

Review of ESD-Manuscript as a Referee: Joseph Romanus Mukabana

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Journal: ESD

Title: Mesoscale atmospheric circulation controls of local meteorological elevation gradients on Kersten Glacier near Kilimanjaro summit

Author(s): Thomas Mölg et al.

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GENERAL COMMENTS

This section addresses the overall quality of the paper based on my evaluation and assessment as a referee.

Sequence to the given review criteria and general obligation for referees, and further having read the manuscript, I would like to state that in my considered opinion:

The authors of this paper have addressed relevant scientific questions related to their topic and scope of their chosen study. The paper outlines novel concepts and ideas including a field campaign / experiment in a complex high altitude environment. In my view, the results are sufficient to support the interpretations and conclusions reached in this study.

As a case study of a high-altitude glacier on a mountain located in the tropics and specifically in the equatorial zone, the authors arrived at substantive conclusions showing that the results augment similar studies on meteorological elevation gradients and also provide a framework that could be used to examine the influence of mesoscale flow on mountains with glaciers. In this study, the authors displayed an amazing teamwork and division of labour that included designing the study, writing the paper, analyzing the data, conducting field work and undertaking the field campaign.

I find the scientific methods used and the assumptions made in this study valid and clearly outlined. The authors description of the field experiments and calculations are fascinating and I believe they are sufficient and precise to allow their reproduction by fellow scientists. The authors took an incisive literature review relevant to the study shown in cited references and also have given proper credit to related work in the body of the text. Moreover, the title of the study reflects the content of the paper and the abstract provides a concise summary of the work accomplished.

The overall presentation of the paper is well structured and the language used is fluent and precise. The mathematical formulae, symbols, abbreviations, and units in the manuscript are correctly defined and properly used and most parts of the paper have clarity and need not be combined or eliminated. The number and quality of references as well as the amount and quality of supplementary material are appropriate for this manuscript.

SPECIFIC COMMENTS

This section addresses individual scientific issues in the manuscript.

1. Introduction

It is stated here that this four-year study (2009-2013) used elevation gradients in basic meteorological variables as model parameters on a chosen domain (5603m and 5872m) on Kersten Glacier of Mt Kilimanjaro– to construct spatially distributed atmospheric drivers of glacier mass balance. It is also stated that if the mass balance model was coupled to an atmospheric model, the coupled model would deliver these parameters at different elevations (e.g. Collier et al 2013).

Question: spatial model resolution allowing (say resolution of 400m or less) and if computational costs were waived, do you think that it would have been better to proceed with a coupled model study, whereby you would see the interaction of the mesoscale systems (local circulation) with regional scale (synoptic scale) systems right away? Or was the lack of information on observed elevation gradients for tropical glaciers a motivation for you to undertake this study that involved field experiments?

2. Methods and Data

It is stated that automatic weather stations (AWS3 at 5873m and AWS4 at 5603m) were placed on Kersten Glacier with intent to gain knowledge of elevation gradients in the basic meteorological variables.

Question: Do you think installation of additional AWS (say, AWS5) at a lower altitude (still close to AWS4, but below and out of the Kersten Glacier zone) would have acted as some kind of *Control* to measure gradients out of the glacier but up-close; just for comparison?

2.3 Processing of the sonic ranger records

It is indicated that, “*The SR0a records from Kibo must be carefully post-processed due to intervals of noise data.*” Also, “*Due to the noise, we usually did not attempt to interpret the hourly data but daily values at the most.*”

Question: Why were the sonic data so important that you had to find a way of applying them (from hourly to daily values) despite the noise? The significance of sonic data is not well explained – what is the advantage of using sonic data instead of other measurement methods?

2.4 Atmospheric model experiment

It is stated that Collier et al (2018) with a spatial resolution of 800m showed that the model reproduces the important features of atmospheric conditions in the summit zone of Kibo (Fig 3). But Kersten Glacier is only represented by one grid cell in this model despite its high resolution. This means, therefore that evaluating simulated gradients on the glacier scale would not be possible.

Question: In your opinion, would it have been appropriate for Collier et al (2018), in designing the model simulations, to take into account the fact that they were dealing with a study of batch of receding glacier (and not expansive ice sheets as found in mid-latitudes) and needed to further increase the model resolution over Kilimanjaro to say 200m – 250m ?

3.0 Results and discussion

It is mentioned here that all elevation gradients are per 100m, which seems practical with regard to the altitude extent of most present mountain glaciers (expansive ice sheets?) and distinguishes from micrometeorological gradients that are usually given per meter.

Question: Considering that the Kersten Glacier is just one significant block of remaining ice on Mt Kilimanjaro, don't you think that the limited area it occupies, and which formed your study domain, could be attributable to the creation of micrometeorological gradients and would thus qualify to have elevation gradients measured per meter?

3.2.2 Non local control factors

It is stated here that, *“These features together indeed suggest that mesoscale circulation communicates the heating signal from the lowlands to higher elevations over the course of the day and mixes potentially warm air upslope; the intensification of this process with altitude helps to explain why daytime elevation T gradients in the summit zone are reduced (Figs 5b & S2).”* Italics mine.

Question: The glaciers on MT Kilimanjaro, Mt Kenya as well as Mt Ruwenzori have decreased substantially over time. This glacier recession has been attributed to global warming and attendant impacts of climate change. In your considered opinion, can the vertical heat fluxes from lowlands and their advection to higher elevation, as explained in your statement, be linked to the recession or decline of glaciers on tropical mountains in the equatorial zone?

III. TECHNICAL CORRECTIONS

This section addresses typographical errors, like spelling or sentence reconstruction, etc.

Section 3. Results and discussion

- a) Paragraph in 250 starting with, *“In the following we report all elevations*”
Since 3 is a section, I reckon that what follows is/are sub-sections, therefore would it not be appropriate if we put the word *“subsection (s)”*, so that the sentence would read, *“In the following subsections, we report.....”*
- b) In the same paragraph under Section 3, there is need to recast the last sentence, which reads *“The derived quantity should thus be a good proxy of solid precipitation, yet we will continue to call it accumulation (ACC) to not forget that the measurement principle differs from a regular precipitation gauge.”* Italics mine.
→ The sentence could read, *“Although the derived quantity is a good proxy of precipitation, we will continue to refer to it as accumulation (ACC) and note that the measurement principle of ACC differs from that which applies regular precipitation gauges.”*
→
- c) Under 385, note the sentence, *“..... a tendency that is maintained for rest of the night and peaks at 7:00LT.”* Please put the word *“the”* after *“for”* to read, *“..... a tendency that is maintained for the rest of the night and peaks at 7:00LT.”*

END