

Calculation of Dense Snow Avalanches in Three-Dimensional Terrain With the Numerical Simulation Program RAMMS

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Numerical models have become an essential part of snow avalanche engineering. Recent advances in understanding the rheology of flowing snow and the mechanics of entrainment and deposition have made numerical models more reliable. Coupled with field observations and historical records, they are especially helpful in understanding avalanche flow in complex terrain. However, the application of numerical models poses several new challenges to avalanche engineers. A detailed understanding of the avalanche phenomena is required to specify initial conditions (release zone dimensions and snow-cover entrainment rates) as well as the friction parameters, which are no longer based on empirical back-calculations, rather terrain roughness, vegetation and snow properties. In this paper we discuss these problems by presenting the computer model RAMMS, which was specially designed by the SLF as a practical tool for avalanche engineers. RAMMS solves the depth-averaged equations governing avalanche flow with first and second-order numerical solution schemes. A tremendous effort has been invested in the implementation of advanced input and output features. Simulation results are therefore clearly and easily visualized to simplify their interpretation. More importantly, RAMMS has been applied to a series of well-documented avalanches to gauge model performance. In this paper we present the governing differential equations, highlight some of the input and output features of RAMMS and then discuss the simulation of the Gatschiefer avalanche that occurred in April 2008, near Klosters/Monbiel, Switzerland.