

The Cryosphere Discuss., referee comment RC3  
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## Comment on tc-2021-38

Timo Vihma (Referee)

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Referee comment on "Deriving Arctic 2-m air temperatures over snow and ice from satellite surface temperature measurements" by Pia Nielsen-Englyst et al., The Cryosphere Discuss., <https://doi.org/10.5194/tc-2021-38-RC3>, 2021

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The manuscript addresses estimation of 2-m air temperature (T2m) over the Greenland Ice sheet and the Arctic Ocean sea ice. The work is based on satellite remote sensing data on clear-sky ice/snow surface temperatures and their comparison with in-situ observations on T2m. I am impressed by the amount of data analysed, originating from different sources, and by the carefulness and detail of the analyses made. Among others, a lot of attention is paid on uncertainty analyses. The manuscript is well organized, the text is well written, and the illustrations are of high quality. The results are important, convincingly demonstrating that T2m estimates based on satellite remote sensing data are useful and reasonably accurate. Hence, they can supplement reanalysis products and rare in-situ observations on T2m. I suggest accepting the manuscript subject to minor revisions.

### Specific comments

I wish to see more attention to the seasonal distribution and accuracy of the satellite-based T2m estimates. The quantitative results are given for the entire data set (e.g. page 22, lines 26-28), but it is well known that over the Arctic sea ice clouds are more common in summer than other seasons. Figure 8 demonstrates that there are less data from summers, but Figure 7 suggests that the estimates are better in summer than in winter, which must be related to smaller thermal differences between the ice and air in summer. Detailed comparison of skill scores (bias and rmse) between different seasons is, however, missing, and it remains unclear how useful the satellite-based T2m product is over sea ice in summer. This could be easily improved by presenting quantitative results for different seasons.

It would be good to make it clear already in the Abstract that the study addresses the Arctic Ocean and Greenland Ice Sheet, but not other land ice in the Arctic. Related to this, in Table 1 land snow must refer to seasonal snow. However, in the Discussion, Conclusions, and Abstract, there is nothing mentioned about results for seasonal snow.

Were the results similar to those for land ice?

Page 1, last sentence: Could the information be updated (2010s vs. 2000s) and extended to also address the strong winter warming over the Arctic sea ice? The latter is evident on the basis of reanalyses.

Page 2, lines 7-8: "In particular" is questionable. It is even more difficult to achieve climate-quality precipitation and air humidity records from the region.

Page 3, lines 4-5: Make it clear that the zones refer to the Greenland ice sheet.

Table 1: Use of Polarstern data as a proxy for 2-m air temperature sounds surprising. According to my knowledge, in the Polarstern weather station the air temperature sensors are located 29 m above the sea surface. In Figure 11, however, the rms-errors are small for Polarstern. Could it be because the data are mostly from summer, when the vertical temperature gradients in the boundary layer are mostly small?

Page 20, line 21: The temporal variability of air temperature is largest in winter because the meridional temperature gradient is largest, the atmospheric circulation is vigorous, and the cloud radiative effect is large (compared to near-zero in summer).

Page 22, lines 1-10: As new results are presented here, consider moving this paragraph to the Results section.

End of page 22 – beginning of page 23: I am surprised that the use of wind speed did not improve the results over sea ice (over Greenland Ice Sheet, the reanalysis errors for near-surface winds may be so large that it is not so surprising there). Also, it looks strange that the correlation coefficients and RMS-errors are exactly the same for the four regressions presented for sea ice in Table 3. I suggest double-checking the calculations.

Page 23, line 30: In summer, the air temperature over sea ice is not so good an indicator for Arctic climate change. Ice and snow are rapidly declining, but T2m remains the same, close to 0 deg C, as long as there is sea ice left. See e.g. Figure 2g in Vihma et al. (2008) (just for information, no reason to cite).

Page 24, last paragraph: The independence of the satellite-based T2m product and reanalyses is stressed here but, as mentioned earlier, reanalyses actively assimilate available in-situ observations. In particular, the ECMWF has had a pioneering role in

assimilation of T2m data, which was done also in the Arctic already in the old ERA-40 reanalysis. However, I fully agree that the satellite-based T2m product is very valuable, and may indeed yield even better results than assimilation of (rare) observations into a reanalysis system. T2m is a diagnostic product in reanalyses, calculated on the basis of surface temperature and air temperature at the lowest model level, and liable to uncertainties in the parameterization of turbulence in the stably stratified atmospheric boundary layer. Note, however, that the NCEP-CFSR reanalysis, which is based on a coupled atmosphere – sea ice – ocean model, has performed better for near-surface atmospheric variables over sea ice.

Figure 6: In the legend, replace “air surface temperature” by “near-surface air temperature” or “2-m air temperature”.