Response to reviewer #1 (Lev Tarasov)

This is a nice model-based examination of glacial cycle permafrost evolution, extending and improving on various aspects of previous studies. The bedthermal permafrost model has appropriate detail and it's great to see a full surface energy balance coupling. The importance of appropriate bedthermal initialization is clearly shown. There is also some thoughtful physical analysis of some of the parametric sensitivities and time evolution. I have only a few comments below that can be easily addressed:

The included sensitivity studies address some of the bedthermal parametric uncertainties. However, the interpretable value of the results would increase if there was more discussion on the temperature uncertainty/bias of the CLIMBER 2 climate+ice sheet model. There are significant uncertainties in the climate forcing which in good part controls the ice sheet extent and thickness evolution. Both of these will affect bedthermal energy balance and permafrost extent.
Even better would be some ensemble results to partly quantify the uncertainties due to climate model parametric uncertainties (only bedthermal parametric uncertainties are considered) and climate model initialization. However, I suspect the computational time for such an endeavor would excessively delay revision.

We fully agree that we assessed only one source of uncertainties (related to bedthermal parameters) and that uncertainties in climate forcings are also important. We now made this point explicit in the paper. However, the latter source of uncertainties is difficult to assess not only because of computational cost but also because our climate model was carefully calibrated to simulate correctly glacial cycles. Obviously, any significant perturbation of climate model parameters will lead to producing of model versions which cannot simulate the temporal evolution of ice sheets correctly. This will make the entire uncertainties analysis not very helpful.

"Laurentide ice sheet (LIS) during the last glacial cycle. Marshall and Clark (2002) suggested that at the last glacial maximum (LGM) 20–40% of the LIS was warm-based but the value increased to 50–80% during glacial termination. Ganopolski et al. (2010) found a temperate base fraction of around 20% throughout most of glacial periods with only a minor increase during deglaciation. Studies including the effect of"
I'm curious why the much higher LGM warm-based fraction of Tarasov and Peltier (2007) isn't discussed nor mentioned. From my perhaps ice sheet centric orientation, that's an important statistic with respect to ice sheet evolution. Part of this difference can be attributed to the better initialization in the current study (going by the larger permafrost volumes with earlier initialization shown in figure 16). Is the rest due to a more advanced treatment of thermal conductivity and the full surface energy balance calculation? But as a counterpoint, the 2007 study had better constraint of LGM and deglacial ice extent/thickness through initial large ensemble calibration against a large set of paleo data. Quantification of the role of earlier initialization in explaining the difference could be made much clearer by a warm based fraction comparison of 120ka versus 780 ka initialization.

The value of warm-based fraction at LGM from Tarasov and Peltier (2007) has been added to the discussion.
As suggested by the reviewer, the initialization makes a difference for the LIS warm-based fraction. In the experiment initialized at 780 ka the warm based fraction is systematically 5-10% lower than in the experiment initialized at LGM (see figure 1 below).
However, even accounting for the different initialization the fraction of warm-based LIS at LGM is still about 20% lower in our study compared to Tarasov and Peltier (2007) (~30% vs ~50%). This difference can be attributed both to differences in climate forcing (first of all annual mean ice surface temperature) and ice sheet model formulation (in particular, the parameterization of basal sliding). This discussion has been added to the text.

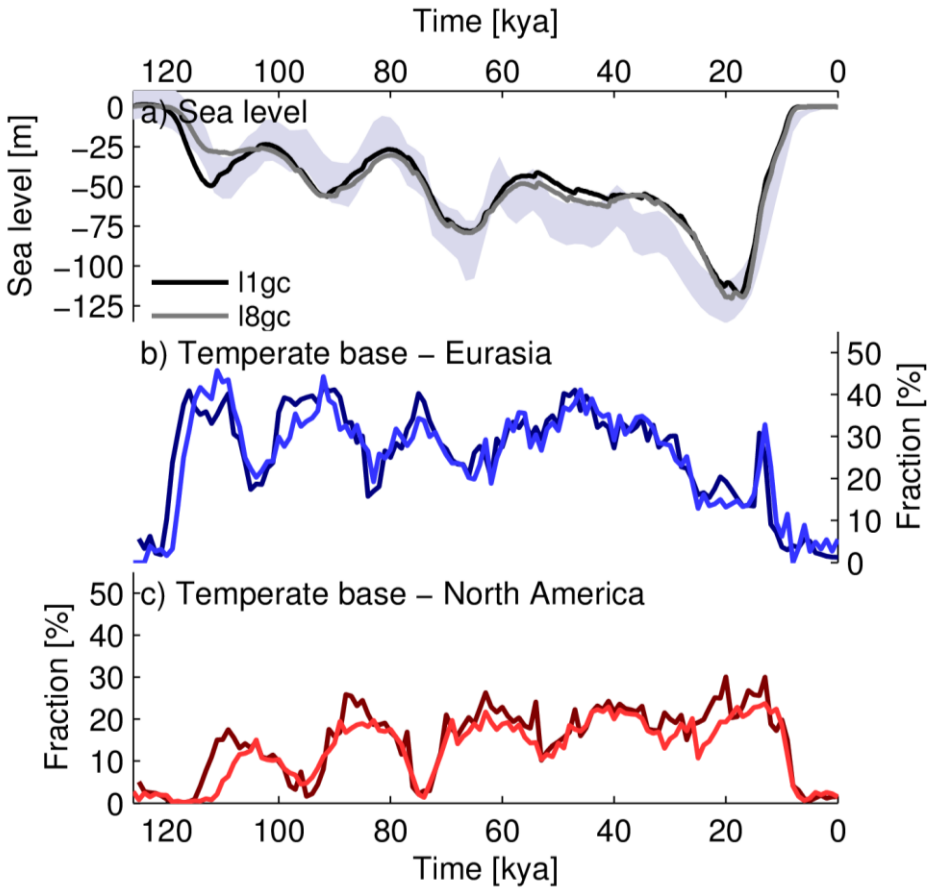

Figure 1 Same as figure 7 in the paper but for simulations with permafrost initialized at the LGM (dark colors) and at MIS19 (light colors).

"simulations indicate that deep permafrost has a memory of surface temperature variations going back to at least 800 kya."
An alternative to such a long run for bedthermal initialization would be an more appropriate choice of equilibrium temperature forcing for initialization, eg as described in Briggs et al, 2013 (TC).

The reported sentence was just intended to highlight the long timescale of deep permafrost. Since the bed will never be in thermal equilibrium on any timescale shorter than that, a more appropriate choice of equilibrium temperature forcing for initialization could affect absolute errors but does not affect the existence of very long response of permafrost.

"The thermal offset is not accounted for in our model as it would require a detailed representation of the seasonally varying active layer, which is beyond the scope of this study focusing on permafrost evolution over much longer timescales."
Or one can regress the impact of the thermal offset as done in Tarasov and Peltier, 2007.

The regression applied in Tarasov and Peltier (2007) is for the thermal offset between air temperature and ground temperature, not for the offset between near surface ground temperature and top of permafrost temperature as would be needed in our case. However we agree with the reviewer that in the future a simple regression between the two temperatures could be used.

"As already shown in Ganopolski et al. (2010); Ganopolski and Calov (2011) CLIMBER- 2 realistically simulates the Northern Hemisphere ice sheets variations over the last glacial cycles."
what does realistically mean? That word gets way over used by modellers. Please be more precise.

The sentence has been rewritten as:
"As already shown in Ganopolski et al. (2010) and Ganopolski and Calov (2011) CLIMBER-2 realistically simulates the overall Northern Hemisphere ice volume variations over the last glacial cycles, as indicated by the reasonably good agreement of modelled and reconstructed sea level and benthic d18O. The model is also able to largely reproduce the ice sheet extent and thickness at LGM (Ganopolski et al., 2010)."

** # minor grammar/wording **********

pg 558 It also allows to address the -> It enables the assessment of the

Done.

pg 560 does generally not freeze -> generally does not freeze

Done.

table 1, kw has wrong units, should be W/m/K

Has been corrected.