Liquid Water in Snow – Workshop 2014

Davos, Switzerland, 2–4 April 2014

At the beginning of April 2014 about 50 researchers attended the workshop 'Liquid water in snow – measurements, techniques and modeling approaches', which took place at the WSL Institute for Snow and Avalanche Research SLF in Davos, Switzerland – the first workshop on this topic since the one held in 1982 in Innsbruck, Austria.

The workshop aimed to bring together researchers dealing with avalanche formation and remote-sensing issues, as well as other cryospheric objectives related to the snow water equivalent of snowpacks. As it was more than 30 years since the last workshop, the aims and scope were to assemble current knowledge across disciplines to compare different measurement techniques and their accuracy, discuss current assumptions on modelling liquid water transport and storage in snow, and gather ideas on how to best obtain good validation and verification data.

The first day was dedicated to measuring techniques while the second focused on modelling approaches. The third day was organized as a field day at the Weissfluhjoch field test site to deploy different measurement techniques simultaneously and compare results and interpretation. To this end some participants brought along their own equipment. The field conditions were rewarding, as about 1.5 m of initially dry snow were considerably wetted during the day.

As an important result, the workshop participants produced a synoptic overview for future research directions for studies in liquid water content in snow, grouped under measurements, models, physical understanding and joint issues. An overall list is available from the workshop website at http://www.slf.ch/dienstleistungen/events/index_EN?viewevent=Workshop_042014, which also provides access to a time-lapse movie of the field day.

On the measurement side, a 'gold standard' or compilation of methods, parameters and physical properties against which to gauge all measurement techniques is urgently needed for an objective evaluation. A long-term issue remains the application of dielectric mixing models, their homogenization and recommendations for use. The optimal combination of classical concepts (e.g. dilution, calorimetry and permittivity devices) with modern approaches such as upward-looking radar, TDR, impedance analyser, micro-CT (computed tomography), application of elastic waves and full-waveform inversion was found to be necessary. In any case, future methodological considerations have to provide high resolution simultaneously in space and time.

Christoph Mitterer explaining the metamorphism of snow using hands-on models of the pore space obtained from micro-computer tomography (Photos: O. Eisen)

As far as models are concerned, bridging the different spatial scales, from micro-scales to hydrological catchments, remains one of the biggest challenges. On larger scales simpler modelling approaches still seem appropriate, as uncertainties and shortcomings in the exact physical description are averaged out when applying such models over larger areas covering different snow regimes.

Our physical understanding of liquid water distribution within the snowpack still needs improvement. This applies to properties on the micro-scale as well as the effect of small-scale structure on emerging properties that are considered in measurements and models. On scales below the snow-cover thickness the application of more sophisticated equations (e.g.

Richards equation) than simple bucket models seems necessary for an adequate description of the distribution and lateral movement of liquid water. The related differential flow and temporal changes urgently require treatment.

For the future, all the above aspects have to be considered when establishing model calibration and validation schemes. Fully understanding the causes of the remaining differences between measurements and models requires consideration on multiple scales, spatially as well as temporally. Higher spatial coverage with several data points in an individual catchment and more experimental sites to cover all regimes to improve our insight into processes within the snowpack are one recommendation. Following the example of other fields in earth sciences (e.g. model intercomparison projects) a standard experiment and suitable datasets across multiple scales have to be developed to achieve improvements towards data assimilation.

Crowded snow pit: after initial surveys with GPR from the surface, two simultaneous sets of pit-wall profiling using several different methods were applied to get information on lateral continuity and reproducibility of water in snow over time (Photo: O. Eisen)

Olaf Eisen, Jürg Schweizer, Christoph Mitterer, Achim Heilig, Lino Schmid

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Group photo (A. Heilig)