6.1. INTERANNUAL VARIABILITY OF CARBON AND ENERGY FLUXES FOR AN OLD-GROWTH RAINFOREST

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1. INTRODUCTION

Eddy-covariance and biometeorological methods show significant net uptake by an old-growth Douglas-fir forest in southern Washington state, the oldest forest ecosystem (500 years old) in the AmeriFlux network. Annual net ecosystem exchange (1.3 - 2 tC ha^{-1} $^{yr-1}$) was comparable to younger ecosystems at the same latitude, as quantified in the AmeriFlux program. Data acquisition at the Wind River Canopy Crane research Facility (WRCCRF) site is ongoing since 1997/98. A detailed analysis of the ecosystems response to changing climatic conditions will be presented. Quantities of interest are the carbon flux and water vapor flux between the forest ecosystem and the atmosphere in dependence of environmental variables such as soil and canopy temperature, soil moisture, vapor pressure deficit and photosynthetical active radiation (PAR).

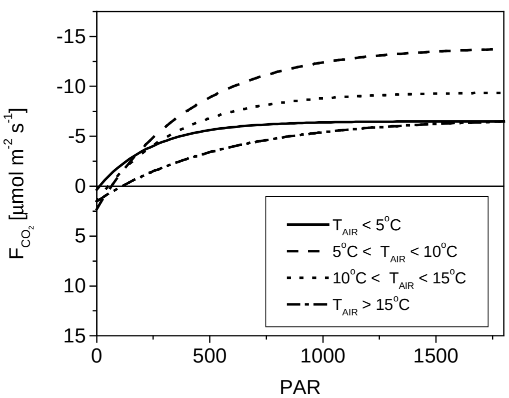

Figure 1: *CO_2-Flux as fitted function of Photo-synthetically Active Radiation (PAR) sorted by temperature class for April 1999. Optimal temperature range for ecosystem photosynthesis lies between 5-10 °C.*

2. RESULTS AND DISCUSSION

The data set into several subcategories for inter-annual comparison: (1) Summer Drought (June - August) and loss of CO_2 to atmosphere; (2)Main Uptake of CO2 (March - May) during Spring; (3) Steady State of CO2 budget in the Winter (December - February) and (4) Fall recharge period (September - November).

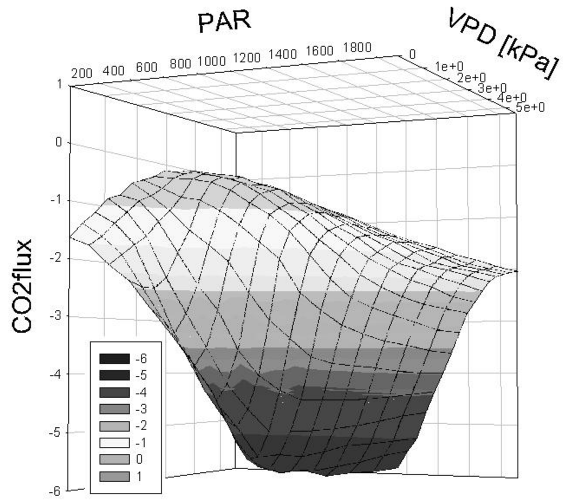

Figure 2: *CO_2-Flux as a function of PAR and Vapor Pressure Deficit (VPD) for all 1998 data, when VPD reached large values due to 78 day drought. CO_2-Flux drops off rapidly with VPD.*

The actual temporal boundaries between the different categories are not static but depend on climatic factors. The main carbon dioxide uptake period for example can extend well into June and the beginning of July if rains continue to fall and temperatures stay cool. Summers can either be hot and dry (1998) or wet and relatively cool (1999).

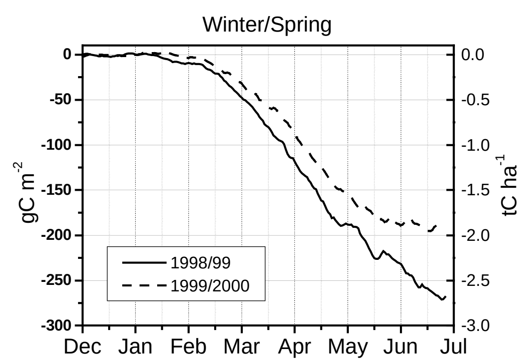

Figure 3: *Cumulative CO_2-Flux for Winter and Spring for 1999 and 2000. Late Spring '99 was cooler and net ecosystem uptake continued through July. In 2000 the uptake slowed significantly in May resulting in a shortfall of 0.7 tC ha^{-1}. Nighttime data was replaced by temperature modeled respiration when u*<0.5 m/s.*

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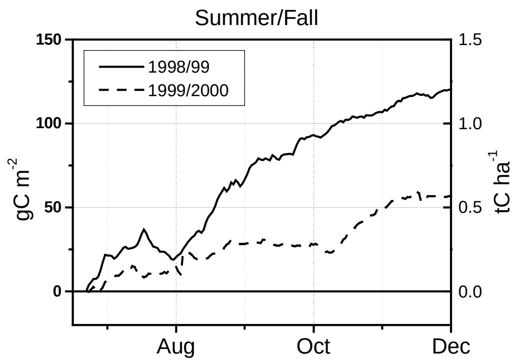

Figure 4: *Cumulative CO_2-Flux for Winter and Spring for 1998 and 1999. The El Nino Summer '98 was extremely dry and warm compared to the following year. Respiration was significantly enhance. Ecosystem Net Loss was higher1 by over 0.5 tC ha^{-1}.*

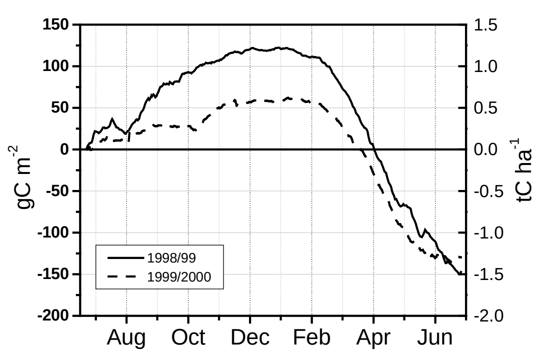

Figure 5: *Cumulative CO_2-Flux for two years, 1998/99 and 1999/2000. Net Carbon Uptake occurs during times of maximum precipitation and low temperatures from late winter to early summer. Interestingly annual NEE is almost equal for both years with 1.5 and 1.3 tC ha^{-1} $year^{-1}$. In 1998/99 increased uptake in late spring compensates for enhanced respiration the previous summer.*

The year 1998 was an El Nino period, where conditions were warmer and drier than normal. By September 1998, soils were at their driest on record, and air temperature and atmospheric vapor pressure deficit (VPD) were both large. In contrast, temperatures and precipitation in 1999 were more typical of long-term means and soil moisture was larger than for corresponding summer months in 1998. It is important to note that this coniferous ecosystem has a very different seasonality than eastern hardwood and coniferous forests.

	NEE	GEP	TER	TSR	TSR/ TER
1998/99	1.5	15.5	14.0	10.9	78 %
1999	2.1	15.2	13.0	8.7	67 %
1999/2000	1.3	18.2	16.9	10.2	60 %
2000	--	--	16.3	11.2	69 %

Table 1: *Wind River Ecosystem Exchange Components (All units are in [tC ha^{-1} yr^{-1}]). NEE: Net Ecosystem Exchange, GEP: Gross Ecosystem Productivity, TER: Total Ecosystem Respiration, TSR: Total Soil Respiration. NEE as measured by Eddy covariance at 70m, TSR as measured by Eddy Covariance at 3m and TSR calculated from a respiration temperature model derived from nighttime EC 70m data for u*>0.5 m/s.*

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)

Table 2: *Site Characteristics at the Wind River Canopy Crane Research Facility (WRCCRF).*

3. CONCLUSION

Extent and severity of the summer drought as well as spring temperature and precipitation regime are the main factors in determining respiration, evapotranspiration and photosynthetic uptake and hence ecosystem exchange with the atmosphere.

4. ACKNOWLEDGEMENTS:

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