Proglacial groundwater storage dynamics under climate change and glacier retreat

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Abstract

Proglacial aquifers are an important water store in glacierised mountain catchments that supplement meltwater-fed river flows and support freshwater ecosystems. Climate change and glacier retreat will perturb water storage in these aquifers, yet the climate-glacier-groundwater response cascade has rarely been studied and remains poorly understood. This study implements an integrated modelling approach that combines distributed glacio-hydrological and groundwater models with climate change projections to evaluate the evolution of groundwater storage dynamics and surface-groundwater exchanges in a temperate, glacierised catchment in Iceland. Focussed infiltration along the meltwater-fed Virkisà River channel is found to be an important source of groundwater recharge and is projected to provide 14-20% of total groundwater recharge by the 2080s. The simulations highlight a mechanism by which glacier retreat could inhibit river recharge in the future due to the loss of diurnal melt cycling in the runoff hydrograph. However, the evolution of proglacial groundwater level dynamics show considerable resilience to changes in river recharge and, instead, are driven by changes in the magnitude and seasonal timing of diffuse recharge from year-round rainfall. The majority of scenarios simulate an overall reduction in groundwater levels with a maximum 30-day average groundwater level reduction of 1 m. The simulations replicate observational studies of baseflow to the river, where up to 15% of the 30-day average river flow comes from groundwater outside of the melt season. This is forecast to reduce to 3-8% by the 2080s due to increased contributions from rainfall and meltwater runoff. During the melt season, groundwater will continue to contribute 1-3% of river flow despite significant reductions in meltwater runoff inputs. Therefore it is concluded that, in the proglacial region, groundwater will continue to provide only limited buffering of river flows as the glacier retreats.

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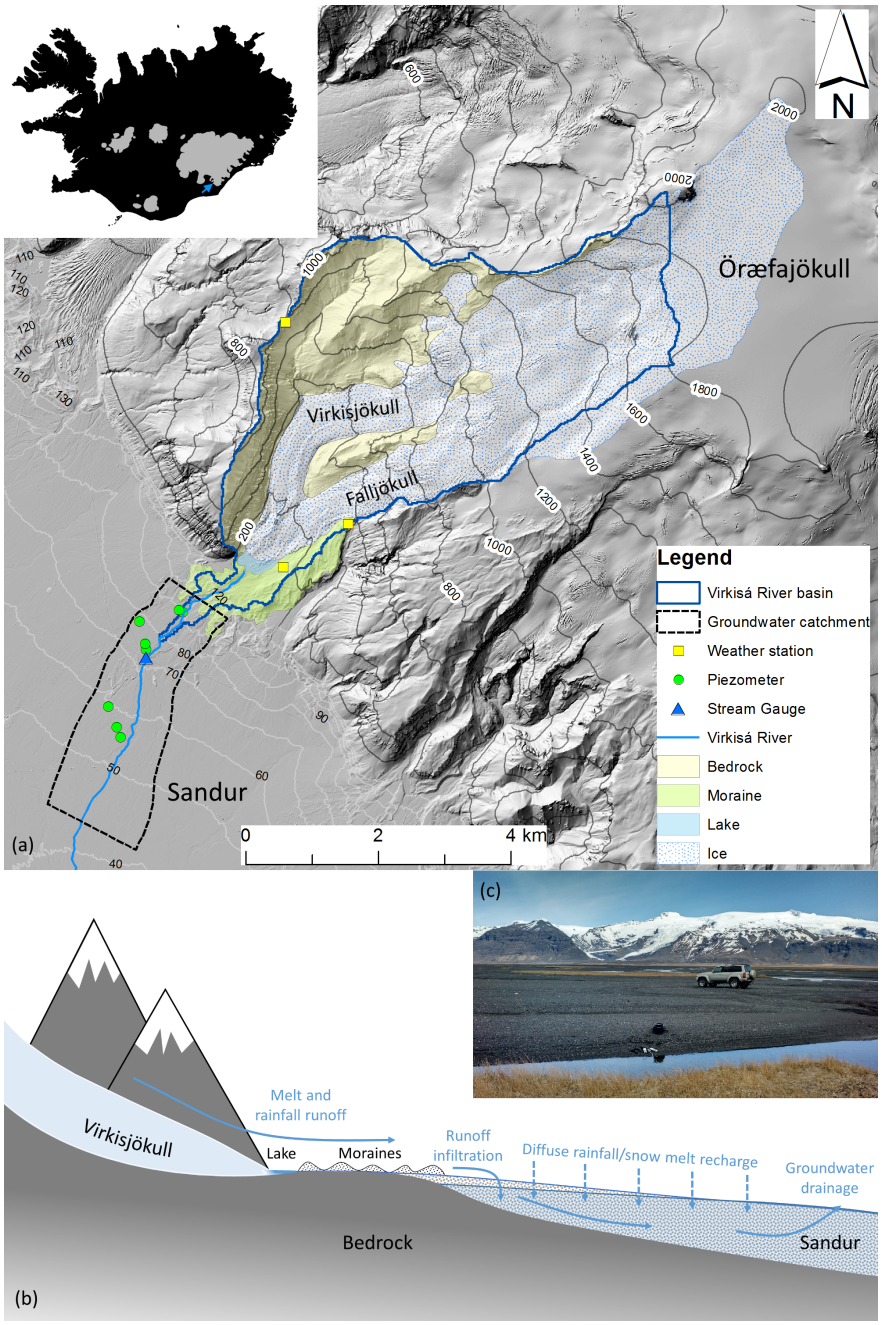

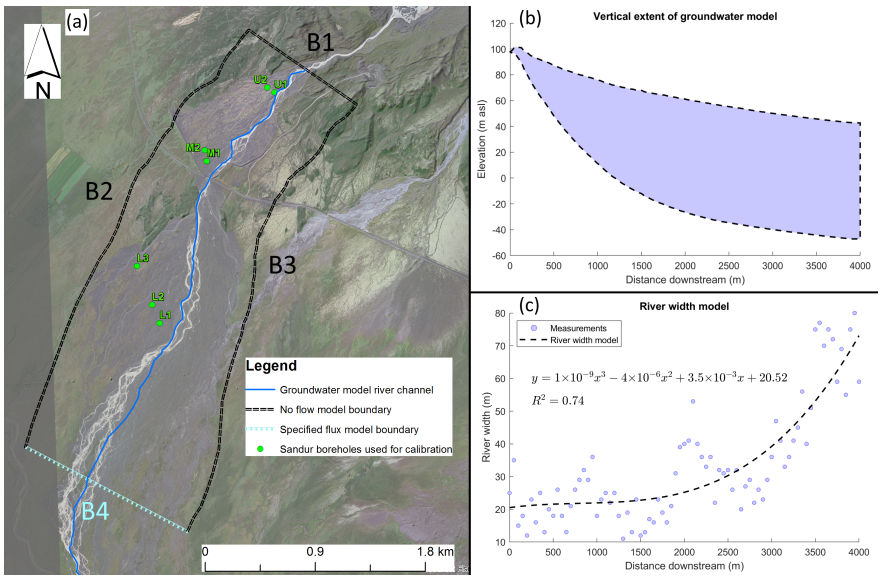

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