# Comments from the Reviewer #1 and the corresponding revision

# SM2RAIN-ASCAT (2007–2018): GLOBAL DAILY SATELLITE RAINFALL FROM ASCAT SOIL MOISTURE

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**Anonymous Referee #1**

*This study provides detailed descriptions of the SM2Rain product and several evaluation results. Overall, the study would be useful for current and future SM2Rain users, and fits the scope of ESSD. However, I do find that the manuscript misses several key information in SM2Rain production and evaluation.*

We thank the reviewer for her/his appreciation of our study and for the valuable suggestions that helped us to clarify and improve the manuscript. A detailed answer to each comment is reported in the sequel clarifying better the procedure used for developing the global SM2RAIN-ASCAT product.

As general reply to all the reviewers, we would like to underline that the paper goal is to present and describe the SM2RAIN-ASCAT global rainfall dataset and to perform a preliminary assessment of the product with respect to other state-of-the-art global rainfall products. We do not want to show a comprehensive assessment of the product. Indeed, we believe that the validation of the dataset should be performed by researchers other than the product developers (indeed the dataset is made freely available and a first paper was already published: Paredes-Trejo et al., 2019; doi:10.3390/rs11091113). Even better, we stress the importance of performing the validation by using the dataset in hydrological or agricultural applications (e.g., flood prediction and agricultural water management). The comparison with raingauges or any reference dataset could be misleading, mainly when the rainfall products include the ground observed information used for their derivation.

*1. Line 24 – 29: The statement here is too strong. I agree that SM2Rain is a useful product in some aspects. However, I have not seen strong evidences that SM2Rain substantially outperforms other merged products, e.g., MSWEP v2.0. Additionally, soil moisture retrievals prior 2002 have very low data quality. I personally doubt if good precipitation can be derived from these soil moisture data sets. Hence, I also suspect whether SM2Rain "is suited to build long-term consistent rainfall".*

The reviewer is right; the SM2RAIN-ASCAT rainfall product will hardly outperform merged products, mainly if the comparison with raingauges is carried out (see comment above). Apart the possibility to include SM2RAIN-ASCAT in merged products, we believe that a strong added-value of SM2RAIN-ASCAT is its expected availability in the next 25 years, with already 12 years of data available, and its independence with respect to the others state-of-the-art satellite rainfall products (e.g., GPM IMERG, PERSIANN, CMORPH). The sentence was misleading as we intended to say that a long-term SM2RAIN-ASCAT dataset, starting from 2007, and it is ensured until mid-2040s, can be built with the

proposed approach. The sentence will be modified in the revised manuscript, accordingly.

*2. Line 147: A global map of ASCAT temporal sampling frequency would be helpful.*

A global map of ASCAT temporal frequency will be added in the Appendix.

*3. Line 201 – 203: I'm wondering if there are any risks of increasing false rainfall events by linear interpolation?*

The reviewer is right; linear interpolation may increase the risk of false rainfall events, but we didn't find better alternative so far. This comment will be added in the revised manuscript.

*4. Line 242: The authors state that runoff at 20km grid is negligible. Can you provide some rainfall-runoff simulation works to support this hypothesis?*

We are saying that surface runoff is expected to be negligible at larger spatial scales due to the possibility that locally generated surface runoff (e.g., over impervious surfaces) can re-infiltrate into more permeable areas in the same pixel. Of course, this hypothesis can be not valid in some areas, but we have indirectly validated this hypothesis as we have hardly seen the ASCAT soil moisture signal to be completely saturated for more than one day. Therefore, surface runoff due to saturated soil is expected to occur very rarely at 20 km scale. This aspect will be clarified in the revised manuscript showing the number of times ASCAT soil moisture signal is saturated for more than one day.

*5. Line 249: I'm a little bit confused by equation 2. First, the authored stated that ET is negligible. Then, why it is still considered in equation 2? Second, it seems g(t) and e(t) should be plus in sign, according to equation (1)?*

The reviewer is right; g(t) and e(t) must be plus in sign, thanks for spotting the error. In previous applications of SM2RAIN, we have assumed ET negligible, during rainfall, but in this study we wanted to test the possibility to include the ET term and to assess its impact for rainfall estimation through SM2RAIN. For that, we left the e(t) component in equation (2).

*6. Line 261: e(t) is calculated using ERA5 ET. The ERA5 ET is expected to depend on ERA5 precipitation. For instance, a dry period seen by ERA5 (precipitation deficiency) will lead to low ET. Therefore, the authors should discuss the dependency of ERA5 and SM2Rain rainfall product, particularly when TC is considered in the later part of the paper.*

We agree with the reviewer, some dependencies between ERA5 ET and precipitation may occur. However, we underline that in the selected configuration (see lines 385-390) the ERA5 ET is not used and, hence, this dependency is excluded. Moreover, in Triple Collocation Analysis application we didn't consider ERA5, to avoid any dependency between the products (see lines 446-447). These points will be underlined better in the revised manuscript.

*7. Line 291: What is the reference rainfall?*

The reference rainfall is the one used for the calibration of SM2RAIN parameter values and the climatological correction factor. In the section "4.1 Selection of the best SM2RAIN processing configuration at 1009 points", we have used ground-based rainfall observations as reference and it will

be clarified in the revised manuscript. As stated at line 392, for the global SM2RAIN-ASCAT dataset production we have used ERA5 rainfall dataset as reference.

*8. Section 3.4: Please also specify the error model used in this TC analysis.*

As in Massari et al. (2017), we have used an additive error model in TC analysis, it will be clarified in the revised manuscript.

*9. Section 3.5: Equations of these scores will be helpful here.*

The equations will be added in the revised manuscript.

*10. Line 367: I'm still not clear which product is used as a reference to correct SM2Rain.*

In the section "4.1 Selection of the best SM2RAIN processing configuration at 1009 points", the ground-based rainfall observations are used as reference. Differently, in the sections "4.2 Generation of SM2RAIN-ASCAT dataset" and "4.3 Regional and global assessment of SM2RAIN-ASCAT dataset", the ERA5 rainfall is used as reference (see line 392). It will be clarified better in the revised manuscript.

*11. Section 4.1 and Line 385: It's un clear how SM2Rain parameters were calibrated (determined) and extended to the global scale.*

SM2RAIN parameter values are calibrated point-by-point by using the reference rainfall as target (see reply to comment 10 for the definition of reference rainfall). As objective function we have used the minimization of the RMSE between SM2RAIN-ASCAT and reference rainfall datasets. There is no linkage between the local scale and global scale calibration, as different reference rainfall and data periods are used in the two calibrations. It will be clarified better in the revised manuscript.

*12. Figure 5: SM2Rain is calibrated against ERA5. Therefore, the consistency of ERA5 and SM2Rain only suggests how well ASCAT was fitted to ERA5. The authors should be clear that this is not suggesting the accuracy or the performance of SM2Rain (Line 414 – 415).*

The reviewer is right; we will remove the terms "performance" and "accuracy" from this section to avoid misunderstanding. We will underline in the revised manuscript that Figure 5 shows the consistency of ERA5 and SM2RAIN-ASCAT. Of course, we expect better performance in the areas in which the consistency is higher, but the preliminary assessment of SM2RAIN-ASCAT is performed in section 4.3.

*13. Line 431 – 433: SM2Rain show better performances relative to which product? It seems that SM2Rain's R is much lower than the other three in Figure 6 a and b.*

Here, we wanted to highlight the regions where SM2RAIN-ASCAT is performing better, not with respect to other products, but only spatially relative to different regions. It will be clarified in the revised manuscript.

*14. Following the comment above, SM2Rain was derived by calibrations against ERA5. However, its performances are consistently lower than ERA5. Then, what's the contribution/ value of SM2Rain?*

There are several important differences between SM2RAIN-ASCAT and ERA5. The most important difference is the possibility to provide SM2RAIN-ASCAT rainfall in near real time (e.g., with latency

lower than 6 hours), while ERA5 is provided with a latency of weeks. Therefore, SM2RAIN-ASCAT can be used in many applications that require rainfall data with short latency, whereas ERA5 (or GPCC) cannot be used. Moreover, we should underline that ERA5 is using ground observations and in the regions analysed in Figure 6 a dense coverage of ground stations is available. Differently, in poorly gauged areas (e.g., Africa and South America) a lower performance of ERA5 might be expected.

*15. Line 446: What products are used for TC analysis? Massari used ERA. However, I don't think this is appropriate for this study. SM2Rain here is calibrated against ERA, and they may have cross-correlated errors.*

The reviewer is right; we didn't use ERA5 but GPCC, GPM Early Run and SM2RAIN-ASCAT as stated at lines 446-447.