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Detection and attribution of changes in arctic ecosystems and atmospheric CO2

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Atmospheric CO_2 responds to terrestrial ecosystem activity widely from sub-hourly to decadal time scales primarily due to photosynthesis, weather and climate variations. The measurements of CO_2 thus consist of source signals from anthropogenic as well as natural ecosystem activities convolved with atmospheric transport. Since the records of CO_2 concentration in ambient air at monthly or finer time resolution began in the late 1950s, the seasonal ecosystem dynamics has enhanced significantly in the recent years (Graven et al., 2013). We further analyse the relative contributions of fossil fuel emissions and atmospheric transport on the CO_2 at a greater number of surface measurement sites since the 1980s using the CCSR/NIES/FRCGC atmospheric general circulation model (AGCM)-based chemistry transport model (ACTM). Our results suggest the trends in fossil fuel emissions and transport have detectable contribution to the CO_2 seasonal cycle chances at the sites in northern tropics to mid-latitudes, and that the seasonal cycle increase in the arctic region is governed mainly by the terrestrial ecosystem.

To attribute causes for the recent changes in carbon cycle dynamics we have chosen the period of 1999-2011, which is covered by high quality process oriented ecosystem parameters from remote sensing and atmospheric CO_2 measurements at the largest network of sites for flux inversion. Our analysis suggests that the early greening by several days in the Alaskan tundra region closely correlated with the amplitude of CO_2 seasonal cycle at Point Barrow, Alaska. But no clear trend in the greening onset is detectable at semi-arid grasslands near Ulaanbaatar, Mongolia, except for the closely coupled interannual variations in greening onset time and CO_2 seasonal cycle amplitude. We estimated CO_2 fluxes from 84-regions of the globe at monthly time intervals using measurements from about 100 sites. The terrestrial CO2 fluxes are estimated after removing the effects of fossil fuel emissions and oceanic fluxes in measured CO_2 concentrations. We find the carbon exchange of the Alaska region of our inversion is increased both for the seasonal cycle amplitude and net annual uptake over the period of 2002-2011.

Our results have large implications for developing the future and validating the present earth system models for studying climate-carbon-biosphere interactions.

Keywords: CO2 seasonal cycle, Ecosystem phenology, Arctic environment