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The Cryosphere Discussions

# *Interactive comment on* "Area and volume loss of the glaciers in the Ortles-Cevedale group (Eastern Italian Alps): controls and imbalance of the remaining glaciers" *by* L. Carturan et al.

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1 Content

This paper addresses the glacier changes in the Italian Ortler-Cevedale group during the period from the early 80s of the twentieth century to the middle of the first decade of the current century. Changes in glacier surface area and altitude are derived by differencing digital elevation models of the respective dates. Glacier extents and equilibrium line altitudes for the 80s and 2000s are derived from Landsat images of the



years 1987 and 2009 respectively. The results are analyzed statistically by correlating the observed changes to different topographic parameters.

2 General comments on the paper

The current study offers a valuable contribution to the community as it presents a consistent regional data set on the rapid glacier change in one of the most glaciated mountain ranges of the eastern European Alps where a comparable set of data did not exist so far. A publication of the paper is desirable even if a range of improvements are required. Generally the paper seems to be informative and concise in the first part (up to roughly chapter 4) where the methods and results of the geodetic procedures are described, but gets more and more unstructured in the second part where the changes are correlated to topographic parameters and sometimes interpreted in a very general and subjective way. The amount of references is very high and biased to the introductory part of the paper including many non-peer-reviewed reports (e.g. WGMS, CGI). Maybe the reference list can be upgraded by (i) focusing on the most important papers describing the methods used in detail and (ii) adding a few key publications where necessary. All figures need improvements regarding the readability (e.g. font size) of labels, legends etc.

3 Main methodological comments

3.1 Decadal representativity of the snowline in late summer 1987 and 2009

Snowline determination and representativity of ELA-calculations from the Landsat images should be discussed more intensively. Field observations (e.g. Secchieri and Valentini, 1992) indicate that the hydrological year 1986/87 (2008/09) was a year with very low (high) winter accumulation in the Ortler-Cevedale group (second highest after 2000/01). This fact should be discussed in terms of ELA-representativity and possible bias in interpretation. The comparison of the AAR for 2009 for Careser (0.06) and Weißbrunnferner (0.24) with the decadal means (2000-2009, Table 2) shows that the accumulation area in 2009 was much larger than in the decadal mean (+500%

for Careser, +100% for Fontana Bianca). The net annual mass balances for 2009 at Careser (-1268 mm w.e.) and Weißbrunnferner/Fontana Bianca (-622 mm w.e.) are by far less negative than the respective decadal (2000-2009) means of -1807 mm w.e and -1142 mm w.e. Similar is true for the 2009 mass balance of Langenferner/Vedretta Lunga which was the second least negative annual mass balance in the period 2003 to 2012. All this indicates that the derived snowlines for 2009 do not represent a decadal mean state of the accumulation area. This definitely results in a significant underestimation of the degree of imbalance of the glaciers in the region.

3.2 Avalanches

By definition avalanching contributes to accumulation on the glacier surface (e.g. Cogley et al., 2011). Not considering this process may bias results. In the manuscript two main questions are not clearly explained: (i) How is avalanche snow distinguished from other snow? (ii) Why is it not considered in the accumulation area calculations? Of course, the high winter accumulation in 2009 also influences all kinds of avalanche related interpretations made in this paper. Thus, a focus on the representativity (comment 3.1) of the years of the satellite scenes helps to improve the manuscript and eases drawing conclusions.

3.3 Controls of the observed changes

Three sections in the paper (3.4, 5.4 and 6.1) address the controls of the observed changes, but none is concise and easy to read. These chapters can be summarized into one clearly written part discussing controls of glacier area changes i.e. (i) changes of climate forcing (interesting data from Careser dam possibly including energy balance studies from Ortler glaciers (e.g. Senese et al., 2012 )), (ii) glacier dynamics (unfortunately not mentioned at all) and (iii) maybe already including findings from the Ortler ice core. So far the discussion of the controls of the observed glacier changes is shallow and mainly consists of a few sentences presenting the long term data series of temperature and precipitation from Careser Dam.



4 Specific Comments

Eq. 1: explain A1

Eq. 2: Use $\Delta$M instead of b to meet the Glossary for Mass Balance Terms (Cogley et al., 2011).

Page 269, line 3: Responses to what. Please clarify!

Page 269, line 13: "...which fairly represents the extent of the accumulation areas over the last decade". We do not agree with this statement as explained in section 3.1 in this comment.

Page 272, line 1: A reference to Kaser et al. (2006) would be appropriate here.

Page 273, line 6: Indeed, glaciers in the Alps are important for hydropower generation. But in general glaciers in the Alps are insignificant for potable water supply and agriculture, otherwise give a reference.

Page 273, line 25: Give portion of cloud cover of satellite images.

Page 274, line 9: Add Verdetta Lunga to the list of glaciers with direct mass balance observations (since 2003/04). Data is reported to the WGMS and the Ufficio Idrografico (Bolzano) publishes annual reports.

Page 275, line 23: Due to their small elevation range, the total surface area of glacierets is either accumulation or ablation, strongly dependent on the individual year of observation. Thus, a clear discussion of the representativity of the satellite images helps to interpret.

Page 275, line 26 and throughout the paper: The term "clear sky radiation" is used in a misleading way. In a meteorological sense, "clear sky radiation" means global radiation on a day without clouds which already incorporates atmospheric transmission. Did you really account for that or do you mean a radiation potential, which is computed from the solar constant, an orbital eccentricity correction and the cosine of the zenith angle

of the sun? In the latter case, we suggest using a less confusing term e.g. "mean summer solar potential".

Page 277, line 6: How is old snow distinguished from firn of multiyear age?

Page 277, line 15+16: See comment 3.1 and in line 23 this statement is contradicted by an error of >100% (AAR from direct observation on Fontana Bianca 2009 = 0.10 and from Landsat scene = 0.22)

Page 277, line 25: Add Bippus (2011) to the quotation of the GlobGlacier report as it is based on this PhD-Thesis.

Page 278, line 16: How was avalanche snow distinguished from "normal" snow and why was it not considered for the AAR calculation? A local ELA-lowering does not seem to be a satisfying explanation. What is the criterion/threshold to define an avalanche-fed glacier?

Page 278, line 24: "Field evidence from glaciers subjected to direct mass balance measurements in the Ortles-Cevedale group indicates an average value of 0.5 for the balanced-budget AAR0". This statement is a central assumption for this paper and therefore needs to be better proved! How is this value estimated/calculated? Gross et al. (1976) and Kuhn et al. (1999) find values around 0.66 for glaciers in the Eastern Alps. An AAR0 of 0.5 is an estimate for maritime glaciers, but the climate in the Ortles-Cevedale Group might not be considered maritime (Fig. 2).

Page 279, line 4: AAR0 of glacierets: a glacier/glacieret cannot be in equilibrium when its AAR = 1.

Page 280, line 2: Use "changes in glacier extent and accumulation area" instead of "snow cover change" which can be understood as seasonal snow cover change.

Page 280, line 25: Can this value also be understood as the error for the whole mountain range, or is it very specific to the mapped glaciers? Please discuss.



Page 282, line 17: Define the objective difference between valley glacier and mountain glacier. "All 14 valley glaciers kept their shape" can be interpreted as no change in area at all.

Page 283, line 14: "reduction of clear sky radiation" is misleading. In this case irradiation does not decrease, but the glaciers receive less due to topographic effects such as surface lowering which enhances shading through surrounding topography. Please clarify!

Page 284, line 13: It would be interesting to compare this volume change to other mountain ranges in the European Alps.

Page 285, line 11 and Fig. 11a: The vertical profile of elevation changes must be discussed with glacier dynamics, otherwise it is of restricted meaning over such a long time period.

Page 285, line 16 versus Fig. 11d: "... stronger elevation losses were detected over slopes with higher radiation inputs." Rephrase or better explain the sentence (Fig. 11d shows minimum elevation change at maximum radiation inputs).

Page 285, line 19: What is the meaning of an averaged snow line altitude? Especially from these two years (1987, 2009) in which the course of accumulation and ablation possibly was not representative for decadal climate?

Page 285, line 26: Don't use "still" which indicates a stationary state of current climate to which glaciers will adapt. This is not the case as there is no reason to assume that the current long-term warming trend will stop in the near future.

Page 287, line 6: "This value is about half that of other recent alpine-wide estimates ($-2\%\ a-1$ from 1984 to 2003, Paul et al., 2011), but it is similar to results of previous investigations in the European Alps." This sentence is confusing!

Page 288, lines 3-5: We can support this finding from the winter and summer mass balance measurements from Langenferner/Vedretta Lunga.

Page 289, line 11: Please specify the "peculiar characteristics of the Ortles-Cevedale glaciers".

Page 289, line 26: "The lowering of the albedo and increased thermal emission from the growing patches of ice-free terrain likely act as positive feedbacks, i.e. its behavior might already be decoupled from climate change." Certain feedbacks or strong debris cover may make it more difficult to extract a climate signal from an individual glacier. Nevertheless, glaciers are never decoupled from climate change.

Page 290, line 9: "Some of them, located in steep terrain at high altitudes, show little change and might in part be composed of cold ice". Is the existence of cold ice proven for any case except of Alto del'Ortles or is this just speculation? Anyhow, is it relevant?

Table 2: In the text it is stated that observations on La Mare started in 2003 (page 277, line 12). This is not specified in Table 2, where an AAR mean for 2000-2009 (also for La Mare) is shown. Please clarify!

Fig. 3: Is not linked to the text. The glacier shrinkage is already shown in Fig. 1. Maybe remove.

Fig. 6: Does not provide any additional information compared to Table 4. Consider to omit one of the two.

Fig. 9: "Mean annual elevation change rates of the Ortles-Cevedale glaciers from the 1981–1984 period to the 2005–2007 period." The caption is misleading as the whole time span between date 1(1981-1984) to date2 (2005-2007) should be referred to as one period. (Do not use "period to period")

Fig. 10: Same problem in figure caption than in Fig. 9: Depicted changes are means over ONE period from date 1 to date 2.

5 References

Bippus, G.: Characteristics of Summer Snow Areas on Glaciers Observed by Means of Landsat Data, University of Innsbruck, Austria., 2011.

Cogley, J. G., Hock, R., Rasmussen, L. A., Arendt, A. A., Bauder, A., Braithwaite, R. J., Jansson, P., Kaser, G., Möller, M., Nicholson, L. and Zemp, M.: Glossary of Mass Balance and Related Terms, UNESCO-IHP, Paris., 2011.

Gross, G., Kerschner, H. and Patzelt, G.: Methodische Untersuchungen über die Schneegrenze in alpinen Gletschergebieten, Zeitschrift für Gletscherkunde und Glazialgeologie, 12(2), 223–251, 1976.

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Secchieri, F. and Valentini, P.: I ghiacciai della Val d'Ultimo (Gruppo Ortles-Cevedale) ed il loro contributo agli apporti idrici dei sottostanti bacini, Geografia Fisica e Dinamica Quaternaria, 15, 171–176, 1992.

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