

## ***Interactive comment on “Area-averaged evapotranspiration over a heterogeneous land surface: Aggregation of multi-point EC flux measurements with high-resolution land-cover map and footprint analysis” by F. Xu et al.***

**F. Xu et al.**

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Dear Referee #1:

We appreciate very much for your valuable comments and suggestions on our manuscript. According to your comments, and those from Referee #2 and Referee #3, we have carefully revised all sections of the paper (revisions and corrections are marked in red). Detailed response to your worthwhile comments and suggestions are as follows:

Main comments: 1. In Introduction section the authors argued that existing integration  
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schemes often assume local flux measures area representative of an individual surface cover and thus result in errors. However, the paper did not explicitly address the issue with the data they used. The reviewer would like to see clearly to what extent and under what conditions the assumption may produce the error.

Response: Thanks for your valuable comments. The three aggregation methods, particularly the simple arithmetic and/or the area-weighted method used before, are based on individual surface types, without high resolution land-use classification and fine footprint analysis. We have revised the relevant section in “Introduction” and believe a better result would be achieved based on present integration method.

2. While EC and LAS measures are valuable for large-scale ET estimation, they have measurement errors, either systematic or random. The errors are mixed or propagated into aggregated ET values. Are the measurement errors large or smaller than the ET differences due to spatial heterogeneity? A careful analysis between EC, LAS and spatial heterogeneity with the matrix flux data would provide valuable insights into the issue which is puzzling for many years.

Response: Yes, both EC and LAS have measurement errors, either systematic or random. For the ECs used in our data analysis (the HiWATER) we have tried to reduce the systematic errors to a minimum with a pre-observation intercomparison (Xu et al., 2013 JGR) and careful maintenance during the observation. The random errors were also analyzed via a separate research (Wang et al., 2015, IEEE GRSL), which can be minimized in an ensemble average. As for the LASs used in HiWATER, major errors are from their data processing processes, for instance, the Bowen-ratio correction problem particularly for observations over Oasis. We have also tried our best to minimize them mainly through intercomparisons with fluxes from EC. All these uncertainties are minor when we compared with the spatial heterogeneity of our study area, especially, the large differences among the four kinds of land-use. We have added some descriptions on data quality and uncertainty of the EC and LAS measurements in our study in Section 2.2.1.

3. Section 4.4 seems not closely relevant to the aggregation topics addressed in the paper. Neither the ET estimates can be validated over the study area as a whole. It is better to remove it from the text.

Response: We are sorry for our unclear statements in section 4.4. We have removed irrelevant information including the comparison with P-M ET products. The statements in the entire section have been re-written.

Specific comments:

Abstract: Page 1 line 20-23: it does not provide any new for audience.

Response: Accepted: Line 20-23 are deleted.

1. Introduction Page 2 line 13: earth - > Earth Page 3 line 2-3: remove one of "remote sensing" Page 3 line 8: there is - > there may be

Response: Accepted.

Page 4 line 9: a nice statement on representativeness of flux measures over individual surface covers. However, the present version failed to explicitly address the assumption in Results and Discussion.

Response: Thanks for your comments. We have added some statements in Section 4, Results and Discussion, to address the assumption explicitly.

Page 5 line 1-2: "disaggregation approach has not been fully investigated" does not absolutely mean it deserve investigation. Please state it more clearly.

Response: We have improved the statements in this section more clearly.

2. Study sites and data Page 6 line 14: two days only? Are they representative or enough to get conclusions that are general?

Response: The two clear days we selected for analysis, 29 to 30 June 2012, are typical (due to the weather, surface status, and extended observations such as aircraft remote

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sensing) and representative for the general conclusions we got. Actually, we have applied the same flux aggregation method for other periods, such as the 6 days from 9 July to 14 July 2012. Figure 1 (attached below, similarly hereinafter) shows the daily ET for four land covers derived. Figure 2 describes the area-averaged daily ET over the study area. All the areal ET and its disaggregation to individual land types are similar to those of the two clear days analyzed.

Page 6 line 16: Please state the last time the irrigation done.

Response: We have added the last irrigation time in the revised manuscript.

Page 7 line 16: It would be better to use local time. Otherwise, explicitly state the time difference to Beijing time.

Response: The time difference between local time and Beijing Standard Time is approximately +1 h 18 min. This has been added explicitly in the revision.

There are many places throughout the paper with mixture use of "remotely sensed", "remote-sensing", "remote-sensing based", "satellite-based", etc.

Response: We have unified the use of "remote sensing" throughout the revised paper.

### 3. Methodology

Page 9 line 8: add a reference here for footprint model.

Response: A reference has been added: Leclerc, M. Y., and Foken, T.: Footprints in Micrometeorology and Ecology, Springer, Heidelberg, New York, Dordrecht, London, XIX, 239 pp., 2014

Page 9 line 11: remove "The". There are many places with misuse of "the" or "a/an"

Response: Accepted. Other places with misuse of "the" or "a/an" have also been checked.

Page 11 line 10: what the mean of "footprint climatology function"?

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Response: We have revised the “footprint climatology function” as “the weighted footprint climatology”. Its meaning is clearly shown with Eq. (8).

Page12 line 23: framework -> data processing flow.

Response: Accepted.

4. Results and discussion Page 12 line 17-19: remove the paragraph. It is useless here.

Response: Accepted.

Please use W/m<sup>2</sup> instead of mm/day throughout the paper.

Response: We have unified the flux unit from mm/d to W/m<sup>2</sup> in Section 4.1. However, in discussing the daily ET in Section 4.4 we still use mm/d as in usual applications.

Page 13 line 13: how about other period? Do the differences change with different periods?

Response: The differences among all maize sites change slightly during the maize grown period. For example, Fig. 3 shows the daily variation of the three major fluxes from 9 July to 14 July 2012. The standard deviations of all maize sites are also shown. All features are about the same as the two days analyzed. We have added some relevant statements in the revised paper.

Page 16 line 16-page 17 line 10: remove the text that describes regional ET over the study area as a whole. It provides no support for the scientific issues addressed.

Response: The major objective of this study is to refine an aggregation method for area averaged fluxes based on our unique, comprehensive dataset of the HiWATER. The results are also useful for the water balance study extended to the whole Heihe River basin. So the results of regional ET over the study area are still kept in Section 4.4. Of course, some irrelevant parts are deleted according to the comments of yours and other two referees.

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Thank you very much again for your valuable comments and suggestions on our manuscript. The revised manuscript is attached as supplement.

Sincerely yours, Feinan Xu Email: xufeinan@lzb.ac.cn

PS. After revising our manuscript and finishing the above responses to you, yesterday, we received the comments from Prof. Thomas Foken (as Referee #4). Some important revisions would be needed based on his comments. A new version might be uploaded within two weeks.

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Please also note the supplement to this comment:

<http://www.hydrol-earth-syst-sci-discuss.net/hess-2016-602/hess-2016-602-AC1-supplement.pdf>

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., doi:10.5194/hess-2016-602, 2016.

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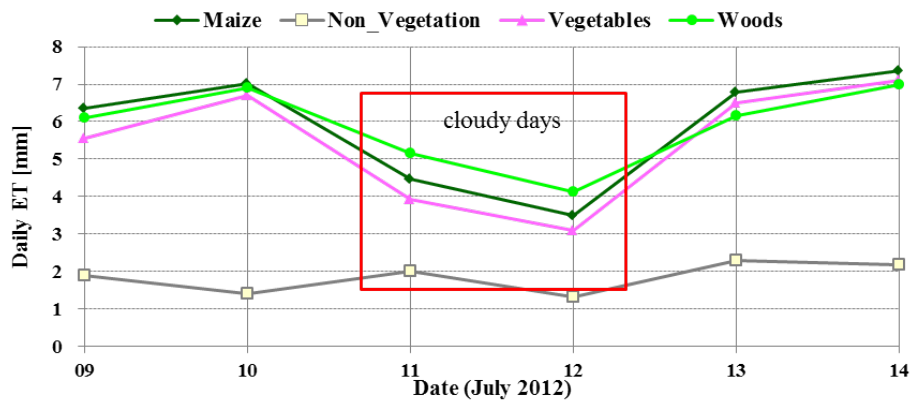


Fig. 1. EC dis-aggregated daily ET for each land covers from 9 to 14 July 2012

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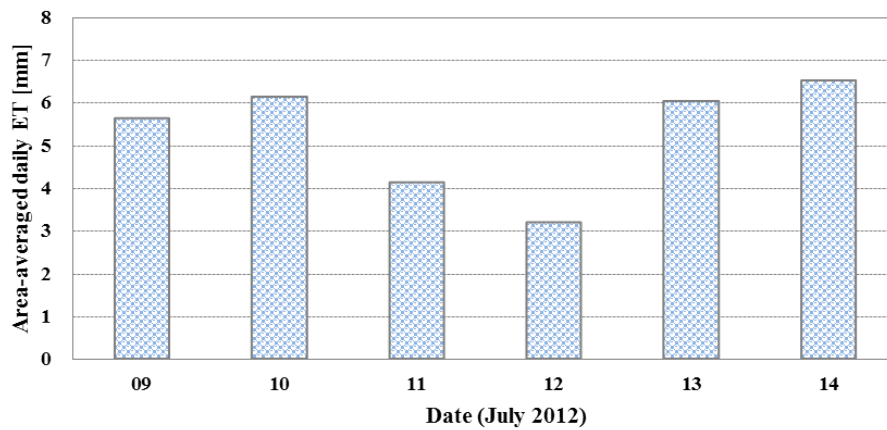
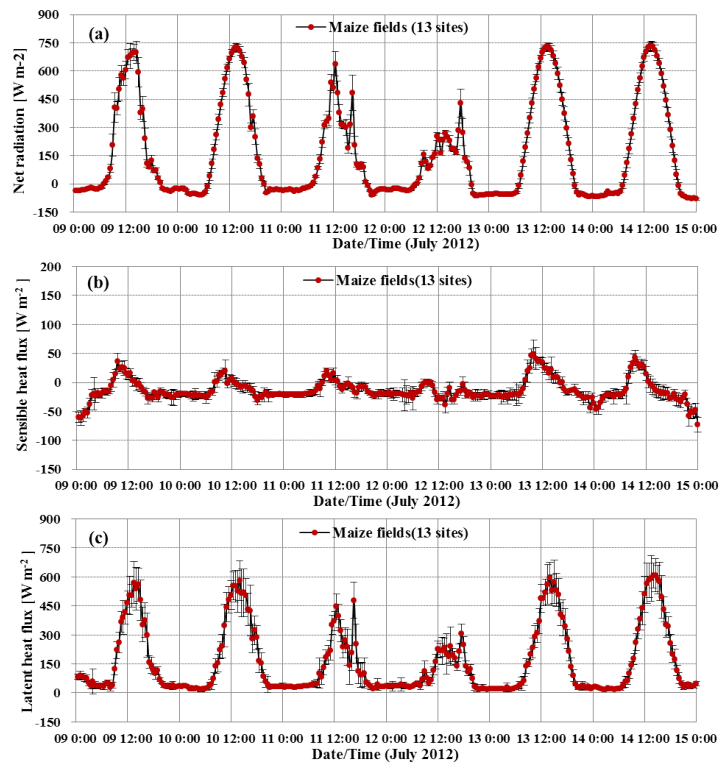


Fig. 2. Area-averaged daily ET over the study area

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**Fig. 3.** Diurnal cycle of the mean net radiation (a), sensible (b) and latent (c) heat fluxes for 13 maize field sites, the errors bars are the standard deviation.