

# ***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.***

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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**

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*R2C1: Page 4, line 14: The Precipitation Correction Factor is mentioned only here without further explanation or details. Is it an important parameter in the model? How is it determined? What are the typical values? In the revised manuscript, I suggest the authors to integrate the description of the Precipitation Correction Factor.*

The Precipitation Correction Factor (PCF) accounts for poor estimation of the precipitation due to climatic non-representativeness of the gauging stations. Its value may be estimated by optimising the comparison statistics with snow cover MODIS data. In the specific application reported here, a value equal to 1.1 was used. Please note that since the corrected areal precipitation is an input to TOPMELT model, both PCF and SCF are not TOPMELT parameters.

*R2C2: Page 8, line 17: How does the conversion snow-water equivalent maps to snow cover maps work? What are the 'suitable threshold values'? I suggest the authors to integrate the description in the text.*

The comparison between model-based SWE and snow cover MODIS maps is carried out by converting the SWE map into a snow cover map using a threshold on SWE. In this paper, a minimum threshold of 10 mm was used. A reference (Parajka and Blöschl, 2008) and a brief note were added in section 4.3 of the revised paper. The revised paper is integrated with the following text: 'Then, the water equivalent maps may be converted to snow cover maps by using suitable threshold values (Parajka and Blöschl, 2008). In this work, we used a minimum threshold of 10 mm for the intercomparison with the MODIS snow cover products.'

*R2C3: Page 9, line 9: The authors should report the estimated fractions of catchment area for the different land uses. Does the model consider interception by various vegetation covers? If so, how? How does the snowmelt module work in forested areas and are there any differences compared to other land uses?*

We thank the Reviewer for this note. The current version of the model does not consider land use for snow melt modelling. Accordingly, the model does not take into account

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neither interception of snow by the vegetation and reduction of solar radiation during melting periods. A version of the model which includes a simplified canopy model is already available, but it is not included in this work, where we focus on the basic elements of TOPMELT (use of statistical distribution of solar radiation and assessment of the impact of its different simplified representations).

*R2C4: Page 13, lines 5-8: I think coniferous forests and discontinuous vegetation might be the dominant land covers in such a catchment. Therefore, given the limits of MODIS in vegetated areas, I suggest to show the comparison between TOPMELT and MODIS for all the land covers, except for the forested areas. As an alternative, the results of the comparison could be shown in a table or in the figures, but distinguishing the various land uses.*

We thank the Reviewer for this note. As we reported in our response to comment R2C3, land use and impact of vegetation is not considered in this work. However, we recognise the limits of MODIS in vegetated areas. To account for this, the revised version includes a new version of Figure 7 (now Figure 6 in the revised version), where we report the land use distribution. The revised version includes also text reporting the fractions of different land uses. This helps understanding the impact of forested areas on OA and better interpreting our results.

### **Answers to minor comments**

*R2C5: Page 2, line 16: Please revise the English in this sentence.*

Revised (see marked-up manuscript).

*R2C6: Page 3, line 23: It is not clear why the fraction of glacier area or debris-covered glacier area is mentioned here without further explanation. Please integrate here with 1-2 brief sentences.*

We removed any reference to the debris covered glacier to avoid unnecessary information, given that this feature was not used in the case study. We revised the text

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concerning the meaning of glacier area fraction.

*R2C7: Title 2.2: Does the model consider interception by different vegetation covers? And how?*

See R2C3 and R2C4.

*R2C8: Page 4, Line 11: It is not clear what interpolation technique is used in the model. Please explain whether there are different options in the model. And please give more details about the Precipitation Correction Factor. How is it obtained/computed? What are the typical values?*

See R2C1. The paper was revised to better explain how the precipitation input is processed and passed to the model (see marked-up manuscript).

*R2C9: Eq 2: Maybe capital letters should be used here.*

In the revised paper we use capital letters for parameters and lowercase for variables, except for temperature T, which would confuse with time t. We added a table with variables and parameter definition (see Table 1 below).

*R2C10: Page 8, line 18: Please explain and provide examples of these threshold values.*

See R2C2.

*R2C11: Page 9, line9: Given that glaciers cover a very small fraction of the catchment area, could you provide estimates for the remaining 93% of the area?*

See R2C4. Glaciers are included within the bare soil/rocks land use.

*R2C12: Page 10, line 18: I guess this is not the correct symbol.*

Thanks, corrected.

*R2C13: Page 10, line 28: Maybe you could consider reporting the figure as supplementary material or as the new Figure 4, if the current one will be merged with Figure*

3.

We merged Figures 3 and 4 in the revised version (see the following comment R2C14).

*R2C14: Fig 3-4: I think Figure 4 could be merged with Figure 3 in order to have only one figure but with two plots. Please consider this change.*

Done, see the new Figure 3 below.

*R2C15: Page 13, line 6: Please provide the fraction for the different land uses in the description of the study area. I think coniferous forests and discontinuous vegetation might be the dominant land covers in such a catchment. Therefore, given the limits of MODIS in vegetated areas, I would suggest to show the comparison between TOPMELT and MODIS for all the land covers, except for the forested areas. As an alternative, the results of the comparison could be shown in a table or in the figures, but distinguishing the various land covers.*

See R2C3 and R2C4. In the revised version (marked-up manuscript), we added text with the fraction of different land use cover.

*R2C16: Figure 5: Please report also in the caption of the figure what TP, TN, FP and FN represent.*

Done (see marked-up manuscript).

*R2C17: line2 Page 14: Please revise the English because the second part of the sentence is not clear.*

Done (see marked-up manuscript).

*R2C18: Fig 8: Please use the same scale for NSE and add a) and b) in the two plots and the caption of the figure.*

Done, see below revised Figure 7.

*R2C19: Page 15, line 11: Why should W4-C10 be the better choice considering ac-*

*curacy and computational efficiency? Based on Figure 8, I would choose W2-C10. Please explain the sentence (your choice) and especially from the computational efficiency point of view.*

For this case study, results obtained with the finest spatial and temporal aggregation are similar to those obtained with an intermediate configuration (W4-C10), despite W2-C10 performs better. TOPMELT, in its W4-C10 configuration, computes the snowpack model for 10 points (classes) and updates the radiation 12 times a year; on the other hand, the W1-C20 configuration performs double the load for computing the snowpack (20 classes) and updates the radiation distribution four times more (48 times a year). Therefore, an intermediate resolution represents a balance between computational efficiency and accuracy. We added this to the revised paper.

Please also note the supplement to this comment:

<https://www.geosci-model-dev-discuss.net/gmd-2018-202/gmd-2018-202-AC1-supplement.pdf>

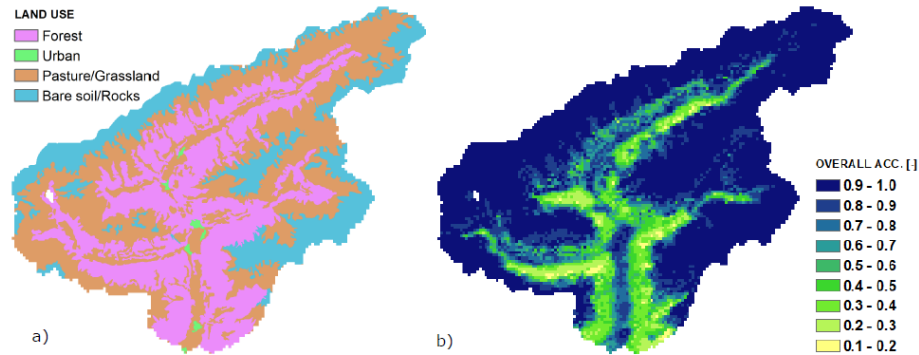
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Interactive comment on Geosci. Model Dev. Discuss., <https://doi.org/10.5194/gmd-2018-202, 2018>.

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**Figure 6.** a) Land use distribution for the catchment and b) pixel based overall accuracy (OA) of the comparison between simulated and MODIS-derived snow cover maps, computed from January 1 to June 30, 2011 for a total of 50 MODIS snow cover maps.

**Fig. 1.** Figure 6, revised paper.

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**Table 1.** Model parameters and variables: short name, description and measuring units. Parameters are written with capital letters, variables in lowercase.

Parameter	Description	Value	Units
<i>ALBG</i>	Glacier albedo	0.3	-
<i>ALBS</i>	Fresh snow albedo	0.9	-
$\beta_2$	Dimensionless parameter for <i>alb</i> computation	0.0919	-
<i>CMF</i>	Combined Melt Factor	0.013	mm °C <sup>-1</sup> MJ <sup>-1</sup> m <sup>2</sup>
<i>DYTIME</i>	Speed of water propagation through snowpack	3	mh <sup>-1</sup>
<i>G</i>	Precipitation gradient	0	km <sup>-1</sup>
<i>LWT</i>	Water holding capacity, fraction of w.e.	0.1	-
<i>NMF</i>	Night Melt Factor	0.16	mm °C <sup>-1</sup> h <sup>-1</sup>
<i>REFRZ</i>	Freezing factor	0.03	mm °C <sup>-1</sup> h <sup>-1</sup>
<i>RI</i>	Radiation Index, mean daily energy	1 ÷ 42	MJ m <sup>-2</sup> h <sup>-1</sup>
<i>RMF</i>	Rain Melt Factor	0.3	mm °C <sup>-1</sup> h <sup>-1</sup>
<i>T<sub>b</sub></i>	Base temperature	0.0	°C
<i>T<sub>c</sub></i>	Snow/rain threshold temperature	1.5	°C
<i>WETH</i>	Water equivalent minimum threshold before ice-melt	5	mm

Variable	Description	Units
<i>alb</i>	Snow albedo (accounting for aging)	-
<i>h</i>	Elevation	m
<i>f</i>	Fusion	mm h <sup>-1</sup>
<i>ice</i>	Freezed water	mm
<i>liqw</i>	Interstitial melt water	mm
<i>p</i>	Precipitation	mm h <sup>-1</sup>
<i>T</i>	Temperature	°C
<i>we</i>	Water Equivalent (w.e.)	mm

**Fig. 2.** Table 1, revised paper.

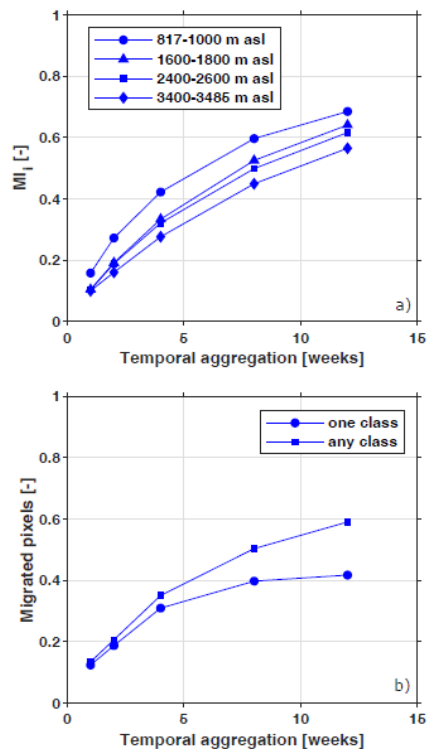
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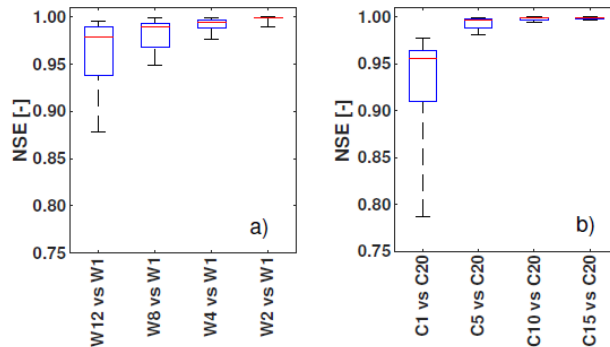






**Figure 3.** a) Band migration index for the five temporal aggregations, reported for four elevation bands (lowest elevation band from 817 to 1000 m); from 1600 to 1800 m; from 2400 to 2600 m; highest elevation band from 3400 to 3485 m). b) Fraction of migrated pixels computed for the five temporal aggregations over all the elevation bands. Circles refers to pixels that migrated of  $\pm 1$  energy class, squares to total migrated pixels.

**Fig. 3.** Figure 3, revised paper.



**Figure 7.** Box plots of NSE computed from the pixel by pixel comparison of the a) temporal and b) spatial aggregation series of w.e. maps, from October 2010 to June 30 2011 at weekly time-step. On each box, the central mark indicates the median, and the bottom and top edges of the box indicate the 25th and 75th percentiles, respectively. The whiskers extend to the maximum and the minimum efficiency. The reference is TOPMELT with W1-C10 configuration for the plot of the left panel, W4-C20 for the plot on the right.

**Fig. 4.** Figure 7, revised paper.

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