

## ***Interactive comment on “Mechanisms leading to the 2016 giant twin glacier collapses, Aru range, Tibet” by Adrien Gilbert et al.***

**M. Truffer (Referee)**

mtruffer2@alaska.edu

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### General Comment

This paper discusses the catastrophic collapse of two glaciers in Tibet within a few months of each other; one of the most astonishing glaciological events ever recorded. The paper provides a thorough analysis of the glaciers' development in the years prior to the event using satellite data and climate models interpreted with a thermomechanical 3D ice sheet model. The paper reaches substantial conclusions that might even be a bit counter-intuitive (i.e. it is not just melting of a previously frozen bed). It should be published after some modification. Most importantly, it needs thorough editing. There are many grammatical mistakes including long convoluted sentences, missing

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pronouns, misused prepositions, confusing singular and plural, and third person singular.

### Specific Comments

1) The method for deriving basal friction is not well explained. It is not very common to use vertical velocities for the cost function in an inversion. There is a reference to Gilbert et al (2016), but that paper uses both vertical and horizontal velocities, which is likely to constrain the friction parameter much better. If I understand correctly, vertical velocities are derived from DEM differences (yielding  $dh/dt$ ) and a mass balance model? If so, why is there a discussion of surface-normal velocities? Both  $dh/dt$  and  $b_{dot}$  are generally evaluated in the vertical direction, so there is no need for this? Intuitively, I'm surprised that this method works so well, but the results do look encouraging. But there should at least be some discussion of errors (which is missing for any of the results).

2) There are conflicting assumptions in the paper that are not always discussed. For example, the derivation of bed topography is based on 'no sliding' (this is shortly discussed). Friction parameters are derived from a linear sliding law, but the discussion is entirely in terms of a plastic till.

3) I would like a bit more information about how stresses are divided between basal shear stress and lateral stress. In a valley geometry, the bed-parallel stress can be both lateral and basal.

4) The Kolka Glacier case is interesting with a rock fall on it. There is a simple argument to be made that for a plastic till the addition of a mass on top of the glacier will lead towards instability if the glacier slope is larger than the friction angle of the till, without invoking pore water pressure changes. Is this potentially the case here?

5) The abstract mentions that this is a response to recent increases of surface melting and rain. Neither is shown in the paper. This is an important conclusion and only

enters the paper via a mass balance model that is discussed elsewhere. For such a substantive statement it seems like there needs to be at least some amount of backup (e.g. a figure of temperature/precip changes)

#### Technical corrections

I won't list grammatical issues, there are too many. This paper needs a very careful editorial revision. Some other comments:

p.2,l.7: unique -> rare (it's not unique you mention another example in the next sentence...)

p.3,l.10: are the two X-band images from the same time of year? Otherwise could the penetration depth change with snow wetness?

eqn (2): d should be y

p.6,l.2: which two cases?

p.7,l.31/32: I don't understand that sentence at all (.. external side of the curve ..)

p.10,l.2: sec 5.2 is a self-reference...

p.10,l.10: How did you observe bedrock roughness. I thought this was all till covered?

p.10,l.17/18: The MacAyeal and Tsai references don't quite seem appropriate here; they don't show plastic till, they assume it in their models.

p.10, last paragraph: I find some of the discussion here confusing. What do you mean when you state that 'plastic rheology becomes the only source of resisting forces'? Or 'increasing pore pressure ... quickly reduced basal shear stress'? Increasing pore water pressure reduces effective stress (not shear stress) and through that the strength of the till. In a plastic rheology you can't reduce the shear stress to the strength; till strength is a limiting stress.

p.11,l.17: What would cause higher lateral stresses? See also my earlier comment:

when does a basal stress become a lateral stress in a valley geometry?

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Interactive comment on The Cryosphere Discuss., <https://doi.org/10.5194/tc-2018-45>, 2018.

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