

**Comments on “Accelerated wastage of the Monte Perdido Glacier in the Spanish Pyrenees during recent stationary climatic conditions”, by J.I. López-Moreno et al., submitted to *The Cryosphere***  
Graham Cogley, February 2016

*General Comments*

This manuscript is an extensive revision of an earlier submission, and I am asked to assess whether the revision responds adequately to comments by previous reviewers. The short answer is Yes, in that requests for broader treatment of local and regional climatic forcing have resulted in the incorporation of data from more weather stations and additional detail about the North Atlantic Oscillation. Moreover the detailed comments of the earlier reviewers, M. Pelto and L. Carturan, have also been attended to carefully.

My own view, like that of Dr. Pelto, is that this is a potentially and actually valuable study of a small glacier using field and remote-sensing methods. The work is documented in detail and has been carried out in accordance with prevailing norms. The annual balances obtained by terrestrial laser scanning are well described and information about this relatively new method is welcome. The mass-balance measurements themselves are intrinsically valuable. The authors conclude that more rapid mass loss in the 2000s, in spite of the climatic forcing remaining essentially constant, is due to the glacier being so far from equilibrium that occasional years of mass gain do not suffice to slow the loss rate. To put this another way, the climate has left the glacier so far behind that it is no longer capable of “catching up”. Appropriately tentative suggestions are made to account for the acceleration of loss, including significant late-winter warming, increasing glacier slope and increasing coverage by thin debris. These would all be suitable subjects for further investigation.

Notwithstanding this favourable assessment, there is still scope for considerable improvement in clarity, stylistic correctness and removal of typos, but if the authors can satisfy the editor about the changes suggested below I would not anticipate a need for yet another review,

*Substantive Comments*

P2

L6, L9           The relation between the 1999 topographic map and the year 2000 that is mentioned at L9 should be clarified.

L17              Rewording needed to clarify the emphasis. “still” and “overall” should both be deleted, and “were” should be “was”, but I do not understand why the mass-balance clause begins with “but” when it seems to agree with the main deceleration clause.

L23-24          I would suggest “by the strong disequilibrium”, and change “climatic conditions” to “climate”.

L8-9             Do you know that the LIA “ended” in the mid 19th century? Unless you have firm data, e.g. from lichenometry, I would say “believed to have been in ...”. And strictly the LIA *culminated* rather than ended then.

P4

L25              “accumulation area ratios”. An “accumulation ablation ratio” could only be the ratio of the accumulation area to the ablation area, which would range inconveniently between 0 and infinity (as would be nearly true of the Antarctic Ice Sheet).

P7

L4               Delete “short”. (You do not yet know that it is over, the two years of slight mass gain being insufficient to establish the point.)

L10             The longitude and latitude of the glacier would be useful information here.

P9

L1               “a.s.l., 2.7 km from the glacier)”. (As at P13 L10.)

L19             I do not understand “unified working under”, but a separate sentence should probably be given to the selection of the datum ED50. At P12 L14 there should be an explanation of how

the DGPS positions referred to ETRS89 were reconciled with the rest of the work done in ED50.

P10

L6

Replace “late summer of 2010” with the exact date if it is known.

P11

L14

More information is needed. It is not obvious how to calculate uncertainty in area given only an uncertainty in position.

P12

L14

See comment at P9 L19.

L19-20

This sentence is incoherent and does not give enough information. Replace it with a proper explanation of how you calculated the uncertainties in the rates of elevation and mass change.

P13

L2-3

This is an odd way of saying what needs to be said. Perhaps “overestimate the mass loss rate for 1981–1999.”

L13-14

What about October?

P17

L17-18

“The greatest thinning was at ...”. Consider rationalizing the terminology; we have had “depth loss”, “thickness decay” and now “loss of thickness”. “Thinning” would be clearer than all of these.

P18

L1

The mixture of signed and unsigned losses and gains makes this section especially hard to follow.

P19

L4

Clean up the garbled “0.070.08”.

L10

Nine readers out of 10 will not know that “rimaye” is the French for “bergschrund”, which is the almost universal technical term.

P21

L19-22

“is that increasing slope of the glaciers, due to greater thinning at lower elevations, affects snow accumulation and constitutes another ...”. But how does the slope “affect” accumulation? Are the lower elevations experiencing greater ablation, in which case the hypothesis is not about accumulation? Or is more snow avalanching off the glacier? Incidentally, there is nothing wrong with “distal” and “proximal”, but they are more common in geomorphology, and most glaciologists have to pause to work out which is which. (At least, I do.)

P22

L24

Delete “average”; you mean “total”. Change “decrease of glacier depth” to “thinning”.

L25

The text keeps switching between m of thickness change and m w.e. of mass change. The earlier numbers in this paragraph are all mass changes, and now the reader suddenly has to change back to thinking in units of length. In other parts of the text, both units are presented, which makes for difficult reading in a different way (too much indigestible information). Along with consistent use of minus signs, I think that presenting changes in just one unit would improve the manuscript greatly. The obvious choice would be m of thickness change, given that the density is only assumed (as in most other geodetic studies).

P23

L1

As far as I can tell from section 3.1, no measurements were made in 2000, so I do not know what this sentence is about.

L10-12

Delete “As mentioned before, also”, and change “must” to the more cautious “may also”. Your conjectures are persuasive, but you have no actual evidence.

Figure 1

The UTM zone of panel a should be mentioned in the caption. The eastings in Figure 5 are ~492 km greater than those of Figure 1, and this must be explained (and corrected if it is an

error). (The scale of a UTM projection is true at eastings of ~320 km and ~680 km, so the zone chosen for Figure 5 is slightly “worse” than that of Figure 1. But the error is negligible.)  
 Table 1 Give Table 1 its correct number, and change “inform of” to “are”.  
 Table 2 The errors that end with a decimal point need a following decimal digit. The caption should explain the integers that appear in the third row.  
 By propagation of the errors in area the errors in area change should be much larger than those given. For example for 1986 to 1999 the upper-glacier error in area change should be  $\pm 0.36$ , not  $\pm 0.06$ . This illustrates why a more complete description and justification of the error analysis needs to be provided. (See P11 L14 and P12 L19-20 above.)  
 This table should be expanded to give all of the thickness changes (or mass changes if you prefer) as well as all the area changes. After all, you yourself assert (correctly) that mass-change measurements “give better information” than measurements of area or length change (P6 L2). This would allow some space to be saved in the text on P17, and perhaps even on P18-19.

*Stylistic Comments*

- P2
- L10 “three times” (no hyphen).
- L12-14 “ $\pm 1.80$ ”, “ $\pm 0.10$ ”, “ $\pm 0.40$ ”, etc. Try to make the whole manuscript consistent in the number of decimal digits provided – a small change that will improve readability noticeably.
- L18-19 Delete “that occurred”.
- L20 “seem not to be enough”.
- L21 “have”.
- L22 Delete “generalized”.
- P3
- L17 “Ötztal”.
- L18 “ $-0.30$ ”, “ $-0.90$ ”. It is a mistake, and introduces ambiguity, to think that losses must not have minus signs. If both gains and losses are unsigned the reader has a much harder job of following your discussion, especially if losses sometimes do have minus signs as at L23-24 (where one is an en dash and one is a hyphen; try to use the en dash throughout). Check the entire text for this.
- L24 “0.7 m” (space).
- P4
- L4 The meaning of “white glacier” is obvious, but it is a very unusual term. It would be simpler just to say “during the LIA, evolved into a rock glacier during the mid-20th century and has suffered marked degradation ...”.
- L7 “southernmost” (no hyphen). (I am pleased to see that this claim has been made more moderate in the revised version. In fact Calderone and the Jezerces glaciers [Milivojević et al. 2008 *Quaternary International* **190** 112-122] are slightly to the south of the Pyrenean glaciers.)
- L19 “Ossoue”.
- L22 “strong since the 1970s”.
- P5
- L1 “current climate”.
- L3 “increased by”.
- L6 “of the glaciers”.
- L10 “on”, not “in”.
- L17-18 As written this makes no sense. A comma is essential after “long-term” (such that there are three timescales of evolution).
- L23 “have examined”.
- P6

L1, L4 “estimates”.

L5 Is this author’s name “Sanjosé” or (as at P22 L33) “San José”?

L8 “based on the glaciological”.

L10-11 “on” both glaciers. Minus signs are needed, as at L15 below. And “thinning” might be preferable to “depth loss”.

L16 “focuses on”.

P7

L1 “associated to a persistently positive North ...”.

L17 Change “next” to “subsequent”.

P8

L4 Change “unique” to “single”.

L10 “disappeared”.

L12 “referred to”.

L21 “estimate” (but perhaps “observation” would be clearer).

P9

L5 “föhn” or “foehn”. The latter is only used when your keyboard cannot produce an o-diaeresis.

L15 “three DEMs”.

L18 “have a cell size of 2×2 m” (or “4×1”, or whatever is correct).

P10

L1 “September 1981” (space).

L8 Change “vertical accuracy” to “elevation”.

L10 Delete “the validity of”.

L12 “terrain near the studied glaciers”.

L13-14 “larger vertical errors”. (“higher” is a confusing adjective when used to qualify vertical quantities.)

L17 Delete “punctually values in the range of”.

L19 “have smoother topographical surfaces, it”.

L21-22 “for DEM differences was < 2.5 m for 1999 minus 1981 and < 2.0 m for 2010 minus 1999”.

L24 “alter the accuracy of the elevation changes”.

L25 “both these errors were considered”.

P11

L2-3 Commas after “comparing” and “procedures” would improve readability.

L12 “control points” (no hyphen).

L14 Delete “value”. “to calculate the uncertainty of glacierized areas”.

P12

L1 Delete “width”.

L4 “the cloud of points” (!).

L9 Delete “Thus,”.

L10 “were placed”.

L15 “for the set of target coordinates was ±0.05 m ... and ±0.10 m”.

L18 Change “40 cm” to “0.40 m”. A change of units here is confusing and unnecessary.

L23 “of firm”.

P13

L1 “adopt” rather than “take”.

L8-10 “The absence of changes ... (2.7 km), suggest that the station ...”.

L16-17 “made it necessary”. “seasons”.

L19-20 End the sentence at “ablation”.

L20-21 “because June and November are the months when ablation and accumulation respectively become generally evident ...”.

L23 “Kendall’s” (correcting the strange apostrophe).

- L23-24 “for Góriz were contrasted with those from three”.  
P14
- L9-10 “at Góriz”. All or nearly all the instances below of “in <place>” need to be changed to “at <place>”. In English idiom a small place is thought of as a point unless the sense implies that it has spatial extent. (E.g. “in” is correct in “If you live in Madrid you suffer three months of invierno and nine months of inferno.”.)
- L12-14 This sentence has to be disentangled. It gives 2<sup>1</sup> temperatures and tries to distribute them to 2<sup>3</sup> possibilities (two anomalies, highest and lowest; two periods; two kinds of temperature).
- L18 “at Góriz is in line with that observed at the three”.
- L20-21 “for either the accumulation period or the ablation period during 1983–2013”. “At monthly resolution” or “On a monthly basis”.
- L22 Change “detected” to “exhibited”.
- L22-23 “increases in May and June, and ... and December, for both maximum ...”.
- L24 “reveal”.
- P15
- L1 “at any”.
- L9 “for most”.
- L12 Insert “significant” after “statistically”.
- L14 “were found at any”.
- L17 “of the longer”.
- L18 “2013”, not “3013”. “exhibits”. Italicize *p*.
- L19-20 “but did not reach statistical significance”.
- P16
- L7 Delete “respectively”, and change “around” to slightly cooler than”.
- L15 “between 1973 and 1978”.
- P17
- L2 Having objected to the switch from m to cm at P12 L18, I have to admit here that the hectare is preferable to the square kilometre, because it requires fewer decimal digits.
- P18
- L12 “losses”.
- P19
- L22 “three times” (no hyphen).
- L23-24 “the rate of loss ... was double that observed”.
- L24 “reported for”.
- P20
- L1 Delete “decline”
- L2 Delete the comma, change “is” to “was”, and provide the same number of decimal digits in both mass-balance rates.
- L3 Delete the comma.
- L7 “that during most”.
- L8-9 “did ... was” or “does ... is”. Change “in” to “at”.
- L22 “that a shift towards more negative NAO has affected the recent evolution”.
- L24-25 “no temporal trends of either variable are found near Monte Perdido since the 1980s.”.
- P21
- L1 Delete “Thus,”.
- L2 Presumably this should be “during the 2000s”. A paper published in 2010 can have nothing to say about changes “after the 2000s”.
- L5 Change “research” to “study”.
- L6 Delete “the available series of”.
- L7 Delete “series available”.
- L13 Delete “spanning”.

L19	“hypothesis”.
L24-25	“-0.39”, “-0.72”.
P22	
L1	“those reported”.
L2	“-0.36”, “-0.70”. “yr <sup>-1</sup> ” (superscript; same at L7 below).
L5	“Carturan”.
L5-6	“lower than those of the fastest retreating ... or that reported for the”.
L8	Change “in” to “on”, and “compared to the lat[t]er” to “than on the French side”.
L9	“on the southern”. “confined to”.
L10	“and the least exposed locations”.
L11	“shielding”. Change “Oppositely” to “In contrast”.
L12	Delete “still”. “on an eastward slope”.
L15	“responsible for”.
L16	Delete “currently”.
L25	“three-year period”.
P23	
L2	“affects almost”.
L3	Change “affects indicate that” to “, so”.
L4-6	End the sentence at “survive” and begin a new one: “There can be years with mass gain, but there is loss in most years and ... in fact there is no cumulative accumulation.”.
L21-22	“westernmost”, “easternmost” (each only one word).
P24	
L4	“response of its mass balance to”.
L15	“The authors are grateful for”.
P25	
L10	“Névés”.
P26	
L15	“Central Pyrenees” (space).
P27	
L10	Do not capitalize titles of papers.
P28	
L1	Change “Michael” to “M.”.
P30	
L17	“change”.
P31	
L4-8	The two Marzeion references should follow the Martínez de Pisón reference. Marzeion et al. 2015 is now in <i>The Cryosphere</i> , <b>9</b> , 2399-2404.
L16	<i>The Cryosphere</i> , <b>9</b> , 1773-1795.
P32	
L1, L3	“Pedido” is a possible participle in Spanish, but surely it should be “Perdido”?
L4	Change “En” to “In”.
L19, L22	Insert line breaks before “Reinwarth” and “René”.
Figure 2	Spelling of “accumulation” should be corrected in panels a, c and e.
Figure 3	“at the stations”. Change “inform of” to “give”. Italicize <i>p</i> in “ <i>p</i> <0.05”.
Figure 6	Panel letters should be added.
Figure 7	“same” is unnecessary. Change “4” to “four”.