INDICATORS FOR SNOW GLIDING: A CASE STUDY AT THE WILDKOGEL, SALZBURG

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ABSTRACT: The release of glide avalanches is very difficult to predict and a great challenge for local forecasters, especially in ski areas. There are reasonable assumptions that the relative proportion of wet snow avalanches (and thus glide avalanches) will increase due to climate change. However, a couple of gaps in knowledge regarding the process of gliding snow still exist, such as the influence of soil conditions or the predictability of glide avalanches; even the relevant physical processes of snow gliding are not yet completely understood. The trigger for glide avalanches is basically a high liquid water content (LWC) at the snow-ground interface, i.e. the transition zone between snow cover and vegetation/soil. While empirical models for the potential of snow gliding already exist, dynamic (real-time) assessment has to incorporate additional processes affecting the soil-vegetation-snow-atmosphere system. At the study site 'Wildkogel', Salzburg, Austria, experts and decision makers from five different institutions (others may follow) are addressing this issue. We aim to develop key indicators to identify snow gliding areas for specific prevailing meteorological-, soil hydrological-, biological- (i.e. vegetation) and snowpack conditions. At the 'Wildkogel', snow gliding is observed regularly, also endangering several parts of the ski area. Since 2014, snow gliding measurements and ancillary measurements of soil water content (SWC) and soil temperature (SoilT) as well as vegetation surveys (biomass, plant functional diversity) are carried out. Additionally, two measuring stations from the Avalanche Warning Service Salzburg are located close to the snow gliding measurement sites, providing a broad range of meteorological – and snow parameters. The assessment of snowpack characteristics by snow profiles for periods with expected snow gliding activity provides crucial information about the detailed properties of the snowpack.

KEYWORDS: glide avalanches, snow-gliding, winter soil erosion.

1. INTRODUCTION

It is generally considered that the expected variability and changes in climate parameters lead to a change in the dynamics of natural hazards. In addition to approved control measures in snow safety management, early warning systems are identified as suitable techniques for protecting people, buildings and infrastructure in mountainous areas. The implications of global climate change, i.e. precipitation intensification and temperature increase (alpS/Umweltbundesamt, 2018), appear to be faster and of greater effect at higher altitudes. Snow is an important element in environmental change in mountain areas. With regard to observed climate variability, climate change could further increase the proportion of wet snow avalanches and probably of glide avalanches. This type of avalanche is related to the liquid water content of the snowpack and consequently at the snow-ground interface that is added by rainfall or snowmelt. The research in the 'Wildkogel' study area aims at a detailed analysis of the driving forces for snow gliding, focusing on the liquid water content, the vegetation, the soil surface, the uppermost soil layers and the vegetation composition.

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2. STUDY SITE

In the case study site named 'Wildkogel' (N47°17′8″, E12°17′50″) in the Upper Pinzgau, Salzburg, Austria, regular snow gliding is observed, also endangering several parts of a famous toboggan run. The joint effort and active teamwork of all involved institutions provides a best practice example for bringing together theory and practice as well as different scientific disciplines (i.e. snow research, meteorology, ecology, avalanche warning).

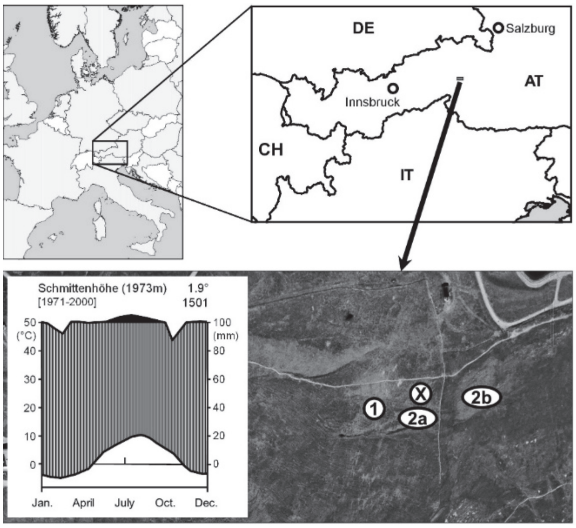

Figure 1: Study site ‘Wildkogel’ is characterized by pastures (1) and abandoned areas (2a-high cover of dwarf shrubs, 2b-high cover of grasses. (X) = automatic weather station (modified after Fromm et al., 2018). Original data for the climate diagram: www.zamg.ac.at

3. RESULTS

Our results show that the vegetation had a significant effect on snow gliding. These findings are in accordance with findings from previous studies showing that the gliding distances were increasing from cut meadows to pastures to not cut or abandoned grasslands. However, the detailed analyses have extended the knowledge up to now by considering more variables describing the vegetation. In this context, it seems that the use of soil moisture sensors is promising for future studies that may focus on the hydraulic processes close to the soil surface. Here, limitations in measuring SWC at the uppermost (partially frozen) soil layers need to be overcome.

The comparison of LWC data collected with the Snow Melt Analyzer (SMA) and the Denoth meter showed that the SMA did not detect daily variations. The SMA tended to under- or overestimate LWC in a contradictory behavior than the Denoth meter. While the spatial variability of manually assessed LWC was high, the assessment of snow profiles and measuring LWC simultaneously was promising to forecast snow gliding.

The ’Wildkogel’ site was also used to confirm the practical relevance and applicability of the Spatial Snow-Glide Model (SSGM) (Leitinger et al., 2008; Meusburger et al., 2014) in combination with Guidelines to Identify Snow-Glide Areas (GISGA) (Höller, 2012).

Please refer to the research article by Höller (2014), and studies addressing research at the study site ‘Wildkogel’ by Leitinger et al. (2018) and Fromm et al. (2018) - with unrestricted access at the Journal *Natural Hazards and Earth System Sciences* (NHESS: https://www.nat-hazards-earth-syst-sci.net/18/1891/2018/).

4. OUTLOOK

Ongoing research activities and data analyses at the ‘Wildkogel’ site will help to overcome remaining uncertainties in the causal chain of the process of snow gliding and could infer easily measurable soil hydrological indicators (i.e. soil moisture, soil temperature) to improve the assessment of snow gliding by specifically addressing processes acting at the snow-ground interface. This could significantly improve the risk assessment of snow gliding.

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