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Night-time CO2 budget influenced by katabatic flow in forest canopy near a mountain crest

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Systematic occurrence of advective fluxes may result in a biased estimate of CO2 net ecosystem exchange if it is based only on the eddy covariance measurements above a forest canopy. The CarboEurope site Bily Kriz (800-900 m a.s.l.) is located in the Moravian-Silesian Beskydy Mts. in the Czech Republic. The site is characterized by a planted even-aged Norway spruce monoculture, which is situated on a relatively steep (25%) but planar slope close to a W-E oriented mountain crest with a shallow saddle. Air flow at Bily Kriz is strongly influenced by the surrounding terrain, major modifications being a pronounced south-north flow channeling and local circulation patterns.

For assessing the contribution of along-slope advection to the CO2 budget, an advection experiment was organised at Bily Kriz in June-September 2004. Two-dimensional flow in the canopy was assumed, and the appropriate measurement system of the Gembloux Agricultural University was installed. It consists of two masts where vertical profiles of [CO2] and horizontal velocity components in the canopy layer are measured, and of near surface [CO2] measurements along the downslope transect. In addition, regular eddy covariance measurements at the main tower top, vertical [CO2] and temperature profiles and some complementary data were used in the study.

Except for the fog/cloud episodes with net radiation close to zero, a shallow katabatic flow tends to form in the sub-canopy almost every night. At Bily Kriz its development depends on the wind direction sector, S or N, of the above-canopy flow. Therefore a separate approach to the data analysis is needed for the south (upslope) and north

(downslope) flow. Near the mountain crest the wind direction above the canopy closely corresponds to the large-scale (synoptic) pressure gradient with the channeling effect mentioned above, and the upslope nocturnal flow is even the most frequent case at the site. Then the upslope-directed pressure perturbation force generated by the flow over the crest counteracts the negative buoyancy force and controls the appearance and depth of the katabatic layer in the canopy as well as the wind speed profile. By contrast, in the case of a downslope flow above the canopy, the development of the katabatic flow depends primarily on the vertical temperature gradient in the canopy. In principle, in both cases the occurrence and structure of the katabatic layer seems to be quite predictable.

Night-time CO2 turbulent flux measured above the canopy at the tower top is substantially lower than the ecosystem respiration. The steep slope generally implies a low CO2 storage in the canopy layer, which is confirmed by the measurements. The storage and both the downslope and the vertical CO2 advection are highly variable during the night. The Lee (1998) method results in overestimation of the vertical advection at Bily Kriz when a detailed vertical [CO2] profile and the velocity component perpendicular to the mean streamline plane (i.e. in the planar fit coordinate frame) at the tower top are used in the calculations.