Interactive comment on "Comparison of different evaporation estimates over the African continent" by P. Trambauer et al.

Anonymous Referee #1

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Reaction to the interactive comment by Anonymous Referee #1 on: "Comparison of different evaporation estimates over the African continent" by P. Trambauer et al., hessd-10-8421-2013

We would like to thank this referee for his/her interesting comments and suggestions that contributed to improve our paper and to clarify specific points. Hereby we present the authors reply (AC) to the referee's comments (RC).

General comments:

RC: A comparison of eight evapotranspiration products is made over Africa, for the 2000- 2010 period. Among these, three are satellite-based and five consist of model simulations. The differences from one product to another can be very large. The differences are analyzed for various African ecosystems. Two model products are close to the mean of all the products: ERA-Land and PCR-GLOBWB. The latter model is used to assess the impact of irrigation and of changes in precipitation or potential evaporation estimates. The paper presents existing products and shows the difficulty in estimating land surface fluxes. However, the results are not very new and it is difficult to see to what extent this work is useful. While the objective is to focus on a region of the globe, there is no direct validation of the products (e.g. independent in situ flux observations are not used), and the analysis of the differences between model simulations is quite superficial. In particular, a given flux may result from contrasting individual values of the components of this flux. Model simulations should be able to differentiate the three main components of evapotranspiration: soil evaporation, plant transpiration, rain interception. Is the fraction of these components similar across models? A Table showing the mean total precipitation and evapotranspiration value for the six regions of Fig. 2 and for the whole continent, together with the three main components of evapotranspiration, would be useful. The quality of key Figures is poor and the results cannot be properly interpreted. The Conclusion section is lacking recommendation/prospects for future research.

AC: In this paper we presented the comparison of eight different evaporation products over the entire African continent, derived from broadly three different state of the art approaches. Moreover, we divided the continent into 21 climatic/geographic regions for a more sensible comparison. We believe that this study is useful particularly in the context of data scarce regions in Africa. There are several studies regarding evaporation estimates in North America, Europe, and other developed regions, but very few address evaporation estimates over Africa. We and several other researchers have found it is very difficult to find evaporation estimates for the entire continent. There are some global estimates but these have hardly been validated in Africa so we do not know to what extent these can be trusted. Through comparing eight estimates from different sources in this study we can give an indication of the variance of these products in different regions. This is useful as it gives some indication of the range of expected values. For example, failure in validating runoff for some basins might be a result of a large over/underestimation of actual evaporation in the hydrological model. The results from this study can then help to make a complimentary validation of the actual evaporation flux. The approach we are using is similar to other recent studies that evaluate the quality of their models/products by comparing them with other existing model(s), in the absence of ground information. For example, Ghilain et al. (2011) compare their model results with ECMWF and GLDAS estimates in Northern and Southern Africa. They found that for both regions their product (LSA SAF MET) showed lower estimates than ECMWF and GLDAS, and the difference with the ECMWF product was the largest. Our study is useful as it provides an indication of the position of ERAI in the spread of possible outcomes. Although the ECMWF operational forecasts used at that time are not identical to ERAI, these two should not differ much.

The distinction between the three main components of evaporation: soil evaporation, plant transpiration, and rain interception is indeed very interesting and in general the models are able to differentiate them. We do have this differentiation for the PCR-GLOBWB products (4 of the 8 products considered) but the data for MOD16, GLEAM and ECMWF products (ERAI and ERAL) are not available to us. Our understanding is that this differentiation cannot be done with MOD16. Regarding precipitation, some of the evaporation products are not developed by us, and while we know what precipitation and other input data they have used (see Table 1), we do not have those precipitation products available to us. Therefore, we preferred not to present these differentiations for only part of the products to maintain consistency in our analysis and discussion.

We agree that the quality of the figures can be improved. However, we do believe that the quality of key figures appears to be poor due to the way they are provided in HESSD. These figures are supposed to be provided in full manuscript page (A4), and we find that when doing so the quality improves a lot and the results can be easily interpreted. An example of one of these figures is presented as a supplement to allow for a correct visualization.

We thank the reviewer for the suggestion to add recommendation to the conclusion section. Recommendations/prospects for future research were added:
Recommendations: "A potential action to improve this comparison study and the EM is to validate the products in different African regions with ground data, where available. Moreover, other available products could be added to the comparison and to the EM calculation to have more information on the variance between the products and a more consistent EM estimate. It is also recommended to compare the computed EM and the variability of the products with the global benchmark recently developed by Mueller et al. (2013). Similarly, in a basin-wide scale, long-term estimates of evaporation could be obtained from the water balance with an uncertainty estimate (Dingman, 1994)."

Dingman, S. L.: Physical hydrology, Prentice Hall Englewood Cliffs, NJ, 1994.

Recommendation: Major revisions.

Particular comments:

RC: - P. 8424, L. 28: "This understanding can lead to improved evaporation estimates"; this objective is a bit vague. The real objectives of this work (e.g. indirect validation of operational tools?) should be clearly stated.

AC: The sentence was changed to:
"This comparison can serve as an indirect validation of methods or tools used in operational water resources assessments. In this study we do not intend to evaluate whether one product is better than the others but to discriminate areas where good consistency can be found between the results of the selected models in contrast to regions where model results diverge. We seek to provide a range of uncertainty in the expected actual evaporation values for the defined regions. The understanding of this range can be useful in, for example, water resources management when estimating the water balance."

RC:- P. 8425, L. 21: why was the PCR-GLOBWB model set up for the African continent? Is this model used at a global scale? For what purpose/application?

AC: PCR-GLOBWB model is used at a global scale for a variety of purposes: seasonal prediction, quantification of the hydrological effects of climate variability and climate change, to compare changes in terrestrial water storage with observed anomalies in the Earth's gravity field and to relate demand to water availability in the context of water scarcity. The model was set up for the African continent in the context of the FP7 EU DEWFORA project ("Improved Drought

Early Warning and Forecasting to strengthen preparedness and adaptation in Africa"). The model is used in this project for hydrological simulation and forecasting. This explanation is added in the manuscript.

RC:- P. 8426, L. 3: LAI presents a marked seasonal and interannual variability. Where does LAI come from in PCR-GLOBWB? Same question for ERA-I and ERA-Land.

AC: In PCR-GLOBWB the Leaf Area Index (LAI) climatology is estimated for each GLCC (Global Land Cover Characterization)-type, with LAI values per type for dormancy and growing season obtained from Hagemann et al. (1999). LAI is thus prescribed by a monthly climatology that follows the growing season and used to compute the crop factor per vegetation type according to the FAO guidelines (Allen et al., 1998). Over irrigated areas, these values are replaced by the crop factors and the implied crop seasons of the MIRCA2000 dataset (Portmann et al., 2008, 2010).

The following references were added:

Allen, R.G., L.S. Pereira, D. Raes and M. Smith (1998), Crop evapotranspiration - Guidelines for computing crop water requirements, FAO Irrigation and Drainage Paper 56, FAO, Rome.

Portmann, F., S. Siebert, C. Bauer and P. Döll (2008), Global data set 895 of monthly growing areas of 26 irrigated crops, Frankfurt Hydrology Paper 06, Institute of Physical Geography, University of Frankfurt, Frankfurt am Main, Germany.

Portmann, F., S. Siebert, C. Bauer and P. Döll (2010), MIRCA2000 - Global monthly irrigated and rainfed crop areas around the year 2000: A new high-resolution data set for agricultural and hydrological modelling, Global Biogeo. Cyc., 24, GB1011, doi:10.1029/2008GB003435

Van Beek, L.P.H., 2008: Forcing PCR-GLOBWB with CRU meteorological data, Utrecht University, Utrecht, Netherlands: http://vanbeek.geo.uu.nl/suppinfo/vanbeek2008.pdf.

LAI in ERAI was prescribed as fixed field, i.e only spatial variability, while ERA-Land has a monthly climatology (Boussetta et al. 2011). This was added to the description of ERAI and ERA-Land. The following reference was added: (ref: Boussetta, S., Balsamo, G., Beljaars, A., Kral, T., and Jarlan, L.: Impact of a satellite-derived leaf area index monthly climatology in a global numerical weather prediction model, Int. J. Remote Sens., 34, 3520-3542, doi: 10.1080/01431161.2012.716543, 2012)

RC:- P. 8426, L. 28: GPCP ends in 2009 while the 2000-2010 period is considered (?)

AC: From September 2009 to December 2010, the mean monthly ERAI precipitation was corrected using a mean bias coefficient based on the climatology of the bias correction coefficients used for the period 1979-2009. While this only corrects for systematic biases, this was the only option available at the time, as a new version of GPCP (version 2.2) was not available. This explanation was added to the meteorological forcing description.

RC:- P. 8431, L. 5 and L. 13: LAI was defined already.

AC: The definition was removed.

RC:- P. 8432, L. 15: LPRM is not a product nor a satellite. Do you mean AMSR-E?

AC: The data was retrieved from the NASA-LPRM (Land Parameter Retrieval Model, Owe et al. (2008)). The LPRM[1] official dataset is based on brightness temperatures from SMMR, SSMI and AMSR-E. Data prior to mid 2002 comes from SSMI and after mid 2002 comes from AMSR-E.

The sentence has been changed to (including the footnotes): "This version of the model is forced with PERSIANN (Precipitation Estimation from Remotely Sensed Information using Artificial Neural Networks) precipitation data, soil moisture and vegetation optical depth retrieved from the NASA-LPRM (Land Parameter Retrieval Model[2], (Owe et al., 2008)), radiation fluxes from ERA-Interim, air temperature from AIRS (Atmospheric InfraRed Sounder) gap-filled with ISCCP (International Satellite Cloud Climatology Project (Rossow and Schiffer, 1999)), and snow water equivalents from NSIDC (National Snow and Ice Data Center (Armstrong et al., 2007).

[1] http://gcmd.nasa.gov/records/GCMD_GES_DISC_LPRM_AMSRE_SOILM2_V001.html
[2] The data are derived from different satellite sensors: SSMI before mid 2002 and AMSR-E after mid 2002.

RC:- P. 8437, L. 17 (Fig. 6): why showing the Saharan region while it "was left out of this analysis"?

AC: The Saharan region has been been removed from this Figure.

RC:- P. 8438: Figures 8-9-10 (especially Fig. 10) are not readable. Too much information is shown in a single Figure. In Fig. 8, I suggest to show the EM, only. The individual model simulations should be shown only for those regions and/or products where noticeable features have to be discussed. The Taylor diagrams of Fig. 10 are particularly useless as they cannot be read nor interpreted. Rather, in order to characterize the spread for each region, adequate metrics could be illustrated in a Table.

AC: As we indicated above we believe that the main reason for the figure not being readable is due to the size in which it is provided in HESSD. When presented at a full size Figure 8 is readable and clearly shows the annual cycle of the different models and the spread between them. For Figure 9, we accept the suggestion of the reviewer and have moved this to the Appendix; furthermore, we have modified Figure 10 to show only the plots for those regions where noticeable features are discussed. We believe that a Taylor plot illustrates the statistics in a nicer way and is easier to interpret than in a Table, and therefore would prefer to retain it but only for selected regions. Following the comments of the reviewer, we will, however make sure that plots are printed to a size that allows them to be easily readable in the final manuscript.

RC:- P. 8439, L. 14-24: should be moved to the Methods Section.

AC: We have moved the sentence as suggested.

RC:- P. 8445 (top): Also, for vegetated areas, less intense precipitation tends to increase the direct evaporation as the rain is more easily intercepted by the vegetation, and thus to reduce the infiltration. Is the interception simulated by the considered models?

AC: Indeed interception is considered in the selected models. To clarify the paragraph starting in page 8444 L22 was changed to:
"For the scale considered in this study, it is clear that rainfall events with higher intensities result in lower evaporation values (see Fig. 7 and Fig. 8) given that PCR_TRMM evaporation is generally lower than PCR-GLOBWB evaporation. This can be explained as higher intensities lead to higher surface runoff, which keeps the water out of reach of evaporation and results in lower evaporation rates. Moreover, for vegetated areas, less intense rainfall tends to increase the direct evaporation as the rain is more easily intercepted and re-evaporated, and this results in reduced infiltration."

RC:- P. 8462 (caption of Fig. 8): "Interannual" or "Seasonal" variation?

AC: The word "interannual" was removed. The caption was changed to "Variation of mean monthly actual evaporation for each region"

RC:- P. 8447, L. 3: do you mean "by the analysis of soil moisture"? What is the explanation of this behaviour of the data assimilation in ERA-I?

AC: Yes. To clarify, the sentence was changed accordingly.

The analysis of soil moisture in ERAI tends to lead to positive soil moisture increments (see Fig. 11). Drusch et. al. (2008) provides a detailed evaluation of the soil moisture analysis scheme used in ERAI. Root zone soil moisture acts as a "sink" variable for the soil moisture increments, in which errors are allowed to accumulate.

This was added in page 8439: "Drusch et. al. (2008) provides a detailed evaluation of the soil moisture analysis scheme used in ERAI, pointing to some of the limitations (e.g. root zone soil moisture acts as a "sink" variable, in which errors are allowed to accumulate). They also present a new surface analysis scheme that is currently operational at ECMWF. "

Ref: Drusch, M., K. Scipal, P. de Rosnay, G. Balsamo, E. Andersson, P. Bougeault & P. Viterbo, 2008: Exploitation of satellite data in the surface analysis. ECMWF Tech. Memo. No. 576, http://www.ecmwf.int/publications/library/do/references/show?id=88712