Response to reviewers

Line numbers mentioned in this reply refer to our clean version of the revised manuscript.

Reviewer #3

Comments:

In this study the authors presented a monthly global C-band backscatter data record by combining ERS (C-band), QScat (Ku-band) and ASCAT (C-band) data for the time period 1992-2021. QScat data has been used to fill a six year gap between the C-band backscatter datasets (1999-2009). For this reason the Ku-band dataset has been rescaled using the overlapping period with ASCAT (2007-2009). The presented rescaling method was found to be robust to both signal trends and sudden changes. Monthly signal differences have been corrected after rescaling based on a decision tree regression. ERA5-land data (monthly rainfall, snow depth and skin temperature) was used to model signal differences in C- and Ku-band. Two types of quality assessments have been carried out. The first one is based on a comparison between the C-band and scaled Ku-band signal on a pixel by pixel bases reporting the distribution of Pearson R, RMSE and rRMSE for the periods 1999-2001 and 2007-2009 before and after the monthly signal correction for 13 regions. The second quality check is using ERS-2 data for the time period 2001-2011 reporting Pearson R for 10 regions. The results overall show that the rescaling and correction method are doing reasonably job fitting the Ku-band data in the C-band data space generating a homogeneous dataset.

Response: Thank you for the positive feedback on our manuscript. We have carefully considered each of the suggestions and made revisions accordingly. Please see below a point-by-point response.

Major comments:

1. While it is clear that this "C-band" dataset is one of its kind, I doubt the novelty of the presented "new data scaling method". It is a simple mean-std rescaling and part of "standard data rescaling techniques". See e.g. 10.1201/b15610-21, 10.1016/j.rse.2008.11.011, 10.5194/hess-14-1881-2010

Response: Thank you very much for providing the references. To address this concern, we avoided calling our method a new one, and referred to all the suggested references. Our revised manuscript now focuses on producing a new data set, instead of a new data rescaling method. Figs. 2 & 3 have been redrawn, all related sentences were changed.

2. I can see the importance of long-term C-band radar data, but a monthly temporal resolution is a big disadvantage and perhaps a no-go criteria for certain applications. The study doesn't explain why this temporal resolution has been chosen in the first place and is also not discussed in chaper 4.3. What is the reason? Would it be possible to get a 14-day, 10-day or lower temporal resolution? Please discuss possible applications and limitations of monthly C-band radar data. E.g. how is it possible to describe/separate vegetation and soil moisture (trends), also taking long-term land cover changes into consideration?

Response: We fully agree with you. Monthly resolution is not suitable for local-scale applications which requires frequent observations, such as phenological monitoring. However, we chose the monthly time resolution because: 1) Although it's possible to merge the radar signals at daily time resolution, daily images do not have a full global coverage. 3) Within the limit of our knowledge, monthly resolution is perhaps the most preferred by global scale studies.

Nevertheless, as stated in the previous version of manuscript, we are actively creating data sets with higher spatial and temporal resolutions. We will release a new data set with a full global coverage, ~4.5 km spatial resolution, and ~4-day time resolution, by merging QSCAT and ASCAT images of the BYU version (https://www.scp.byu.edu/data.html).

Regarding separating vegetation optical depth (VOD) and soil moisture from the radar signal, this is feasible with help of the Water Cloud Model. Our coauthors have achieved it taking African ecosystems as a testbed (Liu et al. 2021), and we are working together on extracting VOD from the CScat radar signals at a global scale.

As for land cover changes, radar signals already contain information about land cover types (please see Fig. R6 below: the values differ among land cover types). Besides, time series of VOD have been successfully used to quantify forest biomass loss due to drought and deforestation (Liu et al. 2015; Fan et al. 2019). Thus, we believe once VOD was properly extracted from the radar signal, it can be used directly to indicate land cover changes.

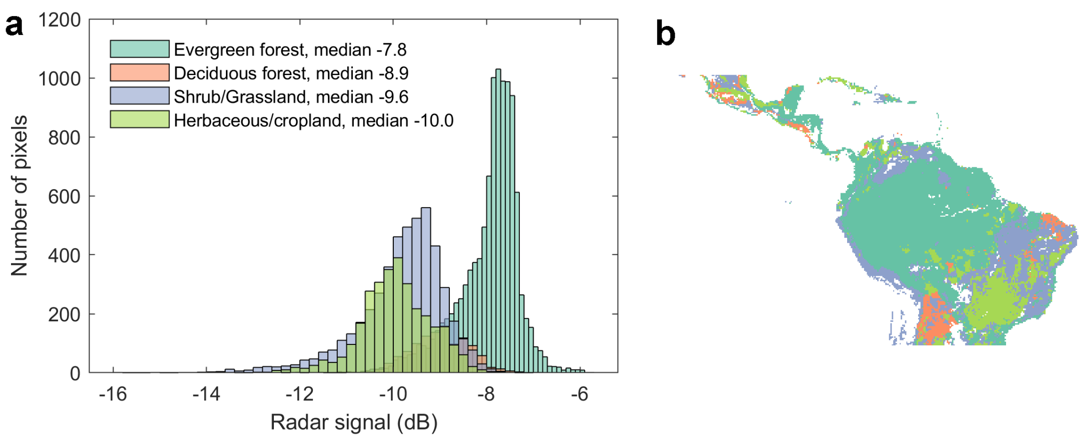

Fig. R6. (a) Histograms of the C-band ASCAT signal (in unit of dB, monthly averaged between 2007 and 2018) for four land-cover types in part of the Neotropics. (b) shows the spatial distribution of the four types of land-cover. Land cover information was taken from the European Space Agency (ESA) Climate Change Initiative (CCI) land-cover map for the year 2015 (maps.elie.ucl.ac.be/CCI/viewer/). This figure is taken from the supplementary of Tao et al. (2022).

In short, to address these concerns, we explained why monthly resolution was chosen in Introduction and Discussion (lines 117-120, 475-485); we mentioned possible applications and especially limitation of the CScat data set (lines 475-477). We also made it clearer that a new data set with higher spatial and temporal resolutions will be released soon (lines 60 in abstract, line 120 in Intro, and 480-485 in Discussion).

3. The manuscript is missing essential background information on decision tree regression. The authors describe that they performed three separate regressions (against monthly rainfall, snow depth and skin temperature) and used MSD to decide on the optimal regression. The term "decision tree regression" is far-fetched and not correct in this context. A decision tree regression would separate the feature space using nodes/leaves thereby selecting the optimal regression/parameter. See e.g. 10.1007/s00704-019-03048-8

Response: Thank you very much for reminding us of Pekel (2020). Following your suggestion, we re-examined our modelling approach, and realized that our way of using decision tree is indeed uncommon. To address this concern, we

1) explained why decision tree is suitable for our study in the Method section (lines 235-248);

2) used decision tree modelling following the practices of Sankaran et al. (2005) and Pekel (2020) as suggested by you;

3) used cross-validation approaches to avoid over-fitting, as Sankaran et al. (2005) and Pekel (2020) did;

4) calculated variable importance using the MATLAB function 'predictorImportance', which "*computes estimates of predictor importance for tree by summing changes in the risk due to splits on every predictor and dividing the sum by the number of branch nodes*" (https://ww2.mathworks.cn/help/stats/compactclassificationtree.predictorimportance.html).

Consequently, all data have been reanalyzed and figures redrawn, but encouragingly, the new results are highly similar to the old ones. This is actually expected: even though with simple single variable linear regression for modelling the signal differences, our previous results in Tao et al. (2022) are highly satisfying. We thank you once again for this very helpful comment, which has substantially improved our manuscript.

Minor comments:

- Title: It is a "C-band" dataset so it should certainly have a C-band signal dynamic. I'd suggest to highlight the fact that a Ku-band dataset is used to fill a gap and create a long-term "C-band" data set.

Response: Following this suggestion, the title of our manuscript has been changed into "*Global long-term satellite radar backscatter data set created by merging C-band ERS/ASCAT and Ku-band QSCAT*".

- p2 - l38: remove "and can be acquired in all weather conditions"

Response: Changed as suggested.

- p2 - l53-54: No unit for RMSE/rRMSE in abstract, is it dB? Also missing in the rest of the article and graphics

Response: The unit for RMSE is dB, but rRMSE is unitless (it's RMSE normalized by the std of signals). We have made changes throughout the paper (lines 269, 784).

- p4 - l102: Metop-SG

Response: Thanks, Metop-SG and a reference (Lin et al. 2016) have been added here (line 99).

- p5 - l131: Please add references

Response: Thanks, references have been added here (lines 132-134).

- p7 - l180: wording

Response: This sentence has been reworded (lines 179-180).

- Figure 4: remove connection of Ku-band time series for the temporal break

Response: We have redrawn this figure as suggested.

- Figure 8: why is there an overlap? shouldn't it be one map indicating type 1,2,3?

Response: We apology for this misleading figure. The same concern was raised by Referee #2. This figure was drawn in GIS and each pixel was shown as a point. Points in GIS have a size; thus their locations appear "overlapping" but actually they do not. We have redrawn this figure into a raster map to address this concern.

- Figure 9: why two different y-axis?

Response: This is because the ERS signals in our CScat data set have been scaled taking ASCAT as a baseline (mentioned in the Method section). We have explained it in the legend of Fig. 9 to address this concern.

- p22 - l450: typo

Response: Thanks, "have" has been changed to "has" here.

On this basis, I found the topic of the paper interesting, but I suggest a major revision and after that reconsider a possible publication.

Response: We hope our revision have addressed your concerns in full. Thank you once again for the very useful suggestions!

References

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