The Seasonal Cycle of CO_2 in the Southern Ocean: Diagnosing Anomalies in CMIP5 Earth Systems Models

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The Southern Ocean (SO) forms a key component of global carbon budget: taking up about 50% (1.0±0.5 PgCyr-1) of the total global oceanic annual uptake of anthropogenic CO2 and accounting for most of the uncertainty in the global ocean CO2 fluxes. A recent synthesis study (Lenton et al., 2013), showed that although Ocean Biogeochemical Models (OBGMs) agree on the mean annual flux of CO2 in the SO, they disagree on both amplitude and phasing of the seasonal cycle and compare poorly to observations. In this study, we used a diagnostic analysis based on the representation of the seasonal cycle of CO2 air-sea (FCO2) fluxes (Mongwe et al., 2016) on seven CMIP5 models. The diagnostic shows how an understanding of the seasonal variability of drivers of CO2 at a seasonal scale helps explain the anomalies between observations and model output. In this study, we show that the model output –observations FCO2 seasonal cycle anomalies are due to differences in the magnitude of the seasonal cycle of dominant drivers of pCO2 i.e. thermal and physical-biogeochemical drivers between the models and the observations. We found that 5 out of 7 CMIP5 models underestimate the influence of physical –biogeochemical driver during the winter, spring-summer seasons. Weak winter convective CO2 entrainment, as well as the impact of summer biological CO2 uptake, have a compound effect on the amplitude of the seasonal cycle of DIC. As a result, the thermal driver SST dominates the seasonal cycle of FCO2. While 2 of the 7 overestimate the physical –biogeochemical driver on pCO2 due to overestimation of the net CO2 biological uptake.