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The Cryosphere Discussions

Interactive comment on "Climatic drivers of seasonal glacier mass balances: an analysis of 6 decades at Glacier de Sarennes (French Alps)" *by* E. Thibert et al.

Anonymous Referee #3

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General Comments:

The authors provide a detailed analysis of 6 decades' mass-balance data from Glacier de Sarennes. Variance decomposition is used to extract a refined temporal signal, from which change points, trends and random fluctuations in seasonally differentiated mass balance data are identified. These data are then used to determine the relationships between mass balance response to both local – and synoptic - scale meteorology. Specific attention is paid to processes of accumulation and ablation before and after the identified change points. Increases in accumulation since 1976 are attributed to warming in early and late winter, whilst the more negative summer balance since 1982

is found to mainly result from a prolongation of the ablation season. The authors also provide a useful analysis of ELA sensitivity and examine temporal variability of ablation response to temperature (melt factors).

Overall I think that this is a well written, thoughtful and scientifically useful contribution to The Cryosphere. The quality and length of the mass balance data, and the thorough treatment they are afforded in this paper is a substantial attribute of the presented work. I find the change point analysis provides a particularly useful framework for probing changes in the prevailing meteorology and there are several important conclusions that the authors present; the substantial effect of prolonging melt season and the stability of melt factors over the 60 year period are two such findings that will be of interest to many readers.

However, I feel that the synoptic dimension of this research is weakly developed and needs to be addressed. The choice of investigating the NAO's influence on the mass balance components seems to be a choice of convenience, rather than of scientific merit and the initial justification for its inclusion is weak. Indeed, the absence of any substantive relationship found after the analysis, leaves me with the impression that little is gained from this part of the study.

In summary, I think the paper should be published, but first needs to be improved by either i) omitting the synoptic aspect of this research and expanding some of the other issues raised in this paper (see the remarks in 'specific comments'); or ii) more clearly defining the aims of the synoptic part of this study, and then adopting a means of analysis to suit. An analysis of weather types (e.g. Grosswetterlagen), or 'local' pressure gradients (as alluded to in the conclusion), would probably be more appropriate for extracting information about synoptic controls on mass balance (see e.g. the classic study by Hoinkes, 1968).

Specific Comments:

Considering the emphasis that is placed on the ANOVA employed in this study, I think

that the section where this is introduced could be a little more comprehensive. For example, how do you calculate the trends? I find this particularly interesting because the authors subsequently correlate trends and NAO anomalies; trends are affected by multiple values, and each value is therefore not independent. Should some mention be made about this with regards to the significance of the correlations? The same point applies to correlations with smoothed NAO anomalies.

Why can't the NAO series be analysed in the same way as the Sarennes data and the local meteorological data (p 2124; lines 10-15)? Surely it's the results that differ (multiple change points). Indeed, perhaps more should be made of these change points - there has been considerable research into change points of the NAO - how do these results compare (see Fealy and Sweeney, 2005 and references therein).

The large ratio between winter mass balance and Besse winter precipitation is interesting, particularly so, because the authors note that this value is similar to that obtained at Saint Sorlin glacier. However, if 'drifts from surrounding nonglacial slopes and avalanches' are responsible for the steep gradient, then wouldn't this indicate a strong dependence on local topography (i.e. snow blow area, exposure etc)? If so, then perhaps such similar values between these glaciers would be surprising. Maybe the authors could comment on this. In any case, to draw such a general conclusion (p2127, lines 31-32) is, I think, unfounded.

The analysis of melt factors is valuable, and I think it would be beneficial if this could be expanded upon. The authors report that the value of the melt factor has been stable throughout the period of study (for both snow and ice). However, it is also reported that the length of the ablation season has lengthened; this might be anticipated to affect the seasonally averaged energy balance (e.g. a lower average albedo if the ice is exposed for longer). Hence, the similarity of the melt factor before and after the change point might not be expected. Maybe this could be commented on.

Related to the above, I think Figure 11 should be appropriately labelled- do the lines

denote means or trends?

Where does the 10% value for the underestimation of ELA sensitivity come from in the discussion regarding ELA sensitivity to a change in temperature? Furthermore, p2132, lines11-12: I think more could be said regarding "feedback due to precipitation, cloud longwave radiation" (this sentence also needs re-wording) –how would changes of these forcing affect ELA sensitivity?

Technical Corrections:

p2125 line 3: change "points up" to "points out"

p2125 line 22: reword "Varying by 1-2°C, the rain snow divide does not significantly change results" to (suggestion): "Varying the rain snow divide by 1-2°C does not significantly change results"

p2127 lines 12-17: reword, this sounds very awkward.

p2131 line 23: "of 138°C" – shouldn't this be "**by** 138°C"?

p2135 line 3: change "form" to "from"

p2135 lines 20 – 21: DJF NAO anomalies are **negatively** correlated with summer balance (Table 3), hence need to change: " . . .this **positive** correlation between summer balance and DJF NAO anomalies.."

p2135 line 27: "Nesje", not "Nasje"

References:

FEALY, R. and SWEENEY, J., 2005. Detection of a possible change point in atmospheric variability in the North Atlantic and its effect on Scandinavian glacier mass balance. International Journal of Climatology, 25, pp. 1819-1833, DOI: 10.1002/joc.1231

HOINKES, H.C., 1968. Glacier variation and weather. Journal of Glaciology, 7(49), pp. 3-18.

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