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Proglacial groundwater storage dynamics under climate change and glacier retreat

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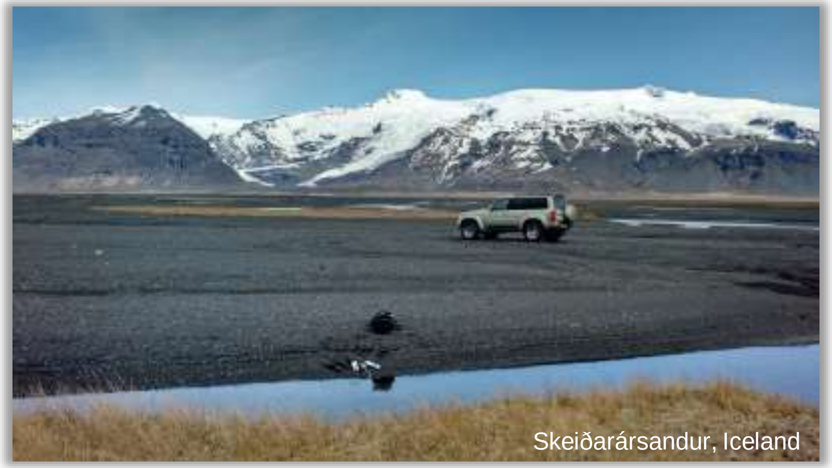
Proglacial groundwater systems

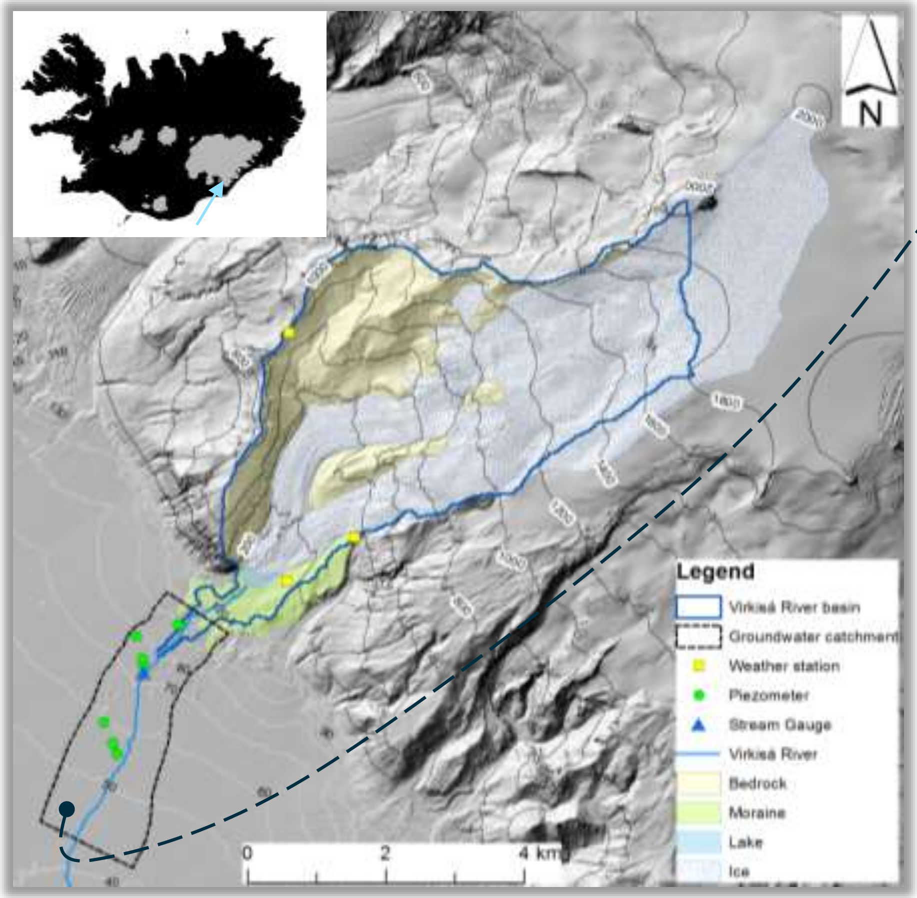
- Overburden materials, alluvial valley aquifers, mountain wetlands
- Remote, rarely studied
- Significant role in mountain water cycling -> downstream water provision
- Ecologically important

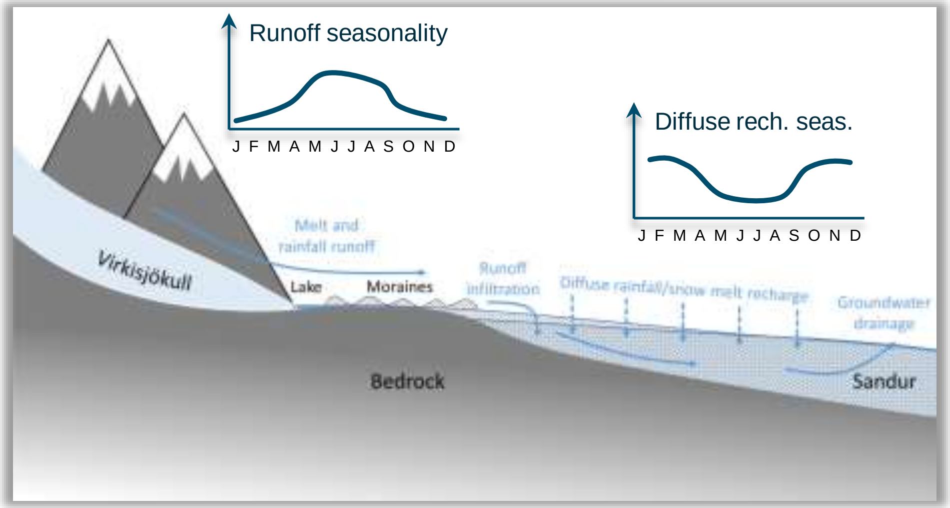


Skeiðarársandur, Iceland

Cerro Comercocha, Peru

Virkisjökull glacier observatory





RESEARCH QUESTIONS:

1) What drives proglacial groundwater storage dynamics?

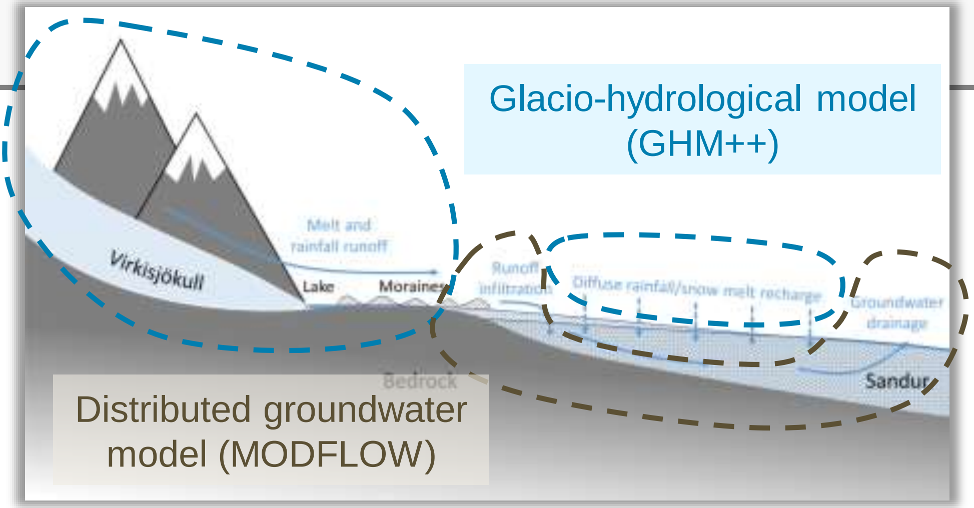
2) How might proglacial groundwater storage dynamics respond to 21st century climate change and glacier retreat?

Methodology: Integrated climate-glacier-GW modelling

280 future climate sequences
↓
336 GHM++ models (Mackay et al., 2019)
↓
94,080 climate/meltwater runoff scenarios
↓
Cluster analysis

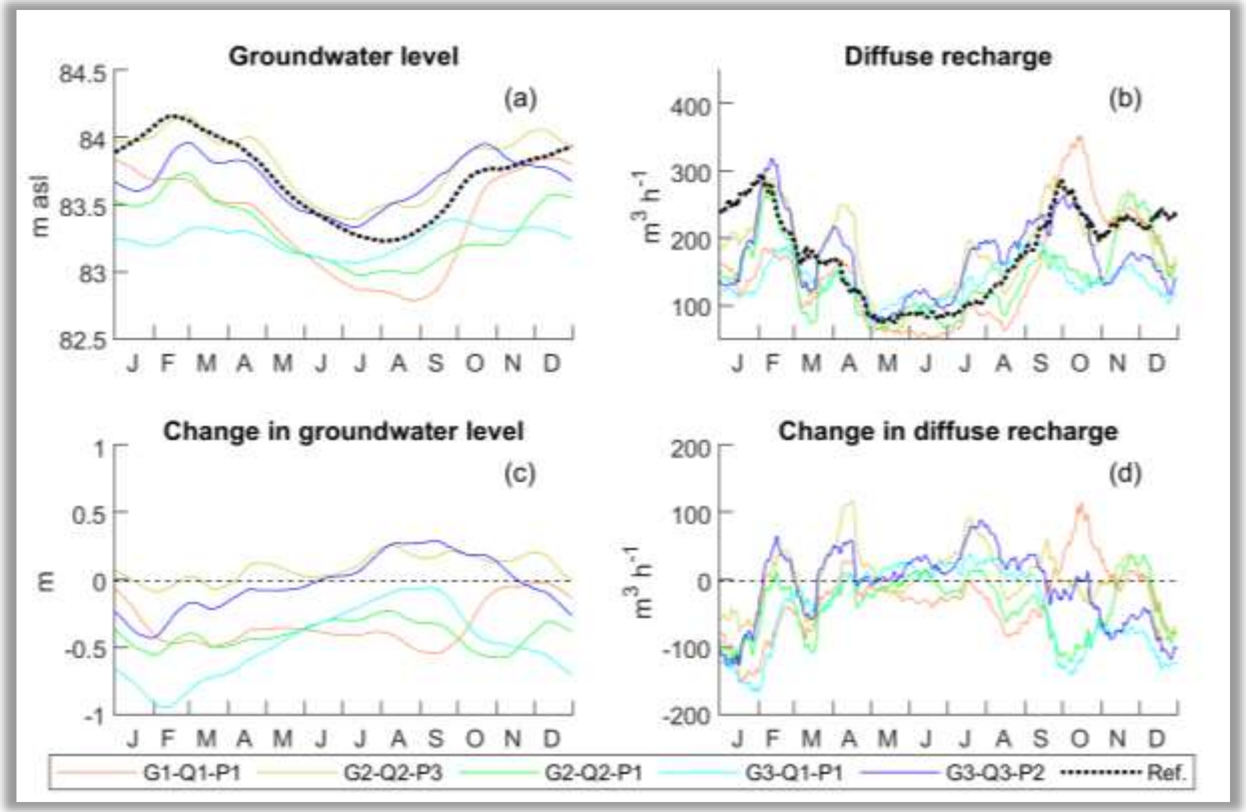
Climate and meltwater runoff scenarios

Scenario	Scenario code	ΔT (ºC)	ΔG (km²)	ΔQ (m³ s⁻¹)	ΔP (mm d⁻¹)
1	G1-Q1-P1	3.1	-8.1	-1.1	-0.6
2	G2-Q2-P3	3.1	-6.4	-0.7	0.2
3	G2-Q2-P1	1.9	-5.6	-0.9	-0.7
4	G3-Q1-P1	1.0	-4.8	-1.2	-0.9
5	G3-Q3-P2	0.7	-3.7	-0.3	-0.2



Findings

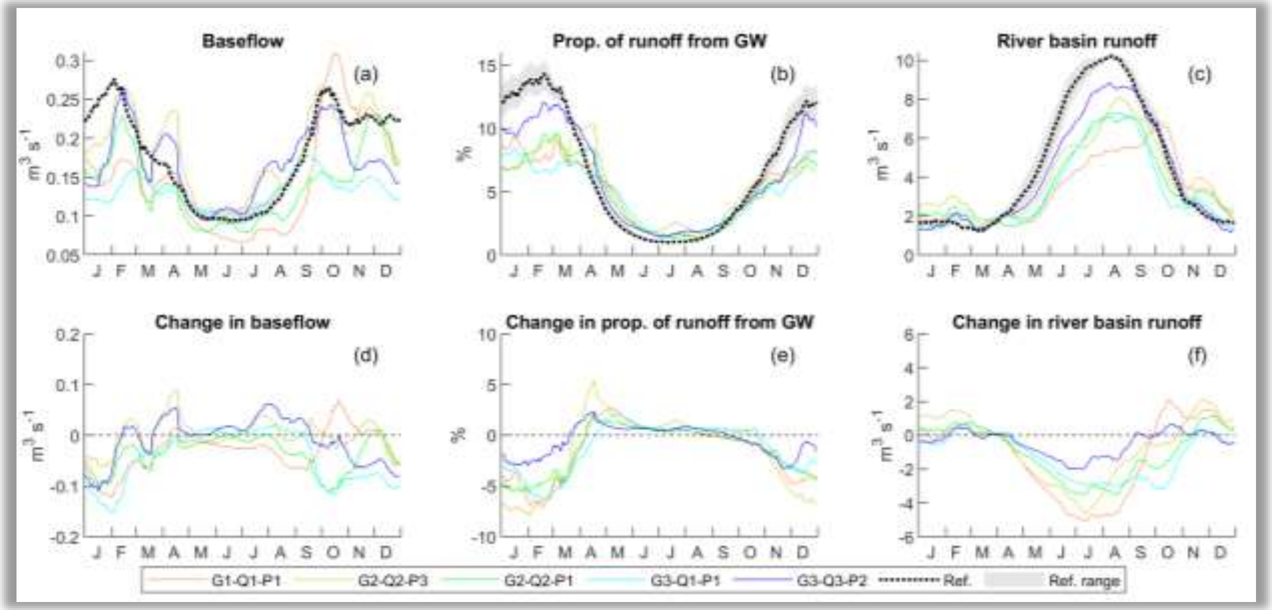
GROUNDWATER STORAGE DYNAMICS



- GWL seasonality relatively stationary
- Groundwater levels projected to fall on average
- Changes in GWL correspond closely to diffuse recharge signal
- Groundwater storage dynamics driven by diffuse recharge

Findings

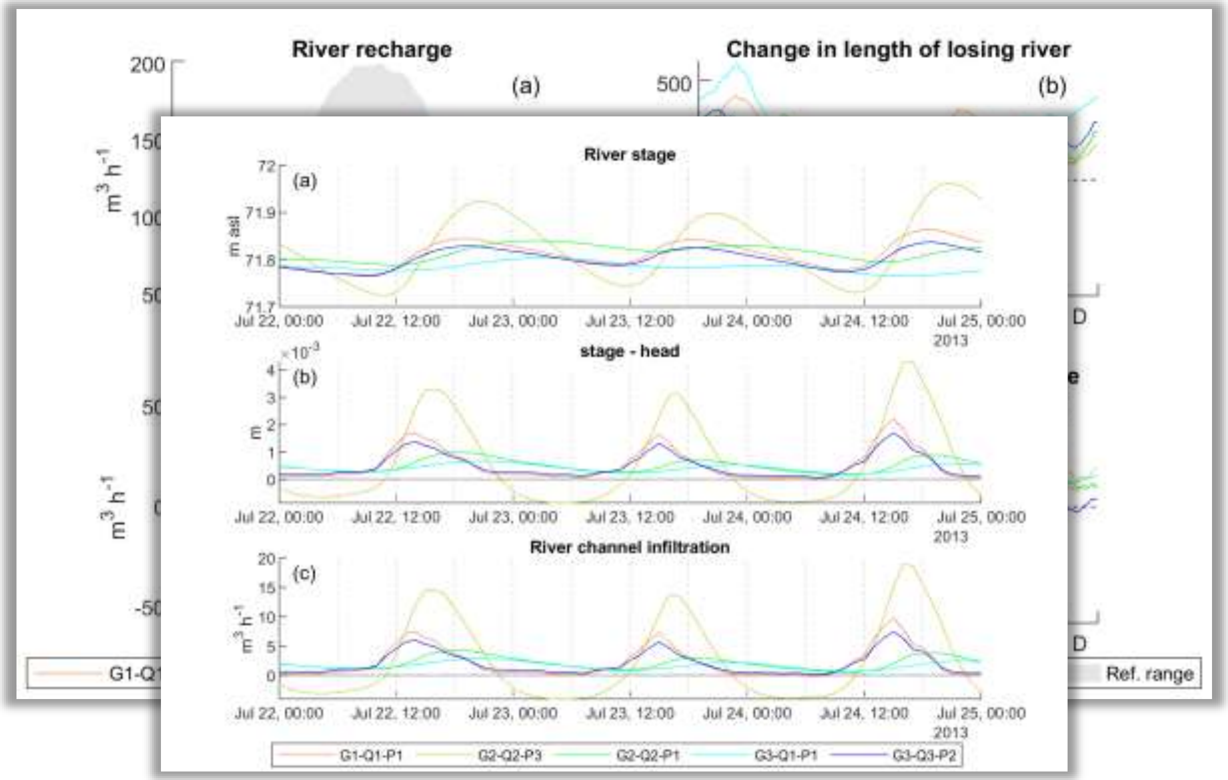
BASEFLOW DYNAMICS



- Baseflow seasonality also closely aligned with diffuse recharge
- As with GWL, baseflow projected to fall on average
- GW contributes up to 15% of runoff
- Projected to fall by up to 8% due to ↓baseflow and ↑ melt runoff

Findings

RIVER RECHARGE DYNAMICS



- River recharge highest in melt season
- Contributes up to 39% (~15% on average) to total recharge
- Seasonality of changes follow length of losing river
- G2-Q2-P3 scenario, reduction in specific river recharge
- Due to loss of diurnal melt signal

Conclusions

- The Virkisá River is a significant source of proglacial groundwater recharge
- Glacier retreat could inhibit river recharge
- Groundwater storage dynamics are resilient to changes in river recharge
- Groundwater continue to buffer proglacial river runoff under climate change

THANK YOU

Any questions?