Eddy covariance measurements on a steep mountain slope

A. Hammerle*, G. Wohlfahrt, M. Schmitt, A. Haslwanter, M. Bahn, A. Cernusca
University of Innsbruck, Institute of Ecology, Sternwartestr. 15, 6020 Innsbruck, AUSTRIA, * Email: albin.hammerle@uibk.ac.at
www.biomet.at.tt

EGU General Assembly,
Vienna, 02-07 April 2006

Funding

Introduction and Objectives

Using single sets of instruments, the eddy covariance method relies on the assumption of horizontal homogeneity of fluxes for determining the vertical net energy and trace gas exchange between ecosystems and the atmosphere, which is best fulfilled in flat and homogenous terrain. Aim of the present paper, which was conducted within the EU FP5 project CarboMont (EVK2-CT2001-00125), is to test the applicability of the eddy covariance on a steep mountain slope in the Austrian Alps. Given the short stature of the prevailing grassland canopy and given that measurements are made relatively close to the surface, we hypothesised that horizontal homogeneity of fluxes should be warranted despite the appreciable inclination of the slope (25°), allowing defensible estimates of the net CO_2, H_2O and energy exchange to be obtained in a one-dimensional measurement framework. In order to test this hypothesis, eddy covariance measurements on the slope are compared against *i*) eddy covariance measurements made on a nearby flat, "ideal" site, and *ii*) net ecosystem CO_2 exchange measurement made with ecosystem chambers.

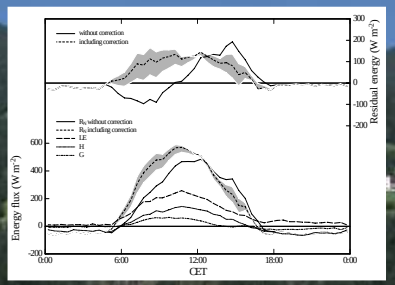

Fig. 1 Effects of correction for inclination and exposition on net radiation. Grey: ± 5° exposition.

Methods

CO_2, H_2O, and energy fluxes were measured by means of the eddy covariance technique using a three-dimensional sonic anemometer (R3A, Gill, UK) and a open-path infra-red gas analyser (Li-7500, LiCor, USA) mounted on a tower at 3 m above ground. A planar fit rotation was performed aligning the coordinate system with the mean wind streamlines.
Half-hourly fluxes were calculated by block averaging the covariance between the turbulent fluctuations of vertical wind speed and the respective scalar concentrations. Raw fluxes were corrected for changes in air density and both high- and low-pass filtering.
Net radiation was corrected for the effects of inclination and exposition of the slope (Fig. 1).

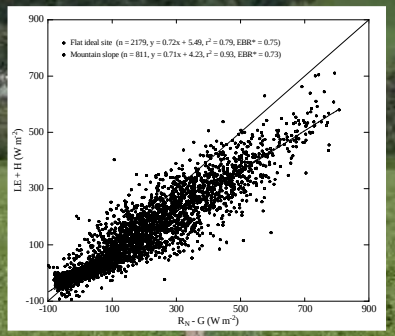

Fig. 3 Energy balance closure. * Wilson et al. 2002

Results

The wind system exhibited characteristics of a typical mountain breeze circulation, air flowing up the slope (70°) at comparably high wind speeds during daytime and flowing down the slope (300°) at comparable wind speeds during the night, the transition between these two major flow directions in the morning and afternoon being characterised by relatively lower wind speeds (Fig. 2). Turbulent energy flux measurements fell short of available energy by 29% at the mountain slope and 28% at the grassland on flat, "ideal" terrain (Fig. 3). Net ecosystem CO_2 exchange measured by the eddy covariance method agreed with corresponding chamber measurements within 19% and 2% at the mountain slope and the flat site (Fig. 4).

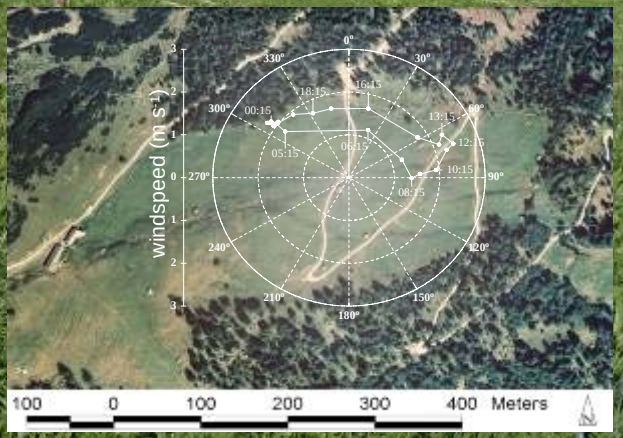

Fig. 2 Half-hourly mean of wind speed and direction.

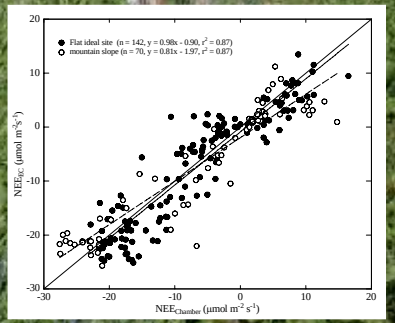

Fig. 4 Eddy covariance *versus* chamber-based NEE estimates.

Conclusion

Eddy covariance flux measurements on the mountain slope exhibited a similar energy balance closure and agreed to a comparable degree with chamber net ecosystem CO_2 flux measurements of a nearby grassland site on flat terrain. We thus conclude, that defensible eddy covariance flux measurements may be made at low measurement heights over short canopies even in steeply sloping terrain.