Linking Disturbance and Nitrogen Availability to Carbon and Water Cycling: Improved Upscaling of Carbon and Water Fluxes from Towers to Continental and Global Scales

Lead authors: Jingfeng Xiao (University of New Hampshire), Scott Ollinger (University of New Hampshire), and Jiquan Chen (University of Toledo)

Outline: Disturbance and stand age are important drivers of forest structure and function, and many components of the forest carbon cycle are related to forest age. Numerous studies have demonstrated that disturbances and stand age have substantial effects on ecosystem carbon fluxes and terrestrial carbon budgets. However, the effects of disturbance/stand age have rarely been explicitly modeled in large-scale carbon cycle studies due to the lack of spatially explicit information on disturbance/stand age. In addition, the availability of nitrogen is an important constraint on canopy carbon assimilation, loss, and net exchange. Few studies have included continuous variation in plant nitrogen status as a driver of carbon cycle processes at regional to continental scales.

Spatially explicit information on disturbance/stand age, aboveground biomass, and leaf nitrogen is now available or being developed at continental or global scales, particularly in North America. For instance, Pan et al. (2010) developed the North American Stand Age Database using forest inventory, large fire polygons, and remotely-sensed data. This database provides stand age information for each 1km cell across North America. Zhang and Kondragunta (2007) developed a continental-scale forest biomass (foliage biomass, branch biomass, and total aboveground biomass) at a spatial resolution of 1km for North America using foliage-based generalized allometric models and MODIS data. Ollinger et al. (2008) recently demonstrated that MODIS albedo and channel 2 near-infrared reflectance data are significantly correlated with both leaf nitrogen concentrations (% by mass) and maximum photosynthetic rates in North America. This relationship has been used to estimate leaf %N for each 1km × 1km cell across North America, and can be potentially applied to the global scale.

Here we plan to combine the LaThuile database of the FLUXNET, satellite observations, and climate data as well as recently available gridded datasets of disturbance/stand age, aboveground biomass, and leaf nitrogen to produce spatially and temporally continuous estimates of carbon and water fluxes over the period 2000-present. We will build predictive models of carbon and water fluxes using upscaling methods such as machine learning approaches and process-based ecosystem modeling. The analysis will first be conducted for North America where spatially explicit information on aboveground biomass and disturbance/stand age is currently available, and then extended to the globe when spatially explicit information on these variables becomes available at the global scale. We will use the predictive models to estimate carbon and water fluxes for each grid cell (e.g., 0.05 degree) and for each 8-day interval (or monthly) over the period 2000-present. By linking disturbance and nitrogen availability to carbon and water fluxes, we will (1) assess the extent to which the incorporation of disturbance/stand age and leaf nitrogen will improve the accuracy of flux estimates, and (2) use these improved, gridded estimates to investigate the spatial patterns, magnitude, and interannual variability of carbon and water fluxes, particularly the impacts of disturbance and nitrogen availability.

References:

Ollinger, S.V. et al. (2008) Canopy nitrogen, carbon assimilation, and albedo in temperate and boreal forests: functional relations and potential climate feedbacks. *PNAS*, 105, 19336-19341.

Pan, Y., Chen, J.M., Birdsey, R., McCullough, K., He, L., and Deng, F. (2010) Age structure and disturbance legacy of North American forests. *Biogeosciences Discuss.*, 7, 979-1020.

Zhang, X., Kondragunta, S. (2006) Estimating forest biomass in the USA using generalized allometric models and MODIS land products. *Geophys. Res. Lett.*, 33, L09402, doi:10.1029/2006GL025879.

Contributing Sites: We plan to use all sites with ≥ 1 year of data (NEE, GPP, ET, micrometeorological data, aboveground biomass, stand age, and other ancillary data) in our analysis. We expect to start with sites in North America, and will expand the analysis to the globe later.

Co-authorship: Co-authorship will be extended to those who make significant intellectual contribution to the analyses and the resulting manuscript(s).