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Erosion dynamics of powder snow avalanches – Observations

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Powder snow avalanches (PSA) entrain massive amounts of material from the underlying snow cover by erosion mechanisms that are not fully understood. Despite their inherent diversity, PSAs have recognizable flow features: they are fast, reaching velocity up to 80 m/s, they develop a tall, low density powder cloud and, at the same time, they can exert impact pressure with similar magnitudes of high density flow.

In this talk, we report observations that underscore the interplay between entrainment and flow dynamics qualitatively shared by several PSAs at the Vallée de la Sionne test site in Switzerland. Measurements include time-histories of snow pack thickness with buried FMCW radar and time-histories of particle velocity using optical sensors, cloud density and cluster size using capacitance probes, and impact pressure measured at several elevations on a pylon.

Measurements show that, at the avalanche front, a layer of light, cold and cohesionless snow is rapidly entrained, creating a turbulent and stratified head region with intermittent snow clusters. Fast and localized entrainment of deeper and warmer snow layers may also occur well behind the front, up to a distance of hundreds of meters, where pronounced stratification appears and snow clusters grow larger. In the avalanche head, impact pressure strongly fluctuates and is larger near the ground. Velocity profiles change throughout the avalanche head, with more abrupt changes localized where rapid entrainment occurs. A basal, continuous dense layer forms as deeper, warmer and denser snow cover is entrained and as suspended material starts to deposit. The thickness of the basal layer progressively increases toward the avalanche tail where, finally, deposition occurs en masse. Toward the avalanche tail, velocity profiles tend to become uniform, impact pressures are lower and nearly constant, while entrainment processes are negligible.

These observations underscore the relevance of entrainment location and the nature of the erodible material on avalanche dynamics and contrast the sharply different behaviors observed at the head of PSAs and well behind it.