Geophysical Research Abstracts
Vol. 15, EGU2013-14074, 2013
EGU General Assembly 2013

Measurements of the micro-scale water flow through snow using laser imaging techniques

Benjamin Walter (1), Stefan Horender (1), Michael Lehning (1,2)

(1) WSL Institute for Snow and Avalanche Research SLF, Davos, Switzerland, (2) CRYOS, School of Architecture, Civil and Environmental Engineering, École Polytechnique Fédéral de Lausanne, Switzerland

Snow avalanches and flood events as a result of partially wet and melting snow cause annually several accidents in the European Alps, demonstrating the need for a better understanding of the formation of these events. Water flow in snow is typically a result of snowmelt caused by strong solar irradiation or turbulent heat fluxes into the snowpack, the latter often in combination with rain on snow. Previous studies mainly quantified the total flow through snow for different snowpack layers neglecting the micro-scale flow dynamics. A detailed description as a basis for quantitative understanding, however, requires knowledge of the micro-scale water flow through snow.

We present spatiotemporally highly resolved Fluorescent Particle Tracking Velocimetry (FPTV) measurements of the water flow in the pore space of a wet snow sample. For these first experiments, ice-cooled water seeded with fluorescent micron-sized tracer particles of diameters of d = 20 – 50 μm was sprinkled on top of the snow sample to produce saturated flow conditions. The snow sample was illuminated with a green laser light sheet and the fluorescent light of the tracer particles was filmed with a high-speed camera. The measurement window was 15 mm $\times$ 15 mm. After processing the raw images, tracking algorithms were applied to obtain the particle trajectories and velocities which are assumed to represent local water flow paths and flow velocities.

Results for a gravity driven, downward flow, and for an upward flow driven by capillary forces are presented. A flow loop found in a pore space in case of the gravity flow as well as the high tortuosity of the trajectories show that the water flow in wet snow is highly 3-dimensional. The average vertical flow velocities in the pore spaces were -10.1 mm s^{-1} for the downward gravity flow and +8.7 mm s^{-1} for the upward flow driven by capillary forces. Velocity histograms show that the fraction of the total water flowing against the average flow direction was about 3-5%, and that the horizontal velocities average to about zero for both, the gravity and the capillary flow. The maximum flow acceleration for the gravity flow was 2.1 m s^{-2} and stronger than the maximum deceleration whereas the maximum deceleration for the capillary flow was -1.9 m s^{-2} and stronger than the acceleration. Generally, FPTV measurements in snow open a wide range of potential investigation to increase the fundamental knowledge on water flow through snow, and may thus help to improve theories describing water flow rates in snow.