Ocean carbon pumps in CMIP5 earth system models diagnosed by a vector diagram

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The ocean stores 60 times more carbon than the atmosphere and therefore the ocean carbon cycle has a critical role in controlling the atmospheric CO2 concentration. The ocean carbon cycle is controlled by several ocean pumps such as soft tissue (organic matter) and hard tissue (calcium carbonate) pumps. In the CMIP5 earth system models, these carbon pumps are explicitly simulated in the model and controls the level of the atmospheric CO2 concentration. In this study, four types of ocean carbon pumps (organic matter, calcium carbonate, gas exchange, and freshwater flux pumps) are defined here and a method for diagnosing effects of individual four carbon pumps on atmospheric CO2 concentration is proposed. In my method, the simulated 3-D field of dissolved carbon concentration (DIC), total alkalinity (ALK), phosphate, and salinity are used for diagnosing the strength of each carbon pump. In addition, the contributions of four carbon pump components to atmospheric CO2 are evaluated in one figure (the vector diagram); each carbon pump component is represented by one vector and its contribution to pCO2 can be measured from the difference in the contour values between the beginning and the end of the vector. The analysis is applied to the climatology and the CMIP5 earth system model simulations. Although all models reproduce the same level of the atmospheric CO2 concentration as the climatology, it is shown that contributions from four carbon pumps are not the same among models. This study demonstrates that the vector diagram analysis introduced here is a useful tool for quantifying the individual effects of the ocean carbon pumps on atmospheric CO2 concentration and also for evaluating the reproducibility of ocean carbon cycle models.

Keywords: carbon cycle, ocean carbon pump

