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Isotopic signatures of glacier, permafrost and streams in the Trans-Himalaya of Ladakh, India

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The importance of glaciers, permafrost and seasonal snow contribution to stream flow in the upper Indus Basin is a frequently discussed topic on the large scale as well as on the regional scale of Ladakh, where the agriculture depends on the melt water runoff of these water sources. A variety of methodological approaches exists in order to estimate the contribution of these different water sources to the runoff. Due to the lack of meteorological and discharge data in many high mountain regions, large scale input data for hydrological models can be derived from remote sensing data. However, their low spatial resolution cannot capture small scale processes caused by the steep topography. Therefore, additional ground-truth information on the cryosphere through natural tracers is highly valuable. Modern possibilities of analysing stable water isotopes allow for a resource efficient way of gathering information in mountain regions.

In this study snap shot samples were collected in 62 locations in three tributaries of the Indus River in Ladakh. The sampling was planned with the aim of covering the major sources for stream flow including glacier melt, springs (most likely melt water from permafrost), streams, groundwater and snow.

Measured stable water isotopes range from -16.04 ‰ to -10.39 ‰ for δ18O and -110.81 ‰ to -69.88 ‰ for δ2H. Based on the results from different water sources a local meteorological water line was calculated: δ2H = 7.85 x δ18O + 10.34. The results show a major dependence on the east to west distribution of sampling locations especially for glacier melt water. Snow samples are more depleted than other sources. Results from springs are highly heterogenic ranging from -14.29 to -10.94 for δ18O and -106.76 and -74.37 for δ2H. In contrast to the broad range of sampling elevation (3,470 to 5,380 m) the results only show a weak correlation to elevation. The measured values directly sampled from glacier meltwater shows some interesting variation. While glaciers in the valleys of Stok and Leh exhibit a similar range for δ18O and δ2H (between -14.34 to -13.91 for δ18O and -98.97 to -97.37 for δ2H) the results from glaciers in the Igoo Valley are significantly more enriched (δ18O > -11.61 and δ2H > -77.86).

These results can help to increase the understanding of underlying processes in the local cryosphere and possible expected changes in the future due to global warming.