



EGUsphere, referee comment RC3
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Comment on egusphere-2022-558

Gurjeet Singh (Referee)

Referee comment on "Soil moisture estimates at 1-km resolution making a synergistic use of Sentinel data" by Remi Madelon et al., EGU sphere,
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General Comments

The manuscript presents an approach for retrieving the soil moisture (SM) at high-resolution (1 km) by using fine resolution observations of Sentinel-1 (Synthetic Aperture Radar Imaging based backscatter coefficient), and Sentinel-2 & 3 (Optical Imaging based NDVI). For high-resolution soil moisture retrievals, the authors adopted the S²MP (Sentinel-1/Sentinel-2 derived Soil Moisture Product) algorithm developed by (El Hajj et al., (2017). The authors used the same approach/ methodology as used for S²MP (neural network with a combination of the Water Cloud Model). This study aims to extend the S²MP from croplands (cereals and grasslands) to herbaceous vegetation types and to explore the use of NDVI derived from Sentinel-3 (S3) instead of Sentinel-2 (S1). The authors provided a comparative analysis of high-resolution soil moisture retrieved through a combination of S1+S2, S1+S3, available soil moisture products of Copernicus Global Land Service (CGLS) SM and Soil Water Index (SWI) and SMAP+S1. For the evaluation of the soil moisture product, the authors used in-situ soil moisture measurements.

Though the topic of the research is important and interesting, I feel there is not much novelty in this research work on high-resolution soil moisture retrieval. The authors adopted a developed approach with only a change of new observations for NDVI (used Sentinel-3 in place of Sentinel-2) without any other improvement/modification. Besides, I feel the authors fail to properly justify why there is a need to use the optical remote sensing-based NDVI to retrieve soil moisture at high-resolution (1 km), which is affected by cloud cover conditions. Since the SMAP-Sentinel products are capable of providing soil moisture at 1 km in all weather conditions, the authors need to identify/justify the adequate research gap to make a novel research statement. On the other hand, extending landcover conditions from "croplands" to "herbaceous vegetation" and using NDVI derived using "Sentinel-3" observations in place of "Sentinel-2) is not a novel research contribution.

Other than scientific fairness, the manuscript structure is poor and needs much

improvement. A well-structured "Methodology" section is also missing. A lot of information is redundant and repeated many times in the manuscript. The authors provided a lot of the details on "Datasets" which are well documented in the scientific literature but fail to provide a clear "Methodology" of how the dataset and algorithms are being used. Besides, the manuscript is poorly organized and lacks coherence. The connection in different sections is missing which creates difficulty in understanding the manuscript. The specific Major/Minor/Editorial (syntax error) issues are listed below.

Major comment:

- Notably, the reported research is just an adaptation of the previous approach (El Hajj et al., (2017) without any other improvement/modification. Since the only changes in the study are "Herbaceous vegetation" landcover in addition to "cropland" and the use of Sentinel-3, I feel there is not much novelty in this research work. The validation of high-resolution soil moisture retrievals on "Herbaceous vegetation" using in-situ measurement is not properly investigated. I can find some correlation comparison in Table 2, but the bias and standard deviation of the difference is not presented for the "Herbaceous vegetation" in Table 3. Besides, the discussion on the different statistics (R², bias, and STDD) missing in the context of their significance (i.e., are these statistics fulfill the accuracy requirement/goal).
- My other concern regarding validation is "why did the authors not calculate the "RMSE" and "unbiased-RMSE" error matrices which are the most important/critical statistics being used in satellite soil moisture product validations?
- I feel that the proposed approach suffers from the cloud cover situation due to the dependency on optical remote sensing-based NDVI observations. Since the approach of this study mostly depends upon the NDVI in addition to the SAR backscatter, the approach might fail during cloud cover conditions. Though the authors used a gap-filling linear interpolation approach to obtain two cloud-free NDVI images per month (1st and 15th of each month), this approach still has limitations during long (> 10-15 days) rainy seasons or cloud cover conditions. Besides, it's worthful to use only two NDVI images (15 days apart) in the month to retrieve daily high-resolution soil moisture where NDVI is an important component of the algorithm?
- Although the authors have presented the details on the use of optical remote sensing (which is susceptible to errors associated and large data gaps due to the clouds, and atmospheric effects) with microwave remote sensing (active/passive) for high-resolution soil moisture retrievals, a proper justification or criticism is missing between the synergistic use of purely microwave remote sensing-based approach like SMAP-Sentinel active-passive approach. I suggest the authors should provide justifications in this regard. My concern is "if SMAP-Sentinel has the capability to provide 1-km soil moisture product using Sentinel-1 SAR observations to a global extent then what is the value addition with the proposed approach, which also uses Sentinel-1 SAR observations to provide 1-km soil moisture retrievals which are limited only to the study regions? Is the performance of the proposed approach better than the SMAP-Sentinel to provide high-resolution soil moisture? If yes then provide adequate analysis and proper comparison. If not, then justify why this study is important.
- The authors did not show any spatial pattern of the high-resolution soil moisture retrievals. I suggest the authors show a few spatial maps (i.e., dry, wet, and moderate soil moisture conditions) of the retrieved soil moisture using the proposed approach and its comparison to SMAP-Sentinel products. Since both the products are based on the Sentinel-1 observations, there will be a similar areal coverage in both the products and will help to understand the spatial distribution of high-resolution soil moisture and the

reasoning behind the error difference.

- The introduction needs much improvement. Firstly, the manuscript needs to critically discuss why this study is important. What is the novel research statement/objective of this study? Secondly, the introduction needs details for an international context. How do the findings of this study inform or build upon the wide range of international research that has been carried out in high-resolution soil moisture retrievals? What does this research contribute? Since ANN-based retrievals are limited only to the study regions, what information from this study will be relevant to international researchers outside of the specific six regions location investigated?
- The "Conclusions" section is full of results only. I feel the conclusion should be a take-home message for the readers and should be related to the work's problem statement in a concise manner. Please revise this section.

Minor comments:

L4: "agricultural plot scale"- What scale are you talking about? It should be quantitative. Since the proposed method is for 1-km soil moisture, using the term "agricultural plot scale" is not optimistic.

L9-10: "A target resolution of 1 km also..."- In what way does 1-km spatial resolution allows to explore the use of NDVI derived from Sentinel-3 (S3) instead of S2? Is S2 not having the potential to provide NDVI at 1-km?

The authors need to revise the section "Section 2. Data". I suggest providing brief details about the well-known datasets. Most of the details look redundant.

Figure-1 is missing the details of in-situ soil moisture measurement locations.

Table-1: In North America, USCRN locations consist of only two measurement locations. Are two locations optimal to represent the spatial distribution with 1-km grid cells? Past studies show that at least 3 locations are required to up-scale the soil moisture within a 1-km grid-cell.

Editorial comments:

Authors should consistent with either "soil moisture estimates" or "soil moisture retrievals" - sometimes authors used "soil moisture dataset" – the terminology used should be consistent throughout the manuscript.

L3: What are other purposes?

L3: The term "For instance" is not appropriate here.

L3-6: "For instance... as inputs to a neural network trained with Water Cloud Model simulations"- the statement is not clear. What is meant by "inputs to a neural network trained with Water Cloud Model simulations"?

L6: "However, for many applications..." – Why the use of "However"? Is this statement contradicting statement with the previous one?

L6 "future climate impact assessment"- why suddenly climate change?

L6-8: statement is very long and difficult to understand.

L10-11: "...Europe and other regions of the globe, for which S1 coverage is poorer."-revise the statement.

L15-16: "...maps were compared to each other and to those of the 1-km resolution Copernicus

Global Land Service (CGLS) SM and Soil Water Index (SWI) data sets as well as to the SMAP+S1 product" – this statement has no meaning. Revise it.

L25: change "data sets" to "datasets"

L25: "HR data sets were also compared ..." What high-resolution dataset refers here- please specify for clarity.

L49: change "data sets" to "dataset" or delete it.

L64: change "in situ data" to "in-situ measurements" – correct throughout the manuscript

Section "4.3.1 Absolute values" What absolute values refer here : This heading is not complete/and doesn't has a clear meaning-please revise.