Interactive comment on “Soil water content evaluation considering time-invariant spatial pattern and space-variant temporal change” by W. Hu and B. C. Si

We would like to express our thanks to Reviewer #2 for his/her detailed and useful comments on our manuscript. Responses to all comments are made below.

Comment 1:

This paper adopts a new method of decomposition of the measured soil moisture in space and time with some modifications. Such decomposition procedure was introduced by Mittelbach and Seneviratne (2012) and the authors suggests the use of EOFs for a further decomposition of the redistribution term Sr(i; j). The aim of the paper is the construction of a model for soil moisture downscaling starting from preliminary information of the space-time dynamics of soil moisture. Even if the topic is certainly of great interest, the paper is not clear in the presentation of the methodology, of the aim of the research as well as in the presentation of the results. I have found very confusing the organization of the paper that contains a number of useless contents that do not help the reader in understanding the real aim of the research. I think that the objective should be clarified reducing the length of the paper and removing all unnecessary contents for the economy of the paper.

Response 1:

The main objective was to evaluate soil water content (SWC) distribution using a statistical model which considers both time-invariant spatial patterns of SWC and spatial variability of temporal changes in SWC. Due to the important role of redistribution term R_{tn} ($S_r(i, j)$ in previous copy) in the construction of the new model, the distribution and influencing factors of redistribution term were also explored to show how does the redistribution term relate to hydrological processes. In order to avoid misunderstanding and put emphasis on more the SWC evaluation, we will remove the contents unrelated to the SWC evaluation. At the same time, the methodology, results, and discussion will be classified as well. In addition, we also adopt the terminology and symbols used by Mittelbach and Seneviratne (2012) to make the manuscript more readable (as suggested by Reviewer #1).

Comment 2:

The paper in my personal opinion is not well presented; there is an excess of useless information and the procedure suggested is not well described. There are two different analyses that in my opinion do not talk to each other the analysis of the EOF correlation with physical factor and the model application. What is the role of the first respect to the second is totally unclear to me. The paper is not fluent and provides a limited test of the procedure suggested on a small experiment with only 23 dates of measurements. In my opinion, the paper is not ready for publication on HESS.

Response 2:

The information unrelated to SWC evaluation will be removed in the revision. The procedure of SWC evaluation will be rewritten in a way more understandable.

Actually, the analysis of the EOF correlation with physical factor and model application are two different aspects, but both of them are closely related to the redistribution term. The objective of analysis of the EOF correlation was to show which factors mainly contribute to the redistribution term. Outperformance of our model over conventional EOF method can be attributed to the inclusion of redistribution term in the model. For avoiding confusion, the analysis of the EOF correlation analyses will be removed considering that our main objective was to evaluate SWC distribution with the new method.

Although the number of measurement dates is limited only to 23, our SWC measurements were made under different soil water conditions during four years. Therefore, they can represent well different soil water conditions in our study area. On the other hand, 23 dates of measurements over 128 locations at 7 depths are actually not small as compared to others, e.g., 13 dates of Perry and Niemann (2007) published in JOH, 14-17 dates of Korres et al. (2010) published in HESS.

References:

Korres, W., Koyama, C. N., Fiener, P., and Schneider, K.: Analysis of surface soil moisture patterns in agricultural landscapes using empirical orthogonal functions, Hydrol. Earth Syst. Sci., 14(5), 751-764, 2010.

Perry, M. A., and Niemann J. D.: Analysis and estimation of soil moisture at the catchment scale using eofs, J. Hydrol., 334(3-4), 388-404, 2007.

Comment 3:

In the following, I have summarized some of my major concerns regarding the present paper.

1. First of all, the reconstruction of soil moisture pattern is relatively easy when space-time data is available for the period under study. The authors in the present paper test the procedure in the ability to reconstruct the SWC pattern starting from a data driven procedure. In my opinion, the real challenge is the prediction of the soil moisture pattern during a not monitored period. This is the challenge that authors should address. Regarding this specific aspect I believe that analysis should be extended over a period of more than one year. In fact, equation 12 is calibrated on the estimated values of EC over the considered period; how can we use these equations over different periods?

Response 3:

In the revision, external validation will also be used to validate the new method. For external validation, the datasets (14 datasets) of the first two years were used for model calibration, and the datasets (9 dataset) of the second two years were used for model validation. Similarly, the EC values during the second two years were estimated with Eq.(12) developed from the measurements of the first two years. The external validation also indicates the outperformance of the new method. According to Fig. R1, the new model outperformed conventional EOF method in case SWC deviated from the average conditions during the external validation. This will be added in the revision

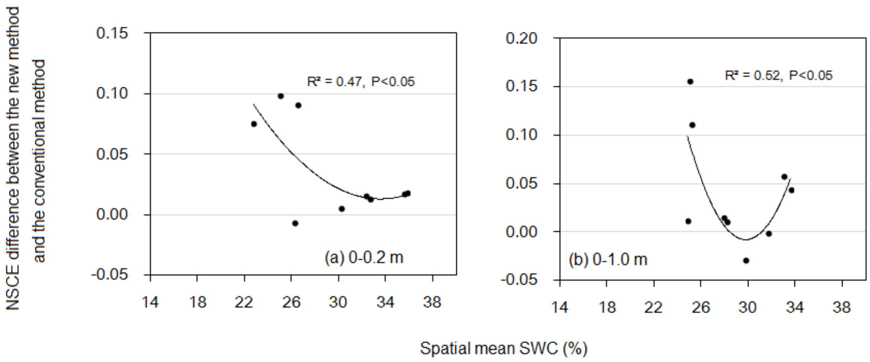

Fig. R1 Difference between Nash–Sutcliffe coefficient of efficiency (NSCE) of soil water content (SWC) evaluation using the new method and that using the conventional EOF method as a function of spatial mean SWC at (a) 0–0.2m and (b) 0–1.0 m. A quadratic function was used to fit the associated relationship. The datasets (14 datasets) of the first two years were used for model calibration, and the datasets (9 dataset) of the second two years were used for external validation.

Comment 4:

2. Analyses have been carried out on 128 sample points in 23 dates. The total number of data used is about 2944. The first consideration regards the period investigated that is limited compared to the spatial sampling density. Some comments of this would be useful. Furthermore, this dataset seems limited to provide a validation of a new methodology.

Response 4:

First, .although only 23 dates of measurements were available, it covered different soil water conditions during four years and these datasets can represent well the soil water conditions of different periods. These points will be added in the revision. We agree that the period investigated is limited compared to the spatial sampling density and the more data, the better. However, the four years of data represent a large temporal variability to be used in validating our method. And perhaps the variability in the data is more important than the number of data points for validation.

In order to provide more confidence in validation, we will group the whole datasets of four years into two parts. The datasets (14 datasets) of the first two years were used for model calibration, and the datasets (9 dataset) of the second two years were used for model validation.

Comment 5:

3. The comparison of the two procedures is made neglecting the level of complexity introduced by the new method. In fact, the second method uses more information respect to the ordinary EOF approach and obtaining limited advantages (see figure 5).

Response 5:

We admit that the new method seems to be more complex. But these two methods use the same dataset. The only difference between these two methods is that EOF analysis was conducted on the spatial anomaly of ***time-varying component*** for the new method, while the EOF analysis was conducted on the spatial anomaly of ***original measurements*** for the conventional EOF method. Both spatial anomalies can be easily obtained from the measured SWC datasets. From Fig. 7 in the previous copy and Fig. R1, the outperformance of the new method over conventional method is obvious especially when SWC deviated from the average conditions.

Comment 6:

4. I agree with the other reviewer regarding the need to provide further analysis of the procedure suggested mainly for two reason: 1) authors cannot compare their results with those obtained by Mittelbach and Seneviratne (2012) (see e.g., page 12843 – lines 26-28), because the two applications refers to different spatial scales; 2) The method proposed is provides limited advantages that are more evident in dry periods. This last result is obtained for a dry or wetter periods where usually it is easier to predict soil moisture pattern due to the reduction of the spatial variance of the process (this s certainly connected to the result obtained and to the shape of the curve reported in figure 7).

Response 6:

For the sentences at lines 26-28 on page 12843, we did not intend to compare the results of these two studies. Instead, we just want to state that different factors may contribute to the redistribution term at different scales. We will clarify this in the revised manuscript.

According to the Fig. R2, variance increased with increasing SWC for both 0-0.2 m and 0-1.0 m. Outperformance can be observed both in the drier and wetter periods (Fig. 7 in the submission copy and Fig. R1), although more evident in the drier periods. But better prediction of SWC at drier condition was only observed for 0-1.0 m using new method, and drier conditions did not necessarily correspond to better prediction in other cases (Fig. 5). Therefore, it is hard for us to relate the performance of a method and better outperformance of the new method to the less variability in the drier periods. Instead, we would contribute the outperformance to the inclusion of redistribution term in the new method, which is also explained in the second paragraph on page 12845.

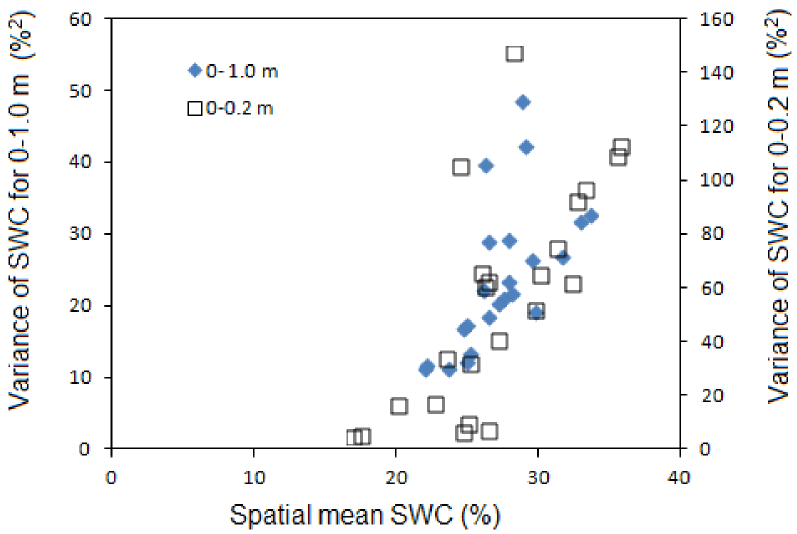

Fig. R2 Relationship between variance of SWC and spatial mean SWC for both 0-0.2 m and 0-1.0 m.

Comment 7:

5. The Section "2.5 Other statistical analysis" describe additional analysis that are not functional for the paper. This section for me does not help the reader to understand the scope of the research. It must be removed.

Response 7:

We agree. We will shorten the paragraph and highlight the SWC evaluation using the new method, and remove section 2.5..

Comment 8:

6. Personally, the paper should focus strictly on the procedure and its validation. All the analyses of correlation of the EOFs with some physical pattern are useless in the economy of the paper. Findings are not surprising and also Therefore, I strongly suggest removing section 3.1 and 3.3.

Response 8:

We agree. We will focus on the procedure and its validation, and remove section 3.1 and 3.3.

Comment 9:

Minor Aspect

Page 12883-line14: Why this term, obtained from the decomposition of _S(i; j), should represent the effect of soil hydrological processes? It means everything and nothing.

Response 9:

This is also commented by Reviewer #1. We will change this sentence to "The R_{tn}

refers to the redistribution of $A_{t\hat{n}}$ among different locations due to topographic, soil and vegetation heterogeneity influencing soil water movement."

Comment 10: Figure 1: in addition to the spatial description of the temporal mean soil moisture, it would be useful for the reader to provide a graph with the evolution of the spatial mean SWC.

Response 10:

Spatial mean soil water content versus measurement dates (Fig. R3) will be added in the revision.

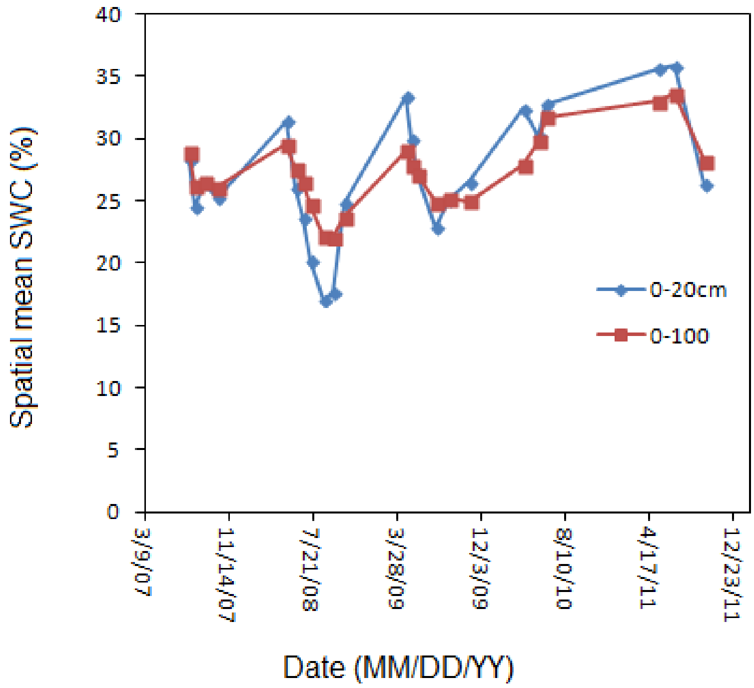

Fig. R3 Spatial mean SWC of 0-0.2 m and 0-1.0 m on different dates.

Comment 11:

Figure 4: Only three dates are plotted over 23 and these raises the reasonable suspect that these dates where chosen among the best performing ones.

Response 11:

Due to the page limit, we cannot plot the results of all 23 dates. Therefore, only three dates, representing dry, moderate, and wet condition, respectively, were plotted. However, the performances of SWC evaluation for all dates are shown in Fig. 5 using the Nash-Sutcliffe coefficient of efficiency (NSCE) to confirm the outperformance of our method.