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Origin and magnitude of interannual variabilities in Southern Ocean air-sea O2 and CO2 fluxes

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The Southern Ocean plays a major role in both the global oceanic uptake of anthropogenic CO_2 and its interannual variations. The size and origin of the interannual variability in the Southern Ocean CO_2 fluxes is debated. Observation-based estimates suggest a large variability (+/- 0.11 PgC/yr) while Global Ocean Biogeochemistry Models (GOBMs) simulate almost no variability. Studying the air-sea fluxes of O_2 can provide independent information that help resolve this data-model inconsistency. Oceanic O_2 is influenced by the same physical and biogeochemical processes as CO_2, but unlike CO_2, its variability is not masked by a large anthropogenic flux. Here, we used 26 years (1994-2019) of monthly O_2 fluxes from 9 GOBMs. These model outputs were compared to air-sea O_2 fluxes inferred from an atmospheric inversion of precisely quantified changes in atmospheric O_2 and CO_2 levels. The 26-year time series of air-sea O_2 fluxes from all GOBMs and the atmospheric inversion exhibited similar temporal variations. This could be linked to the Southern Annular Mode and its influence on air-sea heat flux forcing that induced large-scale changes in observed wintertime Mixed Layer Depth (MLD). However, the amplitude of the interannual variability in air-sea O_2 fluxes was two times higher in the atmospheric inversion than in GOBMs. It possible that this was induced by the general overestimation of the mean wintertime MLD by the GOBM and subsurface vertical gradients in oxygen saturation lower than observed. Implications of these results for the variability in air-sea fluxes of CO_2 will be discussed.