# Seven Years of Carbon Flux Measurements over an Old-growth Rainforest in the Pacific Northwest

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Since July 1998 we have been using eddy covariance techniques to measure carbon dioxide, water vapor, and energy fluxes over and within a 500 year old forest in southern Washington. Below are our key findings and plans for continued research at the Wind River forest.

## Ecosystem $CO_2$ Flux Partitioning

Using a network of eddy flux towers placed at 3 m and 70 m heights in and above the canopy, we are able to decompose net ecosystem exchange (NEE) of carbon into gross ecosystem productivity (GEP), ecosystem respiration (Reco) and its component, soil respiration (Rsoil).

**Reco lags behind NEE ~3 months with a maximum in summer when photosynthetic rates are lowered due to water stress on the tall trees. Maximum NEE occurs in the spring when temperatures are low and Reco is attenuated while water and light are optimal for maximizing GEP.**

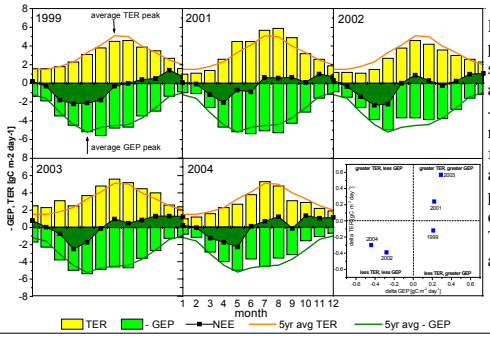



Fig. 1 NEE partitioned data showing daily average TER and - GEP fluxes by month and deviation from the 5-yr average. The last plot shows the deviation of daily TER and GEP on an annual basis.

## Interannual Variability of NEE

**The seasonal rainforest can assimilate carbon at relatively high rates (2.1 Mg C $ha^{-1}$ $yr^{-1}$) under favorable climatic conditions but releases carbon (0.5 Mg C $ha^{-1}$ $yr^{-1}$) to the atmosphere under climatic stress.**

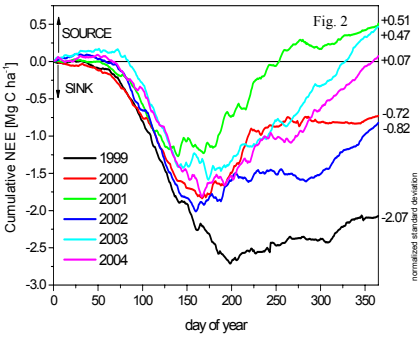



Fig. 2 Carbon flux measurements over the last 6 years show high interannual variability of NEE for the old-growth forest.

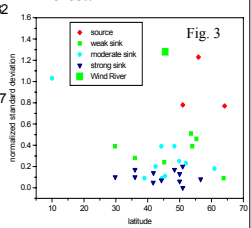
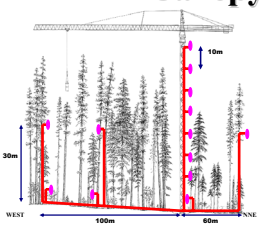



Fig. 3 The sensitivity of annual NEE to environmental conditions results in exceptionally high variability (normalized standard deviation of 1.3), which contrasts markedly with the lower variability of most other FLUXNET sites.

## Canopy Advection




(artwork courtesy R. Von Pelt, Evergreen State College, Tacoma, WA)

Fig. 4 Diagram of the 3-dimensional $CO_2/H_2O$ profile system with a total of 15 intakes distributed on the crane, throughout the canopy, and in the understory.

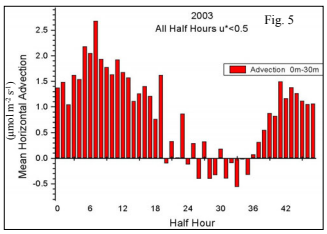



Fig. 5 Advection within the canopy becomes a major mode of $CO_2$ transportation during the nighttime hours.

**Advection can account for 5-20% of the above canopy ecosystem exchange of carbon as measured by eddy-covariance.**

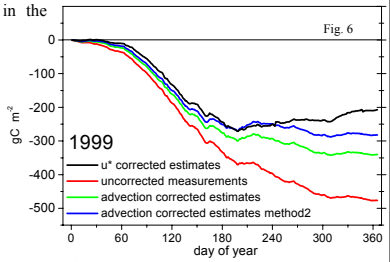
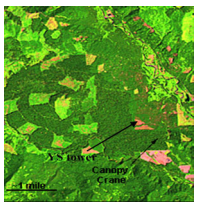



Fig. 6 Cumulative NEE including the advection correction is consistent with the more traditional u* correction method, although it yields a stronger annual sink.

## Chronosequence Research




**This new tower will allow us to quantify how sensitive NEE is to interannual climate variability at different aged stands in the Gifford Pinchot National Forest.**

In August 2005 we erected a 6m tall eddy flux tower in a naturally-established 10-year old Douglas-fir stand. The goal of this project is to study how year-to-year climate variability impacts the carbon and hydrological budgets of a young stand forest. Left: AVIRIS spectral reflectance image shows a history of regional forest harvesting and the site locations of the old-growth and young stand (YS). Right: March 2005 photograph of the YS site.

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**Site Characteristics:**

**Old-growth stand:** Elevation: 371 m a.s.l.; Mean Annual Precipitation: 2528 mm; Mean annual temperature: 8.7 deg C; Vegetation Type: Temperate Rainforest (seasonal); Tree Species: Douglas-fir / Western Hemlock; Age Class: Old-growth (500 a); LAI: 8-11; Tree height 55 to 65 m (maximum 67 m); Total Biomass 619 Mg/ha.

**Young stand:** Slope: 9%; Stand Area: 6 ha; Dominant species: Douglas-fir; Other species: western hemlock, red alder, western white pine; Mean tree height: 4m; Age = ~10yr.