Reviewer comments of M. Pelto mauri.pelto@nichols.edu are italic and underlined

responses

Fischer et al (2016) provide by far the most extensive examination of the impact of ski area management on local glacier mass balance. This is a unique data set that cannot be matched elsewhere; hence this contribution provides a valuable snapshot at a critical moment for ski areas with glacier terrain response to climate change. Most of the comments below are quite minor. Considerable figure consolidation could be completed. Brief reference to the practice in other nations is warranted. Also the impact of new snow and grooming on increasing albedo should be mentioned, even though, the point of this study was not to quantify that impact.

The figures now contain overview graphs and just few examples of the different data sets. The original Figures are shifted to the supplement still as a part of the draft.

We cited all the papers we could find on practice in glacier ski resorts in other nations, and would really like to add additional literature to this topic. Is there citable literature describing the mass balance management on the sites you mention?

We added the following citation to describe the effect of grooming on albedo:

Keller, T. Pielmeier, C. Rixen, C. Gadient, F. Gustafsson, D. Stähli, M., 2004. Impact of artificial snow and ski-slope grooming on snowpack properties and soil thermal regime in a sub-alpine ski area. Annals of Glaciology, 38, 1, 314-318.

Unfortunately, Keller et al. do not find empirical data on the effect of grooming on snow albedo. Measurements of this effect might be difficult for various reasons, amongst them:

- Bidirectional reflection of snow requires careful consideration of all combinations of grooming tracks and incidence angles
- During operation, ski tracks replace grooming tracks, with even more difficult to capture changes in optical properties.

Figure 1: A single skier changes surface albedo on 26.05.2005 in 2850 m.

Taking into account, that grooming during the investigated period ended with mid to end of May, and surface melt processes had been observed mainly from beginning of May onwards, the effect of grooming on albedo during melting season is thus small, which was the reason for skipping that topic initially.

2-1: to store and maintain snow:::.

changed

2-13: The to They

changed

2-17: Not only has visitor demand developed over time but cable car technology has advanced::.

changed

3-3: Crevassed reduced not just at ski areas but on other glaciers too, for example Colgan et al (2016) Pelto and Hedlund (2001).

We agree, this is stated also for example in Fischer, A. (2010) Glaciers and climate change: Interpretation of 50 years of direct mass balance of Hintereisferner, Global and Planetary Change 71, 1-2: 13-26.

3-5: Is removal of rock, sand and dirt from the piste not a goal? Grooming and new snow production oth increase the albedo. This is a goal noted by some of your previous research.

These measures have been included in the first point which comprises measures to decrease surface roughness. We added explicit examples to that point. The albedo topic is included in the third point, reduction of mass loss, as the high albedo is not an aim on its own purpose, but for its influence on mass balance. But as stated before, grooming during ablation season is rare.

7-26: I assume the 35% and 65% reduction are compared to adjacent areas of the same glaciers, if so more clearly state this. Somewhere it would helpful to reference typical thickness loss values from either WGMS reporting Austrian glaciers or from the inventory, as a wider reference.

We restructured the article including a better description of the reference measurements. Typical losses from the glacier inventory have been added.

Abermann, J., Lambrecht, A., Fischer, A., and Kuhn, M.: Quantifying changes and trends in glacier area and volume in the Austrian Ötztal Alps (1969-1997-2006), The Cryosphere, 3, 205-215, doi:10.5194/tc-3-205-2009, 2009.

The thickness of Ötztal glaciers reduced by 0.95 m/year in average between 1969 and 1997, and -0.91 m/year between 1997 and 2006.

9-2: Continuous grooming will increase albedo.

This section was restructured. The albedo discussion was included in the state of the art report. Unfortunately we do not have data on surface albedo.

10-26: I agree with this assertion "In any case, submergence and emergence should be similar for the profiles and the reference profiles"

We rephrased this part.

11-2: Grooming would also reduce albedo.

We added the information that grooming takes place during winter, and the effect is measured in summer, so that a direct influence of grooming on albedo is not very likely.

12-3: It is worth noting that mass balance management extends to Tignes, France; Whistler, BC and Mount Hood, OR.

We added this information together with other ski resorts from our personal knowledge.

12-28: The enhanced prominence of managed area versus managed areas, generates steeper slopes as noted. This in turn should increase ablation. Will also act both as a wind scour and potentially wind trap for accumulation. Is this observed?

Yes, both effects are observed, but not quantified in detail. The removal of snow from previously covered platforms leads to their rapid meltdown once the maintenance stops. The separation of radiative and wind drift effects is hard to measure and drawing general conclusions included high uncertainties.

Figure 1: Ski area boundary line should be more distinct color.

changed

Figures: The number of profile figures is impressive. However, collectively they are redundant and also detract from highlighting important overall trends. The variation from profile to profile becomes the focus. I would suggest utilizing only two sets from each glacier, or focusing more on the central panel. The central panel alternative takes TCD advantage of the fact that Table 3 provides the data from the third panel for each glacier.

We restructured the Figures.

Figure 1 provides profile location. Hence, you could just use the middle panel for all but two profiles on each glacier.

Figure 1 is changed, and we hope that you find it benfical.

Colgan, W., H. Rajaram, H., Abdalati, W., McCutchan, C., Mottram, R., Moussavi, M. and Grigsby, S: Glacier crevasses: Observations, models, and mass balance implications, Rev. Geophys., 54, 119–161, doi:10.1002/2015RG000504, 2016.

included

Pelto, M.S., and Hedlund, C.: The terminus behavior and response time of North Cascade glaciers. Journal of Glaciology 47: 497–506, 2001.

included