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Using 6-year of SMOS soil moisture data in combination with CO_2 flask samples to constrain terrestrial carbon fluxes with CCDAS

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The terrestrial carbon cycle is an important component of the global carbon budget because of its large sink and sensitivity to climate change. However, terrestrial biosphere models used for quantifying carbon fluxes have large uncertainties, which impacts global carbon budget assessments. The land surface carbon cycle is tightly coupled with the hydrological cycle through biological processes in plants. In this context, observations of soil moisture are expected to improve modeling of carbon fluxes in a model-data fusion framework. Here, we employ the Carbon Cycle Data Assimilation System (CCDAS) to assimilate a 6-year SMOS L3 surface soil moisture product in combination with in-situ measurements of atmospheric CO_2 concentrations at global scale. We find that the assimilation of SMOS soil moisture improves simulated soil moisture in regions where the prior model simulation shows poor correlations with SMOS data, but slightly degrades the fit in regions where a strong correlation with the SMOS data is already obtained with the prior simulation. Atmospheric CO_2 concentration are simulated well after the assimilation. Assimilation of SMOS soil moisture shows to be efficient in improving gross (GPP) and net (NEP) fluxes of CO_2 at both site-scale and global scale when compared against independent estimates from atmospheric transport inversions and up-scaled eddy covariance measurements. Our model shows good agreement in the inter-annual variability of global NEP and GPP with these independent datasets, however, larger differences in modeling NEP and GPP are detected in tropical and subtropical regions when compared on smaller scales. In general, CCDAS obtains smaller annual mean NEP values than the atmospheric inversion and multiple Dynamic Global Vegetation Models (DGVMs), but larger GPP values than the upscaled eddy covariance dataset and the MODIS observations. This study demonstrates the high potential of long-term soil moisture in constraining the terrestrial carbon cycle.