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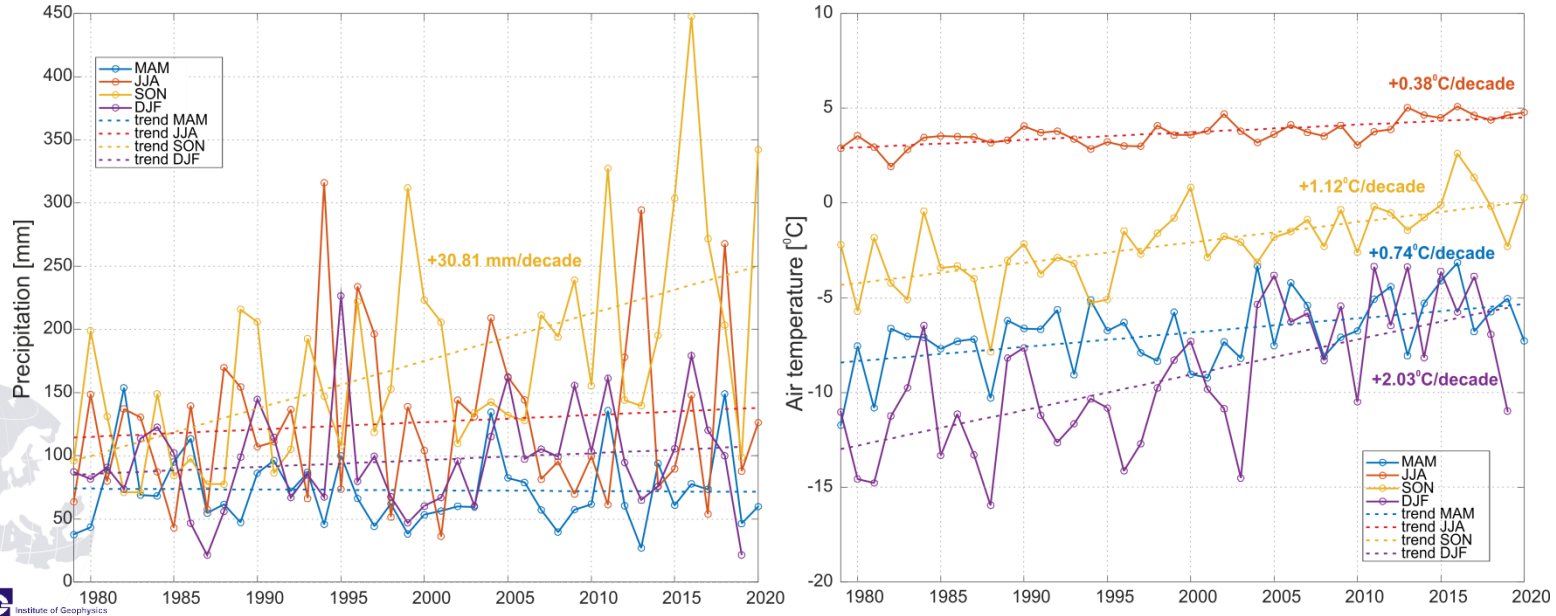
Assessment of streamflow trends in snow and glacier melt dominated catchments of SW Spitsbergen

Marzena Osuch, Tomasz Wawrzyniak (Institute of Geophysics Polish Academy of Sciences)

Elżbieta Łepkowska (University of Silesia in Katowice, Poland)

Motivation

- Atlantic sector of the Arctic is a place of largest observed changes
- An increase in air temperature, changes in precipitation pattern, permafrost degradation, changes in active layer thickness and shorter snow cover duration influence hydrological processes



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Variability of the seasonal sum of precipitation and mean air temperature at Hornsund in the period 1979–2020.

Aims

- The study's main objective is to assess the influence of changes in air temperature, precipitation, and snow cover on the flow in the four Arctic catchments located in South Spitsbergen.
- In particular, we analysed the differences in the hydrological response between catchments with differing percentages of the glaciated area.

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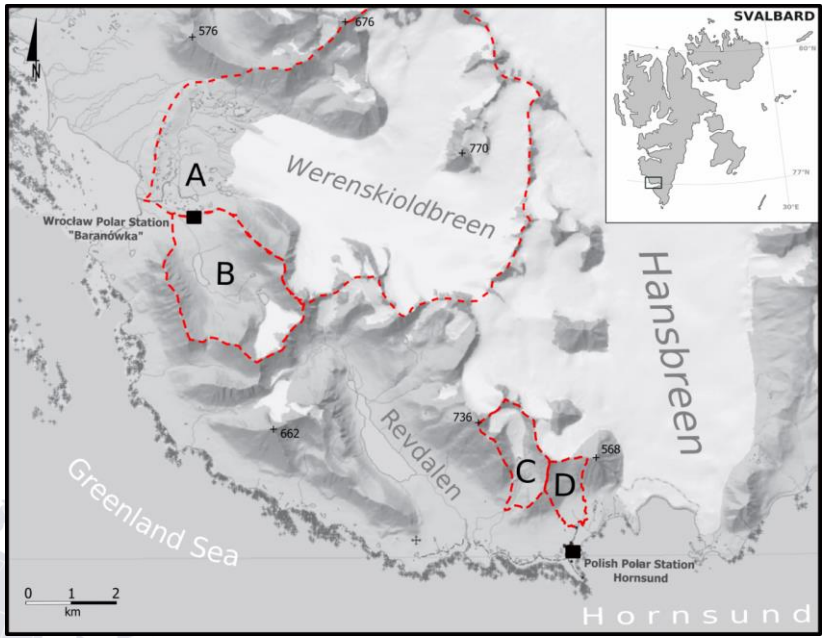
Study area



Study area covers four catchments:

A. Breelva
glaciated in 61% area 44 km^2

B. Bratteggbekken
glaciated in 5.9% area 8.17 km^2

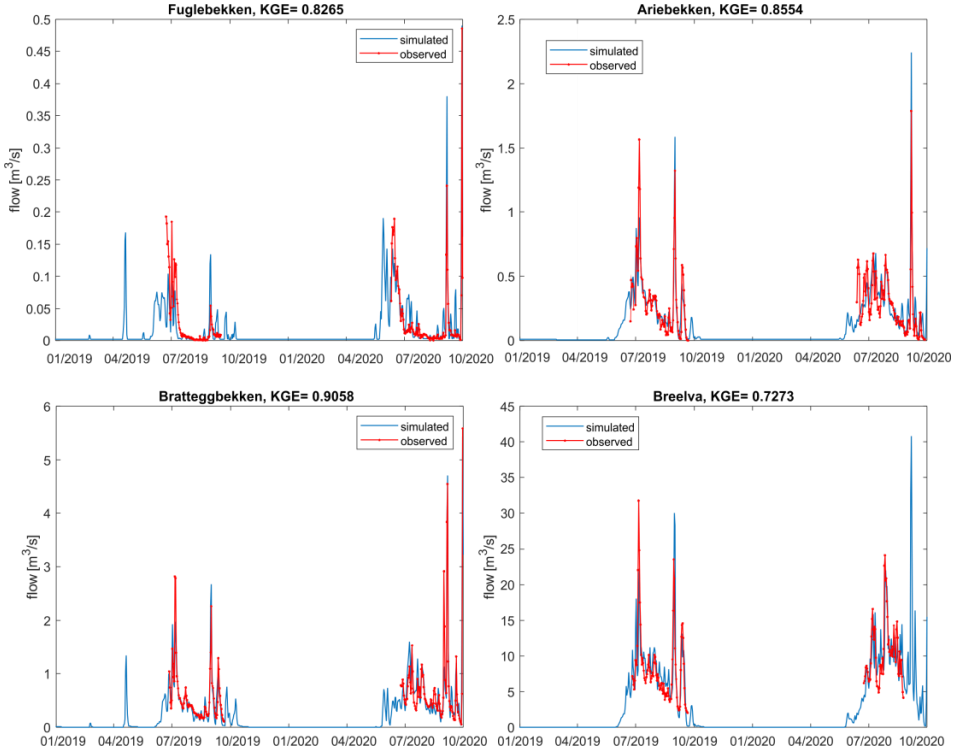
C. Ariebekken
glaciated in 11.5% area 2.30 km^2

D. Fuglebekken
unglaciated area 1.28 km^2

Hydrological modelling

- To simulate hydrological processes semi-distributed Nordic HBV was applied
- The inputs to the models:
  - Air temperature
  - Precipitation
  - DEM including glacial coverage
- Calibration based on flow observations
- Measure of fit – Kling Gupta efficiency criterion (KGE)
- Optimization method – SPS-L-SHADE-EIG

Calibration results



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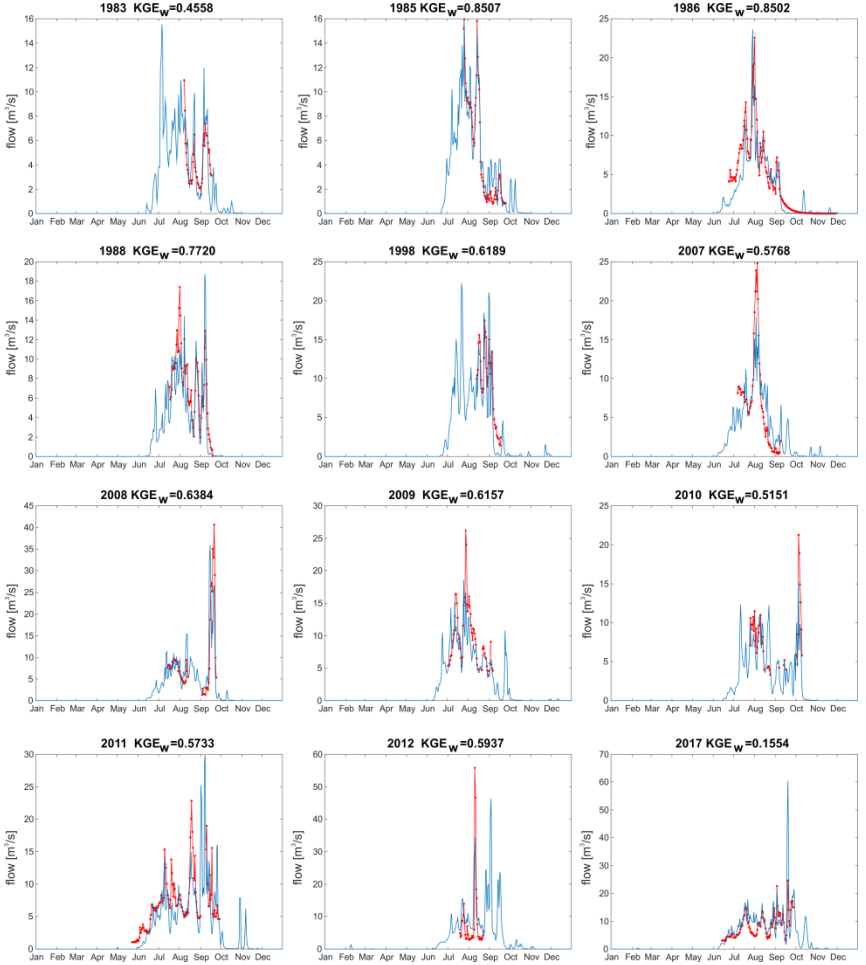
Validation results

- HBV Nordic gave very good validation results in all catchments
- The outcomes confirm the ability to simulate flow in the period 1979-2020
- In the next step, changes in flow regime were analysed

Validation results Breelva Nordic HBV



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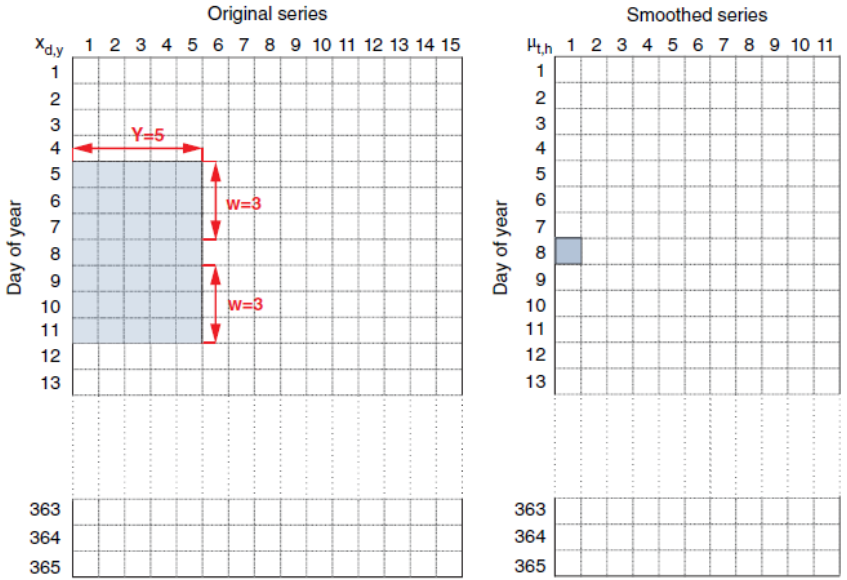
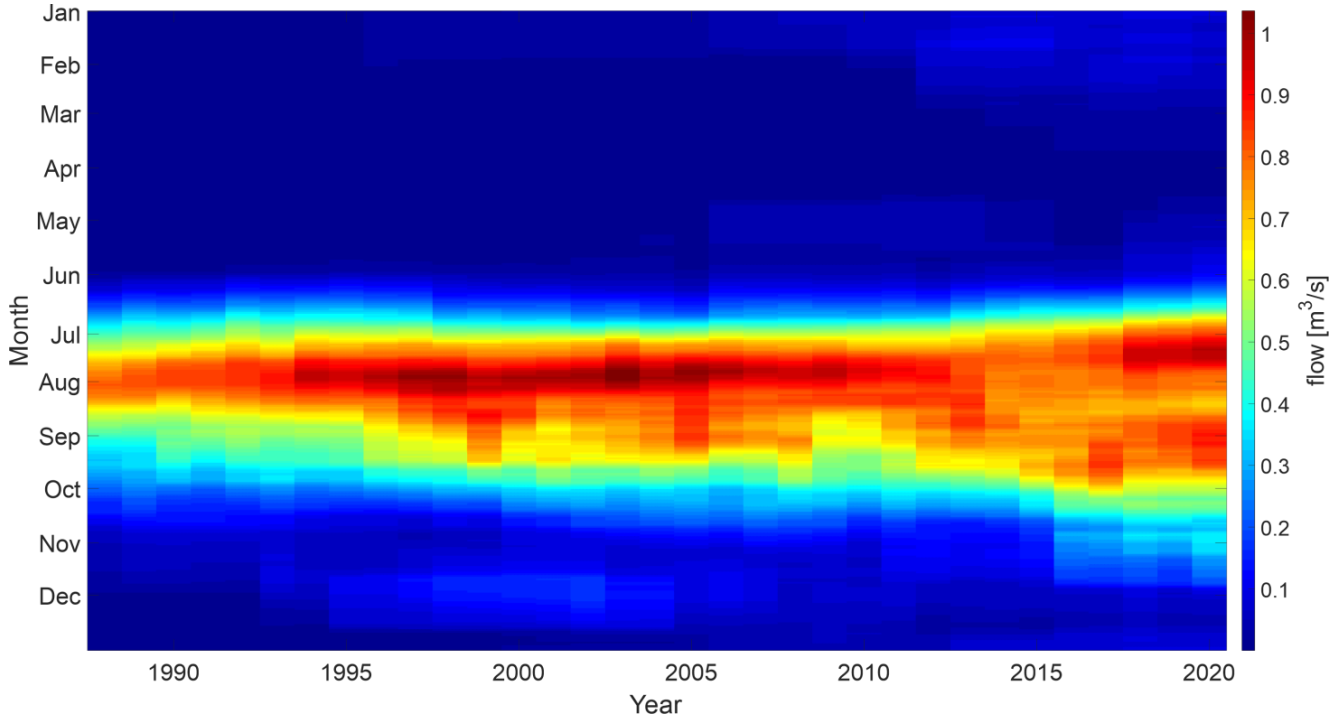
Changes in the seasonality



- MASH method – data averaging against days and years that allows for filtering out small scale (local) variability and make it possible to see longer-term trends
- Trend analysis by modified Mann Kendall method

The simulated flow time series were averaged over 31 days (w=15) and 10 years (Y=10)

Bratteggbekken – changes in flow regime by the MASH method



The matrix of smoothed flows. Colour scale represents flow values. The data were averaged over 10 years and 31 days. The ticks on the X-axis represent the beginning of the averaging period.

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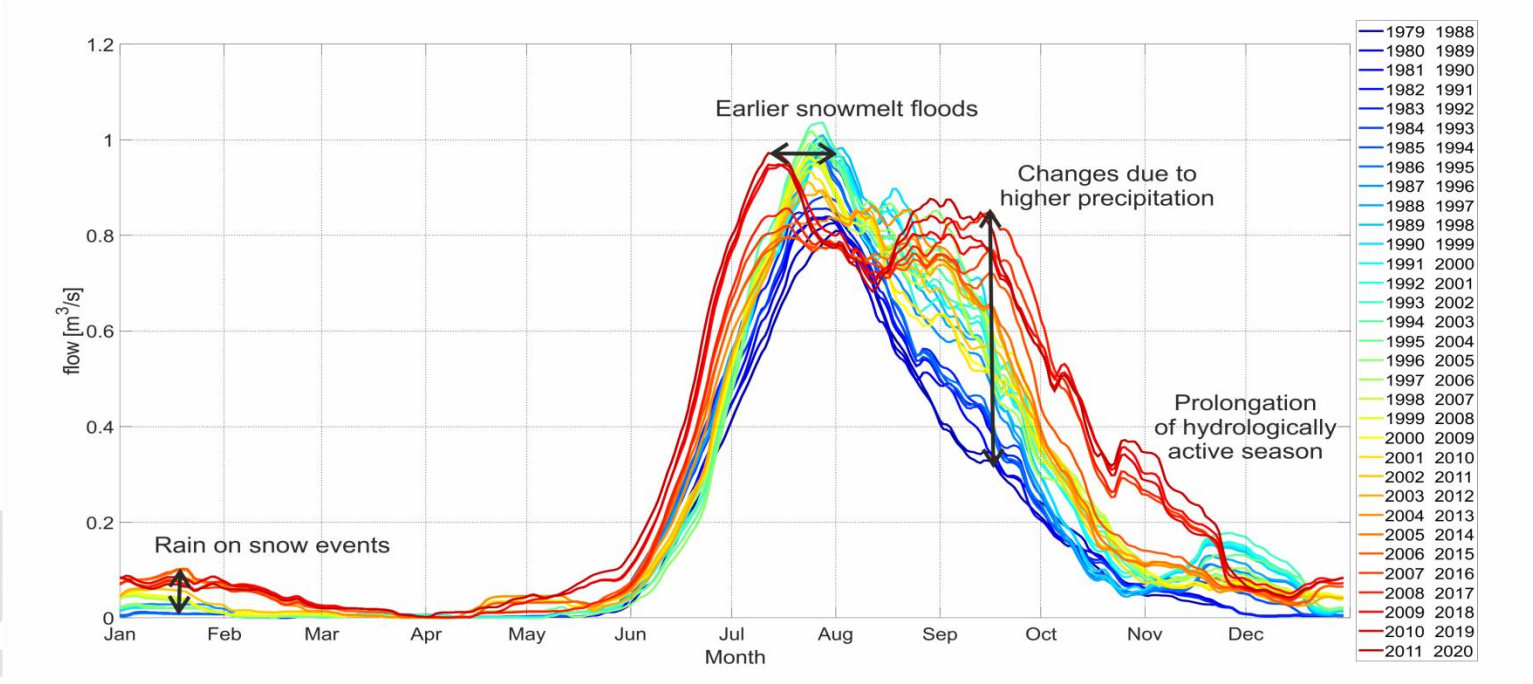
Bratteggbekken – changes in flow regime by the MASH method



The colour of lines represents the period of averaging

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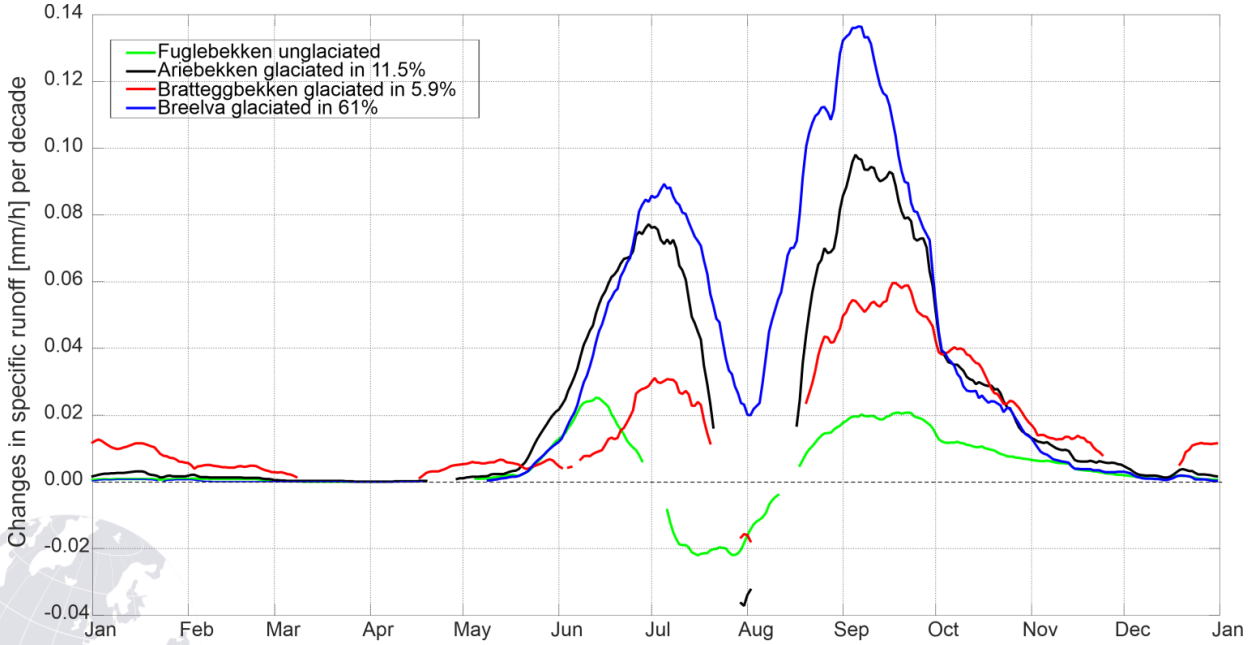
Comparison of trends for all days of the year between catchments



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- Similar response due to similar climatic conditions
- Differences between glaciated and unglaciated catchments
  - decreases in flows in July and the first part of August for unglaciated catchment
  - increases for glaciated catchments
- Magnitude of changes is related to the percentage of the glaciated area.
- The larger the glacierized area is, the larger the changes in the flow regime

Conclusions

- The applied model allowed for reconstruction of hydrological conditions in the four studied catchments
- The results show that the flow regime of the High Arctic catchments is highly sensitive to the ongoing changes in air temperature and precipitation patterns.
- The magnitude of changes also depends on the percentage of glacial coverage.
- More studies are needed that focus on the linkages between drivers, processes, and their feedback.

Thank you for your attention

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