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Application of the RAMMS model to recent and potential rock-ice avalanches in the Mount Cook region (New Zealand)

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The Mount Cook region, central Southern Alps of New Zealand, has been affected by several large mass movements during the past decades. The largest and most spectacular rock-ice avalanche originated in 1991 from Mount Cook east face (3754 m a.s.l.) and deposited 12 x 106 m3 of material on Hochstetter and Tasman Glaciers. In 1992, an 8 x 106 m3 rock-ice avalanche originating from the ridge north of Mount Fletcher (2467 m a.s.l.) reached a glacial lake after having travelled 3 km over the surface of Maud Glacier. Fortunately, both events occurred in remote glacial valleys and did not cause any casualties.

The numerical model RAMMS (RApid Mass MovementS) was applied to simulate the two rock-ice avalanches. The RAMMS model is a solution to the 2D shallow water equations for granular flows, where the frictional dissipation is described using a simple Voellmy approach. Good agreement between model results and observation in terms of travel path, flow heights, velocity, deposition thickness and geometry was found. Both avalanches started in a steep rockwall (slopes $> 60^{\circ}$) and fell onto glaciers which were debris covered in the lower section. As a result for both avalanches, the RAMMS simulations revealed similar best fit input parameters (average Coulomb friction $\mu \approx 0.15$ and turbulent friction $\xi \approx 2900$ m/s2).

A GIS evaluation of the local geology, topography, and permafrost conditions identified Mount Sefton (3161 m a.sl.) and the Footstool (2764 m a.s.l.) situated 2 km further NE as two areas susceptible to future failure. To simulate possible avalanches originating at these sites we used the best fit values of the Mount Cook and Mount Fletcher avalanches as guidelines.

The simulations of Mount Sefton and Footstool show that the Mount Cook tourism center is well protected from rock-ice avalanches originating froms these two mountains as it is situated high on the inner side of a curving valley with some protection provided by Little Ice Age moraine forms. However, in case of an avalanche with a size comparable to the 1991 Mount Cook event, some moraine over-running is possible, which could affect a camping area, parking lot and walking tracks located directly behind the moraine.

As the tongue of Mueller Glacier below Mount Sefton and The Footstool has suffered dramatic changes during recent years and a moraine dammed lake is developing rapidly, it is necessary to account for these environmental changes. In the present case, a decrease of hazard of moraine over-running is expected because the glacial retreat causes an increase of the moraine wall height, which is serving as a deflection dam. Furthermore the frictional resistance of a lake surface may be completely different. The RAMMS model well represents the flow characteristics on a solid surface, but cannot be used to correctly simulate the flow behavior of an avalanche over a water surface. Nevertheless, the amount of debris that is displacing water can be estimated. This information may be useful for estimating subsequent hazards such as the generation of flood waves which can travel much farther.