

Review of Avanzi et al.: S3M 5.1: a distributed cryospheric model with dry and wet snow, data assimilation, glacier mass balance, and debris-driven melt

General comments:

The authors present the S3M model, which is a spatial, hydrology oriented cryospheric model using a hybrid physics-based and temperature-index approach. S3M describes seasonal snow and can also account for glacier evolution.

This manuscript presents a detailed model description of the current S3M version (v5.1). All equations, definitions, assumptions, references as well as the required input are thoroughly described. There is a user manual in the Appendix. An evaluation is presented for an inner-Alpine valley (Aosta valley), including calibration and performance analysis.

The manuscript is therefore interesting and valuable for a broad range of scientists and practitioners.

The source code was uploaded on github and is also available on Zenodo (including doi number).

The manuscript is well written and can be easily followed. The authors have done a great job in presenting this comprehensive model suite. I have only a few issues with regards to the model evaluation, which should be addressed before publication. The largest question I have is with regards to the years used to evaluate the model as opposed to the years used to calibrate the model.

Specific comments:

Evaluation years are supposed to be 2004-2009 and 2019 (as indicated in line 496-498). However, in Figure 6 (Section 3.3), evaluation is shown for the calibration years 2013-2019. Figure 9 (line 572-573) also shows a mix of wy used for evaluation consisting of wy used for calibration and those not used for calibration.

Please correct in line 496-498 and so on or/and restrict the evaluation to the non-calibrated years throughout the results sections.

Figure 5d: Was the simulation data for the evaluation with peak-snow-depth courses rounded, or why does this data set has these sharp steps/lines in it? Please explain.

Evaluation at Torgnon study plot (section 3.3): Could you add some performance statistics or mean day differences for reproducing the timing of peak of accumulation and onset/end of ablation?

Figure 7e and Line 552-553: What is the reason that we only see the aspect impact on spatial SWE due to shortwave radiation in one valley in the south of the Rutor glacier? Is it a color bar issue or are there other reasons that this is not visible in the valleys further to the west? If it is a color bar issue, please consider to illustrate the spatial impact differently.

Figure 9d: Should the number of the shown symbols correspond to the number of stake measurements shown in the individual panels? There are only two green dots shown in 9c but 8 blue crosses in 9d (i.e. for the Petit Grapillon)?

Line 595: Maybe presenting the correlation coefficients between Δh_g and elevation would be more intuitive?

Why does S3M not scale the diagnostic variables of a grid cell, such as predicted grid cell runoff, with current fractional snow-covered area for that grid cell?

Technical comments:

Eq. (13c): Do you mean $p_s=1-p_r$ instead of $p_r=1-p_r$?

Line 217: Maybe consider changing to: m_{rad} is set to zero if the equation above predicts a negative value.

Line 425: Change “piel” to pixel.

Line 441: Maybe rephrase “..develop for several kilometers..” to “..extend over several kilometers..”?

Figure 7, caption: It might be helpful to indicate for which region the spatial averages are shown. I assume it is the entire region as shown in Fig. 3a.

Line 587ff and Figure 11: Please consider referencing that this glacier is located in Fig. 3c (if it is indeed) or describe its location within the Aosta model region, e.g. in the northern part of Aosta valley.