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Atmospheric
Measurement
Techniques
Discussions

Interactive comment on "An automated system for selective and continuous measurements of vertical Thoron profiles for the determination of transport times near the ground" *by* D. Plake and I. Trebs

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General comments:

The authors describe a new measurement system for direct determination of in-canopy (near-surface) transport times and resistances in the field using vertical Thoron profiles. Although the benefits and basic measurement principles of this technique are already well understood, a number of practical issues have limited the accuracy and quality achieved in previous applications. The measurement system described and applied in

this study is designed to remove or alleviate many of these issues, and the authors provide an excellent demonstration of its success via a thorough and exhaustive analysis of systematic and random uncertainties applied to a carefully designed set of field measurements. The resultant conclusions regarding the performance of the new system are highly convincing, and the subsequent comparison of results with common canopy resistance formulae appears to reveal shortcomings in established model parameterizations. This manuscript represents a substantial contribution to scientific progress within the scope of AMT. The scientific methods used are appropriate, thorough and well discussed. Furthermore, the results are well structured and presented, the number and quality of figures / tables are appropriate, and the conclusions are clear and concise. There are a few minor issues listed below which I believe would improve the manuscript. Once these are addressed, I recommend immediate publication.

Answer: We thank the referee for the excellent evaluation of our manuscript.

Specific comments:

Comment: 1. The manuscript is a little too long relative to its content. This is partly due to repetition of descriptions between the system characterization/ determination of uncertainties sections in the Methods (2.4, 2.5 and 2.6), and the corresponding sections in the Results (Sections 3.1 and 3.2) and Discussion (Sections 4.1 and 4.3). Although I don't have any specific suggestions, I do feel that with a bit of effort the manuscript could be shortened and clarified by attention to these sections.

Answer: We will edit the manuscript again and the repetition between system characterization and the determination of uncertainties/results sections will be removed in the final version.

Comment: 2. The discussion of transport characteristics within the three canopy layers of different depth (Section 3.4, Figure 9) is greatly confused by the insistence on using transport times (tau) which depend critically on the layer depth. The authors should consider presenting the results in Figure 9 as resistances (tau/h) rather than transport

times, thereby removing the effects of layer depth differences so that the discussion can focus more clearly upon the physical processes. This will also make the job of comparing results with the model formulations in Section 4.2 easier.

Answer: Since this publication deals with the determinations of transport times and, consequently, addresses Damköhler numbers to investigate the influence of chemistry on measured fluxes and concentrations above the canopy, we would like to use and interpret absolute numbers of transport times rather than resistances. In addition, the normalization to resistances would remove the influence of the chosen measurement heights, which, however, is subject of discussion in our paper.

Comment: 3. Although I understand that this paper is mainly about the technique and its accuracy, I would have liked to see a little more discussion of the possible physical reasons for the observed differences in the diurnal variations of transport times (or use resistances, as discussed above) at different heights in Sections 3.4 and 4.2. In Section 4.2, for example, the authors note transport times inside the canopy at night that are smaller than predicted by the Personne et al. (2009) parameterization. These are attributed to unstable temperature profiles that they observe within the canopy at night. This is an interesting finding in itself, and would benefit from a slightly longer discussion and perhaps a couple of literature references (have others found this?). Also, there was no mention of such physical effects in the discussion of the time series of calculated transport times (or resistances: see above) in Section 3.4.

Answer: Indeed, previous studies have found very similar effects inside canopies (e.g., Jacobs et al., 1994; Nemitz et al., 2000). However, since this publication is a technical paper introducing and describing our measurement system we do not think it is appropriate to include a detailed interpretation of the results. A future publication about turbulence-chemistry interactions within low plant canopies will deal with this subject in detail.

Technical corrections: Listed below are a number of specific minor corrections that I

believe would improve the clarity and readability of the manuscript.

Comment: P2 L6-8: Rewrite sentence as “The two isotopes . . . and 222Rn (Radon), are generated in rocks and natural soils, where their respective mother nuclides . . . occur as common radioactive atoms”.

Answer: The suggested change was made.

Comment: P2 L20: Change “which are sources” to “which act as sources”.

Answer: The suggested change was made.

Comment: P3 L15-17: Rewrite 2 sentences as: “In contrast, . . . to the ground, where its concentration is determined by the competition of transport and the fast radioactive decay. In contrast, Rn decay can be neglected in this layer because of its longer half-life”.

Answer: The suggested change was made.

Comment: P3 L19: Change “Tn. . Consistently, Lehmann” to “Tn. Lehmann”

Answer: The suggested change was made.

Comment: P3 L20: Remove “) to be 28 cm (“

Answer: The suggested change was made.

Comment: P3 L22: Add “to be 28 cm” between right bracket and full stop.

Answer: The suggested change was made.

Comment: P4 L12 & L15: Change “instationarities” to “non-stationarities”.

Answer: The suggested change was made.

Comment: P5 L15: Change “conditions” to “to be monitored”.

Answer: We believe that this is a misunderstanding. Measurements with the RAD7

must be made at atmospheric pressure (in accordance with the manufacturer). That was achieved by the open bleed line at the outlet of the RAD7.

Comment: P6 L15: Change “2,5” to “2.5”. Change “4,0” to “4.0”. P 7 L6: Change “pursued with” to “proceeded in”.

Answer: The suggested change was made in the MS-Word manuscript. The *.pdf file published on the AMTD web page does not have the “,”.

Comment: P14 L6: After “120 s.”, I suggest adding something along the lines of “Temperature measurements indicated that the reduced transport times in the lower canopy at night may be associated with unstable temperature profiles very near the surface (not shown)”. Are these sonic temperature measurements from the 2D anemometers?

Answer: The suggested change was not made because this explanation is mentioned in section 4.2. The authors did not use the 2D sonic anemometer temperatures. In section 2.2 we describe a vertical thermocouple profile. This thermocouple profile was set up next to our inlets.

Comment: P14 L6-8: So why not report / plot these time series results as resistances? (See Point 2 under “Specific comments” above).

Answer: See answer above in “Specific comments”.

Comment: P14 L26: Change “instationarities” to “non-stationarities”.

Answer: The suggested change was made.

Comment: P16 L12: Change “prize” to “price”.

Answer: The suggested change was made.

Comment: P16 L14-15: Rewrite sentence as “However, it has to be kept in mind that the analyzer precision is not sufficient for the low Tn and Rn concentrations found at the surface at many sites, and higher than a few metres above the surface at all sites”.

Answer: The suggested change was made.

Comment: P16 L26: Delete “exemplarily”.

Answer: The suggested change was made.

Comment: P17 L3-4: Rewrite as “. . . Km(hc) the eddy diffusivity coefficient at hc (Km=kappa*ustar*(hc-d)), kappa the von-kàrmàn constant, . . .”.

Answer: The suggested change was made.

Comment: P17 L11: More detail required as to how LAI was estimated by “canopy harvest”.

Answer: We have inserted more details like “biomass harvest and photographic imagery of subsamples (harvested area: 0.29 m2)” in the manuscript.

Comment: P17 L11: Add “ustar, z0s, z0, d, L, Psi_H and Psi_M were estimated using standard micrometeorological techniques (REFERENCE)”. Is this correct?

Answer: The suggested change was made. Yes, this is correct.

Comment: P17 L11: What value was used for alpha_u? (REFERENCE)

Answer: The authors used the value 4.2 as stated in the model description paper (Personne et al., 2009).

Comment: P17 L22: Change “measured temperature profiles” to “measured sonic temperature profiles from the 2D anemometers”. Is this correct? (I’m only guessing).

Answer: No, this is not correct. See answer about the temperature measurements above. The change was not made.

Comment: P19 L1: Delete “exemplarily”.

Answer: The suggested change was made.

Comment: P19 L23: After “total uncertainty” add something like “In other words, when

the Tn concentration at the upper measurement point is very small, the error in the calculated value of tau is dominated by errors in the upper measurement".

Answer: The suggested change was made.

Comment: Figure 3: Add a horizontal line at 0.6m indicating the mean canopy height.

Answer: The suggested change was made, but differently. The authors did not add a horizontal line but a schematic drawing of the canopy instead. Additionally, the two periods which are further analyzed in the manuscript are marked.

References

Jacobs, A. F. G., Vanboxel, J. H., and Elkilani, R. M. M.: Nighttime Free-Convection Characteristics within a Plant Canopy, Boundary-Layer Meteorology, 71, 375-391, 1994.

Nemitz, E., Sutton, M. A., Gut, A., San Jose, R., Husted, S., and Schjoerring, J. K.: Sources and sinks of ammonia within an oilseed rape canopy, Agricultural and Forest Meteorology, 105, 385-404, 2000.

Personne, E., Loubet, B., Herrmann, B., Mattsson, M., Schjoerring, J. K., Nemitz, E., Sutton, M. A., and Cellier, P.: SURFATM-NH3: a model combining the surface energy balance and bi-directional exchanges of ammonia applied at the field scale, Biogeosciences, 6, 1371-1388, DOI 10.5194/bg-6-1371-2009, 2009.

Interactive comment on Atmos. Meas. Tech. Discuss., 6, 867, 2013.