Interactive comment on "Snow Water Equivalents exclusively from Snow Heights and their temporal Changes: The $\triangle_{\mathrm{SNOW.MODEL}}$" *by* Michael Winkler et al.

Anonymous Referee #1

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Dear authors,

congratulations to your impressive paper manuscript. It represents a huge piece of hard work. You have invested significant efforts to publish your ideas and the comprehensive dataset you can utilize. I liked reading your paper and following your argumentation. However, prior to publishing it as final revised paper I recommend a general revision and sharpening of the focus of the manuscript, as well as an improvement of the English.

General comments:

My main point (1) is that the entire paper reads too much like a multi-faceted story

around various aspects of model development, calibration/evaluation, model intercomparison and historical model review. For the final version, the manuscript would benefit from a general re-shaping to a concise description of the particular innovation you developed. The manuscript would also profit from being significantly shortened.

The second issue (2) is the language. I am not a native speaker myself, but I can tell that many phrases and terms are untypical for the particular language that is required for a scientific paper. Maybe you can find a native speaker who can carefully check the final version of the text to make it a clear scientific argumentation with proper formulations.

Finally (3), I added a list of general comments related to particular aspects and formulations in the text.

Despite all criticism the model approach you develop is well worth to invest the required energy into the manuscript to make it a final revised paper.

Specific comments (ad 1):

(i) I recommend to decide what the main focus of your paper is, and delete anything else that is not needed. Why? After reading the paper, it is not entirely clear to the reader if the main focus is (i) the introduction of a new model, (ii) the improvement of an existing model, (iii) a parameterization exercise, (iv) a model intercomparison, or (v) about snow loads. The main focus of the paper changes. I would recommend to limit the aim to one, and to reduce the description of objectives to what leads to the one aim. My personal suggestion would be: the significant innovation is the fusion and improvement of the Gruber/Sturm-Holmgren/Rango-Martinec approaches (as you state in lines 414-416): You could build the paper upon the differences between these approaches and the respective innovation in your model (-> exponential function instead of power law for compaction etc.), and then evaluate the new model version against (i) the other three approaches, and against (ii) observations.

(ii) The paper manuscript lacks a clear description of the data that is used for calibration and for application of the new model version, including a map of the station locations.

(iii) The role of rain-on-snow is crucial and deserves more attention, and not just an announcement for further model improvements. See also (vi)

(iv) You better strictly separate physical process descriptions from code structure descriptions. Skip the latter if your paper is not intended to be a model code introduction (or move it to the appendix). I strongly recommend to leave any code structure elements out of the main body of the manuscript. Better set the focus on the general rules that your model follows in representing the snow layers and their changes.

(v) Your null hypothesis, and its rejection, is not required. You can omit it.

(vi) Your new approach could easily be combined with daily temperature and humidtiy recordings; these are available in many regions of the world. Wouldn't it be most interesting to use these as auxiliary data to derive precipitation phase and melting conditions (and hence, solve some important issues that you address)?

To say it again: I strongly want to motivate and encourage you to elaborate on your manuscript and submit an improved version. The material you already have and the newly developed model version will be a significant and valuable contribution for the snow modelling community.

Ad (2):

Expressions like the following examples should either be replaced with clear scientific statements, or omitted.

- 212: "figuratively spoken the Dry Metamorphism Module acts "over night""

- 284-285: "equations 3) and 4) . . . make no claims of being particularly precise"

- 576: "(Still, lots of them!)"

- 736/737: "The model steps are rather simple, however tricky in details, and all is frankly revealed in this article."

Technical corrections (ad 3):

I started to comment on how to improve the text with the abstract. Then I stopped, because I saw that the manuscript would benefit from substantial language improvement, and this should be better done by a native speaker. Nevertheless, here is what I can come up with for the abstract:

- 1: in Austria?

- SWE = synonymous for snow water equivalent

- 4: skip "fields like"

- 5: better "the respective" than "those"

- 7: better ". . . needs a continuous time series of snow heights without gaps as input"

- 8: better ". . .with arbitrary temporal resolution"

- 12: better make two sentences here; the first is about a general model issue, the second belongs to the particular model application in your paper

- 13: "winters" do not "act". Better something like ". . . data from 73 winters is used for validation"

- 14: replace "squared" with "square" (several locations in the manuscript)

- 16: better ". . . and even thermodynamic . . . do not necessarily perform better".

- 18: Delete "Not least", replace "on . . ." with ". . . of SWE measurements to modeling"

The following comments are therefor mostly suggestions of further improvement of the content of the paper:

- 29-30: "remote sensing" to measure H: which techniques/sensors?

- 25-48: main point missing, should be clearly fomulated: SWE recordings require consideration of the layering of the snow (density can be very different in each single layer), whereas height is a bulk measure and simple to take

- 54: "hydrological", "agricultural", yes, but many more...!

- 70: mainly precipitation, temperature, humidity, wind speed, radiative fluxes and, for some models, air pressure

- 71: what means "... many longterm H series ... do not come along with..." in this context?

- 68-77: better do not put longer parts of text in brackets. Either what you say is important, then it belongs to the manuscript. Or not: then delete it

- 64-77: here I miss the series of SnowMIPs, and the recent papers about snow model performance

- 107: correct "altemative"

- 119: is "snow depth" the same as "snow height"? If you use both in the text, then explain the difference

- 125-135: hence, the presented new model "ΔSNOW.MODEL" is an update of the Gruber-model, based on the Rango/Martinec - approach (exponential function instead of power law for compaction)? See my general comment above

- 141-142: can't find "nixmass" at https://r-forge.r-project.org. All links should be checked if they work

- 149: "section 5 and 6 discuss ...": no, the sections themselves do not do anything. Maybe better: "... in section x and y ... is discussed"

- 157-160: don't switch between physical processes and code structure, same for line 167. See my main comment (1) above: if the paper is not about the new code (and I

suggest to not make a model development paper out of it), then you can omit the model structure (i.e., all that has to do with the modules)

- 177: a "Module" cannot combine anything. Maybe "in ... module, xxx and yyy are combined"?

- 196-197: again, separate model description from code structure ("Dry Metamorphism Module")

- 200: don't repeat (already stated in lines 89/90 and comes again in 762)

- 228: what happens in the model if an intensive rain-on-snow event occurs? This seems to be of importance and comes too short in the manuscript. See main comments above

- 236: in case ΔH (t) > $+\tau$, a rain-on-snow event cannot have occured, or what did I oversee here?

- 242-243: again, don't mix processes with code structure

- 355: probably better write "viscosity at which equals zero"

- 380: were the observations all by the Hydrographic Service of Tyrol, also the ones in the Southern Alps?

- 512: again, better "root mean square error"

- 526: are there other calibration/validation data available in the literature (for the models by Jonas et al. (2009) and Sturm et al. (2010))?

- 545: again, better "root mean square error"

- 558: calibrating "the models" by Pistocchi (2016) and ...

- 560: "... Sturm et al. (2010)'s method probably suffers from the handicap of being calibrated with data from the Rocky Mountains": the model does not suffer from anything. It just was calibrated elsewhere; avoid attributing such values

- 569: "well beaten by . . ."": avoid such formulations generally

- 685: what is a "Fréchet-like distribution""?

- 695: use temperature/humidity, almost everywhere available and easy to interpolate? See my general comment above

- 709/710: "Shouldn't there be more studies, that also comprehensively quantify the abilities of various, especially thermodynamic snow models to simulate SWE¿' The discussion/outlook section is not the place to ask such questions. And, moreover, there are the SnowMIPs and recent papers about snow model intercomparisons/performances

- 761-763: "Given these promising results, the △SNOW.MODEL's ancestors Sturm and Holmgren (1998)'s argument, whereby "snow load plays a more limited role in determining the compaction behavior in seasonal snow than grain and bond characteristics and temperature", might be disproved.""?! I wouldn't say this, because snow load is one of the origins that change grain and bond characteristics, as is temperature, humidity gradient etc.. The compaction behavior finally depends on the magnitude and rate of change of each of these forces, and their interplay. Better skip this entire line of argumentation here, there is no need for it neither any gain.

Figure 1: Better do not assign the same type of symbol (arrows) to two very different things at the same time: program modules (= code structure) and hydrological processes (like runoff). The codes structure (name of the modules) can be deleted here (and in the caption which is way too long). Your new model version is mostly rule based, hence how about a decision tree to illustrate its functioning?