Response to H. Blatter (referee)

(original comments are in black, our response in *red and italic font*)

General comments:

The paper covers an important topic of modeling firn temperatures in high alpine regions. The paper is well written and structured. The paper is publishable if the below question are addressed adequately.

I have three questions concerning the numerical simulations of temperature profiles in the surface layer of firn and for the deep layer.

Specific comments:

1) At line 24 on page 5549 you assume "zero flux" at a depth of 16 m. However, in figure 12 it is obvious that the temperature gradient at 20 m depth is not zero, and I am sure that at 16 m, they are not zero either. I guess that your assumption is based on the assumption that at 16 m depth, there are no variations in the flux (or temperature) due to annual surface variations? However, this would only imply that the flux is constant, but not necessarily zero. How do you justify "zero flux", and have you tested, what impact a different constant flux would have on the results?

We agree that the heat flux at 16 m depth is not zero and we should rather use the flux inferred from measured temperature profiles between 3 July 2012 and 23 October 2012. Figure A shows that this heat flux is almost constant during the simulation period ranginge between 35 and 54 10^{-2} W m^{-2}. However, over such a short simulation period, basal heat flux has no influence on the modeled temperatures above 10 m depth (see figure B) and consequently it does not have any influence on our results. The heat flux influence over the simulation period between 16 and 10 m depth is inferior to 0.1K (figure B). We added an explanation regarding these points in the manuscript in section 3.2.

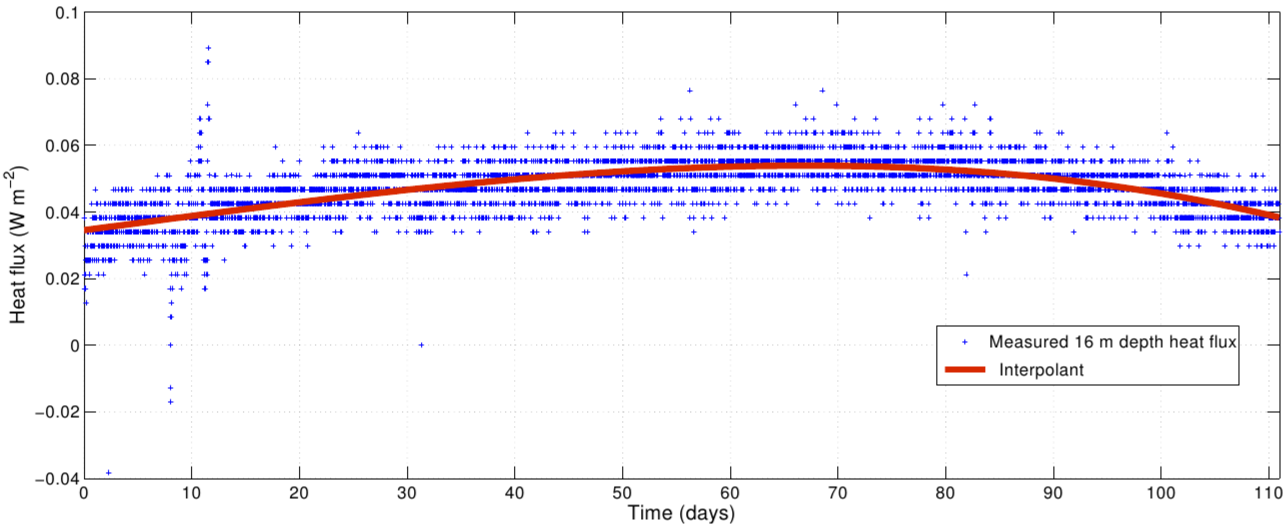

Figure A – Measured heat flux at 16 m depth between 3 July 2012 and 23 October 2012. The thermal conductivity used to convert temperature gradient in heat flux is set to 1.7 W m^{-1} K^{-1} according to measured firn densities at 16 m depth (820 kg m^{-3}) and density/conductivity relationship given by Calonne et al. [2011].

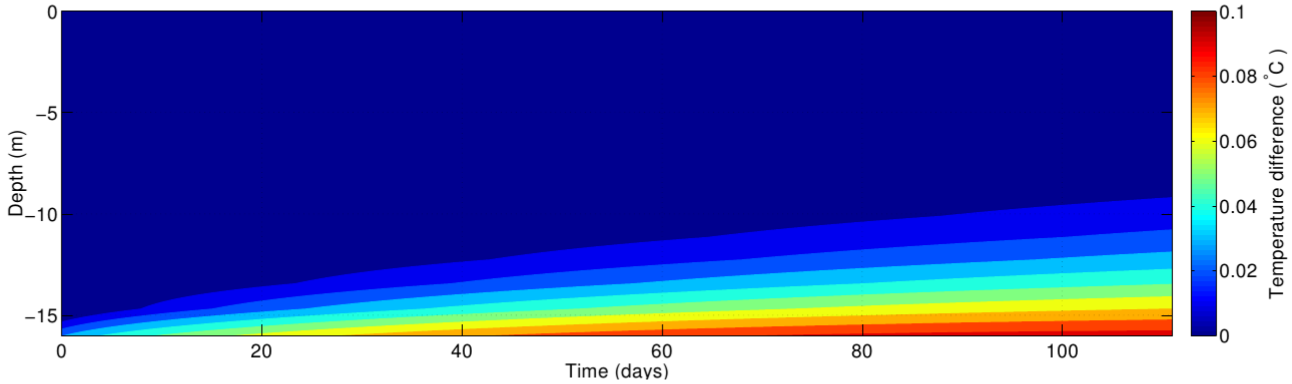

Figure B – Temperature difference between two simulations with zero-flux at 16 m depth and with a mean heat flux of 0.046 W m^{-2} at 16 m depth.

2) On lines 15/16 on page 5558 you wrote that "The basal heat flux is specified at 150 m depth in the bedrock because it can be considered to be constant at this depth. . ." Have you tested this for your multidecadal model runs?

We have tested this assumption by performing simulation at site 2 using a basal heat flux specified at 800 m depth where no change can occur over one century. We show that, at 150 meter depth, heat flux remains almost constant over the whole simulation period and the influence of a constant basal heat flux at 150 m depth on the modeled temperature profile in 2010 is inferior to 0.2 K (see figure C). Furthermore, in this study we focus on the surface temperature variations in the first few meters depth that are not influenced by the basal heat flux at 150 m depth for the simulation timescale. Our conclusions about surface temperature modeling with regard to climatic condition remain unchanged. An explanation has been added in the manuscript in section 4.5.

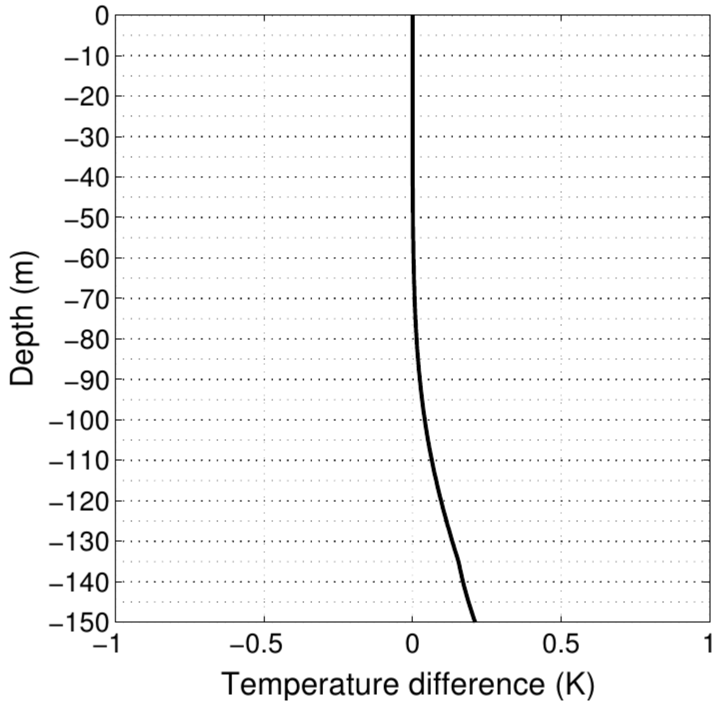

Figure C – Temperature difference between two simulated temperature profiles in 2010 at site 2 first with basal heat flux specified at 800 m depth and second at 150 m depth.

3) Your model runs span the period 1907-2012. What are the initial conditions? Have you tested to what extent your results for the present can be influenced by the choice of initial conditions?

Every simulation starts from an assumed steady state profile in 1907. These steady state profiles are calculated using a constant surface temperature called T_0 *at each site. We used, here, steady state temperature reconstructed in Gilbert et al. [2013] from temperature profile inversion at the three drilling sites. Only the deepest part of the temperature profile simulated at present (close to bedrock) is influenced by initial conditions. The initial profile is therefore well constrained by the simulated bottom temperature for the present but does not influence the upper part of the profile that is only influenced by surface conditions. An explanation has been added in section 4.5.*