tive sites. Analyzing more samples together with previously well-dated reference samples will help us in the interpretation of the obtained results. Also thanks to recent improvements in small scale $^{14}$C analysis of gaseous samples (sample size down to 3 µg C) we have a dating tool with great potential for ice core related paleoclimate studies to improve and extend new and existing chronologies.

Next projects will include ice sampling at the plateau glaciers of Kibo (Kilimanjaro massif, Tanzania) in order to provide an independent age estimate of these ice fields in the current discussion (*Kaser et al., 2010*).

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## 9.10

## Failure of wet snow

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Liquid water changes the properties of snow in a highly non-linear manner and thus complicates the processes that lead to wet-snow avalanche formation. In previous studies, researchers investigated the influence of liquid water on the mechanical properties of snow in field studies (e.g. Brun and Rey, 1987; Bhutiyani, 1994). Since the reproducibility of field experiments is impaired by spatial and temporal variability of the snow, terrain, and weather conditions, systematic experiments under laboratory conditions are needed. The objectives of this study were to conduct first wet-snow experiments in a cold laboratory, test the experimental setup and gain primarily qualitative insights into the mechanical failure behavior of wet snow.

With a force-controlled loading apparatus (Reiweger et al., 2010) natural, homogenous snow samples, i.e. without a prominent weak layer, were loaded to about ~75% of the dry-snow strength. In this way we achieved a critical state prior to the wetting. Using a tube network, water with 0°C was conducted to the top of the snow sample. The loading process was digitally recorded and the resulting stress at failure was compared to water content measurements. Two displacement sensors measured the horizontal and the vertical displacement of the upper sample holder and a displacement field for the whole snow sample was obtained by Particle Image Velocimetry (PIV). In addition, acoustic emissions were recorded as well and were supposed to act as a real-time monitoring system for crack formation processes in the material.

We carried out 24 experiments. A set of results for one experiment is shown in Figure 1. The loading apparatus was suitable for wet snow experiments, however, the tube network was not sophisticated enough to simulate natural precipitation or melting conditions. An average water content slightly larger than 6% by volume was measured at failure, the variance was substantial, though (Figure 1a). Results agree very well with previous findings. With 6% by volume water exists in continuous paths throughout the pore space and thus destroys bonds between the grains. Wet samples failed at an average critical stress $\sigma_{c,w}$ = 4.6 kNm$^{-2}$ which was about a factor of 2 lower than for the same dry sample. Again these findings are in good agreement with those obtained by Bhutiyani (1994). The acoustic activity increased significantly during loading and a certain time before failure during water infiltration (Figure 1b) indicating that percolating water is very efficient in breaking bonds between snow crystals. PIV analysis showed that wet snow allowed much more deformation before failure and rather collapsed than fractured with a recognizable pattern compared to dry snow (Figure 1c).

The experimental setup is in general suitable; nevertheless the setup has to be optimized for recording water content and controlling the water influx.

Liquid water clearly influences the snow microstructure and alters the failure behavior. Water decreases the strength of the snow sample by a factor of 2 which leads to a pronounced collapse failure instead of a shear fracture (dry snow).

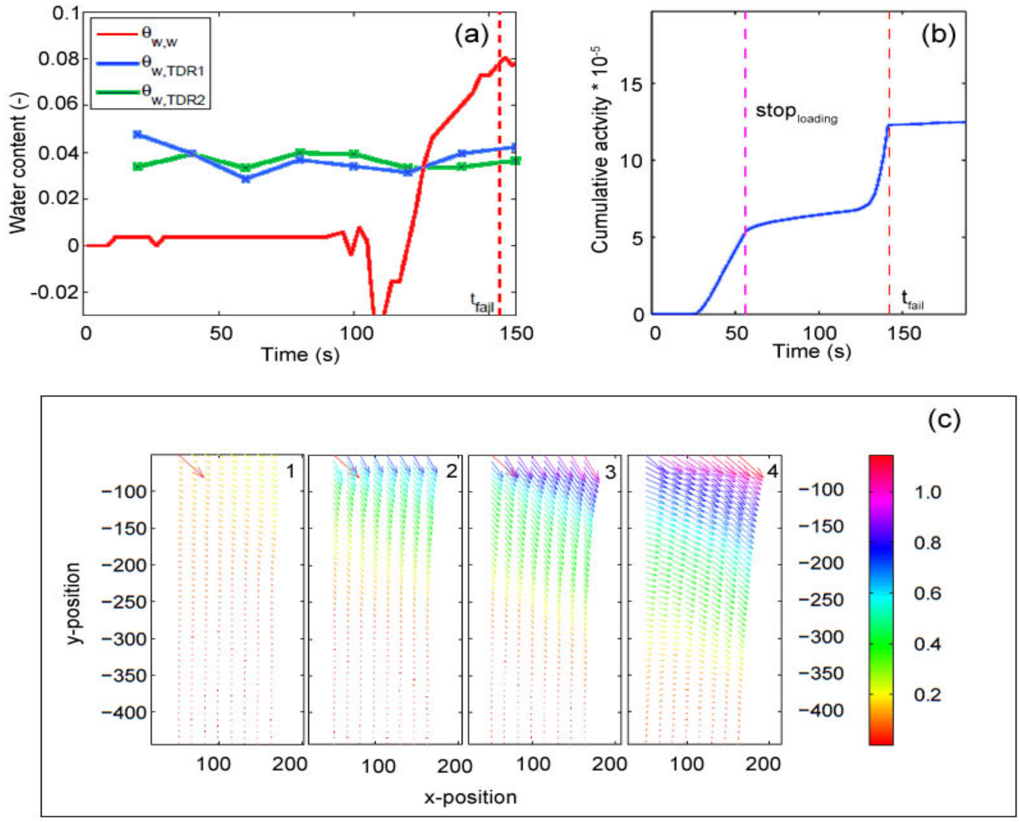

Figure 1: (a) Vol. liquid water content ($\theta_{w}$) recorded with two TDR-probes ($\theta_{w,TDR1+2}$) and calculated using influx data ($\theta_{w,w}$) during experiment 19. Sample failure was at t = 142 seconds (red dashed line). (b) Acoustic emissions: typical example of cumulative count activity for experiment 19. Pink dashed line marks the end of loading and start of wetting, red dashed line marks failure of the sample. (c) Evolution of displacement field produced with PIV. 1 is showing the beginning of the experiment, 4 the last picture before failure of the wet sample. The red arrow is a reference arrow with constant length and direction; units are in pixel size (1 pixel ≈ 0.18 mm).

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