EGU21-13637, updated on 09 May 2021
https://doi.org/10.5194/egusphere-egu21-13637
EGU General Assembly 2021

Seasonal Analysis of Air-Sea CO_2 Flux Variability in the North Atlantic and the Southern Ocean

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Understanding the variability and drivers of air-sea CO_2 fluxes on seasonal timescales is critical for resolving the ocean carbon sink's evolution and variability. Here, we investigate whether discrepancies in the representation of air-sea CO_2 fluxes on a seasonal timescale accumulate to influence the representation of CO_2 fluxes on an interannual timescale in two important ocean CO_2 sink regions – the North Atlantic basin and the Southern Ocean. Using an observation-based product (SOM-FFN) as a reference, we investigate the representation of air-sea CO_2 fluxes in the Max Planck Institute's Earth System Model Grand Ensemble (MPI-ESM GE). Additionally, we include a simulation based on the same model configuration, where observational data from the atmosphere and ocean components is assimilated (EnKF assimilation) to verify if the inclusion of observational data alters the model state significantly and if the updated modelled CO_2 flux values better represent observations.

We find agreement between all three observation-based and model products on an interannual timescale for the North Atlantic basin. However, the agreement on a seasonal timescale is inconsistent with discrepancies as large as 0.26 PgC/yr in boreal autumn in the North Atlantic. In the Southern Ocean, we find little agreement between the three products on an interannual basis with significant seasonal discrepancies as large as 1.71 PgC/yr in austral winter. However, while we identify regional patterns of dominating seasonal variability in MPI-GE and EnKF, we find that the SOM-FFN cannot demonstrate robust conclusions on the relevance of seasonal variability in the Southern Ocean. In turn, we cannot pin down the problems for this region.