Hydrol. Earth Syst. Sci. Discuss.,
doi:10.5194/hess-2016-432-RC1, 2016

Hydrology and Earth System Sciences
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Discussions

Interactive comment on "Evaluating the value of a network of cosmic-ray probes for improving land surface modelling" *by* Roland Baatz et al.

Anonymous Referee #1

Received and published: 14 September 2016

OVERVIEW

The manuscript investigates the value of a network of cosmic-ray probes for improving soil moisture estimation through land surface modelling. Specifically, the assimilation of soil moisture observations from 9 cosmic-ray probes into CLM (Community Land Model) is analysed for the Rur catchment in western Germany (period 2011-2013). The Local Ensemble Transform Kalman Filter is considered as data assimilation technique. Different real-world assimilation experiments were carried out also by considering an erroneous soil map. Results without and with the assimilation of soil moisture data were

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analysed in order to assess their impact for improving the simulation of soil moisture.

GENERAL COMMENTS

The manuscript is well written and clear. The topic is of interest for the HESS readership as cosmic-ray probes represent a relatively new technology for ground measuring soil moisture over large areas. Therefore, we need to assess the impact of this new technology for improving land surface modelling. The paper describes several assimilation experiments in which soil moisture data from cosmic-ray probes are used for improving soil moisture modelling through CLM land surface model. Results are (quite) well described and clearly structured. However, in my opinion, several aspects should be improved/changed before the publication. I reported below a list of the general comments to be addressed with also the specification of their relevance.

1) **MAJOR**: Some of the results shown in the paper are well-known. I am aware that it is important to show real-world experiments, mainly by considering new technology, but the main results given in the paper were already reported in several previous studies: a) the assimilation of ground-based soil moisture data is able to improve soil moisture modelling, b) the joint state-parameter assimilation is better than the state assimilation only, and c) the assimilation is more effective when soil texture information are wrong (i.e., there's larger room for improvement). I believe that the paper results need to be published, but I would like to see some new findings that can be obtained by using the same material (data and modelling) presented in the paper.

For instance: A) What are the results if only one (or two) cosmic-ray probes are assimilated? In the real world it is expected that the number of probes will be limited and, hence, the use of a limited number of probes is surely of great interest. B) What is the impact in terms of fluxes? In section 4.6 a comparison of annual evapotranspiration maps without and with the assimilation is carried out, but simply showing that

the resulting maps are different. However, it is obvious that changing soil moisture will change evapotranspiration. Is it possible to perform an independent validation by using data about the actual evapotranspiration in the basin? Or likely by using discharge observations?

I believe that some new results should be included in the paper (even though I am aware that authors are usually reluctant to perform additional analyses). Moreover, the results in terms of soil moisture simulation should be synthetized (see Comment 5).

2) **MAJOR**: The description of the data assimilation experiments should be improved. As usually, a number of subjective choices were made in the setup of the data assimilation experiments, and these choices may have a significant impact on the results. For instance, a fixed error for soil moisture estimates from cosmic-ray probes is considered (0.03 cm^3/cm^3). Similarly, the perturbation factors for input data (precipitation and shortwave radiation) and parameters (10 and 30%) are arbitrarily selected. A sensitivity analysis on these choices should be carried out. It might be that different choices produce very different results.

3) **MODERATE**: Similarly as above, the selection of one single biased soil texture map is arbitrary. Why only one soil map? Why 80% of sand content and 10% of clay content is selected? What is the average sand and clay content percentage in the basin? Again, a sensitivity analysis is needed. Otherwise, it might be that a very large error in the soil map is used to highlight the positive impact of assimilating soil moisture data. What happens for a less biased map? This aspect should be clarified.

4) **MINOR**: In CLM the subsurface lateral flow is not considered. It has an impact on soil moisture simulation and, mainly, on the capability to modify soil moisture simulations at unmonitored locations. Therefore, I expect that the assimilation of in situ soil moisture data will have a local effect. However, the jackknifing data assimilation experiments show that the assimilation produces significant changes also at unmonitored locations. Why does it happen? I believe it should be clarified in the paper.

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5) **MINOR**: In sections 4.2 and 4.5, too many details are provided in the description of the results for each single site. I suggest focusing on the most important results to improve their readability. Also, discussion section is too generic, especially the first paragraph.

In the specific comments, I added some corrections and suggestions that should be implemented.

On this basis, I believe the paper deserves to be published only after a major revision.

SPECIFIC COMMENTS (P: page, L: line or lines)

Title: The paper, in the current version, demonstrates that the assimilation of soil moisture data from cosmic-ray probes is able to improve soil moisture modelling, not "land surface modelling" (e.g., evapotranspiration or discharge fluxes). Therefore, I suggest changing the title.

Abstract: The abstract should include information on the location of the study area and on the employed data assimilation technique.

P4, L7: Formatting error for Kurtz et al. (2016). Please correct.

P5, L19: It should be COSMIC in place of COMIC.

P12, L11: Is sigma=0.5 considered for perturbing precipitation in all the assimilation experiments? Please clarify.

P12, L25: It should be "four data assimilation scenarios" in place of "six assimilation scenarios".

P19, L18-19: This sentence is too broad, please modify.

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