Answers to reviewers: TC-2021-281

Temporal stability of long-term satellite and reanalysis products to monitor snow cover trends

Ruben Urraca and Nadine Gobron

REVIEWER #1

Thanks very much to the authors for their thorough revisions to the manuscript. In particular, I appreciate the effort to add data from Canada, which means there is now better spatial coverage of the surface snow observations. I have a small number of final comments for the authors to consider:

1. The methodology now explicitly describes the identification of stations that were assimilated into ERA5, and how these were treated within the analysis (Line 165: "These stations were kept for the stability analysis, since their addition to ERA5 may explain some of the discontinuities observed, but were removed from the accuracy analysis to guarantee the independence of the validation set.").

In line 264 it states that 387 stations were used for validation; how many of these stations are part of the 235 stations assimilated into ERA5? Is it possible to use different symbol shapes in Figure 3a to indicate which stations are assimilated?

Answer: The total number of stations used in the study is 527. For the validation (accuracy analysis), we used spatially representative stations (387 out of 527) that are not assimilated into ERA5 (214 out of 527). The number of stations meeting both conditions is 152 out of 527. We have clarified this in the manuscript.

"Only spatially representative stations that are not assimilated by ERA5 are used (152 out of 527)."

As suggested by the reviewer, we have added different symbol shapes (circles and triangles) in Fig 3a to indicate which stations are assimilated into ERA5.

2. Justification for the use of the 2.5 cm snow depth threshold for determining snow cover (and subsequently snow cover duration) is now more clearly described. As noted in my original review, I appreciate the effort taken to quantify the spatial representativeness of the point measurements.

Answer: Many thanks for this positive comment.

3. As noted in my review of the original manuscript, the effort to address the fall trends in the NOAA CDR is important. In Section 5, the key findings are clearly stated (lines 517-522). The original presentation of these findings in Section 3.2.2 is, however, written less clearly. I think this is because the spurious nature of the NOAA CDR fall trends is illustrated by a positive trend in the bias (as opposed to Figure 11 which shows the false trend in actual snow extent), and the wording is sometimes ambiguous as to whether the trend in extent is positive or the trend in bias is positive. I suggest revising Section 3.2.2 for clarity, so that it more clearly links to the conclusions in Section 5.

Answer: Thanks for the comment. We have revised this section clarifying if we referred to 'the trend in the bias of snow cover duration' or to 'the trend in snow cover extent'

4. In general, the manuscript is clearly written, but a final editorial review for grammar would be helpful.

Answer: We have performed a final editorial review.

Editorial

Abstract, line 14: suggest changing "…with the increasing number of satellite data used." to "…with changes to the available satellite data."

Answer: Done.

Abstract line 21: suggest changing to "…while in drier regions such as Russia earlier snow melt occurs despite increased maximum seasonal snow depth."

Answer: Done.

Line 69: Since the first version of this manuscript was submitted, a new manuscript has come out which shows the SMMR to SSM/I transition creates a temporal inhomogeneity in the Snow CCI dataset. I leave it up to the authors to decide whether there is value to add a citation.

Mortimer, C., L. Mudryk, C. Derksen, M. Brady, K. Luojus, P. Venäläinen, M. Moisander, J. Lemmetyinen, M. Takala, C. Tanis, and J. Pulliainen. 2022. Benchmarking algorithm changes to the Snow CCI+ snow water equivalent product. Remote Sensing of Environment. DOI: 10.1016/j.rse.2022.112988.

Answer: Thanks for the update. We have included the new reference.

Line 306: consider changing the wording here to "The positive trend in fall has been previously reported as problematic in several studies."

Answer: Changed.

Figure 6: One too many C's in the ECCC label.

Answer: We have corrected this typo in all the figures.

REVIEWER #2

Urraca and Gobron investigate the long-term temporal stability of snow-related variables produced by two global climate reanalysis products (ERA5 and ERA5-Land) for the period 1950-2020 and the weekly Snow Cover Extent (SCE) charts produced by NOAA Climate Data Records (CDR) for the period 1966-2020.

This article is a valuable contribution as I believe that its results are interesting for the scientific community and The Cryosphere. I only have some minor comments that could help to improve some details regarding presentation and take-home messages.

COMMENTS

I would add to the manuscript the answer that you give the Editor about why you did not include in your article other products such as the Japanese reanalysis. I think that you provide a reasonable argument (one product of each type).

Answer: We have added the following clarification in the introduction:

"The goal of the study is to analyze the temporal stability of snow-related variables form satellite products, global reanalysis, and land reanalysis. We selected one product of each type: NOAA CDR (1966-present), ERA5 (1950-present), and ERA5-Land (1950-present), respectively. They provide the longest temporal coverage in each group."

SUGGESTED TEXT CORRECTIONS

3: Remove the parenthesis

Answer: Done.

3: While the temporal stability of satellite products …, the stability of reanalysis datasets…

Answer: Done.

7: Some of the longest

Answer: Done.

30: a strong snow-albedo feedback

Answer: Done.

150: the 1980s

Answer: Done.

151, 153: the 1990s

Answer: Done.

157: due to the low number of available ECCC stations…

Answer: Done.

158: at least 90%

Answer: Done.

513: In the reanalysis, the incorporation of new data to the data assimilation creates a trade-off between accuracy and stability

Answer: Done.

520: e.g. Cohen et al.

Answer: Done.

FIGURES

Figure 3: (b) coastal station, (c) mountain station

Answer: Done.

Figure 3: In what panel are the stations in grey?

Answer: Pannel (a). For clarification, we have moved the description of stations in grey just after the panel description.

Figure 4: What is the cause for the last big boxplot in ERA5-ECCCC panel?

Answer: Despite having enough number of stations, the ECCC stations available in 2015 (last boxplot) were not as homogeneously distributed over Canada (as during the previous years). Thus, we have removed that year from all plots that aggregate all ECCC stations to one annual metric (like boxplots).

Figure 7 (caption): 2003-04 discontinuities

Answer: Corrected.