Drake Passage oceanic pCO_2: Evaluating CMIP5 Coupled Carbon/Climate Models using in-situ observations

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Surface water pCO_2 variations in Drake Passage are examined using the decade-long underway shipboard measurements. North of the Polar Front (PF), the observed pCO_2 shows a seasonal cycle that peaks in the August, and dissolved inorganic carbon (DIC)-forced variations are significant. Just south of the PF, pCO_2 shows a small seasonal cycle that peaks in February, and SST and DIC play equal roles. At the PF, the wintertime pCO_2 is nearly in equilibrium with the atmosphere, leading to a small sea-to-air CO_2 flux.

These observations are used to evaluate eight available CMIP5 Earth System Models (ESMs). Six ESMs show spatial mean pCO_2 values that are comparable to observations. However, the model amplitude of the pCO_2 seasonal cycles exceeds the observed amplitude of the pCO_2 seasonal cycles due to models biases in SST and surface DIC. North of the PF, deep winter mixed layers play a larger role in model pCO_2 than they do in observations. Four ESMs show elevated wintertime pCO_2 near the PF, causing a significant sea-to-air CO_2 flux. Wintertime winds in these models are generally stronger than the satellite-derived winds. This not only magnifies the sea-to-air CO_2 flux but also upwells DIC-rich water to the surface and drives strong equatorward Ekman currents. The poleward eddy-driven currents are likely too weak to compensate for these strong equatorward Ekman currents, the residual equatorward currents are thus found stronger in the models than in satellite-derived currents. These strong model currents likely advect the upwelled DIC further equatorward due to strong stratification that precludes subduction below the mixed layer.