Data-constrained annual carbon fluxes for Arctic and Boreal ecosystems

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Carbon-rich permafrost soils of northern high-latitude ecosystems have the capacity to release large amounts of carbon dioxide (CO_2) and methane (CH_4) to the atmosphere in response to increasing temperatures. Most studies in these ecosystems focus on the growing season, when measurements are relatively easy to make and remote-sensing methods are not light limited. However, understanding the annual budget of carbon gases requires year-round monitoring, during periods when light and weather limit both remote-sensing and airborne measurements. Recent studies have highlighted the importance of non-growing season fluxes to the total annual budget (e.g. 50% of tundra CH_4 emissions occur during the non-growing season, Zona et al., PNAS, 2016). Long-term records at Barrow, AK, show that CO_2 emission rates from North Slope tundra have increased during the early winter period by 70% ± 4% since 1975, and are linked with rising summer temperatures (Commane et al., PNAS 2017).

Here we bring together data from two NASA airborne programs to assess the regional fluxes of CO_2 and CH_4 across Alaska between 2012 - 2014 (NASA CARVE) and 2017 (NASA ABoVE). We combine prior models with an atmospheric transport model (WRF-STILT) and airborne data in a geostatistical framework to calculate the spatially and temporally resolved regional flux of CO_2 and CH_4 across Alaska (CARVE) and Alaska into northern Canada (ABoVE). Our biogenic CO_2 flux model (PVPRM-SIF) is driven by remote sensing (including snow cover and solar-induced fluorescence) and meteorological reanalysis products, and is constrained to eddy flux data for ecosystems within the domain. We find that Alaska is, on average, an annual net source of biogenic CO_2, but with inter annual variability driven by growing season uptake. We are currently expanding this analysis to encompass northern Canada.