The Evolution of Atmospheric CO_2 Variations in a Coupled Carbon-climate Model

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We compare patterns in atmospheric CO_2 in the Community Earth System Model (CESM), a coupled carbon-climate model, against several types of atmospheric CO_2 observations characterized by different measurement footprints. We use NOAA/GMD surface and aircraft flask measurements, Total Carbon Column Observing Network total column observations, and HIAPER Pole-to-Pole Observation aircraft transects to evaluate the skill of the coupled model in predicting variations in CO_2 on seasonal, annual, and decadal timescales. We show that the interannual variability in the model responds to climatic drivers and that annual mean spatial gradients are consistent with those seen in observations, but that seasonal variations and horizontal gradients in atmospheric CO_2 are underestimated relative to observations (Fig. 1), suggesting that net ecosystem exchange in the land component of CESM is too weak. Using aircraft data, we show that CO_2 is vertically redistributed too efficiently in the CESM atmosphere, particularly during northern hemisphere summer, which impacts both the spatial and temporal patterns in the model. Despite these limitations in the current realization of CESM, coupled carbon-climate models will become an important tool in constraining the sensitivity of carbon fluxes to future climate change, and therefore in constraining the sensitivity of climatic change to these carbon fluxes. We present a preliminary analysis of changes in atmospheric CO_2 in response to two emission trajectories. These results will be useful in developing future monitoring strategies to resolve changes both in natural carbon fluxes and in anthropogenic emissions of CO_2.

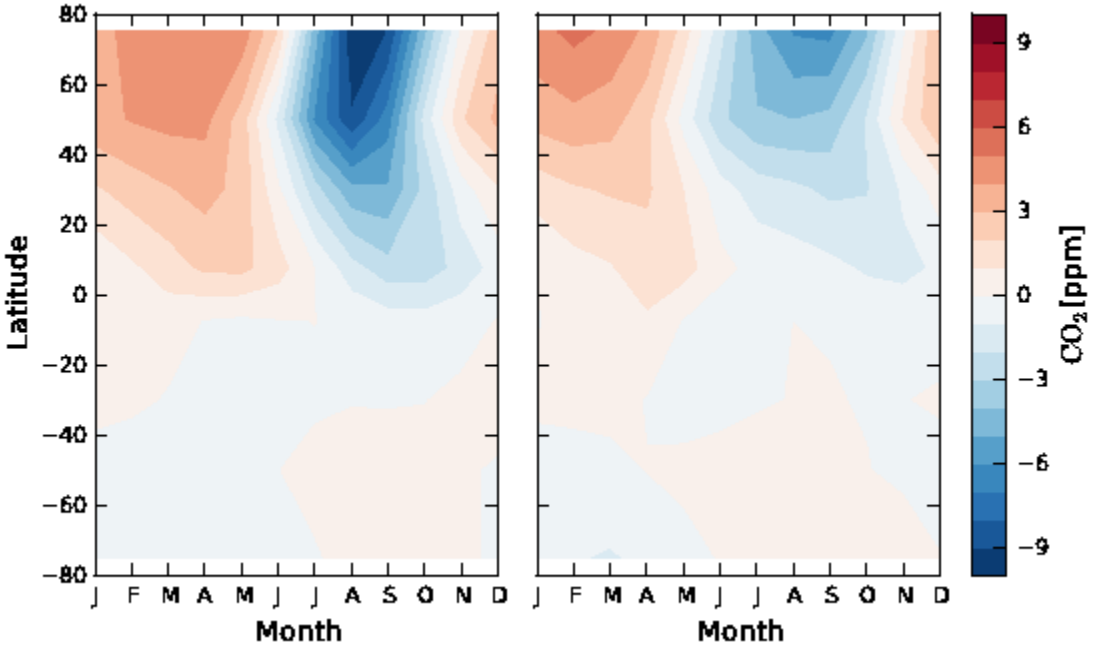

Figure 1. Hovmöller diagram showing seasonal patterns in surface CO_2 in observations (left) and CESM (right). Growing season uptake of CO_2 is weak in the coupled model, resulting on smaller meridional gradients and shallower seasonal cycles in the northern hemisphere.