Response Letter

The value of ASCAT soil moisture and MODIS snow cover data for calibrating a conceptual hydrologic model

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In the following document, we reproduce all the comments of the Referees in italic characters followed by our responses.

Response to referee #2

The study of Tong et al. focuses on using ASCAT soil moisture and MODIS snow cover, together with runoff for the calibration of the TUWmodel for 213 catchments in Austria. To do so, the study defines three calibration strategies for soil moisture and runoff, snow cover and runoff, and soil moisture, snow cover and runoff together. In addition, runoff is included with different weights for each calibration strategy. The authors conclude that the soil moisture data helps the soil moisture simulations, and the snow data the snow simulations.

Generally, the authors present a thorough analysis, and their conclusions are well supported by their data. Nevertheless, I need to raise some concerns, and I hope the authors can improve on these issues.

I think the manuscript could be made more concise and to-the-point. For example, twelve figures and 8 tables seems a bit much to me. Most figures and tables are also double, for the calibration and the validation, and the text becomes for that reason sometimes a bit repetitive. As these findings are rather similar, I would suggest that the authors focus more on one of the cases, for example the validation data, and move half of the figures to the Supplement. Some of the tables could be moved to the Supplement as well, as the figures already show the same data. I suggest as well to make Table 7 or 8 a similar figure as Figures 5 and 6, and remove the examples in Figures 11 and 12, that, in my view, do not add much compared to the full picture in the Tables 7 and 8. In addition, there are still relatively many unclear sentences and small issues with the figures., such as missing units.

In response to this comment, we have simplified the Figs 5 and 6 and moved a part of them to the Supplement. We have also moved Table 7 and 8 and Figs 11 and 12 to the Supplement, as suggested by the reviewer.

More methodologically, the calibration on soil moisture is carried out for a much shorter period compared to the snow cover. At the same time, the authors conclude that the snow data are more efficient in improving snow simulations than the soil moisture data are in improving soil moisture simulations. Is it still a fair comparison? There is much more information in the snow data in this case.

It is true that in this study, the observation records of soil moisture are less than for snow cover. In a follow up study (Kuban et al, in preparation) we test a longer calibration period (2005-2014) and the soil moisture efficiencies are very similar as found in this study. Therefore, we believe that the availability of soil moisture and selection of the calibration/validation periods here does not have an impact on the interpretation of results. We plan also to investigate further the impact and inter-relation of snow and soil moisture data in the next study.

To conclude, I generally like the approach and methodology, but some major improvements are needed. I hope the authors find my comments useful and I am looking forward to an improved version of the manuscript.

We want to thank the reviewer for her/his positive, helpful and insightful comments on the manuscript.

Minor comments

P1.L29. I think many more references could fit here, such as Kavetski et al. (2006), Wagener and Montanari (2011)

References added.

P5.L126. from digital elevation model → from a digital elevation model?

Revised as suggested.

P5.L131. Except of → except for

Revised as suggested.

P9.L233. Than the WQ variants. → What do you mean? To what are you comparing the red boxes in Fig.3? These are the WQ-variants already, correct?

Yes, it is a typo, thank you for pointing this. We have rephrased the sentence as follows:" The correlation between ASCAT and simulated soil moisture (Figure 3, centre) has a much larger regional variability (i.e. variability between catchments) than the variability of OQ (Fig.3, top panel) for all wQ. ".

P9.241. Particularly for WQ between 0.3 and 0.4. → How can I see this exactly? Please help the reader a bit.

More quantitatively is this relative improvement and difference between calibration variants evaluated in Figure9. From this evaluation it is clear that the wQ=0.3 has the largest relative improvement if merging all three performance measures.

P12.L294. signals .Accordingly → signals. Accordingly

Revised as suggested

P12.L291-295. Generally, it may also have to do with the depth that the remote sensing products "sees". The active rooting zones are much shallower in agricultural lands, whereas trees root much deeper.

Thank you very much for your suggestion. We added "The active rooting zones are much shallower in agricultural lands, whereas trees root much deeper. Hence the satellite soil moisture data used in this study which monitored for the top 100 cm soil layer may fit the soil moisture for arable land better." to explain this point.

P13.L303-304. The largest...only (wQ=1) →Do you mean for AP or in general?

It is in general. In response we modify this sentence to "The largest negative correlation of soil moisture efficiency and attributions is found for calibration to runoff only (w_Q=1) in general ..."

P13.L304. Is larger than ...(SDGR). → I do not see this. You still discuss OSM in the second panel, correct?

True, there was mistakes. In response we modify it to "…is larger than 0.7 for MELE, catchment elevation range (ER), and standard deviation of MAT and mean daily potential global radiation (SDGR)."

P16.L328. The medians of the model parameters → of all the catchments, correct?

Yes, we added "for all catchments".

P16.L335-336. and adding snow and soil moisture is complementary → regarding the findings for the snow parameters you mean, correct? Please be specific.

We modified it to "This suggests that adding soil moisture satellite data in model calibration affects the soil-related parameters strongly and adding snow and soil moisture satellite data is complementary for influencing both snow and soil moisture related parameters."

P18.L375-376.has a median relative improvement about 4% to 25% lower → So you mean the difference between the red and blue line here? Seems more than 4 and 25% to me, if I look at it correctly.

Thank you for the remind. It should be 3%-35%.

P19.L386. WQ>0.6 → Not the other way around? WQ<0.6?

Yes, less than.

P24.L441. Previous studies → please add the references

We added the references as below: Parajka et al., 2008, 2009; Sleziak et al., 2018;

P24.L441-445. If it is the same model, this is not very surprising and it doesn't seem to relate to the previous analyses as shown.

Indeed, it is not surprising, but we wanted to provide a link to previous studies performed by the same model, in the same region.

Sec.4.3. The title of this section relates also to what is discussed in the previous paragraph on Figure 8.

The idea of section 4.3 is to compare the model efficiencies. In response to this comment we have revised the title to:

Comparison of multiple objective and runoff only calibration efficiencies

Fig3. Please add in the caption that the boxes represent the values from the different catchments. In addition, as WQ is a full calibration on Q only, I would here just show one boxplot. The three should be identical here, correct?

Revised as suggested.

Fig.5. Is it correct that these come from the calibration SSM+SCM+runoff?

Yes, in response we added "SSM+SCM+runoff" in the caption.

Fig.7. Please add the units of the parameters.

Units added.

Fig.8. You could group the parameters here also for snow, soil moisture and runoff, maybe by just putting a thick line between them.

Revised as suggested.

Table7,8. I would suggest to turn these Tables into similar figures as Figures 5 and 6.

Taking into account the suggestions of reviewer #1 and comments related to the number of figures, we have moved these Tables into the Supplement.