# *Interactive comment on* "Evaluation of soil moisture in CMIP5 simulations over contiguous United States using in situ and satellite observations" *by* Shanshui Yuan and Steven M. Quiring

R. Orth (Referee)

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Review of Yuan and Quiring "Evaluation of soil moisture in CMIP5 simulations over contiguous United States using in situ and satellite observations"

This article is on the validation of the performance of CMIP5 models over the continental US in terms of the simulated soil moisture, using in situ and satellite-derived soil moisture data as observational reference. While the agreement of the multi-model mean with the observational references is overall satisfactory, the paper reveals strong inter-model differences, general difficulties of the models to capture the observed spa-

tial pattern of absolute soil moisture, but also differences between in situ and satellite-based soil moisture.

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General comments:

The article adresses an important topic and contributes valuable results, and should be of interest for the HESS audience. It helps to guide Earth System Model development, as well as the development of large-scale observational soil moisture products.

However, I do have several concerns:

(1) Both, the spatial downscaling of the CMIP5 output, and the gap filling of the in situ soil moisture records, are - in my view - unnecessary data manipulations which could introduce errorneous signals to the raw data. Instead of the downscaling of the model data, I would recommend to upscale the observational data to the coarse spatial resolution of the CMIP5 models, especially because you only focus at the regional-continental scale. Instead of the gap filling, I would compute the models' monthly averages using only the same days available in the observations. In any case I would expect some analyses indicating the impact of any data pre-processing you perform on the final results.

Also the satellite-based soil moisture data might not be available anywhere and anytime. The current manuscript does not mention how the authors deal with this.

(2) The comparison between the absolute soil moisture in the ECV data and the CMIP5 models is maybe not appropriate. I think the absolute soil moisture amount in the ECV data has been scaled using data from land surface model simulations, while only the temporal variations are a truly observed feature. This would mean that when comparing the spatial patterns of the absolute soil moisture contents you actually compare model against model.

(3) I think the results of this study can be very useful to guide model development, as

well as the development of large-scale observational soil moisture products. While I recognize that this is not the main goal of this study, I would like to see some more explanations why poor model performance or differences across in situ and satellite-based soil moisture are seen at several of the performed comparisons. This could then lead into explicit advice for the developers of the models and the soil moisture products.

(4) The results section can be significantly shortened. Description of results displayed in figures does not need to be so comprehensive.

(5) While the manuscript is clearly structured and overall easy to read, there are many small language errors (such as missing articles). I recommend that the authors take special care of these when revising the manuscript.

I recommend publication of this study after major revisions.

I do not wish to remain anonymous - Rene Orth.

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Specific comments:

Title:

... over the contiguous United States...

Abstract:

line 15: maybe replace 'magnitude' with 'amount' throught the manuscript

line 16: 'variations in model performance' could be spatial, temporal, or across models (which is what you mean, I guess). Please clarify.

line 16: 'especially in the near-surface', please replace with 'at' or 'for the near surface'

line 17: deeper soil layers

page 2:

line 5: please explain 'ground fluxes'

line 8: remote sensing observations

line 21: change 'predict ... earlier in ...' to 'better predict'

line 23: 'from satellites remote sensing', improve phrasing

line 30: Why is it a problem that ASCAT soil moisture is influenced by precipitation and evaporation? Soil moisture is by definition influenced by these quantities.

line 32: abbreviation AMSR-E not introduced

page 3:

line 7: 'offline land surface models', please improve phrasing

line 8: at a variety of depths

line 9: biases

line 11: please currect citation style

line 22: difficulties to accurately simulate

line 28: abbreviation CONUS not introduced

line 31: ... followed by the presentation of the results and a discussion in section 3. Limitations and conclusions of the study are ...

page 4:

section 2.1: How do the adjustments of the region perimeters influence the results of the study?

section 2.2: Why was this particular emission scenario used here?

line 3: please refer to 'eight sub-regions' instead of 'regions' throught the manuscript (as also CONUS is a region)

lines 7-10: a table would be suitable to present these information;

line 12: provide soil moisture data

line 15: 'with the greater number of in situ observations', please improve phrasing

lines 16-18: please improve phrasing

line 25: using a bilinear interpolation method

line 30: Daily in situ soil moisture data from ...

page 5:

section 2.3: Do your results depend on the amount of stations in each sub-region?

section 2.4: What version of the ESA CCI soil moisture is employed? Maybe an upgrade (if possible) would improve the coherence between the in situ and satellite-derived soil moisture results?

line 1-2: These stations belong to eight ...

line 2: Quality-controlled daily soil moisture data have ...

line 4: gap filling of missing data: Beside the main comment above, how does it work?

line 15: 'provides an overview of soil moisture simulations in CMIP5 models'?

line 19: For a regional evaluation...

page 6:

line 22: remove 'starting'

page 7:

line 1: agreement in terms of what?

line 5: 'which is similar to the 0-10 cm soil layer', please improve phrasing, maybe use

'Similar results are found for the 0-10 cm soil layer.'

line 18: and of the negative biases

line 26: ECV shows more spatial heterogeneity

line 34: '(regions with a wet bias)'? remove?

page 8:

line 25: in the 0-10 cm soil layer

page 9:

line 5: please rephrase

page 10:

line 7: the driest conditions

line 20: is more strongly correlated

page 11:

line 14: comparatively dry 'substantial bias in the deeper soil layer', can you speculate why that is?

line 17: the observed spatial pattern

line 21: varies significantly across sub-regions

line 27: the CMIP5 ensemble

line 31: 'relatively consistent', not in the SS sub-region

page 12:

line 3: point out that

Figure 1, caption: and the boundaries of

Figure 2: Please use the same x and y-axes in all plots.

Figure 3, caption: CMIP5 ensemble mean (black line)

Figure 4: Maybe add white color in the middle of the color bar such that locations with good agreement do not show up?

Figure 9: Please label color bars. I find it interesting that the correlations for the SS sub-region are consistently low, whereas in Figure 8 the correlations for the model ensemble mean in that sub-region are high. Can you comment on that?

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