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Identifying the underlying mechanisms of present and future inter-annual variability of oceanic carbon uptake using a machine learning approach with CMIP6 simulations.

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The ocean plays an instrumental role in regulating the Earth's climate through the buffering of the anthropogenic-induced excess carbon. Our capacity to predict long-term future oceanic carbon uptake depends on highly sophisticated numerical Earth system models, whose simulations of future climate have a wide inter-model dispersion. Inter-model spread in projections arises from three distinct sources: 1) internal variability of the climate system, 2) model uncertainty, and 3) scenario uncertainty. The spread related to (1) and (2) is even greater when predicting changes at regional scales. In order to elucidate the main origins of present and future internal variability and model uncertainty in oceanic carbon uptake, it is important to identify the uncertainty and sensitivity of the major underlying mechanisms in different ocean regions and across models. A limitation of this approach is the high costof computational and manpower required to systematically assess all mechanisms and identify processes that are important in a consistent way, especially across a large ensemble of model sets. Machine learning methods can be applied to simultaneously estimate the sensitivity of variable sets and explore them automatically across the ensemble of models. Here, we use the Kernel non-linear regression approach to reconstruct the inter-annual carbon uptake variability using monthly outputs of surface temperature, salinity, nutrient, dissolved inorganic carbon,alkalinity, atmospheric CO2 concentration, surface wind speed, and sea-ice cover. The exercise was performed on preindustrial, historical, and future scenario simulation outputs. The algorithm was optimized with a subset of 'training' data and evaluated with 'test' data. We applied bootstrapping method to delineate the main drivers for the projected inter-annual sea-air carbon fluxes variability in different ocean domains.