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Hydrology and Earth System Sciences Discussions

Interactive comment on "A new perspective on the spatio-temporal variability of soil moisture: temporal dynamics versus time invariant contributions" *by* H. Mittelbach and S. I. Seneviratne

Anonymous Referee #1

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Overview

The study investigates a new perspective for the analysis of soil moisture spatial-temporal variability that considers the variability of the soil moisture temporal anomalies instead of the absolute values. Results indicate that the time invariant term contributes for 94% of the spatial soil moisture variance whereas the contribution of the spatial variance of the temporal anomalies is quite limited. Moreover, by applying the classical temporal stability analysis to the absolute values and the temporal anomalies, the

findings are quite different.

General Comments

The paper is well written, well structured and clear; the language is fluent and precise. The topic of the paper is of great interest for the HESS reader as the analysis of soil moisture spatial-temporal variability both in terms of absolute values and anomalies has significant effects for the effective use of soil moisture observations for many hydrological, meteorological or agricultural applications (to cite a few). Actually, from my working experience on the same issue, I found several times that the spatial variability of relative soil moisture data, obtained by normalizing the data to the range 0-1 (degree of saturation), can be quite different from the one of the absolute values. The paper clearly underlines this aspect and, hence, it represents a clear and welcome contribution on the analysis (and use) of soil moisture spatial-temporal variability. Despite the paper significant merits, I found some issues to be solved before its publication.

In the Methods section, the equation (4) could provide some inconsistencies for its application. In fact, while S_{tn} and a_{tn} are two matrices, the term a_{tn} is a vector. Therefore, the summation of a_{tn} and m_n is formally wrong. I suggest modifying this equation and, accordingly, also the following ones. Additionally, in equation (7) the second term should be without "cov", please correct.

Some parts of the description of the results should be revised. The analysis of Figure 4a contains a lot of symbols and numbers. It is not easy to follow the main findings that should be extracted from this analysis. Additionally, which is the reason of the analyses shown in Figure 5? Please specify.

The main problem I found is in the temporal stability analysis. Why the relative and absolute differences are analyzed (Figures 6a and 6b)? The results are basically the same. Figure 6d seems to be wrong as I expected that the rank of the sites should be the same of the one reported in Figure 6c (see also page 830, lines 16-17). Please

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check. Again, the large number of symbols does not allow to easily derive the main outcomes of this analysis. I suggest showing the temporal stability analysis only for the relative (or absolute) differences of 1) the soil moisture original values, 2) the absolute value of the anomalies and 3) the temporal mean soil moisture values.

I suggest smoothing out some of the conclusions of the paper. The authors are well aware (see page 833, lines 19-21) that the results are dependent on the investigated dataset. In fact, the climatic conditions, the spatial extension of the area, the soil texture and land use of the investigated sites and the layer depth are expected to have a significant influence on the obtained results as it occurs for the analysis of soil moisture absolute values. For instance, the authors only analysed grassland sites; this aspect may have a significant impact on the spatial distribution of soil moisture and also on the sampling requirements (e.g. *Manfreda and Rodrìguez-Iturbe, 2006*). Specifically, by performing some preliminary analysis with two data sets at my disposal, I obtained quite different results (e.g. the contribution to spatial variance of the spatial variability of anomalies is found to be higher than the time invariant contribution). I also would like to see the proposed framework applied to the different soil moisture datasets that, nowadays, are widely (sometimes also freely) available.

On these bases, in my opinion, I find that the paper may become worthy of publication on HESS after a moderate revision.

Specific Comments/ Technical Corrections (P: page, L: line or lines)

P822, L5: See also *Brocca et al. (2012)* and *Crow et al. (2012)* who investigated the upscaling of soil moisture observations at different spatial scales.

P827, L14: Why are the data "daily aggregated"? Are daily averages? This could have a non-negligible effect on soil moisture temporal variability thus influencing the overall findings of the paper. Please specify and discuss better this aspect.

P828, L1-2: Why is a minimum of the spatial variability of anomalies expected for

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values close to zero? With a different data set, I obtained a different pattern. Please specify.

P828, L13: What does "spatial P and T_{air}" mean? Spatially averaged values? Please specify.

P829, L6-21: This part is not clear and it should be revised (see also General Comments).

Figure 3: This figure is quite small and hard to read.

Figure 4b: This figure is not needed because it is simply a check of the correctness of the analysis.

Additional Reference

Brocca, L., Tullo, T., Melone, F., Moramarco, T., Morbidelli, R. (2012). Catchment scale soil moisture spatial-temporal variability. *Journal of Hydrology*, 422-423, 71-83, doi: 10.1016/j.jhydrol.2011.12.039.

Crow, W., A. A. Berg, M. H. Cosh, A. Loew, B. P. Mohanty, R. Panciera, P. de Rosnay, D. Ryu, and J. Walker (2012). Upscaling sparse ground-based soil moisture observations for the validation of coarse-resolution satellite soil moisture products. *Reviews of Geophysics*, in press, doi: 10.1029/2011RG000372.

Manfreda, S. and I. Rodrìguez-Iturbe (2006). On the spatial and temporal sampling of soil moisture fields. *Water Resources Research*, 42, W05409.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 9, 819, 2012.