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Poster #68

Inter-Annual Variability of Net and Gross Ecosystem Carbon Fluxes: A Review

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As the lifetime of regional flux networks approach twenty years, there is a growing number of papers that have published long term records (5 years or more) of net carbon fluxes between ecosystems and the atmosphere. Unanswered questions from this body of work are: 1) how variable are carbon fluxes on a year to year basis?; 2) what are the biophysical factors that may cause interannual variability and/or temporal trends in carbon fluxes?; and 3) how does the biophysical control on this variability differ by climate and ecological spaces? To address these questions, we surveyed published data from 59 sites that reported on five or more years of continuous measurements, yielding 544 site-years of data.

We found that the standard deviation of the interannual variability in net ecosystem carbon exchange (162 gC m^{-2} y^{-1}) is large relative to its population mean (-200 gC m^{-2} y^{-1}). Broad-leaved evergreen forests and crops experienced the greatest absolute variability in interannual net carbon exchange (greater than +/- 300 gC m^{-2} y^{-1}) and boreal evergreen forests and maritime wetlands were among the least variable (less than +/- 40 gC m^{-2} y^{-1}).

A disproportionate fraction of the yearly variability in net ecosystem exchange was associated with biophysical factors that modulated ecosystem photosynthesis rather than ecosystem respiration. Yet, there was appreciable and statistically significant covariance between ecosystem photosynthesis and respiration. Consequently, biophysical conditions that conspired to increase ecosystem photosynthesis to from one year to the next were associated with an increase in ecosystem respiration, and vice versa; on average, the year to year change in respiration was 40% as large as the year to year change in photosynthesis. The analysis also identified sets of ecosystems that are on the verge of switching from being carbon sinks to carbon sources. These include sites in the Arctic tundra, the evergreen forests in the Pacific northwest and some grasslands, where year to year changes in respiration are outpacing those in photosynthesis.

While a select set of climatic and ecological factors (e.g. light, rainfall, temperature, phenology) played direct and indirect roles on this variability, their impact differed conditionally, as well as by climate and ecological spaces. For example, rainfall had both positive and negative effects. Deficient rainfall caused a physiological decline in photosynthesis. Too much rain, in the humid tropics, limited photosynthesis by limiting light. In peatlands and tundra, excess precipitation limited ecosystem respiration when it raised the water table to the surface. For deciduous forests, warmer temperatures lengthened the growing season, increasing photosynthesis, but this effect also increased soil respiration.

Finally, statistical analysis was performed to evaluate the detection limit of trends; we computed the confidence intervals of trends in multi-year carbon fluxes that need to be resolved to conclude whether the differences are to be attributed to randomness or biophysical forcings. Future studies and reports on interannual variations need to consider the role of the duration of the time series on random errors when quantifying potential trends and extreme events.