

The author's answers are indicated in red color, as well as old text passages. New text passages are indicated in green color.

This manuscript describes three approaches (ANN, Exponential filter, and CDF) to estimate subsurface soil moisture from surface soil moisture data in the Qilian Mountains of China. Authors identified the Exponential filter as the best model and applied this model in different ways throughout the manuscript. The topic is of great interest, but I think that the manuscript requires a significant restructuring in order to be considered acceptable for publication on HESS. My major concerns are:

Response:

Thanks for your comments. We have made a significant restructuring in the revised manuscript.

1. The organization of the manuscript and its presentation is not fluent. It seems that a series of tests and analysis have been listed one after the other without a logic.

Response:

Thanks for your comments. In the revised manuscript, we have deleted some contents that are not important for the analysis, and we made a drastic restructuring and reorganization to make the revised manuscript easier to understand.

The revised manuscript is now divided into three parts. Firstly, we evaluated the different methods for estimating subsurface soil moisture (SM). The ExpF method was found to be the most suitable method for further application in the study area.

Secondly, our results indicate that the median value of  $T_{opt}$  can be used for application of the ExpF method in the study area.

Finally, the ExpF method derived with the median value of  $T_{opt}$  was combined with the SMAP\_L3 surface SM product to estimate the subsurface SM. The subsurface SM was also compared to the SMAP\_L4 root zone SM product (a widely used large-scale root zone SM product). Results indicated that the combination of the ExpF method with the SMAP\_L3 surface SM product can significantly improve the estimation of profile SM in mountainous areas. Furthermore, the combination of SMAP\_L3 and the ExpF method (with the median value of  $T_{opt}$ ) was applied to estimate the temporal and spatial distribution of profile SM in the study area.

2. For instance, I do not see any added value in the preliminary analysis of the soil moisture data. It is quite obvious that surface and subsurface soil moisture are linked or coupled. Remove this part or avoid stating that it is an outcome of the study.

Response:

We have deleted this part in the revised manuscript.

3. Second step in the manuscript is the intercomparison of different models. In this step, it seems that the use of ANN is made just applying a matlab tool without providing enough details about the approach adopted.

Response:

We have added the details of the ANN in the revised manuscript. (Line 153-165)

The ANN method is a data-driven method to predict subsurface SM from surface SM (Zhang et al., 2017a). If properly trained, ANN are able to describe nonlinear relationships between dynamics of SM at different depths (Kornelsen and Coulibaly, 2014). The commonly used feed-forward ANN (with one hidden layer and 10 neurons, Levenberg–Marquardt algorithm, Ford et al., 2014) was used in this study and the ANN modelling was carried out using MATLAB (neural network time series tool, R2017b, The MathWorks). The output of the ANN was calculated using:

$$y = f[W_2g(W_1X + b_1) + b_2]$$

where  $y$  is the output,  $f$  and  $g$  is the activation function of the hidden layer and the input layer, respectively.  $W_1$  and  $W_2$  are the weights of input layer and hidden layer, respectively.  $b_1$  and  $b_2$  are the bias of input layer and hidden layer, respectively. The tangent sigmoid function was choiced as the activation function as it has the good performance in the hydrological studies (Yonaba et al., 2010). As suggested by Zhang et al. (2017a), 70% of data were randomly selected for training the ANN and the remaining 30% were used for validation. A separate ANN model was developed for every depth combination and every site.

4. The intercomparison may be influenced by the different approaches used for the calibration of the methods. In fact, authors states that 70% of the data was used for validation of ANN and CDF, but they do not provide such indication for the exponential filter. If they used the entire database for this last, this may affect the results.

Response:

The  $T_{opt}$  parameter of the ExpF method reflects the characteristic length of the temporal dynamics of soil moisture. Earlier studies revealed that  $T_{opt}$  is highly dependent on the sampling interval of soil moisture data (De Lange et al., 2008). In our study, we found that when using the random sampling with 70% training data as for the ANN method,  $T_{opt}$  was not suitable for the remaining data. Since it was not possible to use the same training method for ExpF method as for ANN, we used the entire soil moisture time series to estimate  $T_{opt}$ , which was also the standard procedure in earlier studies (e.g. Wagner et al., 1999; Albergel et al., 2008; De Lange et al., 2008; Ford et al., 2014; Wang et al., 2017).

5. I personally do not understand the need to include a section of the cross-correlation analysis. It seems out of the scope of the manuscript. Moreover, no significant results are discussed herein. Please remove this section.

Response:

We have deleted the part of cross-correlation analysis in the revised manuscript.

6. Authors proposed some multilinear functions to describe relative value of T, which is fine, but it is not connected with anything else in the manuscript. It is another element somewhat independent from the main objective of the manuscript. Consider to

Response:

We have changed the manuscript. We deleted the regression equation for  $T_{opt}$  that is not connected with the further analysis any more. Meanwhile, the evaluations of the other four methods for estimating  $T_{opt}$  were kept, as the results indicated the usability of the median value of  $T_{opt}$  for the ExpF method, which is important for data-scarce mountainous areas. What's more, the median value of  $T_{opt}$  was used to derive the ExpF method to estimate the subsurface soil moisture from the SMAP\_L3 surface product in the revised manuscript (Section 4.3.2). Thus, this part was connected to the further analysis in the revised manuscript.

7. In the last section, we start another new section where SMAP is used first in comparison with the observation revealing some limitation for higher values. Such statement should take into consideration the existing gap in the spatial resolution of the two measurements. Rough resolution tend to smooth out higher values. This is quite obvious.

Response:

We have noted the problem of scale mismatch between the in-situ observations and SMAP product. We have added the discussion about the introduced error from the scale mismatch in the revised manuscript. (Line 291-294)

Here, it is important to note that the SMAP\_L3 product is provided at a  $9 \text{ km} \times 9 \text{ km}$  resolution while the in-situ measurements are point-based and soil moisture has a strong spatial variability in mountainous areas (Tian et al., 2019). Thus, part of the variability in Fig. 6 is due the disparity of spatial scales between the point-scale and the satellite footprint (Jin et al. 2017).

8. Finally, authors close with a comparison of exponential filter applied on SMAP. The regression are not used for this scope, other methods are not considered in this section, cross-correlation and spatial dynamics also neglected. I reached this point and I realized that authors are following a random walk of activities and I felt confused and disoriented.

Response:

We have made a drastic restructuring and reorganization in our revised manuscript. In the revised manuscript, we deleted the content related to the cross-correlation analysis and the regression analysis of  $T_{opt}$ , which were not connected to the further analysis. After establishing that the median value of  $T_{opt}$  can be used for the ExpF method, further calculation of subsurface soil moisture from SMAP\_L3 surface soil moisture used the median value of  $T_{opt}$  in the revised manuscript.

This manuscript requires a DRASTIC RESTRUCTURING and REORGANIZATION before being considered for publication. It will also benefit of a significant shortening of useless contents.

Response:

As stated above, we have revised the manuscript with a drastic restructuring and reorganization.

### Reference:

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