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Hydro(geo)logical and geochemical approach to investigate the impact of active layer groundwater on runoff in the Austrelovenbreen watershed (Western Spitsbergen - 79°N)

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The recent climate evolution has led to a strong reduction of the continental cryosphere in High Arctic environments. The meltwater from both glacier and permafrost active layer has therefore notably increased. However, the impact of the permafrost-active layer on the runoff has been little studied. The studied watershed is that of the Austreloven glacier (10 km^2), close to Ny-Ålesund (Spitsbergen, 79°N) in a continuous permafrost area. Since the end of the Little Ice Age, this glacier has displayed a surface reduction with an average rate of 18 m.a^{-1}. During the summer (June to September), the thawing of the active layer forms a temporary water-table above the permafrost, that may exchange water and solutes with the surface water. In order to investigate the river water/groundwater exchanges, several monitoring have been undertaken since 2010: physicochemical characteristics of surface water and groundwater, potentiometric level, soil temperature). Geophysical prospecting (GPR and electrical resistivity) are used to study the geometry of the system. Besides, a total of 151 water samples were taken from the suprapermafrost water table, springs, ponds, subglacial river and main streams during the summers 2011 and 2012 in order to study the exchanges and to discuss the origin of the different water end-members (geochemical and isotopic end-members signatures, water-rock interactions and solute acquisition processes).

The hydrographs at the catchment outlet show a seasonal evolution closely linked to climatic factors. However, although the meltwater from snow and glacier ice strongly contributes to the outlet flows, it does not fully explain all the hydrological events. Indeed, the discharge from subglacial river and suprapermafrost groundwater are shown to constitute a river base flow. The groundwater water-table reaches a thickness up to 1.50 m for an active layer thickness of 2.50 m at maximum. The contribution of water-table towards the rivers might be consequent as this process proceeds all along during the hydrological season.

The predominant water-type is sulfate-bicarbonate calcium. The contents in major elements (SO_4^{2-}, HCO_3^-, Ca^{2+} and Mg^{2+}) indicate that the carbonate dissolution (calcite, magnesium calcite and/or dolomite) and pyrite oxidation are likely to occur in the system. Possible gypsum dissolution is not to exclude to explain high concentration in sulfates. The combination of hydrochemical and isotopic tracers are helpful to separate all different end-members. Indeed, the stable isotopes contents of the water molecule show that the outlet signature is a mixing between the enriched and evaporated precipitations (δ^{18}O between -8 and -7‰, the evaporated suprapermafrost groundwater (δ^{18}O between -12 and -11‰ and the highly depleted subglacial river (δ^{18}O between -16 and -14‰. The preliminary results in ^{87}Sr/^{86}Sr show that all isotopic signatures of analyzed waters are radiogenic. Furthermore, this isotopic tracer seem to confirm that the outlet signature (^{87}Sr/^{86}Sr = 0.730) is a mixing between the suprapermafrost groundwater (^{87}Sr/^{86}Sr = 0.750) and the subglacial river (^{87}Sr/^{86}Sr = 0.726).