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- towards climate change services

Regional energy and CO_2 exchange over transitional grassland of Inner Mongolia - a weight-shift microlight aircraft study.

S. Metzger (1), W. Junkermann (1), L. Wang (2), K. Butterbach-Bahl (1), X.H. Zheng (2), and T. Foken (3)

(1) Institute for Meteorology and Climate Research, Karlsruhe Institute of Technology, Garmisch-Partenkirchen, Germany (stefan.metzger@kit.edu), (2) Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing, China, (3) Department of Micrometeorology, University of Bayreuth, Bayreuth, Germany

In environmental science spatial representativeness of measurements is a general problem. Often ground-based measurements can be commenced only at the expense of either scale or resolution. Airborne platforms have been shown to overcome this problem. However typical research aircraft are expensive to operate or not even applicable, e.g. in remote areas. Unmanned aerial vehicles do not yet allow a comprehensive sensor package due to payload restrictions. Here the Weight-Shift Microlight Aircraft (WSMA) can provide an alternative. After successfully applying a WSMA to aerial imagery, aerosol and radiation transfer studies, the feasibility of Eddy Covariance (EC) flux measurements in the Atmospheric Boundary Layer (ABL) was explored.

Careful calibration and validation was followed by application of the WSMA to comprehensive ABL soundings over the grassland of the Xilin River Catchment (XRC) in Inner Mongolia, China. The XRC is subject to vast human activity, which influence to capture was objective of measurements from June to August 2009. Simultaneously to the WSMA soundings, half-hourly tower EC fluxes were measured at 3 control sites, two of them non-grazed (C4 dominated Leymus, C3 dominated Stipa) and one heavily grazed (3 sheep unit $ha^{-1}y^{-1}$, HG). The idea of this setup was to a) validate the spatial representativity of process-based regional flux simulation and b) allow for scenario study of advancing grassland degradation. WSMA soundings took place around sun apex, and followed multiple repetitions of 2 to 80 km long line transects, organized in vertical stacks. Operational results at lowest flight level (50 m, AC50) averaged to fluxes of sensible heat Q_H = -177±78 Wm^{-2}, latent heat Q_E = -78±40 Wm^{-2} and carbon dioxide Q_C = 0.02±0.2 mg CO_2 $m^{-2}s^{-1}$ throughout the campaign. At a radiation budget Q_{S*} = -412±86 Wm^{-2}, which was 16 % lower than the control sites, the energy balance from AC50 measurements was closed to 72±18 % on average. AC50 measured Q_H was found comparable in magnitude to the HG control site, whereas Leymus and Stipa sites were 30 % higher on average. The magnitude of Q_E was comparable to the Leymus site, Q_E from Stipa and HG were ≥35 % higher on average. AC50, Stipa and HG measurements indicate marginal CO_2 release / uptake, only Leymus displayed notable CO_2 assimilation (-0.07±0.3 mg CO_2 $m^{-2}s^{-1}$). The chronology of AC50 Q_H , Q_E , Q_C measurements throughout the campaign correlated best to Stipa, Stipa / HG and Leymus site, respectively. Ceilometer backscatter and radiosonde data allowed to determine the ABL height (1860±680 m) and to estimate the average Q_H VFG throughout the ABL (-0.12±0.08 Wm^{-3} campaign average). Stacked patterns however show that the Q_H VFG throughout the surface layer was significantly enhanced and more variable with -0.19±0.38 Wm^{-3}, indicating possible development of internal boundary layers. Consideration of stacked pattern VFGs during post-processing should improve comparability to control sites and the closure of energy balance.

This study shows that the WSMA, which can be easily shipped to and operated from remote places, provides a suitable tool to close the gap between local and spatial measurements.