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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 #1

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This paper presents a detailed analysis of the seasonal mass balance measurements of Sarennes Glacier, French Alps. The climatic drivers for the variabilities in winter and summer balance are detected and discussed. The authors find a significant prolongation of the melting season that explains two thirds of the recent increase in glacier mass loss. Furthermore, they quantify the sensitivity of the ELA and mass balance on air temperature change based on high-quality field data. The relation with the NAO is analyzed, but only when smoothing the NAO signal, a significant correlation is obtained.

The paper by Thibert et al. is well written, comprehensive and interesting in both the



analytical methods as well as the results, and will be a valuable contribution to The Cryosphere.

Nevertheless, I have some comments that should be addressed by the authors, and might contribute to a further strengthening of the conclusions. My major concerns are given below:

- 1. Novelty of the study:** Although the analysis is comprehensive the authors might try to better work out what is *new* and "exciting" about their study. The last years have seen quite a number of publications about the Sarennes mass balance series (Thibert et al., 2008, JoG; Thibert and Vincent, 2009, AoG; Eckert et al., 2010, JC; Eckert et al., 2011, JoG). Therefore, it is important to clearly make the separation of these studies which are based on the same data set.
- 2. Surface elevation changes:** Relating measured mass balance at point locations to climatic drivers is straightforward as the dynamic response of glacier area can be neglected. I however assume that some of the measurement points experienced a quite significant decrease in surface elevation also having an impact on the relation of local mass balance to climatic forcing. The lowering of the surface and the potential effect on the results should be discussed, and if necessary, be corrected.
- 3. Sensitivity to temperature change / surface albedo change:** The authors find a constant sensitivity of mass balance on air temperature throughout the entire study period. The implications of this in terms of future climate change and glacier evolution could be discussed in more detail.

On many alpine glaciers a decrease in surface albedo was observed in the last years (e.g. Oerlemans et al., 2009, JoG). I assume that this might also be the case for Sarennes. Could the authors comment on this, and investigate whether a potential decrease in surface albedo (or a change in the energy balance components in general!) might cause a change in the sensitivity of mass balance



to temperature change. As this sensitivity is basically the degree-day factor that is used in many modelling approaches of snow and ice melt, a more in-depth assessment of this issue might be of major interest to many readers.

4. **Prolongation of melting season:** I find the quantification of the relative importance of melting season length on the recent increase in melt rates intriguing, and the authors might want to highlight this result even more. Why do the higher temperatures only have such a small effect? Is the simple relation "higher temperature cause more melt" a misunderstanding, and should we direct more of our future attention to the prolongation of the melting season? Additional analysis of the drivers for the high relative importance of melting season prolongation would be most interesting and contribute to the quality of this paper.
5. **NAO-effect:** The discussion of the effect of the NAO on Sarennes Glacier mass balance are not very conclusive and I asked myself if we know more after the analysis. However, I am not sure to provide any good advice how to strengthen this section. Furthermore, is the smoothing applied to get a significant correlation is statistically sound? When producing smoothed time series based on running means, the number of data points stays the same, but every annual data point is used more than once (running mean!) in the correlation. Maybe the authors might comment on that. I would rather propose to build pentadal / decadal means first, and then correlating these low-frequency components.

In the very last sentence of the paper the authors take up the issue that Alpine mass balance could also be correlated with the Atlantic Multidecadal Oscillation (AMO). It is not clear why it was decided to use only the NAO for detecting potential large-scale drivers and climatic control on the mass balance of Glacier de Sarennes, and to neglect other possible indices. As it stands now the statement of the last sentence remains poorly supported by the analysis performed in this paper.

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- **Several instances:** Rank citations consistently, i.e. after date of appearance.
- **page 2119, line 8:** When discussing the Claridenfirn data (almost 100 years of seasonal mass balance measurements), also the equivalent series of Aletsch- and Silvrettagletscher should be mentioned.
- **page 2121, line 25:** How were the trends determined?
- **page 2127, line 10:** Is there some explanation why the findings of this study are inconsistent with the results by Beniston and Jungo (2002)?
- **page 2127, line 16:** Clariden
- **page 2128, line 13:** Is it possible to compare these increases in melt season length with studies for other glaciers? Are the findings consistent for the Alps, or even beyond?
- **page 2128, line 21:** Here, and for other analyses in this paper, snow and ice ablation is separated. The authors state that this is done directly based on the field measurements. However, some more details on this procedure need to be given. According to the data section, mass balance readings are performed 6-7 times throughout the melting season. But is this sufficient to obtain a daily accuracy that is needed for the investigations carried out in this paper? Probably some temporal interpolation between the individual measurements is performed. This should be described, and the authors should address the potential uncertainties in their conclusions (e.g. melting season length and sensitivity to temperature change) due to their approach.
- **page 2129, line 24:** Omit "Glacier" (only Claridenfirn)

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- **page 2130, line 15:** How does this sensitivity compare to degree-day factors in temperature-index models, as e.g. compiled by Hock (2003, JH)?

TCD

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