Climate change, water resources and the hydropower system in Iceland

Supplemental

EGU, Vienna, Austria & Online | 14–19 April 2024

Innovation in Hydropower Operations and Planning to integrate Renewable Energy Sources and optimize the Water-Energy Nexus | PICO

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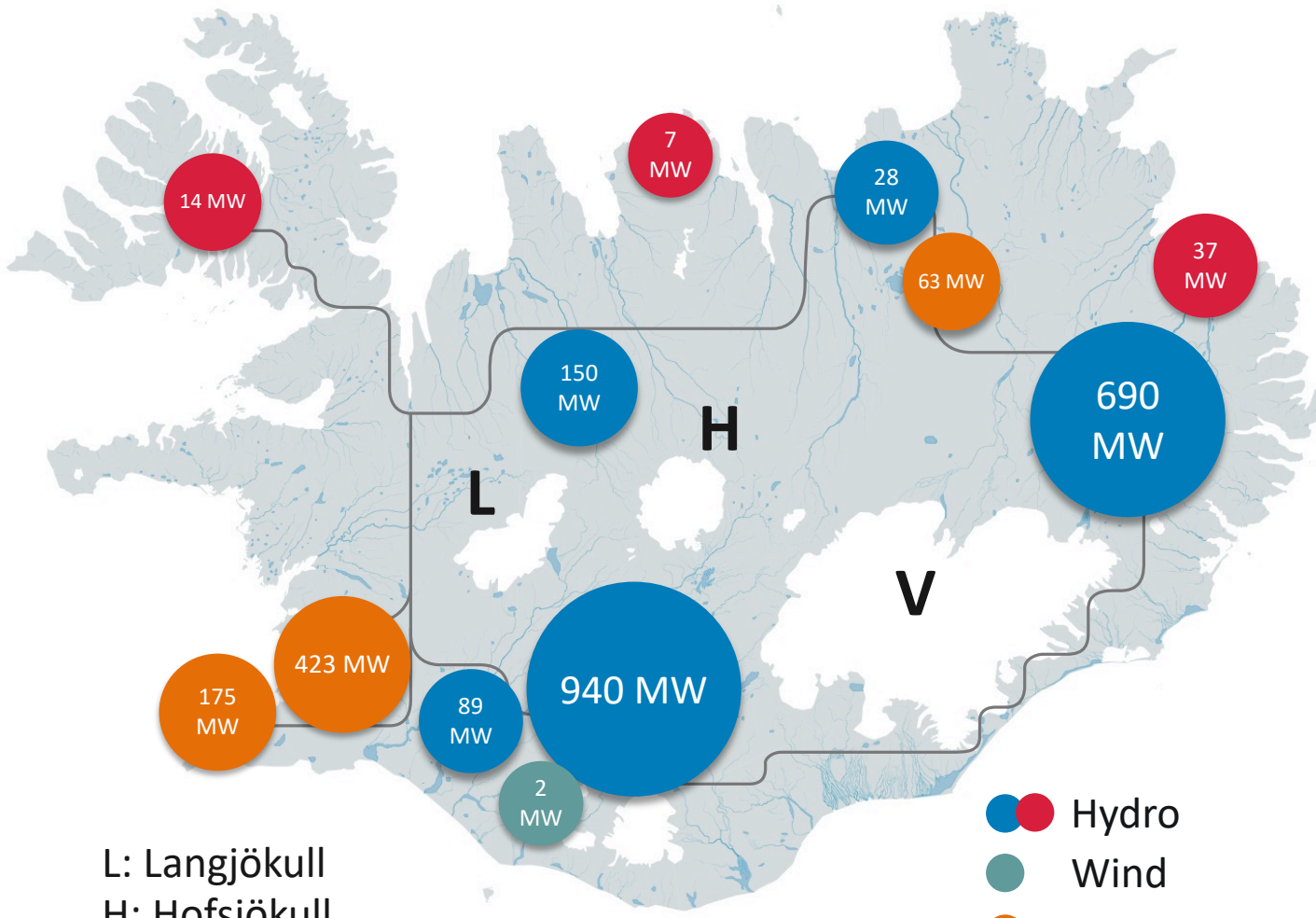
Energy System in Iceland

Based on 100% renewable resources

Electricity generation

- 72% Hydro (1908 MW)
- 28% Geothermal (742 MW)
- < 0.1% Wind (4 MW)

- **+80% power intensive load (high base power)**
- **No interconnections**
- **Hydrological variability dominates inflow energy variability**



L: Langjökull
H: Hofsjökull
V: Vatnajökull

Installed Power 2650 MW

Source Orkustofnun, National Energy Authority

Water resources in Iceland

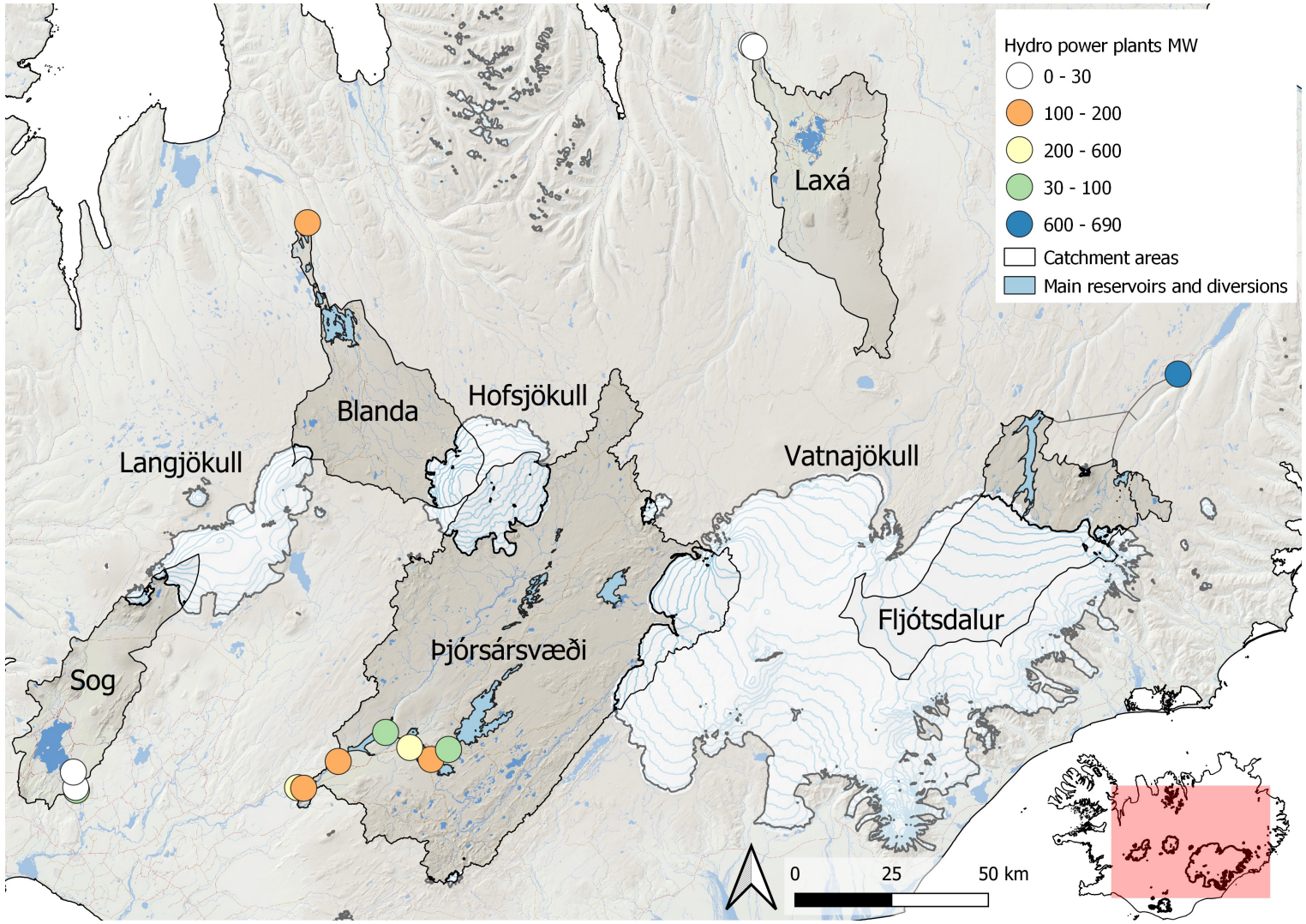
5 main hydro catchments

Highland catchments cover 13% of Iceland

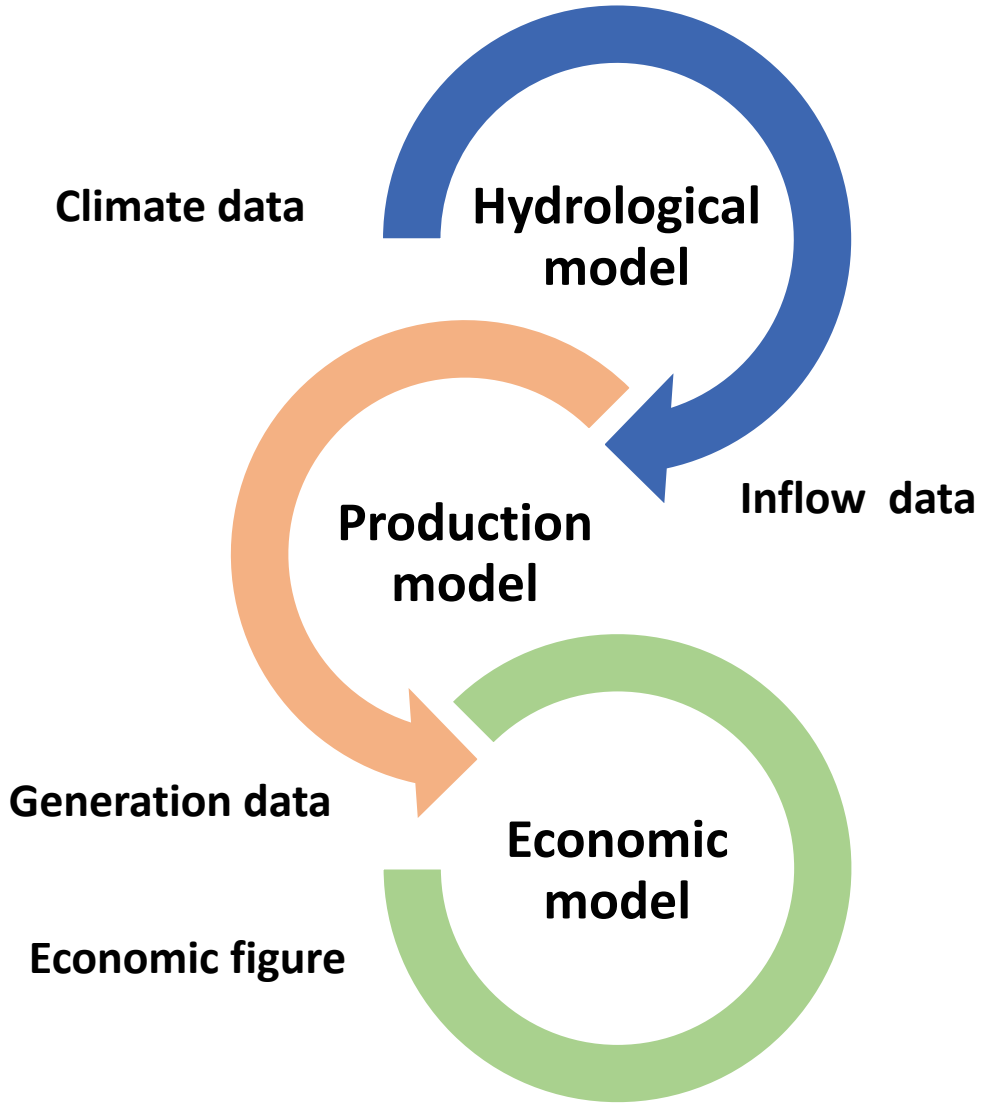
- 23% glaciated (~50% of inflow energy)
- Seasonal snow (~15% of inflow energy)

- Recent hydrological changes
  - Less seasonal snow
  - Increased glacier melt

- Driven by natural variability and climate change



Adapting hydro to current and future climates



Current flows
Calibrated models from historical flows
adjusted for current climate
Temperature adjustments to input
Represent current variability in flow
Used for:
Short- and long-term planning (mo / yrs)
Operational planning (days/weeks)

Reconstructed historical flows
Calibrated w. observations
Represent historical variability
Climate reconstructions
Used for:
Model development
Baseline generation

Future adjusted flows
Future glacier geometry
Future temperature changes
Used for:
Refurbishments of old HPP
Prod. capabilities of new HPP
Add capacity to old HPP

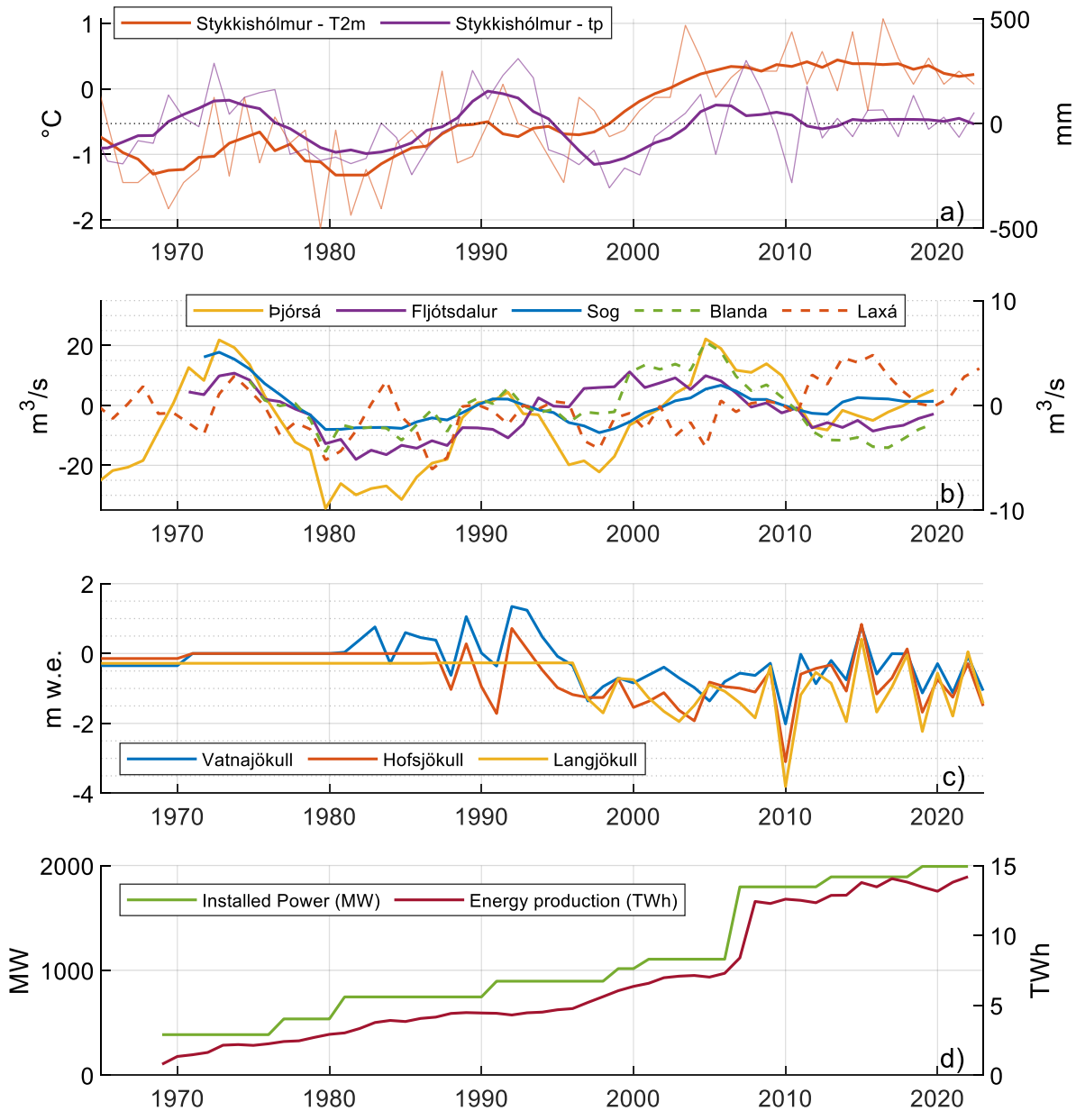
Historic flows 1950-2000

Current flows 2000-2020

Future flows 2035-2050

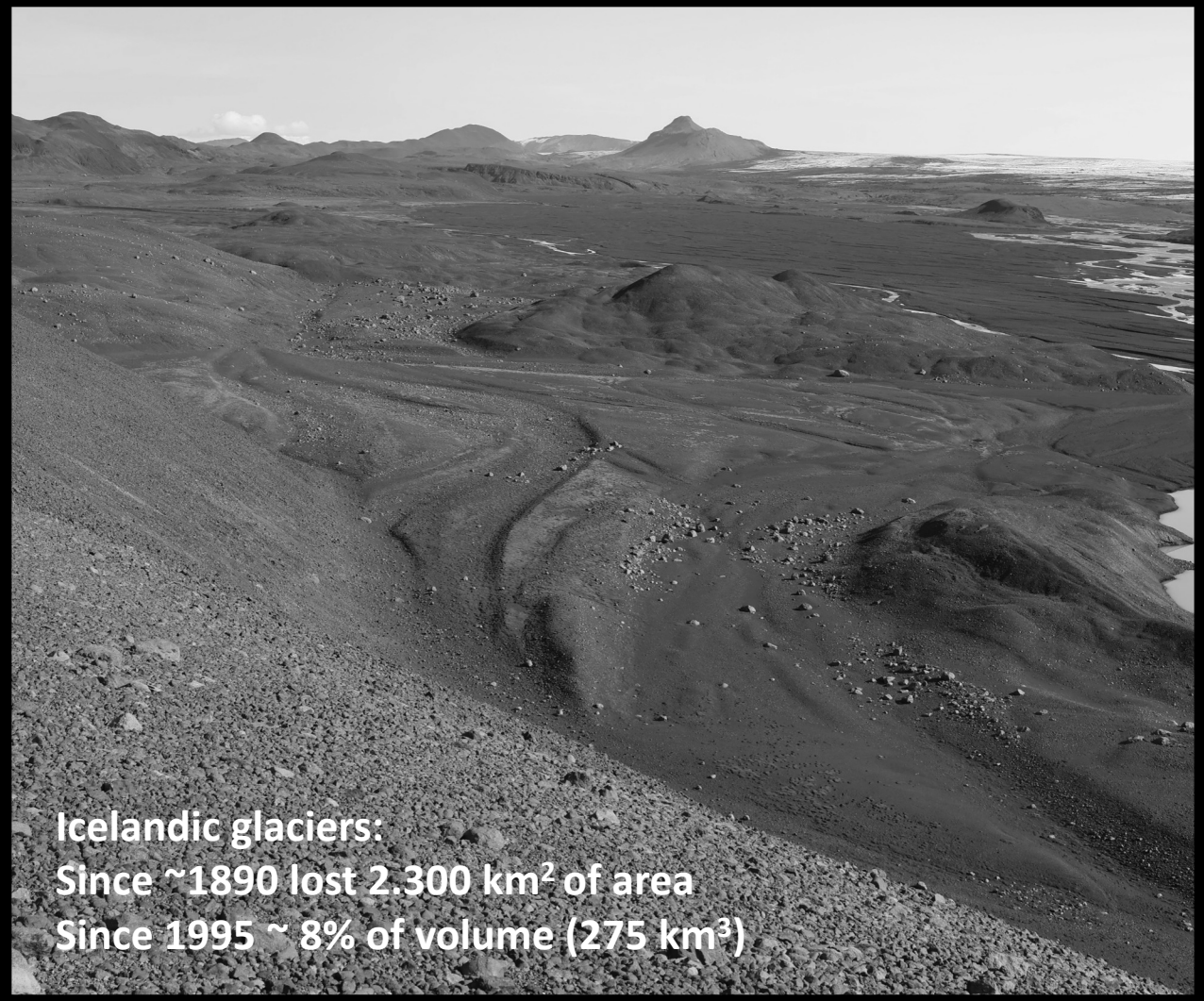
Recent changes

- In Iceland, significant warming has occurred since the beginning of the 20th century,
  - ~1.0 °C per century, for the period from 1900 -2020.
  - More pronounced during winter (1.4 °C per century)
  - Less during summer (0.7 °C per century).
- Annual mean precipitation has increase from 1500 mm on average during the last century to approx. 1600 - 1700 mm
- Icelandic glaciers have gradually been losing mass and area in recent decades
- At present, the accumulated mass loss since the end of LIA
  - 16% of the LIA glacier mass
  - ½ total mass change has occurred post 1994.



Tungnaárjökull glacier

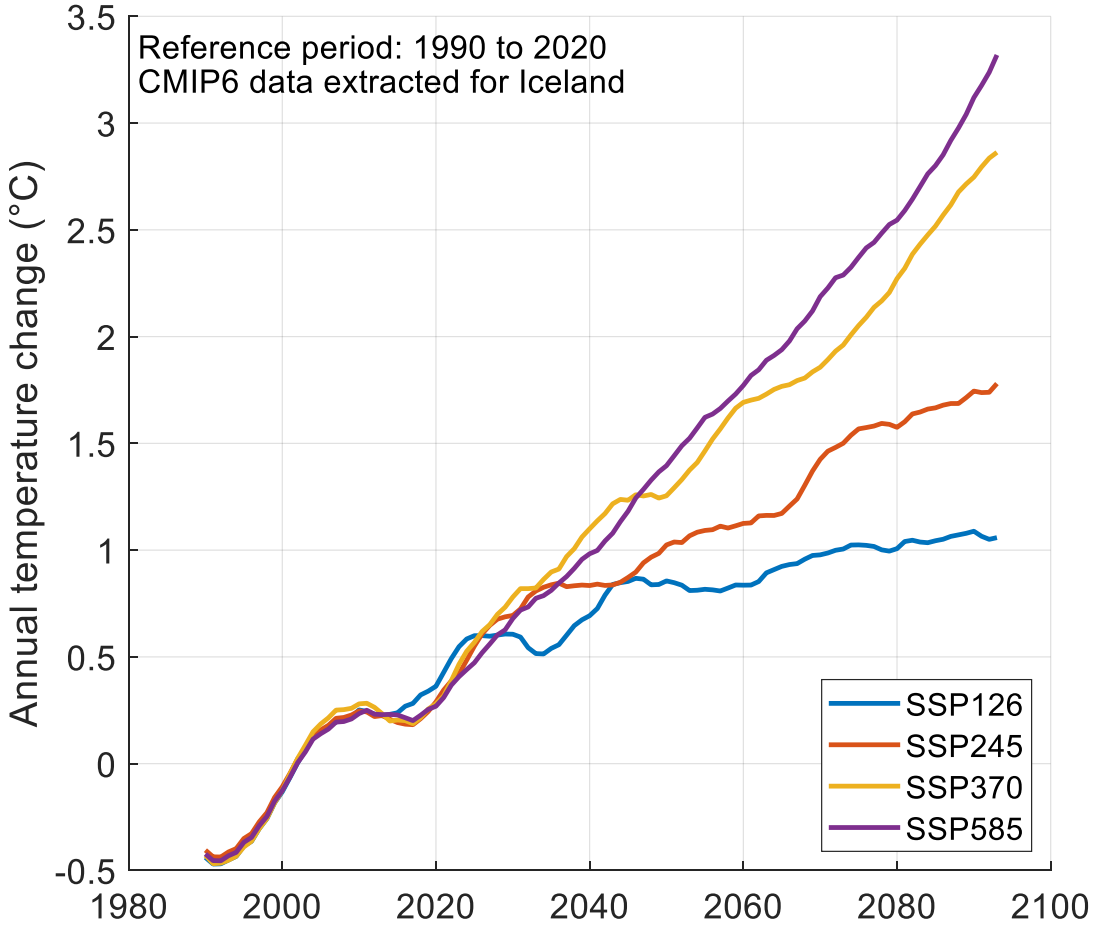
1950

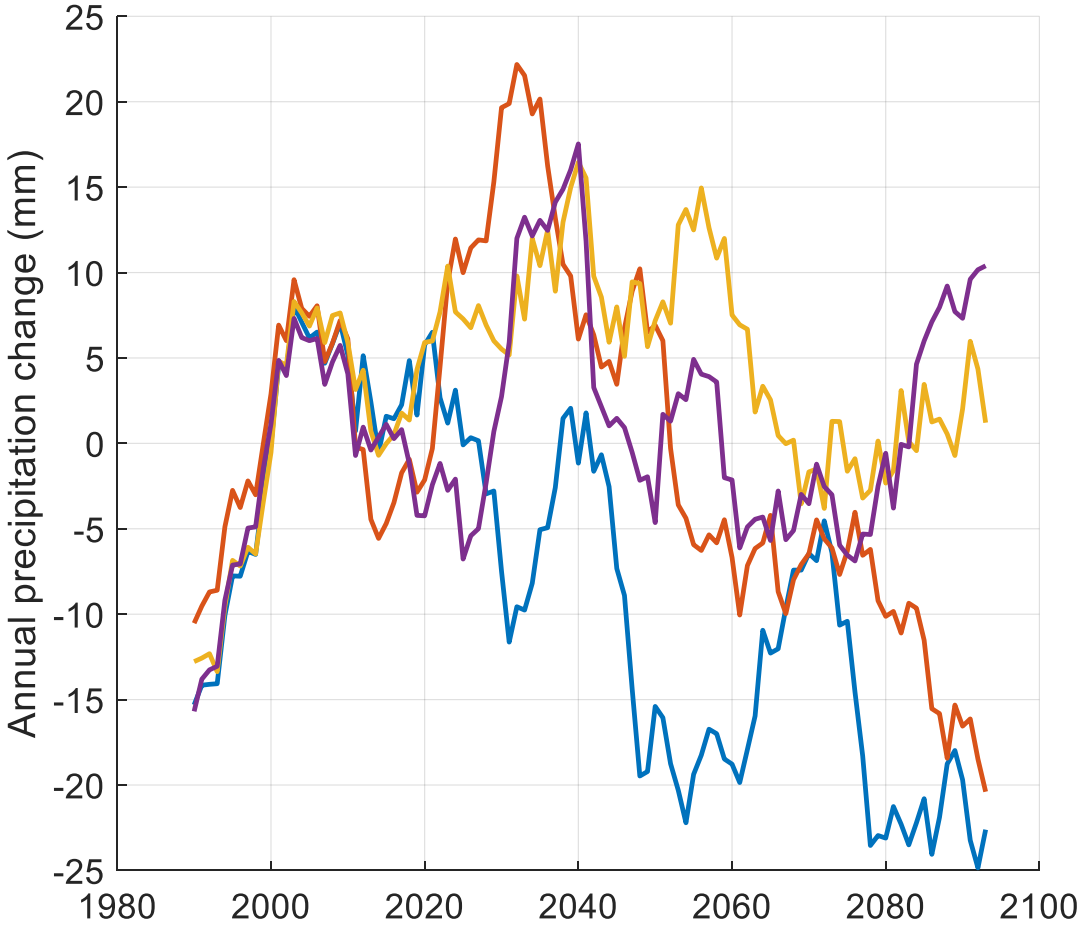


2023

Future changes

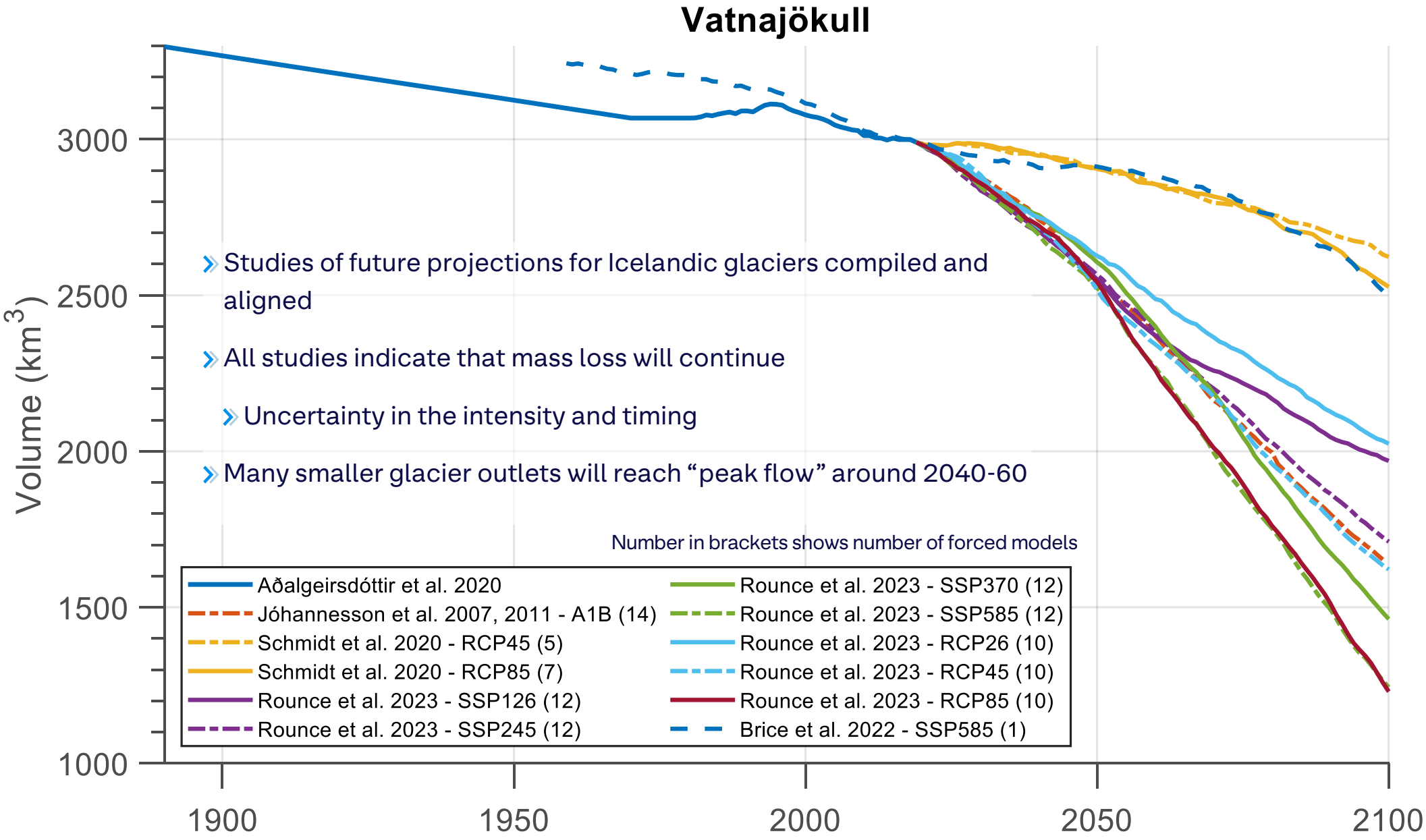
All scenarios agree on future warming
Less pronounced signals for precipitation changes





Model averages

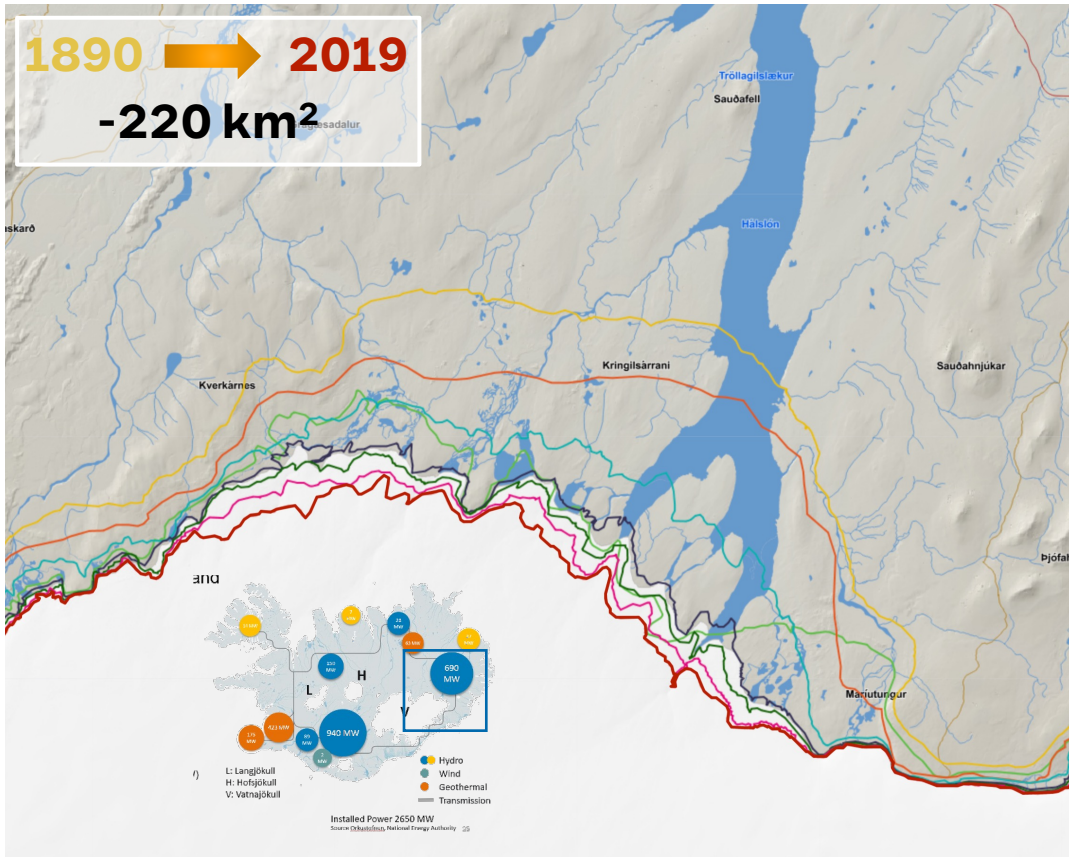
Future changes of glaciers

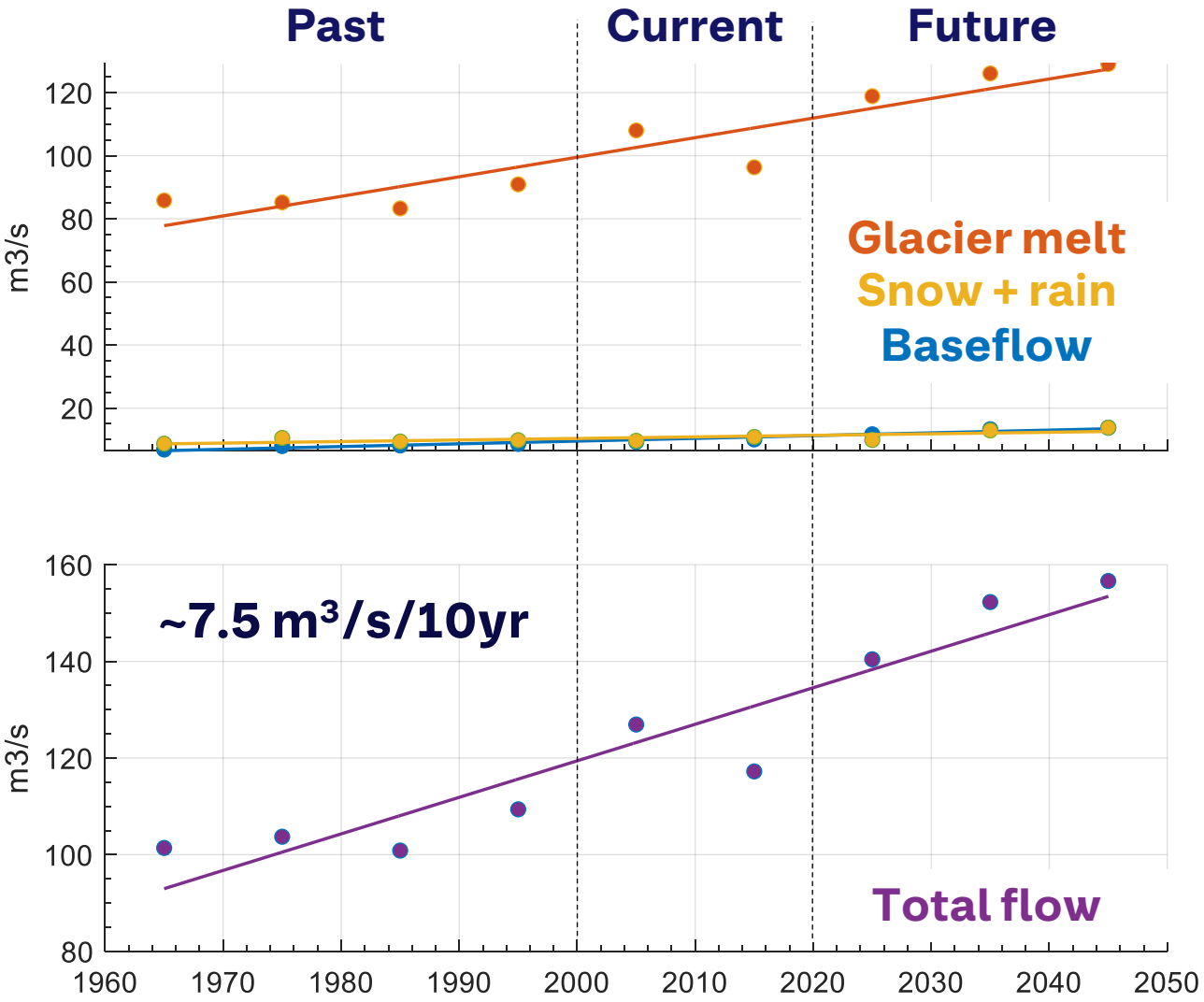


Example: Inflow changes 1960 – 2050

Jökulsá á Dal (Hálslón)

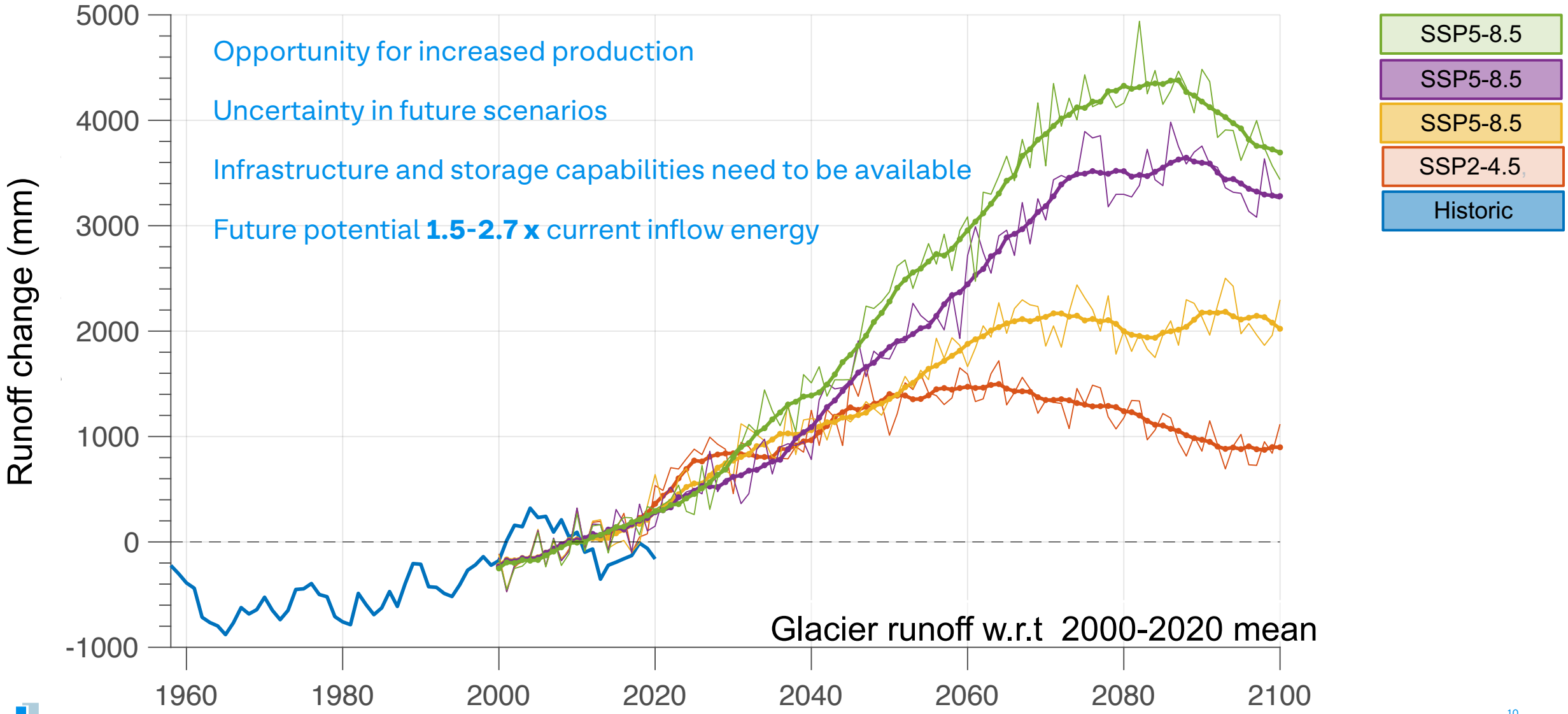
Jöklar munu halda áfram að hopa, hversu hratt og hvenær hámark





Increased glacier melt provides opportunities

Glacier melt runoff increase for Brúarjökull in NE-Vatnajökull



Rounce et al. – 2023 / Brice et al. - 2022