

## ***Interactive comment on “Post-LIA glacier changes along a latitudinal transect in the Central Italian Alps” by R. Scotti et al.***

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### General comments

The paper by Scotti et al. “Post-LIA glacier changes along a latitudinal transect in the Central Italian Alps” combines both regional and long-term (post-LIA period) approaches in the study of glacier shrinkage, that is not common for the Italian Alps. It proposes five new inventories (in 1860, 1954, 1990, 2003, and 2007) of the extent of the glaciers in three massifs in the northern Lombardy. It proposes a latitudinal transect through this Alpine region in order to investigate differential climatic (from continental to maritime) and topographical controls on a set of one hundred glaciers. This latitudinal transect develops along only c.  $0.5^\circ$ , but mean annual precipitation strongly decreases northward from c. 1700 mm to c. 1150 mm while seasonal precipitation

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regime changes. Comparing the glacier shrinkage between the three massifs, the authors demonstrate that the southern, maritime Orobic massif experiences - in contrast with other studies - a much lower rate of annual decrease of its glacier surface area in the recent period. This results from glaciers that are mainly snow-avalanche fed, by the combination of topographic (high, steep rockwalls above north-facing glaciers) and climatic (greater precipitation, especially during the accumulation season) controls.

Methods and assumptions are valid and clearly outlined. The number and quality of references are appropriate, and the authors give proper credit to related work. The overall presentation is well structured, the language is fluent and precise, and the title and the abstract are fully adequate. Five tables and a figure are proposed as supplementary material.

I propose some specific comments and suggestions, and technical corrections for improvements (see below); in my opinion, the paper is acceptable for publication with minor revisions.

#### Specific comments

o On Fig. 3, 2012 extent is represented, while we read at p4082 L9-10: 'The most recent inventor(y) of glacial extent ha(s) been reconstructed from 2012 digital orthophotos'. But it is only p4095 L23-24 that we are informed that 2012 extent was realized for the three glaciers on which mass balance is surveyed since 2007. This should be corrected.

By the way, the maximum glacier elevation in 2012 on Fig. 3 is higher than in 2003 and 2007, recovering the foot of the rock wall towering the glacier (Piz Paradisin). This suggests that this larger extension of the glacier top area is in fact due to snow field present this year at the moment of the photo shooting - as confirmed p4082 with remarks about the very limited snow cover in 2003 and 2007. It would be useful to shortly explain this in the caption of the Fig. 3.

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o p4090 L8-10: '(...) in the Orobie we observe an opposite behaviour between 2003 and 2007, with Emin and Emax overlapping around a null elevation change rate (Fig. 9c), an indication of about volumetric stationarity.'

If (i) change in elevation rates is null, that is to say that top and front of glaciers do not change during the period 2003-2007, but (ii) the Orobie glacier surface area continues to decrease (AAD around  $0.05 \text{ km}^2 \text{ a}^{-1}$  as shown on Fig. 9c), therefore the total volume of these glaciers would decrease and not be stationary. Moreover, the very hot and dry 2003 Summer melted down ordinary perennial snow fields in the upper glacier areas, that reformed latter and were likely considered to be part of the glaciers in 2007. The huge Emax rate change from 1990-2003 to 2003-2007 is probably due to this bias.

o p4091 L1-2: 'Interestingly, in the Orobie (...)'

Explain what is interesting in the two mentioned observations.

o p4091 L3-25 and Fig. 11

Would have not been more relevant to compare the relationship between AAD and 'The elevation difference between the Erc and the ELA0', because as mentioned p4084 L17-19 this latter 'is considered to be correlated to both the degree of avalanching contribution to the glacier's mass balance and the shading effect of the rock walls upslope of the glacier', rather than the relationship between AAD and the Erc?

o p4094 L3-5: 'In order to partly solve this issue and conduct a more sound comparison of our results with other inventories, we consider the AAD values associated with the 1860–1990 and 1990–2007 periods.'

Would have not been more relevant to compare the three periods: 1860-1954 (trend of a negative mass balance), 1954-1990 (positive mass balance), and 1990-2007 (negative mass balance)?

o Section 5.3 p4095-4096 and Fig. 12 & 13: caption of Fig. 12 indicates that 'Specific mass balance data are measured with two ablation stakes placed across the ELA0 of

each glacier’

But how consider that these two ablation stakes (5 on the Fig. 3) are representative of the specific mass balance when they are located at the theoretical ELA (the ELA0), that can be very far from the actual annual ELA? Therefore, the data is surface mass balance at the location of the stakes, not specific mass balance of the glaciers.

o And finally, a more general comment: as glaciers are becoming smaller and smaller through the period 1990-2007, each  $m^2$  of surface area that is lost represents a larger and larger % of AAD. Then, what is the significance of the AAD expressed in % (see e.g. Fig. 7b), especially for small to very small glaciers?

Technical corrections

p4085 L10-13: ‘W  $m^2$ ’ has to be corrected with ‘W  $m^{-2}$ ’

p4086 L20: replace ‘apex’ by ‘acme’.

p4090 L14: explain what is the ‘glacier relative relief’ (to do in Section 3, p 4083-4084, as for other attributes). In contrast, p 4091 L4-5: ‘(i.e., the elevation of the ridgcrest located upslope of the glacier)’ is not necessary as Erc has already been explained in Section 3.

p4093 L17-18 : correct the AAD values in this sentence ‘(…) Les Ecrins (AAD = 0.45%  $a-1$ ; MAP  $\sim 1200-1400$  mm  $a-1$ ), the Mont Blanc (AAD = 0.25%  $a-1$ ; MAP  $\sim 1400-2000$  mm  $a-1$ ), and the Vanoise (AAD = 0.20%  $a-1$ (…))’ with: ‘(…) Les Ecrins (AAD = 0.38%  $a-1$ ; MAP  $\sim 1200-1400$  mm  $a-1$ ), the Mont Blanc (AAD = 0.15%  $a-1$ ; MAP  $\sim 1400-2000$  mm  $a-1$ ), and the Vanoise (AAD = 0.39%  $a-1$  (...))’, as indicated Tab. 4 p. 49 in Gardent & Deline (2013).

p4093 L17: complete ‘(…) the Mont Blanc (…)’ as follows: ‘(…) the French side of the Mont Blanc (…)’

p4093 L19: correct ‘Gardet and Deline, 2013)’ with Gardent and Deline, 2013)’; same

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correction to do p4095 L15 and p4103 L8.

p4094 L12: correct 'his' with 'this'?

p4098 L2: add '(Fig. 11c)' at the end of the sentence.

p4100 L2: correct '...(SGL). A non-profit (...)' with '...(SGL), a non-profit (...)'.

p4103 L8: correct 'francersi' with 'francesi'.

p4106 L4: correct 'Radic'.

p4113: correct '(see Fig. 6)' with '(see Fig. 4)'.

Supplement p1: in Supplementary Table S1, add '(n)' or '(number of glaciers)' as unit to 'ABR'.

Supplement p4: in Supplementary Figure S1, line type used for Livigno on charts is different than in the caption.

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