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Energy, Entrainment and Dissipated Work in Snow Avalanches

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The energy and mass balance of seven large snow avalanches is determined using the results of large scale avalanche experiments at the Swiss Vallée de la Sionne test site. We show that snow avalanches are "inefficient" thermodynamic engines converting 10% to 20% of their potential energy into translational kinetic energy. The total potential energy depends strongly on the initial and entrained snow mass, indicating that entrainment processes cannot be ignored when predicting terminal velocities and runout distances. We find dissipated work rates on the order of 1 GW for avalanches with flow volumes larger than 100'000 m^3. The complete fluidization of the fracture slab can be identified in the experiments as an increase in the work rate. The initial rapid acceleration of avalanches after release is due to the almost frictionless sliding of the slab. This too, is visible in the dissipation analysis. Interestingly, the work rates of the fluidized regime appear to be constant along much of the track, indicating thermodynamic steady-states. The field data is additionally used to formulate bulk rheological friction laws governing snow flow. The energy dissipation in snow chute experiments is likewise discussed.