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Mass balance and hydrological contribution of glaciers in northern and central Chile

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Water is a critical resource in the northern and central regions of Chile, as the area supports more than 40% of the country's population, and the regional economy depends on agricultural production and mining, which are two industries that rely heavily on a consistent water supply. Due to relatively low rates of rainfall, meltwater from snow and ice bodies in the highland areas provides a key component of the annual water supply in these areas. Consequently, accurate estimates of the rates of ablation of the cryosphere (i.e. snow and ice) are crucial for predicting current supply rates, and future projections. Whilst snow is generally a larger contributor of freshwater, during periods of drought, glaciers provide a significant source. This study aims to determine the contribution of glaciers to two catchments in northern and central Chile during a 2.5 year period, which largely consisted of extreme dry periods, but also included the recent El Niño event.

This study combined field and modelling studies to understand glacier and rock glacier contributions in the Tapado (30ºS), Yeso (33ºS) catchments. In the field we undertook glaciological mass balance monitoring of three glaciers, monitored albedo and snow line changes using automatic cameras for three glaciers, measured discharge continuously at several points, installed six automatic weather stations and used thermistors to monitor thermal regime changes of two rock glaciers. The combination of these datasets where used to drive energy balance and hydrological models to estimate the contribution of ice bodies to streamflow in the two studied catchments.

Over the course of the study all glaciers maintained a negative mass balance, however glaciers in central Chile lost more mass, which is due to the higher melt rates experienced due to lower elevations and higher temperatures. Areas free of debris generally contributed more to streamflow than sediment covered regions, and snow generally contributed more over the course of a season than glacial ice, however there were marked differences between seasons. The modelling studies showed that in the northern (drier) site, during the lower precipitation season, glacier contribution could be as high as 20% verses only approximately 5% in 'wetter' periods. Comparatively, in central Chile, glaciers contributed approximately 15% during 'wetter' periods, and as much as 35% of total streamflow during the extremely dry year. This study suggests that the continuation of long-term glacier monitoring projects in the semi-arid Andes is necessary in order to better constrain hydrological models in these environments.