Understanding Changes in Iceland's Streamflow Dynamics in Response to Climate Change

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Landsvirkjun

UW HYDRO
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DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING
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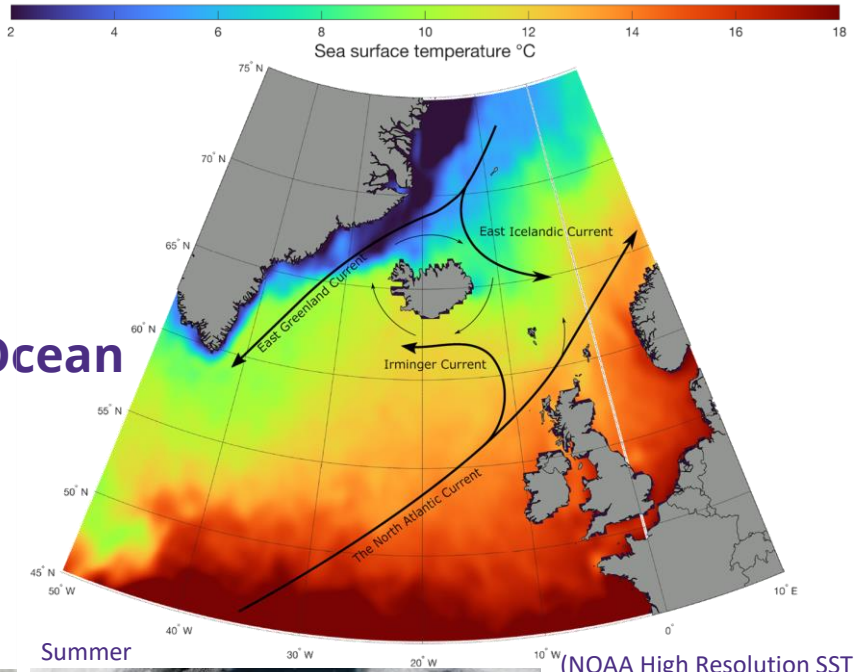
Iceland

- A small island in the North Atlantic Ocean
- Hydrology is dominated by seasonal snow and glaciers



(NOAA High Resolution SST data, August 2020)

MODIS true color images

Winter

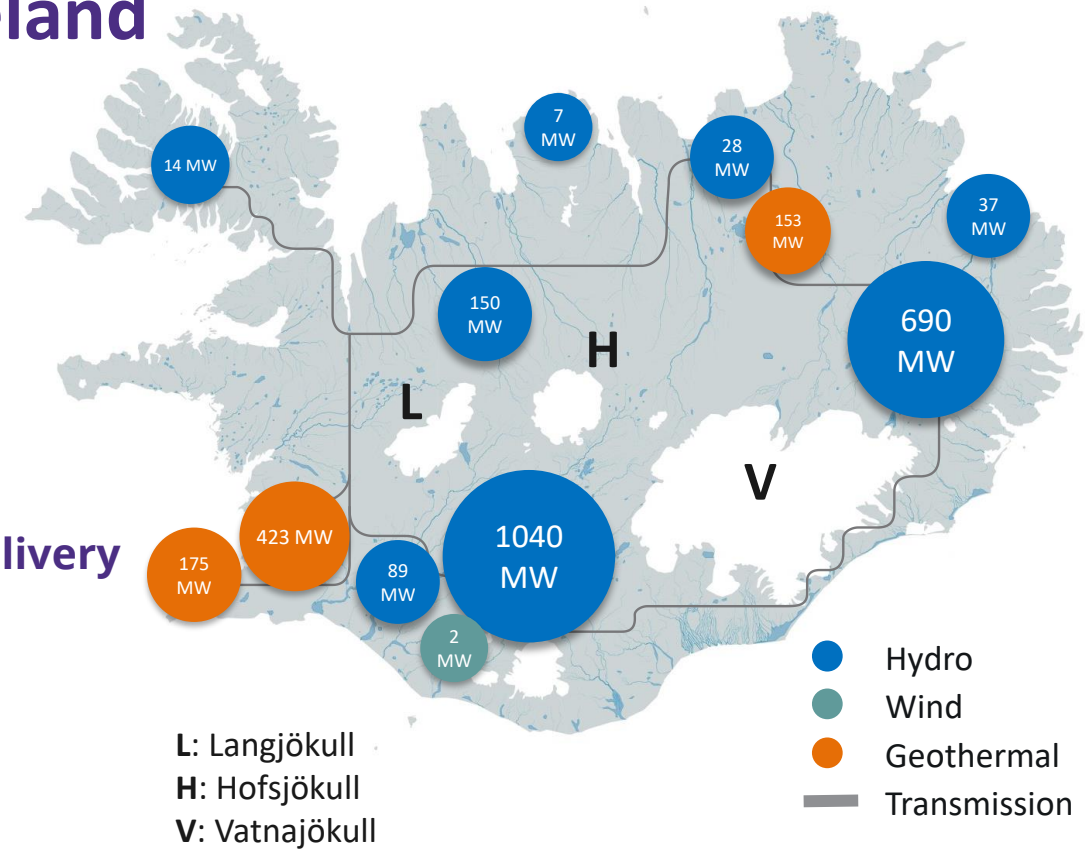
Spring

Summer

Gunnarsson, A. 2022

Energy system in Iceland

- **100% renewable**
  - Hydro: 75%
  - Geothermal: 25%
- **No interconnections**
  - No import/export of electricity
- **Hydrology dominates energy delivery**
  - >50% of hydro from glacier ablation
  - ~15% of hydro from seasonal snow



L: Langjökull
H: Hofsjökull
V: Vatnajökull

Installed Power about 2840 MW

Source Orkustofnun, National Energy Authority
Figure: Landsvirkjun

Changes in climate

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Article | Open access | Published: 11 August 2022

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Mika Rantanen, Alexey Yu. Karpechko, Antti Lipponen, Kalle Nordling, Otto Hyvärinen, Kimmo Ruosteenoja, Timo Vihma & Ari Laaksonen

Communications Earth & Environment **3**, Article number: 168 (2022) | Cite this article

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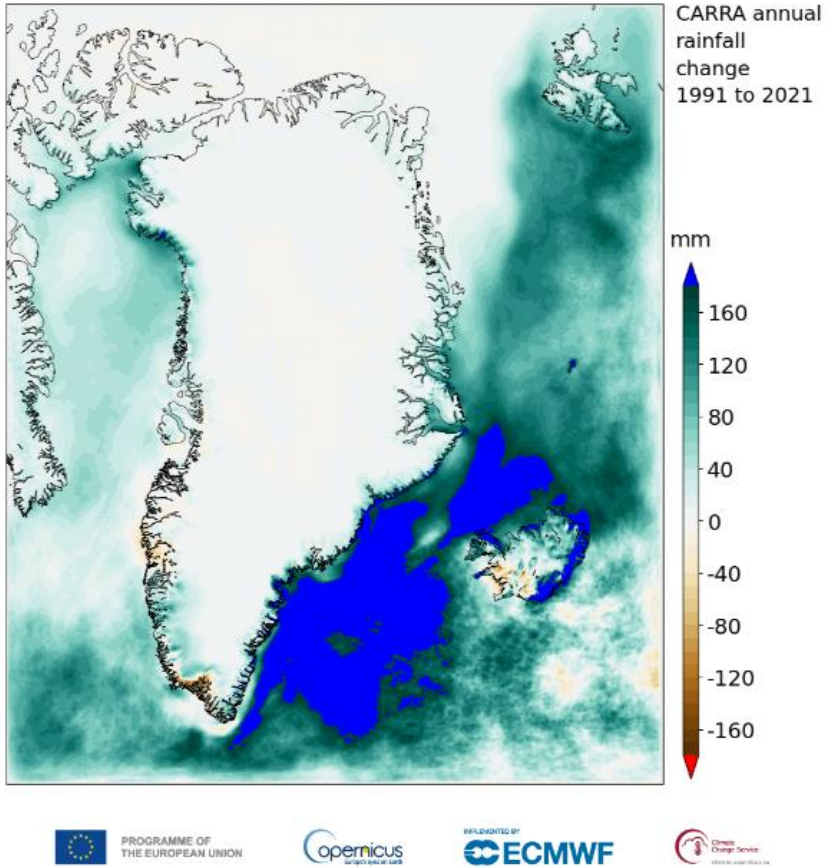

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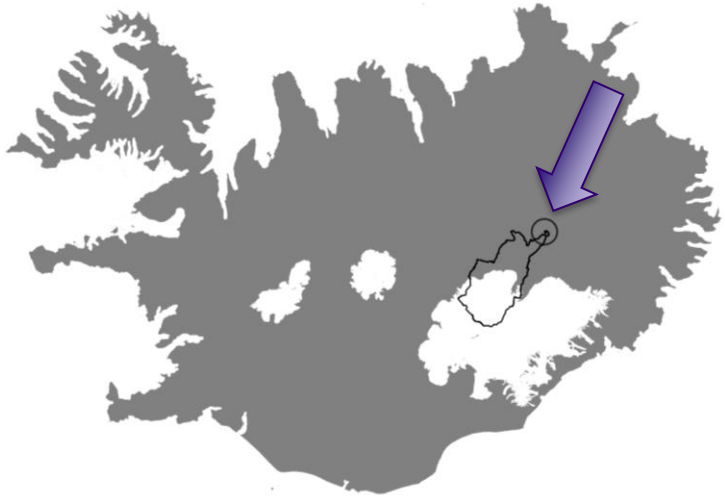
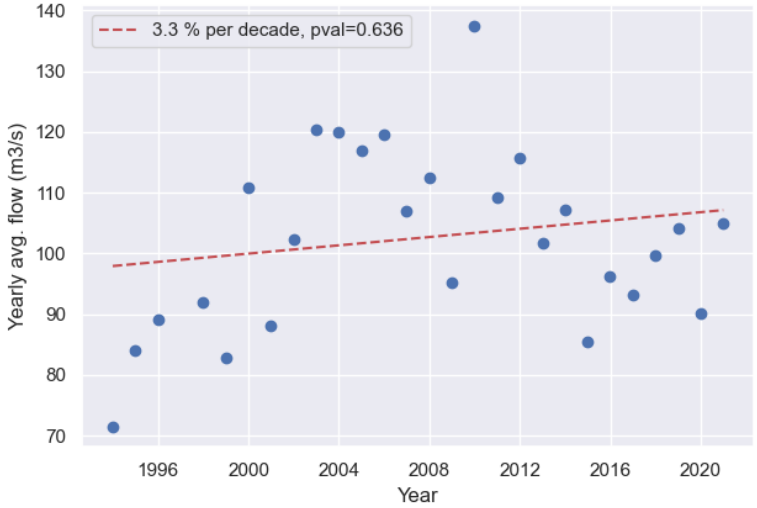
(Copernicus, 2023)

How does this affect streamflow in Iceland?



Gauge: Jökulsá á Fjöllum, Upptyppingar
Annual average flow



Jökulsá á Fjöllum, Upptyppingar – August 4th 2023

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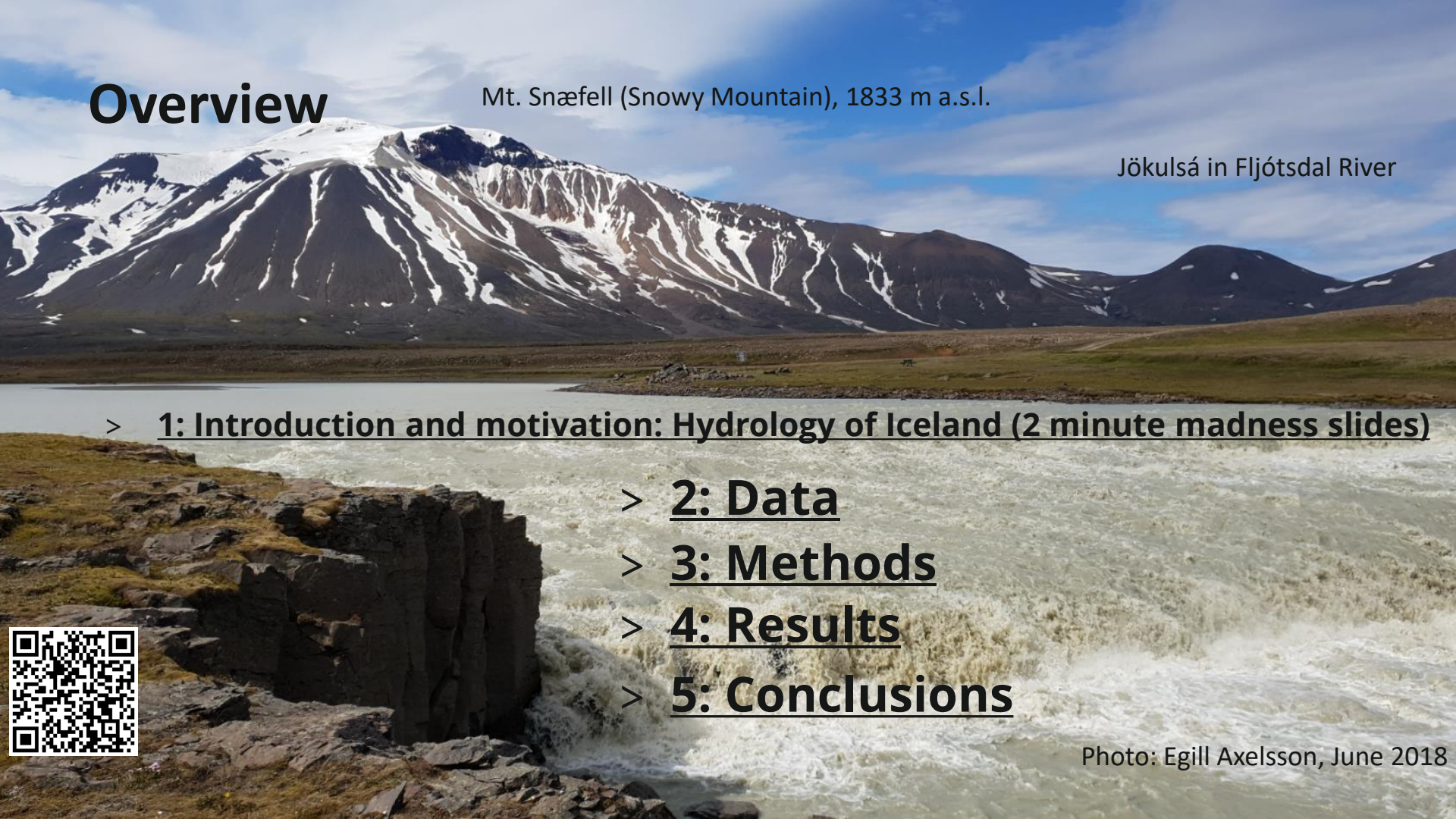
Overview



Mt. Snæfell (Snowy Mountain), 1833 m a.s.l.

Jökulsá in Fljótsdal River

> 1: Introduction and motivation: Hydrology of Iceland (2 minute madness slides)

> 2: Data

> 3: Methods

> 4: Results

> 5: Conclusions

Photo: Egill Axelsson, June 2018

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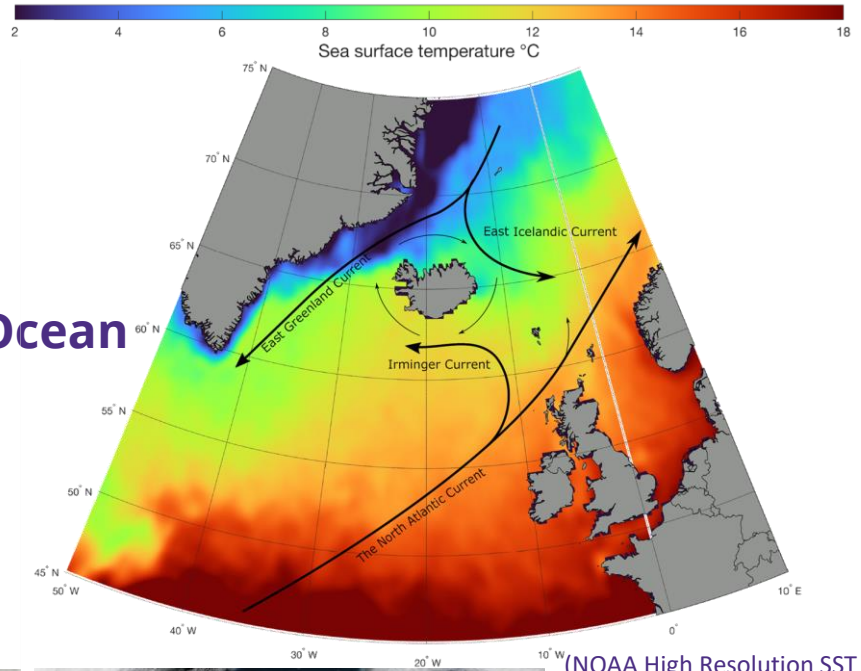

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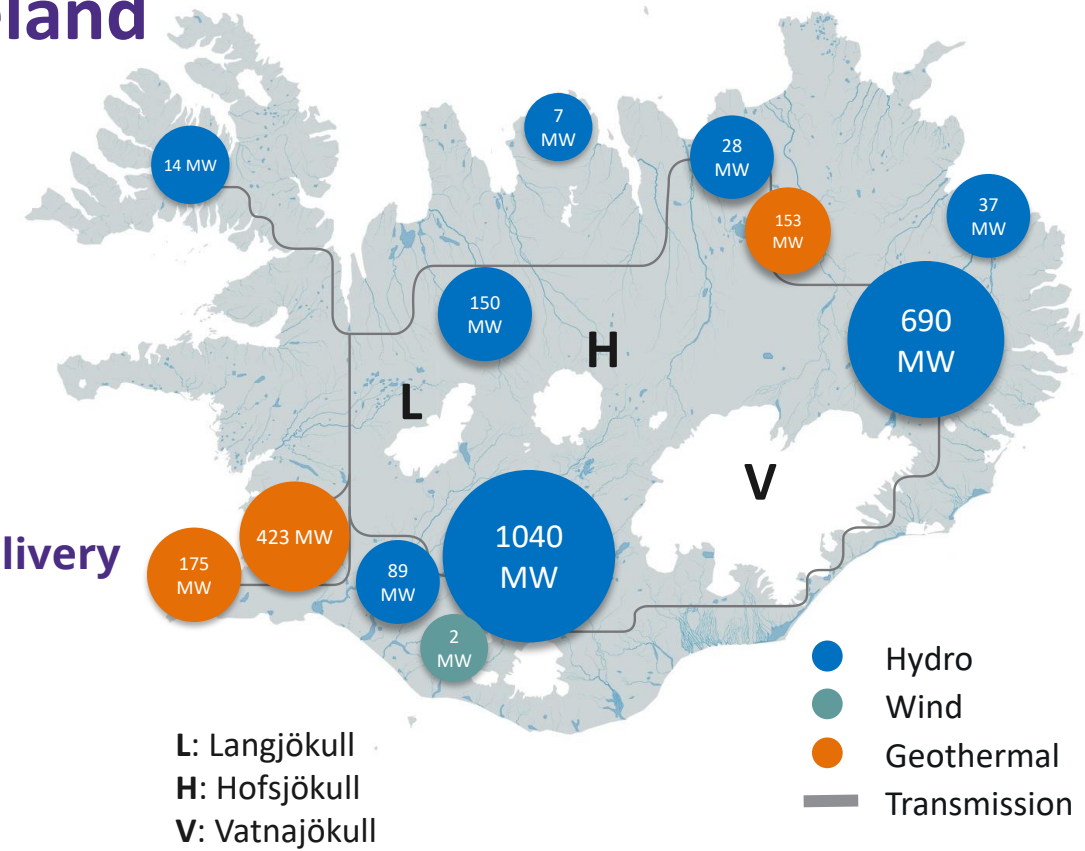

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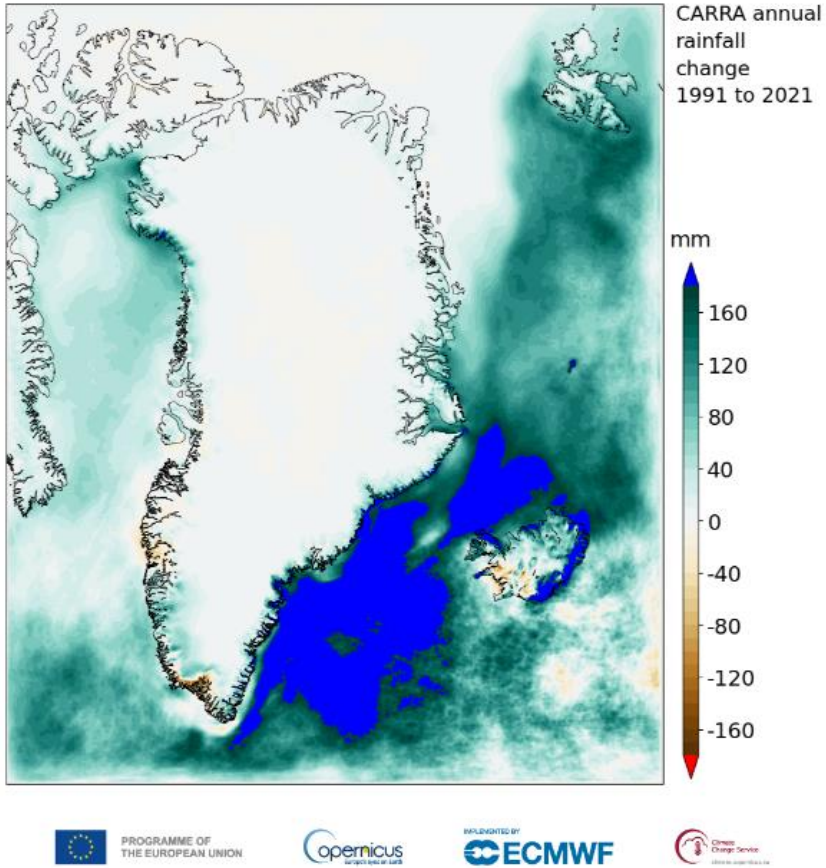

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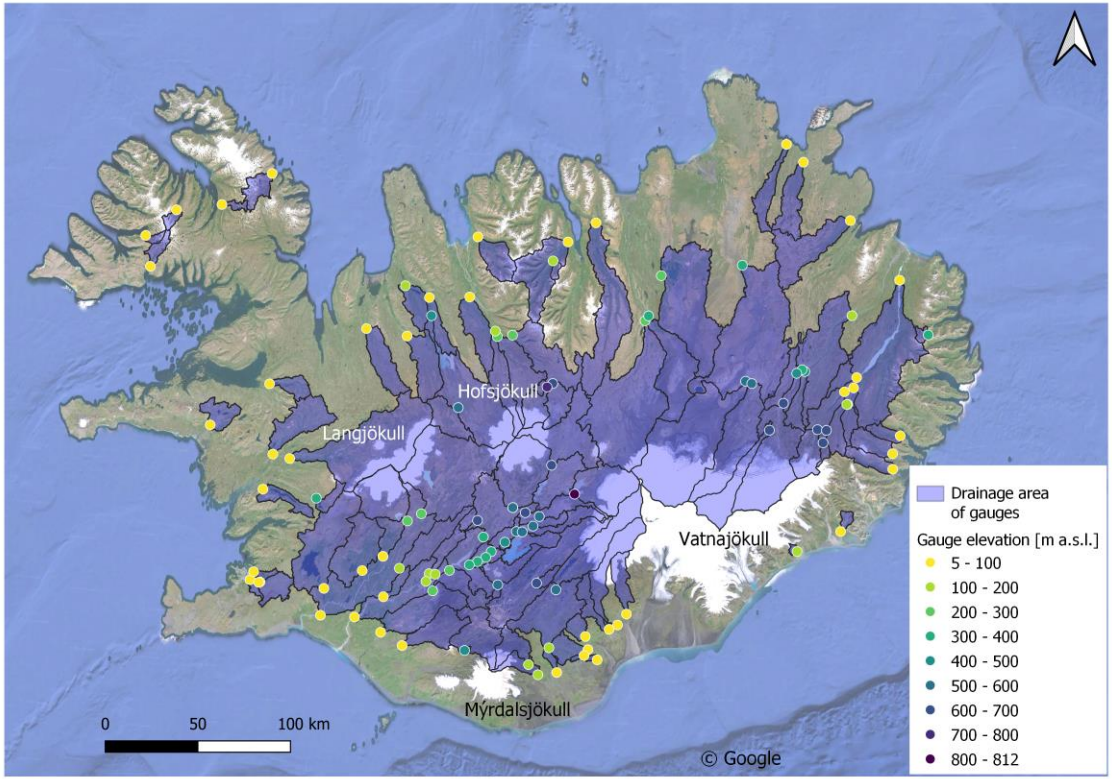
(Copernicus, 2023)

2. Data - LamaH-Ice: LArge-SaMple Data for Hydrology and Environmental Sciences for Iceland

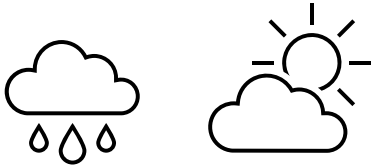
- **107 streamflow gauges**
  - **79 exhibit natural flow conditions**
- **Catchments cover:**
  - **45% of the country**
  - **60% of the glaciers**



(Helgason and Nijssen, 2024)

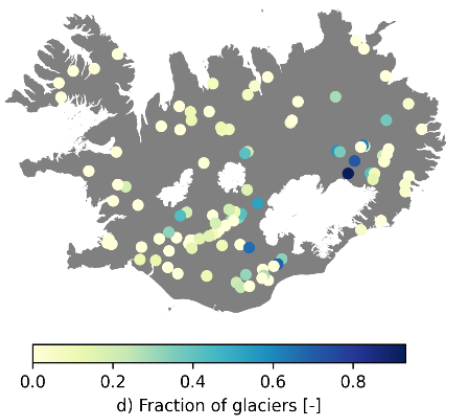
2. Data - LamaH-Ice: LArge-SaMple Data for Hydrology and Environmental Sciences for Iceland

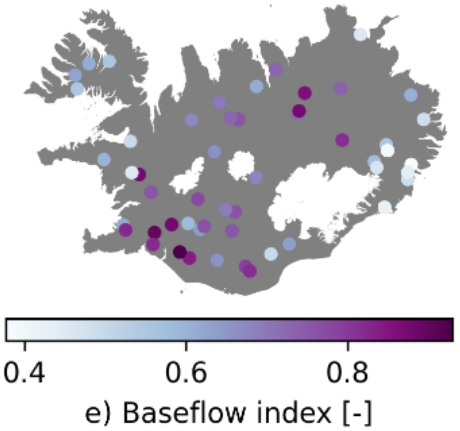
- **Timeseries from ERA5-Land atmospheric reanalysis**
  - **Temperature, precipitation, snow water equivalent (SWE)**
  - **Averaged on watersheds**



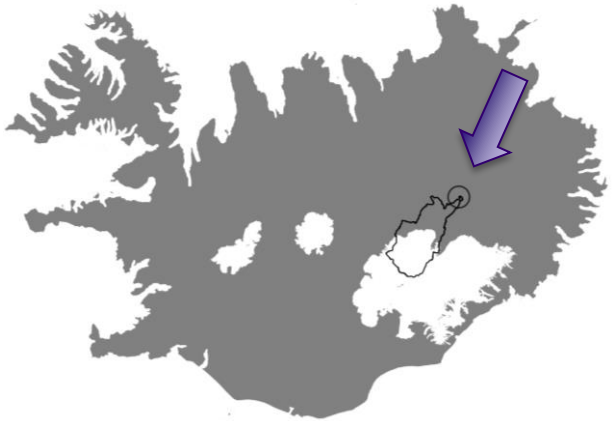
(Helgason and Nijssen, 2024)

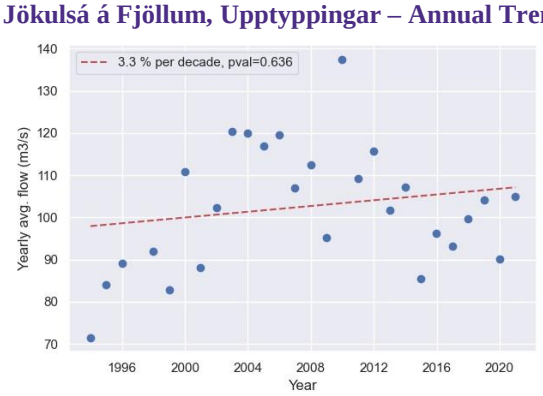
- **Catchment characteristics**

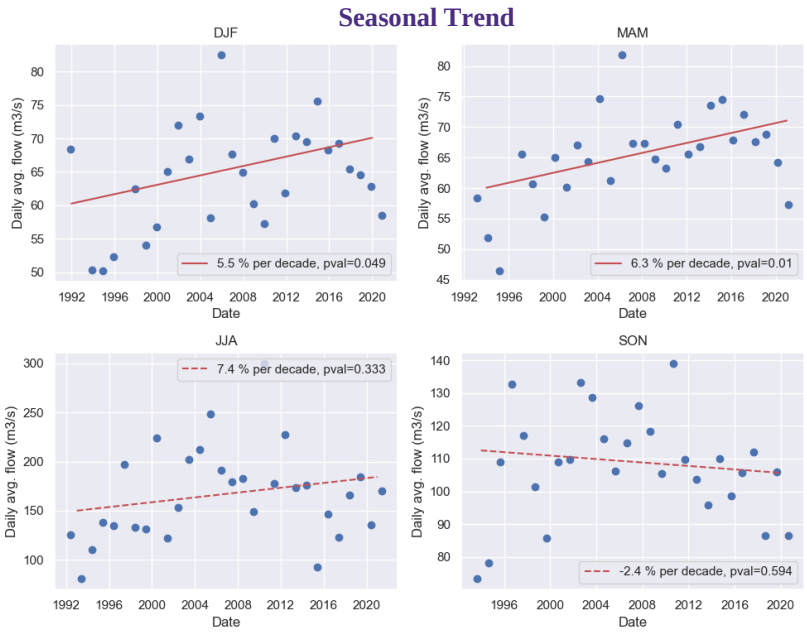




3. Methods







- **Calculation of annual, seasonal and sub-seasonal trends**
  - **Theil-Sen estimator utilized for calculating trend magnitude**
  - **Modified Mann-Kendall test used to account for autocorrelation (Hamed and Rao, 1998)**

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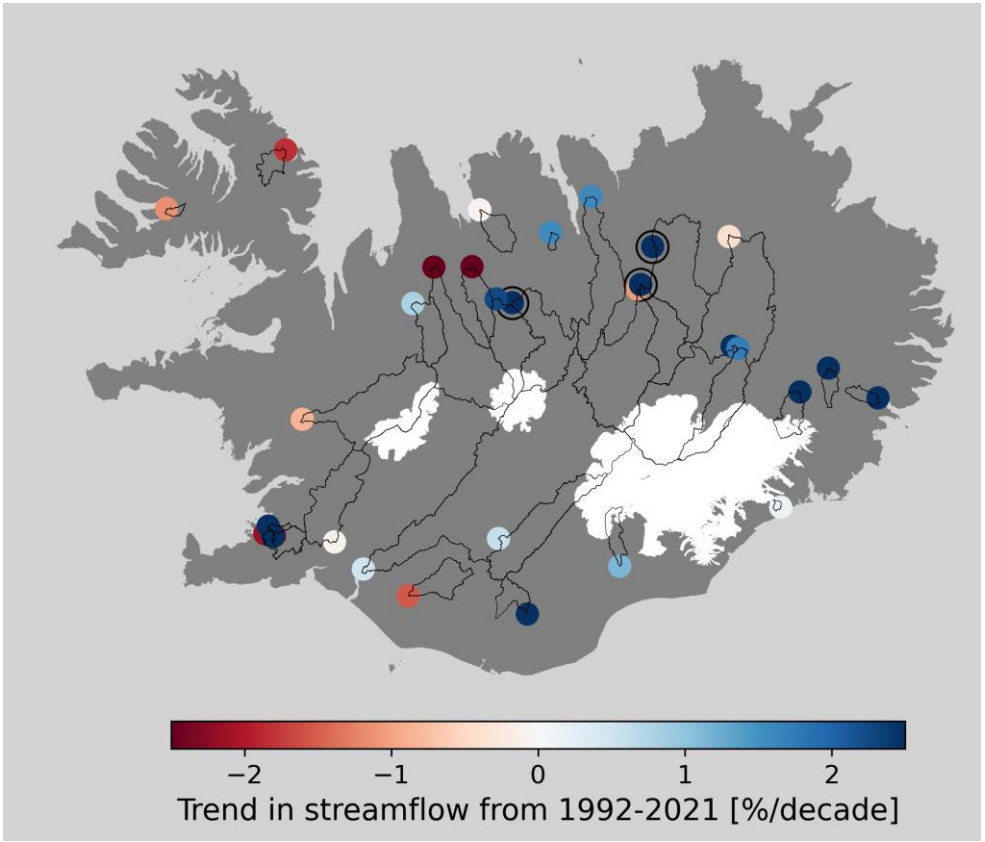
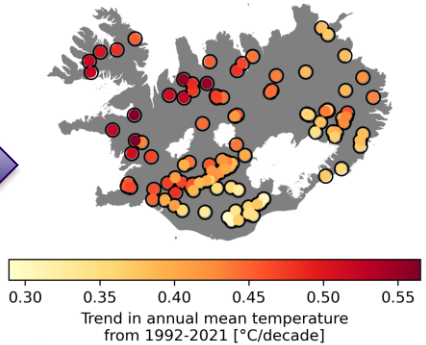
4. Results: Annual Trends 1992-2021

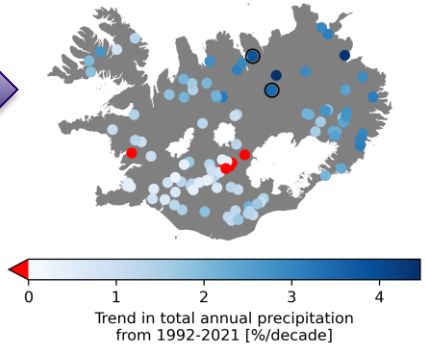
Streamflow



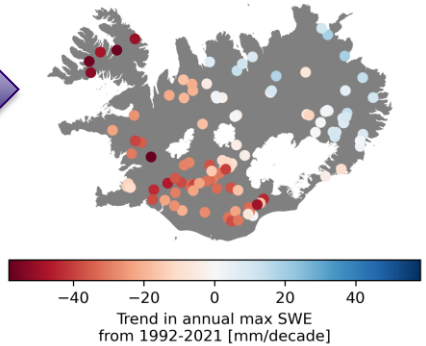
Temperature



Precipitation



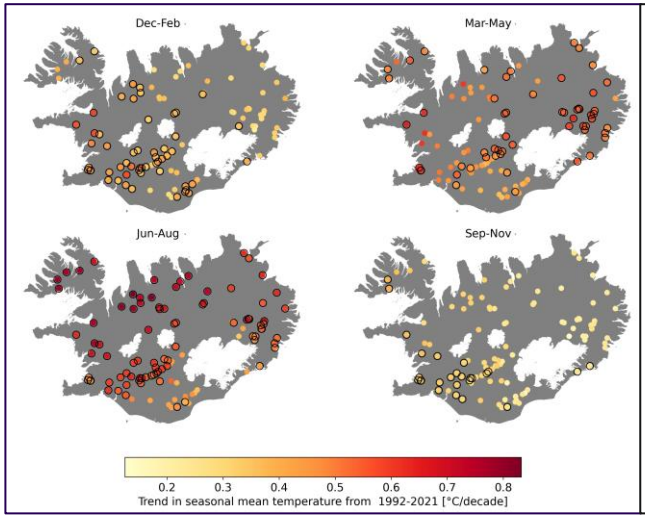
Annual max SWE



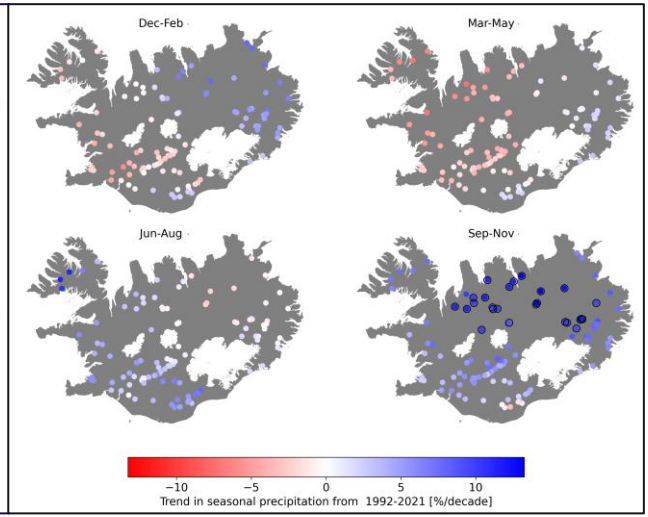
Black circle around marker denotes that trend is statistically significant (5% significance level)

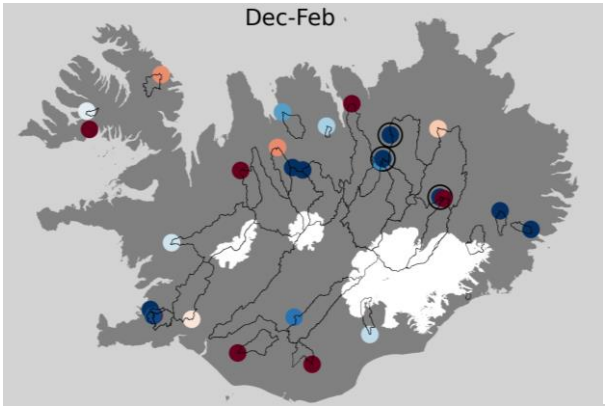
4. Results: Seasonal Trends 1992-2021

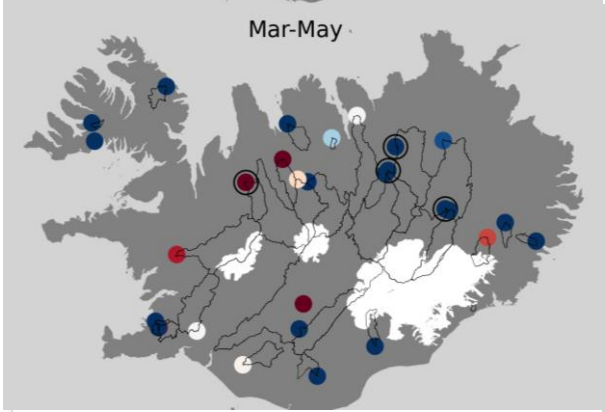
Temperature

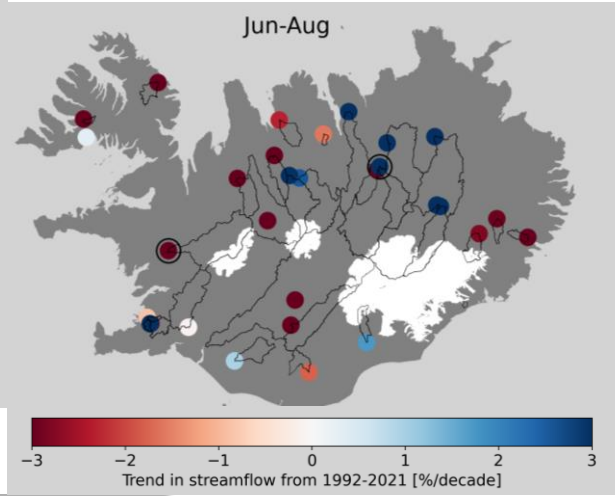


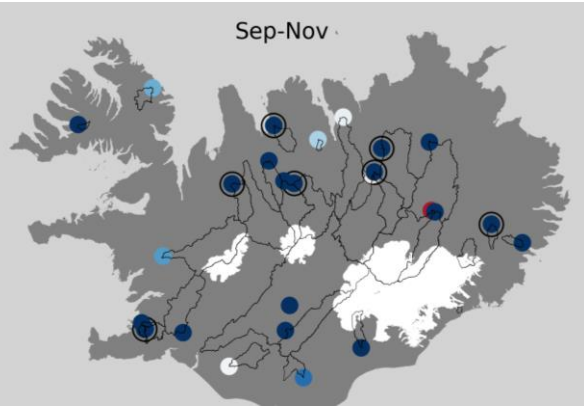
Precipitation











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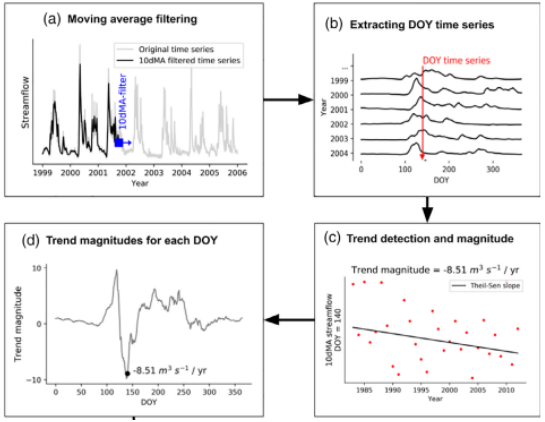
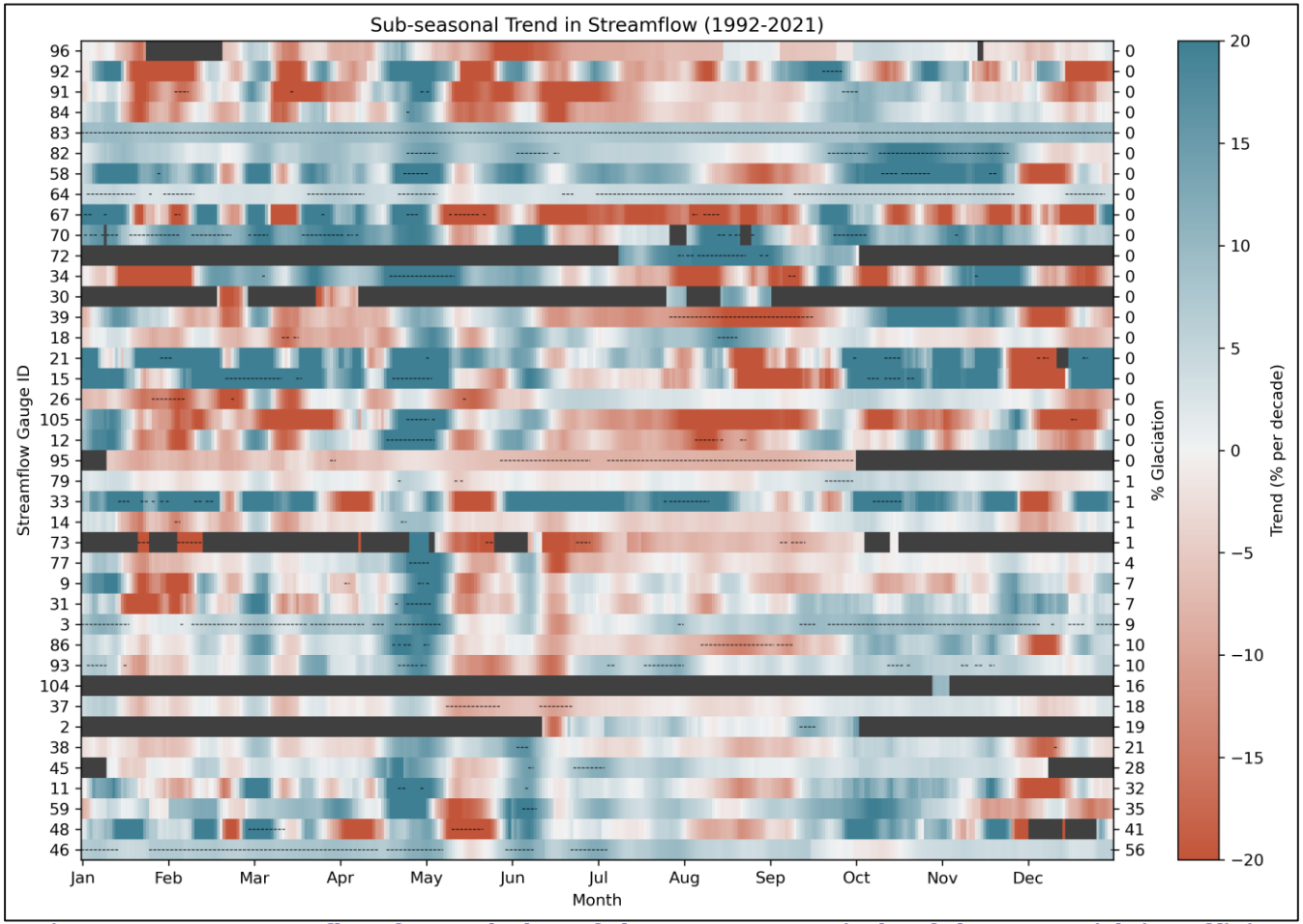
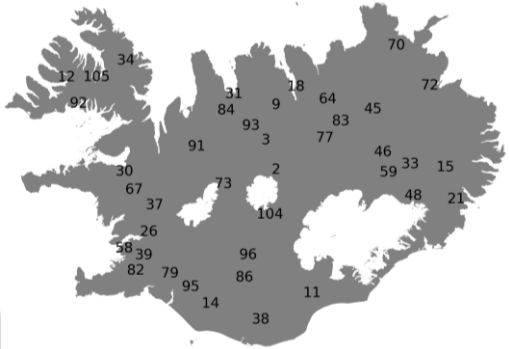


(Image: Skålevåg and Vormoor, 2021)

Sub-seasonal trends in streamflow (10DMA) 1992-2021



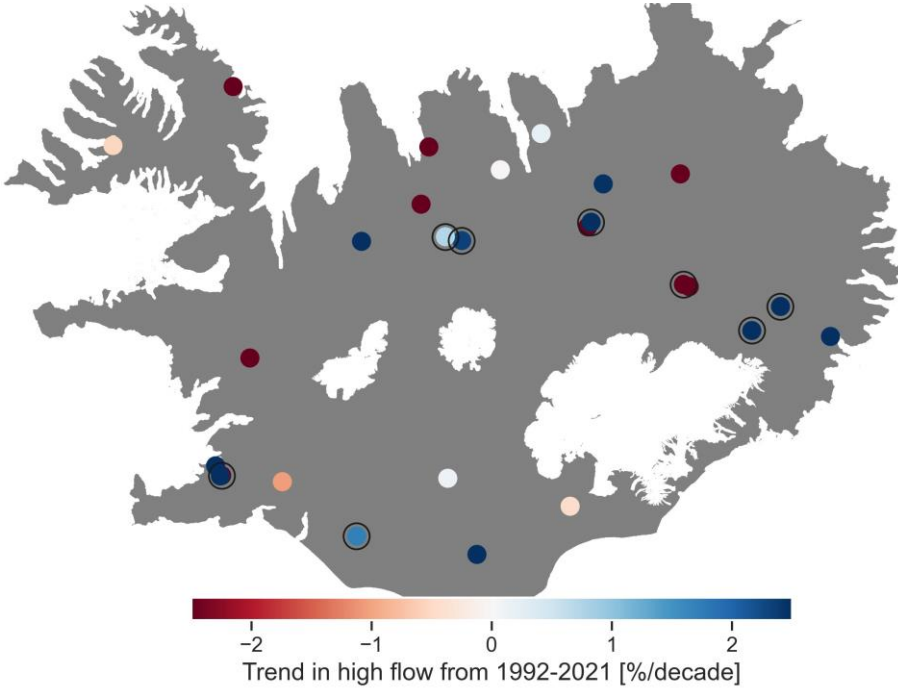
Locations of gauge IDs



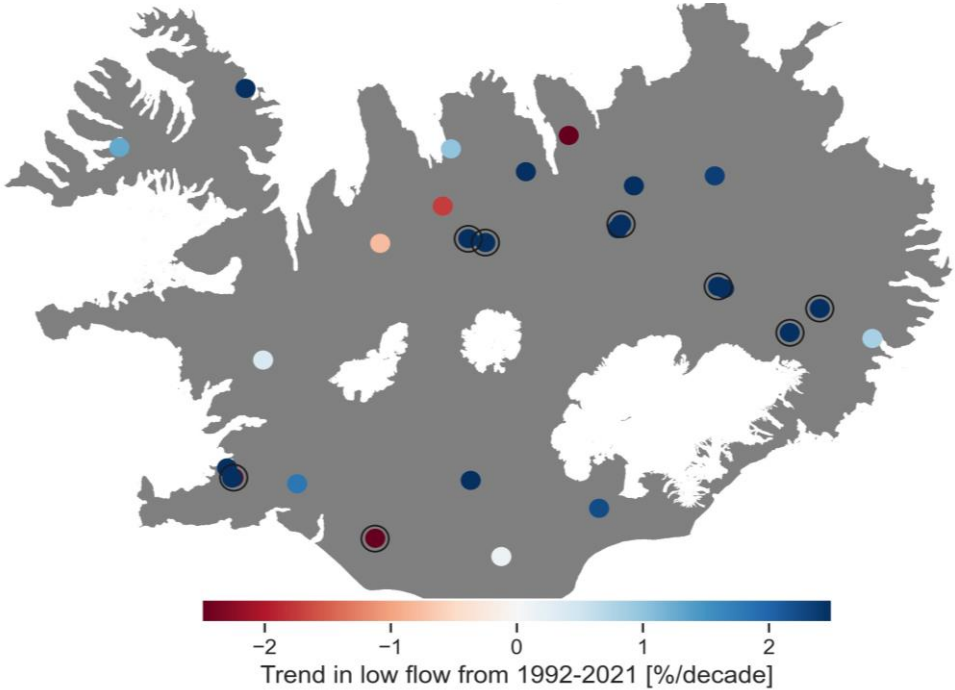
Colors show the trend in 10-day moving average streamflow for each day of the year. For periods of the year with insufficient data available, a dark gray color is shown ( ) An overlying dashed black line indicates that the trend is significant ( )

4. Results – High and low flows

Annual high flow (90th percentile)



Annual low flow (90th percentile)



5. Conclusions: Streamflow in Iceland 1992-2021

- **Spring freshet occurs sooner**
  - Spring temperatures have increased
  - Streamflow ↑ in April and ↓ in May
- **Streamflow in fall has increased**
  - Precipitation has ↑
- **Streamflow ↓ in summer**
- **Annual low flows have ↑**
- **Useful information for water resources managers!**

Jökulsá á Fjöllum, Dettifoss

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