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Internal- and intra-model variability in CMIP5 interactive carbon cycle projections of fossil fuel CO_2 invasion into the ocean

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The fifth coupled model intercomparison project (CMIP5) simulations also include Earth System Model experiments with an interactive carbon cycle. In these experiments fluxes of carbon between the ocean, land reservoirs and the atmosphere have an impact on the atmospheric CO_2 concentration and hence climate, allowing for investigations of climate-carbon cycle feedback mechanisms within the Earth System. Yet, compared to simulations with prescribed atmospheric CO_2 concentrations which have been widely used before, such interactive carbon cycle simulations may also introduce new uncertainties to climate projections due to the processes that are poorly constrained. We investigate the internal- and intra-model variability in the projections of fossil fuel CO_2 invasion into the ocean by comparing simulations with interactive carbon cycle versus those with the prescribed atmospheric CO_2 concentrations provided by several Earth System models within the CMIP5 framework. The historical simulations with fixed and free atmospheric CO_2 are similar, they both fairly well reproduce the broad spatial pattern of observed ocean carbon cycle parameters. Differences become apparent when the CO_2 is increasing under a high CO_2 scenario of representative concentration pathway (RCP8.5). The majority of models with interactive carbon cycle produce higher surface ocean pCO_2 and slightly stronger acidification. By the end of the 21st century, the multi-model ensemble mean differences of global mean pCO_2 and pH are 90 ppmv and 0.03, respectively. The largest differences appear in the deep water formation region of the North Atlantic, in the subduction region of the North Pacific, and in the Southern Ocean.