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Glacier and snow melt contributions to streamflow on James Ross Island, Antarctic Peninsula

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Antarctic Peninsula region experienced a rapid increase in air temperature during the second half of the 20th century. Although the warming was interrupted in the first decades of the 21st century, future climate projections predict that air temperature will increase significantly until the end of the 21st century in this area. Changes in air temperature have large impact on runoff process, especially in proglacial environment. Even though these changes affects both terrestrial and marine ecosystems, runoff generation in Antarctic Peninsula region is still poorly understood. Therefore, we analysed runoff process in small, partly glaciated catchment on James Ross Island, which belongs to the largest deglaciated area in Antarctica. Our objective was to 1) describe runoff variability in this area and 2) to estimate glacier, snow, and rain contributions to runoff in relation to climate variability.

Due to limited discharge measurements, we used semi-distributed bucket-type HBV model to simulate runoff process in years 2010–2020 in a daily temporal resolution. Input data for the model were time series of in situ measured air temperature, and simulated precipitation. Precipitation was simulated by the Weather Research and Forecasting model driven by ERA5 reanalysis. The HBV model was calibrated against measured daily discharge from six weeks long period in February and March 2018, and seasonal ablation measurements from years 2014–2020.

The results showed that 93% of the annual runoff occurred from October to May. The highest mean monthly runoff occurred in the second half of summer due to combination of strong glacier and snow melt. Additionally, large runoff was found in November which was caused by melt-out of seasonal snow cover. The major part (53%) of runoff originates from snow cover, 41% originates from glacier and only 6% from rainfall. Snowmelt runoff dominated during winter (with overall low absolute values of runoff) and in autumn. In summer, snowmelt runoff was almost the same as glacier runoff. In autumn, contribution of glacier to total runoff was slightly higher than contribution of snow. Contribution of snow to total runoff was higher in colder years with higher precipitation. In contrast, melting glacier contributed more during warmer years with less precipitation.