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Flux Sites Revisited: New Insights From a 3D-LiDAR Survey

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Exchange processes of carbon dioxide and water vapour between the Earth's surface and the lower atmosphere are usually examined based on micrometeorological measurements from tall flux towers, thought to be representative of large area averages. A limitation of this approach is that the impact of land-surface heterogeneity at small or large scale on the fluxes is not yet completely understood. For example, structural heterogeneity of vegetation likely contributes to within-stand spatial variability in the measured fluxes. This impact is thus important to consider when examining the representativeness of a forest biome at regional, national or even global scale.

In this contribution, we present first results from an airborne LiDAR survey conducted in August 2008 at the three Boreal Ecosystem Research and Monitoring Sites (BERMS) located in the southern boreal forest, Saskatchewan, Canada (Canadian Carbon Program). The objective of this study is to determine whether within-stand canopy structural variability and local elevation changes influence carbon dioxide and water vapour fluxes, and if so, to what extent.

LiDAR data are used to determine site and forest stand characteristics such as tree height, canopy depth, canopy fractional cover, and elevation changes at very high, three-dimensional resolution (35 cm). The data reveals that even though the present sites are rather homogeneous compared to many other flux tower sites, site and forest stand characteristics vary noticeably. The impact of this within-stand variability on the fluxes is analysed with footprints describing the source area of the flux measurements. Such footprints are derived for the growing seasons of 2005 to 2007. Taking into account the prevailing wind direction during each sample period this so-called footprint climatology provides high temporal resolution spatial information on the actual sources/sinks distribution. The information is overlaid with the above site characteristics and related to measured carbon dioxide and water vapour fluxes. Results illustrate that both structure of vegetation and small changes in elevation impact net fluxes almost as significantly as meteorological driving mechanisms. These findings suggest that upscaling approaches may improve with the incorporation of within-site variability by weighting of fluxes.