We would like to thank both reviewers for their careful and constructive reviews of our manuscript. Please find our responses (*italic*) to comments (**bold**) below. Where no response is given, the suggestion was incorporated exactly as indicated into the manuscript.

Reviewer #1

Specific comments

1) Consistent and proper use must be made of the terms 'mass balance' and 'surface mass balance'.

Agreed. However, while the glacier model does not include among other things ice dynamics, it does include some internal accumulation and ablation processes in the near subsurface. We have therefore amended the manuscript to use the term 'climatic mass balance,' following the recommendation of the Glossary of Glacier Mass Balance and Related Terms (2011) to denote both the surface and near-subsurface mass balance. Accordingly, the model acronym has been changed to WRF-CMB.

2) It should be clearly stated that in the study presented here, glacier geometry is kept constant, so full interaction (including ice dynamics and hence the temperature elevation feedback) is not aimed for.

Added to Sect. 2 Methodology (p107, l26): "… with the period of 1–25 June discarded as model spin-up time. Here we use the term interactive to denote surface-atmosphere exchanges through heat, moisture and momentum fluxes only and not through topographic feedbacks, as glacier geometry is held constant over our brief simulation."

3) The authors state that increasing the diffusion (essentially lowering the model resolution) enhances the precipitation. This is somewhat unexpected. Are all prognostic variables subjected to this smoothing? How do you explain that smoothing enhances precipitation in mountainous areas?

In WRF, the 6^{th} order diffusion scheme is applied to all three wind components, potential temperature, moisture variables, passive scalars, and subgrid TKE (Knievel et al. 2007). There are some previous studies that recommend that explicit diffusion schemes only be applied to wind variables (e.g., Zängl et al. 2004; Langhans et al. 2012); however this is not an option in the scheme available in WRF. Note that the 6^{th} diffusion option is highly scale selective, such that the high effective resolution of WRF is maintained (Knievel et al. 2007).

We decided to use explicit diffusion based on the findings of previous work: improved simulation of near-summit precipitation (Mölg and Kaser, 2011); reductions in grid-scale noise and energy while retaining the small-scale detail and energy spectral density of the vertical velocity (Kusaka et al. 2005; Langhans et al. 2012); and smoother cloud distributions (reduction in "grid-scale diamond" convective cells reported by Takemi and Rotunno (2003); Langhangs et al. 2012).

However, there are few studies on the influence of explicit diffusion on precipitation in complex terrain. Furthermore, the paper that presents the 6^{th} order diffusion scheme in WRF (Knievel et al. 2007) does not make a recommendation for the strength of the diffusion parameter (β in Eq. 2 in their paper). The authors state, "for many of our simulations we chose a coefficient of diffusion that theoretically produced a nominal diffusion rate of 24% per time step," for an application of WRF over relatively smooth terrain down to 1.1-km spatial resolution. In D3 of the WRF-CMB simulations presented in this manuscript, we selected β=0.36, which corresponds to a damping of $2\Delta x$ features by 36% each time step.

The increase in precipitation itself appears to result from additional diffusive transport of moisture along coordinate surfaces (in this study, diffusion is calculated along coordinate surfaces as the model in its current configuration is unstable when it is calculated in physical space). However, rigorous analysis of the influence of the diffusion scheme on precipitation and therefore glacier

CMB is complex and on-going work that will be presented in a subsequent study. In any case, it is clear that the choice of diffusion scheme, its strength, and its influence on the prognostic variables to which it is applied requires more investigation for our area of interest and model configuration.

The following changes have been made to the manuscript to emphasize the uncertainty in the influence of the diffusion scheme over complex terrain as well as our plans to explore its role in a future study:
p109, l21: "The choice of the diffusion parameter value is uncertain; sensitivity studies revealed that increasing the strength increased simulated precipitation at high elevations, which may be attributable to increased diffusive transport, with the best agreement with the Urdukas AWS data found for the selected value.

p123 l5: "Simulations of glacier mass balance are also inherently sensitive to the modeled solid precipitation \citep{molg11}, which is influenced in our study by the choice of microphysics scheme. Furthermore, the optimal choice of diffusion scheme, its strength, and its influence on simulated precipitation and therefore glacier CMB are beyond the scope of this paper and have not been investigated fully for our area of interest and model configuration."

p123 l8: "…however, the extent to which modelled CMB is dependent on both the model physics, the choice of numerics, and the spatial resolution of the finest domain represents an important uncertainty that will be explored in future studies."

4) With a model resolution of 2.2 km and filtering applied, the glacier is not resolved. Please discuss.
Amended p112, l15 to: "… with an average (maximum) width of 2.1 (3.1) km (Mayer et al. 2006). Therefore, in WRF-CMB the Baltoro glacier is represented by at least one grid point in the along-glacier direction and we resolve longitudinal rather than transverse gradients in surface conditions."

5) Page 115, section 3.2, first paragraph: if AWS and model gridpoint differ 300 m in elevation, then why is the temperature not at least 2 degrees different?
The fact that there is no offset between the AWS and model temperature data despite the elevation difference suggests that WRF-CMB has a positive bias at this grid point compared with the station data. The main driver of the temperature bias at this grid point is greater incoming shortwave radiation: on average, it receives an additional 112 Wm^{-2} over the simulation period compared with the AWS data. The discrepancy could be attributable to the calculation of topographic shading at 2.2-km spatial resolution (or to deficiencies in cloud cover that are consistent with missing simulated precipitation events. To clarify the source of the data disagreement, the daily-mean incoming shortwave radiation curve has been added to Figure 3. Another potential contributor to the temperature discrepancy is reduced or absent snow cover at this grid cell as a result of missing precipitation events. Underestimation of snowfall and snow cover could contribute to a temperature bias through its modulation of surface temperature and therefore sensible heat exchange with the overlying atmosphere. Unfortunately, we do not have snowfall or cover observations from the AWS site with which to evaluate this potential source of error.

The main intent of our comparison with AWS data is to show that WRF-CMB captures the approximate magnitude and variability of atmospheric conditions in the vicinity of one of the largest Karakoram glaciers, using the few available measurements. We evaluate the glacier component more rigorously using the stake and MODIS data, a comparison that is perhaps more representative due to the greater area considered and the fact that it directly considers improvements due to the inclusion of additional glacier CMB processes.

Amended p115 l17: "However, the good agreement in near-surface temperature despite a difference in real and modelled elevation of ~ 300 m (4022 vs. 4322 m a.s.l., respectively) suggests that there is a positive temperature bias in WRF-CMB at this grid point. The greatest contributing factor is higher incoming shortwave radiation: averaged over the simulation period, the surface in INT receives an additional 112 \,\unit{W\,m^{-2}} more radiation than measured by the AWS (not shown). The discrepancy is most likely due to insufficient simulated cloud cover and humidity (Fig. 3b), with a potential contribution also from the computation of topographic shading at 2.2 km resolution."

p115 l22: "Missing precipitation events are also reflected as discrepancies in the time series of relative humidity (cf. Fig.~3b, e) and are consistent with an overestimation of incoming shortwave radiation as a result of too little cloud cover."

6) Can you propose potential reasons for the underestimated humidity, which leads to underestimated precipitation and is therefore a serious issue for surface mass balance modelling?

There are many potential error sources for the underestimation of humidity and for the missing precipitation events. For example, errors in the forcing data at the lateral boundaries (ERA Interim data) could contribute. The 2.2-km spatial resolution of the finest model domain could be insufficient to fully capture orographically-forced uplift, cooling and saturation of air, or microscale topographically-induced complex flow features that influence precipitation at the AWS location. Although WRF D3 is convection permitting at this spatial resolution, we do not fully resolve cumulus convection processes (previous studies have found a grid spacing on the order of 100's or even 10's of meters is required to resolve the dominant length scales), which contributes to an underestimation of precipitation. Finally, the difference in the land surface types adjacent to the AWS and WRF grid cell may play a role. In reality, the AWS is located next to a debris-covered section of the Baltoro glacier (mean debris thickness adjacent to the AWS at the Urdukas site is 8.6 cm and coverage exceeds 90%), while WRF-CMB has a clean glacier/snow surface. The differing thermal properties of the surface, specifically the limiting of temperature at the melting point on the clean glacier area, may impact localized convection.

Added additional discussion paragraph after p115, l22: "The disagreement in measured and simulated humidity and precipitation may reflect several sources of error, such as in the forcing data at the lateral boundaries. In addition, the spatial resolution of WRF D3 may be insufficiently fine to fully resolve orographic uplift or microscale complex flow features that affect precipitation at the AWS. Furthermore, we do not use a cumulus parameterization in the finest model domain and therefore assume that convection is explicitly resolved. However, studies indicate that a grid spacing on the order of 100 m \citep{bryan03,petch06} or even 10 m \citep{craig08} is needed to capture the dominant length scales of moist cumulus convection. A final potential error source is the difference in the land surface type adjacent to the AWS and model grid cell: the Baltoro glacier is debris-covered at the Urdukas site, while WRF-CMB has a clean snow/ice surface. The differing thermal properties of the adjacent surface area, specifically the limiting of temperature at the melting point in WRF-CMB, may also contribute to differences in localized convection."

7) Page 117, l. 12: Temperatures are higher/lower, not warmer/colder. Please check MS throughout.

8) Section 3.3: the differences between INT and OFF are really small when compared to the difference between INT and observations. The level of detail in this section, which stretches over almost five pages, is therefore not in balance with that of the previous section, which only covers two pages. I would therefore like to see more discussion on

the deficiencies of the model results and possible reasons, and less detail about the impact of the interactive coupling so that both end up with a similar level of detail.
We have incorporated further discussion on the points above with regards to model deficiencies. We also tried to remove unnecessary detail in section 3.3 and make the text more succinct. We hope this addresses your comment.

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