**Hydrology and
Earth System
Sciences
Discussions**

Interactive comment on "Footprint issues in scintillometry over heterogeneous landscapes" *by* W. J. Timmermans et al.

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Referee Comment on ' Footprint issues in scintillometry over heterogeneous landscapes', by W. J. Timmermans, Z. Su, and A. Olioso

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The paper needs major modifications before it can be accepted for publication. The general comments are given below followed by some specific points both in this document and in the supplement of this review.

General comments:

The paper discusses the impact of footprint contribution of complex land surfaces with different sensible heat fluxes from each component land patch to the sensible heat flux measured by LAS, both by simulation and by experimental field data. This subject is very interesting and innovative.

However, problems are seen in the way that the simulation was setup and the way of evaluating the experimental data, which in turn has an influence on the results and conclusions drawn (see specific comments below).

The paper structure needs some re-arrangement, it is suggested to separate clearly the descriptions of the general approach, the simulation schemes, and the schemes for the tests on the experimental data (see specific comments both below as well as in the supplement file).

English writing needs to be refined, in particular, sentences are often too long and not written in a scientific manner. Precise descriptions on approach and the data collections are expected (see also the specific comments below).

Specific comments:

1. Section 2.3 Footprint implication

Since the consideration of 'source area' contribution to the LAS measured heat flux by incorporation with a footprint modeling is the innovative point of this paper, it would be useful to describe in more detail how the modeled footprint was combined with the weighting function of the LAS to calculate the new 'weighting factor' rfpj.

To calculate the reference heat flux, the authors have applied the same weighting factors as those for LAS measurements to the component surface fluxes (Eq. 21), this is conceptually not correct. While the simulated as well as the measured LAS heat flux is determined both by the scintillometer response function (as presented by W(u) in Eq. 2) and the footprint of the LAS measurements (by the way, these two terms are differ-

ent, see below for clarification), the integrated reference heat flux is the inherent nature of the surface and is not relevant to the LAS response function. It could be calculated by weighting the flux of each component by the areal fraction of each component that is fallen in the LAS footprint. The definition of reference flux taken by the authors (Eq. 21) may have led to the self-correlation in the results shown in Section 3 (also see the comments on section 3 and Fig. 1 below). [The weighting function (W(u)) of LAS signal is more related to the inherent properties of scintillation than being the result of the heterogeneity of the surface heat fluxes, though the latter does have impact on the integrated heat flux. It can be interpreted as the response function of the measured structure parameter of air by scintillation along the path length, no matter the surface is heterogeneous or not.]

2. Section 3 Simulation

The simulation setup was not very well described, it was very hard to follow. In section 3, four aggregation approaches were proposed and tested with the simulation data. The authors have commented that the large difference (Fig. 1 a and e) between the average sensible heat flux from the aggregation approach 1 (say by Lagouarde et al 2002a) and the reference sensible heat flux is due to the fact that 'a linear weighing based on the contributing area is assumed' to give the reference sensible heat flux. The authors therefore proposed a correction on the estimate of reference sensible heat flux by applying the weighting factors of the two components derived from the combination of LAS weighting function and the footprint modeling. This does not sound robust (see comments above for 'Section 2.3 Footprint implication').

Page 2110, line 8 – 20: this paragraph need a careful re-writing, it is confusing as it is now.

Fig. 1.: The caption of Fig. 1 is not sufficient, it was very difficult to understand the simulation results shown in the figures. It is suggested to give more explanations in the caption of Fig. 1 and indicate abbreviations of simulation schemes in the figure.

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Page 2110, Line 13 – 20 and Fig.1 d and h: The authors have stated that: 'When finally taking the weighting function into account for aggregating the aerodynamic properties the errors reduce to zero, see Fig. 1d. and h, meaning that the nature of the scintillometer measurements is properly simulated'. The aggregation approach proposed by the authors is not only applied to the integration of aerodynamic properties, but more importantly for the aggregation of the spatially averaged structure parameter <Cn2>. The improved results could be due to better aggregations of both. As commented above, the results of 'zero errors' need be checked for 'self-correlation' due to the inadequate approach from which the reference heat flux was calculated.

Page 2110, line 21-27: It is not clear what was written in this paragraph. The major difference between the two methods by Lagouarde et al (2002a) and by Ezzahr et al (2007) respectively is that L-method estimated the areally aggregated <Cn2> by weighting values of component Cn2 according to scintiilometer weighting function so that it has to deal with the non-linearity of the Cn2 along the path; while the Ezzahar method <Cn2> was directly calculated from component Cn2 that avoided the above mentioned non-linearity in Cn2. It is suggested to refine this paragraph.

3. Section 4 SPARC2004 Experiment

It would be easy for readers to have an outline of the experiment and the data used in the study if a table can be included to give a summary of relevant measurements and fields.

Page 2113, line 20: A constant available energy flux (450Wm-2) was used to derive LAS sensible heat fluxes for all the 69 intervals of measurements that might not be necessary to be under the similar solar radiation conditions, neither available energy flux. Though the accuracy of available energy flux is not as important as other parameters, taking the sole value of available energy flux for any time of a day does not sound reasonable since it may vary significantly during a day.

Page 2115, Section 4.3 Results: The caption of Fig. 3 needs to be refined. More infor-

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mation needs to be included. It would be useful to give a figure showing the sensible heat fluxes measured by the EC systems over the three land surface types to give a general idea what the magnitudes are and how different are the fluxes from different surfaces. As can be understood in Fig. 2, under the case of 1D and two components, the LAS beam was assumed to overpass vineyard and wheat-stubble fields. The ratio between the two components along the LAS path were not given in the paper. The LAS beam went through three types of surfaces with very different sensible heat fluxes, the authors didn't show the simulated footprint of the LAS under different atmospheric conditions (both the wind directions and the stabilities). Analysis and discussions were less relying on the quantitative footprint modeling results, the latter is important for such a complex land surfaces composite. The way that reference sensible heat flux was estimated is still a problem as indicated above.

4. Section 5 Discussion

The authors have stated that the unrealistic results were partly caused by the fact that stable conditions were included in the calculation. Such conclusion would have been more confident if the stable conditions could have been excluded in the analysis. However, this might have not been the only reason if one looks at Fig. 4 in which the significant overestimate of the simulated H over the reference values is still quite obvious for many cases that were under unstable conditions .

It was stated by the authors that the large discrepancies between the simulated LAS sensible heat fluxes and the reference fluxes were probably partly attributed to incorrect flux measurements by the three eddy correlation systems, however there was no evident for such a argument. Such argument would lead one to think about the reliability of measured heat fluxes by the ECs that were used for the whole analysis. A more appropriate explanation is expected here.

The caption in Fig.5 needs to be refined.

It is not indicated which aggregation scheme was used in producing the results in Fig.

5a and b, and what were the surfaces considered in calculating the ratio?

5. Section 6 Conclusions

The authors have stated that 'The soundness of the method is demonstrated by reproducing simulated component fluxes by model inversion'. This was not discussed in the paper.

According to the authors the disagreements (mainly overestimates) between the simulated and reference sensible heat fluxes were attributed to the 'nature of the available data' that is the observations under stable conditions were also included in the analyses. However, there was no discussion on the energy balance closure associated with turbulent heat fluxes measurements by the three EC systems which often was documented to yield severe underestimates of both sensible and latent heat fluxes.

Please also note the Supplement to this comment.

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