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Partitioning the contribution of light absorbing impurities to albedo reductions on Plaine Morte Glacier, Swiss Alps using a novel Hysperspectral Microscopy method

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The presence of light absorbing impurities (LAI) plays an important role in reducing a glacier's surface albedo, contributing to accelerated glacier melt. LAI include black carbon, mineral dust and organic (humic) substances. We investigated the role of LAI on glacier melt of Glacier de la Plaine Morte (7.88 km2 area) in the Swiss Alps. More than 90% of the Plaine Morte surface lies between 2650 and 2800 m a.s.l.; the low and narrow elevation range results in the glacier being particularly susceptible to melt. The glacier melt over the last 10 years ($^{-1}$.7 mw.e. yr-1 on average) was almost double compared to the Alpine average. Plaine Morte has been almost entirely snow free in summer for the last 8 years, and has consequently accumulated a layer of LAI on the exposed surface after snow melt. The aim of this project is to: determine the relative abundances of the three classes of LAI, their spatial distribution on the glacier's surface, and to identify the relative contribution of each LAI to albedo reductions. Snow samples were collected at 110 sites that were spatially distributed on the glacier's surface. Relative quantities of elemental carbon (EC), organic carbon (OC) and mineral dust were determined for all samples collected with a thermal optical analyser; which combusts the sample separating OC and EC in the combustion process by their temperature (what is not combusted is considered mineral dust). The mineral composition, examined with X-ray diffractometry, indicated that local rock is the major source of mineral dust. Through an innovative hyperspectral imaging spectrometric technique developed for this purpose, a characteristic reflectance spectrum was defined for each of the three classes of LAI. Comparing the characteristic spectra, we determined to what extent black carbon, humic substances and minerals might be able to contribute to a lower albedo. Taking into account the average relative abundances on the glacier, we obtained that in the case of Plaine Morte, mineral dust is (with 87.6%) the overwhelming contributor to the albedo reduction, whereas humic substances and black carbon play a minor role (9.9% and 2.5%, respectively).