Response to Anonymous Referee #2 comments

Referee comments in grey italics, our response in blue.

I agree with referee #1 that the format of the paper is a little odd in that the only evaluation of the model is showing the computational efficiency of the different modules using "default physical options" (Section 4.2). I think this information is valuable but for it to be the only results shown was a little puzzling.

We sincerely thank Anonymous Referee #2 for his careful review that helps improve this article.

As noticed by Richard Essery (Referee #1), although our initial manuscript did not provide simulation results, it provides a detailed and unprecedented review of the abundant literature providing simulation results with this model. This review provides a more comprehensive description of the capacities of the model than what can be done in this article. However, to account for the remark of the Referee, we added a new Appendix in the revised version of the manuscript with an overview of simulation results at the 10 ESM-SnowMIP reference sites corresponding to the published code version. This can be considered as a benchmark of the model skill that can be useful to assess the impact of future model developments.

If this is purely a paper synthesizing recent advancements of the physical formulas and parameters used in Crocus and referencing the specific studies they come from, I think a schematic diagram for what Crocus does (e.g. Vionnet et al., 2012 Fig. 1) and which processes are relevant to this current study would be helpful. It could even be something like Figure 1. I would have liked this to be referenced earlier to provide some context about what was traditionally incorporated in the Crocus model and what's been added.

Figure 1 provides a comprehensive description of the processes represented in the model. Following, the suggestion of Anonymous Referee #2, we added labels « NEW » and « UPDATED » on this Figure to emphasize changes compared to the previous reference paper (Vionnet et al., 2012) and the revised manuscript refers earlier to this Figure in the introductive paragraph of Section 2.

Some other general comments include; grammatical errors, and unclear wording, and many of the provided equations are never actually referenced in the text (e.g. 135 and 136).

We apologize for the grammatical errors and unclear wording. They were carefully corrected in the revised manuscript following both reviewers recommendations. Eq. 135-136 (137-138 in the revised manuscript) are now referenced in the text. We believe that it is not always necessary to reference equations in the text when they come directly after a clear introductive sentence.

Specific comments:

Lines 10-12: confusing as written.

The sentence was split into two parts and reformulated in the revised manuscript to make it easier to understand.

Lines 43: "to evolve"

We are sorry but we don't see where to implement this suggestion at this line.

Lines 49: It wasn't immediately clear to me what was meant by diagnoses

We added examples of diagnoses in this sentence to make this sentence easier to understand.

Lines 51-53: Confusing as written.

The sentence was split into two parts and reformulated in the revised manuscript to make it easier to understand.

Line 69 :"are set to zero"

We corrected the word « component » (singular) to make this sentence gramatically correct.

Line 82: "in an appendix."

Corrected

Line 85: might be helpful to describe LAP in more context. I think its actually defined later in the manuscript.

As suggested, we added a sentence to better introduce this paragraph : « *Light Absorbing Particles (LAP) are organic or mineral substances able to increase radiation absorption in snow.* »

The acronym LAP (Light Absorbing Particles) is also defined earlier in the manuscript (Line 71 of the preprint), as it is necessary to describe the forcing variables. Section 2.4.10 describes the evolution laws of LAP contents in the snow layers.

Line 132-133: confusing as written.

This sentence was split into two parts to make it easier to understand.

Line 136: "relatively" – "relative"

Corrected

Line 160: "When a layer i is split"

Corrected

Line 246-249: Confusing as written. Either .. either.

Corrected (either/or)

Line 252: "They depend on conditions of…"

Corrected

Line 258-260: Confusing as written.

The sentence was modified in the revised manuscript to make it easier to understand.

Line 348: "In addition, a threshold is applied on the mobility indice in case melt forms:"

Melt Forms corresponds to a grain type in the international classification of snow on the ground. However, we reformulated this sentence to remove any ambiguity :

"In addition, a threshold is applied on the mobility indice in case liquid water had been present at any time in the snow layer."

Line 394-395: "The last modification of absorption related parameters" ??

Replaced by *« The last modification about absorption of solar radiation »*

Line 513: "and G0 is the flux obtained by applying Eq. 95 with T1."

Corrected

*Line 530: "This allows **us** to represent" ??*

Corrected by *« This allows representation »* following Richard Essery's recommendation.

*Line 549: "…And to **solve** the linear system… modified **according** to the new values.*

We modified this sentence to avoid its separation into two parts by the equations and improve readability.

Line 558: "solving MEB"

Corrected

Figure 1: Reference earlier.

Figure 1 was already referenced before its position in the text (line 557 of the preprint). In the revised manuscript, as explained above, Figure 1 is now referenced much earlier at the beginning of Section 2, following Anonymous Referee 2 recommendations.

Line 578-579: Confusing as written.

We corrected the syntax of this sentence and added « available heating energy ». We believe this sentence now allows a clear introduction of Equation 120 (Equation 119 in the preprint).

Line 598-599: "Either… or" instead of "Either … either"

Corrected

Line 623-625: Confusing as written.

The sentence was modified in the revised manuscript to make it easier to understand.

Line 640: "removing" instead of "deleting"

Corrected

Line 644-645: Reads as somewhat conflicting. Crocus does not modify or update snow microstructure, yet you cannot track surface hoar buried underneath the snow?

We provide extended explanations in the revised manuscript to avoid any misunderstanding :
« Microstructure properties are not modified. Therefore, in case of deposition, the current Crocus snow model only increases the mass of the surface snow layer but it does not allow the formation of a dedicated layer with microstructure properties typical of surface hoar. As a result, it is neither possible to track the burying of surface hoar in the snowpack. »

Line 655-57: Does this mean model output variables that can be used for model evaluation and diagnostics? I think a little more of a description here and possibly in the introduction would be helpful.

Yes. We added in the text the following description : « *These diagnoses can be useful for model evaluation or interpretation in research or operational applications. »*

Line 695: "For understanding stability indices of the snowpack, shear resistance Rsi is computed for each layer i."

The shear resistance is actually a diagnostic which is necessary for the computation of stability indexes, and it is only computed for this reason. We prefer to maintain the meaning of the initial sentence, but we fixed the incorrect syntax.

Line 707-708: Confusing as written

The sentence was modified in the revised manuscript to make it easier to understand.

Line 709: typo – "values"

Corrected

Line 790: typo "then" – "that"

Corrected

Line 817: typo "spatialized" – "spatial"

Corrected

Line 848: typo "score" – "accuracy"

Corrected

Line 866-870: confusing as written

This sentence was split into two parts in the revised manuscript with extended explanations to make it easier to understand.

Line 903-905: could be written clearer.

We now explain that the variable size of the state vector (as formulated with the vocabulary of data assimilation) is linked to the variable number of layers in Crocus (which is clearly explained in the article).