Hydrol. Earth Syst. Sci. Discuss.,
doi:10.5194/hess-2016-252-AC2, 2016

Hydrology and Earth System Sciences
Discussions

Interactive comment on "A site-level comparison of lysimeter and eddy-covariance flux measurements of evapotranspiration" *by* M. Hirschi et al.

M. Hirschi et al.

martin.hirschi@env.ethz.ch

Received and published: 24 August 2016

We thank Referee #2 for the comments (in italic in the following) and will address them point-by-point below.

This manuscript reports on a long monitoring of evapotranspiration measurements obtained by different techniques. The topic is not novel, even if it benefits of the use of the lysimeter observations. The paper is generally well written and organized and easily to understand, except for the Figures, which should report on their caption the meaning of each of the used acronym. In the follow, I have included all the modification I retain necessary before the paper publication.
We will adjust the captions of the figures with the explanation of the acronyms.

Title: please avoid the use of the dash in between eddy and covariance.
We will adjust the title accordingly.

Introduction: the authors should expand the number of studies similar to that conducted by them.
We will expand the number of mentioned studies in the respective paragraph. However, as mentioned in the manuscript a lot of the available comparison studies are limited by the length of the analyzed time periods. Here, we are in the rare situation of having both techniques (lysimeter and EC) operated in parallel at the same location over a multi-year time period. This also shows the value of the presented data and analysis.

Methods and data
Figure 2 is not easy to interpreter; Figure 2 should include the map of the site, with the footprint area of the micrometeorological EC tower.
We will link an aerial online map of the site in order to facilitate the interpretation of the figure (see https://s.geo.admin.ch/6de2dcf3b5). Note that the lowest measurement level used here (2 m) was chosen to minimize the footprint area (see lines 163/164). Nevertheless, up to 10% of the measurements are potentially affected by obstacles (trees and a farmhouse) in the area, whereas only 1% of the measurements within the main wind direction (i.e., from west, see Figure 2) are potentially influenced (Peter, 2011, based on the footprint model of Kljun et al., 2004).

Eddy Covariance measurements: it is not clear if the sonic and the IRGA have the same point of measurements; please explain.
As mentioned on lines 178/179, the IRGA and the sonic have a horizontal separation of 0.2 m. Thus they have not the same point of measurement, as the IRGA would impact the sonic measurements.

Is the level of measurement consistent with the presence of the roughness sub-layer; how the authors have determined it?
A roughness sub-layer thickness of up to three times the canopy height, i.e. maximum

of 1.2 m in the present study, is assumed according to the well-established rule of thumb mentioned in the provided literature. We will note this on line 166:
"Note that this level is well above the vegetation height (mostly below 15 cm, maximum 40 cm), and clear of the roughness sublayer (estimated three times the canopy height; see Kaimal and Finnigan, 1994; Foken, 2008)."

At the end, which method (among those indicated) was used to correct the energy balance closure? Details should be added. In this case, the authors refer too much to studies conducted by others.
All three energy balance closure approaches are applied (see line 205) with the aim to provide the possible range of E_{EC}. Accordingly, we show the data from all three methods in the figures. The aim of the paper is not to evaluate the energy balance closure problem in detail, but to inter-compare the two measurement techniques (lysimeter and EC) based on the rare fact of having both techniques operated at the same location over a multi-year time period.

Catchment water balance measurements: The reason why the authors have applied this simplified hydrological water balance should be better justified. The temporal resolution of these estimates does not match with the EC resolution. The used approach appears too much simplified and the reason why some variables have been neglected should be indicated.
As mentioned in Section 2.4 (line 218), the catchment water balance is able to provide an additional estimate of the evapotranspiration amount over a hydrological year. It is used since it is a valuable independent way to evaluate the local-scale lysimeter measurements over the long measurement period. As also mentioned (line 221), it neglects storage changes from year to year. This assumption generally only holds for long-term averages ($\geq$1 year), thus it is unfortunately not possible to apply the catchment water balance for higher temporal resolution. Of course, the higher temporal resolution data from the lysimeter and EC measurements have been accumulated over the hydrological year for these comparisons.

How Q_C was obtained?
Q_C is the runoff captured at the catchment outlet at the gauge "Rietholz-Mosnang" (see lines 232/233). In order to clarify this, we will adjust the corresponding sentence to:
"Runoff (Q_C) is captured at the catchment outlet . . ."

Additional measurements at the site: How many soil temperature probes were used? Sometimes the lack of EB closure may depend on the correct estimation of the G term. Please include specifics.
Three soil temperature sensors were used. This will be clarified on line 247.

Results
The results are mainly affected by the choice of the authors to compare data with different temporal resolution of acquisition. This may be only justified from their wish to provide a suggestion to the readers. But this motivation does not appear into this paper.
We do not completely understand what is meant with this comment. We provide comparisons on annual down to hourly time scales in order to document the data from the two measurement techniques on various time scales. We do not see what is wrong with the presentation of the data in this form, as the temporal resolutions of compared time series are consistent.

The BR correction procedure should be explained.
The Bowen ratio correction is a commonly used approach to correct EC data (see e.g., Twine et al. 2000) and we refer to corresponding papers on line 212. We will expand the respective description as follows:
"Approach (i) (E_{EC_BOWEN}) is a commonly used assumption in the literature (e.g., Twine et al., 2000, Jaeger et al., 2009; Jung et al., 2010). It assumes that the Bowen ratio is correctly measured by the EC method so that λE and H can be adjusted to balance equation (3)."

In such a work, I would have expected to find at least the analysis of unstable and

stable conditions of the EC fluxes.
This analysis would be interesting for characterizing the planetary boundary layer and comparing the micrometeorological conditions to other sites. While we acknowledge that the analysis of stability is performed for corresponding studies focusing on EC measurements, we want to point out that this paper focuses on the comparison of different evapotranspiration estimates, which are defined here as upward fluxes (see lines 140 and 331). Thus, evapotranspiration from EC measurements is based on (neutral to) unstable conditions only in the lysimeter vs. EC comparisons. In our opinion an analysis of the atmospheric stability would not add to the focus of the article.

Finally, I have not evinced any message from this work, to improve knowledge of the scientific community. For these reasons, I only suggest Major Revision to this paper, to be reconsidered for publication.
As mentioned, the rare fact of having lysimeter and EC measurements operated over a multi-year time period is one of the values of this paper. Presenting this data to the scientific community is indeed worthwhile and the presented inter-comparisons shed light on the quality and reliability of monitored data from the different methods at different temporal scales and over an extended time period.

Additional references:
N. Kljun, P. Calanca, M.W. Rotach, H.P. Schmid (2004). A Simple Parameterisation for Flux Footprint Predictions. Boundary-Layer Meteorology, 112, 503-523.

I. Peters (2011). Turbulence measurements and footprint estimates at Rietholzbach. MSc Thesis, ETH Zürich, Switzerland.

T.E. Twine, W.P. Kustas, J.M. Norman, D.R. Cook, P.R. Houser, T.P. Meyers, J.H. Prueger, P.J. Starks, M.L. Wesely (2000). Correcting eddy-covariance flux underestimates over a grassland. Agricultural and Forest Meteorology, 103, 279-300, doi:10.1016/S0168-1923(00)00123-4.
