EGU23-14338, updated on 25 Mar 2024
https://doi.org/10.5194/egusphere-egu23-14338
EGU General Assembly 2023

Influence of sun cups on surface albedo of wet Alpine snowpack

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In high elevation Alpine areas, characterised by high snow accumulation and radiation-driven melt processes, the formation of peculiar ablation features called sun cups can be observed. Sun cups likely influence the energy and mass balance of the wet snowpack by locally reducing the snow albedo, leading to an enhanced ablation in the hollows. To our knowledge, these phenomena are to date poorly explored in the literature and little to no attempts have yet been made to study their evolution in time and correlate them with meteorological forcings and energy fluxes over the wet snowpack.

The dynamics of the sun cups was investigated at the high elevation Alpine site of Weissfluhjoch (Davos, Switzerland) over the Spring of 2022. At the site, the snow surface was mapped on an hourly basis by means of a fixed, automated high-resolution 3D terrestrial laser scanner. Snow height maps were obtained by processing the registered point clouds.

Sun cups were individually and automatically detected over the snow surface maps by a delineation algorithm in Python. The evolution of sun cups in time was studied with respect to their maximum depth and cross-section.

The maximum depth and cross-section evolution of sun cups showed a high correlation with the measured albedo, especially when they are fully-formed. This finding suggests that peculiar snow surface formations that can be detected by means of remote sensing systems can give valuable additional information about the ongoing processes within the wet snowpack, paving the way to a radar-assisted modelling of the snowmelt dynamics. In an era of increasing concern over the availability of water resources, a better understanding and modelling of snowmelt dynamics is of major importance, especially in remote areas where accurate predictions are required for operational purposes (e.g. hydropower and irrigation).