Southern Ocean CO_2 fluxes: the importance of realistic representation in climate models

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Oceanic models, atmospheric data, and oceanic observations indicate that the Southern Ocean is a net sink for atmospheric CO_2. However, recent evidence suggests that this sink has substantially weakened in the last few decades, relative to the expected sink from rising atmospheric CO_2 and fixed physical climate. It has been proposed that the primary cause of the sink reduction is a trend in the position and intensity of the Southern Hemisphere westerly winds and the subsequent increase in the upwelling and equatorward transport of CO_2-rich waters. Projections of future climate from coupled models consistently find a trend toward stronger, poleward shifted winds over the Southern Ocean during the next century, and the potential for continued weakening of the Southern Ocean CO_2 sink. However, questions remain as to the ability of large-scale, coarse-resolution ocean models to predict changes in CO_2 flux. These models are hampered by parameterizations of gas exchange that are based upon sparse spatial and temporal sampling of the Southern Ocean.

Here, we demonstrate the importance of realistic representation CO_2 exchange in the Southern Ocean by performing a suite of sensitivity experiments with a simple ocean physical and biogeochemical model. We modify the boundary conditions for atmospheric wind stress and atmospheric CO_2 concentration over a 100-year period, and couple this with different representations of gas exchange to arrive at a range of uncertainty for the Southern Ocean CO_2 sink by 2100.