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Towards inferring the variability in oceanic CO_2 fluxes at high latitudes using atmospheric O_2 observations

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The oceanic CO_2 sink displays year-to-year to decadal variabilities which are not fully reproduced by global ocean biogeochemistry models, especially in the high-latitude oceans. Oceanic CO_2 is influenced by the same climate variability and the same ecosystem processes as oceanic oxygen (O_2), although in different proportions. Unlike for CO_2, oceanic O_2 flux is not influenced directly by the rise in atmospheric CO_2, and therefore its variability reflects purely climatic and biogeochemical variability and trends. Therefore, natural climate variability and changes in oceanic processes controlling air-sea exchanges of CO_2 can be studied by focusing on oxygen (O_2), where the signal is unencumbered by direct anthropogenic influence. A global time series of oceanic O_2 flux was obtained by building a global O_2 budget, with an approach similar to the one used for the global carbon budget. The global O_2 budget is based on atmospheric O_2 observations and fossil fuel statistics, and infers the partitioning of the land and ocean fluxes using constant C:O_2 ratios for land processes. One key result of this analysis is that air-sea O_2 exchange induced significant year-to-year variability in observed atmospheric O_2. Estimates of regional oceanic O_2 fluxes were obtained from an atmospheric transport inversion analysis that inferred air-sea O_2 exchange based on global atmospheric O_2 observations and a global atmospheric transport model. For the Southern Ocean, a comparison was made between time series of winter oceanic O_2 fluxes from this inversion method and winter mixed layer depths from Argo floats. Results from this comparison confirmed the previously suggested relationship between the winter ocean mixing and air-sea O_2 exchange, which might be controlled by the climate variability induced by the Southern Annular Mode. Finally, these global and regional air-sea O_2 fluxes were compared with outputs from six global ocean biogeochemistry models to examine their current skills in simulating O_2 variability. Preliminary results suggested that all models underestimated the interannual variability in oceanic O_2 fluxes, however they were able to simulate some of the observed multi-annual variability in O_2 fluxes at high latitudes. We discuss the implications for the model's representation of the variability in CO_2 fluxes.