The Cryosphere Discussions

The Cryosphere Discuss., referee comment RC2
https://doi.org/10.5194/tc-2021-15-RC2, 2021

Comment on tc-2021-15

Anonymous Referee #2

Referee comment on "Impact of dynamic snow density on GlobSnow snow water equivalent retrieval accuracy" by Pinja Venäläinen et al., The Cryosphere Discuss., https://doi.org/10.5194/tc-2021-15-RC2, 2021

SUMMARY OF THE PAPER

This study concerns the treatment of snow density in the GlobSnow SWE product (post-processing only). It develops and tests new dynamic snow density estimates based on data collected at snow courses and telemetered snow sites in the Northern Hemisphere. These estimates are compared to the existing approach, which assumes constant snow density in space and time. The new dynamic approach is first developed at a subset of measurement location. Snow density is averaged each day of winter over different periods (multi-decadal, decadal, and annual), then interpolated in time and spatially mapped using ordinary kriging interpolation. All three approaches show improved mapping of snow density against observations relative to the constant density assumption, however lower density values (300 kg/m3) are underestimated. The snow density estimates based on annual values are slightly improved over the multi-decadal and decadal versions. Post-processing of the GlobSnow SWE data is then conducted for each of the three dynamic density datasets, with SWE errors lowest for the multi-decadal and decadal values of snow density, and improved over the case of constant density. The decadal version was then applied to the northern Hemisphere GlobSnow and SWE was post-processed. This yielded slightly better agreement in SWE compared to ground truth data. SWE errors were consistently reduced at all reference SWE values in Eurasia but only at SWE greater than 100 mm in North America.

COMMENTS

1. The Sturm density method was briefly mentioned as a candidate approach, but found to not improve retrieval skill notably (Lines 63-64). Was that analysis published? If not, it could be worth including in the current study, as it would be an interesting point of comparison that would be of interest to the community.

2. For the SNOTEL data, did the authors check to ensure that the snow depth sensor measures snow depth on top of the snow pillow? This is not always the case at SNOTEL stations, and when snow depth is recorded at a location next to the snow pillow, an estimate of density from the SWE and depth data may be biased. Unfortunately, documentation on the layout of sites is inconsistent. Careful inspection of site photos can reveal which SNOTEL stations may have collocated SWE and depth measurements.

3. The results in Figures 5 and 6 appear to be contradictory. Figure 5 suggests that that snow density estimation is improved (but only slightly) relative to decadal and multi-decadal across a range of ground truth density values. In contrast, Figure 6 suggests

much larger SWE errors associated with the annually-derived snow density when compared to mulit-decadal and decadal versions. Given the post-processing (equation 5), the differences in SWE must be due solely to differences in snow density errors and not errors in baseline SWE. However, Figure 5 suggests the snow density errors are lower for the annual estimate. How do you rectify these conflicting results? Are you sure these have been analyzed correctly?

4. Overall, the discussion section is brief and does little to connect the current study to previous work (no other studies are actually cited in the discussion). For example, there have been other studies that have compared the constant density assumption versus dynamic snow density for passive microwave SWE retrievals and found improvements with dynamic snow density (e.g., Tedesco and Narvekar, 2010), and other studies have called for improved density representation for passive microwave (Kelly et al., 2003). How do the results of the current study build on established knowledge?

5. Ignoring the potential issues with SNOTEL-based values snow density (see comment #2 above), there are issues with the location of SNOTEL stations (mountains where snow is deeper and possibly denser, and GlobSnow does not produce SWE), and differences in temporal sampling. To the latter concern, it would be possible to check whether the temporal sampling of snow density influences the density curve development and validation, compared to the case of less frequent snow course measurements (e.g., Canada and Eurasia). The differences in GlobSnow SWE for constant versus dynamic snow density were smaller in North America (where SNOTEL are located) versus Eurasia (snow courses only), as seen in Figure 7. To what degree do the differences in daily snow density (SNOTEL) versus 10-15 day snow density (elsewhere) influence the result? This could be checked by sampling the SNOTEL density to a similar interval as snow courses and recomputing the statistics.

6. The results seem rather marginal and potentially overstated. An example is Lines 292-293, which state "…the accuracy is considerably better with RMSE for the baseline being 31.87 mm and for the post-processed dataset, the error is 30.87 mm." I question the significance of a 1 mm reduction in SWE error and whether this is "considerably better".

GENERAL COMMENTS
- Please consider the number of significant digits for the error statistics reported in the text, figures, and tables. What is the measurement precision of the snow density observations? Are we really confident in density to the tenth or hundredth of a kg/m3? Are we really confident in SWE to the hundredth mm?

- A histogram of snow density values (development and validation data) would be useful context, especially for interpreting Figure 5. - Figures 8-10 are all referenced in the text before Figure 7 (see Lines 289-304). Consider reorganizing the text or renumbering/reordering the figures.

- The Discussion section and the Conclusion section are mislabeled and should be Sections 4 and 5, respectively.

- There is some discussion-like comments mixed into the results section (e.g., Lines 293-294, 302-304). Please consider reorganizing.

TECHNICAL CORRECTIONS
- Line 34: Should be "data are also available" since "data" are plural.
- Line 40: Should be "in deep snow".
- Line 44: Should be "observations".
- Line 59: The Maurice and Harold (1981) citation is not included in the References

section. Please add.
- Line 62: Please rearrange parentheses such that it reads “Sturm et al. (2010)”.
- Line 91: Is a subsection required here? There is a 2.1.1.1 but no 2.1.1.2, so this subsection title may not be warranted.
- Line 101: Should be “were used”.
- Line 120: This should be “Figure 2”.
- Line 130: Add “The” before “North American”.
- Line 132: Should be “observations”.
- Lines 132-133: Can you state why only SNOTEL stations in Alaska and the northwestern USA were selected, and not SNOTEL stations farther south in the USA?
- Line 147: Please rearrange the parentheses here such that they are for the year only (two cases).
- Line 186: Add “the” before “variogram”.
- Line 208: Add “the” before “baseline”.
- Line 224 and Table 1: The period of validation reported here does not correspond to what is described earlier in Lines 100-105. The annual data do not appear to span 2000-2009, and the decadal was previously described as 1999-2009.
- Line 229: Should be “decadal” rather than “decal”.
- Line 243-244: Add “separately” after “performed” to indicate that the validation was done for two different cases of SWE values.
- Line 254: Should be “decadal” rather than “decal”.
- Line 282: Is this supposed to be “SWE values up to 500 mm and 150 mm” rather than “density values”?
- Line 291: Replace “improves” with “reduces”.
- Line 329: Should be “SWE retrievals” at the end of this line.
- Line 330: Replace “effects” with “errors”.

TABLE AND FIGURE COMMENTS
- Figures 5, 8, 9, 10: The vertical axis should read “Estimated” rather than “Estimates”.
- Figure 5 caption: Should be “decadal” rather than “decal”.
- Figure 7 would be more effective if a third panel was included that showed the different in SWE estimates from GSv3.0 vs. post-processed. In the current form, I can only tell subtle differences between the two maps.
- Figure 7: Note the title above each panel is overlapping text below (90 deg W). Please correct.

REFERENCES
Kelly, R. E., Chang, A. T., Tsang, L. and Foster, J. L.: A prototype AMSR-E global snow area and snow depth algorithm, IEEE Trans. Geosci. Remote Sens., 41(2), 230–242, doi:10.1109/TGRS.2003.809118, 2003.
Tedesco, M. and Narvekar, P. S.: Assessment of the NASA AMSR-E SWE Product, IEEE J. Sel. Top. Appl. Earth Obs. Remote Sens., 3(1), 141–159, doi:10.1109/JSTARS.2010.2040462, 2010.