TC-2022-237 **2nd revision**

**Brief Communication: Rapid ~335 $10^6$ $m^3$ bed erosion after detachment of the Sedongpu Glacier (Tibet)**

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## 2nd revisions in response to referees

### General response

We would like to thank again referee #2 for his careful and constructive comments and suggestions. We implemented almost all suggestions, with the exception of a very minor one regarding the naming of Brahmaputra vs. Yarlung Tsangpo.

Referee comments are in *italic*, and our response in normal font.

An annotated version of our revised manuscript with track changes is attached.

## Response to Referee #2, Max Van Wyk de Vries

*I thank the authors for their rapid response to the two reviews and edits to the manuscript. The changes to the manuscript go a long way towards addressing my previous concerns, particularly by enhancing the discussion around the causes of the extremely rapid erosion episode and the broader implications of the work. I am glad to see this newly added sentence in the abstract "The recent erosion volumes at Sedongpu are by order of magnitude equivalent to the average annual denudation volume of the entire mountainous part of the Brahmaputra River basin, and illustrate a potential and intensity for rapid post-glacial landscape evolution and the hazards related to such high-magnitude low-frequency events that have rarely been considered so far." which I think will interest a whole new group of potential readers.*

Thanks

*Overall, I recommend the authors make minor revisions to complete a few of the additional changes described here, after which this manuscript would be suitable for publication in TC.*

Thanks

*If the intention was to create a full-length manuscript, I would have recommended that the authors add in a component of landscape modelling to the manuscript alongside the remote sensing. The two methods would complement each other nicely in evaluating this extreme event, and may allow for some constrains on the properties of the sediment (e.g. erodibility). This remote-sensing only manuscript makes for a good Brief Communication with the changes and does not have space for this added material, but it may be worth noting briefly in the discussions. It could make for a good follow-up paper to this.*

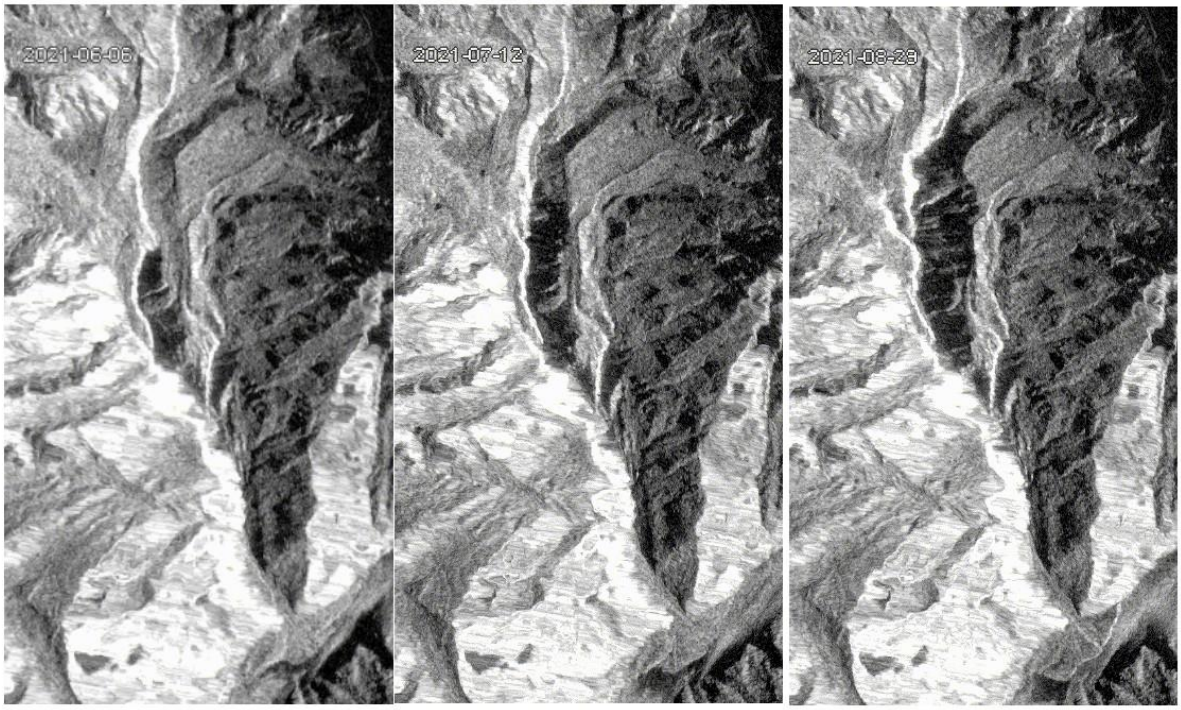
Added a sentence in the discussion: "Numerical modelling of the landscape evolution at Sedongpu could provide further constrains on the properties of the sediments and their mobilization but is beyond the focus of this brief communication."

*Finally, the new supplementary material is very useful and should be discussed in a little more detail. The Sentinel-1 timeseries shows the rapid unzipping of the landscape in a way that is not currently captured in the manuscript. In addition, the period of rapid change in the delta within the Tsangpo from June to Aug 2021 provides some clues into when sediment was being delivered to this river. I would like to see 1-2 more sentences describing this. I am not sure if there is space for a new figure in the manuscript, but showing the following three images really highlights the processes occurring during the period between the two DEMs (e.g. below). Maybe it could be a figure in the sup mat and referred to directly.*

We replaced Fig 3 (profiles) with Sentinel-1 images, added the profiles in a small version to Fig 2, added the full-size profiles to the Supplement and added text in the main paper: "The Sentinel-1 image time series over summer 2021 (Fig. 3 and animation in the Supplement) shows rapid changes of the Sedongpu fan in extent, shape and height, but still these changes appear rather minor compared to the 279±5 $10^6$ $m^3$ erosion volume that should have entered the fan during this time period."

and

"Another indication that supports this interpretation of gradual erosion is the fact that the fan of the Sedongpu valley in the Yarlung Tsangpo showed rapid changes during summer 2021 but seemed to have never dammed up the main river (Sentinel-1 images in Fig. 3 and the animation in the Supplement). Such damming happened after the 2018 glacier detachment."




*Finally, I am wondering about one other potential implication of this event. The volumes of sediment mobilized are on the same order as a very large landslide. This sediment happened to be delivered to the Tsangpo, one of the rivers with the greatest sediment transport capacity in the globe, so could largely be accommodated into the system. However, if this had occurred in a smaller catchment, there would be a very high chance of the river being temporarily dammed with associated outburst flood risk. It is somewhat speculative, but it could be useful to note this point in the broader implications.*

Added: "… hazards related to it from debris flows and impacts on rivers. For instance, only the very large sediment transport capacity of the Yarlung Tsangpo let the river accommodate the extreme short-term erosion volumes delivered to it without causing major river-damming."

*A few specific points:*

*L8 (and elsewhere) remove 'River', it is not needed.*

We left 'River' at the first occurrences of 'Yarlung Tsangpo' and 'Brahmaputra', but removed else.

*L15 'mountainous part of the…' Not quite clear what this means. Could you be more clear and reword?*

Modified to "…of the entire Brahmaputra basin upstream of the location where the river leaves the Himalayas, …"

*L42 maybe "Yarlung Tsangpo (also known as the Brahmaputra in its lower reaches)"?*

We prefer to keep as is. To our best knowledge and research, 'Brahmaputra' refers typically to the entire river, including the Tibetan reach. However, in Tibet the Tibetan reach (and only this one) is called 'Yarlung Tsangpo'. The Chinese literature refers typically to Yarlung Tsangpo. At the very end this naming question turns into a historical and political one, and even one about cultural appropriation. As written now, we try to be neutral to these questions.

*L52 'should have been' -> 'was'*

Changed

*L73-80 I understand that this material was added in response to the other review's question about removal of material in the initial event, but I am not very convinced by it. The ongoing destabilization of this glacier raises questions about many of the assumptions underpinning the ice-thickness calculations in both the Farinotti et al., 2019 and Millan et al., (2022) datasets. The problems may be more apparent in Millan et al.'s dataset, but the Farinotti et al., dataset may match the elevation loss by coincidence (examining the spread within the different models averaged at this location may give some idea). Finally, the uncertainties in both of these datasets for an individual glacier are much larger than the DoD and I am not sure about the usefulness of this comparison. You can mention it, but it will need to be framed by more discussion about the inherent uncertainties of these data.*

*Beyond this, I am not sure how much it matters whether the initial collapse was entirely composed of ice or entrained basal sediment for the remainder of this manuscript. If you say something along the lines of 'Pre-collapse ice-thickness datasets are not of sufficient accuracy to evaluate whether the initial event was entirely composed of glacier ice, whether it entrained basal sediment, and what the volume of sediment entrained might have been.*

*Examination of post-collapse optical imagery could not identify a large erosional scar in the subglacial sediment (Kaab et al., 2021), although this was not confirmed by direct field observations.'*

Added both suggested sentences in the manuscript.

*L103 I am genuinely astonished that this volume of material could be removed without the occurrence of debris flows. I only had time to have a very quick read through Yang et al.'s preprint, but do you have an*

*idea what scale of debris flow could have been missed by their equipment? It sounds like it was moved to a point higher in the channel in 2021 following the March event, so may have been less sensitive?*

We investigated closer and modified the text: “In fact, state-of-the-art early warning installations including cameras and geophones at the outlet of the Sedongpu valley registered rock-ice avalanches (following section) but no massive debris flows from the former glacier bed and no river blockings of the Yarlung Tsangpo are reported (Yang et al., 2023).However, a new early warning station further up in the Sedongpu valley was only installed in May 2022, and then also able to detect debris flows from the catchment.”

*L143-150 It would be good to refer to the Sentinel-1 imagery in this, as it supports the description (which appears a little speculative without it).*

Done

*L180-183 Again, really happy to see this larger-scale description here, which is one of the most remarkable findings in my view. This sentence needs a reference (or several) for the source of the basin-wide erosion rate data.*

Done. Added also a sentence on long-term uplift/denudation rates in the region in the study site description.

*L192-193 The two halves of this sentence are not entirely equivalent. While the volume and rate of the Sedongpu erosion dwarf GLOF, the relative frequency of each is (as far as I know) not known. This should be added to the sentence or reworded so it is not implying that these events are an even larger driver of erosion in the Himalaya (which I don’t think is what you are trying to say).*

Reworded to “Lake outburst floods have been suggested to be major drivers of erosion in the Himalayas (Cook et al., 2018). The erosion volumes and rates at Sedongpu dwarf even those from lake outburst floods, though it is unclear how the frequency of both event types and thus their long-term volumes relate to each other.

*Code availability: This change is good and it makes it easier for readers to find the exact information.*