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The effect of vegetation cover on the formation of glide-snow avalanches

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Glide snow avalanches release on steep, smooth slopes and can be prevented either by protection forests or by artificial defense structures. To minimize the risk for people and infrastructure, guidelines have been formulated concerning structure, height and distance between avalanche prevention bridges. These guidelines assure the major functions of the defense structures: first to prevent the release of avalanches and second to withstand the static and dynamic forces of the moving snow cover. The major functions of protection forests are generally similar and therefore guidelines on the maximum tolerable size of forest gaps exist in Switzerland. These guidelines are based on a static relationship between the pressure of the snow cover and the resistance of the defense structure and on empirical observations (forest). Whereas ground friction is only qualitatively taken into account, we assume it to play a crucial role in glide snow avalanche formation. To prove this assumption we collected data on the predominant vegetation cover of 67 release areas in the region of Davos, Switzerland. Our observations reveal a strong relationship between vegetation cover type, slope angle and slab length. We were able to quantify the Coulomb friction parameter μ by applying a physical model that accounts for the dynamic forces of the moving snow on the stauchwall, the fixed snow cover below the release area. The stauchwall resists the dynamic forces of the snow cover, until a critical strain rate is reached and then fails in brittle compression. This failure strongly depends on the friction between snow cover and soil. A typical value of μ for grassy slopes is 0.2. Snow characteristics like density are implemented in the model as constants. We compared the model results with the guidelines for defense structures and forest gap sizes and found accordance for certain friction parameter values. Forest gaps of 40 meter length and a 35° slope angle require friction values of 0.5 corresponding to stumps or tree regeneration to assure protection. Therefore forest gap guidelines in Switzerland imply a relatively rough surface to prevent avalanche formation. The calculated slope angle and slab length for smooth, grassy slopes corresponds to defense structure distances for shallow snow heights. Guidelines for defense structure distances correspond to a smooth surface like grass or low dwarf shrubs which are common vegetation types for regions above the tree line. Therefore we could confirm that artificial defense structures, built in accordance with guidelines prevent glide snow avalanche releases, even on smooth terrain.