Geophysical Research Abstracts
Vol. 17, EGU2015-7023-2, 2015
EGU General Assembly 2015

Inter-annual variability in Alaskan net ecosystem CO_2 exchange

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The high-latitude biospheric carbon cycle's responses to climate change are predicted to have an important role in determining future atmospheric concentrations of CO_2. In response to warming soil and air temperatures, Arctic wetlands have been observed to increase rates of both soil C efflux and vegetation C uptake through photosynthesis. However, insights into the regional-scale consequences of these processes for net C uptake have been limited by the large uncertainties existing in process-based model estimates of Arctic net ecosystem CO_2 exchange (NEE).

The Polar Vegetation Photosynthesis and Respiration Model (PolarVPRM) instead provides data-driven, satellite-based estimates of high-latitude NEE, using a framework which specifically accounts for polar influences on NEE. PolarVPRM calculates NEE as the sum of respiration (R) and gross ecosystem exchange (GEE), where GEE refers to the light-dependent portion of NEE: NEE= -GEE + R. Meteorological inputs for PolarVPRM are provided by the North American Regional Reanalysis (NARR), and land surface inputs are acquired from the Moderate Resolution Imaging Spectroradiometer (MODIS). Growing season R is calculated from air temperature, and subnivean R is calculated according to soil temperature. GEE is calculated according to shortwave radiation, air temperature, and MODIS-derived estimates of soil moisture and vegetation biomass. Previously, model validation has indicated that PolarVPRM showed reasonably good agreement with eddy covariance observations at nine North American Arctic sites, of which three were used for calibration purposes. For this project, PolarVPRM NEE was calculated year-round across Alaska at a three-hourly temporal resolution and a spatial resolution of $\frac{1}{6}^{\circ} \times \frac{1}{4}^{\circ}$ (latitude $\times$ longitude).

The objective of this work was to gain insight into inter-annual variability in Alaskan NEE, R and GEE, and an understanding of which meteorological and land surface drivers account for these observed patterns. This was accomplished by first examining regional-scale PolarVPRM output in conjunction with airborne observations of atmospheric CO_2 concentrations from NASA's Carbon in Arctic Reservoirs Vulnerability Experiment (CARVE). These regional-scale findings were then examined carefully in relation to eddy covariance observations from sites along Alaska's North Slope. This was completed in order to validate PolarVPRM estimates of NEE, as well as to examine the extent to which the model structure and inputs were capable of capturing inter-annual variability in NEE observed at Alaskan eddy covariance sites.

Statistical analyses were then applied to elucidate regional-scale inter-annual variability in PolarVPRM NEE, R and GEE, as well as their associations with NARR meteorological drivers and MODIS land surface inputs. These analyses were conducted with a specific focus on inter-annual variability across wetland regions of Alaska's North Slope. Analyses indicated that inter-annual variability in growing season length, soil moisture, vegetation biomass, air/soil temperatures, and shortwave radiation induced inter-annual variability in observed and modeled Alaskan net ecosystem CO_2 exchange.