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Snowpack displacement measured by terrestrial radar interferometry as precursor for wet snow avalanches

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Wet snow and full depth gliding avalanches commonly occur on slopes during springtime when air temperatures rise above 0°C for longer time. The increase in the liquid water content changes the mechanical properties of the snow pack. Until now, forecasts of wet snow avalanches are mainly done using weather data such as air and snow temperatures and incoming solar radiation. Even tough some wet snow avalanche events are indicated before the release by the formation of visible signs such as extension cracks or compressional bulges in the snow pack, a large number of wet snow avalanches are released without any previously visible signs.

Continuous monitoring of critical slopes by terrestrial radar interferometry improves the scale of reception of differential movement into the range of millimetres per hour. Therefore, from a terrestrial and remote observation location, information on the mechanical state of the snow pack can be gathered on a slope wide scale. Recent campaigns in the Swiss Alps showed the potential of snow deformation measurements with a portable, interferometric real aperture radar operating at 17.2 GHz (1.76 cm wavelength). Common error sources for the radar interferometric measurement of snow pack displacements are decorrelation of the snow pack at different conditions, the influence of atmospheric disturbances on the interferometric phase and transition effects from cold/dry snow to warm/wet snow. Therefore, a critical assessment of those parameters has to be considered in order to reduce phase noise effects and retrieve accurate displacement measurements.

The most recent campaign in spring 2015 took place in Davos Dorf/GR, Switzerland and its objective was to observe snow glide activity on the Dorfberg slope. A validation campaign using total station measurements showed good agreement to the radar interferometric line of sight displacement measurements in the range of 0.5 mm/h. The refinement of the method led to the detection of numerous gliding patches distributed over the entire slope. Typically, patches showing (full depth) snow gliding reach extensions from 5x10 metres up to 40x60 metres.

Using a sampling interval of 1-3 minutes, the temporal displacement of such snow glide-hot spots can be tracked and thus revealing the individual signature of deformation. Nearly linear behaviour over several days, peaking in a final acceleration releasing an avalanche was observed as well characteristic acceleration and deceleration cycles during day and night could be captured. These cycles sometimes trigger an avalanche and sometimes reach a full stop of the differential snow glide movement.

Findings of the different campaigns will be presented. We put them in the context for possible future campaigns that could be used to solve scientific questions regarding the mechanical properties of the snow pack. We evaluate the possibilities for the use of terrestrial radar interferometry for hazard management and avalanche forecast.