Air-sea CO_2 flux variations in the tropical Pacific simulated with two ESMs embedded an ocean data assimilation system

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Interannual-to-decadal fluctuations of the global-mean atmospheric CO_2 concentration are observed associated with internal climate variations, and these fluctuations sometimes cancel out and at other times support the centennial increasing trend of the global-mean atmospheric CO_2 concentration due to accumulation of anthropogenic CO_2 emissions. One direct cause of the fluctuations is the oceanic absorption or release of CO_2 through the global air-sea CO_2 flux variations which are mainly dominated by the tropical Pacific. Therefore, deeper understanding of the tropical oceanic processes and properly initializing oceanic states including marine ecosystem are of importance in future predictions of the global CO_2 concentration together with quantification of human-influences. In the present study, we examined the simulated air-sea CO_2 flux variations in the tropical Pacific in two ESMs (MIROC-ES2L and MIROC-ESM) with the same ocean data assimilation system. Although the assimilation procedures are the same, observed anti-correlated relationship between interannual variations of the upward air-sea CO_2 flux and the sea surface temperature (SST) in the tropical Pacific are well captured in MIROC-ES2L, but the relationship is reversed in MIROC-ESM. Tropical climatic-mean state of MIROC-ESM shows significant biases of weaker trade winds as well as more diffuse equatorial thermocline than observations, and simulated amplitude of interannual variations of NINO3-SST is about half as large as observations. When observations are assimilated into the model, these biases lead to non-negligible correction terms on the governing equations of ocean temperature and salinity, which induces an anomalous spurious equatorial upwelling during El-Niño events. The spurious upwelling brings dissolved inorganic carbon rich water in the subsurface layer to the surface mixed layer. Consequently, an anomalous upward air-sea CO_2 flux is occurred during El-Niño, as opposed to observations and MIROC-ES2L. Better modeling physical processes in the tropical climate system is suggested to be essential for better marine ecosystem modeling and reanalysis.

Keywords: Earth system model, data assimilation, air-sea CO2 flux, ENSO

