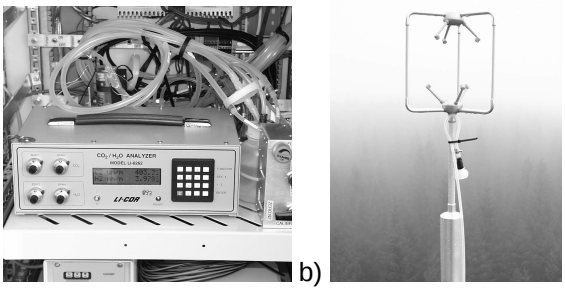
10.2. COMPARISON OF OPEN-PATH AND CLOSED-PATH EDDY COVARIANCE SYSTEM

Peter M. Anthoni*[1], Michael Unsworth[2], Beverly Law[2], James Irvine[2], Dennis D. Baldocchi[3], Olaf Kolle[1], Alexander Knohl[1], and Ernst-Detlef Schulze[1].
[1]Max Planck Institute for Biogeochemie, Jena, 07745, Germany.
[2]Oregon State University, Corvallis, OR 97331 USA
[3]University of California, Berkeley, CA 94720 USA

Micrometeorological measurements of the exchange of carbon dioxide, water vapor, and energy between terrestrial ecosystems and the atmosphere are being made at sites worldwide (e.g. the AmeriFlux, EUROFLUX and AsiaFlux networks) to evaluate responses of exchange rates to biotic and abiotic factors (Baldocchi et al., 2001). Exchange rates, measured via the eddy covariance technique are generally calculated from fast response measurements of three dimensional wind speeds and co-occuring scalar fluctuations (eg, temperature, carbon dioxide, and water vapor).

Instrumentation used at various sites is not standardized. Many flux sites in the Europian flux network use a common instrumentation setup with a Gill Solent sonic anemometer and a Licor infrared gas analyzer (often a Licor IRGA model Li-6262), which is not necessarily located near the sonic. Air from the vicinity of the sonic is drawn through a sampling tube to the Licor, where the CO_2 and H_2O concentration of the sampled air is measured. This setup is often referred to as a "closed-path" eddy covariance setup (CP) (Fig. 1).



a) b)

Fig. 1 "Closed-path" eddy covariance setup with Gill Solent R3 sonic anemometer with co-located sampling tube and the Licor Li-6262 IRGA located inside a instrument rack at the base of the tower.

*Corresponding author: Peter M. Anthoni, Max-Planck Institute for Biogeochemie, Jena, D-07745, Germany, email: panthoni@orst.edu

Another instrumentation setup is the so called "open-path" eddy covariance setup (OP), where a different IRGA design is employed; ambient air can pass freely between the IR source and detector of the IRGA. To be able to measure the gas concentration fluctuations it is essential that the open-path IRGA is located close to the sonic (Fig. 2).

Fig. 2 Open-path eddy covarianc setup with a Gill Windmaster sonic anemometer and a Licor Li-7500 open-path IRGA.

In Summer of 2000 we have compared the two approaches at a young Ponderosa pine site (trees on average 3m tall and 15-years old, 44°26' N, 121°34'W, elevation 1188 m). A Licor Li-7500 IRGA was setup near a CSAT-3 sonic anemometer (Campbell Scientific Inc., Logan, Utah) located at 12m above the surface. Air from the vicinity of the same CSAT-3 was also drawn down a sampling tube through a Licor Li-6262 IRGA located at the base of the tower. Data were recorded with a 10Hz sampling rate on a CR5000 data logger. During post-processing the exchange rates were calculated from the high frequency sonic and IRGA data for each setup. Open-path eddy covariance systems require corrections for density fluctuations in the sampled air (Massman

and Lee, 2001; Webb et al., 1980) and in general closed-path system require incorporation of a time lag and corrections for the loss of high frequency information, due to the air being drawn through a long sampling tube (Massman and Lee, 2001; Moore, 1986; Munger et al., 1996).

Fig. 3 shows the comparison of the half hour CO_2 fluxes as measured by each setup. There was generally good agreement between the measured CO_2 fluxes ($F_{c.cp} = 1.033 * F_{c.op} + 0.706$ µmol m^{-2} s^{-1}, n = 2475, $r^2 = 0.95$), but consistent small differences were evident at night, with the CP system estimating ~1.0 µmol m^{-2} s^{-1} higher respiration on average. Daytime differences between the OP and CP systems were smaller, with the CP system estimating ~0.4 µmol m^{-2} s^{-1} lower F_c during the daytime.

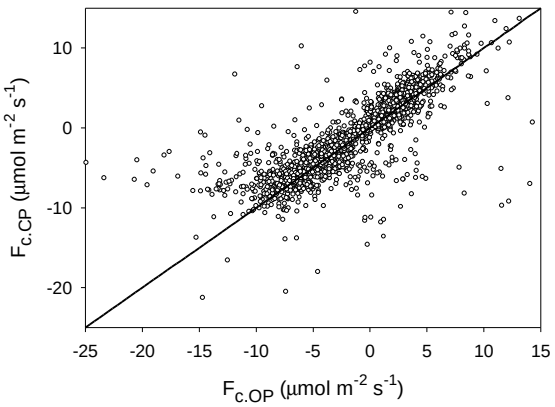


Fig. 3 Open-path ($F_{c.OP}$) versus closed-path ($F_{c.CP}$) CO_2 flux during 54 days in Summer 2000 at the young ponderosa pine site.

Overall differences between OP and CP systems appeared to be systematic and lead to a significant different estimate of cumulative net ecosystem exchange (NEE). Cumulative NEE over the 54 days was a net uptake of -33 gC m^{-2} for the CP system and -72 gC m^{-2} for the OP system, i.e. the CP estimate was 54% smaller than the OP estimate. This uncertainty extrapolated through the whole year would result in potentially different estimate of the annual NEE of up to 200-300 g C m^{-2}. Since CP systems are used by many sites worldwide and many groups start to employ the new Licor Li-7500 open path IRGA, it is important to resolve this uncertainty by conducting comparisons of instrumentation over different surface types and in a wide range of atmospheric stabilities.

References:

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