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Release of Wet Snow Avalanches: A Grain-scale Approach

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This work provides a first grain-scale investigation of wet snow avalanches, considering the role of temperature field, mass transfer, and phase changes of snow grains. Snow avalanche release can be related to the dynamics of snow grains, which have typical sizes of 0.5-1 mm. The basal layer, with a thickness of only a few centimetres, is often the weakest link responsible for the instability of the whole snowpack. Previous investigations of snow avalanche release using discrete element methods have mainly focused on "dry" snow. "Wet" snow avalanches are governed by a variety of grain-scale processes, including melting within the snowpack and water flow in surrounding micro-pores. We separate the triggering mechanisms of wet snow avalanches into two categories: (1) infiltration of melted ice into the weak layer located near the ground surface, and (2) melting of snow grains within the layer. The first mechanism corresponds to cases with ice melting in the snowpack above the basal weak layer, while the second mechanism is due to heating from the ground. The purpose of this paper is to present a discrete element method that describes the generation of fluid due to melting of snow grains, and the transport of fluid along the surrounding pores. By varying the total amount of liquid in terms of these two mechanisms, we will show that as the basal weak layer undergoes a transition from low saturation to high saturation the bulk snowpack could start sliding. We will motivate the idea that the balance between these grain-scale weakening mechanisms is a major factor controlling the onset of wet avalanches. We will further discuss the roles of other possible grain-scale effects on this instability phenomenon, including the effects of adhesive forces and lubrication.