

Interactive comment on “Estimating fractional snow cover from passive microwave brightness temperature data using MODIS snow cover product over North America” by Xiongxin Xiao et al.

Anonymous Referee #1

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This manuscript describes the development and validation of a technique to estimate fractional snow cover (FSC) from passive microwave brightness temperatures. Optical FSC estimates for algorithm training and validation were derived from MODIS Collection 6. Surface snow depth measurements and an independent passive microwave snow extent classifier were also used for evaluation. Overall, the study is comprehensive and detailed. I commend the authors for the thorough nature of the study – multiple combinations of passive microwave measurements are considered, sensitivity to various configurations of the retrieval are compared, and multiple datasets are used

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for evaluation. Because of this comprehensive approach, description of the analysis is sometimes unclear in some places, and the logic is not always clear on the back and forth conversion between FSC information derived via the retrieval and comparison with MODIS, and binary snow extent information used for evaluation. This can get confusing in places. But overall, the technique shows good promise, and this initial overview makes for a new contribution worthy of publication The Cryosphere.

Please note that the paper requires a thorough edit for grammar, English usage, and word choice. Edits of this nature were too numerous to identify individually in my review.

General comments

Please double check all the data citations in Section 2.1 and Section 2.2. Some citations are missing from the reference list. While it's fine to provide the URL to the NSIDC webpage which hosts the data, the proper data citations (which are provided under the "Citing These Data" tab on the NSIDC webpages) must also be used.

Section 2.3.2: why is the IGBP land cover data product described here in addition to the MCD12Q1 product? This dataset does not seem to be used in the analysis. . .

Page 6 lines 14-23: Previous work has shown the potential for passive microwave SWE datasets, despite high uncertainty in the SWE retrievals, to provide useful snow extent information. This provides additional justification for the approach developed in this study. A brief mention of this could be added to this paragraph, including a citation to: Brown, R., C. Derksen, and L. Wang. 2010. A multi-dataset analysis of variability and change in Arctic spring snow cover extent, 1967-2008. *Journal of Geophysical Research*. 115: D16111, doi:10.1029/2010JD013975.

Section 3.1: I was disappointed that the analysis period was limited to January and February. This is a real limitation because the spring period is the most important with respect to the snow-albedo feedback and the contribution of snow melt to streamflow. Additionally, the snow melt period may pose significant challenges to the use of passive

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microwave data because of a loss of sensitivity to snow when it is wet. This limitation to the study is acknowledged in Section 5.1, but I suggest the conclusions and discussion clearly emphasize that these results are applicable to dry snow conditions, and that performance is likely to be weaker during snow melt.

Section 3.2: the short-term cloud filter for single days of cloud cover is clearly described (page 8 line 21) but it's not clear how longer cloudy periods are dealt with. If cloud is present for two or more consecutive days, is that pixel masked as cloud as described on page 9 line 3? Please state this clearly.

Section 4.1.1: there is virtually no difference in performance between scenarios 1, 4, and 5, as summarized in Table 4, with the main difference in performance between scenarios due to the inclusion of ancillary fields (lat/lon; topography). While I agree that "location information and topographic factors play a crucial role in snowpack distribution" can a more physically-based explanation be provided for these results?

Section 4.3/Figures 6 and 7: the scatterplots seem to illustrate that the retrieval is capable of identifying low snow fraction and high snow fraction, but with less skill across the intermediate values. This may be in large part due to issues with the reference snow fraction from MODIS, which seems to be clustered around low and high snow fraction values as shown in Figure 7 (with the exception of forested areas as shown in Figure 7a). Please consider adding some text to the first paragraph of Section 4.3, or strengthening the text on page 20 lines 10-20 to make clear how the performance of the retrieval can be influenced by the behaviour of the reference dataset.

Figure 8: the paper would be strengthened with more emphasis on the presentation of spatial results. Figure 8 is really important, but I found it unclear, especially panel D (the sub-panels within panel D are hard to read). Why is there so much white space in panel B? Zero snow fraction needs to have a separate colour than the range of 0 to 0.3, in order to clearly show where the retrieval estimates no snow versus very low fractions of snow (e.g. 0.1 to 0.3). I suggest a clear set of maps be presented, with emphasis

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on a comparison between MODIS and passive microwave estimates at the continental scale (as in panels B and C) for some key events which extended the snowline.

Page 18 lines 3-6/Page 19 lines 27-28/Page 22 lines 1-3: the explanation for the potential over-identification of snow in the microwave retrievals (compared to the Grody product) is not convincing. The misclassification of snow extent due to non-snow scatterers (like cold deserts/frozen ground) is not a prevalent issue in North America. To better understand the statement that “the non-snow scatterer is the major source of snow cover misclassification for random forest FSC results” it would be clearer to show a map of locations where the RF classifier identifies snow and the Grody algorithm does not. This aspect needs to be explored in more detail in the final manuscript.

Editorial comments: Abstract line 23: change ‘0.31 million’ to ‘310 000’ Abstract line 26: I suggest not referring to the passive microwave dataset used for comparison as ‘Grody’s snow mapping algorithm’ in the abstract. Page 2 line 2: change ‘cycles’ to ‘cycle’ Page 2 line 5: ‘vast number of water resources’ awkward wording Page 3 lines 20-25: when possible, try to use product names instead of the author names. For example, the Kelly (2009) reference refers to the NASA standard AMSR-E snow water equivalent product. The citations should be retained, just the product names changed. Page 3 line 28 and page 20 line 17: change ‘patch’ to ‘patchy’ Page 4 line 7: change ‘predict’ to ‘retrieve’ Page 5 line 7: change ‘America’ to ‘United States’ Page 8 line 4: not clear what is meant by ‘fill’ Page 18 lines 10-14: this text is unclear and seems very anecdotal. I think it can be removed. Figure 1: Add units to the legend. Why is there negative elevation? Figure 4: caption is not clear Figure 9: add x-axis label to indicate snow depth Figure 10: add axis labels

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