

Low Water in Switzerland

On Different Spatial and Temporal Scales

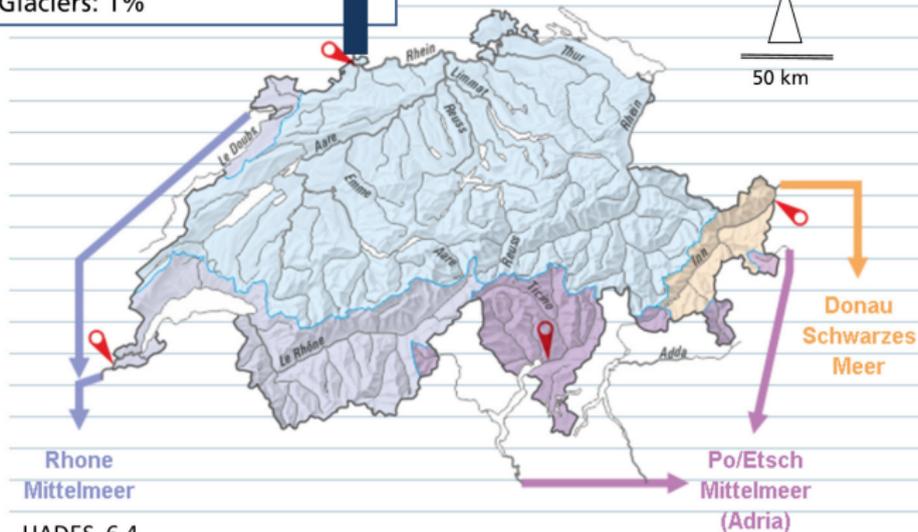
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Basel – The best location to discuss Swiss hydrology

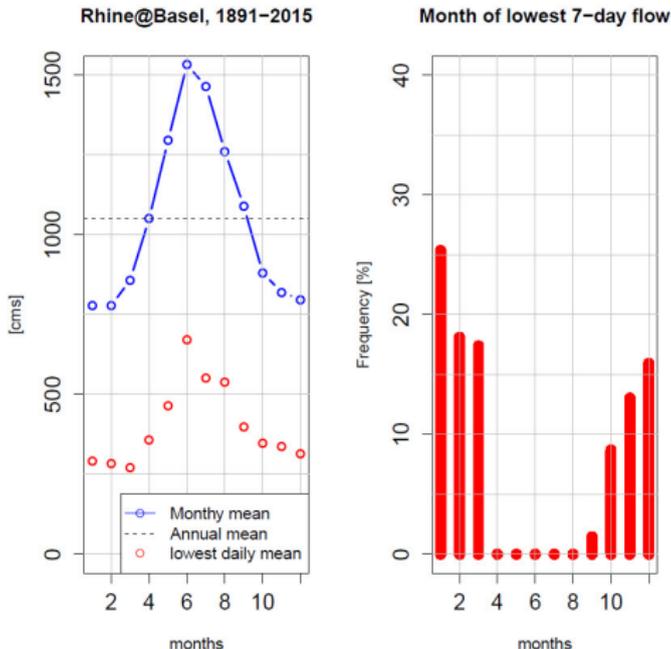
Integral hydrological answer of Northern Switzerland

Rhein@Basel
A = 36'000 km²
Mean elevation: 1052 m asl.
Glaciers: 1%



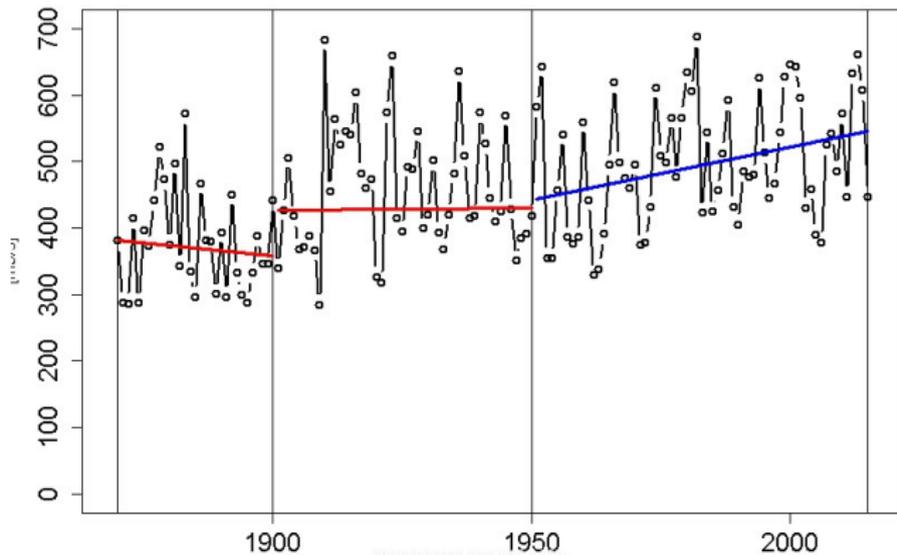
Snow-melt dominated regime. Winter is the low flow season. Data: BAFU

Talk: Focus on lowest annual flow over 7 days (AM7).



Rhine@Basel: Time series 1870 - 2016 of lowest annual mean flow over 7 days (AM7)

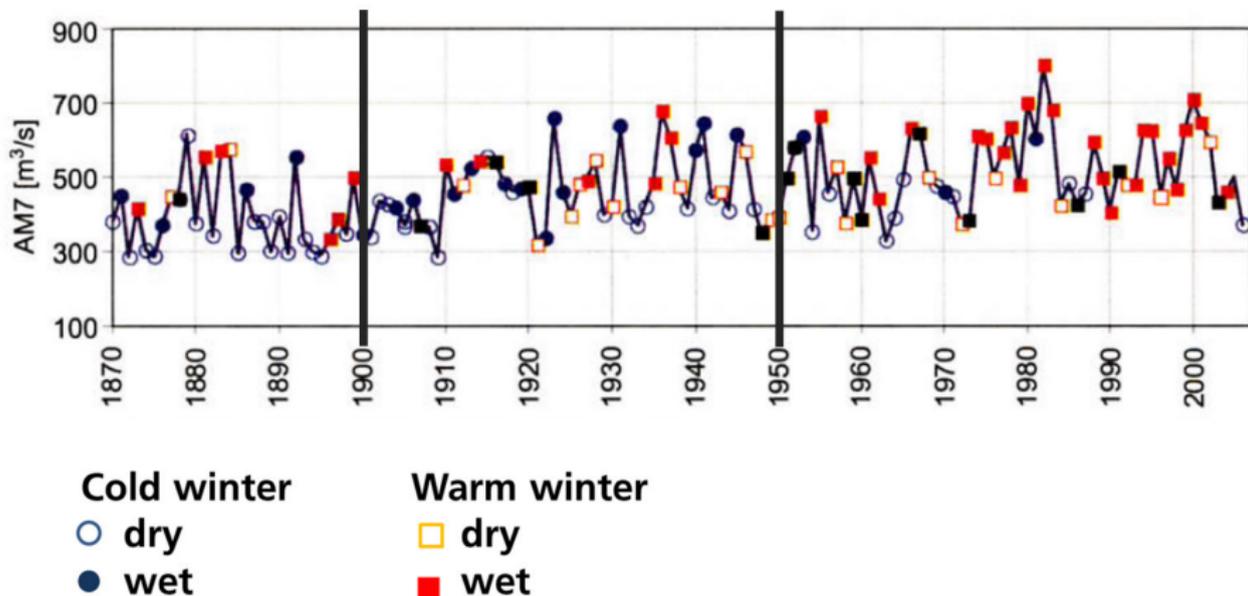
Low flows have increased over time. 3 distinct periods.
Role of climate and human impact?



Role of climate

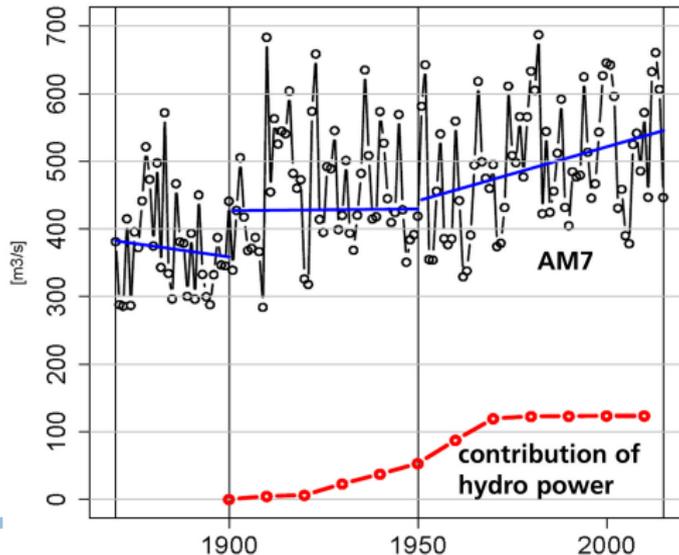
AM7 and the correspondent climatic condition

After 1950: Increase of warm and wet winters.



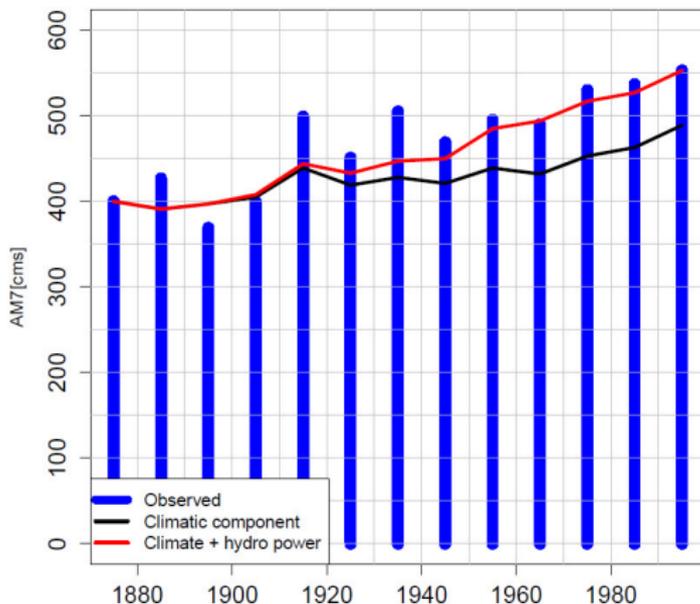
Human impact – Expansion of Hydro power

In winter: Water from artificial storage lakes produces electricity and thus is running off. → Substantial contribution to natural runoff with significant increase between 1950 and 1970 due to the expansion of storage volumes. (today: net volume 2 km³) → + 120 m³/s.



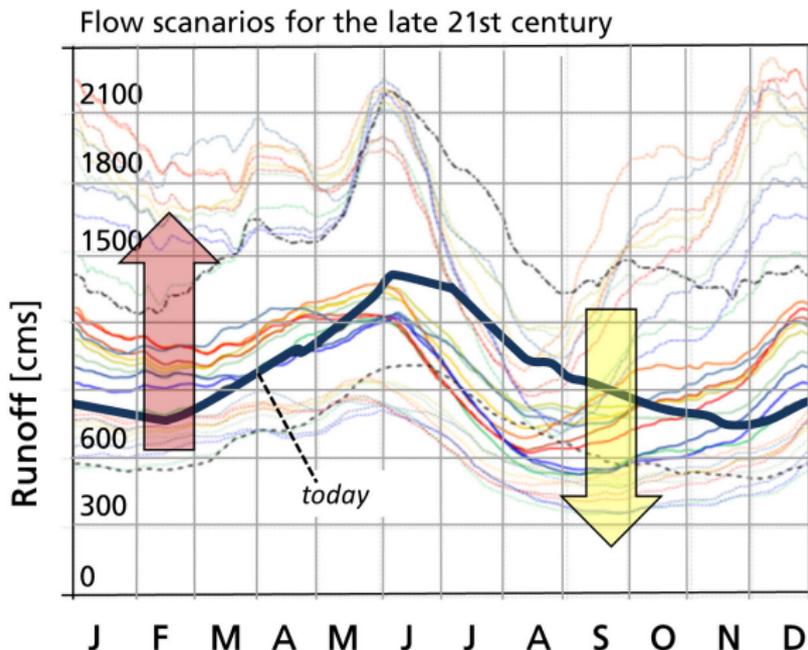
A statistical model puts the influences into perspective

Decadal changes of AM7 and processes behind



Rhine 2085: Low flow will occur in summer

Drier summer, decreased influence of ice and snow melt.



The Basel low flow index

Years with extreme summer low flows in Basel are years when society and economy are suffering.

1540:

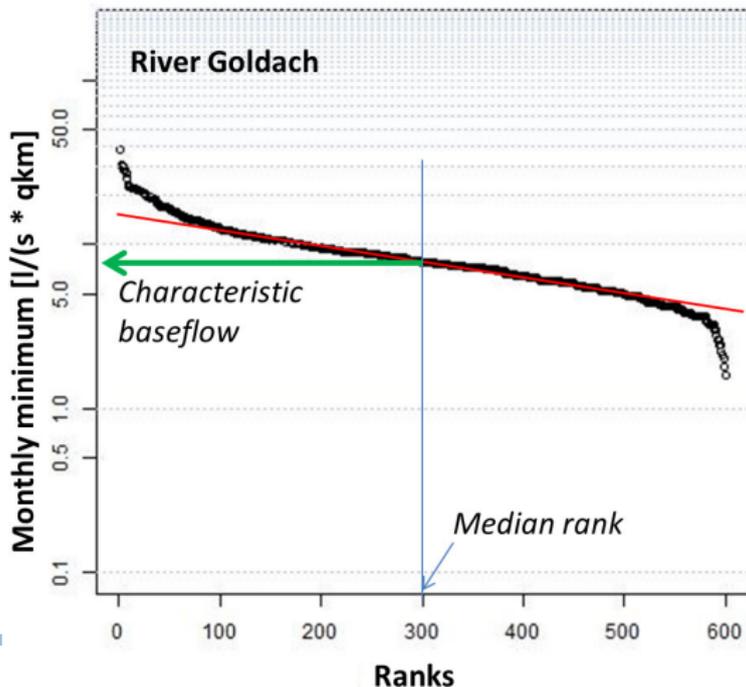
- > Rhine: 10 % of mean (2003: 50 %)
- > very low harvest → starvation
- > poor water quality → diseases
- > limitations everywhere → aggression in society

Source: B. Meyer in Transhelvetica 42

1. Climate change → **Increase** of low flow in winter
2. Hydro power production → **Increase** of low flow in winter
3. Future climate change → **Summer** as the main low flow season

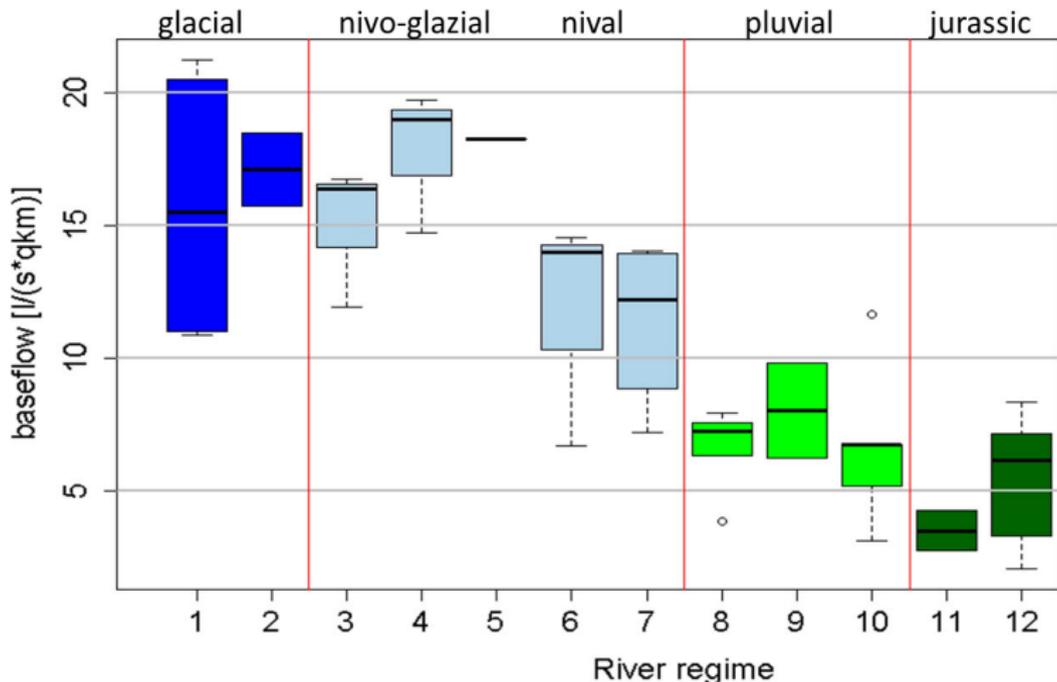
Spatial pattern of low flow in Switzerland

Method: Baseflow analysis acc. *Kille 1970* based on minimum monthly flows.



Spatial pattern of low flow in Switzerland

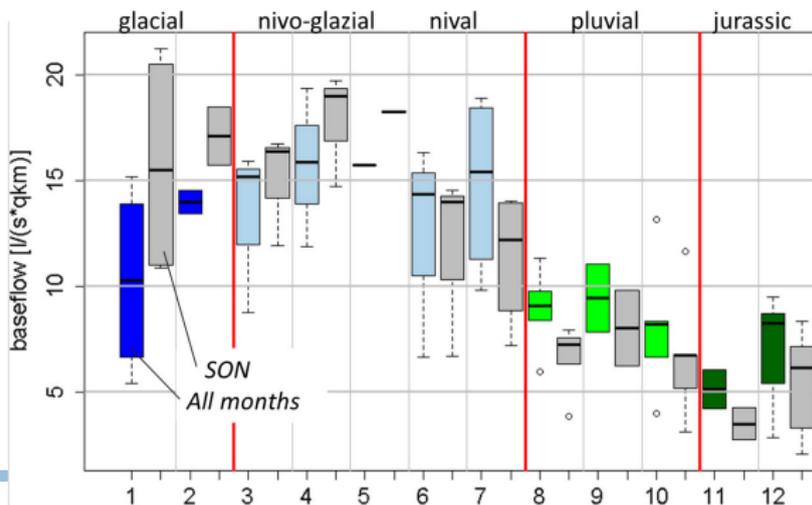
Distinct pattern as a function of climate and physiography (i.e. river regime type) is observed.



Baseflow analysis based on SON only ("without snow")

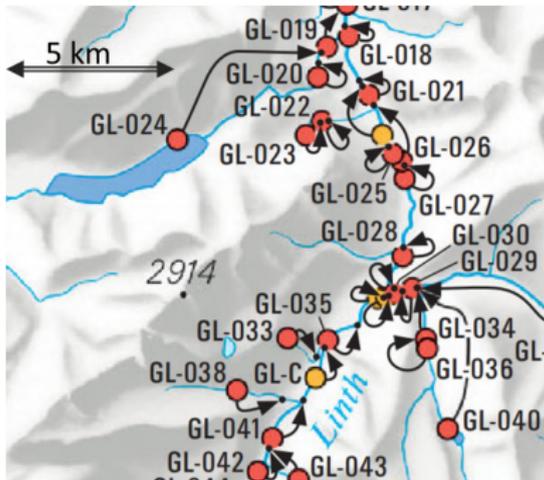
Baseflow in

- > Alps/pre-Alps: 10 - 20 $l/(s * km^2)$
- > Mittelland (Plateau): 5 - 10 $l/(s * km^2)$
- > Jura: around 5 $l/(s * km^2)$

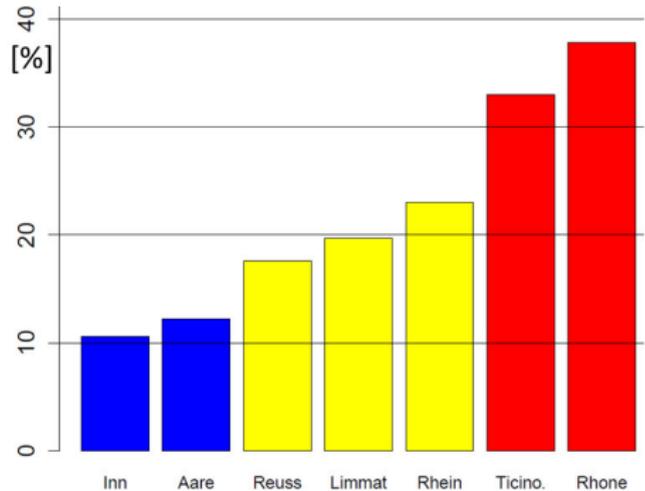


Human impact

Human impact, i.e. man made low flows, is very substantial.



Abstractions, Canton of Glarus



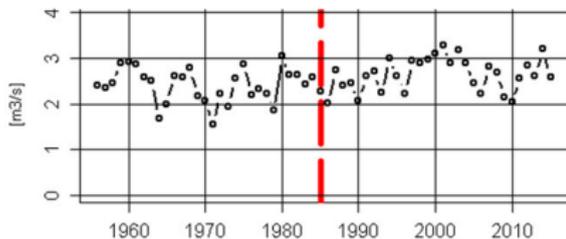
Portion of river sections where river flow is altered (→ residual flows)

HADES (2007) und Weingartner (1999)

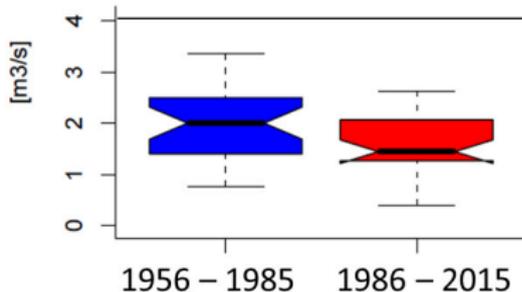
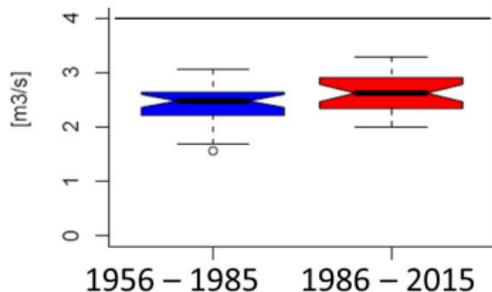
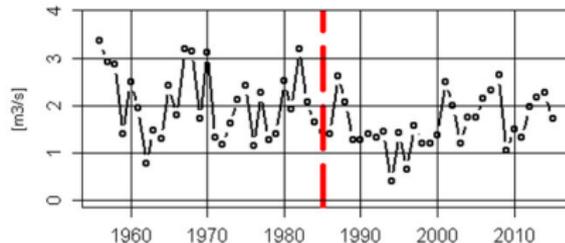
Have low flows (AM7) changed over time

1985 as the emerging year of climate change

Luetschine@Gsteig, AM7



Areuse@Boudry, AM7

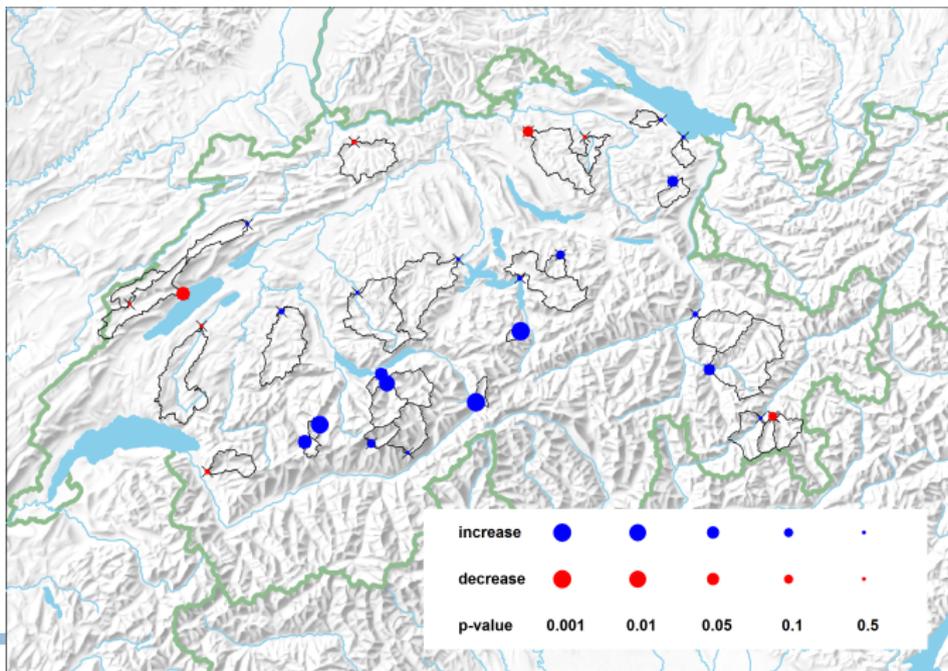


➔ Significant increase ●

➔ Signifikant decrease ●

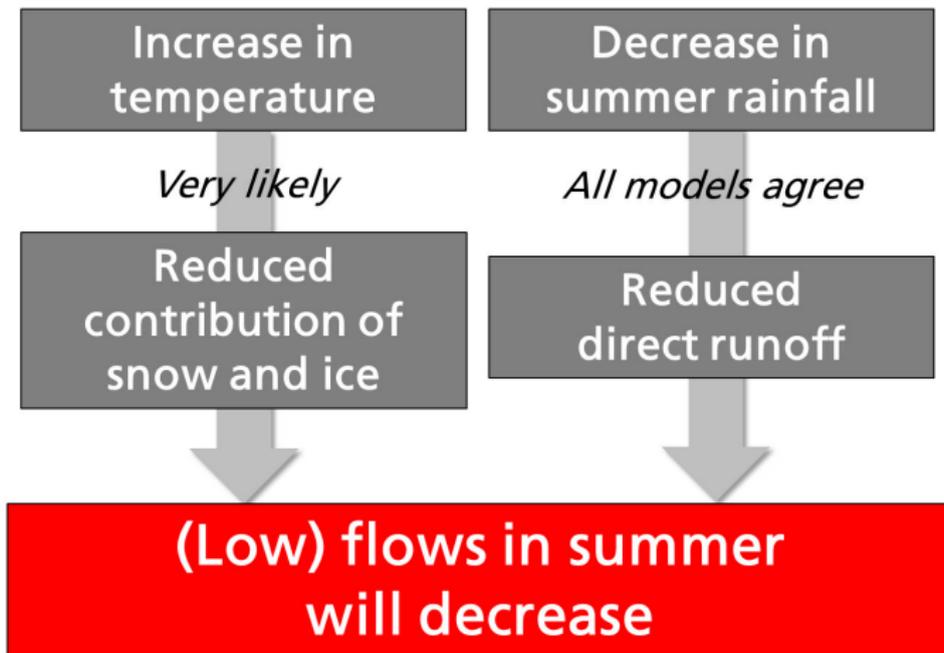
Low flow in a changing world

Increase in Alps and Pre-Alps (AM7 in winter), slight decrease in Mittelland / Jura (AM7 in summer or fall).



Low flows in a changing climate

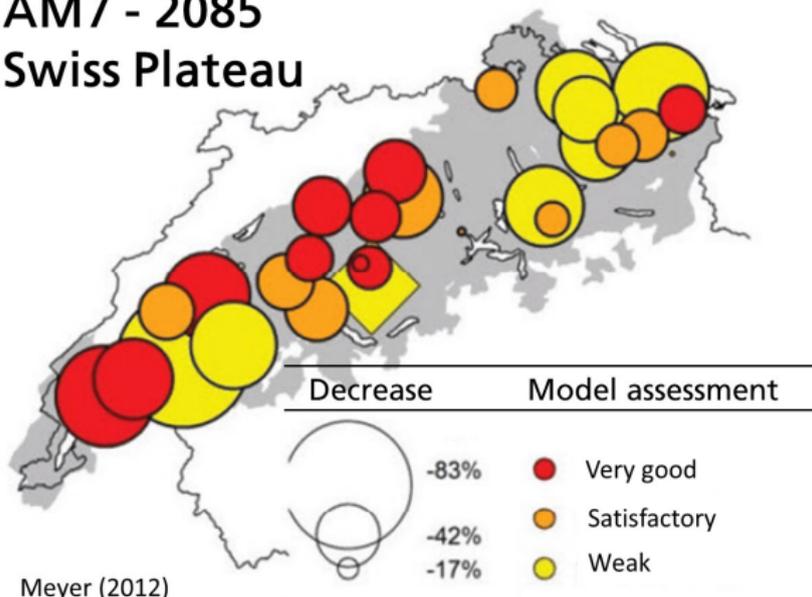
The future seems to be quite clear.



Low flows in a changing climate (2)

Swiss Plateau will be strongly affected.

AM7 - 2085 Swiss Plateau

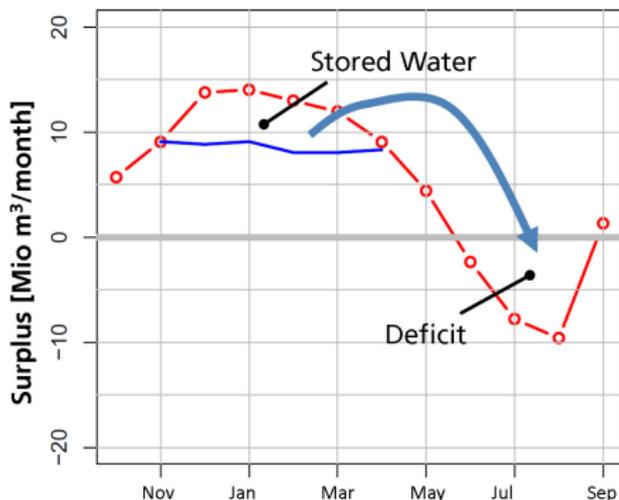


Meyer (2012)

The need for multi-purpose storages

Broye (Western Swiss Plateau): Monthly water balance in a dry year (around 2085) which will occur almost every third year.

Challenges are a) to store water in winter and b) to distribute stored water for multi-purpose use in summer



1. Clear spatial pattern of low flows.
2. Substantial human impact → Challenge: To re-assess environmental flows ("Restwasser") in a changing climate.
3. Situation in summer will become more and more critical
→ Adaptation is urgently needed (beside mitigation of course). It is time to start a pro-active planning now (multi-purpose storages, IWR as a prerequisite).