

Interactive comment on “Snow mass decrease in the Northern Hemisphere (1979/80–2010/11)” by Z. Li et al.

Anonymous Referee #2

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Summary: In this paper, the authors introduce a merged data product of Northern Hemisphere snow water equivalent (SWE) derived from three remote sensing products. The original remote sensing products are compared to in situ observations of snow depth and assumptions on snow density, with the NSIDC data closer to observations when SWE < 30 mm and the Globsnow data closer to observations when SWE > 30 mm. The merged data then are used to assess trends in SWE between 1979/80 and 2010/11 using the Mann-Kendall Test. Large declines in the months of January and February are found, with more moderate trends in December and March. Coincident with these trends are rises in air temperatures that may have led to the SWE declines.

There are some results in this manuscript that will be of interest to the readership of the

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journal. However, there are considerable issues with the paper including its structure, the validation of the SWE data and the trend analyses. The language and graphics also need improvement as described in my report below:

General Comments:

- 1) Some of the language used in the paper needs to be considerably improved. Some language issues are highlighted in the specific comments below.
- 2) The introduction is rather brief and should be expanded to better summarize existing SWE products and their relative accuracy. Further to this, motivation for this work and hypotheses or research questions should also be provided in this section.
- 3) How sensitive are the inversion algorithms for the remotely sensed SWE data to the assumed snow densities? How realistic is the assumption of a constant snow density over time?
- 4) Rather than using meteorological stations that record snow depth and then make assumptions about snow density to infer ground-based SWE measurements, why not use direct observations of SWE? There are many snow pillow stations or snow survey sites in the United States (e.g., SNOTEL stations), Canada (e.g., BC River Forecast Centre snow pillow stations) and Russia (snow survey sites) that would be suitable for this comparison.
- 5) Throughout the text, consider using “data blending” rather than “data merge”.
- 6) Aspects of the methodology are provided in section 3 (“Results”) and should therefore be moved to section 2 (“Methods”) instead. This includes information on the Mann-Kendall trend test (p. 5629) and what p-value is considered statistically-significant in the present study. Furthermore, the source of the air temperature and precipitation data needs to be provided along with the exact regions over which trend analyses are assessed.
- 7) As the remote sensing products are not capable of inferring deep snow (SWE >

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180 mm to 200 mm), regions where this threshold is often surpassed during winter (e.g., the mountainous terrain of western North America, Alaska, and northern Quebec and Labrador) should be masked out from the analyses (Figures 3-5). Given regions that experience commonly deep snowpacks contribute disproportionately to the overall snow mass of the Northern Hemisphere, how reliable are the trend results provided here (Figure 6)? Further to this, given the errors found in Figure 2 are as large as the observed trends shown in Figure 5, can one trust the results of the trend analyses?

Specific Comments:

- 1) P. 5624, line 4: Revise to “are lacking”.
- 2) P. 5625, line 8: Change to “Imager”.
- 3) P. 5625, line 9: List the AMSR-E Le Global SWE product as the second one in your list, and then the GlobSnow SWE product as the third.
- 4) P. 5625, line 11: Delete “the” before “two”.
- 5) P. 5625, lines 16-18: The language could be improved here.
- 6) P. 5626, line 11: Change the “&” with “and”.
- 7) P. 5626, line 16: Delete “the” before “Boston”.
- 8) P. 5626, line 24: Change the “&” with “and”.
- 9) P. 5627, line 11: Insert “the” before “Global”.
- 10) P. 5627, lines 12 and 14: Delete “in order” where it is not needed.
- 11) P. 5628, line 2: Delete “the situations”.
- 12) P. 5628, line 19: Delete “in order”.
- 13) P. 5628, line 22: Replace the “&” with “and”.
- 14) P. 5628, line 26: Change to “Simulated data were. . .”

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- 15) P. 5629, line 3: Change to “simulated data were. . .” and delete “in order”.
- 16) P. 5629, line 8: This sentence could be improved.
- 17) P. 5629, line 9: Delete “the” before “four months”.
- 18) P. 5629, line 11: Change to “(SSMR and SSM/I)”.
- 19) P. 5631, line 15: Insert a comma after “(Gan et al., 2013)”.
- 20) P. 5631, line 20: Insert the year of publication for Gan et al. and replace “faster” with “stronger”.
- 21) P. 5631, line 21: Replace “slower” with “weaker”.
- 22) P. 5631, line 22: Change to “Discussion”.
- 23) P. 5632, line 3: Delete the comma after “that” and replace “the” with “this” before “conclusion”.
- 24) P. 5632, line 7: This should read “necessarily”.
- 25) P. 5632, line 9: What is the source of the air temperature and precipitation data?
- 26) P. 5632, line 12: Replace “To find out” with “To explore”.
- 27) P. 5632, line 27: Change to “the melt and sublimation”.
- 28) P. 5634, line 6: Change to “data are”.
- 29) P. 5635, line 3: Gan et al. is not in the proper alphabetical order.
- 30) P. 5636, line 19: Sturm et al. is not in the proper alphabetical order.
- 31) P. 5636, line 26: Delete “online first” and update this reference.
- 32) P. 5636, line 30: Delete “online first” and update this reference.
- 33) P. 5637, Figure 1: This map is difficult to read, especially the weather stations

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selected to evaluate the SWE data. Perhaps only these stations should be shown on the map, rather than all snow stations? For the figure legend, delete "The" before "weather station". In the figure caption, change to "The crosses represent".

34) P. 5638, Figure 2: What do the vertical grey lines represent? Please consider using box plots to show quantiles in the SWE errors. Note also the font size on the two y-axis labels for the panel on the right differ.

35) P. 5639, Figure 3: Note the spelling mistake in "products" within the figure caption. The font size for the legends is small and not legible. Areas where deep snow occurs should be masked out from the maps.

36) P. 5640, Figure 4: The color scale could be enhanced to better the range of SWE values. If the remote sensing data are unable to accurately infer deep snowpacks, why does the range exceed 200 mm? In the caption, insert "monthly" before "SWE".

37) P. 5642, Figure 6: Why not add the trend lines to this graph? Rather than just Northern Hemisphere trends, why now add results for both North America and Eurasia?

38) P. 5643, Figure 7: Is Figure 7(b) already published and copyrighted? If so, permission must be obtained to reproduce the figure here.

39) P. 5644, Figure 8: Is it unclear over which domain the trend analyses are assessed.

Interactive comment on The Cryosphere Discuss., 8, 5623, 2014.