Geophysical Research Abstracts,
Vol. 11, EGU2009-6567, 2009
EGU General Assembly 2009

The role of spring and autumn phenological switches on spatiotemporal variation in temperate and boreal forest C balance: A FLUXNET synthesis

A.D. Richardson (1), M. Reichstein (2), S. Piao (3), P. Ciais (3), S. Luyssaert (4), R. Stockli (5), M. Friedl (6), N. Gobron (7), and 21 FLUXNET Site PIs ()

(1) Complex Systems Research Center, University of New Hampshire, Durham, NH 03824, United States (andrewr@solo.sr.unh.edu), (2) Max Planck Institute for Biogeochemistry, Jena, Germany, (3) LSCE-CNRS Gif-sur-Yvette, France, (4) Department of Biology, University of Antwerp, Wilrijk, Belgium, (5) MeteoSwiss, Zurich, Switzerland, (6) Boston University, Boston MA, USA, (7) Global Environmental Monitoring Unit, EC JRC, Ispra, Italy

In temperate and boreal ecosystems, phenological transitions (particularly the timing of spring onset and autumn senescence) are thought to represent a major control on spatial and temporal variation in forest carbon sequestration. To investigate these patterns, we analyzed 153 site-years of data from the FLUXNET ‘La Thuile’ database. Eddy covariance measurements of surface-atmosphere exchanges of carbon and water from 21 research sites at latitudes from 36°N to 67°N were used in the synthesis. We defined a range of phenological indicators based on the first (spring) and last (autumn) dates of (1) C source/sink transitions (‘carbon uptake period’); (2) measurable photosynthetic uptake (‘physiologically active period’); (3) relative thresholds for latent heat (evapotranspiration) flux; (4) phenological thresholds derived from a range of remote sensing products (JRC fAPAR, MOD12Q2, and the PROGNOSTIC model with MODIS data assimilation); and (5) a climatological metric based on the date where soil temperature equals mean annual air temperature. We then tested whether site-level flux anomalies were significantly correlated with phenological anomalies across these metrics, and whether the slopes of these relationships (representing the sensitivity to phenological variation) differed between deciduous broadleaf (DBF) and evergreen needleleaf (ENF) forests.

Within sites, interannual variation in most phenological metrics was about 5–10 d, compared to 10–30 d across sites. Both spatial and temporal phenological variation were consistently larger at ENF, compared to DBF, sites. Averaged across metrics, phenological variability was roughly comparable in spring and autumn, both across (17 d) and within (9 d) sites.

However, patterns of interannual variation in fluxes were less well explained by the derived phenological metrics than were patterns of spatial variation in fluxes. Also, the observed pattern strongly depended on the metric used, with flux-derived metrics generally explaining more, and remote sensing-derived metrics generally explaining less, of the variation in flux anomalies. We found that GPP (gross primary productivity) was consistently more sensitive (both in terms of magnitude and statistical significance; ≈3 g C m-2 d-1 for DBF and ≈2 g C m-2 d-1 for ENF) to phenology than was Reco (ecosystem respiration), which meant that NEP (net ecosystem productivity) tended to be increased both by earlier springs and later autumns. Without exception, when the difference between DBF and ENF in the sensitivity to phenological anomalies was statistically significant, DBF sensitivity was always larger in absolute magnitude than ENF sensitivity.

Phenology explained a much larger fraction of the variation in fluxes across sites compared to within sites. Across sites, the rate of increase in GPP with an “exta” day in spring (≈10 g C m-2 d-1) was much larger than in autumn (≈3 g C m-2 d-1). Furthermore, a one-day increase in growing season length across sites increased annual NEP by just ≈2 g C m-2 d-1; this resulted from an increase in GPP of ≈6 g C m-2 d-1 being offset by an increase in RE of ≈4 g C m-2 d-1. In general, there was no statistically significant difference between DBF and ENF in the sensitivity to spatial variation in phenology for either NEP or the component fluxes GPP and Reco.

In relation to both within- and across-site variation in phenology and fluxes, the results obtained tended to depend on the phenological metric used, i.e. definition of “start” and “end” of growing season, emphasizing the need for improved understanding of the relationships between these different metrics and ecosystem processes. Furthermore, the differences in flux-phenology relationships in the context of spatial and temporal variation in phenology raise questions about using results from either short-term or space-for-time studies to anticipate responses to future climate change.