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Snow gliding and avalanches in a south-facing larch stand

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Abstract Release zones of avalanches are common in forests sites, especially in low density stands near the timberline. Observations showed that slab avalanches (caused by weak layers like surface or depth hoar), as well as glide avalanches, are possible in larch stands with a low canopy density. The main condition for the formation of glide avalanches in forest sites is a strong increase in the rates of snow gliding. This investigation shows that snow gliding is strongly influenced by the forest canopy. Less dense forest canopies were associated with higher snow glide rates. The total distance of snow gliding in the dense forest did not exceed 100 mm; however, total gliding in forest clearings reached values up to 1700 mm. Gliding is more frequent in winter periods with deep snow and less frequent in those years where the snow depth was below average. Snow gliding in forests increases over February, March and April; but there is no gliding in January because of low snow temperatures.

Key words snow gliding; glide avalanches; forest cover

INTRODUCTION

Snow gliding is a downhill motion of snow on the ground. In der Gand & Zupancic (1966) showed that it is mainly influenced by the ground surface roughness—the smoother the ground surface, the higher the glide rates—and the wetness of the lowermost boundary layer of the snow cover.

High glide rates can result in damage to young plants in the subalpine zone. To protect afforestations from snow gliding, relevant investigations were conducted in the 1950s (In der Gand, 1968). In the 1980s, Lackinger (1986) worked on the mechanism of glide avalanches, and McClung *et al.* (1994) investigated snow gliding on steep rock. Recently Höller (1997) and Newesely *et al.* (2000) have researched on snow gliding processes in alpine ecosystems.

This paper deals with the phenomenon of snow gliding in different forest stands and the possible effects of forest density on glide rates.

EXPERIMENTAL SITE AND METHODS OF MEASUREMENTS

The investigations were done in the Stubai valley (approximately 35 km from Innsbruck, Austria) in and beside a larch stand near the timberline at about 1900 m a.s.l. (aspect south). Several measuring zones (open field, small clearing, large clearing, larch stand with a low canopy density, dense forest site) were selected.

The monitoring programme included snow gliding measurements (which were done with glide shoes) as well as meteorological (air temperature, radiation, etc.) and snow observations (snow depth, snow temperature, etc.).

RESULTS

The measurements were conducted over the last seven winter seasons (Fig. 1). The results show that snow gliding is strongly influenced by forest cover. Snow gliding is low in the forest but increases in the clearings (the total glide distance can reach values of up to 1700 mm). While in the dense forest (canopy density 90–95%) the total gliding does not exceed 100 mm, higher amounts of snow gliding (up to 250 mm) can be found on those sites where the canopy density is less than 90%. As canopy density decreases to a cleared state, snow gliding increases rapidly. The measurements show that the total glide distances in a large clearing (20 × 30 m), as well as in a small clearing (8 × 8 m), are significantly higher than in the forest (Fig. 1). As a consequence, the formation of slides and small glide avalanches is possible and was observed on these sites.

The degree of snow gliding may change from year to year. As shown in Fig. 1, total glide distances in the clearings were higher than those in the forest during 1992/93, 1994/95 and 1999/2000. The variability of gliding differences can be explained by the different weather and snow conditions. Snow gliding in forest sites cannot be observed in January because of low snow temperatures, but regularly increases over February, March and April.

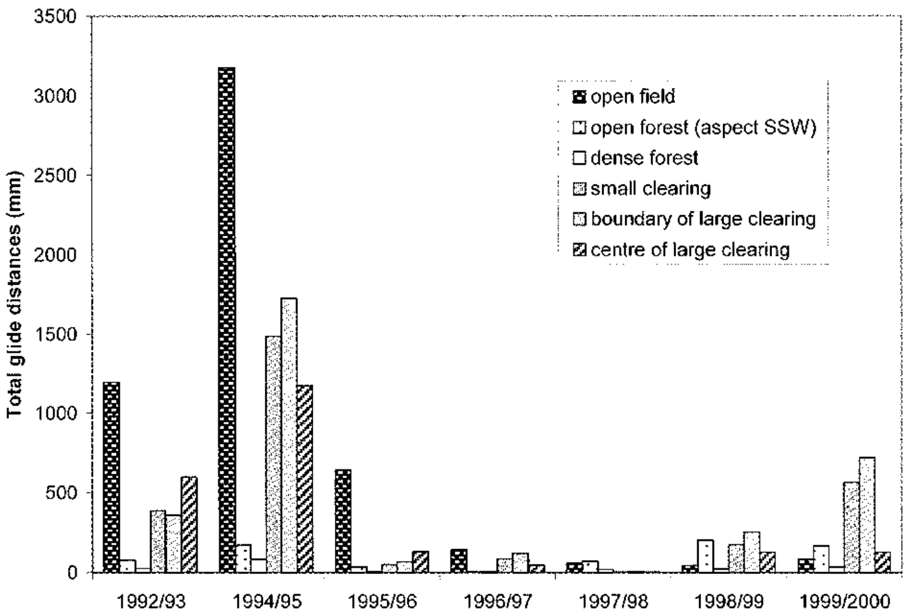

Fig. 1 Total glide distances (in mm) on different measuring locations of the experimental site in the Stubai valley (1992/93 to 1999/2000).

Conversely, snow gliding on the open field can reach a maximum at the beginning of the winter period (especially in 1992/93, 1994/95 and 1995/96); in 1994/95 these values led to a total distance of 3200 mm of gliding on the open field. High glide rates can be measured when the soil temperature (5 cm below the surface) exceeds 0°C at the time of the first snowfall. In 1992/93 the experimental site was snow-free until the second week of January (the soil temperature 5 cm below the surface was about 3°C). As snowfall started in the middle of January, about 1000 mm of snow gliding was measured within two weeks. A similar situation was found in 1994/95 and 1995/96. In 1994/95 the soil temperature was between 0 and 1.5°C when the study field received a

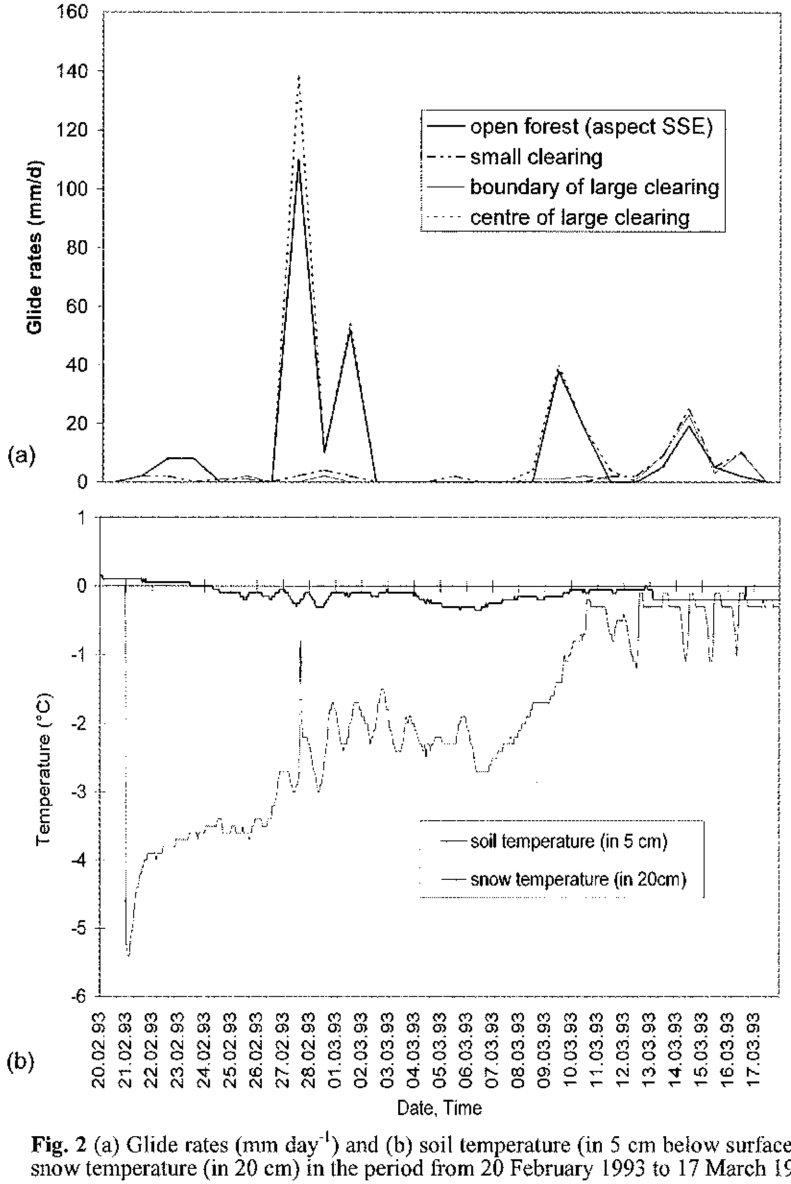

Fig. 2 (a) Glide rates (mm day^{-1}) and (b) soil temperature (in 5 cm below surface) and snow temperature (in 20 cm) in the period from 20 February 1993 to 17 March 1993.

few centimetres of new snow in December; in 1995/96 the snowpack built up in early November when soil temperatures were about 2°C. In both cases snow gliding increased (1800 mm in December 1994, 600 mm in November 1995).

Increased snow gliding corresponds to increased snow temperature, especially at temperatures near the melting point. On 27 March 1993 (Fig. 2) the snow temperature (in 20 cm above the ground surface) increased from –2.7 to –0.8°C which led to high glide rates at two measuring locations. As shown in Fig. 2, the highest glide rates were measured in the open forest (110 mm day^{-1}) and in the centre of the large clearing (138 mm day^{-1}).

Gliding was most continuous in periods with deep snow and unsteady in those years where the snowpack was below average. It can be assumed that, in the case of a shallower snowpack, when dwarf shrubs are only partly covered with snow and stand out from the snowpack, the short-wave radiation may warm the ground surface which could lead to an increase of temperatures at the base of the snowpack and subsequently to unsteady glide rates. Similar observations were made by Clarke & McClung (1999) who investigated snow gliding on steep rock. He found that, in areas of thin snow cover, the rock is warmed by absorbed short-wave radiation, and snow is melted by emitted long-wave radiation; he concluded that some full-depth avalanches may have been the result of snowmelt by radiative heating of rock surfaces.

CONCLUSIONS

Snow gliding is a common phenomenon on south-facing larch stands near the timberline and may affect the formation of glide avalanches. Gliding is strongly influenced by forest cover. As the canopy density decreases to a cleared state, snow gliding increases rapidly. While in dense forest the total gliding does not exceed 100 mm, the glide distance in clearings can reach values up to 1700 mm. Increasing glide rates are associated with increasing snow temperatures. During a period with increasing snow temperatures (March 1993), glide rates of more than 100 mm day^{-1} could be measured in the open forest and in the centre of the large clearing.

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