EGU21-10933
https://doi.org/10.5194/egusphere-egu21-10933
EGU General Assembly 2021

Lab experiments to quantify wind induced microstructural modifications of surface snow

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The microstructural evolution of surface snow under the influence of wind is hardly understood and poorly quantified, but crucial for polar and alpine snowpacks. Only few field studies addressed the process of wind affecting surface snow at the snow-atmosphere interface in detail. Available descriptions are based on empirical relations between snow density, wind velocity and air temperature. A microstructural picture discerning independent controls of snow crystal fragmentation, abrasion and sublimation is yet missing.

The goal of this project is to analyze the relevant physical processes responsible for wind induced microstructural modifications, and develop parametrizations from controlled wind-tunnel experiments. A ring-shaped wind tunnel (RWT) with an infinite fetch was used in a cold lab to quantify the snow microstructural evolution through systematic variations of flow, snow, and temperature conditions. For the drift experiments, dendritic fresh snow was produced in a WSL/SLF snowmaker and slowly added to the wind tunnel during the experiments simulating precipitation. Measurement techniques like X-ray tomography, SnowMicroPen, density cutters and IceCube were applied to characterize the snow density (ρ), specific surface area (SSA), particle size and shape and vertical layering before and after the highly dendritic new snow was exposed to the wind.

The vertical heterogeneity of the deposited snow was characterized by SnowMicroPen measurements, showing increasing densities towards the snow surface. Densification rates (normalized by the initial density ρ_0) of the surface layer measured with a density cutter show an increase with increasing wind velocity and are two to three orders of magnitude higher than those measured for isothermal metamorphism, underlining the importance of accurately understanding wind induced microstructural modifications. Densification rates simulated with stat-of-the-art snow physical models span an order of magnitude, significantly deviating from the measured values. The SSA, measured with the IceCube instrument, decreases with a rate of change of approximately -0.1 h^{-1}, which is an order of magnitude higher than the rates for isothermal metamorphism. We hypothesize that the smallest fragments disappear because of sublimation while being transported by the wind.

The results of this project will lead to an improved, fundamental understanding of optically and mechanically relevant microstructural properties of surface snow and are thus applicable to many cryospheric processes like avalanche formation, exchange of chemical species with the atmosphere, alpine and polar mass balances, or radiative transfer.