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Long-range transported dissolved organic matter, ions and black carbon deposited on Central Asian snow covered glaciers

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Ninety percent of the Central Asian population depend on water precipitated in the mountains stored in glaciers and snow cover. Accelerated melting of the snow and ice can be induced by the deposition of airborne impurities such as mineral dust, black carbon and co-emitted species leading to significant reductions of the surface albedo. However, Central Asia is a relatively understudied region and data on the source regions, chemical and microphysical characteristics as well as modelling studies of long-range transported air pollution and dust to the Tien Shan mountains is very scarce.

We studied the atmospheric aerosol deposited most likely between summer 2012 and summer 2013on three different glaciers in the Kyrgyz Republic. Samples were taken from four snow pits on the glaciers Abramov (2 pits, 39.59 °N, 71.56 °E, 4390 m elevation, 240 cm deep, and 39.62°N, 71.52 °E, 4275 m elevation, 125 cm deep), Ak-Shiirak (41.80 °N, 78.18 °E, 4325 m elevation, 75 cm deep) and Suek (41.78 °N, 77.75 °E, 4341 m elevation, 200 cm deep). The latter two glaciers are located roughly within 6 and 38 km of an operating gold mine. The snow was analyzed for black carbon, ions, metals and organic carbon. We here focus on the results of inorganic ion measurements and organic carbon speciation based on analysis with an Aerodyne high-resolution time-of-flight aerosol spectrometer (HR-ToF-AMS) and potential pollution sources that can be deduced from the chemical information as well as back trajectories.

Average contributions of snow impurities measured by the HR-ToF-AMS were dominated by organic carbon. Relative concentrations of organic carbon, sulfate, nitrate and ammonium in snow were 86 %, 3 %, 9 % and 2 % respectively for Abramov, 92 %, 1 %, 5 % and 1 % for Suek, and 95 %, 1 %, 3 % and 1 % for Ak-Shiirak. Generally, impurities on Suek and Ak-Shiirak were three and five times higher than on Abramov. Mass concentrations of organic carbon were on average 6 times higher in samples with visible mineral dust pollution, and concentrations of nitrate and ammonium were twice as high while sulfate was not enhanced. Further analysis of the organic carbon revealed average ($\pm 1\sigma$) O:C and OM:OC ratios of 0.75 ($\pm$ 0.22) and 2.13 ($\pm$ 0.29) respectively for Abramov, 1.01 ($\pm$ 0.24) and 2.46 ($\pm$ 0.30) for Suek and 1.09 ($\pm$ 0.34) and 2.56 ($\pm$ 0.43) for Ak-Shiirak. These relatively high ratios are comparable with winter-time biomass burning influenced findings in the Central Himalayas. Here, also marker ions for biomass burning from levoglucosan were found as well as organic nitrogen.

In addition, atmospheric measurements during August 2013 conditions were conducted to obtain information on background aerosol number concentrations, size distributions and chemical composition. The average black carbon concentration for the high altitude glaciers was 0.26 μg/m^3 ($\pm$ 0.24 μg/m^3).