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The Cryosphere Discussions

Interactive comment on "Development and analysis of a continuous record of global near-surface soil freeze/thaw patterns from AMSR-E and AMSR2 data" *by* Tongxi Hu et al.

Anonymous Referee #1

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The paper presents a very interesting application of joint AMSR-E and AMSR2 remote sensing data to freeze/thaw (F/T) patterns in the context of permafrost evolution. Whereas the general usefulness of the approach becomes apparent, which should be further studied and explored, the present state of the manuscript contains many methodological flaws (or at least inaccuracies) which from my perspective prohibit that the paper can be published without very serious modifications and improvements. These I will list in the following.

(1) First of all the paper suffers from many inaccuracies of the english language, the format (missing blanks between words, readability of the figures, especially the axes and colour scales) and the references.

(2) The F/T signal from the remote sensing data is compared with air temperature to assess the accuracy. This very probably introduces a strong bias, as not only soil specific factors are neglected, but also, and more importantly, the isolating effect of the snow cover is neglected! As the snow cover is very variable spatially and temporally, its impact on soil freezing will also be non-trivial and cannot be neglected. For the global application (which does not make much sense in my opinion anyway, see below) air temperature data might be justified, as soil temperature is difficult to obtain, but for permafrost areas such as the Qinghai-Tibetan Plateau, this information is available.

(3) because of (2), the "accuracy" mentioned is rather a statistical correlation between different variables, as not the same variable is compared.

(4) the statistical results are given with too many decimals considering the large uncertainties inherent to the approach. Furthermore, many of the statistical analyses are scientifically meaningless without explaining what they are used for (e.g. what does a globally averaged number of frost days could mean on this level of accuracy and temporal and spatial scale ?).

(5) page 1, line 29-30: Significant changes in frost days are obtained mainly for regions of discontinuous and transient permafrost: this can potentially be influenced by a strong bias through a variable and changing snow cover, as the latter tend to be changing strongly in these climatic zones.

(6) An analysis of the influence of a spatially/temporally changing snow cover on the F/T cycles is completely missing - yet, it has a very significant influence on seasonal and permanently frozen ground, as has been demonstrated by numerous papers - including papers about the Qinghai-Tibetan Plateau.

(7) it is often mentioned that the remote sensing data are compared with "in-situ" measurements without explicitly detailing which measurements are meant: always in-situ air temperature measurements ?

(8) Equations (1)-(3) give the discrimination values between frozen and thawed ground. But even though the authors mention several times that physically a large transition range exist between the two states, where temperature stays at or near the freezing point, but liquid water and ice content may vary as they can co-exist, no transition range in the discrimination value is given. Else, one could incorporate this transition range into an uncertainty estimation to better assess the overall accuracy of the approach. A binary cut-off at 0°C will certainly introduce many uncertainties near the freezing point.

(9) My main criticism of the global application of the approach concerns the accuracy calculation using equation (4): here it is not differentiated at all between stations that show frequently or at least some freezing days and stations that have no significant freezing at all. If the number of TT is much larger than FF (or if FF = 0), the accuracy is 100% or close to it by definition and does not explain anything at all regarding the accuracy of your approach. Without excluding the TT cases in regions where no freezing occurs, a global analysis of F/T accuracy will look much better than it really is.

(10) page 6, line 7: "...to exclude some outliers..." - to unspecific: how many outliers were excluded by this ? are there systematic patterns in the outliers etc

(11) What is the uncertainty/accuracy of Eqs (5)-(8) or in other words, how large are the residuals ?

(12) page 6, line 29-32 and page 7 first paragraph: see comment above: the accuracy values are meaningless in my opinion if all data are evaluated, as too many parts of the data set exhibit no freezing. Compare Figures 3 and 4 with Figure 8 and you will see that large parts of your global data sets have no frost days. These should be excluded from the accuracy analysis as they will incorrectly bias your accuracy values towards high values.

(13) page 7, line 10: that's absolutely true, it will very often be the case! That's why I am surprised that you validate the F/T signal with air temperature and not with soil temperature.

(14) page 8, line 9-10: you assume that the descending time is approx. the time of minimum temperature. Even if that would be true, it does not tell you whether it stayed below 0°C during the full 24h. Your satellite frost days (Equation 9) are therefore something totally different than the frost days defined above.

(15) page 8, line 16: I do not see where these numbers are "coinciding" ?

(16) sections 3.4, 3.5 and 3.6.1: parts of these sections are more a general discussion than a result. Many statements in these section are quite trivial (e.g. that frost probability depends on latitude and season) - here, and regarding the many figures, there is large potential for shortening. Without providing a real science question or an application, the statistics provided are a bit meaningless.

(17) Why do you not use soil temperature data or active layer data from the many studies that were published about permafrost evolution/distribution on the Qinghai-Tibetan Plateau ? These data are available, and I see no reason why you don't use them and show them to compare your data (Figs 11-17). Similarly, why do you not use the snow information which is available for this specific region ?

(18) page 9, line 34-35: "This may be associated with climatic anomalies in these summers": didn't you check the climatic data of these summers ? That can easily be verified and the corresponding sources be found.

(19) section 3.6.3, page 10, line 14-15: "57.16% and 12.03% of the area begins to freeze in July and August...": I doubt whether the 57% in July is correct, it much more probably is due to STILL FROZEN ground conditions in July. Depending on snow conditions and altitude, the active layer in permafrost starts to thaw in late spring/early summer, so it probably is still frozen in the beginning of July at higher altitudes.

(20) page 10, line 34: the term "near-surface" is used throughout the text, but it is not always clear (e.g. here) whether you mean atmospheric near surface or soil near-surface ? That has to be clarified.

(21) page 11, line 12-13: "validated using in situ 4-cm soil temperature" –> that's the first time this important fact is mentioned !! to which figures does that apply ? How many stations are used ? Where are they located ? These details are important to assess the real accuracy of your approach!

(22) The conclusion is a mixture of repeating out-of-context statistical values and statements which refer to aspects which have not been discussed in the manuscript, e.g. the ice content and related sensitivity of permafrost to climate change. Discussion and Conclusion have to be better separated.

(23) Figure 3 and Figure 4: these figures are misleading, as there are no or little frost days in many regions on this map. Trivially, the accuracy is 100% or close to 100% there. Both maps are rather maps of frost days than real accuracy maps.

(24) Figure 5: what are the error bars ? Explain in the caption.

(25) Figure 6: which line is which year (green / black). Explain in the caption.

(26) Figure 8: here, the large area without frost days become apparent. The analysis should be restricted to the areas with frost days, i.e. basically the mid- and high-latitude northern hemisphere.

(27) Figure 10: What is the word "water" above the colour scale referring to ? The location of the Qinghai-Tibetan Plateau should be indicated somewhere.

(28) Figures 11, 12, 16 and 17: the colour scales cannot be read!

(29) Figure 14 and 15: the format of the x-axis has errors.

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