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Interactive comment on "Glacier dynamics in the Western Italian Alps: a minimal model approach" *by* D. Peano et al.

Anonymous Referee #1

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General comments:

This paper deals with the response of glaciers in the western Italian Alps to climate change. The objective of this study is to test a minimal glacier modeling approach to reconstruct snout fluctuations in the past. The authors use this model and climatic scenarios to obtain the evolution of these glaciers for the next century. The approach followed by the authors in this paper is very simple and requires few data. This paper is generally clear. Unfortunately, this paper contains several misleading statements and I believe that the results and conclusions cannot be supported by the simplified models used in this paper.

First, the method used to simulate the mass balance is very simplified. The authors used seasonal (June-September) temperature and precipitation October-May) data to

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calculate the wide glacier mass balance. It is clearly an oversimplification for the following reasons. The authors adjust three parameters a, b and c to fit reconstructed snout changes on observations. From Table 3, "b" can have positive or negative values. For negative values of "b", it means that a precipitation increase leads to a decrease of mass balance. Similarly, Table 2 shows a positive value for "a" (Grand Etret) which means that an increase of temperature would lead to an increase of mass balance. I do not believe that the observations can support these results. Consequently, I do not believe this approach can be used for projections. Moreover, from this paper, it is difficult to evaluate the relationships given that the authors do not provide the performance of the correlations between observed and reconstructed mass balance (for Ciardonney and Grand Etret glaciers). More important, the parameters a, b and c have been calculated using the relationships between wide glacier mass balance and temperature and precipitation, calibrated over the last decade. Equation 5 means that wide glacier mass balance does not depend on the geometry of the glacier. From numerous previous studies (Elsberg et al., 2001; Harrison et al., 2005; Huss et al., 2012), it is obvious that these relationships changed with time due to the geometry changes of glaciers. In Conclusion, the authors recognize that "our approach is sensitive on changes in the a, b, c parameters values" but I believe that it is not sufficient. The change in the surface areas cannot be neglected whatever the approach. Consequently, these relationships obtained from observations of the last decades cannot be used for the next hundred years. The authors should take into account the decrease of the surface areas and thickness changes. Secondly, in order to reconstruct the dynamic behavior of the glaciers, the authors used the very simplified approach of Oerlemans (2011) with idealized glaciers geometries. According to this approach, many large assumptions have been made. The width of each glacier is fixed and uniform over the entire surface area of the glacier. The thickness is uniform too. The width does not change with time. The slope is uniform over the entire surface area. This is obviously a crude approach. Following this oversimplified approach, the response of the glacier is related directly to mass balance. The authors recognize that "The approximation assume an

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instantaneously response time to climate forcing". According to this direct relationship, the reconstructed length changes should be similar to the calculared cumulative mass balance changes. Consequently, from Figure 6, we should conclude that the mass balance changes are very different from a glacier to another glacier. This conclusion, resulting from the reconstruction of this model, is not supported by observations. Indeed, several studies based on observations show a very similar pattern of cumulative mass balance over the last century (Vincent, 2002; Huss et al., 2008). I added some specific comments below but, unfortunately, I believe this paper is not ready for publication. This study is based on coarse assumptions and approximations which lead to results which cannot be supported by observations. Consequently, the future projections cannot be not reliable.

Elsberg, D. H., W. D. Harrison, K. A. Echelmeyer and R. M. Krimmel, 2001. Quantifying the effects of climate and surface change on glacier mass balance, Journal of Glaciology, 47(159), 649–658.

Harrison, W. D., D. H. Elsberg, L. H. Cox and R. S. March, 2005. Different mass balances for climatic and hydrologic applications, Journal of Glaciology, 51(172), 176.

Huss, M., A. Bauder, M. Funk, and R. Hock. 2008. Determination of the seasonal mass balance of four Alpine glaciers since 1865, J. Geophys. Res., 113, F01015, doi:10.1029/2007JF000803

Huss, M., R. Hock, A. Bauder and M. Funk. 2012. Conventional versus reference-surface mass balance. J. Glaciol., 38, 278-286, doi:10.3189/2012JoG11J216.

Vincent, C. 2002. Influence of climate change over the 20th Century on four French glacier mass balances, J. Geophys. Res., 107 (D19), 4375, doi:10.1029/2001JD000832.

Specific comments :

p. 1480, l. 11-12: : "High mountain regions present an heterogeneous landscape,

which includes glaciers, rocks, debris, streams and lakes, and rich ecosystems": I believe this sentence is unuseful. The authors should remove it.

p.1480, l.21: "they can be used as indicators of the "health" of the local mountain environments Âż what does Âń the health of glaciers Âż mean ?

p.1481, l.1-3: : "According to the combination of these and other factors, some glaciers are more sensitive to variations of winter precipitation, while others are more sensitive to summer temperatures. Âż :The authors should add a reference

p. 1481, l.4-5 : "The time and mode of response to climatic oscillations vary from one glacier to another, and even between different parts of the same glacier (Calmanti 5 et al., 2007). Âż : not clear : what are varying ? thicknesses ? ice floxw velocities ? This sentence should be removed.

p. 1482, l. 1-5: "Most of them have been classified as small or very small: 101 (13 %) have a surface smaller than 0.05 km2, and 591 of them (73 %) have a surface ranging between 0.05 to 1km2. The inventory identified 308 glaciers in the Western Italian Alps (38% 5 of the total), accounting for 42% of the total glacierized area in the Italian Alps.": I do not think these information are needed in this paper. The authors should remove these sentences

p. 1483, l. 1-3: "Series of measured length variations, ELA position and mass balance data are available from 1971 to 2009 for the Ciardoney glacier and from 1997 to 2009 for the Grand Etrèt glacier, as shown in Fig. 2.": confusing: the mass balance data are available since 1992 and 2000 for Ciardonney and Grand Etret respectively, not since 1971 and 1997. Rephrase it.

p. 1483, l.14: the authors should give the size of the grid in kms.

p. 1483, l.19-22: this sentence is confusing. The surface mass balance respond to meteorological variables but the response of snout fluctuations is more complicated. Rephrase it.

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p. 1483, l. 23-25: the seasonal averages precipitation and temperature have been standardized by removing the average and dividing the standard deviation. Is it useful to divide by the standard deviation (normalized values)? The authors should give more explanations.

p. 1484, l. 1-12: the authors use (i) temperature and precipitation from ARPA database between 1959 and 2009 to calibrate the model and (ii) temperature and precipitation from RCP projections for the future. These data are very different (grid size...). The authors should provide more explanations about the connection and the overlapping of these series over the common period.

p. 1486, Equation (4): the authors should rewrite Equation 4 to be clear. Equation 4 is similar to the first term of the second member of Equation 6 in Oerlemans and others (2011). The authors should explain how they simplified the minimal model given Equation 4 is a simplification of the very simplified model of Oerlemans and others.

p. 1485 and p.1486: the authors assume a constant value of width (W): no change with time. Do the observations support this assumption over the last 50 years ? and for the future ?

p. 1486, l.1-18: The response of the glacier is related directly to mass balance. The approximation assume an instantaneously response time to climate forcing. According to this direct relationship, the length changes should be similar to the cumulative mass balance changes. Consequently, from Figure 6, it would mean that the mass balance changes could be very different from a glacier to another glacier. This conclusion, resulting from the reconstruction of this model, is not supported by observations. Indeed, several studies based on observations show a very similar pattern of cumulative mass balance over the last centuries (Huss et al., 2008; Vincent, 2002).

p. 1487, l. 7-17: The parameters a, b and c have been calculated using the relationships between wide glacier mass balance and temperature and precipitation. These relationships obtained from observations of the last decades cannot be used for the

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next hundred years ((Elsberg et al., 2001; Harrison et al., 2005; Huss et al., 2012).

p. 1487, l. 18-26: the authors should provide the scores of these correlations for each variable and both variables. A table with correlation values is needed.

p. 1487, l.19-26: check the unity of a, b and c.

Interactive comment on The Cryosphere Discuss., 8, 1479, 2014.