The impact of glaciers on the long-term hydrology of a high-elevation Andean catchment

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The Andean cryosphere is a vital water resource for downstream populations. In recent years, it has been in steep decline as a whole, but shown strong spatio-temporal variability due to climatic events such as the current mega drought in central Chile. Glacio-hydrological models are necessary to understand and predict changes in water availability as a result of changes to the cryosphere. However, due to a lack of data for initialisation, forcing, calibration and validation, they are rarely used, especially in the Andes, for periods longer than a few years or decades. While useful insights can be gained from short-term modelling, there is a gap in our understanding of how glaciers impact hydrology on longer timescales, which may prevent local communities and governments from achieving effective planning and mitigation. Here we use the glacio-hydrological model TOPKAPI-ETH – initialised, forced, calibrated and validated using unique and extensive field and remote sensing datasets – to investigate glacier contributions to the streamflow of the high-elevation Rio Yeso catchment, Chile, over the past 50 years. We focus in particular on: 1) fluctuations in glacier surface mass balance and runoff and associated climatic variability; 2) if peak water has already occurred and when; 3) the effect of supraglacial debris cover on seasonal and long-term hydrographs. We offer insights into some of the challenges of running glacio-hydrological models on longer timescales and discuss the implications of our findings in the context of a shrinking Andean cryosphere.