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Interactive comment on "TOPMELT 1.0: A topography-based distribution function approach to snowmelt simulation for hydrological modelling at basin scale" *by* Mattia Zaramella et al.

Mattia Zaramella et al.

mattia.zaramella@unipd.it

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Our point-to-point response is reported below. Reviewer's Comments are reproduced in italics; the Authors' Responses are given directly afterward. All reviewer comments are identified using the code RXCY, where X is the reviewer number and Y is the reviewer comment number (for example R1C3 means Reviewer 1 Comment 3). Line numbers in authors' responses refer to the original manuscript unless otherwise stated.

Additionally, we enclosed a marked-up version of the revised manuscript.

Answers to main comments

R3C1: The structure could be improved. 1) in the Introduction, the manuscript should emphasize the gap and importance of the research and how you are going to achieve, instead of model introduction as in lines 21-35 (page 2) and lines 1-10 (page 3).2) Section 4 kind of mixes the methodology and model results.

In the revised version, we improved the Introduction by pointing out three important implications of integrating ETI snowpack models into semi-distributed runoff models. 'Integration of ETI snowpack models into lumped or semi-distributed hydrological models may have the potential to increase spatial transferability of calibrated snowpack model parameters for hydrological applications over ungauged mountainous basins, as shown by Comola et al. (2015). Another important implication of the stronger physical basis of the ETI model with respect to simpler 'degree day' models is that it might be more appropriate for the study of climate-change impact on melt regimes, as shown by Pellicciotti et al. (2005). Finally, increasing the accuracy of the modelled snow water equivalent may improve the outcomes of data assimilation procedures of remotely sensed snow cover information.' We substantially modified Section 4 by including analyses of scale dependency of radiation aggregation level. For this, we examined the control exerted by the catchment size on runoff simulations. We subdivided the study basin into a number of sub-basins characterised by different drainage areas. We isolated 5 basins with mean drainage of 20 km^2, 10 basins with mean drainage area of 10 km^2, and 20 basins with mean drainage area of 5 km^2. Results are reported in the new Section 3.4 of the revised version (also, see the answer to the next comment).

R3C2: The model calibration is too short. For new model introduction, people are interested in model parameters, their sensitivities, or how to estimate these parameters. It is not clear here.

The revised Sections 4.3 and 4.4 have been substantially modified, by including new work on the model sensitivity to spatial and temporal aggregation levels. We added a table (see Table 2 below) reporting the results of the validation for different model aggregation in space and time. It is evident from results that the model is not sensitive to different configurations: this is due to the relatively large size of the basin. This basin size was chosen not to get best model performance, but to demonstrate model functionality in terms of output products and possible applications. As aforementioned in the answer to comment R3C1, we also examined the influence of the catchment size on runoff simulations. We subdivided the study basin into a number of sub-basins with different drainage areas. We isolated 5 basins with mean drainage of 20 km^2, 10 basins with mean drainage area of 10 km^2, and 20 basins with mean drainage area of 5 km^2. Results are reported in the new Section 4.4 of the revised paper. We added an additional table (Table 3, reported below) showing the sensitivity of the TOPMELT-ICHYMOD model to the catchment size .

R3C3: Comparison results are also missing. For example, there is only one simulation presented in Figure 6, while there are so many simulations have been done (if I am right). How does snow parameters affect hydrograph or snow cover? (see also point 2 above).

See our response to comment R3C2.

R3C4: I am not clear how radiation is calculated. Is it based on station data or theoretical solar radiation equation? How did MODIS data come into play? Section 2.1 and/or section 4.1 could explain something on this.

Radiation is computed theoretically based on the models mentioned in Section 2.1 'Clear sky potential radiation computation and derivation of radiation distribution‘.

R3C5: The integration of TOPMELT and ICHYMOD is also not clear, especially on the routing. My understanding is that ICHYMOD is a lumped model and its routing scheme shouldn't consider elevation bands. Then how is water from each cell (combination of elevation bands and radiation classes) routed to the outlet?

ICHYMOD is a semi-distributed model which spatially aggregates the TOPMELT water output generated by the combination of elevation bands and radiation classes to

provide a lumped input to the model soil module (which accounts for infiltration and groundwater storage). Hence, the routing scheme is a lumped description of the water transfer at the basin scale, through both slow and fast pathways. We modified the text in the presentation of ICHYMOD to highlight this feature.

R3C6: English is readable. However a native speaker might improve the manuscript

Thanks, the work was checked by a native English speaker.

R3C7: Section 5 seems more like a summary.

We modified the conclusions to highlight the implications of the results obtained in this work (see the attaches marked-up manuscript).

Minor comments

R3C8: Line 24 of page 1 and Line 1 of page 2. I don't understand the logic

We are here introducing two extreme modelling approaches: the temperature index based modelling (simplified but efficient) and physical modelling (more realistic but complex). We do this to introduce TOPMELT approach, which is intermediate.

R3C9: There is a duplication (line 29 of page 3, and line 1 of page 4)

Corrected (see marked-up manuscript).

R3C10: Equation 1.What is the range of G

The range of G is limited to positive values. Since the precipitation gradient is linear with the elevation with slope governed by G, the precipitation can become negative at lower elevation bands for increasing values of G. In this case the code automatically limits the gradient, providing an automatic correction.

R3C11: Figure 6: add the content of bottom plot in the caption.

Content added (see marked-up manuscipt).

R3C12: Figure 7: why don't you use the whole simulation period?

We do not show the whole simulation period because we wanted to focus on an active snow melting phase. We chose this period in particular because the sample MODIS map of Figure 7 falls within this time range.

R3C13: 'reference fields' in the second last line of Page 14: what are they?

We changed 'fields' to 'w.e. distribution over space'. We better explained what we meant by 'reference' for Figure 8, both in the text and the caption (see the marked-up manuscript).

R3C14: Figure 8: What is your point? To me, models with similar spatial or temporal resolution should give similar results.

We wanted to yield In Figure 8 the sensitivity of modelled w.e. spatial distribution to different model configurations. To do so, the finest temporal and spatial model configuration was chosen as reference or Figure 8a and Figure 8b respectively. Additionally, please see our response to comment R1C4.

References

Comola, F., B. Schaefli, P. Da Ronco, G. Botter, M. Bavay, A. Rinaldo, and M. Lehning: Scale-dependent effects of solar radiation patterns on the snow-dominated hydrologic response, Geophys. Res. Lett., 42, 3895–3902, doi:10.1002/2015, 2015.

Pellicciotti, F., Brock, B., Strasser, U., Burlando, P., Funk, M. and Corripio, J.: An enhanced temperature-index glacier melt model including the shortwave radiation balance: development and testing for Haut Glacier d'Arolla, Switzerland, J. Glaciol., 51(175), 573–587, doi:10.3189/172756505781829124, 2005.

Please also note the supplement to this comment:
https://www.geosci-model-dev-discuss.net/gmd-2018-202/gmd-2018-202-AC2-supplement.pdf

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Table 2. Nash-Sutcliffe index (NSE) of the TOPMELT-ICHYMOD model at different spatial aggregation and temporal resolution, from October 2001 to October 2007.

W4C1	**W4C5**	**W4C10**	**W4C15**	**W4C20**
0.73	0.73	0.71	0.73	0.73
W1C10	**W2C10**	**W4C10**	**W8C10**	**W12C10**
0.71	0.71	0.71	0.70	0.71

Fig. 1. Table 2, revised paper.

Table 3. Mean value of the Nash-Sutcliffe index (NSE) of the comparison between W4C1 and W4C10 TOPMELT-ICHYMOD simulated flows and the reference flow simulations, obtained by using the W4C20 set up, over basins of three different drainage areas: 5, 10 and 20 km^2. Comparisons carried out over the March, 1 to June, 30 period.

Model set-up	**Sub-basin area**		
	5 km^2	10 km^2	20 km^2
W4C1	0.77	0.91	0.99
W4C10	0.97	0.99	0.99

Fig. 2. Table 3, revised paper.