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Hydrological role of large icings within glacierized Sub-Arctic watershed: case study in Upper Duke River valley, Yukon, Canada.

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Sub-Arctic glacierized catchments are complex hydrological systems of paramount importance for water resources management as well as for various ecosystem services. Such systems host many climate-sensitive water sources. Among those, icing is an important component as they provide substantial amount of water during the melt season. Moreover, collecting water of different origins during their formation, icings can be seen as an indicator for different water sources and water pathways that remain active during the freezing period. The present study focuses on genesis and dynamics of large icings within both proglacial field and neighboring alpine meadow in Upper Duke River valley, Yukon, in order to i) provide new insights on water sources and pathways within Sub-Arctic glacierized watersheds, and ii) to quantify contribution of icings to the total runoff of those hydrological systems.

A multi-approach technique was applied to cope with the high hydrological complexity met in Sub-Arctic mountainous environments. Time series of positions of large river icings within the study area were obtained using Landsat images for the period 1980-2016. Four time-lapse cameras (TLC) were installed in the watershed targeting two proglacial fields and two alpine meadows in order to monitor icing dynamics all year long. Meteorological data was measured by an Automatic Weather Station in the main valley. In addition air temperature and relative humidity were measured at the location of each TLC. Finally, four icings along the Duke River valley, as well as 2 icings in its main tributary were sampled for stable water isotopes, solutes concentrations and total organic carbon. In addition, samples of freezing exclusion precipitates from icing surfaces were taken.

Remote sensing data shows the persistence of large icing complexes in the area during last 30 years: icing within proglacial field appear with almost constant position relative to main glacier tongue on the 30 years long period. Absolute position of icings limits is changing however, and is shifting upstream following glacier retreat. TLC show that appearance and growth of icing is correlated with occurrence of milder but still negative temperature episodes. Hydrochemical analysis suggests that main source of water for icing formation within alpine meadow is groundwater, whereas icing formed within proglacial field are fed by both glacier and possibly buried ice water.

Thus the multi-technic approach reveals a tight connection of proglacial and river icing formation in Upper Duke River valley with current and past glacier systems: sub-glacial drainage water as well as water from buried ice are collected in a form of icing during mild winter episodes and then are being redistributed to total runoff during ablation season contributing substantially. Moreover, observed relation between icing formation and air temperature regime in the valley suggests that hydrological role of icings in Sub-Arctic glacierized watershed will be subject to changes under changing climate.