

***Interactive comment on* “Brief communication: Glacier thickness reconstruction on Mt. Kilimanjaro” by Catrin Stadelmann**

Anonymous Referee #2

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1. General comments

In this study, the authors estimate the ice thickness of Northern Icefield and Kersten Glacier on Mt. Kilimanjaro in 2000 and 2011 using the ice thickness approach by Fürst et al (2017). Three different “experiments” are conducted to estimate the ice thickness, which either improves or are within the estimates from previous studies. The study makes good use of the few available observations, and the method and results are generally sound and interesting. I know this is a brief communication, but there are some key pieces of information that are missing within the data and model descriptions which I think are necessary to understand the manuscript, and the results would benefit from a discussion of uncertainties. In addition, the conclusion needs to be rewritten, as it does not seem to fit with the rest of the paper. In general, the manuscript would

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also benefit from an increase in specificity and clarity, as I often had trouble following the text. I hope the technical comments are useful for improving this.

2. Specific comments

L40: Location of the AWS is not on Figure 1. Also, for how long a period has the AWS measured and what components are measured (and with what uncertainties)?

L48-49: This is not quite correct. The thickness estimate was created from the GPR by doing kriging interpolation, and it is an estimate from the whole area, not just the flat central part. Later in the manuscript (L 169), you seem to use the estimate that Bohleber created from the DEM, so I would mention that result here too. E.g. “In addition, ground penetrating radar (GPR) profiles from September 2015 (Fig. 1) were created by Bohleber et al. (2017). Using a kriging interpolation and the KILISoSDM, the authors estimated the mean thickness to be between 21.2 ± 1 m and 27 ± 2 m.”

L55-56: The Bohleber estimate is from 2015 and the consensus estimate is from 2000, so that should also contribute to the differences.

L39-56: For most of the observations you do not provide uncertainty estimates

L61: You have a point measurement in one location. How do you get distributed mass balance maps from one point on one glacier? And do you use the mean SMB from 2005-2013 for the 2000 and 2011 estimation? If you do, you should mention this as a possible source of uncertainty (and if you don't, how do you find the 2000 SMB?).

L61-65: Again, what do you use as forcing for NIF if the AWS is on KG? And how do you use the sonic ranger to test refreezing on NIF if it is mounted on KG? In addition, you should mention the sonic ranger in the data section and not only in the methods.

L87: What method do you use for interpolating?

L109-122: A table with the different main thicknesses estimates would be useful and make comparison easier for the reader. I would e.g. include the mean thickness for

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each experiment, the mean thickness in the consensus estimate and Bohleber et al, and perhaps the thickness at the borehole locations. I know this is a brief communication and you are not allowed more figures, but maybe as a supplement.

L122: is it possible to calculate an uncertainty on the mean numbers? e.g. by leaving some GPR points out of the simulation and using those points for validation? Or if that would be too much work, you could give an approximation from the core location values (but then only for 2000). You already give it in percentage in the discussion, but here you could use the maximum absolute value.

L124-174: The discussion would benefit from a short discussion on model uncertainties. For example for the constant viscosity runs, did you conduct a sensitivity analysis? Can you give an approximate uncertainty estimate of the SMB? And are there any uncertainties associated with the use of SIA?

L181-183: Why did you use a method which uses the SIA if the glacier is dynamically inactive? Would a plastic approach not be a better choice? Also, I think this section would fit better in the discussion.

L184-190: I was a bit puzzled on how you reach this conclusion. You suddenly mention “mean viscosity” experiments for NIF, although you did not mention this anywhere in the paper (Only for KG, as written in Table 1). For all three experiments, you always generated a viscosity field from observations for NIF (first from the margins, then using Bohleber et al data). You write that “the reconstructions reveal that if there are no thickness observations available, better results can be achieved with a mean viscosity value as input for ice thickness, instead of margin ice thickness generated from DEMs and glacier outline difference” but from what do you reach this conclusion? For KG you wrote the results for the margin method and the viscosity method were almost equal (and you use the margin method to get the mean viscosity in the first place), and for NIF you did not test it. Please clarify. And if you did do the mean viscosity test for NIF too, you should provide it in the paper.

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L196-198: Wouldn't how well the margin method → mean viscosity method works depend on the size of the glacier?

3. Technical comments

L10: Add the thickness in 2000 too

L11: Write the unrealistically thick value

L11: change “meanwhile” to “have become”

L13: change “indicator” to “indicators”

L14: delete “As”

L20: delete “to”

L24: “assessment on” to “assessment of”

L25-28: You haven't introduced what you will do in this study yet, so a bit odd to talk about comparison already. I would suggest changing to: “A recent study attempted to reconstruct the distributed ice thickness for all glaciers outside of Antarctica using a consensus of up to 5 models (Farinotti et al. 2019). This estimate generated ice thicknesses estimates for Northern Icefield (NIF) and Kersten Glacier (KG) using ensembles of 2 and 3 models, respectively.” Then at the end of line 37 you can add “The resulting thickness estimates are then compared with the consensus estimate” or similar.

L28-31: I would suggest dividing the sentence in two to make it easier to read: “. . . (Farinotti et al. 2019). In addition, it was recently discovered that KG has separated into two fragments, which is not in agreement with the estimated high thickness values in the study.” I would also add a citation for the separation.

L34: I would suggest adding a line describing the model here, e.g. something like L80-83. Currently you mention a SMB model in L 39 without introducing that you even use

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it first.

L39: either delete “the distributed surface mass balance (SMB) model and” or introduce the model in the introduction.

L41: define DEM the first time you use it

L41-43: missing reference for SRTM and Landsat 5

L43: change “from a merge of” to “by merging”

L46: reference Fig 1 after describing the redefinition

L46: Future separation? Earlier you wrote it already separated?

L47: delete “apart from” and add “were” before drilled

L48: can you add the borehole locations to figure 1 instead? It would be nice to have all the observations in the same figure.

L48: Definite GPR first time you use it

L54: change “showed a mean” to “had a mean”

L54: give the value for NIF, “similar value” is too vague

L61-65: You should explain the reason for the model changes first, as it will be easier for the reader to follow. E.g. “The full MB model has only previously been verified for KG. However, because of the low slope angles of NIF, meltwater cannot run off from the surface of its planar top before refreezing sets in (Mölg and Hardy 2004), which was not captured by the model. Therefore we upgraded the model so that refreezing of meltwater is allowed on a bare ice surface with a slope angle below 5 degrees. With these changes, the model is capable of reproducing the observed surface height changes observed by a Sonic Ranger mounted to the AWS.”

L76: change “nowadays” to “currently” or “2011”

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L89: change “increase” to “increased”

L90-91: I suggest changing the structure so the reasoning is before the how, e.g.: “In order to smooth the surface slope during reconstruction we use use the coupling length parameter, which is defined a a multiple of the local ice thickness.”

L95: add “by” before “combining”

L98: the values are inferred and then the values are interpolated for the whole area?

L117: change “a distribution” to “the distribution”

L144: reference is missing a year

L147: what is “the better model”?

L149: change the end of the sentence to “.. the consensus estimate underestimates the the thickness at these points.”

L165: mention the 10 and 5 m experiments in methods

L169: remove “where the very high ... as well”

L178: remove “became ice free or”

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