

## #essd-2024-451 - Author's response

The authors thank the reviewer for their constructive feedback and for recognizing the improvements made following the initial round of revisions. We appreciate the acknowledgement that the updated analysis is robust and that the paper has potential to be a strong contribution. Suggestions contributed to clarifying key aspects of the manuscript and improve presentation of our results in line with ESSD's focus.

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### Reviewer 2

**General Comment** — This paper compares Northern Hemispherical snow datasets (snow depth and SCF) from Crocus-ERA5 to long-term in situ station observations and its predecessor model, Crocus-ERA-Interim. It is important to assess the accuracy of this dataset, as both CNRM and ECCC are using it to evaluate changes in Arctic snow cover.

I believe Reviewer 1's comments addressed many of the concerns I had with the manuscript, and the authors' subsequent responses have led to marked improvements. Therefore, I have taken those comments and improvements into consideration in this review.

While this paper has the potential to be a strong contribution to the literature, the manuscript requires significant restructuring. There is a lot of valuable information and analysis, but it is scattered somewhat randomly throughout the sections, making it challenging to follow exactly what the authors did. This is especially important for a paper submitted to ESSD, as the journal primarily focuses on dataset production and methodology.

I believe the updated analysis provided by the authors is robust, so my comments mainly focus on providing more detail on the datasets/models and reorganizing Sections 1–3. That said, I believe these changes constitute a major revision, as large portions of text should be moved and better integrated into the appropriate sections.

**Reviewer Comment 2.1** — Introduction

L49–65: As described in more detail below, remove this text and integrate into Section 2.

**Reply:** First of all, we would like to clarify that the changes were made to the text that had already been modified in response to Reviewer 1. The structure of the text has changed considerably. Several paragraphs have been moved to Section 2 (Data and Methods). These large-block moves make point-by-point explanations unhelpful. For this reason, we do not provide detailed explanations here. For example, lines 49–65 were split and redistributed into the Introduction (lines 49–51), Section 2.2 (lines 51–54), Section 2.4 (lines 56–57), and so on.

To track these changes, we used the `trackchanges` package in LaTeX. However, please note that when blocks of text were moved, the “old” locations are not highlighted. Only new insertions

appear as tracked changes. Due to limitations in LaTeX's ability to track changes across large text blocks, some modifications may not be fully visible. Nevertheless, all essential updates are retained in the LaTeX tracked version and can be seen in the diff/track PDF file.

**Reviewer Comment 2.2** — Section 2. Data/Methods: This section contains a mix of background information, data description, and is confusing to read. For example L80-83, the section begins with a topic sentence that is background information that has limited pertinence to the data or methods described in this paper:

“Warming and more frequent winter thaws are contributing to changes in snow pack structure with important implications for snow distribution. The performance of snowpack modelling in this context of climate change, can be summarized by the two main variables used as indicators of climate change because of their interactions and feedbacks with surface energy: the snow depth and the snow cover.”

This is a well written passage, but belongs in the Introduction!

Given this paper being submitted to ESSD, I believe there needs to be a central description of the modeling framework in the Data section. This information could be moved and updated from L49-65. Some questions to think about:

How does Crocus work (i.e., model physics)?

What variables does it need to run?

What variables does it produce?

How are Crocus-ERA5 and Crocus-Interm-ERA5 different?

Some of this information is in the paper but scattered in many different places. Please include a table that clearly shows the difference between Crocus-ERA5 and Crocus-Interm-ERA5 differences (i.e., spatial resolution, time period, model physics, etc.).

I'm not going to go line by line here, but have one subsection describing the models/data used in this study and one subsection describing the methods used to analyze these data. Move all other information that justified the importance of modeling to the intro. Again, I think most of this text is very well written, just needs to be reorganized!

**Reply:** In response to the imperative need for clarification, we have classified and grouped the information as much as possible within Sections 1–3. We have carefully revised the manuscript with the goal of improving its clarity and organization, aligning it with ESSD's emphasis on dataset production and methodology.

The following improvements were made to enhance the clarity, structure, and readability of the manuscript:

- The introductory material has been reorganized to better guide the reader through the context.

- We have clarified the presentation of the datasets and provided a more detailed description of the Crocus model.
- Background information and methodological details have been consolidated and streamlined.
- Redundant or scattered content has been moved to appropriate sections to enhance the flow and coherence of the manuscript.

The section 2 ("Data and Methods") now includes five subsections: Atmospheric Forcings, Crocus-ERA5 Framework, Snowpack Modeling, Analysis Methods, and Observational Data. In this section, we provide detailed responses to the reviewer's questions:

- **How does Crocus work (i.e., model physics)?**

This is addressed in Section 2.3 *Snowpack Modeling*, where we describe Crocus as a multi-layer snow model.

- **What variables does it need to run?**

Section 2.2 *Crocus-ERA5 Framework* specifies the input variables required to force Crocus, such as air temperature, humidity, wind speed, incoming shortwave and longwave radiation, and precipitation.

- **What variables does it produce?**

Section 2.2 *Crocus-ERA5 Framework* lists the available output variables, which are accessible at its Zenodo repository.

- **How are Crocus-ERA5 and Crocus-Interim-ERA5 different?**

This is explained in Section 2.1 *Atmospheric Forcings*, which describes the differences between the ERA5 and ERA-Interim reanalysis used as atmospheric forcing for Crocus.

A table summarizing the differences between the ERA-Interim and ERA5 reanalyses, which are used to force Crocus, has been added.

**Reviewer Comment 2.3** — L139–148 (and new text added in response): This passage is a great data description. I think it belongs in the Data description section.

**Reply:** We appreciate the suggestion to move this section to section 2 ("Data and methods"). Now, this paragraph takes part of Section 2.1 *Atmospheric Forcing* but were split as its main part were putted in the Table 1 describing differences between reanalysis. All informations are preserved and enriched by highlighting the type of snow model used by the two reanalyses, which is single-layer and therefore takes no account of vertical variations in the snowpack.

**Reviewer Comment 2.4** — Figure 2: Updated figure from response document is much improved and addresses all my concerns with the original figure.

**Reply:** Figure 2 has been redrawn. It integrate now the autumn season (SON). This inclusion allowed us to better support the meaning of this representation concerning especially filled circles.

**Reviewer Comment 2.5** — Figure 4: Change color scheme – this looks like an elevation model. White/gray to dark blue commonly used for snow depth.

**Reply:** Thank you for the suggestion. The color scheme of Figure 4 has been updated to a white/gray to dark blue gradient to better represent snow depth.

**Reviewer Comment 2.6** — Figure 5: Use the same color scheme as Figure 4 to keep consistent.

**Reply:** The color scheme of Figure 5 has been updated to match Figure 4, ensuring consistency across the figures.

**Reviewer Comment 2.7** — L245: Any statistical analysis should be described in the Methods section and not be first introduced here. As noted prior, I would create a methods subsection where all this information can be contained.

**Reply:** We thank the reviewer for this suggestion. We have moved the description of all snow depth diagnostics to the *2.4 Analysis Methods* subsection. In the Section 3, these diagnostics are now only referenced without detailed definitions.

**Reviewer Comment 2.8** — L352: Please include a paragraph summarizing the findings. The manuscript abruptly ends with discussion of future work.

**Reply:** Thank you for the comment. The main findings have been summarized in the first part of the Conclusions and Perspectives section. We have reviewed and ensured that the key results are clearly presented before discussing future work.

### Technical Comments:

Numerous technical and grammatical errors exist in the document. Please check for correctness closely. I only list a few below.

1. L259: "...reproduced well..."
2. L334: SWE already defined.
3. L339: Check citation.

**Reply:** Thank you for your careful review. We have re-read the manuscript carefully and had it cross-checked by co-authors as well. Regarding the specific points:

- L259 : The wording around has been revised for clarity.

- The abbreviation SWE (snow cover extent) was defined when it first appeared in the abstract, main text and each figure.
- Citations has been checked and corrected if necessary.

**Please note that Figures 7 and 8 have been updated in this version. Initially, we provided a rationale for the representation of the standardized snow cover extent anomaly. However, in light of Reviewer 1's comments and to ensure greater consistency across the dataset presentation, we have revised these figures accordingly. We hope these changes address the reviewer's concerns and enhance the overall clarity and impact of the manuscript."**