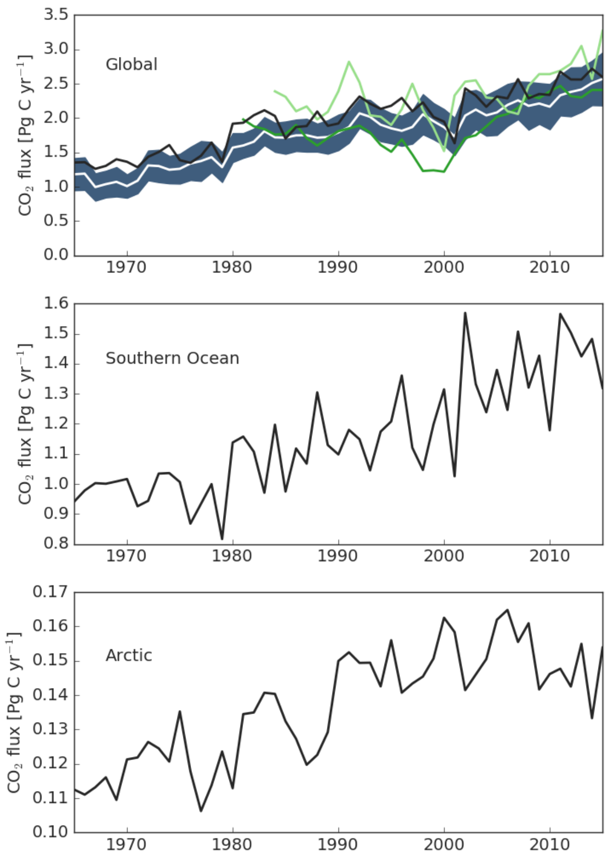

Figure 1: *Air-sea CO_2 flux simulated with FESOM-REcoM2 for (top) the global ocean, (middle) the Southern Ocean and (bottom) the Arctic Ocean. Positive numbers are fluxes into the ocean. In the top panel, the white line shows the mean of the eight models that contributed to the Global Carbon Budget 2017 [**??**], the blue shaded area shows one standard deviation around the mean of the individual models. The black line shows the CO_2 flux simulated by FESOM-REcoM2 and the two green lines show the observational-based estimates.*

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