SESSION: (B6) Frontiers in earth system prediction

(B6-01)

Decadal predictability of the ocean carbon uptake variation

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The global oceans, as an important sink of CO2 emitted by humans, play an essential role in modulating the global carbon cycle and hence the global climate change. To achieve the Paris Agreement goals of limiting surface warming below 2.0°C and even pursuing to limit it to 1.5°C relative to the preindustrial level, one major requirement will be discerning the anthropogenic carbon emission pathway in the Earth System in order to verify the effectiveness of fossil fuel emissions reduction measures. Recent observation-based studies have revealed unprecedented strength in decadal variation of the ocean carbon uptake in the last decades, challenging our ability to predict the variability of the ocean carbon sink and the future global warming on decadal timescales.

Grand ensemble simulations starting from different initial states revealed possibility for Earth system models (ESM) to produce the decadal variation of ocean carbon sink that is comparable to observations, and suggested an essential effects of initial conditions on the evolution of ocean carbon sink [Li and Ilyina 2018]. By applying decadal prediction framework to the Max Planck Institute ESM (MPI-ESM), we found a potential predictive skill of North Atlantic CO2 uptake up to 4-7 years through improvement of the initial states in the ocean physics [Li et al., 2016]. Séférian et al. [2018] confirmed the potential predictive skill of the ocean carbon sink up to 6 years based on a 'perfect model' approach. Such a skill was confined to the model world due to large gaps in observations.

We extend our decadal predictions by assessing the skill of the global ocean carbon sink against observation-based estimates. Based on a high resolution configuration of MPI-ESM, assimilating observed temperature and salinity, we are able to reproduce the observed carbon uptake variability. We demonstrate a predictive skill of the global ocean carbon sink in 2 years through ensembles of hindcast simulations starting from the assimilation state, which is close to observations. Such a predictive skill is more prominent in winter months, mainly because of the improved representation of the ocean dynamics due to initialization.

Decadal prediction study of the ocean carbon uptake and corresponding processes is still at its early stage and facing a number of challenges arising from limited ocean biogeochemical observations and lack of proper initialization strategies.

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