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# *Interactive comment on* "Influence of snow surface processes on soil moisture dynamics and streamflow generation in alpine catchments" *by* Nander Wever et al.

**Anonymous Referee #1**

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In the manuscript "Influence of snow surface processes on soil moisture dynamics and streamflow generation in alpine catchments", the authors present a comprehensive modeling study using the model Alpine3D which was complemented with new descriptions for simulating soil moisture and streamflow. The distributed model was forced using meteorological station data at several points and validated by means of snow depth, soil moisture, and runoff measurements.

General Comments

The manuscript presents a modeling study using a detailed set of modules and methods to tackle the challenge of simulating the hydrology in a complex mountainous catchment with a fully distributed, spatially highly resolved model. The focus lies on



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the simulation of snow depth, soil moisture and the respective interplay of precipitation, snow melt, and runoff dynamics. The study gives valuable insights in the involved hydrological processes. The manuscript is well elaborated and written and is technically of very high quality. I recommend its publication after minor revisions. Generally, the presented analysis is a bit incomplete because of the lack of a groundwater description in the model. This is mentioned in the manuscript at the respective sections. But it should be emphasized even more that this is a major shortcoming of the study and it should be addressed in future work with the model setup. Another criticism is the description of the presented streamflow model. It is not quite clear to me how it was coupled to the model and what the flux input at or from different depths mean (sections 3.2 and 4.3). As I understand it, the water fluxes from the soil model at three different depths (lateral flux or excess out of the respective soil layer?) were taken and "streamed" into an external streamflow model. This streamflow model is calibrated using the respective fluxes which produces the shown streamflow simulations for three different depths. This approach is quite unusual and definitely needs further explanation in the manuscript. Why is the flux taken separately from the depths and not combined? The runoff dynamics clearly reveal that a groundwater module is missing. But this missing groundwater module could be "replaced" by a calibrated low flow component of the water flux (baseflow) which seems to be totally missing (Fig. 7, underestimated low flow / baseflow in the winter months). All other presented findings regarding soil moisture, freezing, as well as event-based precipitation and melt are well elaborated and very interesting. Some more questions that need clarification are listed in the following specific comments.

Specific Comments

P.1 L. 6: "in close proximity to" instead of "in close proximity of"

P. 1 L. 9-15: "Streamflow simulations performed with a spatially-explicit hydrological model using a travel time distribution approach coupled to Alpine3D provided a closer agreement with observed streamflow at the outlet of the Dischma catchment when

including 30 cm of soil layers. Performance decreased when including 2 cm or 60 cm of soil layers. This demonstrates that the role of soil moisture is important to take into account when understanding the relationship between both snowpack runoff and rainfall and catchment discharge in high alpine terrain. " The differences in NSE for three simulations are so small that I would not give this strong statement. It is also not at all an evidence for your second statement as you show no simulations without the new soil model, see comment below (P. 10 L. 18/19). It is for sure correct that soil moisture has to be taken into account but you show no real proof in this work.

P.1 L. 17: "which shows" instead of "and this shows"

P. 3 L. 7: Rephrase: "The measurement site Weissfluhjoch (WFJ), which is focused on snow-related measurements, as well as several permanent meteorological stations are located in close proximity to the area." instead of "The measurement site Weissfluhjoch (WFJ), which is focussed on snow-related measurements, is located in close proximity of the area, as well as several permanent meteorological stations."

P. 3 L. 14: "of total precipitation" instead of "of all precipitation"

P. 4 L. 7: Better use "focused", not "focussed" (see also above P. 3 L. 7)

P. 5 L. 14: Lower computational costs compared to what other approach? Please add an example for clarification!

P. 5 L. 21: Remove brackets in citation!

P. 6 L. 13: Rephrase the first two sentences / the beginning of this section ("Two important components to initialise Alpine3D simulations are the digital elevation model (DEM) for the Davos area, provided by the Swiss Federal Office of Topography (swisstopo). Also the soil has to be initialised for each pixel, although limited information is available.") e.g.: "Two important components to initialise Alpine3D simulations are the digital elevation model (DEM) and distributed soil information. The DEM is provided. . . "

P. 7 L. 6: Either remove “on a computer cluster from 2008.” or preferably provide some more information about the HPC system (e.g. type and clock speed of nodes). I guess the 14 hours per year using 36 CPU cores are the necessary wall clock time (or CPUh?). Please add this information in the manuscript.

P. 7 L. 11: Remove “also”.

P. 7 L. 12: Why didn’t you additionally inspect hourly values if you have the respective measurements? You could add at least some examples for showing the model performance on a smaller, hourly timescale, which would be very interesting to see.

P. 8 L. 6 ff and above and Figures 3 – 5: Consequently use one throughout the manuscript: either “snow depth” or “snow height” (personally, I prefer “depth”).

P. 8 L. 12 ff and Fig. 3: Please try to remove the measurement errors in Fig. 3 (high frequency fluctuations, especially in the summer months)! In June / July 2012 and 2013, the model seems to miss the measured spring snow fall at stations (a) and (b). Why does this happen? Add a respective explanation in the manuscript.

P. 8 L. 15: To be consistent with the section title of 4.1 either remove “Measurements and Simulations” or add it in 4.1

P. 9 L. 20: “S1” instead of “S3”

P. 9 L. 27: Are the r2 values calculated using the daily or hourly values? I guess daily, but please add this in the manuscript for clarification.

P. 10 L. 12: Remove “us”.

P. 10 L. 15: Please either explain your concept of the “virtual lysimeter” or use another notion! I think you are referring to the water fluxes at the three depths, but this is not clear here.

P. 10 L. 18/19: I am not sure if I understand this right, but the statement “The results suggests that the updated soil module of SNOWPACK is contributing to a better

prediction of streamflow in the summer months. “ is misleading or drawn without any evidence. You show no Alpine3D runoff result without the new model, because – as I understand it – there was no soil moisture or runoff description in the model before. So a valid statement would be something like “The results show that the new soil module of SNOWPACK is enabling a simulation of streamflow.”

P. 11 last paragraph of section 4.4: The conclusions here are of course valid but were somehow clear before your study and should be underlined with existing literature.

Fig. 2, 3, 4, 5 and S1 – S5: Please add the year to the time-axis. This makes it much easier to look at when you write about single years in the text.

Fig. 7, caption: typo “tics”

Fig. 8, caption: I cannot see any data points plotted on the x-axis as stated in the caption. When you add them, please add the real value somehow because it is of interest how negative the NSE values are in these periods.

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