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Interactive Comment

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

A. McNally et al.

mcnally@geog.ucsb.edu

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Thank you for your comments. We have addressed each of your points below, we hope that this clarifies some your questions and we look forward to including these improvements in our revised manuscript.

1. There are some papers that have estimates soil moisture using NDVI but these have not been reviewed by the manuscript.

RESPONSE: In the discussion we did mention and cite the work that correlated NDVI with in situ soil moisture observations by Adegoke and Carleton, 2002; Wang et al., 2007; Gu et al., 2008; Schnur et al., 2010. We can highlight this work in more detail in the introduction.

2. Soil moisture contents are different for different soil depths. What is the depth of soil moisture estimated from NDVI in the paper?

RESPONSE: We calibrated the NDVI to observations averaged at 40-70cm in Niger [see line 24 in ‘In situ soil moisture measurements’, and line 27 in ‘4 soil moisture estimated with antecedent precipitation index’]. We can be clearer with this point when we address comment #1 that the methods are confusing.

3. Soil moisture has great spatial variability. The eMODIS NDVI is at 250m resolution originally. Can one point observations of soil moisture represent the 250mx250m area?

RESPONSE: First, the positional accuracy of the in situ observation coordinates restricts us to a 750mx750m area. We compared the NDVI at the Tondi Kiboro and Wankama sites. The NDVI signal was the same despite difference in the observed soil moisture time series. This question speaks to the broader issue of making point versus pixel comparisons which was also brought up by the other reviewers. In general we found that the NDVI can represent the seasonal timing observed at the points (which, for example, agrees at the both the Wankama and Tondi Kiboro, Niger sites). We are unable to resolve the peaks because this fine scale variability is site specific. In other words, there may be local influences like slope and aspect at the soil moisture probe that will not necessarily be captured by 750x750m NDVI let alone 10km x 10km NDVI that we used for our analysis. However, we did find that when we aggregated to the country-crop zones (Section 9 Comparison with WRSI and yields) our NDVI-derived soil moisture estimates did capture inter-annual variability as measured by the Water Requirement Satisfaction Index (WRSI) and FAO millet yields, as shown in ‘Table 1. Rank correlations.’ In summary, our estimates of soil moisture derived from NDVI represent regional moisture conditions, and this scale is relevant for agricultural drought monitoring.

4. The multi-satellite rainfall estimates (RFE2) at 0.1(10km) from NOAA CPC were used to calculate the antecedent precipitation index (API). While, the NDVI-derived soil

moisture (NSM) was at 250m resolution. When comparing the API and NSM data, how to identify the resolution effects?

RESPONSE: ‘Section 3 Soil moisture estimated from NDVI’ line 22: “We also aggregated NDVI to 0.1 âŮę (âĹij 10 km), matching the resolution of the bias corrected RFE2 satellite rainfall estimates. . .” We can be clearer with this point when we address comment #1 that the methods are confusing.

5. When evaluating the results of API and NSM models, the in-depth analysis were missing. Why the model results are different?

RESPONSE: Thank you, we’ll expand on this point for our revised manuscript. We will note a few main points here: First, the API generates a signal with relatively low variance compared to the NDVI-derived estimates. This can be seen in clearly in Figure 6 (API=blue dash). This is likely a result of the fact that this model aggregates over the previous six dekads (∼60days) while the NDVI-derived estimates are derived from two dekads (∼20 days) of NDVI observations. This allows the NDVI model to capture more of the intra-seasonal variation. The relatively small variance of the API is also evident in Section 9 Comparison with WRSI and yields, Figure 8. Here API stays relatively close to the mean compared to the other data products, especially in 2009. Another point is that at the southern extent of the range mapped in Figure 5, the eMODIS NDVI experiences cloud contamination during the middle of the rainy season. This error reduces the correlations between the rainfall and NDVI derived estimates. Finally, a major difference that we touch upon with the Kenya analysis is that the API can be thought of as a ‘supply side model’. It relies on rainfall inputs and its parameters represent how the soil dries, which will be a function of drainage (soil type and slope) and evapotranspiration rates (related to aspect, average time between storm events and atmospheric moisture demand). We did find that when we recalibrated the API to local, Mpala soil moisture observations it was able to represent the observed soil moisture reasonably well. In summary, the API’s parameters represent aspects of the system which are relatively local characteristics, which will limit the robustness of our single calibration approach across a heterogeneous landscape. The NDVI model, on the other hand, can be thought of as a 'demand side model', where plants are responding to whatever soil moisture is available. Thus, the parameters in this model represent the lag between peak soil moisture storage and peak vegetation greenness. This lag can vary over space, but has been shown to be relatively consistent: NDVI is highly correlated with the current and two previous months of rainfall for regions where annual rainfall is between 200-1200mm (Nicholson et al. 1990).

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