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Interactive comment on "Air temperature variability over three glaciers in the Ortles-Cevedale (Italian Alps): effects of glacier disintegration, intercomparison of calculation methods, and impacts on mass balance modeling" *by* L. Carturan et al.

Anonymous Referee #1

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General comments

The authors present a new dataset from several high-elevation weather stations installed during summer 2010 and summer 2011 to study the air temperature distribution over three glaciers in the Italian Alps. This work aims to provide a comparison of different methods for calculating on-glacier temperature from off glacier data. The methods are commonly applied by mass balance models forced with off-glacier data and the pa-

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per demonstrates how the accuracy of air temperature estimations impacts the outputs of such a model. Overall the paper is well written. The motivation and methodology is clear and well described. However, on the basis of the data presented, I do not see any new insights regarding the effect of glacier disintegration on air temperature variability. Title, abstract and conclusion 1 suggest that the paper provides new experimental evidence about the changes in the air temperature field during glacier decay. This finding is supposedly supported by stronger cooling effects observed in the ablation area of the larger La Mare Glacier than on the very small Careser Occidentale Glacier. However, the authors ignore in their discussion that this difference in temperature depression can be very well explained by differences in flow path lengths (FPL), which is the most important variable of the tested methods to extrapolate air temperature over a glacier. The FPL explains perfectly the differences in the cooling effect observed at Car-gl_3144 (FPL 354 m, cooling effect -0.18°C) and Mar-gl_3140 (FPL 805 m, cooling effect -0.47°C) or Mar-gl_2973 (FPL 2132 m, cooling effect -0.9°C) in summer 2011. There is indeed no sign of a "reinforcement mechanism during glacier decay" (page 6148, line 13), and glacier disintegration seems to have no effect at all on air temperature variability in function of FPL. This is my major concern and I therefore doubt that the title of the paper reflects the content of the paper and major findings of the study.

For a revised paper, the authors should consider calculating glacier-wide summer glacier mass balances and not only point mass balances at stake locations like in the current paper. The main interest of the different methods to distribute air temperature over a glacier is at the distributed scale, and not at the point scale. I also think the meteorological data that are available have the potential to provide insights for distributed modeling beyond the discussion of existing methods for air temperature distribution. In the current manuscript the authors stick to the methods available from literature although it is known that the methods are not valid for the specific conditions. For instance the G&B model is not valid close to the glacier borders (the G&B model only considers two processes of an air parcel traveling down an infinite glacier slope:

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adiabatic heating and turbulent cooling), and the G&B model is also not applicable to Car-gl since this glacier does not have a down-glacier wind, which is the main assumption of the model. In a revised paper the authors could therefore address several research questions regarding this issue: What would be the best modeling strategy for sites like Mar-gl_2709 or the Careser glaciers? How relevant is it for distributed glacier mass balance modeling to take into account 'border effects' on air temperature? The authors are aware of these open questions as they make clear by conclusion 2 ("these methods... still need refinements, in particular for areas close to the margins and for the smaller units..."). The paper would be much more interesting if some of these questions could be answered or at least addressed and if the relevance of these open questions for distributed mass balance modeling could be clarified.

Other main comments

- Based on the text it seems that the method by Khodakov (1975) is valid only for the location of the firn line. It is not clear to me how this method can be used to calculate the cooling effect at all the stations. Is L in equation (1) equal to the Flow Path Length (FPL) or is it a constant?

- A comment on the first three methods: All of them are empirical and the coefficients were calculated in very different environments. In my opinion, they oversimplify the problem and are clearly inferior to S&M and G&B methods, which reflect a better understanding of the physical processes involved in the air temperature distribution over melting glaciers. They are also not commonly applied by mass balance models. I wonder if it is necessary to include them in the paper.

Specific comments

- Title: not sure if 'glacier disintegration' is the correct term here. Maybe 'glacier fragmentation' or 'glacier retreat' would be more appropriate.

- 6148 25: What is snowfall limit?

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- 6149 20-30: Maybe more recent references than Charbonneau (1981) and WMO (1986) would be more appropriate.

- 6152 10: Which was the explanation gave by Petersen et al (2013) for this result?

- 6152 17: Indicate by numbers what you consider small, medium and large glaciers

- 6153 22: What do you mean by "active" retreat?

- 6156, Section 3.3: It seems most of this is repeated later in section 4.2. Consider removing this section.

- 6160: The mass balance model only considers clear sky radiation and not the daily cloudiness. Daily variations in cloudiness therefore represent a source of error for mass balance calculations. Since incoming shortwave radiation is measured at the AWSs, why not considering daily cloudiness for mass balance calculations?

- 6161 15 and elsewhere: I think is better to say that the lapse rates are 'steeper' and not 'lower'.

- 6161 19-22: Here it is not clear when you are talking in general and when you refer to your data. Please re-phrase.

- 6161 20: Write standard deviation instead of SD.

- 6162 15: You do not know which is the best method to extrapolate above your highest off-glacier station (Bel_3328) since you have no data from there. Please re-phrase.

- 6166 9-11: Could you explain better why x0 is larger (x0=1440) when the freezing level is above the top of the flow line than when the freezing level is below this point (x0=0)? This is not clear to me.

- 6168 13: I do not agree that these results provide a quantification of mechanisms during glacier disintegration. Differences in the glacier cooling effect between Mar-gl_2973 and Car-gl_3144 can be explained by differences in the FPL (see general

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comments above).

- 6169 5-6: The loss of sensible heat does not have the opposite sign in the case of up-glacier wind.

- 6170 10-12: It needs to be mentioned that those methods also fail because there are other processes, apart from glacier cooling, influencing temperature at those sites.

- I think that the paper needs a Figure with the FPL of the studied glaciers. This is a key variable for all the methods (or at least S&M and G&B).

- Figure 7 caption text: 'summer 2010 and 2010', please correct.

Interactive comment on The Cryosphere Discuss., 8, 6147, 2014.