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Rapid melting dynamics of the Morteratsch glacier (Swiss Alps) from UAV photogrammetry and field spectroscopy data

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The impact of atmospheric impurities on the optical properties of snow and ice has been largely acknowledged in the scientific literature. Beyond this, the evaluation of the effect of specific organic and inorganic particles on melting dynamics remains a major challenge. In this contribution, we examine the annual melting dynamics of a large valley glacier of the Swiss Alps using UAV photogrammetry. We then compare the melting patterns to the presence of surface impurities on the glacier surface.
Two surveys (in July and September 2016) with a lightweight Unmanned Aerial Vehicle (UAV) were organized on the ablation zone of the Morteratsch glacier (Swiss Alps). The UAV (DJI, Phantom 4) was equipped with a high resolution digital camera, and flew at a constant altitude of 150 from the glacier surface. 30 ground control points were placed on the glacier, and their coordinates were determined with a differential GPS (dGPS) for georeferencing UAV images. Contemporary to the UAV surveys, field spectroscopy data were collected on the glacier surface with an Analytical Spectral Device (ASD Field spec.) spectrometer covering the visible and near infrared spectral ranges, and ice samples were collected to determine the abundance of microorganism and algae.
From the UAV RGB data, two point clouds were created using Structure from Motion (SfM) algorithms. The point clouds (each consisting of about 15M points) were then converted in Digital Surface Models (DSM) and orthomosaics by interpolation. The difference between the two DSM was calculated and converted in Snow Water Equivalent (SWE), in order to assess the ice lost by the glacier during the ablation season. The point clouds were compared and the displacement vectors were estimated using different algorithms. The elevation changes estimated from UAV data were compared with the abundance of microorganisms and algae.
The reflectance spectra of ice with microorganisms and algae show a chlorophyll absorption feature at 680 nm. The depth of this absorption was extracted from reflectance spectra using a continuum-removal procedure and correlated to the abundance of microorganisms and algae in the snow sample. This result opens interesting perspectives for mapping the spatial distribution of organic material on the glacier surface using remote sensing data, enabling a better understanding of the effect of specific organic particles on melting dynamics.