Reply to:

"Interactive comment on "Footprint issues in scintillometry over heterogeneous landscapes" by W. J. Timmermans et al. By Anonymous Referee #1"

First of all we would like to thank the reviewer for the comments and suggestions, which have been very helpful. The paper has been substantially revised following the suggestions of both reviewers. We have modified the figures and the main text to address both reviewer's questions and concerns.

Please find below the numbered interactive comments made by reviewer 1, between quotes followed by our responses in italics.

General comments: The heterogeneity of land surface is a significant problem faced by the applying of LAS observation and validation of surface fluxes estimated from remote sensing with ground measurements. The objective of this paper is to verify different aggregation methods based on EC and LAS measurements, as well as footprint model. However, the analysis of this paper is not comprehensive; more substantial improvements need to be done before its publication.

The authors thank the reviewer for his/her comments. We have substantially improved the manuscript by following the reviewers concerns and are confident the paper now more clearly conveys the study's objectives and conclusions. Please see below for specific comments.

Major comments:
1. When EC and LAS measurements are constructed over heterogeneous surfaces, the measuring errors are inevitable, so rigorous post processing is needed. The author neither indicates the data processing of EC and LAS measurements, nor how about the data quality of the data used, so the results are suspicious.

We have added additional information on the data processing for the EC and Las systems in section 4.1. In addition extra lines on the post-processing, yielding the 69 observations for the current study are provided in the same section.
Moreover, the experiences with this particular instrument at INRA since 2000 with a continuous monitoring of an agricultural field showed that problems in flux integration was not critical for the calculation of H only (which is very different for the computation of LE and CO2 flux). For the Campbell CA27T, 1D sonic anemometers the nominal calculation procedure given in the CA27 instruction booklet is followed which relies on a 10 minute covariance calculation with a 10Hz scanning time. We have been using this model for more than 20 years and we had several occasions to check that this integration procedure is working without problem even if none of the very complex calculation procedures applied over more advanced 3D anemometer measurements currently in use in many of the flux measurement networks (note that in this case, the 30 minute integration time is not only a question of signal wavelength to catch, but also related to the required integration time for applying all of the required correction for LE and CO2 flux calculations). Comparison to other H flux calculation and by means of water balance integration

over longer period have been usually successful (see in particular Cellier and Olioso 1993, Ortega et al. 2004). Please also notice that the H flux calculation with the two types of instruments 1D - CA27 and 3D - Young were compared for 2 years over the INRA experimental site without noticing large discrepancies.
Summarizing, we are confident in the use of the 3D and 1D anemometer in Barrax.

2. It is stated in this paper that the EC data used were 10min averaged, but from the principle of EC system, 30min interval is the optimum averaging time.

The reviewer is very correct here in remarking that the 30 minute time interval is considered the optimum averaging time (Foken, 2008). For the current study this is also examined by processing the EC data over the vineyard using 10, 30, and 60 minute intervals. Possible low frequency losses resulting from too short an integration time (10 min) could be ruled out as the longer integration times did not bring about any significant increase in flux estimation, see also Su et.al. (2008). Over the wheat and corn site for the days of the current experiment a 10 minute averaging interval was chosen. For the sake of proper comparison therefore also the 10 minute averaging interval data is used from the vineyard (EC and LAS). A remark is added in the revised manuscript with respect to this issue.

3. The paper indicate the LAS measurements cannot discriminate the direction of sensible heat flux, but the author make no judgment on the atmosphere stability, so some data under stable conditions may be included in the analysis, such as the circled points in Fig.4a.

Indeed the analysis was carried out on a dataset which for certain time periods had both stable and unstable conditions in the footprint of the scintillometer, which has an effect on the final results, as demonstrated in Figure 4.a. This is recognized as one of the main reasons for deviations between reference fluxes and aggregated fluxes in the Discussion section.

4. In the “Discussion” part, the author analyzed the reasons of the difference between Href and Hsim. Besides aggregation methods, the fluxes for components that were not covered by EC, incorrect component fluxes because of different source areas of EC and LAS, etc, there are still other reasons, such as measuring errors of EC and LAS, the existing of large eddies which cannot captured by EC (Von Randow et al., 2008), how about the heterogeneity of the surface layer.

With respect to the measurements errors we have minimized these after careful analysis which is added in the revised manuscript in section 4.1. Concerning the large eddies; the reviewer is very correct here, this is a well-known phenomenon. We have also looked at that and added some remarks in the revised manuscript, see also points 1 and 2. Several references have been added as well.

5. The author considers the single landcover as “pure” or “homogeneous”, but in fact, the heterogeneity of soil condition or surface temperature should be explained using thermal infrared satellite imagery (Hoedjes et al., 2007). This may be one of the reasons caused the discrepancies between Hlas and Href in Fig.5a.

The reviewer is correct here once again. In the original manuscript we had recognized this effect and already referred to the suggested paper (p2117, line 2) for determining not only within EC footprint variations but also for providing additional information on landcover units that were not covered by EC systems. Unfortunately not for every day in the experiment this type of thermal data was available. We have added an extra comment on this topic in the Discussion section.

6. The author only gave limited dataset, only 69 datasets, to get the results, so the analysis is not reliable enough.

After the post-processing of the observations made during the SPARC 2004 campaign (effectively 7 days) a visual check was performed and spikes removed. Despite the different footprints of the several instruments, a cross-checking was performed to further remove observations that showed unrealistic large deviations. Part-time instrument failures further reduced the final dataset to 69 observations during which the LAS as well as all three sonics were providing good quality observations. Naturally, longer-term monitoring will provide a stronger statistical base, but these are typically not possible during short-term intensive campaigns. Currently, continuous flux monitoring is being carried out simultaneously using EC and LAS apparatus (Su et.al. 2009) to provide a longer times series. However, after careful analysis, we feel quite confident that the observations used were of good quality, as such providing a proper base for the analysis made. Additional information is now added in the revised manuscript.

7. Fig 1, 3, 4, 5 are not clear and hard to read, it would be better to indicate the data source and method used in the graph.

The figures have been adapted and additional explanation is provided in the captions.

References:

Cellier, P., et Olioso, A., 1993. A simple system for automated long-term Bowen ratio measurement. Agricultural and Forest Meteorology, 66, 81-92

Hoedjes J.C.B., Chehbouni A., Ezzahar J., Escadafal R., de Bruin H.A.R., 2007. Comparison of large aperture scintillometer and eddy covariance measurements: Can thermal infrared data be used to capture footprint-induced differences. Journal of hydrometeorology 8: 144-159.

Ortega-Farias, S., Olioso, A, Antonioletti, R., Brisson, N., 2004. Evaluation of the Penman-Monteith model for estimating soybean evapotranspiration. Irrigation Science, 23, 1-9.

Von Randow C., Kruijt B., Holtslag A.A.M., de Oliveira M.B.L., 2008. Exploring eddycovariance and large-aperture scintillometer measurements in an Amazonian rain forest. Agricultural and forest meteorology 148: 680-690.