

Review of “Frequency and distribution of winter melt events from passive microwave satellite data in the pan-Arctic, 1988-2013”

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Summary: In this paper, the authors undertake an analysis of mid-winter snow melt events across land areas of the pan-Arctic domain above 50°N using microwave remote sensing. An algorithm is developed to infer liquid water in snowpacks using variations in surface brightness temperatures from SSM/I and SSMIS over 1988-2013. Mid-winter melt events are relatively rare with ≤ 7 occurrences (days) each year across most areas under study, with higher frequencies in temperate regions. The spatial patterns in winter snow melt events inferred from air temperature obtained from reanalysis products concur with those detected by the microwave remote sensing data. Further analyses reveal few statistically significant trends in winter melt events with the notable exception of northern Europe.

This is an interesting paper with novel results and it should be suitable for publication in *The Cryosphere* following some moderate revisions. My report provides guidance on how the paper should be revised prior to publication:

General Comments:

- 1) In-text references do not follow the format used by *The Cryosphere*, i.e. round rather than square brackets should be used for references.
- 2) Has validation of the proposed algorithm been performed in regions other than Canada and Finland, such as Russia and Alaska?
- 3) At times snow melt events occur just below the surface of the snowpack – is the proposed methodology able to detect such events?
- 4) The results presented in this paper focus on terrestrial snowpacks – can the methodology also be applied to snow on sea ice?
- 5) How reliable is the algorithm when applied to complex terrain such as the western Cordillera of North America?
- 6) If only the afternoon overpasses are used to infer snow melt events across the pan-Arctic, how are melt events during other times of the day accounted for?
- 7) Probability values should be reported for all correlation coefficients presented in the paper.
- 8) The findings of recent rising air temperatures during fall (SON) with no trends in winter (DJF) and spring (MAM) across the Northern Hemisphere seem to contradict results from other studies (see Figure 12). These results should be placed into context (time period and area of interest). Why are temperature trends not reported only for the domain of study (i.e. pan-Arctic land areas above 50°N) for comparison with the snow melt analyses? Why are the seasonal air

- temperature trends not inferred from the Mann-Kendall test instead of linear regressions? Probability values for these trends should also be reported.
- 9) Further to this, how reliable are trend analyses for a rather short (25 years, 1988-2013) period of study? Are the reported trends greater than the variability experienced over the period of study, i.e. is the signal greater than the noise in the data?
 - 10) The authors should consider suggestions for future work in the final paragraph of Section 4.

Specific Comments:

- 1) P. 1, line 12: Insert “GHz” after “19”.
- 2) P. 1, line 19: Replace “7” with “seven”.
- 3) P. 1, line 22: “ERA” and “MERRA” are not defined.
- 4) P. 2, line 34: Insert a comma after “events”.
- 5) P. 5, line 104: Define “EASE”.
- 6) P. 6, line 126: Insert “GHz” after “19” and insert a space in the second “37 GHz”.
- 7) P. 7, line 151: Add a comma after “e.g.”
- 8) P. 8, line 170: Change to “one week”.
- 9) P. 8, line 195: Insert a comma after “disappearance”.
- 10) P. 9, lines 197/198: Delete “degree” and define acronyms used here.
- 11) P. 9, line 203: Why are 30-day moving averages of daily mean air temperatures used here for analysis?
- 12) P. 10, line 224: Insert a space in “Table 2”.
- 13) P. 11, line 246: Delete the space in “0°C”.
- 14) P. 11, line 248: Should this be “1 cm” instead of “-1 cm”? Replace the contraction “didn’t” with “did not” and delete the space in “0°C”.
- 15) P. 11, line 250: Delete the space in “0°C”.
- 16) P. 12, lines 269/270: More information in the Methods must be provided on the selection of Daring Lake and La Grande IV as areas to test the algorithm to detect snow melt events. Provide for instance the province/territory where these locations are found and a brief description of their environment (vegetation, physiography, etc.) What does “La Grande IV” mean?
- 17) P. 13, line 285: Revise to “(Figure 5c). A pixel-wise”...
- 18) P. 13, line 286: Delete the second “winter”.
- 19) P. 14, line 301: Insert a comma after “e.g.”.
- 20) P. 14, lines 316 to 318: Are any of these trends statistically-significant? It is difficult to interpret linear trends when associated probability values are not provided. Figure captions for trend analyses do report a statistical significance of 90% and as such the Methods section must discuss use of this level as definition of statistically-significant trends.
- 21) P. 14, line 319: Delete “are shown in” and insert brackets in “(Figure 9).”
- 22) P. 15, line 321: Avoid tentative language such as “tends”.
- 23) P. 15, line 323: Delete “period”.
- 24) P. 15, line 327: Again avoid the use of tentative language.

- 25) P. 15, line 334: What is the probability value for the correlation coefficient reported here?
- 26) P. 15, line 336: Replace “are” with “is”.
- 27) P. 16, line 348: Revise to “lasts”.
- 28) P. 16, line 363: Change to “northern”.
- 29) P. 17, line 370: Replace “which” with “that”.
- 30) P. 17, line 383: Replace “which tend to” by “that produce”.
- 31) P. 17, line 386: Delete “which revealed”.
- 32) P. 18, line 404: Should this be “pan-Arctic”?
- 33) P. 18, line 405: Any thoughts on possible future work that could be added here?
- 34) P. 18, line 409: Replace “which” by “that”.
- 35) P. 28, Table 1: How does the change in SSM/I orbital overpass from descending (July 1988 to December 1991) to ascending affect the results presented in this study?
- 36) P. 31, Figure 2: Are snow pit data available for this site in Finland, as presented in Figure 3 for Manitoba?
- 37) P. 32, Figure 3: If possible, this figure should have the same format (two panels) as shown in Figure 2 for consistency between them. Are Tmin and Tmax not available for this site?
- 38) P. 33, Figure 4: The caption should specify the location where these time series results apply.
- 39) P. 34, Figure 5: How do these results compare to those presented by Choi et al. (2010)?
- 40) P. 35, Figure 6: The color scale should be identified as “Days”.
- 41) P. 36, Figure 7: Why are results for June not presented here? Please define the color scale here as well.
- 42) P. 37, Figure 8: What are the units for the color scale? Why are these results presented and how relevant are they to those on the detection of snow melt events from microwave remote sensing?
- 43) PP. 38/39, Figures 9 and 10: The text must specify what level of significance trends are reported at. Insert “Days” for the color scales here too.
- 44) P. 40, Figure 11: What are the probability values for the correlation coefficients presented here?
- 45) P. 41, Figure 12: This figure could be improved by using a program other than Excel for plotting. The y-axis lacks a title and units.

References:

Choi, G., Robinson, D. A., and Kang, S.: Changing Northern Hemisphere snow seasons, *J. Climate*, 23, 5305-5310, 2010.