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The Cryosphere Discussions

# *Interactive comment on* "Assessing high altitude glacier volume change and remaining thickness using cost-efficient scientific techniques: the case of Nevado Coropuna (Peru)" *by* P. Peduzzi et al.

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Disclaimer: I was asked to review this paper after the final comment by the authors on 3rd December. In order to make this review as fair as possible I have decided not to read any of the previous comments posted.

1. General Comments

In this paper the authors present calculations of the total volume and volume changes, hence estimate the mass balance, of the Coropuna glacier, Peru. Total volume is calculated by first using a radar survey to derive thickness and then extrapolating this to the rest of the glacier. They do this by fitting a model to the radar thickness measure-



ments based on slope, aspect and altitude. They then use this model to infer thickness elsewhere on the glacier. Volume changes are calculated by comparing ice elevation and extent measured in 1955 (from a published map) with elevation measurements from more recent satellite measurements.

Scientifically this paper is of importance for assessing the volume and volume changes of the Coropuna glacier. However, it is unlikely to have a wider impact because the methods are not innovative enough or have not been sufficiently described. Moreover the volume changes of this glacier have been previously estimated by Racoviteanu et al. (Global Planetary Change: 2007) for a similar time period. Although the methodology and results of Peduzzi et al. differ from this previous paper they do not treat their errors with sufficient rigor to have confidence in their results.

The spelling and grammar in the paper is poor. There are too many errors for it to be useful individually listing them, particularly as this paper should be substantially rewritten before publication. If published the final version of the paper will need proof reading, not only for spelling and grammar but for clarity.

The structure of the paper is poor. The core is divided into:

Section 2 Data Collection

Section 3 Methodology

Section 4 Results and discussions

These sections are not clearly defined and the content seems to be distributed amongst them in a non-intuitive way.

2. Specific Comments

Although the authors state their method is an improvement on (Racoviteanu et al. 2000) therefore they were able to use the ASTER DEM, without sufficient error analysis it is extremely hard to be convinced that this paper adds new results on elevation

change (hence volume change) that are worthy of publication. The Racoviteanu et al. study found “The ASTER DEM had a RMS error of 61 m with respect to GPS points [off glacier] and displayed 200–300 m horizontal offsets and elevation ‘spikes’ on the glaciated area when compared to the DEM from topographic data”. It is clear that on the glaciated area the errors in the ASTER DEM data are large. The authors of this paper have failed to address this issue adequately. Deriving a total average elevation and then subtracting one dataset from the other does not appear to be a substantially better method from calculating the difference at each point and then giving a total average difference over the whole area. The authors fail to present a convincing error analysis for their approach.

Page 835: Why have all of the NASA DEMs been included in a table with a statement that they are not being used? Only details of the ones used are needed. Also there are no references to the likely influence of snowfall so the selection of these months is not fully explained. There is inadequate detail on the selection or the expected accuracy of the NASA DEM or even the expected errors in the ones rejected. The paper states selection on “quality” of the dataset, how was this ascertained?

There are insufficient data on the sources of the DEMs and both their positional and elevational accuracy. Proper references are needed for the DEMs obtained (e.g. to NASA papers/databases). A proper summary of the errors is needed In particular the first two DEMs which are I believe may not be publically available, or published in an accessible format need far more description of the processing and errors.

For total volume calculation the authors use a radar to calculate ice thickness. There is no discussion of errors in the electromagnetic velocity used. There is no real detail of the distance or area covered in the methods section where it should be. The radar profiles provide little coverage of the glaciated area, although the authors cover a range of altitudes, slopes and slope aspects which is good. The model used to extrapolate the thickness to the whole glacier has been inadequately described. These results are the part of the paper which is most novel. However, without a proper treatment of



thickness errors both from the initial radar measurement and then from extrapolation of these measurements to the whole glacier these results cannot be evaluated.

The section on data collection contains some irrelevant information on batteries etc. whilst missing more relevant information on the physical setup of the radar.

3. Technical Corrections

Page832 line 23 Over what period? Sentence is not specific enough.

Page 833 lines 7-9 Maybe “In the Andes, ... an acute retreat of glaciers, ... from 725 km2 to 600 km2 from 1970 to 1996 in Cordillera Blanca, Peru (Silverio and Jaquet, 2005).” Note the change of spelling to Cordillera, I think this is right.

Page 833 Lines 11-12. Maybe it should be “"Cooperacion Peruano Alemana Para la" and “(COPASA)”

Page 833 line 21 Maybe “surface area”?

Page 834 line 8 your geographical coordinate format is unclear

Page 834 line 18 “today, Digital Elevation Models (DEMs)” the word ‘height’ is not needed as it is covered by the word ‘elevation’

Page 834 line 19 You do not need to say it was generated by Walter Silvero because he is one of the authors on the paper.

Page 834 Do you mean you digitised the elevation contours from the map of 1955? Isoline is too general and can mean lines joining equal points of many different quantities. If so what map? Where is the reference to it? What is the estimated accuracy of this technique (and the original map)?

Page 835 line 8 “longer” not necessarily “better”

Page 835 line 12 Which DEM?

Page 835 lines 18-20 An electronic device? You mean the actual unit? You do not

need to say it included this or batteries it is sufficient to say you used an “xxxradar with 100 MHz shielded antennas.” You do not need to say you buried it every day so that you didn’t have to carry it. Section 2.3.1 What did you actually use the laptops for in the field? You have a lot of detail about hard drives etc. which people may find useful if they haven’t worked at high altitude before.

Page 836 line 4. It was not set to emit at 438 MHz, as you show in Table 2 that was the sampling frequency

Page 836 Eq. 1 is wrong it should be 2l = CT. Although this error has not affected their calculation which is correct

Page 843 The last paragraph of the conclusions is poor and could be cut entirely Figure 1: A general location map showing where this place is in the Andes would be useful, either as a separate figure or an insert. The figure caption offers very little explanation of what is in it. What are the contours? What separation? What are the different colours of the dots? Are the dots representing places where coordinates were measured by GPS? Some of this may be in the text but it is really needed in the figure caption so it is possible to know what you are looking at.

Figure 2: Does not really add anything to the paper

Figure 3: Caption “Example of an interpreted profile...” Because of your interpretation line it is not at all clear in this figure that you have a bedrock reflector.

Figure 5: No distance scale

Figure 7: Inadequate caption, what does grey represent? It needs to be stated in the caption not just in the text

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