Review of the TCD-publication:

Climatic controls and climate proxy potential of Lewis Glacier, Mt Kenya

By Rainer Prinz, Lindsey I. Nicholson, Thomas Mölg, Wolfgang Gurgiser and Georg Kaser, 2015

I believe this paper about Lewis Glacier is **very relevant for understanding the climatology of the Mount Kenia and Eastern Africa** as a whole and **I'm recommending the publication - with some improvements - for the final series of 'The Cryosphere'**.

As mentioned, I have some suggestions and comments and just these (of course also these from other reviewers and the editor) can help the authors to make their publication even more understandable and the lines of evidence clearer, so I'm much in favour that the authors take the chance and have the possibility to realize a final paper.

Goals of this publication

As the author state, this paper aims to

(i) **extend** the **point surface energy and mass balance** from Nicholson et al. (2013) to **glacier wide-values** for **Lewis Glacier (on Mount Kenia)**,
(ii) **evaluate** the **climate sensitivity** of the **glacier-wide surface mass and energy balance**
(iii) **explore climate conditions** under which the **late 19th century maximum extent of Lewis Glacier** might have been sustained and
(iv) **discuss** the **potential** for **using shrinking of Lewis Glacier to quantify climate change** for a time period not covered by instrumental records.

General comments

As mentioned, I believe that this publication is very relevant for the climatology of the Mount Kenia region. All the same, I think it is important that also readers not extremely familiar with tropical glaciers and particularly Lewis Glacier and Mount Kenia should understand your results and its significance. So, I think for the interested public not specialized in tropical glaciers and this region it would be a good idea to explain a little bit more in detail, what are the peculiarities of your data and results, without compelling the reader to consult a plethora of related papers. Of course, this does not mean that all previous findings have to be incorporated in all details, but in condensed form these which are key to understand your present data and results.

Moreover, you present some data which sound strange for readers who have been never on Lewis Glacier. Why is mean fresh water snow equivalent 350 kg/m3?

Perhaps, solid precipitation on Lewis glacier is in most cases extremely wind pressed graupel or very wet snow or a similar peculiarity can be given as an explanation.

Why is air temperature divider between snow and rain 4.5°C? Why so high?

Perhaps, naturally ventilated air temperature means sometimes almost not ventilated …and large amounts of reflected sunlight hitting the air temperature sensor… or so…

Moreover, present, past and future Climatology of Mount Kenia is not really mentioned, except of a short indication that there is a 'long rain' and a 'short rain' season bringing accumulation and the sentence, that 'the East African glaciers capture a climate signal from atmospheric levels, between approximately 5 and 6 km a.s.l , where our knowledge of climate change is scarce and controversial. This is of course the case, on the other hand, there are long term precipitation measurements – especially on the agriculturally used slopes of Mount Kenia(!) - indicating that 'long rains' in MAM are generally diminishing since (at least) the 1950ies (e.g. Schmocker, 2013) with some acceleration since 1998 (e.g. Schmocker, 2013; Yang et al., 2014). In the Mount Kenia region 'short rains' in OND seem to be stable since the 1950ies with perhaps some slight upward trend since the 1998 climate shift (e.g. Schmocker, 2013). Additionally, it could be a valuable information that it is not clear - for the time being - whether GCM precipitation projections are properly reflecting future precipitation development for Mount Kenia (e.g. Yang et al., 2014).

If the authors could explain shortly these peculiarities they would give the interested reader some feeling about the conditions at Mount Kenia. In this way the reader gets more involved and this makes the lecture of this publication more attractive, in my opinion.

Suggestions

Energy (EB) and Mass Balance (MB) Model: page 3892, Lines 26ff

The authors refer to several other publications what the EB and MB modelling concerns. They mention also that measuring interval is 30 minutes. But does this mean that this is also the time step of the model for Lewis glacier is 30 minutes?

Cloudiness: page 3894, Lines 17ff

The authors mention several times that effective cloudiness (n eff) is an important input value, e. g. for longwave parametrization, but from where do they have this value? Is it measured, observed or parametrized in different way during day and night?

Fresh snow density: page 3900, Lines 23ff

Mean densities of 315 kg/m3 for fresh snow - or, as can be seen from table 2, the estimated value by Nicholson (2013) of even 370 kg/m3 - are unusually high. What do the authors understand by fresh snow? Snow which is measured immediately after falling? Even 315 kg/m3 for fresh snow seems to be very high, if comparing this value with long time average value of new snow, or even more so for 'fresh snow', e.g. in the Alps (Rohrer et al., 1994). Is this really snow? Or is perhaps more wind-packed graupel? As already mentioned, to give in this context some explanation would help the reader not having visited Mount Kenia so far to understand conditions on LG much better.

Snow/rain divider: page 3903, Lines 6ff

A value of 4.5°C as a snow-rain divider seems extraordinary high (e.g. L'Hote et al, 2005). How do you explain such a high value?

Sensitivity scenarios: page 3899, Lines 12ff

I find it is really a good idea to explore the sensitivity of a glacier mass balance with several mutually linked input variables. But for me, the information about how exactly these scenarios have been accessed is very sparse. It would be a good idea to say a little bit more about this. For example, if looking at table 3, it seems that there is no explicit precipitation scenario. What is exactly the reason for this and how are the other variables linked to the resulting precipitation (scenario)? In this context, the author's statement that the measurements are in-line with the recent decades TMPA and Era-I values is somewhat confusing to me. What is about the variable space in earlier decades or in a future world, how is the author's estimation about this? Do they have evidence that their 'scenario space' is valid for the whole period from 1930 to 2010 (for which exist glacier outlines), but as well for projected conditions up to 2100? I think this is an important information to the reader, as the authors state explicitly that a goal of this publication is to quantify climate change for a time period not covered by instrumental records.

Tables and figures:

Table 2: Why is the snow/rain divider not mentioned?

Table 4: Evidently there is no explicit precipitation scenario. As mentioned, I'm not convinced if this is adequate, but anyway, as an output, I think, there is a resultant precipitation. And this quantity would of course be interesting. So, I would suggest, that you would indicate this value in this table. Anyway, it is the question, if it is not adequate to communicate the different input scenarios additionally in a graph.

Figure 1: It would help in interpreting the climate controls if there was an additional sketch map showing LG and Mount Kenia in a greater context and the two overpasses of the ITC (perhaps in different colours for 'long rains' and 'short rains') and the corresponding prevailing wind directions indicating the dominant transport of moist air masses.

Figure 3: the figure caption is somewhat confusing to me: I suppose that the indicated formula is only a part of the albedo parametrization, or not? Perhaps the authors could also enhance the figure by indicating in the figure, what surfaces are modelled in the course of time (snow, ice, …).

Suggestion for an additional graph:

An additional graph showing the used input scenarios in spider net plot or similar would point out in a more direct way how the different scenarios differ from one another.

References:

L'Hote, Y., P. Chevallier, A. Coudrain, Y. Lejeune and P. Etchevers, 2005: Relationship between precipitation phase and air temperature: comparison between the Bolivian Andes and the Swiss Alps. Hydrolog Sci J, 50(6), 989-997.

Nicholson, L. I., Prinz, R., Mölg, T., and Kaser, G., 2013: Micrometeorological conditions and surface mass and energy fluxes on Lewis Glacier, Mt Kenya, in relation to other tropical glaciers, The Cryosphere, 7, 1205-1225, doi:10.5194/tc-7-1205-2013.

Rohrer, M.B., Braun, L.N. and Lang, H., 1994. Long-Term Records of Snow Cover Water Equivalent in the Swiss Alps 1. Analysis. Nordic Hydrology, 25: 53-64.

Schmocker J, 2013. Long-term precipitation trends and rainy season performance in view of climate change in the Mt. Kenya region. Master Thesis Submitted to the Faculty of Natural Sciences of the University of Bern, 91p., http://www.cde.unibe.ch/CDE/pdf/MA_Schmocker.pdf.

Yang, W., Seager, R., Cane, M.A., Lyon, B., 2014. The East African Long Rains in Observations and Models. J. Climate 27 (19), 7185–7202. http://dx.doi.org/10.1175/JCLI-D-13-00447.1.