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The surface energy balance of an active ice-covered volcano in south-central Chile

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To investigate the influence of volcanic activity on the glaciation of ice-covered volcanoes (and *vice versa*) an integrated study of glacier mass and energy balance and ice flux has been established at Volcán Villarrica, an active volcano with an ice-covered area of c. 40 km^2 in the Lakes District region of Chile (39.42˚ S, 71.93˚ W). Deposition of volcanic ash during frequent volcanic eruptions (on average every 7-8 years) has a significant impact on the surface energy balance of the glacier. Ice below the equilibrium line is covered by a continuous insulating mantle of ash, of variable thickness in the cm to m range depending on elevation and ice flow, while the albedo of the winter snowpack and permanent snow in the accumulation zone is reduced by fine particles of windblown ash. During the 2003-2004 and 2004-2005 ablation seasons an automatic weather station was established on snow close to the equilibrium line at c. 2000 m a.s.l., recording incoming and reflected shortwave radiation and net allwave radiation fluxes, air temperature, humidity and wind speed (2 m), which provide data for a surface energy balance and melt model. The conductive heat flux through ash of differing depths was calculated by monitoring temperatures at the ash surface and ash-ice interface. Melt rates of snow and sub-ash ice were also measured at ablation stakes at intervals ranging from a day to a year. The variable impact of ash on the surface melt rate was investigated experimentally by recording daily ablation on plots artificially covered with ash ranging from a few wind blown particles to a continuous cover of several cm depth, and compared with the 'clean' snow melt rate. Key aspects of the surface energy balance of snow and ash surfaces on Volcán Villarrica will be presented. It will be shown that while snow melt rates are enhanced due to the lowering of albedo by particles of windblown ash, the melt rate of ice is greatly reduced due

to the very low thermal conductivity of the ash, which effectively insulates underlying ice even when only a few mm depth. Hence, the net impact of volcanic activity at this site may be to preserve ice at a time of overall negative mass balance.