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The Cryosphere Discussions

Interactive comment on "Rapid glacial retreat on the Kamchatka Peninsula during the early 21st Century" *by* Colleen M. Lynch et al.

Anonymous Referee #1

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This paper presents data on areal changes of comprehensive dataset of glaciers on the Kamchatka Peninsula, obtained using satellite imagery from 2000 and 2014. It reveals a widespread reduction in glacier area, which is compared to older inventory data and to a more recent inventory. The paper then explores possible correlations between glacier shrinkage and climate reanalysis data, in addition to glacier characteristics (e.g. size, elevation, aspect, etc.). The paper is concise (perhaps too concise), well-written and well-organised, with some helpful Figures and Tables (albeit that could be improved and supplemented). It presents an impressive dataset and, given that this region is comparatively poorly studied, I'm generally very supportive of publication in The Cryosphere. However, I would suggest that there are a number of issues that would need to be resolved and clarified prior to publication, which I detail below.

The most important and serious of these issues is that the authors need to be much

clearer about what they have actually mapped and how this compares to other approaches and previous inventories. The authors appear to have mapped "exposed ice", but then make very little comment on how much debris might be obscuring glaciers in this region. In addition to some additional clarification and discussion, it is important that the authors provide some detailed comparisons of their mapping with other approaches. As it stands, the methods and results are somewhat lacking in transparency.

ABSTRACT

P1, line 9: consider deleting "With this in mind"

P1, line 10-12: this line notes that "glacier margins" were digitised and then quotes data on "total exposed-ice area". This raises a number of questions that need clarifying. Are the digitised glacier margins (presumably the entire glacier) the same as the total exposed ice area? If so, it implies that there is no debris cover on these glaciers? Is this correct? The authors should be very clear what they have actually mapped, both here and in the Methods. This issue permeates much of the manuscript.

INTRODUCTION

P1, line 23: The term "non-climatic forcing" is somewhat confusing. Glacier mass balance can only be 'forced' by climate. Non-climatic factors might then modulate the response of the glacier to a forcing, but it's unclear what the authors mean by non-climatic "forcing". Please re-word or clarify.

P1, line 25: "area of exposed ice" is mentioned here again, but it is unclear whether this is the entire glacier area (i.e. including debris-cover) or not? Further detail is required.

STUDY AREA:

In section 2.1, all of these place names mentioned should be labelled on Figure 1, which is lacking key information (see comments below under Figure 1).

P2, line 8: consider deleting "Sandwiched"

Section 2.3 should include a brief review of previous work on glacier change in the region. As it stands, it implies that virtually nothing has been done in this region, but several papers are cited and discussed later in the manuscript that should first be discussed here. This is important because it will help the reader see how the present studies builds on previous work. It will also give clear credit to previous work.

METHODS

In section 3.1 (data sources), there is no mention of any earlier imagery, e.g. from the 1980s, or 1990s. I suspect most readers will wonder why no attempt was made to collect data from earlier dates to increase the temporal resolution of the data. Thus, it would be very helpful to state why only 2 time-steps were chosen and why these specific time-steps were chosen. i.e. 2000 and 2014.

Section 3.1 should also provide some comment on the vertical and horizontal resolution of the SRTM data and its accuracy in this region.

P3, line 31: the authors note that semi-automated methods "often underestimated the exposed ice extent". How do they know that? Compared to what objective measure? Are there any detailed maps of individual glaciers that could be used as a more objective measure? Further detail is required.

P4, line 14: change "an actual glacier" to "a glacier"

P4, line 20: I think it is "DeBeer" not "Debeer"

P4, line 28: "exposed ice". See above. It is still not clear whether this means the total glacier area or not. Moreover, lines 31-32 make it clear that some glaciers do have debris-cover. Throughout the manuscript, this needs clarifying, i.e. what have they actually mapped?

P5, line 1, I'm surprised that it is possible to use satellite imagery to define debris cover to the nearest cm. Is this correct? With what (un)certainty?

P5, line 9: what elevation does the reanalysis data relate to? Isn't it the case that you can obtain data from different heights above the surface?

RESULTS P5, line 26: It's noteworthy that so many glaciers have disappeared in just 14 years. It would be really nice to show an example of this disappearance in a Figure. Because the authors fail to show some detailed mapping, the methods and results are somewhat lacking in transparency. Indeed, the authors might also want to consider making their dataset more widely available (this is a requirement in some journals).

Section 4.2 – I wonder if it might be better to show how the distribution of glacier areas have changed through time, i.e. show a histogram of binned areas in 2000 to 2014?

P6, line 23: "does not", rather than "doesn't"

DISCUSSION

P7 – many of the papers cited here relating to previous work should be properly introduced in the section on the Study Area (see comments above)

P7, lines 6-10: I find it surprising that two inventories can be so different. This is somewhat brushed under the carpet as a function of the semi-automated techniques misclassifying snow patches as glacier ice. This may be the case, and it would be really nice to show a Figure that illustrates this potential misclassification (or at least shows us some close-ups of how the two outlines compare for different glaciers), but is debris cover also an issue? This manuscript only presents data on "exposed ice", I think. Is this a part of the explanation? Some further discussion and illustration would really help the reader.

P7, lines 19: the recent increase in precipitation is, indeed, notable. I was surprised that there was no discussion of the form of the precipitation, i.e. increases s in ppt in spring, summer and autumn are likely to be dominated by rain (?), which may not impacting on glacier mass balance to the same degree as winter snow. The discussion here seems to be rather brief too simplistic and could do with some more detailed

explanation.

P8, line 8 – this sentence needs re-writing

P8, line 11 – this sentence also needs re-writing. Suggest you split the sentence at "however, "

P8, line 24 – again, debris cover is mentioned, leading to some confusion as to what the authors have actually mapped in this study

P8, line 28: is there any indication as to when this volcanic activity might have taken place?

P8, line 30: again, this mention of surge-type glaciers should have been included in the Study Area chapter. At this point in the manuscript, some further detail on evidence for/against surge-type glaciers would be helpful. Even if you do not have the data that captures a surge, there might be other evidence on the imagery (see Copland et al., 2003: Annals of Glaciology)

CONCLUSIONS:

P9, line 10: It's not possible to detect a "notable acceleration" from the two time-steps. I think the preceding sentence needs to make it clear over what time-steps the rates of change in brackets apply to.

P9, line 30: this is an interesting point made earlier in the manuscript, but there needs to be some appreciation of the altitude of these small glaciers. If most of them are at high elevations, they may not necessarily disappear. Perhaps explain how many of the small glaciers are at lower elevations and are most vulnerable.

FIGURES AND TABLES:

Table 1: it would be very useful if this Table also included the scene IDs for each image.

Table 2: as noted above, this table could easily be supplemented with some histograms

of glacier area distribution at each time-step.

Figure 1: this figure is lacking some important information. Please add key place names that are mentioned in the text and locate Kamchatka on the inset map. I'm also puzzled why the authors do not used a coloured hill-shaded rendition of the DEM.

Figure 2: at this scale, it is almost impossible to see why the different methods are in disagreement. It would be much better to show a close up, maybe as a panel 'b' to this Figure? This will allow the authors to more clearly illustrate what they are mapping and why other methods misclassify the glaciers

Figure 3a: the data on glacier change are far too small on this Figure. I suggest it fills a whole page and maybe even includes some nice close-ups from areas of interest

Figure 3b: this histogram is useful, but the extreme growth of one glacier is interesting. Did this really occur? Can it be illustrated on a Figure and can it be explained? It seems odd to ignore any explanation.

Figure 4: for context, can the outline or location of this figure be shown on one of the earlier Figures, e.g. Fig. 3a or 1?

Figure 5 – the caption on panel (a) says "annual change" – what does this mean? Is this the annual data? Assembled from what? Daily means, monthly means?

Figure 6b and d – what does glacier relief mean? Elevation? Elevation of what (min, mean, max)?

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