Reply to referee 1

This paper conducted a comprehensive study of energy balance for a debris-covered glacier using turbulence-resolving numerical simulations. The paper is well organized and written, and the conclusion is supported by the results. I am generally favorable to publication. However, I feel that the following point needs to be addressed before publication.

My major concern is that the one-meter spatial resolution used in the paper is way beyond the dissipation range, so I would be very hesitated to call it a DNS. I would like to be clear that I am not questioning the validity of the numerical results and the corresponding conclusion in this paper. I agree that a one-meter resolution, constant eddy viscosity model should outperform a 10-meter resolution LES-SGS model. However, instead of calling it a DNS, I would suggest calling it a different name, e.g., a constant eddy viscosity LES, a high-resolution LES, or a quasi-DNS? The authors did show that doubling the spatial resolution (and the Reynolds number) had a small impact on the simulation results. In my opinion, this only indicates that, numerically, increasing the grid resolution has a limited impact on the simulation results. However, whether a one-meter resolution simulation can explicitly capture the right physics (small-scale turbulence behavior) in the atmosphere is still not quite clear. I suggest the authors conduct a validation that compares the quasi-DNS results with field experiments. I am also curious to see how a LES model behavior, compared with the quasi-DNS runs. Without such a comparison, it is hard to justify the one-meter resolution DNS configuration.

We thank the anonymous reviewer for their time, and their insightful and helpful suggestions to make the manuscript more accessible and accurate.

To make the differences and links between LES, DNS more clear we have now included in the introduction L97-102:

"Turbulence can be simulated by two techniques: LES (Large Eddy simulations) and DNS (Direct Numerical simulations). The difference between them is the treatment of the smallest scales in the flow; LES uses a subgrid parameterization and DNS resolves these explicitly. DNS at atmospheric viscosity is computationally unfeasible, but it is not always necessary to resolve all scales as many flow characteristics become independent of the Reynolds number at much larger values for the viscosity than that of the atmosphere. In this paper, we build on this property (see Appendix A). One could also refer to this technique as LES with a constant eddy viscosity."

In this manuscript we presented a DNS with a viscosity much higher than the atmosphere to simulate a flow with moderate Reynolds numbers. The essential quality of our simulation is that we have demonstrated that the viscosity is sufficiently large to show Reynolds number independence for the statistics that we are interested in. This allows us to do less computationally expensive simulations and obtain similar results. The terminology of the simulations we performed in our research is not trivial, since the modelling techniques we used are novel. We do not claim to provide the ultimate solution but we used this technique to get better insight into turbulence above complex terrain. Further research should show which technique performs best. We now choose the terminology DNS with constant eddy viscosity in the manuscript (L140-141), however we appreciate some guidance of the editor on what is preferred from the perspective of The Cryosphere.

We included in the old manuscript a thorough discussion about the use of DNS and LES to cover this topic (Section Suitability of DNS). In that Section we elaborated also on why we think a LES comparison does not add value, due to the inappropriate surface model under high Reynolds numbers in complex terrain. This means comparison to LES won't give more insight in turbulent flows than DNS with a constant eddy viscosity.

The reviewer would like to see a comparison with field measurements, however we already did this in the old manuscript. We have compared the DNS simulations to unique Eddy Covariance measurements on Lirung Glacier in the Results section (Figure 8). Those show for the location of the EC-tower the simulated and measured sensible and latent heat flux aggregated over 1 hour for fair comparison. As the measured spatial surface temperature is input data for the model we can not use this for validation of the simulations. The comparison with the EC-measurements show acceptable agreement with the simulations, demonstrating MicroHH captures important processes.

For the further improvements of our analysis and presentation we refer to our replies to the reviewer's specific comments below

Some minor comments:
Line 97, page 3. “using a novel DNS mode”, please be more specific in terms of what novel algorithms or techniques are used in the DNS solver?

- *While the code is relatively new, the numerical methods are established finite difference methods (Morinishi et al., 1998). We will remove the qualification “novel”.*

Page 8. I suggest the authors add a schematic to illustrate the boundary conditions and especially, the immersed boundary method used to represent the DEM. Also, please be more specific why did the authors use 0.2 mˆ2 sˆ-1 as the eddy viscosity, as opposed to other possible values?

In this paper we want to focus on the application and usability of turbulence resolving models rather than discuss the model technical details. We therefore give all user-specific information and model input needed to continue with this study. We included only a limited description of the model in the methods, since this information (including the immersed boundary method) can easily be found in the main paper of the MicroHH model (van Heerwaarden et al., 2017). We think the cryospheric reader would be mainly interested in the applicability of this study.

We include an explanation about the eddy viscosity term in L208: “We used a constant eddy viscosity of 0.2 m^2s^{-1}. Preferably the viscosity of the atmosphere is used in the simulations, however this is computationally unfeasible in our simulations. Therefore we chose the lowest possible eddy viscosity and checked the results for convergence.”