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Discussions

Interactive comment on "Estimating root zone soil moisture using near-surface observations from SMOS" *by* T. W. Ford et al.

T. W. Ford et al.

twford@tamu.edu

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Response to reviewer comments on "Estimating root zone soil moisture using near-surface observations from SMOS

Response to comments, Dr. L. Brocca We thank Dr. Brocca for his comments and outline our responses below:

1) The papers mentioned in his comment are very relevant to the methods and results of our study and will therefore be included in the literature review and discussion sections of the revised manuscript

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2) The authors agree the analysis of SMOS for obtaining root-zone soil moisture estimates is not fully developed in the current manuscript. SMOS comparisons with near-surface in situ soil moisture measurements will be more explicitly analyzed in the revised manuscript and include a more exhaustive SMOS root-zone performance analysis with multiple, complimentary error metrics. The SMOS analysis was initially completed only for Oklahoma because of the availability of in situ soil moisture data for 2011. However we have recently acquired AWDN (Nebraska) station measurements for 2011 and the SMOS analysis will be extended for Nebraska in the revised manuscript. The conclusion that the exponential filter method, applied to SMOS data, performed well in Oklahoma will be supported with figures and performance statistics in the revised manuscript. With respect to the CATDS Level 4 SMOS Drought Index product, we were not able to acquire the SMOS-based product from the website provided. The authors agree the comparison of this product to station-based root-zone measurements would make for an interesting and impactful paper and consider this a possible avenue of future research.

3) The revisit time information of the ERS 1-2 SCAT and MetOp ASCAT is indeed daily and this will be corrected in the revised manuscript.

Thank you again to Dr. Brocca for his comments and constructive recommendations. âĂČ

Response to comments, Dr. C. Albergel We thank Dr. Albergel for his comments and outline our responses below:

1) The authors agree the analysis of SMOS for obtaining root-zone soil moisture estimates is not fully developed in the current manuscript. SMOS comparisons with near-surface in situ soil moisture measurements will be more explicitly analyzed in the revised manuscript. The performance of the exponential filter method when generating root-zone soil moisture estimates from SMOS data will also be better detailed using multiple metrics and descriptive figures in the revised manuscript.

HESSD

10, C5111–C5118, 2013

2) The authors agree the introduction literature background is insufficient and the papers mentioned in the comments will be included in the literature review and discussion sections of the revised manuscript. The authors thank Dr. Albergel for making us aware of these relevant studies.

Specific Comments: 1) We will mention that root zone soil moisture controls evapotranspiration in the abstract in the revised manuscript.

2) The initial SMOS reference in the introduction will be changed to Kerr et al. (2010, 2012)

3) Kerr et al. (2001) will be updated to one of the more recent papers.

4) The SMAP mission will be included in this section.

5) Soil temperature data are available for Oklahoma stations, but not for Nebraska stations. Stations in Nebraska are more likely to be affected by freezing/thawing, but we do not have soil temperature data to directly analyze how soil temperature/frozen soils might impact our results. All twelve months of the year were considered in all our analyses, although freezing and thawing could possibly influence the relationship between near-surface and root-zone soil moisture.

6) The North American Soil Moisture Database is in its final stage of construction and data will be available shortly on the website. The only connection the NASMD has with the International Soil Moisture Network is that some data are included in both databases (SCAN, SNOTEL, etc.). The period considered for Oklahoma was 2000 – 2012, while the period considered for Nebraska was 2006 – 2010. SMOS data were only available for 2011 so the period considered for the SMOS analysis was 2011 for both the SMOS and station data. The measurement frequency of both networks is daily. These data descriptions will be better detailed in the revised manuscript.

7) This sentence will be reconstructed in the revised manuscript.

8) Thanks for your comment. We agree that the purpose of the exponential filter is

HESSD

10, C5111–C5118, 2013

different from ensemble kalman filtering. We have added a discussion of this to our paper (and a reference to your paper in HESS).

9) SMOS-derived will be changed to SMOS.

10) The original purpose of this sentence was to include limitations of the exponential filter method. However, it caused confusion and so it will be rewritten in the revised manuscript.

11) The authors agree that question 3 needs to be enhanced in the manuscript. The revised manuscript will include a more detailed analysis of question 3.

12) Thank you for bringing these papers to our attention, we will include these in this section for the revised manuscript.

13) We obtained 5 cm SWI by standardizing measurements using the maximum and minimum volumetric soil water content measurements during the entire time series. Thus an SWI of 1 represents the wettest soil conditions over the entire study period (Oklahoma: 2000 – 2012, Nebraska: 2006 – 2010). However we compared in situ station SWI to SMOS SWI only for the 2011 because we only have SMOS data for 2011. Therefore in order to make SWI comparable between the two datasets, we re-calculated SWI for each station using only 2011 data. The soil moisture data for each station was standardized using the maximum and minimum water content values over the year of 2011. The revised manuscript will include a better description of how SWI was calculated for each analysis. The optimal T parameter was calculated using the NS score to match the methods used by Albergel et al. (2008). After plotting R2 values for various T parameters, the optimal T parameter values are the same. In the interest of only showing the most relevant results as figures, we only show the NS score as a function of the T parameter. However, R2 results will be mentioned in the text.

14) We applied the filter to daily data. That is how we obtained one root-zone estimate from the exponential filter per day. This will be clarified in the revised manuscript.

HESSD

10, C5111–C5118, 2013

15) The NS score decreases in March in Oklahoma. However, soils are very rarely frozen that far into the spring season. If frozen soils did influence the performance of the NS score, we would expect the lowest NS values in January and February, which is not the case.

16) The revised manuscript will include more details and results comparing SMOS surface retrievals to 5 cm station soil moisture as well as SMOS SWI and 25 cm station observations. This section will also be presented in a SMOS results section, which will be separated from a SMOS discussion section.

17) By anomalies we are referring to SWI. However, the term “anomalies” is not the most accurate term for SWI, as the soil moisture are standardized by the maximum and minimum and not by the mean. We will rephrase the beginning of this section in the revised manuscript.

18) The station observation sections are based on different time periods: Oklahoma 2000 – 2012, Nebraska 2006 – 2010. The SMOS section is based on the year 2011 for all datasets. SMOS data was only available for 2011 and was thus standardized to SWI by the 2011 max and min soil moisture values. This is not clear in the original manuscript and will be better detailed in the revised version.

19) We tested T values higher than 10, but the accuracy of the exponential filter estimates consistently decreased after T = 10 days. The SMOS and station soil moisture data were both daily, although the SMOS data had significantly more missing data values than the station data. One point is we did not test for an optimal T value for SMOS data, but instead used the T values derived using the station-based soil moisture data. We will include an analysis of optimal T values for SMOS data over Nebraska and Oklahoma in the revised manuscript.

20) We will acknowledge the previous research using the exponential filter method for estimating root zone soil moisture in the revised manuscript. As mentioned in the response to Dr. Brocca, we were not able to obtain SMOS root-zone soil moisture

HESSD

10, C5111–C5118, 2013

products. However we would like to compare these products to the estimates from this study in future research.

21) The revisit times and SMAP information will be updated in the revised manuscript.

22) The period considered for Oklahoma is 2000 – 2012 and 2006 – 2010 for Nebraska. We will include these details both in the text and table captions in the revised manuscript. The data shown in Table 2 are accumulated across all Oklahoma and Nebraska stations and do not have a time component. A time series would be difficult to create from these data. Bar graphs are a possibility, but would be too clustered to provide more clarification than confusion.

Thank you again to Dr. Albergel for his comments and constructive recommendations.

âĂČ Response to comments, Referee #2 We thank Referee 2 for their comments and outline our responses below:

1) The authors agree a more detailed evaluation is needed to assess the accuracy of SMOS soil moisture retrievals and the root-zone estimates based on the SMOS data. Also, more detail is needed when describing how SMOS was used to estimate root-zone soil moisture. These issues will be addressed in the revised manuscript.

2) The difference in spatial resolution between SMOS and station observations is a limitation of any satellite – in situ data comparison. We attempted to address this issue by using the standardized SWI product for all SMOS-station data comparisons. Using SWI instead of volumetric water content ensures both datasets have the same range and mean, this way differences in variability can be properly assessed. These details will be described in the revised manuscript.

3) When comparing SMOS soil moisture to the in situ observation, we did the comparison station by station because only rarely did more than 1 station fall into a single SMOS footprint.

4) We will include the SMOS DGG over the study area map in the revised manuscript.

HESSD

10, C5111–C5118, 2013

5) All evaluations of the exponential filter method are in SWI (unitless). If we had expressed the errors in volumetric water content, they would be much less.

6) The legends in Figure 2 will be corrected in the revised manuscript.

7) This line will be changed in the revised manuscript.

8) Because we state the study will investigate three questions, we prefer to keep the numbered questions instead of small caps.

Thank you again to Referee 2 for their comments and constructive recommendations. âĂČ Response to comments, Referee #3 We thank Referee 3 for their comments and outline our responses below:

1) The authors agree more detailed analysis of the differences between SMOS and station observations is needed. The revised manuscript will include investigation of the differences in mean, variability, and correlation between the two datasets. Unfortunately too many days are missing from the daily SMOS data to calculate serial autocorrelation. In addition because we are only using one year of SMOS data, any serial autocorrelation could be an artifact of the short time period and not necessarily representative of SMOS retrievals in general. Therefore we cannot provide a comparison based on serial autocorrelation. However, the revised manuscript will include an analysis of optimal T parameters for SMOS data over Oklahoma and Nebraska.

2) Tables 3, 4 and 5 will be replaced with maps in the revised manuscript. This will better show any spatial coherence in the results across the two states.

3) Figures 4 and 5 will only show lagged correlations up to 25 days and no negative lags in the revised manuscript.

4) We calculated the autocorrelation of surface in situ soil moisture and have included a few sentences discussing the serial autocorrelation and the cross correlation between surface and root zone layers. However, to keep the number of figures to the absolute relevant minimum, we only show the cross correlation plots.

HESSD

10, C5111–C5118, 2013

5) We attempted to show average water content on a map, but because of the low spatial density of stations, the figure was not as clear as the bar graphs in Fig. 3.

6) Figures 4 and 5 will not include any negative lags, and the font size will be increased in the revised manuscript.

7) We will update the annotation of the equations and include a description of m in the revised manuscript.

8) Equation (2) should be K_(n-1) and this will be updated in the revised version.

9) We will use different color shades and limit the x axis to 25 days in the revised manuscript.

10) We used SMOS soil moisture data product 2 (SMUDP2). The data were not available every day of the year so comparisons are only done for days with SMOS data available.

11) The revised manuscript will include a more in depth analysis on the differences between SMOS and ground stations. An optimal T parameter will be calculated for the SMOS surface retrievals and employed in the exponential filter. Time series of ground station-estimated root zone soil moisture, actual ground station root zone observations and SMOS-estimated root zone soil moisture will be included as well.

Thank you again to Referee 3 for their comments and constructive recommendations.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 10, 8325, 2013.