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Validation of two energy balance closure parameterisations using field measurements

Fabian Eder (1), Frederik De Roo (1), Katrin Kohnert (1,2), Raymond L. Desjardins (3), Thomas Foken (2), Hans Peter Schmid (1), and Matthias Mauder (1)

(1) Institute for Meteorology and Climate Research, Atmospheric Environmental Research (IMK-IFU), Karlsruhe Institute of Technology (KIT), Kreuzeckbahnstrasse 19, 82467 Garmisch-Partenkirchen, Germany (fabian.eder@kit.edu), (2) Department of Micrometeorology, University of Bayreuth, Universitätsstrasse 30, 95444 Bayreuth, Germany, (3) Agriculture and Agri-Food Canada, 960 Carling Avenue, Ottawa, Ontario, K1A 0C6, Canada

Eddy Covariance (EC) measurements often do not close the energy balance. This indicates that surface heat fluxes are underestimated, likely because large-scale eddies and stationary circulations are not captured. Because EC is a widespread tool in environmental science to assess energy fluxes and trace gas budgets, it is essential to quantify the 'missing' fluxes. In the literature, two approaches to parameterise the lack of energy balance closure can be found. The first one by Huang et al (2008) is based on large-eddy simulations (LES) and perceives the energy imbalance as being the result of large-scale turbulent organized structures. The second approach by Panin and Bernhofer (2008) suggests an empirical approach which focuses on surface roughness heterogeneities on the landscape-scale. We tested both approaches with EC data from three sites, located in southern Germany, of the Terrestrial Environmental Observatories (TERENO) programme. Additionally, we applied the parameterisations to aircraft data from Canada, which were conducted as part of the Boreal Ecosystem-Atmosphere Study (BOREAS) experiment and the Boreal Ecosystem Research and Monitoring Sites (BERMS) programme. For each flight, the flux contribution of turbulent structures larger than 2 km, determined by wavelet analysis, serves as an estimate of the missing flux of conventional EC measurements. In most cases, the two parameterisations do not give a reliable prediction of the energy balance residual. The approach of Panin and Bernhofer (2008) disregards topographical effects, differences in surface moisture and surface temperature and thus, it cannot explain the poor energy balance closure of the TERENO sites. However, above the flat terrain of the airborne measurements in Canada, it works surprisingly well. The parameterisation by Huang et al (2008) was developed for homogeneous terrain, a condition which is almost never met in field studies. In addition, there is a general mismatch between LES and tower-based measurements: the simulations almost close the energy balance near the surface, presumably due to the too coarse grid resolution. Therefore, this parameterisation is not really applicable to typical flux measurements in heterogeneous landscapes that are usually conducted in the surface layer.

References:
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Panin GN, Bernhofer Ch (2008) Parametrization of turbulent fluxes over inhomogeneous landscapes. Izvestiya Atmos Oceanic Phys 44:701-716.