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Discussions

Interactive comment on "High-resolution estimation of the water balance components from high-precision lysimeters" *by* M. Hannes et al.

M. Hannes et al.

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Reply to the comments (Referee 1)

We would like to thank the reviewer for the valuable and constructive comments and suggestions which helped us to improve the paper. We have addressed all the comments and suggestions in our response letter and adapted the revised version of the manuscript accordingly. In the following, we provide detailed answers to all comments and suggestions.

However, I found the paper describing a technical procedure with little advances in terms of science. Therefore, I found the paper more appropriate as technical note instead of scientific

paper.
We agree with the reviewer that the paper is of very technical, however, for the large lysimeter community, of very relevant nature. The length of the paper required to explain the filtering procedures exceeds the length of *a few pages* as requested in the HESS guidelines for a Technical Note. When submitting the paper, we were inspired by the recent HESS paper by Peters et al. (2014) which is of similar technical nature and was also published as a regular research paper of comparable length. We think that the paper cannot be shortened substantially without losing the required justification and demonstration of the proposed method. In order to inform the reader early about the rather technical content of the paper and not to raise false expectations, we changed the title to "A comprehensive filtering scheme for high-resolution estimation of the water balance components from high-precision lysimeters" and revised the abstract accordingly.

1) The first question raised in my mind is related to the costs. It is shown in the paper that lysimeters can be very useful for estimating high-quality rainfall, evapotranspiration and drainage fluxes, also with high temporal resolution. However, I was wondering what are the costs of a lysimeter measurement system? I believe that a network of 18 lysimeter sensors is quite expensive, but likely I am wrong. How do they compare with standard raingauge or eddy-covariance sensors? What are the maintenance costs? What is the actual applicability of lysimeter data for hydrological applications? I would like the authors address some of these questions in the paper.
We would like to thank the reviewer for his/her valuable suggestions. We have revised large parts of the introduction and now address some of the points.
The reviewer is correct that lysimeter systems are expensive and require a high maintenance and data processing effort. However, they are currently the only method for directly measuring all components of the terrestrial water balance (see e.g. Seneviratne et al., 2012) and are regarded as standard for evaporation measurements which are used to validate data from other methods (Shuttleworth, 2012, p. 91). In addition, there already exists a large number of lysimeter facilities which provide these data. For example, Lanthaler and Fank (2005) carried out a survey about lysimeter stations in Europe and found more than 2400 lysimeter

vessels, of which about 400 were weighable. So, despite the high costs, the value of lysimeter measurements has long been recognized and the number of existing lysimeters for various purposes is quite large. The number of 18 lysimeters from the Bad Lauchstädt site used in our study of course is rather exceptionel but only a small part of the filtering procedure presented in the paper (described in sect. 2.3.3) uses data from all lysimeters running in parallel. The filtering steps described in the preceding sections can be applied to a single lysimeter and do not require data from a whole set of lysimeters. Besides for the synchro filter, we have used the data from the neighboring lysimeters in section 3 to estimate the accuracy of the filtering procedure and to address uncertainties of the filtered flux estimates. We have clarified the manuscript in this respect.

Even if we do not have exact numbers, from our experience we assume the costs and maintenance effort for lysimeter and Eddy covariance systems to be quite comparable. For a detailed comparison of actual evapotranspiration and precipitation estimates from lysimeters with eddy covariance and rain gauge measurements, we would like to refer to the recent study of Gebler et al. (2015).

2) I was wondering what is the impact of using a dataset for a period of only 2 months on the results. I am aware that it is not easy to obtain lysimeter data, but I believe that the analysis with only 2-month might be not enough to really understand the goodness of the filtering scheme proposed in the paper. Very likely, in another season different results will be obtained. Is it possible to extend the analysis period? If this is not the case, I suggest the authors to add some comments on this issue.

We agree with the reviewer that the data set appears to be rather short in length. However, for discussing the effects of the filtering schemes on the data we need to look at them at very high resolution. A longer data set would have hidden the details of the filtering effects. We have discussed at which occasions (that are not included in the analysed time period) our filtering scheme would run into problems and we have not found many of them. Times which are always challenging to handle are dates where agricultural work (e.g. sowing, harvesting of crops, soil management (tillage), ...), which disturbes the weighing data, is conducted on

the lysimeter. On these dates, manual filtering/data processing procedures will definitely be required before the automatic filtering routines can be applied. Other periods that might be challenging to handle are periods where the lysimeters are snow covered, since the snow cover on the lysimeter is often connected to the snow cover outside the lysimeters which, in turn, heavily disturbs the weighing data. This, however, is a well known problem in lysimetry which by nature produces unreliable weighing data that also need to be removed manually from the data set. Here, of course additional information about the site conditions (snow cover) during winter is required. All other situations should be well evaluable with the current filtering scheme. We now discuss this issue in the new section 3.6 in the revised manuscript.

3) The first step of the processing scheme is the manual filter. While I fully understand the importance of the visual inspection of the data, this manual step does not allow applying the filter automatically, and hence may strongly limit the operational use of lysimeter data (e.g., for flood forecasting as reported in the Introduction of the paper). Can the authors add some comments on that? Specifically, what is the impact on the results if the manual filtering step is removed? We can accept a slight deterioration of the results if the processing scheme can be applied automatically.

As described in section 2.2.1, the manual filter is applied to remove defective data periods which induce heavy disturbances in the measured data, e.g. during maintenance or problems during data transfer. These exceptional events can have rather strong effects on the weighing data, are hardly detectable and currently cannot be compensated by the subsequent filters. Strictly speaking, this filtering step could potentially be automized by connecting the filtering procedure to a standardized field protocol of the technical staff and to the data transfer protocols which, however, is not the focus of this study. We will add a comment about this to the paper.

4) Finally, I believe that the authors should add the information about the availability of the filtering code. Do the authors make the code freely available? This would be highly important for the users of lysimeter data and it will be important to increase the relevance of the paper

(at least in my opinion).
We would like to thank the reviewer for this valuable suggestion. The filtering code can be made available by the authors upon request. We have added a respective note to the acknowledgement section of the paper.

P572,L20: typo: "ocuur"
corrected

P575,L1: typo: "floodforecasting"
corrected

P575,L5: change "to what extend" in "to what extent"
done

P579,L2: Can the authors quantify "noticeable deviations"?
Although such erroneous fluxes are typically in the order of 0.01 mm/h (depending on the smoothing time length), such errors can accumulate to an overestimation of about 22 mm in the cumulative water balance of a one year period, as the following simple estimation shows. As this is a systematic error that leads to overestimated values of precipitation and evapotranspiration, this effect should be considered in the data processing.
(erroneous flux) · (average night time) ·$\frac{1}{2}$ (half of the oscillation is positive) · (days of the year))
$0.01\,mm/h \cdot 12\,h \cdot \frac{1}{2} \cdot 365\,y^{-1} = 21.9\,mm/y.$
We have added this information to the manuscript.

P580,L13: Is ET the potential or the actual evapotranspiration? Please specify.
Lysimeters always provide actual evapotranspiration. We now explain this in detail in the introduction and in the following simplify it as "evapotranspiration"

P590,L15: "on the detailed control of the pumps at the lower boundary". Can the authors specify better this sentence?
done

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