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Sources and pathways of stream generation in tropical proglacial valleys of the Cordillera Blanca, Peru

Ryan P. Gordon ^a  , Laura K. Lutz ^a, Jeffrey M. McKenzie ^b, Bryan G. Mark ^c, Daniel Chavez ^b, Michel Baraer ^d

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Summary

Tropical glaciers supply approximately half of dry-season stream discharge in glacierized valleys of the Cordillera Blanca, Peru. The remainder of streamflow originates as groundwater stored in alpine meadows and other proglacial geomorphic features. A better understanding of the hydrogeology of alpine groundwater, including sources, storage zones, and the locations and magnitudes of contributions to streamflow, is important for making accurate estimates of glacial inputs to the hydrologic budget, and for our ability to make predictions about future water resources as glaciers retreat. This field study focuses on two high-elevation meadows in valleys of the Cordillera Blanca, in headwaters and mid-valley locations. Tracer measurements of stream and spring discharge and groundwater-surface water exchange were combined with synoptic sampling of water isotopic and geochemical composition in order to characterize and quantify contributions to streamflow from different groundwater reservoirs. At the headwaters site, groundwater supplied approximately half of stream discharge from a small meadow, with most originating in an alluvial fan adjacent to the meadow and little (6%) from the meadow itself; however, at the mid-valley site, where meadows are extensive, local groundwater has a large impact on streamflow and chemistry through large net contributions to discharge and turnover of surface water due to gross exchanges with groundwater. At the mid-valley site, stream discharge increased by 200 L s⁻¹ (18% of average discharge) over 1.2 km as it descended a moraine between two meadows. Such valley-crossing moraines, which create significant steps in the down-valley slope, are likely locations of substantial groundwater contribution to streams.