CES Nordic Project on Climate and Energy Systems

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Impacts of historic climate variations on streamflow characteristics in Icelandic rivers

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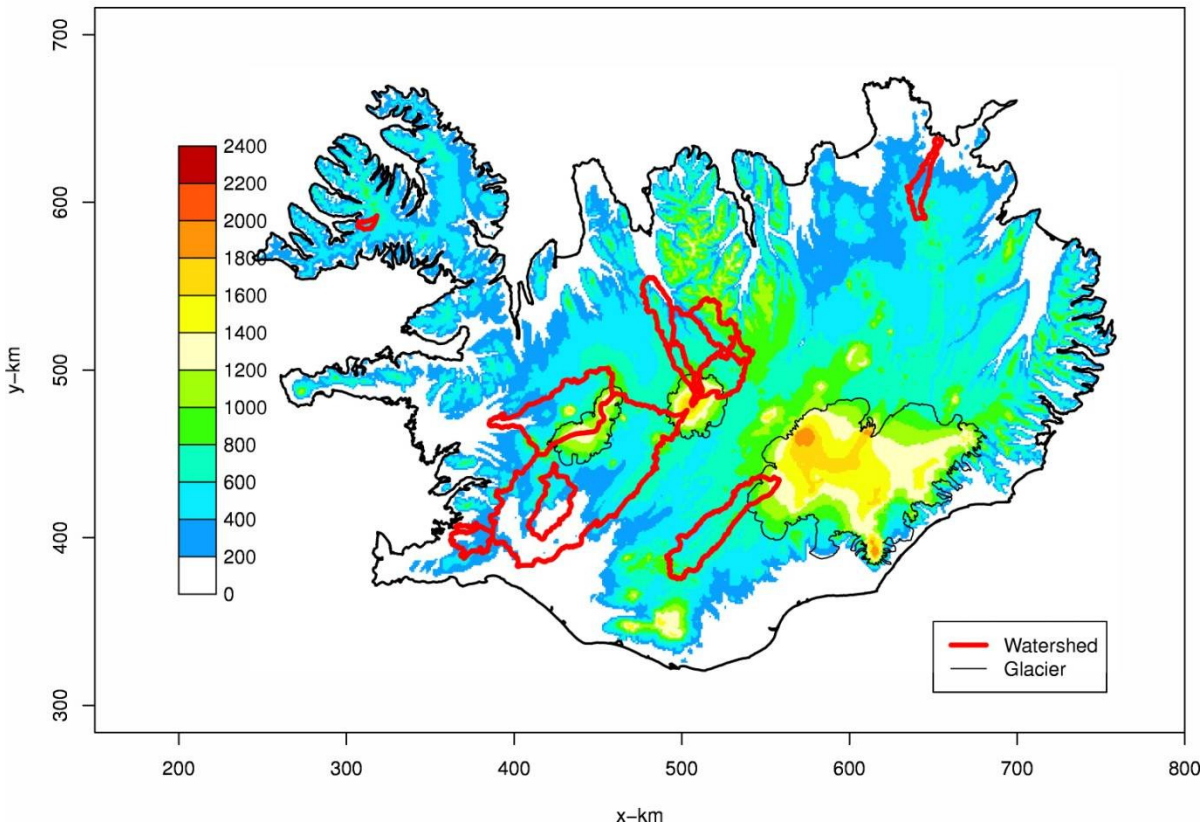
Objective

- To analyse the hydrologic response of 11 river basins in Iceland to past climate variations, especially temperature variations.
  - Streamflow characteristics
    - » Discharge seasonality
    - » Mean annual discharge
    - » Number of floods (POT)
  - Snow storage characteristics
    - » Annual maximum
    - » Snow cover duration
  - Daily snowmelt rates
    - » Annual maxima
  - Daily glacial melt rates
    - » Annual maxima
    - » Duration of melting period

25% warmest years
25% coldest years
1971-2000

11 River basins



- **D**irect runoff rivers
- **S**pring-fed rivers
- **G**lacial rivers (5)
- **L**akes

Size: 42 km^2 – 5687 km^2

Mean elevation: 163 m – 863 m

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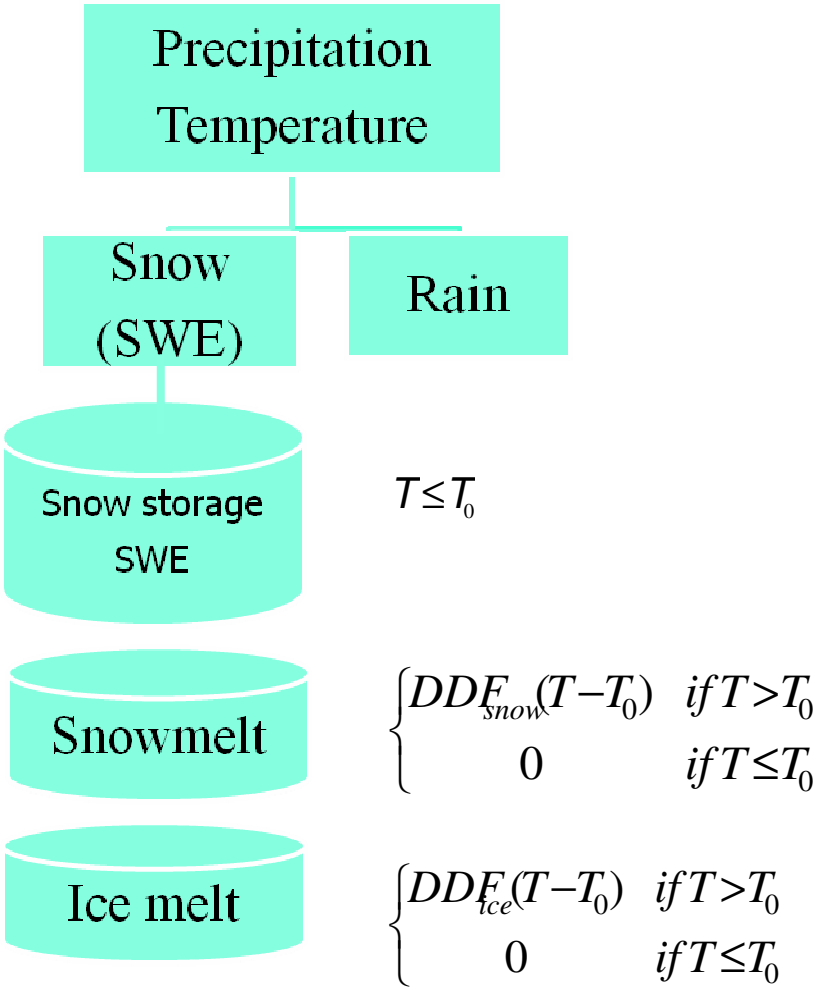
Data

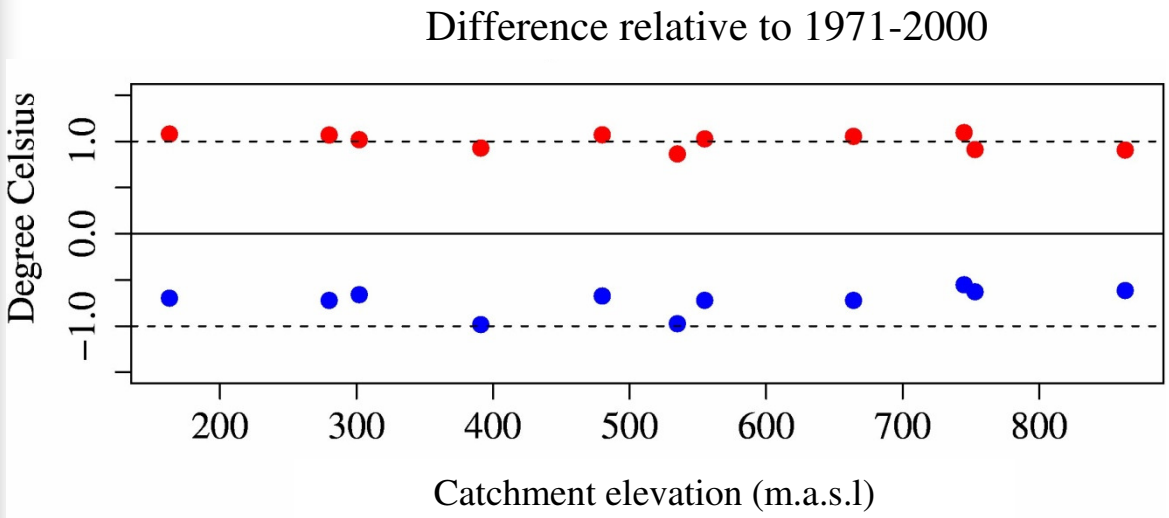
- Discharge measurements (daily) (1929-2007; 1971-2007)
- Gridded temperature: daily, 1 km (1949-2007)
  - Enhanced spatial interpolation (DEM)
    - Spline + lapse rate 6.5°C/km
- Gridded precipitation: daily, 1 km (1958-2006)
  - LT-model (Smith & Barstad 2004)
    - Input: ECMWF precipitation, wind & temperature; DEM
    - CE project (Crochet et al., 2007, Jóhannesson et al., 2007)

Derived data (1958-2006)

(daily, 1 km^2, catchment averaged)

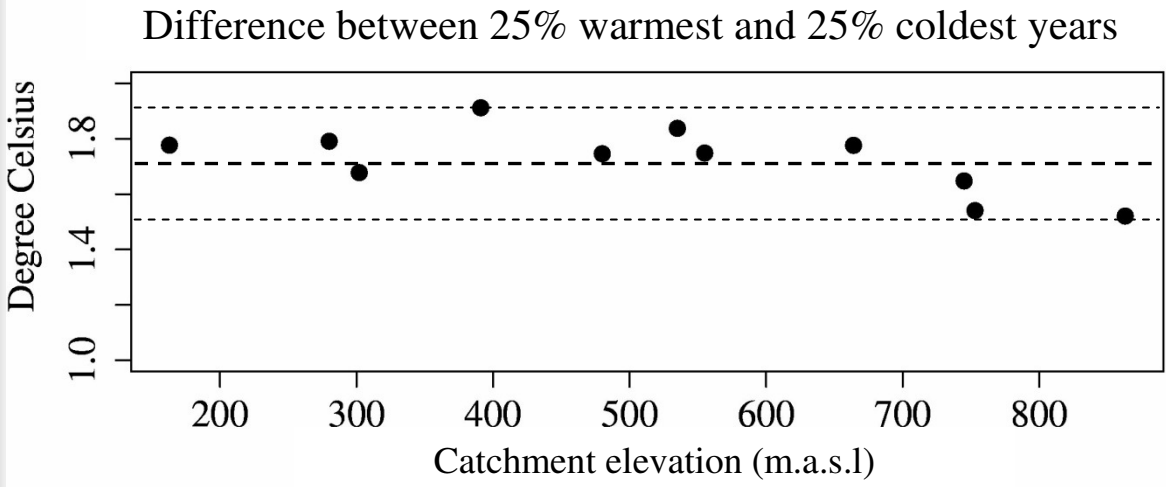


Mean annual temperature difference



→ +1°C (25% warmest)

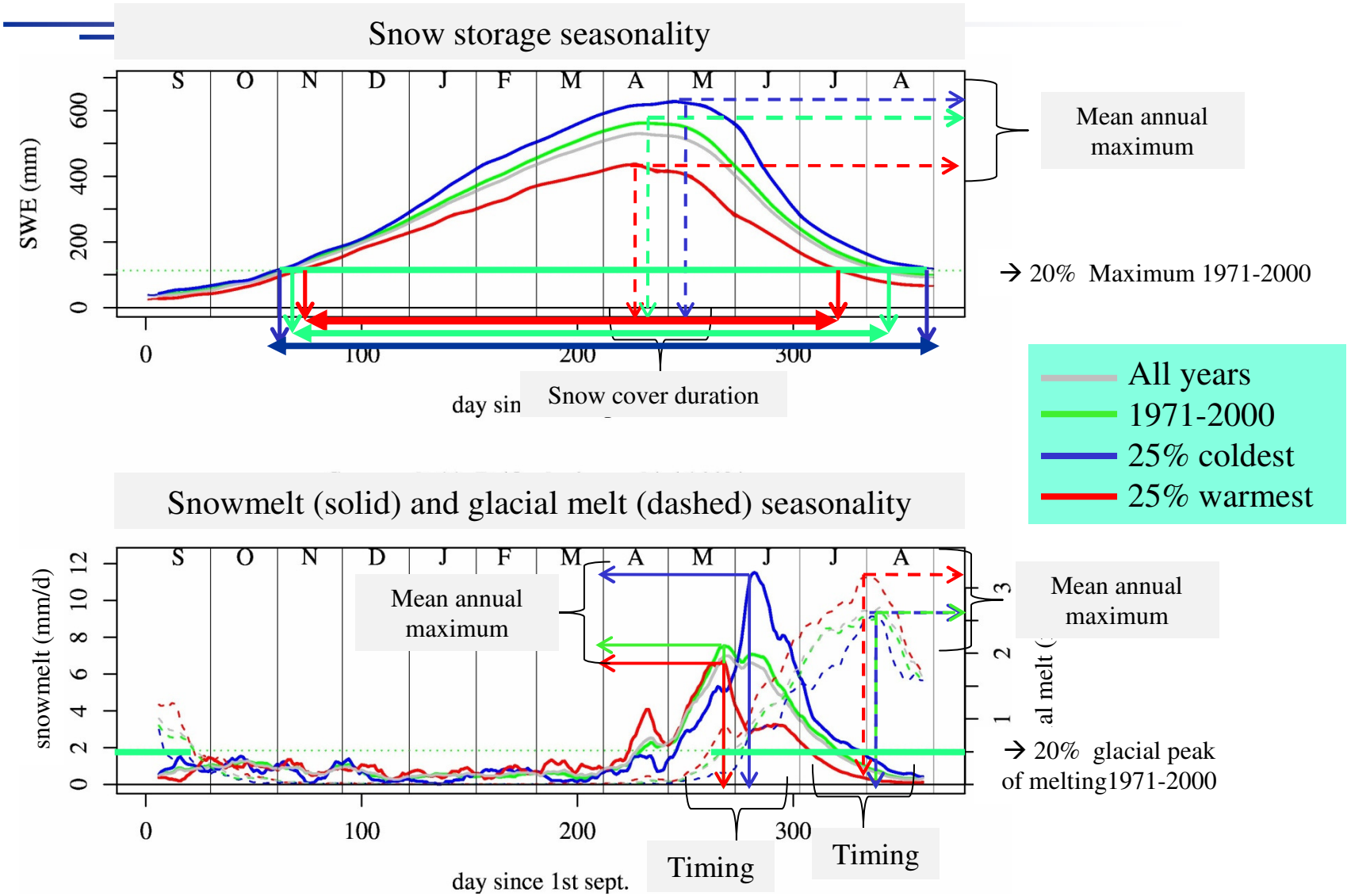
→ -0.7°C (25% coldest)



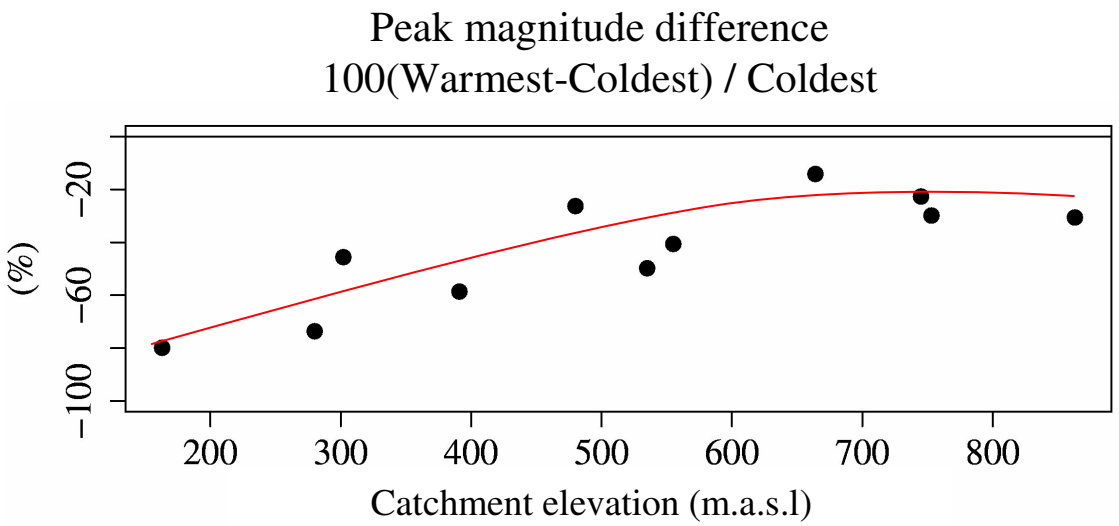
→ +1.7°C

Austari-Jökulsá, 12% glacier covered

Northern part of central highlands

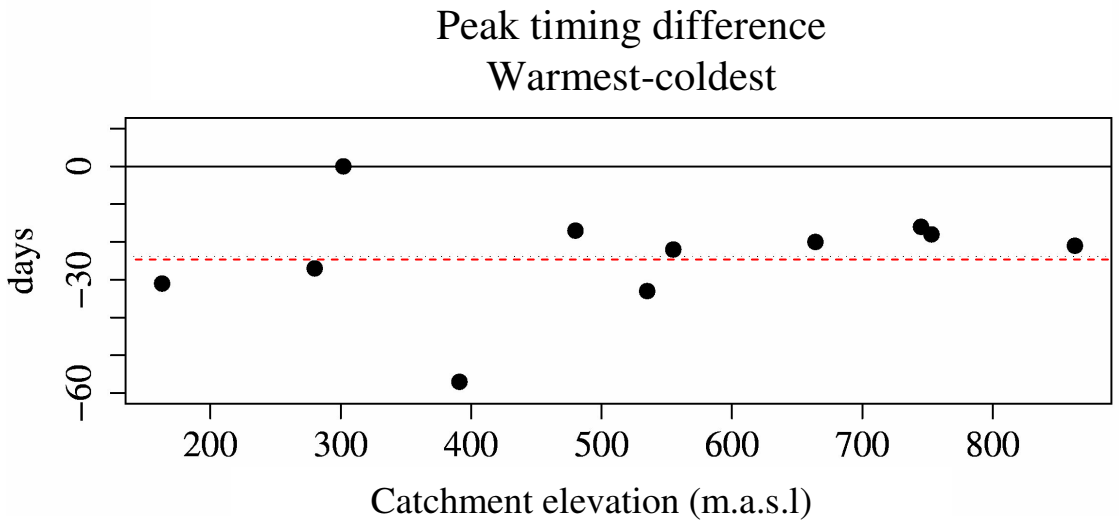


Mean yearly maximum snow storage difference between 25% warmest and 25% coldest years



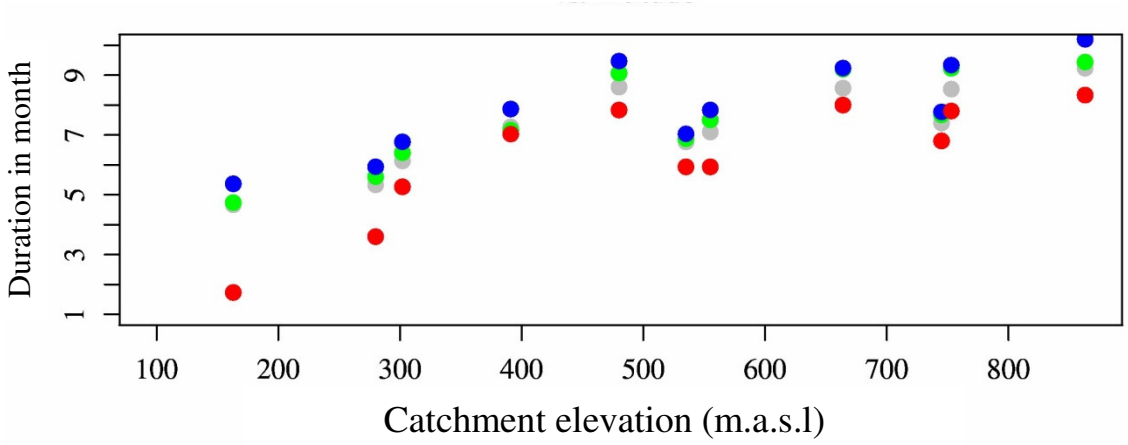
-20%
-80%

+1.7°C



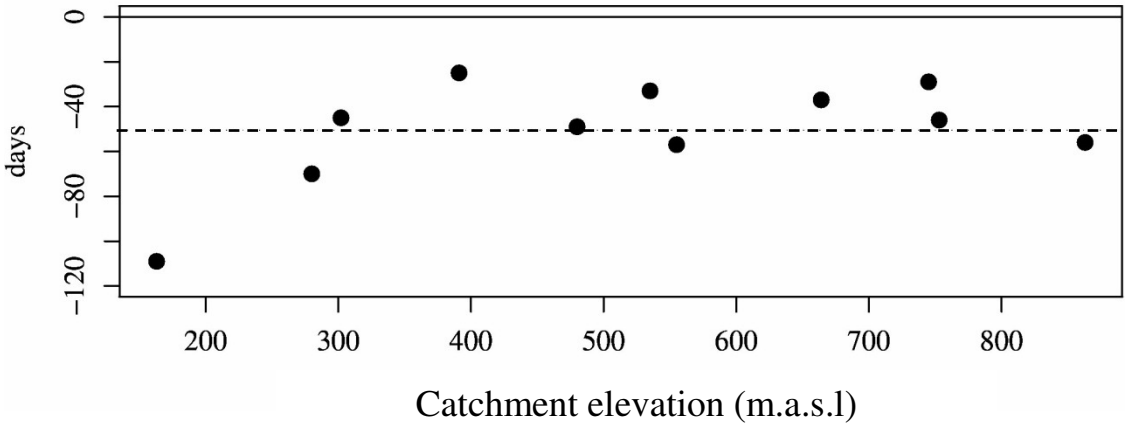
→ 24 days earlier

Mean snow cover duration



All years
1971-2000
25% coldest
25% warmest

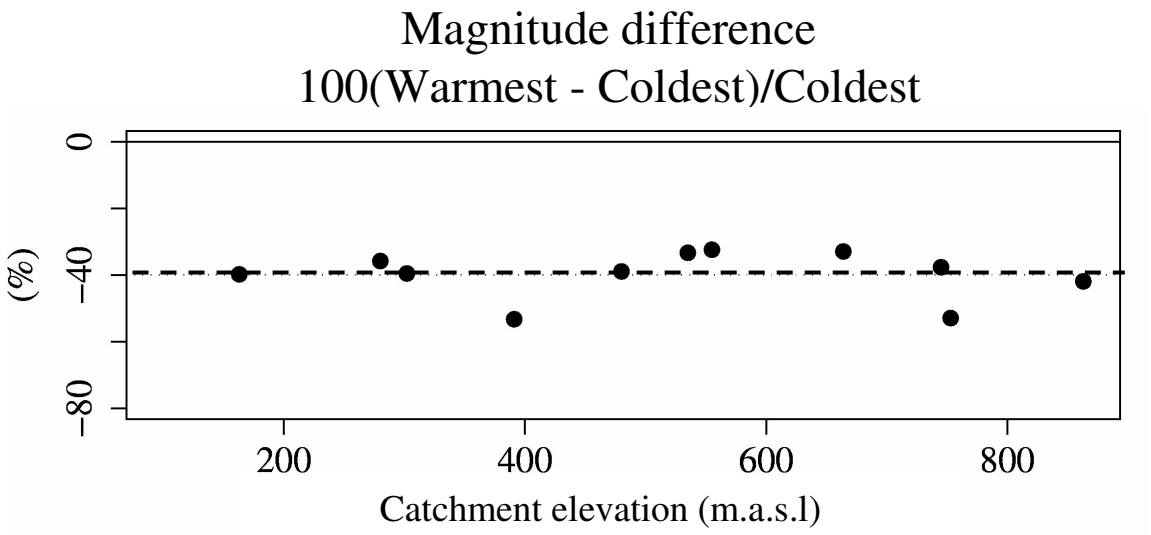
Difference in snow cover duration
between 25% warmest and 25% coldest years



+1.7°C

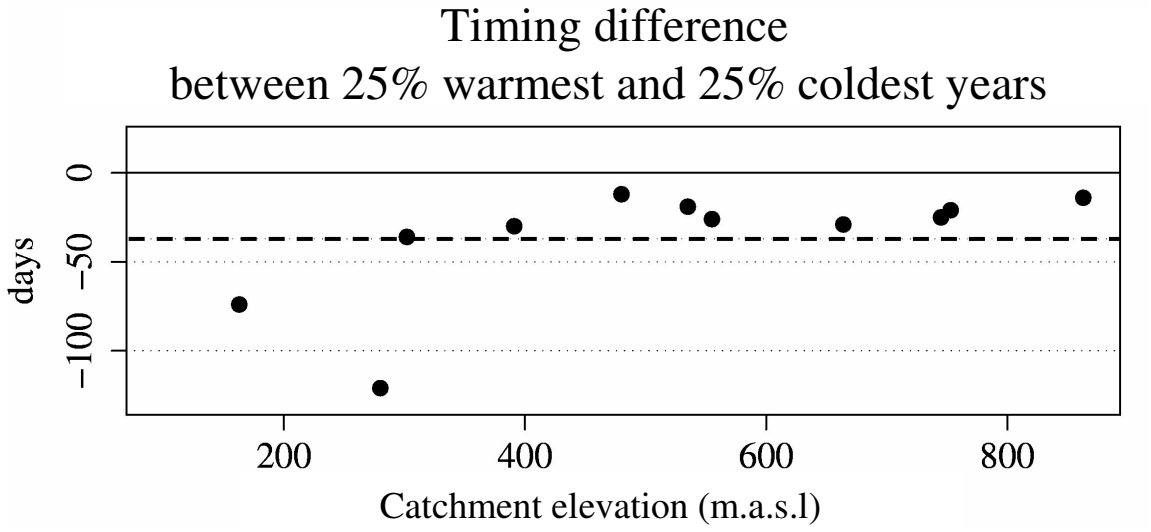
→ -50 days
(23% shorter)

Mean yearly maximum snowmelt rate



→ -40 %

+1.7°C



→ -37 days

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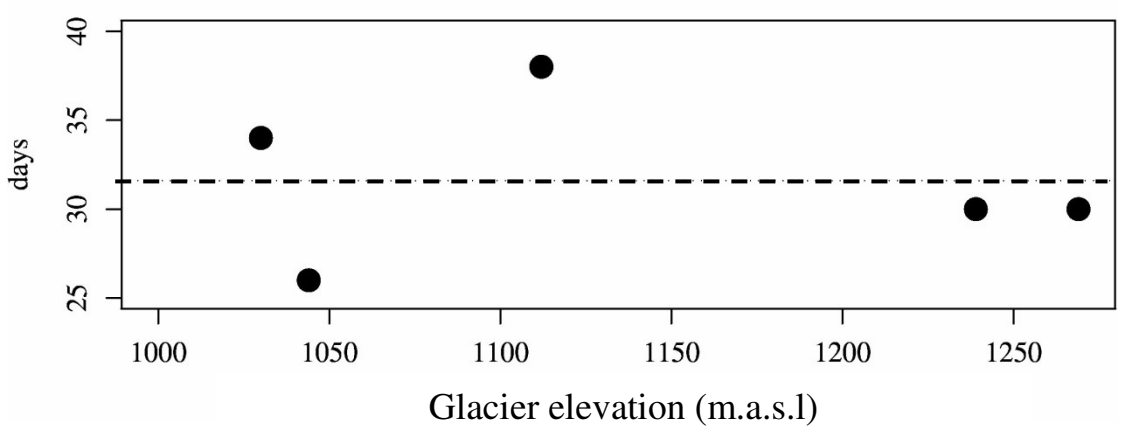
Average glacial snow and ice melt

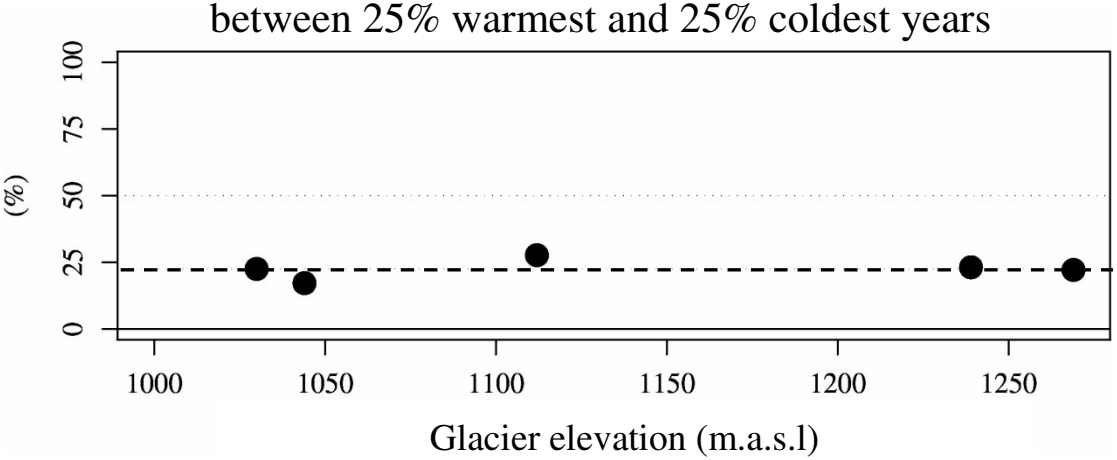
Difference in average duration of glacial melt period
between 25% warmest and 25% coldest years



~ 1 month longer

+1.7°C

% Change in mean yearly maximum glacial melt
between 25% warmest and 25% coldest years



→ +23%

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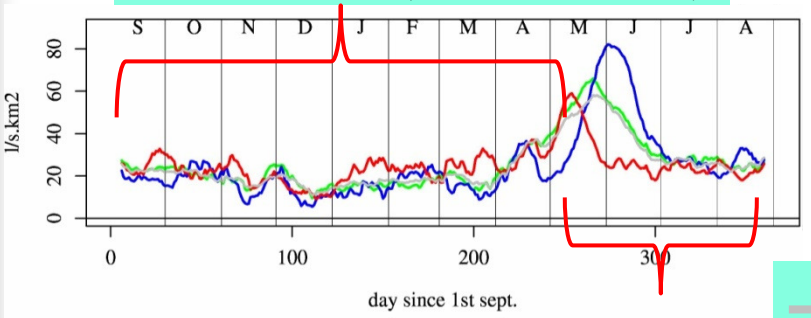
Average discharge seasonality

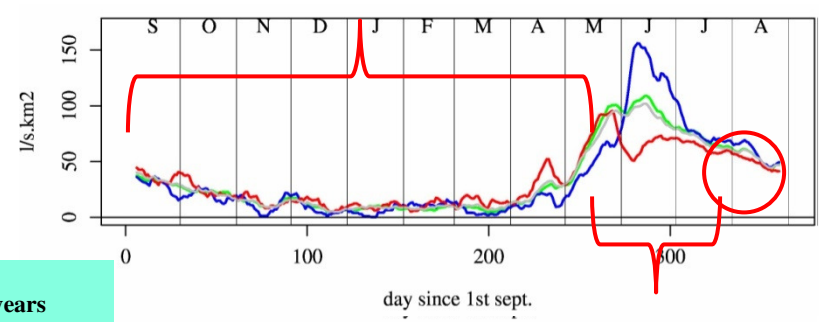
VHM-10 (Svartá), North (ice free)

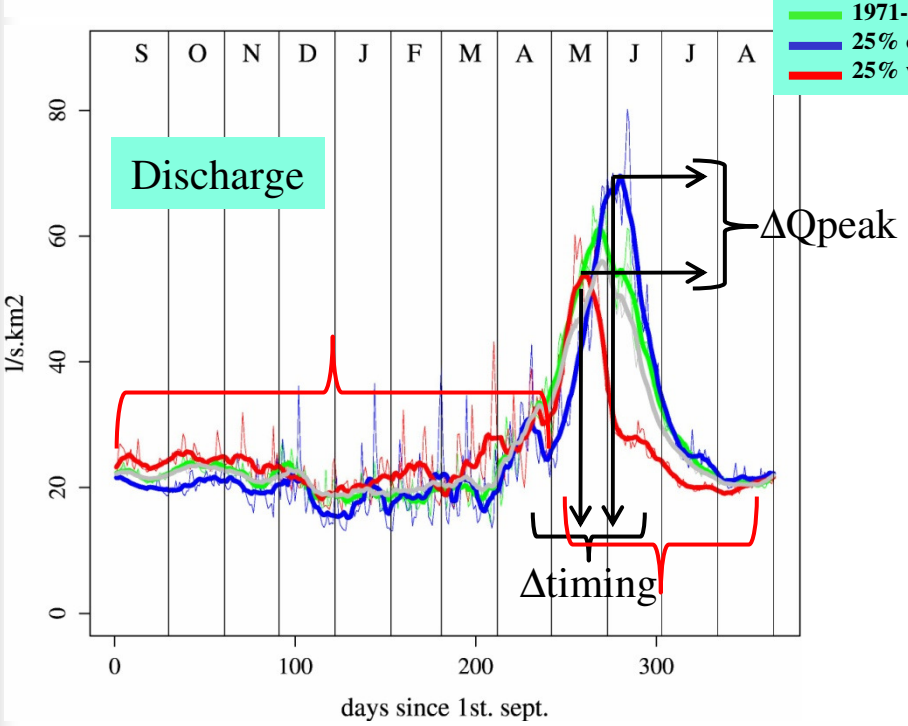
VHM-144 (Austari-Jökulsá), central N, glacier covered

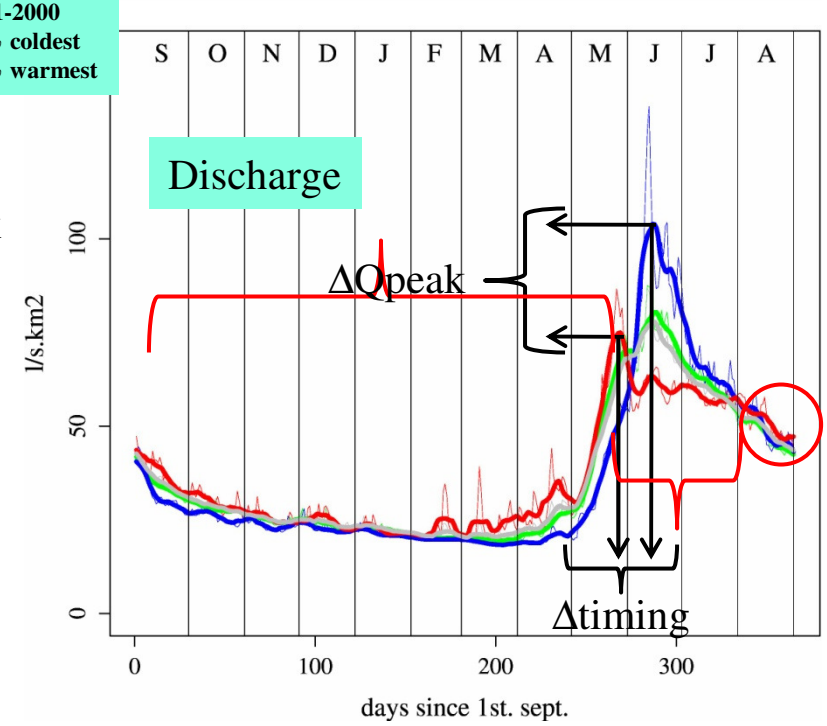
Surface runoff (snowmelt + rain)



Surface runoff (snowmelt + glacial melt + rain)







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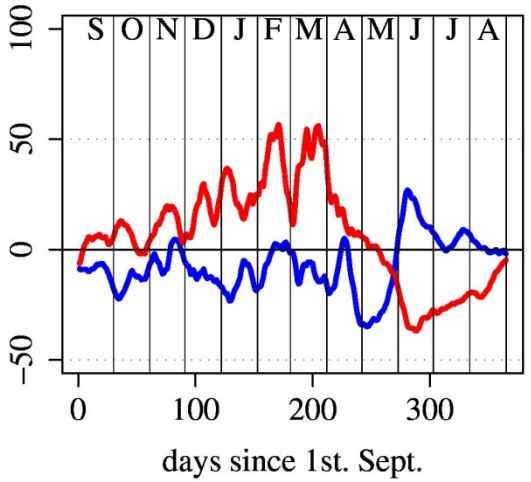
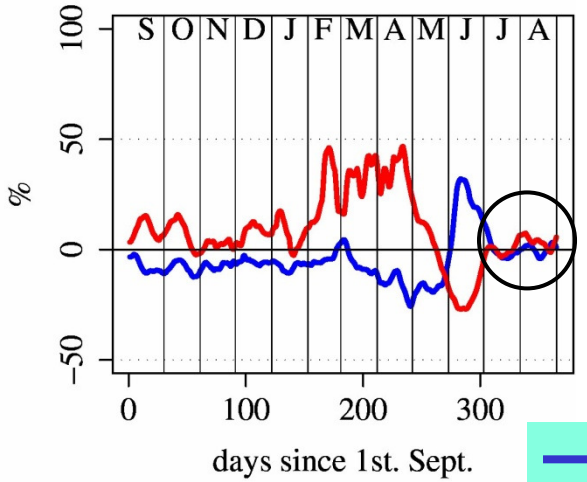
% Change in average daily discharge in coldest and warmest years relative to 1971-2000

Ice free
North
D+S
VHM-10
VHM-19
VHM-26

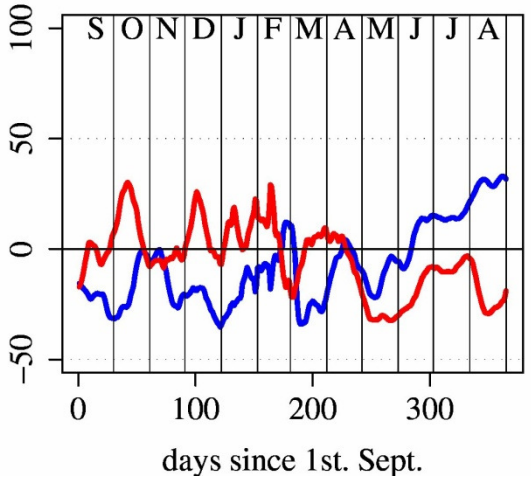


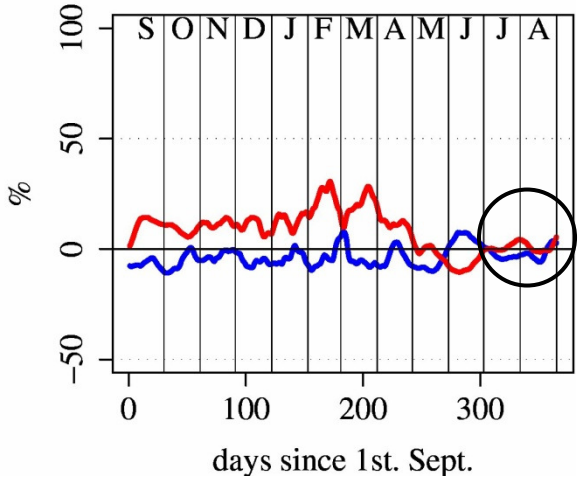


Glacier covered
Central Highlands
D+G+S
VHM-144
VHM-145
VHM-96

25% coldest
25% warmest

Ice free
SW
D+S+(L)
VHM-81
VHM-301





Spring-fed
SW Highlands
S+(G)+D
VHM-66 (G)
VHM-64 (G)
VHM-43

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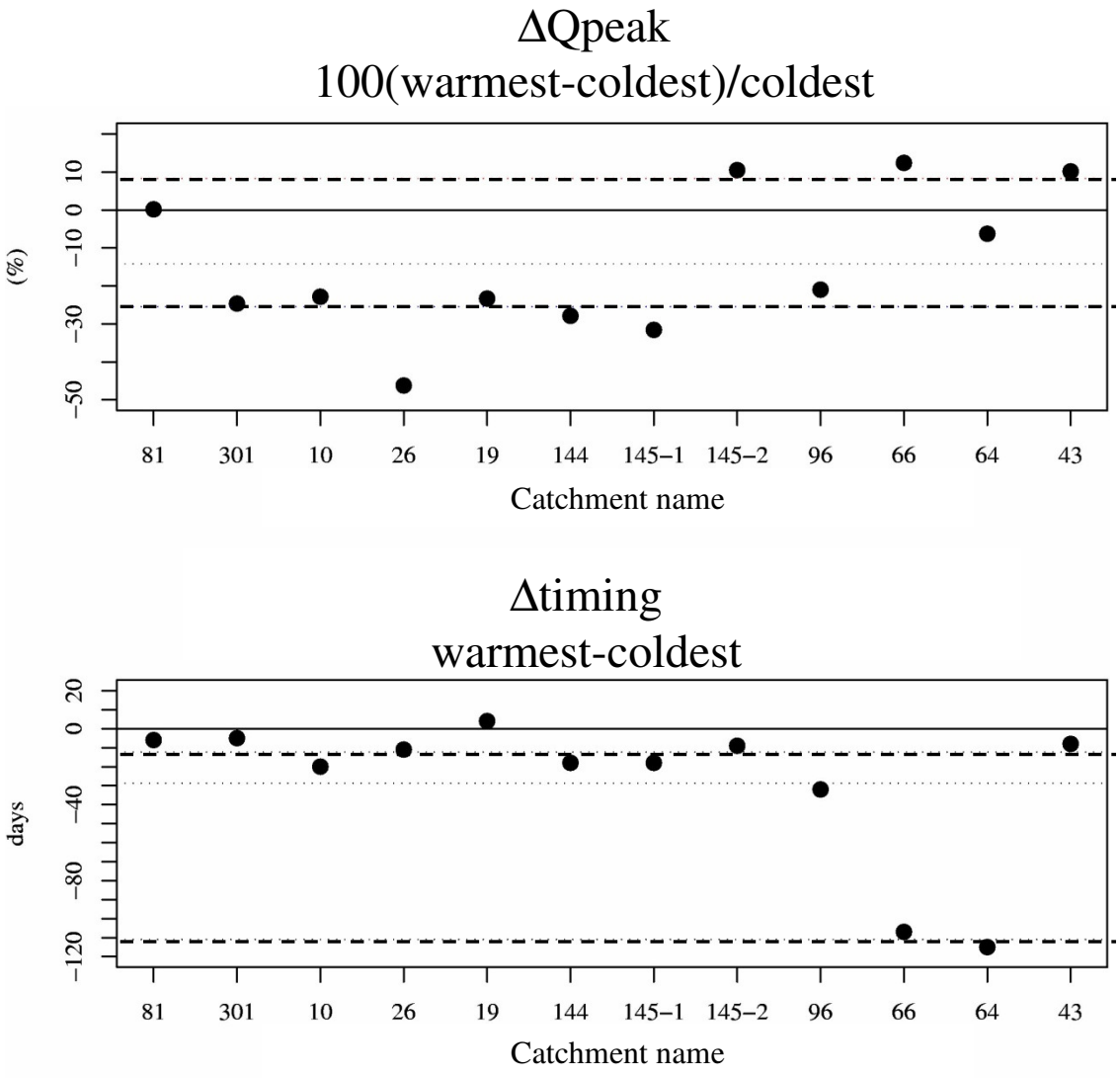
Change in mean yearly maximum discharge



→ +8 %

→ -25 %

+1.7°C

→ -12 days

→ -111 days

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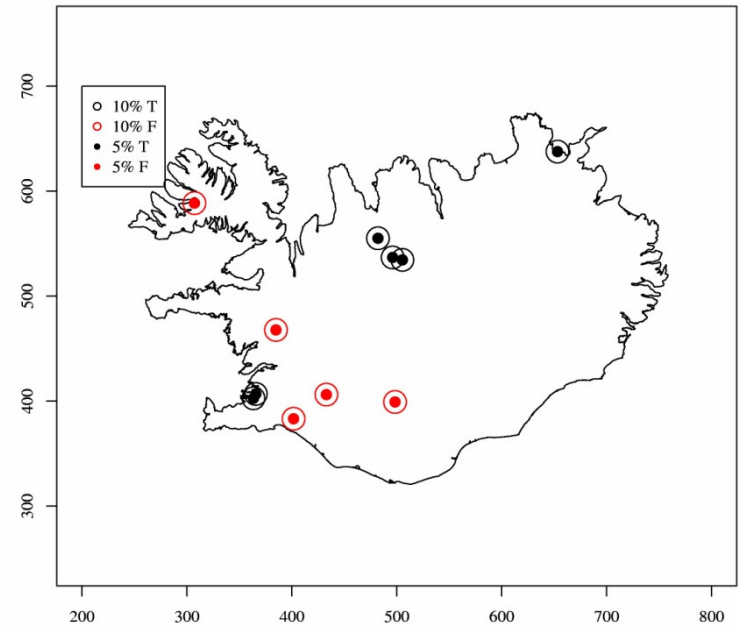
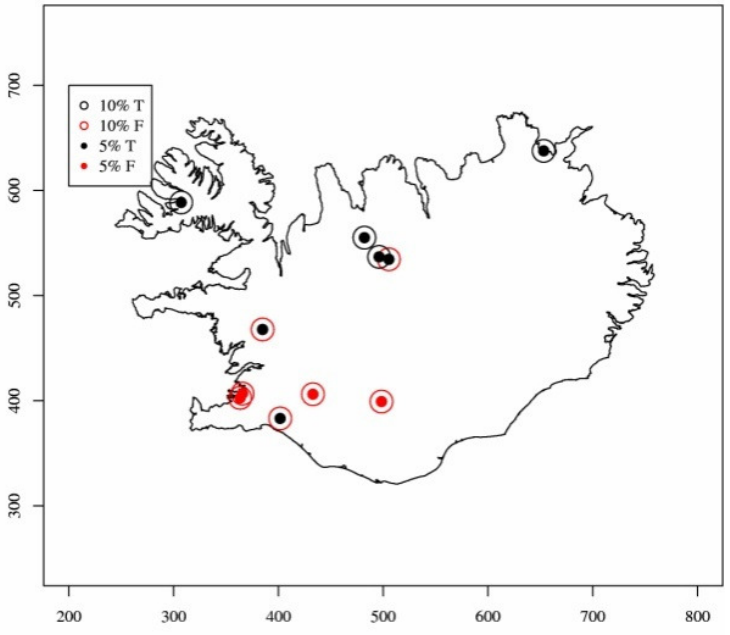
Mann-Whitney test between 25% coldest and 25% warmest years
α=10% (open circle), α=5% (filled circle)

Annual Discharge



Annual Precipitation



- Not different
- Different → +12%

+1.7°C

- Not different
- Different → +15%

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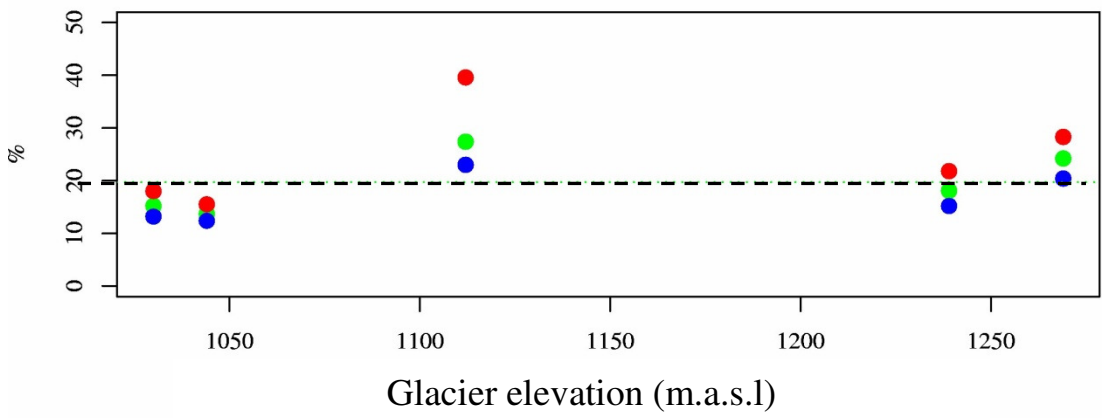
Glacial runoff contribution to annual discharge

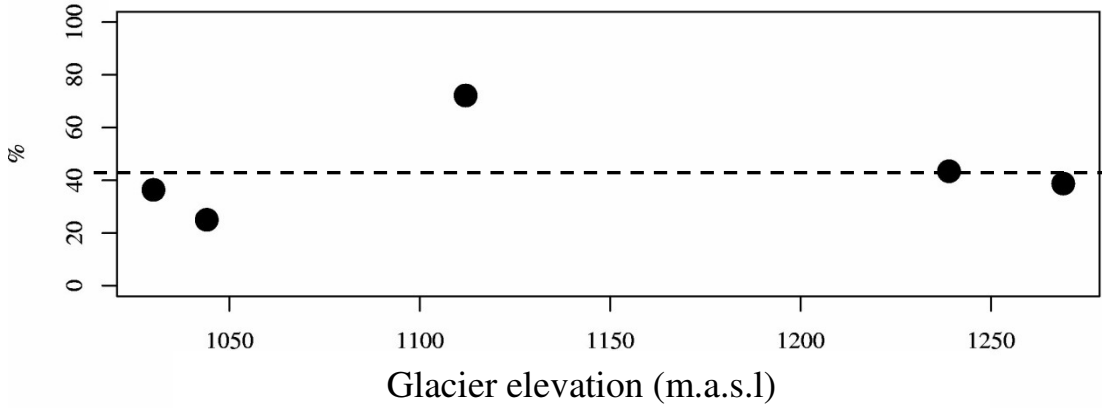


→ ~ 20 %

All years
1971-2000
25% coldest
25% warmest

% Change
between 25% warmest and 25% coldest years

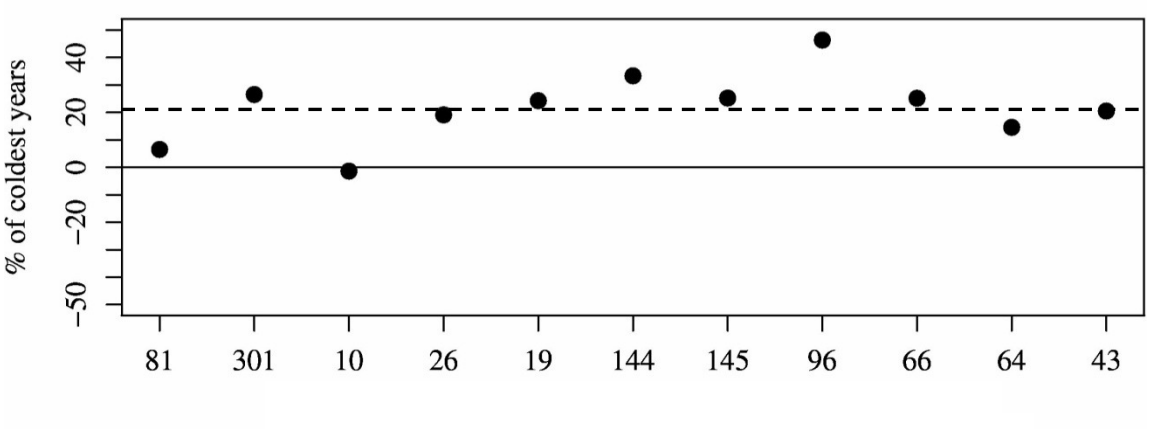
+1.7°C



→ +43 %

Change in number of flood events (POT) between 25% warmest and 25% coldest years

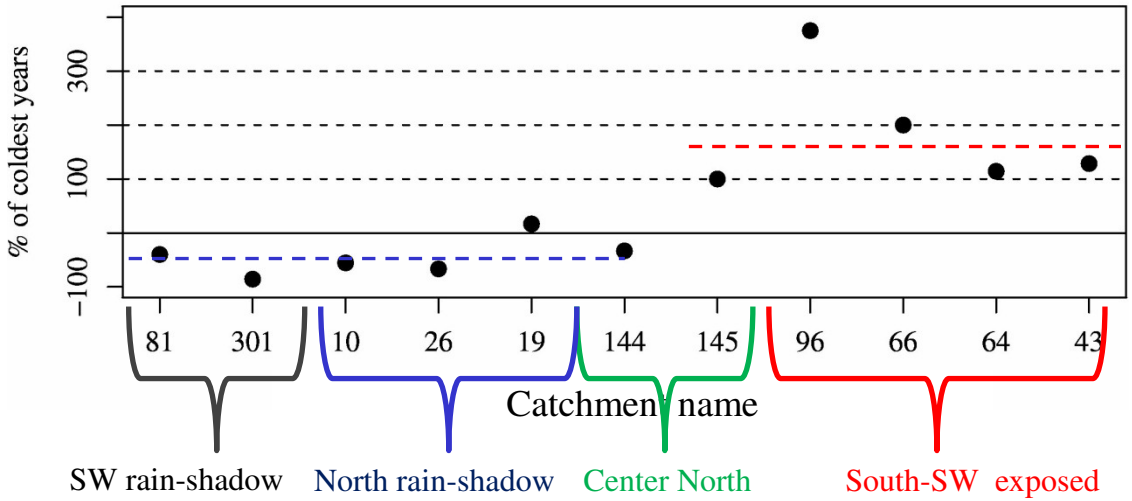
POT > median Q peaks (71-00)



→ +22%

+1.7°C

POT > mean annual maximum Q (71-00)



→ +156%

→ -56%

Summary

- All catchments showed signs of great sensitivity to relatively modest mean annual temperature variations (+/- 1°C; +1.7°C)
- Temperature variations impact on:
  - Snow storage development and snowmelt rates
  - Runoff contribution from glaciers
  - Streamflow characteristics:
    - Seasonality
      - Annual peak discharge timing & magnitude shifts
      - Warmest years: reduced amplitude between base and peak flows
      - Coldest years: enhanced amplitude between base and peak flows
    - Annual discharge in the South (Precipitation)
    - Number of flood events (moderate and extremes)