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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Estimating Sahelian and East African soil moisture using the Normalized Difference Vegetation Index" *by* A. McNally et al.

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Thank you for your comments. We hope we address your concerns below and look forward to improving the manuscript by including some additional analysis with microwave soil moisture data, while still highlighting the utility of in situ observations.

1. The use of a limited number of local moisture ground measurements could not be sufficient for the analysis of relationships at regional scale. Satellite moisture products could be more efficient for the proposed analysis.

RESPONSE: While we agree that satellite moisture products could are a useful tool that we would be willing to include in this analysis. We have had good results with this approach in a paper that is currently in preparation. We do however, think that

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there is utility in showing how the limited in situ observations that are available can provide some interesting perspective on the relationship between rainfall and NDVI. The reviewer states that the limited observations can not be sufficient at the regional scale. However, we are able to extract the relevant information on seasonal timing and scale which are the parameters needed for NDVI to be transformed into the same units and phase as soil moisture. There are ways however that we can use microwave estimates to validate our current approach and we will incorporate these into a revised manuscript.

2. What about effect of scales for analysis between local ground moisture measurements and satellite NDVI or precipitation products. We know that for these Sahel sites, there is a high heterogeneity in precipitation.

RESPONSE: scales are an important consideration. One advantage of NDVI over available microwave products (e.g. ECV CCI merged active/passive microwave soil moisture (Dorigo et al. 2011) is that it is available at finer resolutions and closer to real time. We agree that the spatial heterogeneity of precipitation likely influences the ability of gridded NDVI to accurately estimate the exact soil moisture signal at a point.

3. Authors propose one relationship between moisture and vegetation for all the sites. Or we know that the vegetation cover changes from one site to another.Also, relationship could be different from one month to another function of vegetation growth and precipitation cycle.

RESPONSE: Answering this questions would be an interesting use of the available microwave data. We argue that the model that we developed is relatively robust given that it is able to estimate the timing of the seasonal cycle at both the Mali and Kenya site, and is highly correlated with rainfall derived estimates of soil moisture in the same annual rainfall zone (200-1200mm) that Nicholson found close coupling between rainfall and NDVI at a consistent lag. I hypothesize that the our soil moisture model is capturing the same lag defined by Nicholson (NDVI is related to the current and two

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previous months of rainfall). If we repeated the analysis we should be able to better define where our assumption about this lag does not hold. We are particularly interested in ways of leveraging any and all available data in sparsely gauged locations, thus we would do not want to eliminate the possibility that our method works well across broad regions that are characterized by semi-arid, savanna vegetation on sandy soils. We will look into this avenue further for the revised manuscript.

4. Ground soil moisture measurements: it is not enough clear what are the exact depths of measurements for the different studied sites? And (5). Authors consider moisture values between 40 and 70cm. The reason is not evident, particularly in Mali area with low vegetation cover and then limited root zone area?

RESPONSE: The aim was to represent condition in the rootzone. Profile plots at these sites suggest that the surface and upper 1m are closely coupled due to the well drained, sandy soils. We will verify the rooting depth of the dominate vegetation at the Mali site and be more clear about the depths of our observations and model results (see similar comment from Reviewer #1).

6. Models are calibrated for Niger sites and tested for other sites in Mali or Kenya. Or vegetation cover and its effect in root zone soil moisture could not be the same. Is it possible to retrieve the same statistical model for all studied areas?

RESPONSE: The statistical models, when locally calibrated were similar. We can include these results into our revised manuscript and discuss the similarities and difference between the different sites.

7. In introduction, authors write: “For regional estimates, microwave remote sensing data can detect wetness in the upper ïňĄve centimeters of soil, but are compromised if thick vegetation is present.”. Different algorithms using ASCAT or SMOS show a precision close to 5% in volumetric moisture, which is a good precision. For high vegetation density, precision is certainly lower, but this is also the case of NDVI because of the index saturation.

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RESPONSE: we agree, that wasn't a very well placed comment given that the microwave does perform well in low density vegetation regions like the Sahel.

8. Figure 4 illustrates difïňĄculties of using a general estimated soil moisture from NDVI index, with limitations for extreme years, dry and wet, for which, a global statistical analysis could be not sufïňĄcient (NDVI saturation etc. . . .). This difïňĄculty could be probably improved if we consider monthly relationships.

RESPONSE: Good point, this might be useful given that we are mainly interested in a two month period during the rainy season when soil moisture peaks and plants have the highest water requirement.

9. Application of equation (1) retrieved from sites in Niger to all the subsaharian area (ïňĄgure 5) seems not clearly justiïňĄed. In fact, we have to consider variations in soil texture, rainfall seasons, and vegetation cover.

RESPONSE: One of the main questions of this paper is if this is or is not a justifiable approach. Figure 5 suggests that since two independent models of soil moisture produce estimates that are highly correlated that the assumptions in our model may be valid. If soil type and co-varying/co-located vegetation class produced a very different NDVI signal than what we observe at the Niger site then we would expect low correlations between the two models. This is supported by the literature on the relationship between NDVI and rainfall where there is a relatively consistent temporal lag between the two variables across the Sahel. We can more carefully discuss this question if we compare the single site calibration results presented here with pixel-by-pixel calibration to microwave estimates (see comment #3).

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 10, 7963, 2013.