Answers to REVIEW2
Interactive comment on "An improved perspective in the representation of soil moisture: potential added value of SMOS disaggregated 1km resolution product" by Samiro Khodayar et al.

Answers to Reviewer 2

We thank reviewer 2 for all his/her suggestions. All of them will be considered in detail for the correction phase of the manuscript. In the following a general description of the main changes to be applied and detail answers to the comments is presented.

Kind regards,
Samiro Khodayar on behalf of all co-authors.

In the following a description of the main changes suggested is summarized,

- Proposed title change:
  An improved perspective in the representation of soil moisture: potential added value of SMOS disaggregated 1 km resolution "all weather" product

Better definition of the objective, novelty and relevance of this study improving the structure, content and length of the publication accordingly:

1. To examine the benefits of the SMOS L4 version 3.0 or "all weather" high resolution soil moisture disaggregated product (~ 1 km, SMOS_L4$^{3.0}$).
   - *The added value compared to SMOS-L3 (~ 25 km) and L2 (~15 km) is investigated.*
   - *High-temporal (every 10 min over several years) and spatial (7 stations in an area of about 10 x 10 km) soil moisture observations from the Valencia Anchor Station (VAS; SMOS Calibration/Validation (Cal/Val) site in Europe) are used for comparison and assessment of the spatio-temporal performance of the satellite derived soil moisture products.*
   - *The SURFEX-ISBA model is used to simulate point-scale surface SM (SSM) and, in combination with high-quality atmospheric information data, namely ECMWF and the SAFRAN meteorological analysis system, to obtain a representative SSM mapping over the VAS.*

2. First study, to the authors knowledge, apart from the quality report, that makes use of the newly SMOS L4 3.0 "all weather" soil moisture product.

   - *Added value compared to Level 2 and 3 SMOS products*
   - *Validation of the SMOS_L4$^{3.0}$ product in a different climatic region than REMEDHUS (Quality Report, Piles et al 2015)*
   - *Temporal and spatial assessment of the performance of the SMOS_L4$^{3.0}$ product including a seasonal analysis*
   - *First examples of possible applications of this product for initialization of off-line Soil-Vegetation-Atmosphere Transfer models (in this case SURFEX-ISBA) in stand-alone or regional approaches.*

3. The comparison carried out helps drawing guidelines on best practices for the sensible use of these products. Currently, there is not a consensus about what is the "best" SMOS product. Different users utilize different products depending on their application rather than based on performance arguments. This study and the conclusions obtained on the comparison are important to provide information on the advantages and drawbacks of these datasets.
Furthermore, regional SM maps with high accuracy are needed for flood forecasting, crop monitoring and crop development strategies, among others. Correct initial conditions for model simulations of these SM maps are fundamental to obtain a good accuracy. SMOS-L4$^{3.0}$ could fill the actual information gap and fulfil this requirement.

- New references have been included following the reviewers suggestions:

  - Piles, M., Pou, X., Camps, A., Vall-llosera, M. (2015): Quality report: Validation of SMOS-BEC L4 high resolution soil moisture products, version 3.0 or "all-weather". Technical report. Available at: http://bec.icm.csic.es/doc/BEC-SMOS-L4SMv3-QR.pdf

  - SMOS-BEC Team (2016): SMOS-BEC Ocean and Land Products Description. Technical report. Available at: http://bec.icm.csic.es/doc/BEC-SMOS-0001-PD.pdf

  - Malbéteau, Y., Merlin, O., Balsamo, G., Er-Raki, S., Khabba, S.,Walker, J. P., Jarlan, L. (2018). Toward a Surface Soil Moisture Product at High Spatiotemporal Resolution: Temporally Interpolated, Spatially Disaggregated SMOS Data. Journal of Hydrometeorology, 19(1), 183-200.

  - Djamai, N., Magagi, R., Goïta, K., Merlin, O., Kerr, Y., Roy, A. (2016). A combination of DISPATCH downscaling algorithm with CLASS land surface scheme for soil moisture estimation at fine scale during cloudy days. Remote Sensing of Environment, 184, 1-14.

  - Louvet, S., Thierry Pellarin, Ahmad al Bitar, Bernard Cappelaere, Sylvie Galle, Manuela Grippa, Claire Gruhier, Yann Kerr, Thierry Lebel, Arnaud Mialon, Eric Mougin, Guillaume Quantin, Philippe Richaume, Patricia de Rosnay (2015). SMOS soil moisture product evaluation over West-Africa from local to regional scale. Remote Sensing of Environment, Volume 156, Pages 383-394, ISSN 0034-4257, DOI: 10.1016/j.rse.2014.10.005.

GENERAL COMMENTS

1) **The manuscript investigates a relevant topic. The recent availability of 1-km soil moisture products from the disaggregation of coarse resolution retrievals, and from high resolution microwave sensors (e.g., Sentinel-1), still need to be thoroughly assessed and, particularly, tested the potential added value in hydrological or climatic applications. By reading the title, I was really interested to the paper and I thought its content was different with respect to the current text. I expected a more general view in which the added value of the high resolution product in real-world application(s) was determined. Therefore, I firstly suggest changing the title that is misleading.**

The main goal of this study is to investigate the added value of the 1 km "all weather" product with respect to coarser resolutions, the SMOS-L3 (~ 25 km) and L2 (~15 km) products, undergoing an evaluation against in situ observations. Additionally, in a first simple approach examples of possible applications of this product for initialization of off-line Soil-Vegetation-Atmosphere Transfer models (in this case SURFEX-ISBA) in stand-alone or regional approaches are presented.

As described for the reviewer 1, in a new study of the first author, which is about to be submitted to HESS, the suggestion of the reviewers is explored, in which we assess the benefit of using the SMOS-L4 product for the initialization of high-resolution convective-permitting simulations to improve the predictability of extreme weather phenomena such as heavy precipitation.

We suggest to slightly modify the title: An improved perspective in the representation of soil moisture: potential added value of SMOS disaggregated 1 km resolution "all weather" product, to better reflect which product we refer to, as suggested by the reviewer.

Major comments:

The paper is too long, not well organized (e.g., several repetitions), and not focused to a clear message.

We will follow the reviewer's suggestion and try to remove all repetitions and better describe the main goals/focus of this study.

The new SMOS L4 (v3.0) "all weather" product is introduced. However, a little description of the product is carried out, with a reference to a "Quality Report" not present in the reference list. As highlighted by reviewer 1, many details are missing (e.g., spatial resolution of ERA-Interim LST, its merging with MODIS-derived LST, . . .). These points need to be clarified. The title should be changed to underline the presentation of the new product. The whole paper should be focused on this new product.

The references to the quality report as well as other publications of relevance to the topic have been included in the reference list. Additional information regarding details of the SMOS L4 3.0 product which could be helpful for the reader will be included in the text. The title has been slightly modified to better identify the product we are discussing. We do not intend to introduce the new SMOS L4 (v3.0) "all weather" product, which is not ours (it was developed at BEC as described in the manuscript), but just to show the added value of the product with respect to other SMOS-derived SM products and give a simple example of the potential benefit of the new product.

2) More important than point 1, the paper should be focused clearly on the more relevant aspects the authors want to convey to the readers. The disaggregated product as a spatial resolution of 1-km, the assessment should be carried out with observations and/or modelling at 1-km resolution. It is not done in the paper. As in most "soil moisture downscaling papers" the assessment of the disaggregated product is carried out in the TEMPORAL DOMAIN, usually concluding that as the disaggregated product shows similar performance than the coarse resolution product. Being at higher resolution, it is a better product. Unfortunately, for me it is wrong and misleading. I expected that the new disaggregated product was compared with high resolution modelled data (constrained by in situ observations) in the SPATIAL DOMAIN. This comparison is needed to understand if the disaggregated product is able to reproduce the high resolution soil moisture variability (at 1-km scale). Of course, the model should be forced with high resolution meteorological forcing (e.g., radar rainfall), and it is hard to be done.

The spatio-temporal correlations are analysed through comparison with point-scale observations over the VAS region. A network of six stations is located in an area of about 10x 10 km^2. Section 4.2, lines 438 to 477, is devoted to the comparison of SMOS L4 and –L2 products to the in situ measurements from the VAS network. Statistics for individual comparisons at all stations are summarized in Table 3. Figures 7, 8 and even 9 are devoted to these comparisons, although it is not possible to always show all stations due to space issues. In the description, details are given about the better accuracy of –L4 product. An assessment of the quality of the SMOS L4 product using high resolution modelled data, even when constrained by in situ observations, is not a correct approach since modelled data present relevant biases. In general, the observations, as used in this study are considered "the truth"; hence, they are used for validation of satellite products. Indeed, when for example soil moisture products are used for initialization and/or assimilation in our models the correct approach is to apply CDF (Cumulative Distribution Function) matching methodology to similarly rescale both products.

In my opinion, the comparison with SMOS L2 and L3 products should be strongly reduced and the authors should focus on the SPATIAL assessment of the SMOS L4 "all weather" product (likely compared with SMOS L4 v2 product not including ERA-Interim LST). If the new product is able to reproduce the spatial variability of high resolution modelled data, then the authors can say that "the SMOS L4 v3 product captures the 1-km soil moisture spatial variability". Otherwise, all the sentences similar to this one should be removed by the paper.

We agree with reviewer 1 that an analysis of the SMOS level 4 data and its added value compared to Level 2 or Level 3 data is interesting since no reference is given elsewhere. The comparison carried out helps drawing guidelines on best practices for the sensible use of these products. Different users utilize different products depending on their application rather than based on performance arguments. This study and the conclusions obtained on the comparison are important to provide information on the advantages and drawbacks of these datasets. Nevertheless, following the reviewer's suggestion we will reduce this part and only focus on the most relevant information, always reinforcing the role of the SMOS L4 3.0 product.
Concerning the comparison with the SMOS L4 2.0 product, the comparison was made during our analysis but results were not included in this manuscript, but following the reviewer's suggestion we will describe in the text the most relevant conclusions obtained from this comparison.

3) The analysis for the initialization of modelled data is, at least for me, not clear and likely not appropriate. To assess the added value of the soil moisture product, the authors should

introduce the product into the modelling (e.g., through data assimilation) and assess the model performance without and with the use of the product. Specifically, the authors should assimilate different SMOS products into the modelling and then assess the best product based on the simulation results after the assimilation. The authors only showed that if different initial soil moisture conditions are considered, different results are obtained. However, this is highly expected and largely shown in the scientific literature. An assimilation analysis I guess goes beyond the scope of the paper. Therefore, I am suggesting removing, or strongly reducing, this part.

As the reviewer correctly points out a data assimilation exercise was not the goal of this study and it was out of the scope of this paper. The problematic associated with the initialization of soil moisture in model simulations across scales is also a well-known and still a hot topic that deserves further consideration. As the reviewer pointed out "if different initial soil moisture conditions are considered, different results are obtained", in our first initialization exercise we wanted to stress this point out and assess the potential change that could be expected when different "normally" used initialization values are used. In the second part of the analysis, an initialization exercise using SMOS L4 3.0 information is presented. Following the reviewer's suggestion we will reduce this part and better clarify our purpose and results.

Some specific comments and corrections should be also addressed. For instance, the introduction introduces ONLY SMOS among the satellite soil moisture products currently available. We have SMAP, ASCAT, AMSR2, ESA CCI and Sentinel-1 as operational products freely available. They should be at least mentioned.

We agree with the reviewer and we will include in the introduction additional information regarding other operational products freely available.