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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Combined impact of local climate and soil properties on soil moisture patterns" *by* Thushara Gunda et al.

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Responses to Referee # 1 Comments (latter are bulleted)

Interactive comment on "Combined impact of local climate and soil properties on soil moisture patterns" by Thushara Gunda et al. Anonymous Referee #1 Received and published: 3 August 2017

The manuscript by Gunda et al., (2017) evaluated the soil moisture patterns in Sri Lanka based on soil moisture deficient that was calculated from meteorological measurements. The soil moisture from SMAP was also applied for the analysis. In general, the study was well designed and written. However, I would like to discuss the following points with the authors:

Response: We thank the referee for a thoughtful assessment of this paper. We have made modifications, as summarized below, in response to the points raised by the referee and are confident that this has resulted in a significantly improved manuscript.

1. The title of the paper emphasizes the soil moisture patterns. And the spatial variations of soil moisture were highlighted in the whole manuscript such as abstract, introduction, discussion and conclusion sections. I expected that there are figures or plots showing spatial patterns of the soil moisture. However, the current analyses are mainly based on station measurements. I think it is not appropriate to use spatial patterns or spatial variations in the manuscript.

Response: Since the focus of our analysis is long-term changes in soil moisture patterns and satellite measurements only provide spatial coverage for recent decades, we used station-level measurements, which are available from 1880s in Sri Lanka. Station-level measurements have been successfully used to understand variabilities in space for soil moisture analyses (e.g., Hirschi et al., 2011, Nature Geoscience, doi: 10.1038/ngeo1032). Although the stations we used capture the dominant spatial variabilities in climate across Sri Lanka, we recognize that they are not capable of capturing the variabilities across soil types. This is one of the primary reasons that our analysis focuses on spatial patterns at a zonal-scale (i.e., the wet, intermediate, and dry zones) and a station-scale. However, in acknowledgement of the reviewer's point regarding the value of country-wide visuals, we will add supplementary material that presents the interpolated historical soil moisture deficit values over space and time.

2. SMAP soil moisture was used to cross compare with the calculated soil moisture deficits such as Figure 4. In page 8 line 1, the statement is not true, because the seasonal patterns from SMAP and calculated deficit are quite different for station Colombo. The authors should discuss the reasons. In addition, I am wondering how accurate is SMAP soil moisture over these stations. Did you validate the SMAP soil moisture over the study area? Why do you choose SMAP rather than other soil moisture products such as ESA CCI?

Response: The seasonal patterns in Colombo from SMD vs SMAP show generally good agreement, with high soil moisture during May-Jun and Nov-Dec and low soil moisture during Aug-Sep. There is some disagreement between the two datasets regarding the timing of low soil moisture values in the first half of the year, with SMD indicating lowest values in March while SMAP indicating lowest values in January. These differences are most likely due to the different time periods covered by the two datasets; SMD data covers 1878-2014 while SMAP data covers 2015-2017. The discrepancy in these patterns reflects a rainfall shift over the last few years (https://www.worldweatheronline.com/colombo-weather-averages/western/lk.aspx), and correspondingly, shift in soil moisture deficit towards earlier months. We will update the discussion to include this information. Regarding validation, we were not able to directly validate SMAP data over the study area due to lack of direct soil moisture measurements. However, the accuracy of SMAP data has been assessed across multiple regions of the world (Chan et al., 2016, IEEE Transactions on Geoscience and Remote Sensing, doi: 10.1109/TGRS.2016.2561938; Colliander et al., 2017, Remote Sensing of Environment, doi: 10.1016/j.rse.2017.01.021) and we followed the quality protocol associated with the dataset to exclude poor signal qualities (associated with heavily forested and high water regions) from our analysis. In addition to comparing general seasonal patterns, one of our goals for using the SMAP dataset is to highlight future capabilities in soil moisture monitoring. A significant advantage of the SMAP dataset over other soil moisture products is the near real-time availability of this dataset (it is updated every 2-3 days), which can be incredibly helpful for local planning efforts.

3. The name of the sections should be more precise, for example, section 2 Methods should be Study area and methods. Section 2.1 should be Study area rather Study site. Section 2.1.1 Soil moisture calculations should be Soil moisture deficit calculation. Could you provide more details on the equations of soil moisture deficit? It is not clear for me how do you calculate SMD.

Response: The water balance data generated at each station (as part of the PDSI calculations) includes soil moisture values. The SMD was calculated by: 1) subtracting these soil moisture values from the corresponding station's available water content (AWCs; i.e., max soil moisture) and 2) normalizing by the AWCs. The resulting SMD then represents the fraction of soil moisture deficit relative to the local available water content for the top 1 m. We will add an equation and reorganize some of the text to clarify the calculations associated with the SMD. We will also revise the section names as suggested.

4. The conclusion part could be improved to answer the research questions that were raised in the introduction section. In addition, the last sentence is not clear for me, as far as I know, the downscaling method for SMAP can only provide soil moisture at 1-10 km. For regional agriculture applications, the soil moisture at tens of meters is more required. Is soil moisture at scale of km enough for the "informing local practices"?

Response: By local, we were referring to national-level and zonal-level agricultural planning efforts (i.e., not farm-level analyses), which can be greatly informed by downscaled soil moisture datasets. We will revise the conclusion to clarify our intentions.

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