

The manuscript by Tsutaki et al. combines surface elevation changes, surface flow velocities, changes in glacial area, and surface mass balance and ice dynamic modelling to investigate the difference in thinning rates of two neighbouring glaciers in the Bhutan Himalaya. One of these glaciers is lake-terminating, the other is defined as land-terminating; the aim of the study is to examine the influence of a proglacial lake on the thinning rates of the glaciers. The study is interesting and the figures are clear and well presented. The manuscript is mostly well-written, but various sections need to be better discussed, explained and justified so that it is clear how the authors have achieved their results. Although the results and conclusions appear to be well supported, there are large uncertainties in the modelling that make it hard to determine how well supported these conclusions are. It would be very interesting for the modelling predictions to be compared with what has occurred to Thorthormi Glacier since 2011, as suggested by a previous reviewer, although it is acknowledged that this would involve a lot more work.

General comments:

1. I find it quite difficult to follow the state of a proglacial lake (or not) at the terminus of Thorthormi Glacier, as contradicting information is drip-fed through the manuscript. Is there a proglacial lake, and when does it form? The timeline (to date) needs to be presented coherently in Section 2 and other mentions in the manuscript then need to correspond. This could also be helped by delineating the lakes in one of the panels in Figure 1. Although the authors made a case against this in their response as the lake area varies over time, even a visualisation of the minimum/maximum lake area for each glacier would be beneficial. A brief investigation of historical Google Earth imagery showed me that Thorthormi Glacier has a proglacial lake that has expanded up both sides of the glacier tongue, along the lateral moraines. I had not grasped this from the manuscript, having understood that there were a few limited supraglacial ponds at the margins.
2. The discussion in Section 5.3 of whether Lugge Glacier has reached floatation seems to be too little, too late. If the glacier tongue was near floatation in 2002, is it not possible it reached floatation during the study period? And if so, surely that may have a large impact on the results: how is it known whether changes in surface elevation are due to the glacier thinning, or changes in the lake volume? This is rather a large assumption to make, and needs justifying or debating earlier in the manuscript.
3. I'm not sure I see the value in including the change in glacial area as delineated from Landsat images. It involves quite large uncertainties, and in my opinion, detracts from a study that is assessing how proglacial lakes affect glacial thinning rates.
4. The comparison of the DGPS-DEM with the ASTER-DEM, after the ASTER-DEM has been calibrated with the DGPS data seems circular, and thus contradictory. If the ASTER-DEM has been calibrated with the DGPS data, it would be fairly obvious that the changes in elevation from each would be very similar. The suggestion from a previous reviewer was to compare the DGPS data with a DEM that has been externally verified, but ASTER does not have any ground-truthing, so it is not an ideal product for this. I suggest that the ASTER-DEM (calibrated with the DGPS data) is instead used for subsequent analysis of surface

elevation changes, which would give elevation changes over a larger area and thus mitigate the large uncertainties involved with interpolating the DGPS data.

5. A number of the uncertainties that are reported are extremely large, and in some cases the errors are significantly larger than the values presented. Furthermore, the calculation and reporting of uncertainties is not consistent through the manuscript (e.g. DGPS DEM uncertainty calculations in Section 3.1 which are reported as something different in Section 4.1), some have not/cannot be given a value (such as the interpolation of the DGPS DEM), uncertainties are given as a range of values without explanation (L437), and other uncertainty ranges are discussed but not defined (L344), but yet the data do not lie within any uncertainty (one standard deviation?) of each other. Similarly, in one instance, calculated and observed velocities are reported as being within 7% of each other, yet in the Author Response this is reported as a mean and therefore only half the data will lie within this %. Other specific issues include the use of a quadratic sum (L134 & L239), which is not defined nor what Bolch et al. use, and the undefined extrapolation of the bedrock upglacier in the model inputs (L278), which must also have large uncertainties.

6. Debris cover is mentioned sporadically throughout the manuscript, but without any real weight or meaning. The authors clearly consider it important as it is mentioned in the abstract, a debris melt model is included in the SMB calculations, and debris-covered areas must have been calculated for different SMB values to be presented for debris and debris-free regions in Section 4.4. These values are certainly interesting, but without an idea of the debris thickness in the debris-covered surfaces, are not so useful (L368-371). The manuscript would benefit from a greater discussion of how the debris cover varies (expand the paragraph from L99 and refer to Figure S1), and what influence this might have on the conclusions drawn about ice dynamics.

Specific comments (by line number):

1: Suggest singularising the title and every other occurrence of “lake- and land-terminating glaciers” to “a lake- and a land-terminating glacier”, as you now only consider one of each type.

14: “supraglacial lakes” is not directly relevant, unless you specify that supraglacial lakes can evolve into proglacial lakes, which is what you consider in this study. Perhaps change to “proglacial lakes”.

23: “over half” – later in the manuscript, this value is reported as three quarters?

33: What do you mean by “the Bhutanese glaciers”? All Bhutanese glaciers?

37: Change “monsoon influenced humid” to “monsoon-influenced, humid”

38-40: This sentence would read better if it were condensed.

L43-46: This section would also benefit from a brief description of how proglacial lakes can be formed from supraglacial lake formation, growth, coalescence and downcutting, which is likely what has occurred at Thorthormi Glacier in recent years?

L51: No space between number and % sign, throughout manuscript.

L65-67: Two points are made here about the superiority of remote-sensing techniques: 1. that the surface of debris-covered glaciers can be highly variable due to cliffs and ponds, making access difficult to get large amounts of data; and 2. that UAVs can potentially obtain higher-resolution imagery than satellite-imagery, and thus resolve the highly variable thinning rates more accurately. Suggest restructure to make these points clear.

L68-69: DGPS is not remotely sensed, so this doesn't follow on from the previous sentence unless it is explained why it is superior (higher resolution data/no permits required compared to UAVs/etc).

L69: Change "is" to "can be".

L76-77: This sentence sounds like the only reason the glaciers were selected was because of their similar elevations. Any other reasons – debris cover, size, access? Suggest adding the sentence about safety and proximity to trekking routes, but surely the most important reason is the lake/developing-lake scenarios?

L88: If something thins at a negative rate, it is thickening. Remove negative sign. Same on L95.

L99: Needs more discussion of the ponds and cliffs on each glacier to later prove these don't contribute to thinning rates. Google Earth shows a heavy amount of crevassing on both glaciers, which could be a reason why few lakes are found in the ablation regions.

L103-106: These are methodological details and would fit better in Section 3.4

L118: Move website to reference list, and reference instead. Same for L125.

L122-123: Refer to Figure S1.

L135: Change "In previous studies" to "Following previous studies"

L163: Is the 0.9 threshold picked according to information given by COSI-Corr, or some other method? Please specify. This and the next few lines are not clear: how many filters do you apply or are they all the same? Suggest rewrite to state, step-by-step, what you did and why. Should "attitude" be "altitude"?

L173-174: Remove "in a geographical information system" – manual delineation is sufficient to describe the method. Also change "Following to the previously" to "Following previously".

L185: 'Thick' debris that suppresses ice melt is anything deeper than ~5 cm.

L248: "glaciers" should be singular.

L275: Why use yet another DEM when the first section describes four different DEMs? What year was this DEM from, and why was it necessary to "filter the elevations"?

L299-301: It is not clear how the conditions for creating a proglacial lake at Thorthormi Glacier were decided upon; they currently seem entirely random. How was it decided where to 'put' the proglacial lake for Thorthormi Glacier? It doesn't look to be at the current terminus, so this needs some explanation. Similarly, how was a calving front thickness of 106 m chosen? And why would the surface level of the

proglacial lake be identical to the supraglacial ponds in 2004? I understand that this is hypothetical and likely a good place to start, but surely it depends on the time of year, amount of melt, how well the hydrological system has developed, etc, as to the level of the ponds. Additionally recommend changing “assumed” to “simulated” to make it clear this is a hypothetical modelled situation.

L305: What years do you actually run the model from and to? The input data seems to be from a large number of different years... Also needs clarifying in Section 4.5

L331: Is this from the DGPS or ASTER DEMs? Needs specifying, and also in the caption for Figure 1a.

L335: Looking at Figure 2b, it seems that the most negative values are actually found (just) within the upper elevation bands.

L353: Remove sentence beginning “In this region...” as it is an interpretation, not a result, and belongs in Discussions. Same applies for all other instances, particularly of methodological details that are mentioned in the results, but not actually in the methods section.

L355: Report “0.99 years” in number of days to be consistent with start of paragraph.

L357: Change “and accelerated loss” to “which accelerated”

L374: The debris cover must have a more significant influence than this in order to produce 2 m w.e. less melt per year, as reported in the previous paragraph?

L381: I think the experiment names would be clearer as “Present terminus conditions” and “Reversed terminus conditions” as this is what you are changing (not the geometry).

L386: Change “In contrasted to the observed decrease” to “In contrast to the downglacier decrease”

L387: At what distance from the terminus is the 40 m/y velocity reached?

L402-404: Change “Although we assumed” to “Due to the assumption that” – by assuming the glaciers to be temperate, of course most of the ice flow will be due to basal sliding. But how can most of the ice flow be due to basal sliding, but also a “moderate amount” be due to ice deformation? Suggest rewording these two sentences to be clearer as to what you found, and whether the assumption of temperate ice had a significant influence or not.

L450: The repetition of these exact same measurements looks like a mistake; suggest remove the second and change “for the period” to “for both the periods”.

L501-503: Remove the reference to making hypotheses and just state what has been shown.

L506: Was the thinning accelerated?

L515: Change “less thinning” to “thickening”

L517: In Section 4.2, Lugge Glacier is described as having a convergent flow where the glacier width narrows. How might this contribute to, or affect, the stretching flow regime?

L531: Should the first 2000-2010 be 2000-2011?

L540: What are the implications of this?

Figure 1: The red and white centrelines of each glacier need more explanation, both in the figure caption and in the text. What is the difference between the red and white, and how is it used?

Figure S6: Needs error bars for the DGPS data – if these are already present, they are too faint and cannot be seen so need to be a darker colour than the ASTER error bars.