1.3 Flux partitioning in an Old-Growth rainforest and the canopy microclimate: Daily, seasonal and interannual dynamics

Matthias Falk[1,*], Matt Schroeder[1], Sonia Wharton[1] and Kyaw Tha Paw U[1].

[1]University of California, Davis, California

1. Introduction

We investigate the decompostion of eddy flux measurements of net ecosystem exchange (NEE) into gross primary productivity (GPP), ecosystem respiration (Reco) and its components like soil respiration (Rsoil), important switches and lags to illustrate the temporal dynamics of component fluxes for 6 years of data from long-term measurements of carbon fluxes above and within Old-growth Forest at the Wind River Canopy Crane AMERIFLUX site.

Trees at the site are up to 500 years old and 65 meters tall. The forest structure at the site is complex for a temperate conifer stand with seven gymnosperm and two angiosperm tree species in the 2.3 ha crane circle, large standing biomass and large amounts of woody debris on the forest floor. The distribution of the Leaf Area Index (LAI) is bottom heavy with the LAI maximum located between 10 and 30 m.

2. Results and discussion

The forest structure modifies the microclimate, resulting in unstable or neutral stratification near the forest floor during nighttime periods, whereas the upper canopy environment above the LAI maximum displays strongly stable stratification. The absence of stable nighttime conditions within the lowest layer enables the use of eddy-covariance methodology at the lowest level during those times without the necessity of u* triggered corrections. Spectral analysis confirms this observation for the turbulence and CO2-measurements. Further we report small upward sensible heat fluxes (H) of 5-10 W m^{-2} during the night. Latent heat (LE) flux is negligible during the night and positive during the later part of the day when H becomes negative indicating the transport of warmer air from the upper canopy into the lowest layer.

Soil respiration (R_{soil}) is a major contributor to the carbon budget at the site with an average of 11 tC ha^{-1} per year but ranges from 9.5 to 12 tC ha^{-1} per year accounting for 65-75% of Ecosystem respiration (R_{eco}). The net ecosystem exchange (NEE) of carbon ranges from a strong sink (-2.2 tC ha^{-1} per year) to a source (+0.5 tC ha^{-1} per year) also displaying a high degree of variability.

Summers are usually warm and dry (1998, 2001) but relatively wet and cool ones have been observed (1999). Precipitation levels throughout the observation period varied from 1600 to 2500 mm. The main period of maximum carbon uptake is limited to the months March through May when ecosystem respiration and water stress are low. Stand-level light response functions show optima for low temperatures close to the average annual air temperature of 8.7 ^{o}C. R_{eco} also shows a clear seasonal pattern but lags significantly behind NEE with a maximum in summer by about 2-3 Months. i.e. maximum NEE occurs when temperatures are low and respiration is attenuated. On the other hand when respiration is at maximum photosynthetic rates are attenuated due to water stress on the overstory trees. The difference in seasonality is clearly visible with a lag time of roughly 3 months. This offset also influences the seasonality of GEP and the partitioned carbon flux for the layer between 3 and 70 meters rising much earlier than respiration with a typical lag of 2-3 months. The spring of 2003 however shows a much earlier onset of respiration during the 2002/2003 El Nino event due to much warmer temperatures.

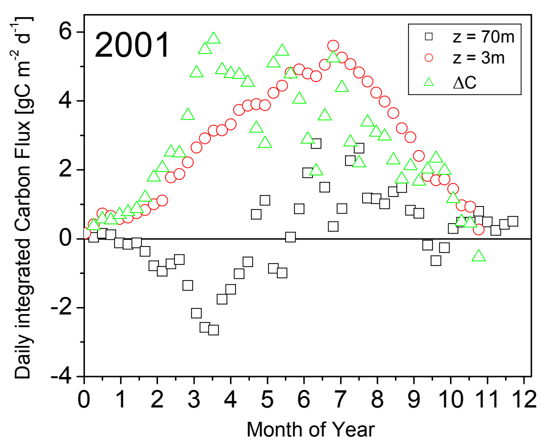

Figure 1: Flux Partitioning for the year 2001. Shown are 8-day averages of daily integrated fluxes for the EC70 (black) and EC03 (red) as well as the difference (green) between the two levels.

* *Corresponding author address*: Matthias Falk, Univ. Of California, ESPM, 151 Hilgard Hall #3110, Berkeley, CA 94720-3110; email: mfalk@nature.berkeley.edu

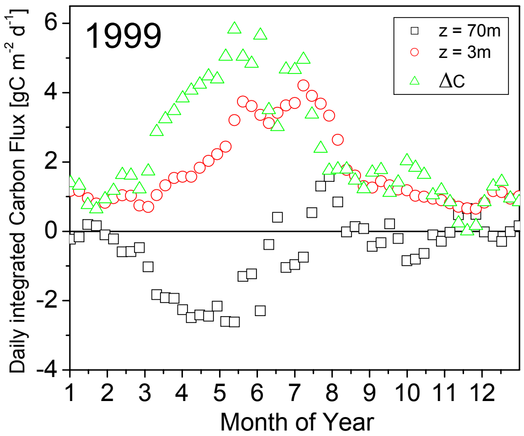

Figure 2: Flux Partitioning for the year 1999. Shown are 8-day averages of daily integrated fluxes for the EC70 (black) and EC03 (red) as well as the difference (green) between the two levels.

The seasonal course of soil / understory exchange clearly shows the much reduced respiration during the year of 1999 and marked increase for the year 2000. This is both evident in the width and height of the respiration peak during the year.

Significant amounts of Carbon are recycled within the canopy as the carbon flux at the below canopy measurement level is always upward. The maximum values reach 4-6 μmol m^{-2} s^{-1} of CO2-flux into the canopy air space during the summer months, thus often equaling the downward fluxes measured at the above canopy level.

3. Conclusion

Limitations of water supply during the summer drought and potential respiration in the form of large carbon pools are the determining players for the carbon dynamics at this high biomass forest. High temperatures in the summer cause water stress and reduce photosynthetic uptake. At the same time respiration is generally enhanced during this period until soils get too dry. Interannual variability is dramatic as different patterns in rainfall timing and temperature regime can cause large response of both respiration and photosynthetic uptake of the ecosystem.

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