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Discussions

Interactive comment on "A modified micrometeorological gradient method for estimating O₃ dry deposition over a forest canopy" *by* Z. Y. Wu et al.

Anonymous Referee #3

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The authors present a modified micrometeorological gradient method (MGM) to infer trace gas fluxes from gradients, which should overcome the problem of very small gradients above the canopy. The small gradients above canopy require high sensitivity and accuracy of the sensors when using the aerodynamic gradient method (AGM) or the modified Bowen ratio method (MBR). To increase the gradient a level below canopy top is included in the gradient calculations as the canopy is a substantial sink (or source) for many trace gases. The authors use a 7 years data series of parallel measurements of O3 fluxes measured by eddy covariance (EC) and trace gas profiles to test their method. A well-known problem for inferring fluxes within tall canopies are so called counter gradient fluxes, which means the turbulent flux is in the opposite direction than implied by the gradient. Roughly 70 % of the available data was rejected because of the occurrence of counter gradient fluxes (74 % rejected in total). For the remaining 26 % of the data points there was an overall agreement of all methods on the diurnal cycle, but flux-gradient methods gave larger values of the deposition velocity (factor ∼1.2 to 2.3) than EC. Best agreement was found between EC and MGM, with the MGM derived deposition velocities being on average about 20 % larger than those derived from EC measurements.

General comments:

Deposition velocities are commonly used to parameterize deposition in models. Direct EC measurements of reactive species like O3 or often not available or just made during campaigns. Therefore, methods that infer deposition velocities from profiles, which are more often acquired by long term measurements, are a valuable contribution to atmospheric sciences. However, this method replaces the problem of the small gradients above canopy by a more complex calculation that has to deal with height dependent fluxes within the canopy. Although the method proved to give similar results as the EC-method (based on the ∼ 25 % of data left after the selection process) I would recommend some further analysis before publishing. Of special interest would be an evaluation of the meteorological conditions that lead to the most or least fraction of rejected data. The authors should as well extend the discussion on the underlying dynamical processes of turbulent motion at canopy top. The occurrence of coherent structures that penetrate the canopy causes a deviation from flux-gradient relationship and counter gradient fluxes (Denmead and Bradley, 1985). Therefore, I assume that excluding counter gradient data will remove most of the periods where the transport is influenced or even dominated by coherent structures. The detection of coherent structures has been used to qualitatively describe the coupling of the different canopy layers (Thomas and Foken, 2007). Furthermore, efficient vertical trace gas transport from the forest floor throughout the canopy has been linked to coherent structures (Sörgel et

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al., 2011; Foken et al., 2012; Zeeman et al., 2013). I wonder if this effect will cause a bias towards lower fluxes as there might be more frequent cases with a decoupled sub canopy that otherwise contributes to the flux as well (O3 at or within the ground is zero). Are the deposition velocities scaled to the same O3 concentration (reference height)? This would mean that the fluxes are overestimated by all gradient methods. Any reasons for this behavior? The authors report that the model (with a given LAI-profile) is most sensitive to changes in the wind speed attenuation coefficient and displacement height (d). As the roughness elements (tree-crowns) are inhomogeneously distributed, do you expect a dependence of these values on wind direction? Furthermore, d has been reported to be stability dependent as well (Zilitinkevich et al., 2008; Zhou et al., 2012). Might this be a reason why MGM overestimates fluxes during night?

Specific comments:

P785 L9: As this is a basic assumption one should mention here that Baldocci (1988) says that based on the work of Bache (Bache, 1986), his measured SO2 profile and the more theoretical considerations of Corrsin (1974) he"...suggests that 'K-theory' models may be valid for estimating SO2 exchange in tall vegetation because the length scales of the turbulence are probably smaller than the distances associated with changes in the concentration and wind speed gradients." This means, that this assumption is not proven it's just plausible.

P790 L 5: From Fig. 3 it seems that photochemical O3 formation is still dominant until the early afternoon (O3 maximum). Furthermore, what about reactions that eliminate O3. I.e. reaction with NO and unsaturated VOCs.

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