Response to Robert Parinussa's Comments

Reviewers summary: A relatively simple approach for downscaling soil moisture, based on high spatial resolution remotely sensed vegetation and surface temperature data, was presented. A number of different satellite based products and product combinations from various sensors were used and the resulting soil moisture datasets were evaluated against the Remedhus network located in Spain. The particular downscaling approach is not entirely new, there are several studies presenting a similar approach. However, this approach is relatively simple and still yields results in line with much more complicated approaches. Other interesting findings relate to the relative performance of polar orbiting and geostationary satellites and to the different vegetation products that were used. Overall, the manuscript is well organised, reads well and is very relevant for regional scale hydrological studies. I only have a few minor comments to further improve the manuscript (see below).

Response: We thank you for your time and encouragement, as well as the constructive comments. In the following, we provide an item-by-item response to your specific comments. Your comments are written in italic black color; our responses are shown in upright font blue color.

P8510, L1: Correct the text, 'like e.g. the as'

Response: Thanks. The sentence has been changed to "Normally the polar orbiting satellites such as Moderate Resolution Imaging Spectroradiometer (MODIS) and Advanced Very High Resolution Radiometer (AVHRR) are in general used for downscaling microwave soil moisture, while the geostationary satellite data are rarely applied."

P8510, L4: Geostationary data is indeed not widely used for surface soil moisture retrievals but Hain et al. 2011 (and its references) might be an interesting example to mention here. They successfully developed the ALEXI model that uses the observed land surface temperature gradient from geostationary satellites and uses this information, together with additional information, to estimate surface soil moisture conditions at a relatively high (3x3 km) spatial resolution.

Response: Thanks for pointing this out. The following sentences have been added into the manuscript. "Hain et al. (2011) successfully used ALEXI model together with thermal infrared observations from geostationary satellites to estimate soil moisture at a relatively high spatial resolution of 3 km."

P8510, L9-L11: A study that already inter compared the performance of geostationary (ALEXI model, see previous) and orbit satellites (ASCAT & AMSR-E sensors) is Parinussa et al. 2014. An intercomparison study of remotely sensed soil moisture products at various spatial scales over the Iberian Peninsula. However, the highest spatial resolution evaluated in their study was 10x10 km meaning that this study can push this forward.

Response: Thanks for letting us know this paper. We have integrated the following sentences into the manuscript. "Parinussa et al. (2014b) further inter-compared the geostationary satellite-based soil moisture with microwave-based soil moisture products at various spatial scales over the Iberian Peninsula. They found that all these products agree well with ground-based observations."

P8512, L12: Remove the word 'popular' or replace by 'commonly used'.

Response: According to the comment of referee 3, the sentence has been replaced by: "Similarly, Albergel et al. (2013) provided an evaluation of CCI SM and two reanalysis soil moisture products using in-situ observations from five networks across the world. They concluded that the CCI SM product correlates well with in-situ observations with average R of 0.60."

P8519, L21: Please use 1:30 am/pm instead of 13:30 am/pm.

Response: Corrected, thanks.

P8522, L23, L24 & P8524, L3 & P8525, L7-L8-L11-L20: Typo's.

Response: Corrected, thanks.

P8524, L9-L10: That's obvious if VTCI is perfect, but I suggest to rewrite/remove this line.

Response: The sentence here is aimed to emphasize the importance of original CCI soil moisture and VTCI. The accuracy of the downscaled soil moisture is expected to improve if we have accurate CCI or VTCI. The sentence here also functions as an answer to one question asked by referee 3. The sentence has been changed to: "if the VTCI can better represent the soil moisture."

General comment 1: Make sure that all figures are referred to in the main text, and also pay attention to the order.

Response: Thank you for the comment, we have double checked already.

General comment 2: This is more a general comment regarding the biases that were found, and particularly those of the ESA CCI product. To me, this is not a relevant topic. Firstly, owing the production chain of this dataset in which the original remotely sensed products are scaled to adopt an alternative mean and amplitude. And second because there should be a bias at all times as remote sensing and in situ represent a different vertical layer. Finally, most applications are blind for biases. Nonetheless, presenting the results regarding this metrics would be fine with me - but I would never draw (major) conclusions on those.

Response: Thank you for the comment, we fully agree with you. The evaluation of satellite-based soil moisture product is quite important. And the accuracy (bias) of the remote sensed soil moisture is affected by many factors such as (1) scale mismatch between satellite pixel and in-situ point; (2)mismatch between satellite penetration depth and in-situ measurement depth;

(3)the uncertainties of the soil moisture retrieval algorithms. These issues all need to be solved in order to quantify the uncertainties and improve the accuracy of satellite-based soil moisture. The CCI soil moisture has been comprehensively validated around the world (Dorigo et al., 2015). The evaluation of CCI soil moisture in this study is to explore if its accuracy level is better or worse than the accuracy reported by Dorigo et al. (2015). Therefore, similar statistic metrics were used here.

General comment 3: As was indicated in the text, several coarse(r) scale remotely sensed soil moisture products are available at the global scale. Over the recent years, a number of verification techniques were developed to evaluate their quality, some of them were also applied at the global scale. An important finding of these studies is that the global quality can widely vary for an individual product, and that there are usually clear relations with climatological conditions and performance. Based on this knowledge, readers should be aware that it's very likely that the developed approach will perform (very?) differently under different climatological conditions than those at the Remedhus network. Applying the developed method and evaluating it in other regions in the world could therefore simply be suggested as a follow on study, or as the other reviewer suggest, extending the current study area. Most important is to make the reader aware that obtained results are likely unique for the Remedhus and comparable climatological conditions.

Response: Thank you very much for the comments and suggestions. It is indeed very important to apply and validate the proposed method under different climates and surface conditions. We actually have evaluated the proposed method over Yunnan, China. It has a subtropical climate while Remedhus has a continental semiarid Mediterranean climate. Both study areas present similar results. Nevertheless, further application of the developed method over different study areas will be conducted in the future studies, to evaluate the feasibility of this method under various climatological conditions. The following sentence has been added into the manuscript:

"Application of the proposed method in other regions and comparison with other downscaling methods will be conducted in future studies."

References:

Dorigo, W. A., Gruber, A., De Jeu, R. A. M., Wagner, W., Stacke, T., Loew, A., Albergel, C., Brocca, L., Chung, D., Parinussa, R. M., and Kidd, R. (2015). Evaluation of the ESA CCI soil moisture product using ground-based observations. Remote Sensing of Environment, 162:380–395.