

Response to the review by Duncan Quincey

This is an unusual submission that contributes more to the literature than is necessarily apparent at first glance. First, it highlights that small and debris-free glaciers also surge - most recent studies on surging in the Karakoram focus on large and often debris-covered glaciers because they are easily identified in medium to coarse resolution satellite imagery. Second, it gives some useful information on surge return periods, which is generally lacking for this region (although historical reports and papers are relatively untapped I suspect). Third, it emphasises that surging glaciers are difficult to integrate into studies of climate-glacier coupling, and recommends they are excluded from such analyses. Therefore, despite this paper not conforming to a 'normal' research article, I would be pleased to see it published, and only have a handful of relatively minor comments that I hope will improve it.

Thank you for this positive evaluation.

P2598

Line 10: 'might help to demonstrate'... I think you can be more certain and remove the word 'might'.

Agreed.

P2599

Line 9: 'what is going on' is probably better phrased as 'morphological changes' or similar

Yes, agreed. Will be replaced with 'in demonstrating dynamic aspects.'

Line 26 delete 'these days'?

Yes, of course.

P2600

Line 6 (and elsewhere in this paper): probably 'surface lowering' is more technically correct than 'down-wasting'

Yes, surface lowering could also be used. But I think down-wasting is more than surface lowering, it also implies that the extent of the ice is more or less unchanged, i.e. surface lowering without retreat. This can actually be very clearly followed for the post-surge phase of several glaciers. The ice mass that is down-wasting is more or less decoupled dead ice showing otherwise a stable extent.

P2601

Line 1: remove the word 'basically' and replace with 'and'?

Agreed, good idea.

Line 4 (and elsewhere in this paper): if possible it would be better to remove references to yourself e.g. 'to my knowledge'

Yes, agreed and removed.

Lines 11-12: I think you can remove this last sentence. Why would you publish a discussion with only initial perspectives?

I think this has been written here because more detailed studies are required for a more substantial discussion. But I agree that the sentence could also be removed.

Lines 14-15: should 'and including' have commas before and after?

That might be well the case. I am happy to add them

P2603

Lines 9-11: can you label and refer to these four glaciers in the appropriate figure?

Yes, of course.

P2604

Lines 11-13: do surge velocities really overlap with those of non-surge glaciers? Not in my experience...

This will likely depend on the criteria used to identify a glacier as surge-type. Some of the glaciers in the region advance very slowly but over several decades (e.g. North Chongtar started its advance in 1970) while others advance rapidly (2-3 years) and have high surface flow velocities (e.g. South Chongtar, Chiring or Drenmang).

Lines 22-25: I'm not sure you need to include this analogy - suggest removal

Although I like the analogy as it might also include a physical explanation for this kind of surges, I will remove it as also the anonymous reviewer suggested to remove it.

Line 26 onward: I'm not sure I follow this sentence. Are you saying that one glacier has a 30 yr quiescence and 2 yr surge whereas another has a 15 yr surge and a few yrs quiescence? Perhaps you can word this better?

Yes, this was the point. I will rewrite it to get it clear.

On another matter, is the 15 yr advance really a surge? Or is it simply an advance? I'd suggest the latter given those timescales...

I would say yes, it is a surge, but as already mentioned above it depends to some extent on the criteria used to define a surge. The frontal advance rate or advance duration is certainly not good indicators. There is simply too much variability here. But when a heavily crevassed surface, distorted moraines, or an advance in the km range are used as a criterion, the assignment might be more evident. The study by Hewitt (2007) and the spatial pattern of mass changes revealed from DEM differencing by Gardelle et al. (2013) also clearly assign it to a surge-type glacier being in its active phase since 2000. Maybe also check the nice time series in Google Earth (one example is shown in Fig. 6).

P2605

Lines 1-9: Here you are touching on the fact that glacier surges cannot be neatly pigeon-holed. I think you should state this, and leave it at that, rather than suggesting a new 'Karakoram surge type' - fundamentally, many surges in the region do not conform to your description (so the term would be misleading), but also there are more 'types' than we could ever find categories for.

I fully agree and will describe the different types of surging glaciers in another study.

P2606

Line 2: 'supra-glacial' does not need hyphenating

Ok, thanks.

Section 3.6: I'm not sure this section adds anything and think it should be removed

I think this is actually a rather important observation for all kinds of calculations. For example, the accuracy assessment of velocity fields should give no flow on stable terrain (i.e. off-glaciers). By using the here presented animations one can see both

the consistency of the orthorectification for the entire time series and the regions that are not stable-terrain despite being off-glaciers.

P2608

Lines 2 and 12 and elsewhere: do you show us surface elevation data anywhere? I think you have to be careful assuming that because the glaciers are small, they are steep. Probably you are right, but your data do not show it.

Surface elevation data are indeed not shown here. Can I assume that everybody is familiar with checking topography in Google Earth? I will then add this as a source of information for the stated steepness.

P2609

Line 25: Why 'finally'? Is this a hangover from a previous draft?

No, the finally has no special meaning and will be removed.

Section 4.4: I'm also not sure this section is really required. It is background (methodological?) information

I agree that this section can be shortened somewhat and will do it. However, I would like to keep it, as I encourage application of this method in other regions and image availability, quality, and consistency of the orthorectification might be different elsewhere. In particular the good correction of the 3 ETM+ SLC-off scenes are worth mentioning, as they were essential for the animations.

P2611

Line 26: probably worth clarifying they are out of phase 'with one another'

Yes, agreed.

Figure 1: The regional map is poor - can you digitise something rather than use this map product? And zoom in more to focus on the HKH belt?

Yes, the in-set map will be exchanged and will get a close up.

The underlying image needs a scale-bar, and could be presented in colour?

Agreed, a scale bar will be added and a colour version provided.

Figure 6: needs a scale bar. And can you cross-reference this image to Figure 2?

It actually has one (in the lower left corner), but I agree it is rather small and I will increase it. The glacier will be marked in Figs. 1 and 3.

Also, why do you choose 2004 imagery for these figures?

There was no particular reason for it apart from being cloud-free and demonstrating the good correction (with some remaining artifacts) of the ETM+ SLC-off scenes that were essential for these animations (see also reply to the comment to Section 4.4.

Can you not use some of the (radiometrically improved) OLI imagery that has no striping?

Radiometrically the image quicklooks used in this study are all very similar and I think showing the striping is important as a guide to what is visible in the animations.

Supplementary

I strongly suggest you insert a time-gap at the end of every loop, as it takes a good few seconds or longer to work out where the first and last images are in each sequence. And perhaps

slow them down? Or provide two speeds - one slower one for orientation (training of the eye) and the second at full speed? Given you put these forward for educational purposes, you need to make sure that the inexperienced viewer can follow what is happening for themselves.

The basic idea for providing only this high-speed version was that several aspects of glacier dynamics can only be seen here and that all images used are freely available at earthexplorer.usgs.gov. There is also a 50 MB limit of supplemental material and I have already used it. Inserting a time gap at the end (with empty frames) would result in a strobe effect causing eye-damage and a headache after a few seconds. There might be other possibilities (e.g. repeating the last image several times), but they would increase the file size. There is certainly the possibility to also use different (slower) animation speeds or frame rates, but this is also a matter of personal taste. As a compromise, I have decided to additionally provide the individual images on a separate server so that anybody being interested can compile its own animation time series from it.

A scale-bar wouldn't go amiss on the images either...

The disadvantage is that every annotation stands out like a 'flying above the scene' emblem and is thus distracting. It will also be difficult to follow the changes in a particular region and see the scale bar at the same time. For this reason all sub-sets are also shown in the paper with a scale bar. But I will try it and think about it.