Detailed response to referee comments

We thank the author for this last round who has spotted a few inconsistencies and mistakes due to a large amount of change in the article from the previous round. We have fixed the different mistakes and made the appropriate changes.
We believe now that the paper is clearer thanks to both reviewer comments.

Fixed issues in the manuscript

Reviewer Comment (R.C): Firstly, on line 313, the additional text provided in this section is very helpful but it is still unclear what data from the Karisto and Loven study is being used. There was a lot of different data used and produced in that work so I think you just need to replace the word "data" with a more specific phrase e.g. "road weather station observations".

A.C, author's comments: Thank you for this comment. We have modified the beginning of the paragraph by specifying the different observations sources. We also added the reference of the merged observations on the Zenodo's project.

A.C Changes in the manuscript: (l313-315) To validate the model, we used the road surface temperatures observations from the dataset of Karsisto (2018) used in the study conducted by Karsisto and Loven (2019). Corresponding atmospheric observations measured by the Salo Hajala road weather station have been provided by the Finnish Meteorological Institute and available in the Zenodo of Colas (2024).

R.C: Secondly, regarding figures 7 and 8: The change from showing SWE amount to SWE events has made it much easier to interpret comments about the timing of snow cover but there are still numerous references throughout the text to snow mass and snow depth that no-longer have figures to back them up. I think these statements are valuable but would benefit from the inclusion of figures showing SWE quantities. I think there are a number of ways the authors could address this. The simplest solution would be to include both the original SWE quantity plots and the new SWE occurrence plots. Alternatively, the SWE quantity timeseries could be included, perhaps with altered axes, but also with event shading bars to highlight the snow cover occurrences.

A.C, author's comments: Thank you for finding these inconsistencies. In the text, we used "mass contents" and "snow and ice occurrences" equally. To remove the confusion, we have clarified the text without these confusions and replaced the corresponding " mass contents" in the result section for the Finish experiment. Regarding the author comment, we have chosen to keep the occurrences only to have consistent comparisons. Indeed, the performance of the sensors for ice and snow depth is suspicious as outlined in the article.

A.C Changes in the manuscript: (l395-396) In this section, we take advantage of the detailed observations at the Finnish Salo Hajala road weather station to further validate the physics of the model, in particular, in terms of water content, ice and snow water equivalent (SWE) occurrences at the road surface.

(l419-420)In both models, the simulated SWE occurrences are consistent with the observed snowfall but fail to match the observed SWE occurrences on the road.

(l425) For the road conditions, the models have varying degrees of success in representing the ice and SWE occurrences.

(434-435) In TEB-ES, the water produced by the snow mantle melting is frozen and the model accurately reproduces the observed occurrences on the road which was presumably ice.

R.C: Line 22: Remove duplication of 'mainly'

A.C, author's comments: Thank you, it has been removed line 22.

R.C: Line 28: The last sentence of the first paragraph of the introduction does not flow well from previous one - review.

A.C, author's comments: thank you for this comment. We have modified this sentence to make it flow better with the previous one.

A.C Changes in the manuscript: (l28) Also, the city climate may have a feedback effect on winter conditions, as some evidence suggests that the urban heat island decreases the amount of snowfall and increases the amount of rainfall Liu et al. 2024.

R.C: Line 92: "artificial winter conditions" doesn't sound quite right here. Consider changing to something along the lines of "anthropogenic impacts on winter surface conditions".

A.C, author's comments: We have modified this sentence accordingly.

A.C Changes in the manuscript: (l92) Section 6 comments on the findings of this study and the limitation of TEB-ES to represent winter conditions on artificial surfaces subject to anthropic impacts.

R.C: Line 133: Remove triplication of word "water".

A.C Changes in the manuscript: (l134) Thus, the evolution equation of the water equivalent content Ws is :

R.C: The text in figures 1 & 2 is extremely small. If it's possible to remove any more of the white space around the figures in order to increase the size that would be beneficial.

A.C, author's comments: Indeed, when we have added the original TEB scheme next to the previous one, we did not adapt the figure size. We slightly modified both figures, with a tighter layout and almost no margin. We believe the modification improves the quality and the readability of both figures.

A.C Changes in the manuscript: New figures:
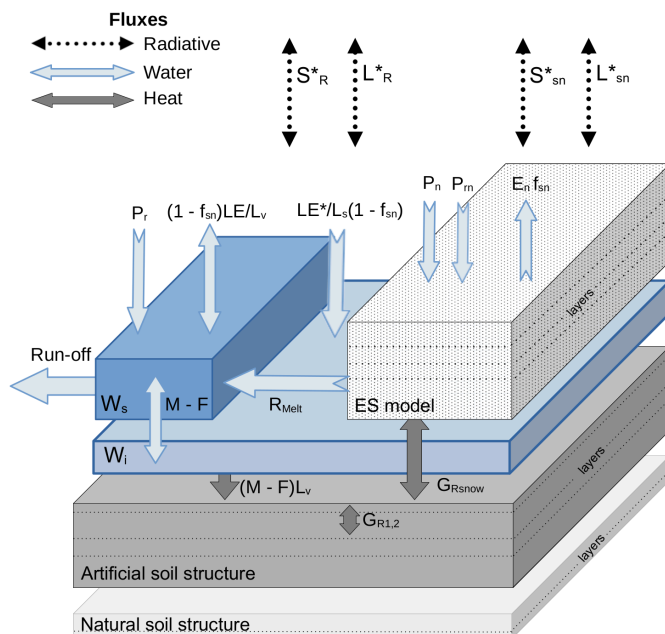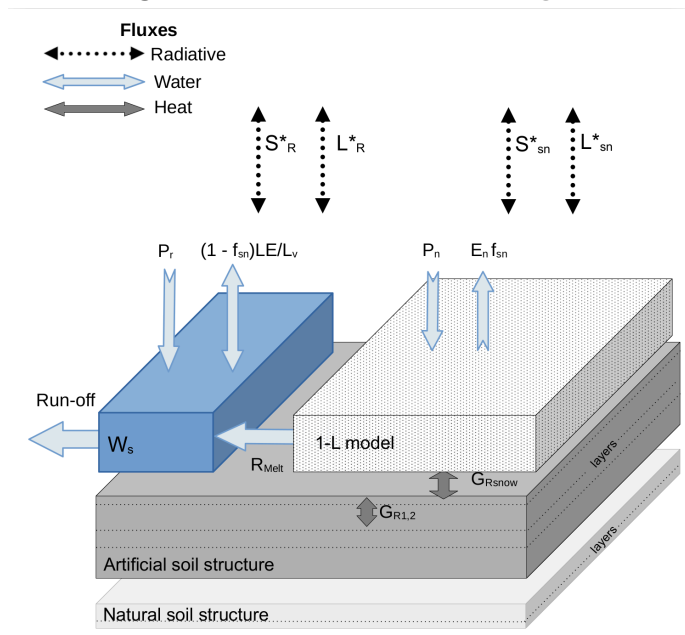
R.C: Line 254: The Sentence beginning 'Indeed' seems very out of place here if the reader is unfamiliar with the findings that are introduced later on. Perhaps instead frame it as 'at Col de Porte we also compare to ISBA-Route/CROCUS – a model that has previously been shown to perform well at this site {ref}'.

A.C, author's comments: This sentence was here to support the absence of ISBA-Route/CROCUS simulation on the southern Finland case study. It is true that without the results knowledge it is difficult to understand this argument. So, we used the fact that the model has already been tested at this location and shows good performance to support this decision.

A.C Changes in the manuscript: (l254-255) ISBA-Route/CROCUS has previously been shown to perform well at this site Bouilloud et al. 2006. Therefore, it is used in comparison at this location only.

R.C: Line 332: This section is a really helpful addition but there are a couple of references to 'PN' which are probably meant to be FN or TN? Please check.

A.C, author's comments: Thank you for seeing this mistake. PN has been modified accordingly with FN.

A.C Changes in the manuscript: (l333) detection rate = TP/(TP + FN), missed event rate = FN/(TP + FN)

R.C: Line 338: "experience" probably ought to read "experiment".
A.C, author's comments: Yes, thank you.

R.C: Line 533: capitalise "PLUMBER".
A.C, author's comments: Yes, thank you.

R.C: Lines 261, 534, 554 and 567: Use either numbers or letters to label appendices, not a mix. At the moment the appendices are labelled as 1 & 2 in the text but A & B in the appendix headings.

A.C, author's comments: Yes, the appendix references and how they are named in the article was different. We have modified the references and are now labeled A and B lines 261 and 534.