

Interactive comment on “Cornice dynamics and meteorological control at Gruvefjellet, Central Svalbard” by S. Vogel et al.

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1) In the abstract and in the beginning of the paper the authors call the observed events "cornice fall avalanches". This is a term that is generally associated with avalanches that are released after triggering by cornice falls. Later in the paper (P2294) it is stated that there is little or no entrainment in the track. Hence I suggest calling the observed events "cornice fall", leaving out the term "avalanche".

Clearly, the size and magnitude of the avalanches was primarily controlled by the size of the collapsed cornices. Still, since in particular the avalanches categorized as D2.5 and larger showed significant amounts of snow deposits in addition to the broken cornice blocks in the runout zone, we used the term cornice fall avalanches. This also applied for the cornice failures in the very beginning and towards the end of each snow

C1494

season, when the snow cover on the slope beneath the cornices was shallow or even discontinuous and hence the amount of entrainable snow limited.

2) In the first five lines of the abstract (P2280, L 2-6) and the last lines in the conclusion (P2301, L 19-21), the fact that life and infrastructure are at risk due to cornice fall is used as the reason for the research. For a scientist this may be a good reason to carry our research, but for society in general and specifically for the people living below the cornices, it is not very reassuring that research must be carried out over several years to come to an understanding of the process. Has it been considered that installing safety measures are more important than research to keep the 200 people living in the houses safe? In this respect I also miss the very clear conclusion that with the observations provided here it is clear that warning is not a very good option when considering safety measures for the housing at risk.

Our research clarifies the processes involved in cornice fall avalanches, which display a recurrent natural hazard for life and infrastructure at the foot of the slope. Today there are no protective measures in place, but this has been considered in the past. Our results are a first step towards a better predictability of cornice fall avalanches and highlight meteorological factors which are crucial for the collapse of cornices, but also indicate that cornice fall avalanches are in particular hard to forecast. Based on our detailed observations, any type of warning is not an adequate measure to take to ensure safety for the housing at risk. Permanent protective measures either on the plateau, along the plateau edge or located on the basal concavity of the slope would without doubt increase the safety for life and infrastructure. An overview of mitigation measures, their application and effectiveness is given in Chaudhary and Singh (2006), possible mitigation measures for a very comparable site in western Iceland are discussed by Hákonardóttir et al. (2008). McCarty (1986) reviews the effectiveness of cornice control using explosives. However, it is not within our possibilities to directly establish protective measures. We do, however, feel that by improving the process understanding we also provide knowledge for future protective measures.

C1495

McCarty, D., Brown, R.L. and Montagne, J. 1986. Cornices: Their Growth, Properties, and Control. Paper read at the International Snow Science Workshop, at Lake Tahoe.

Chaudhary, V. and Singh, G. 2006. Structural Measures for Controlling Avalanches in Formation Zone. *Defence Science Journal* 56.

Hákonardóttir, K.M., Margreth, S., Tómasson, G.G., Indridason, H.D. and Pórdarson, S. 2008. Snow drift measures as protection against snow avalanches in Iceland. Paper read at International Symposium on Mitigative Measures against Snow Avalanches, at Egilsstaðir, Iceland.

3) It seems that the measurements done on for example the crack width are relatively simple and somewhat "ad hoc" solutions. This may explain some of the results where the crack opening is reduced by 20 cm while the crack is not actually being closed (P 2291 L 17-18). Could the methods be improved, for example by installing extensimeters or tiltmeters used for example to monitor movements in rocks? This would be valuable information for others trying to do similar observations.

Our study displays the first attempt to measure and quantify cornice crack opening rates. The particular site and nature of cornices demonstrates some crucial limitations for any kind of more sophisticated installations. The sudden collapse of the cracked cornices can destroy the installations and may impede to receive any data. During our study, the measuring set-up of the second series of cornice crack measurements between 5 and 10 February 2010 was destroyed by an entire cornice failure. Furthermore the steep and exposed slope beneath the cornices is difficult to access to relocate and if necessary to download any data of the cornice crack development. In addition to this, all installations are affected by melt towards the end of the snow season. This would also impede any distance measurements using a reflector type. Therefore we chose a simple but immediate method to measure the cornice crack opening. It might be worth trying to insert tiltmeters into the cornices at an early stage of their development, and to place these in a sturdy box equipped with a Recco device to relocate after collapse

C1496

and melt out. The measurements of a cornice crack closure are a consequence of the measurement set up as we measured the relative distance between the reference stake on the plateau and the measuring stake inserted into the cracked cornice. To avoid the measuring rope being buried, we attached it permanently on the tip of the cornice stake. A slight backward tilting of the cracked cornice mass thus led to the reduction of the relative distance between the two measuring stakes without actually reducing the cornice crack width.

4) It is commented (P 2293 L 25-27) that solar radiation might contribute to cornice failure, and this has been shown in other literature referenced. Do you have any way of quantifying this? For example by using radiation measurements from a place close to the observations? Or, alternatively, this is worth mentioning as a possible improvement to the observation set-up. The high frequency of up to six photographs per day of the Sverdrup-cam enabled us to investigate the frequency of cornice failures in the course of a day. Here we found a trend of increased cornice failures during late afternoon, when the sun hits the cornices. Still, these cornice failures were mostly partial failures of comparable lower magnitude. We found that the meteorological conditions concurrent with cornice fall avalanches are less important than the time period since cornice crack initiation. The meteorological station situated on the Gruvefjellet plateau does not record solar radiation, thus this data are not available. Though, including measurements of solar radiation might be useful in future studies to analyze the relationship of solar radiation and general cornice activity.

5) On P 2294 the size and runout length of the detached cornices are reported. The results are not discussed further in the "Discussion" section. The results are somewhat obvious as they are presented and it might be worth adding some heavier scientific discussion here. For example that for avalanches and other rapid mass movements it is generally the case that events with large volumes have longer runout distances than events with smaller volumes.

Our study showed that the size of a cornice fall avalanche was mainly controlled by

C1497

the size of the collapsed cornice, but moreover that the morphology of the starting zone and avalanche path determine the potential avalanche magnitude. The amount of entrainable snow was of less importance as we observed high magnitude failures in different parts of the snow season. Maximum snow depths on the slope below the cornices are usually observed in April. Despite this, cornice fall avalanches categorized as “D3R4” avalanches occurred both in the very beginning and at the end of the snow season when the snow cover on the slope was shallow or uncontinuous. Irrespective the actual size of a cornice fall avalanche, single cornice blocks reached significant longer runout length than the main avalanche mass. However, in our study area we did not observe slab avalanches triggered by cornice failures, which involve substantial amounts of snow.

Interactive comment on The Cryosphere Discuss., 5, 2279, 2011.