Proglacial groundwater storage dynamics under climate change and glacier retreat
Proglacial groundwater systems

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

Runoff seasonality

Diffuse rech. seas.
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

Climate and meltwater runoff scenarios

| Scenario | Scenario code | ΔT (°C) | 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        |

280 future climate sequences

336 GHM++ models (Mackay et al., 2019)

94,080 climate/meltwater runoff scenarios

Cluster analysis

Glacio-hydrological model (GHM++)

Distributed groundwater model (MODFLOW)
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
Any questions?

THANK YOU