Environmental Controls on Loblolly Pine Productivity in Central Virginia

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ABSTRACT

Loblolly pine is the most important forestry species in the southeastern United States, and represents a major managed ecosystem at the continental scale. Quantifying how pine carbon, water, and energy fluxes respond to environmental variability is critical for anticipating how carbon uptake and other climate regulation services may change with future climate and atmospheric chemistry. To address this need, we established a flux tower in a loblolly pine stand in central Virginia that includes a unique combination of eddy-covariance, aerosol characterization, and radiation instrumentation (Sweet Briar Land-Atmosphere Research Station – AmeriFlux site US-SBC). Here we present data from the first two years of the study allowing us to examine variation in carbon, energy, and water fluxes over timescales ranging from half-hourly to annual. The two years examined are especially interesting because they coincide with a strong El Niño in the middle of the time series. Initial results indicate that net ecosystem productivity was highly sensitive to both the magnitude of incoming light and the light quality (direct vs. diffuse), aerosol concentration (through the creation of diffuse light), atmospheric vapor pressure deficit, and the recent history of soil moisture. The net ecosystem exchange during the summer following the El Niño was higher than the summer prior to the El Niño. To better characterize environmental controls on regional loblolly pine productivity we compared the carbon and energy balance at our site to two other loblolly sites in the AmeriFlux database that are situated in warmer climates.

SITE DESCRIPTION

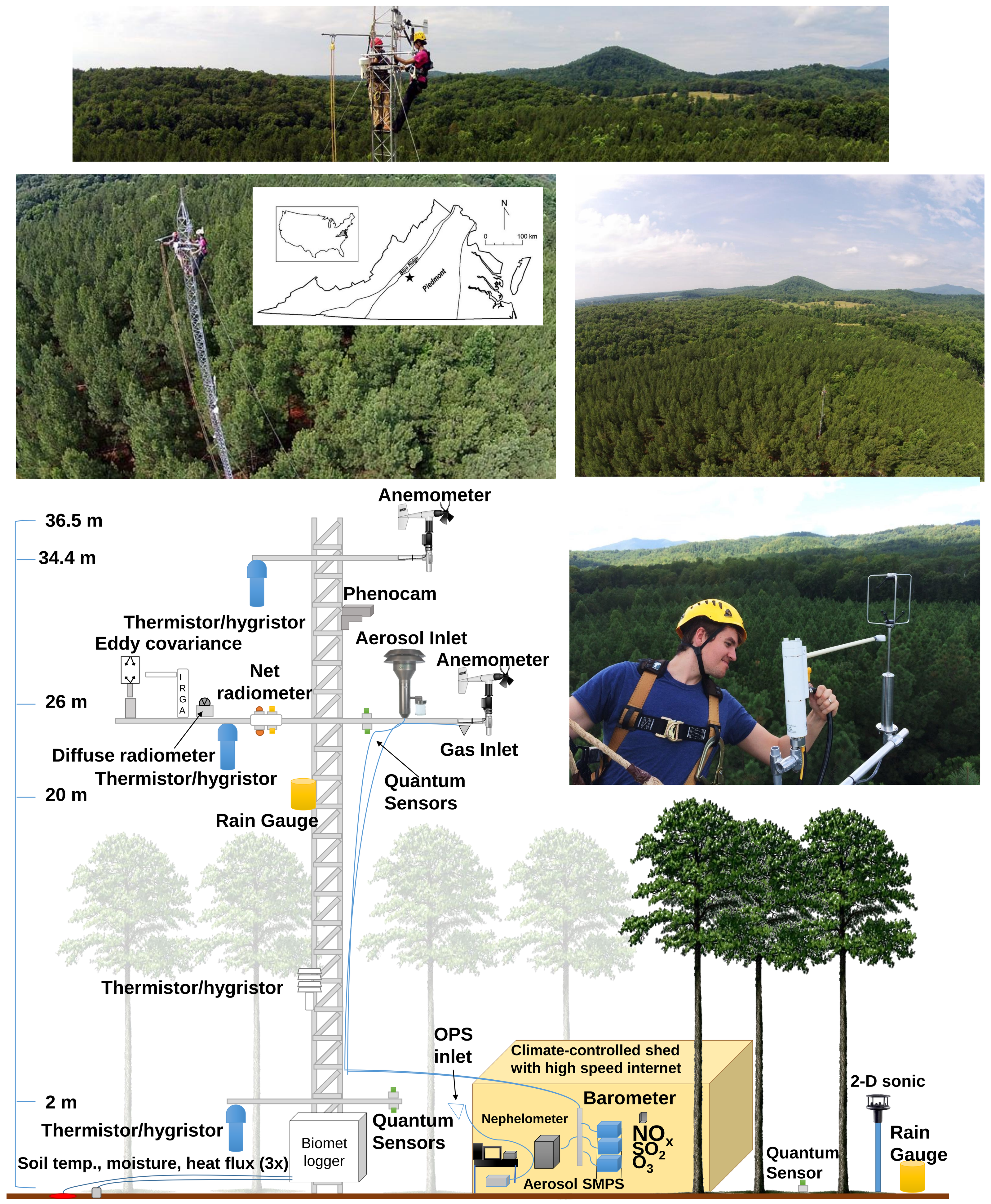


Figure 1. The Sweet Briar College Land-Atmosphere Research Station is situated in central Virginia in a loblolly pine plantation at the foothills of the Blue Ridge Mountains. SBC-LARS is a registered AmeriFlux site and a PhenoCam core site.

PRELIMINARY RESULTS

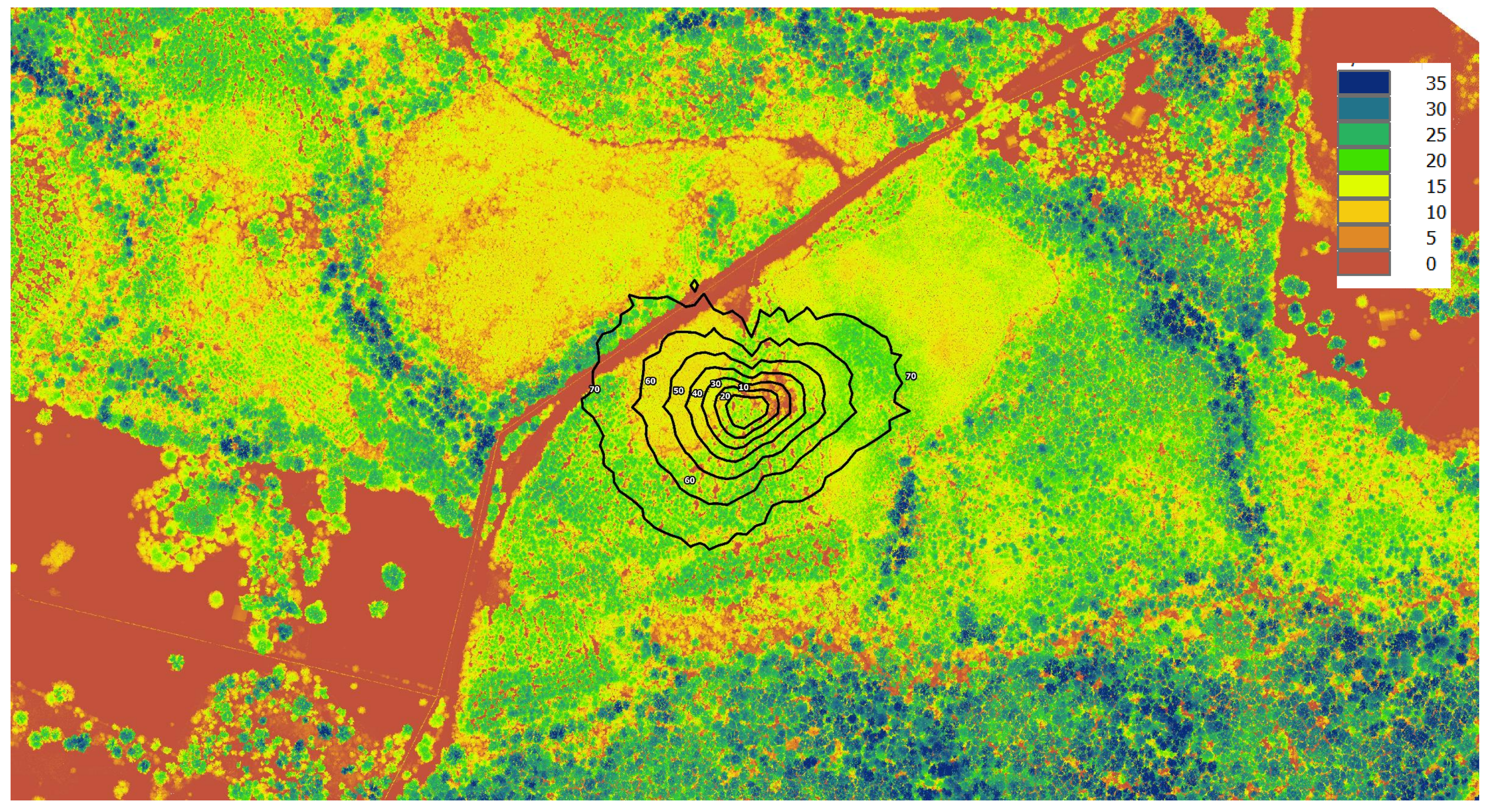


Figure 2. LIDAR canopy height model in meters with 10% isopleths of the cumulative flux footprint climatology (*Schuepp et al. 1990*).

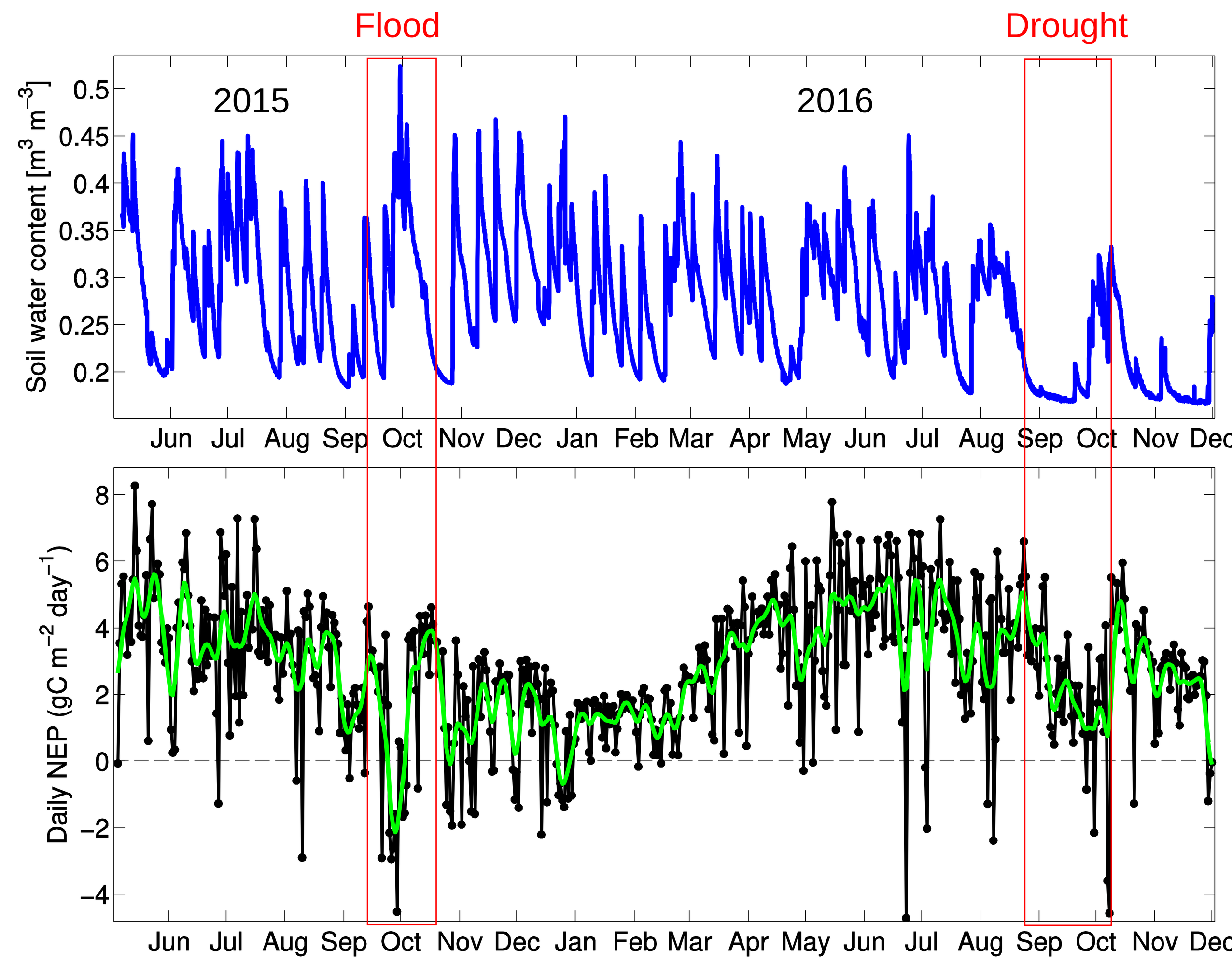


Figure 3. 220 mm (8.6 in) of rain fell on October 2-5, 2015. This was the same lethal storm that deposited up to 660 mm (26 in) of rain in South Carolina. A modest drought occurred in August and September of 2016. Both of these events lead to extended periods of reduced NEP that affected fluxes at the annual scale (Figure 4).

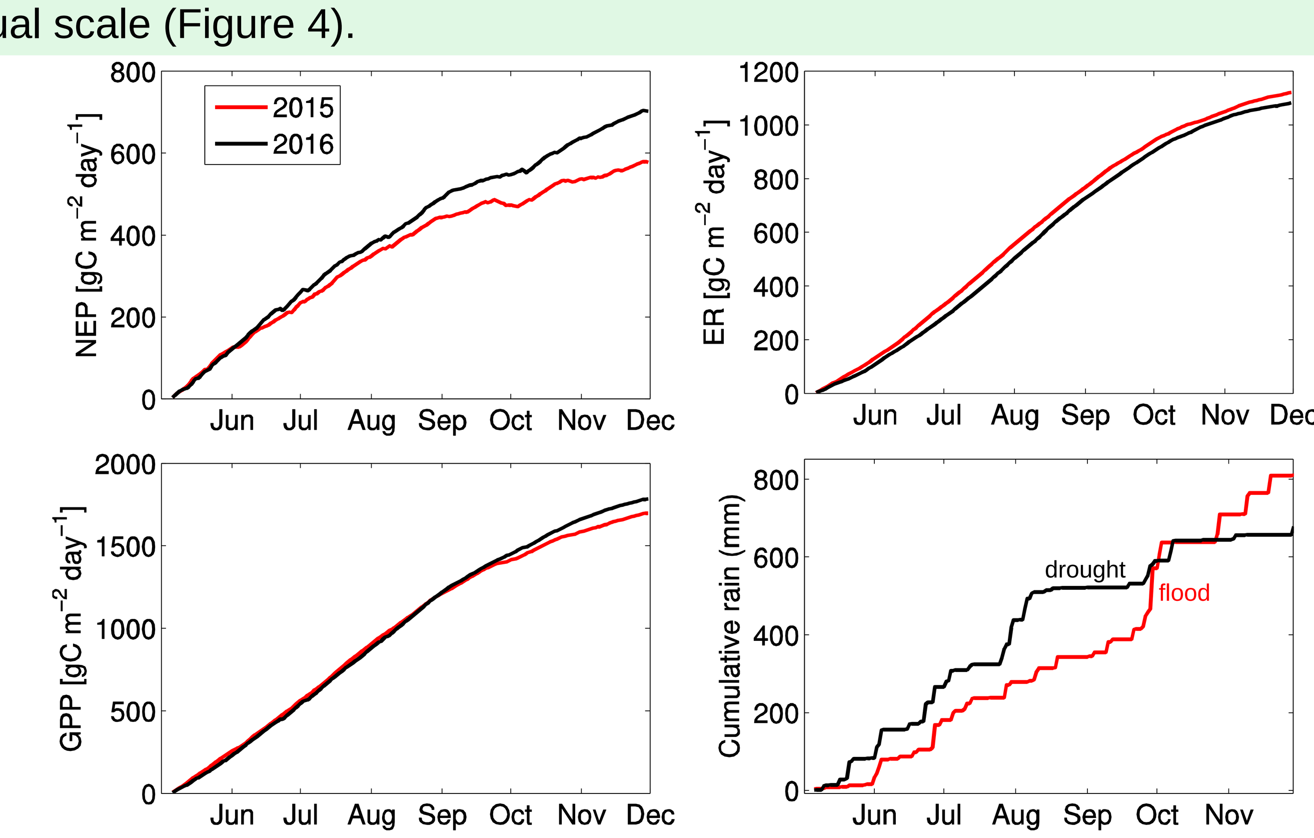
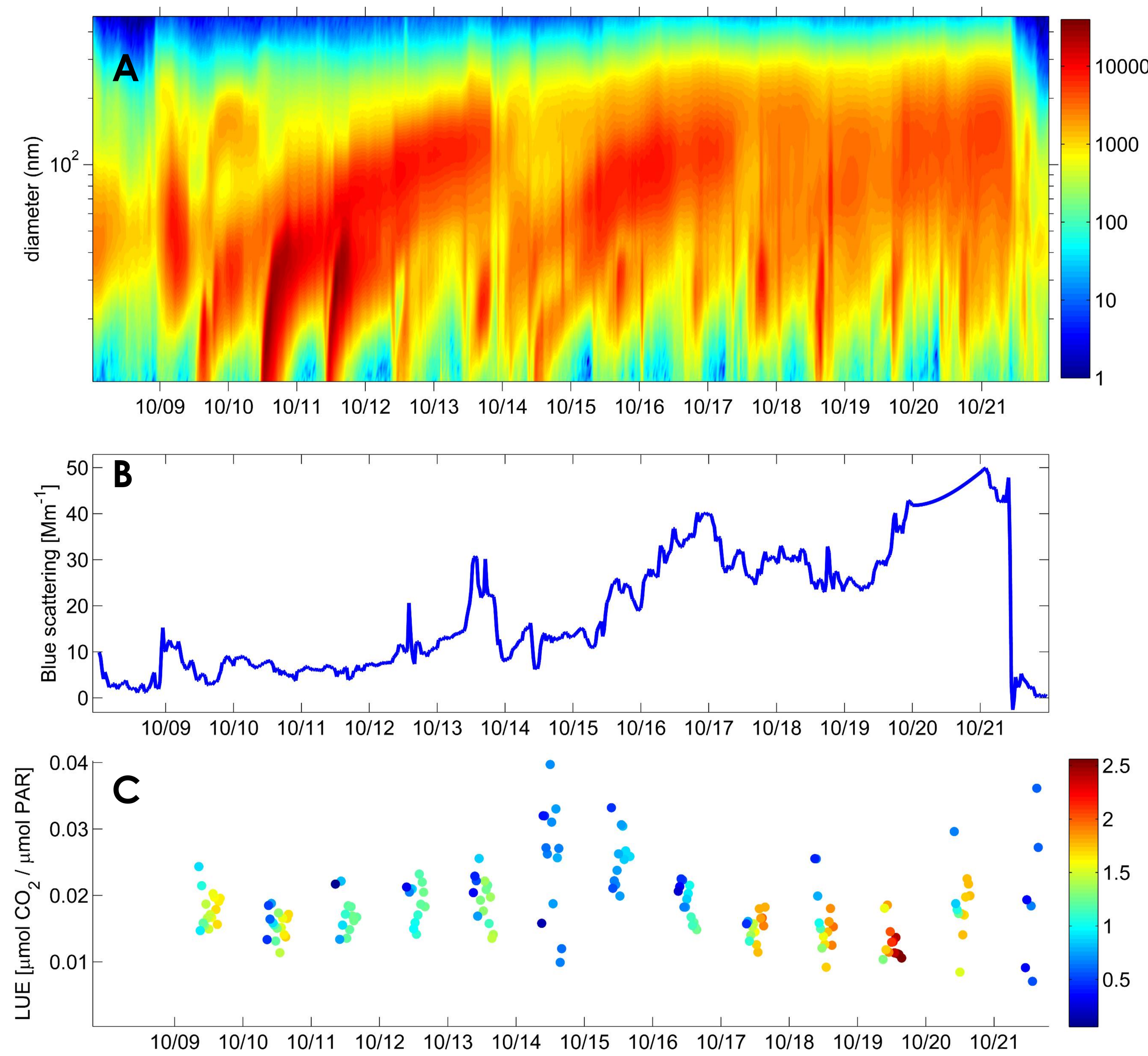


Figure 4. Cumulative sums of gap-filled fluxes and precipitation for the overlapping period of 2015-16. ER was generally higher in 2015, while GPP was nearly the same in both years until the flood in early October 2015, at which point GPP is reduced. The net result is 20% less NEP in 2015 for this period.



←Figure 5. (A) Aerosol size distributions (color, # cm^{-3}) show frequent new particle formation and growth events. The increase in aerosol surface area leads to increased blue light scattering **(B)**. The half-hourly light use efficiency does not follow the trend in light scattering, but rather is more influenced by **(C)** vapor pressure deficit (color in kPa).

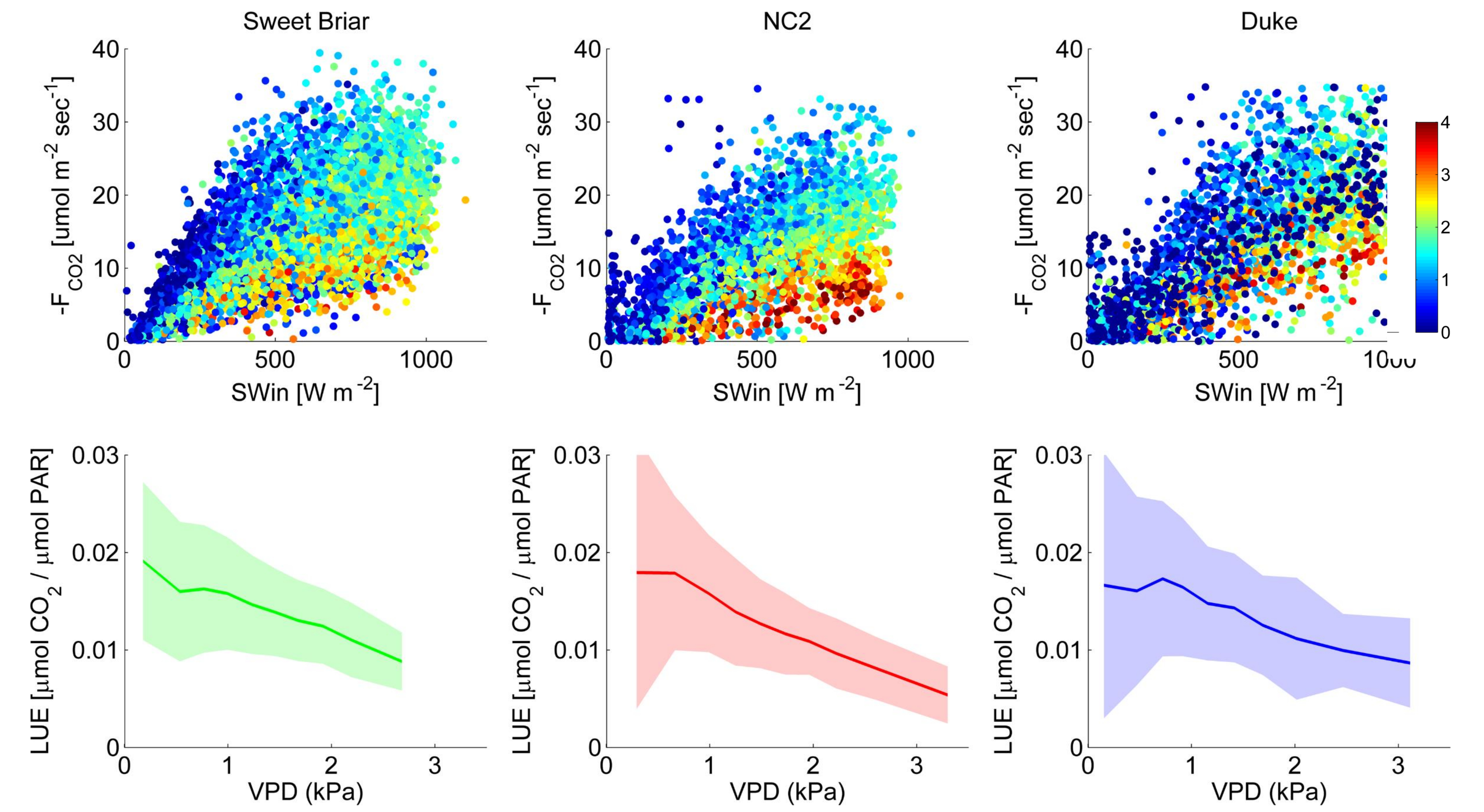


Figure 6. Light use efficiency (LUE) as a function of vapor pressure deficit (color, kPa) for three loblolly pine sites in Virginia and North Carolina. Radiation and VPD explain about 60% of the variance in half-hourly NEE at these sites, where the response is nearly identical.

FUTURE WORK

- ❑ Untangle VPD-diffuse light-aerosol effects on GPP and LUE
- ❑ Examine soil moisture controls on ER and GPP
- ❑ Compare annual fluxes with biometric measurements
- ❑ Examine fluxes by flow direction (different stand ages and properties)

ACKNOWLEDGEMENTS

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