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Uncertainty analysis of analytical flux footprint models

Anneke van de Boer (1,2), Alexander Graf (3), Arnold F. Moene (1), and Dirk Schüttemeyer (2)

(1) Meteorology and Air Quality Group, Wageningen University, The Netherlands (anneke.vandeboer@wur.nl), (2) Meteorologisches Institut der Universität Bonn, Germany, (3) Agrosphere (IBG-3), Forschungszentrum Jülich, Germany

During the last decade, a growing number of footprint models have been developed to estimate the source area for measured surface fluxes. While a large part of recent progress is focused on advancements in the numerical treatment of complexity, analytical or parameterized models still are used most in practise to operationally determine whether the source area of the measurements is representative. These models may be expected to perform best in a flat landscape with small differences in roughness length. Ideally, the measured fluxes themselves would also be homogeneous to fulfil all assumptions underlying analytical models. However, spatial contrasts in at least one flux are a prerequisite not only to the need for footprint models, but also to their validation with natural tracer experiments.

In this study, eddy covariance flux measurements from a flat heterogeneous landscape dominated by three land use types are presented. Three EC-stations were positioned in a wheat, barley and sugar beet field, with 3D sonic anemometers and open-path infrared gas analyzers at 2.5 m and 6.0 m height. A seventh equipment was installed near the boundary between the barley and the sugar beet field. We use the models of Hsieh et al. (2000) and Kormann and Meixner (KM, 2001) to calculate the contribution of each land use type to each station. The Gaussian crosswind dispersion from KM is used for both models. The results of both models, as well as of different ways to obtain input data such as roughness length and stability, are compared to each other.

Results show that the KM and the Hsieh model predict footprints of similar magnitude with some minor differences in the shape and the weight of parts of the footprint. The relative contribution of each land use type following from the combination of the model output and a land use map is sensitive to the resolution of the land use map. An effort to validate both models by predicting the fluxes obtained at the station with a heterogeneous footprint from fluxes measured at stations with a sufficiently homogeneous footprint indicates that in many cases the models may have predicted too large footprints. We discuss these findings against the background of existing literature evidence on footprint model validation. We also discuss implications for any effort to derive flux estimates from multiple point measurements above a heterogeneous landscape, a detailed example of which will be given in a companion poster.

References

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