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A thorough comparison of simultaneous observations of the temperature structure parameter by scintillometers, sonics and unmanned aircraft

Miranda Braam (1,2), Frank Beyrich (1), Arnold Moene (2), Bram van Kesteren (1), Jens Bange (3), Andreas Platis (3), Sabrina Martin (4), and Björn Maronga (5)

(1) Deutscher Wetterdienst, Meteorologisches Observatorium Lindenberg, Tauche - OT Lindenberg, Germany (frank.beyrich@dwd.de), (2) Wageningen University, Meteorology and Air Quality Group, Wageningen, The Netherlands, (3) Eberhard Karls Universität Tübingen, Zentrum für Angewandte Geowissenschaften, Tübingen, Germany, (4) Technische Universität Braunschweig, Institut für Geoökologie Klimatologie und Umweltmeteorologie, Braunschweig, Germany, (5) Leibniz Universität Hannover, Institut für Meteorologie und Klimatologie, Hannover, Germany

In recent years large aperture scintillometers (LAS) have been increasingly used to determine the path-averaged surface fluxes of sensible heat. The basic parameter derived from LAS is the structure parameter of the refractive index of air (Cn2). It can be linked via the structure parameter of temperature (CT2) through a non-linear relationship to a path-averaged surface sensible heat flux using similarity theory. While several studies have proven the reliability of the LAS based sensible heat fluxes over different types of terrain, an independent experimental validation of CT2 along a LAS path has not been reported so far.

During the LITFASS-2009 experiment we made high-resolution temperature measurements with the unmanned meteorological mini aerial vehicle (M2AV) along a LAS-path. First results for a single case study of comparing CT2 obtained with the M2AV and with the LAS were presented at a previous conference, they showed a tendency of overestimating CT2 by the aircraft with respect to the scintillometer. We have now analyzed a larger data set comprising M2AV flights performed during seven days in 2009 and in 2010. Moreover, we applied a more elaborated data processing to both types of data, this includes a translation of all measurement data to a reference height, the reduction of the averaging time for the scintillometer data to exactly match the duration of the flights, a correction of the scintillometer signal for saturation, the proper treatment of the effect of humidity on the refractive index, the use of alternative methods to derive the structure parameter from the M2AV data, and the application of the scintillometer path-weighting to the M2AV data. As a side-effect of this analysis we are able to evaluate the relative importance of these elaborate data processing options for derived CT2. For comparison, we also determined the temperature structure parameter from two sonics operated at heights of 50 m and 90 m on a meteorological tower.

We conclude that the differences found in the former case study occur for the other measurement days as well. The more elaborate data analysis does affect the CT2 values of all systems, it partly reduces the discrepancy between the systems, but it can by far not explain it. Using LES we additionally considered possible limitations of the sampling strategy and we also investigated uncertainties in the determination of Cn2 from the scintillation measurements depending on the data processing.