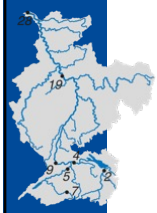
Climate change impact on rain, snow and glacier melt components of streamflow for the River Rhine: synthesis of a model experiment and relevance for water use

Please read & cite the following report, avail. at www.chr-khr.org from 1 June 22

Stahl, K., Weiler, M., van Tiel, M., Kohn, I., Hänsler, A., Freudiger, D., Seibert, J., Gerlinger, K., Moretti, G. (2022): Impact of climate change on the rain, snow and glacier melt components of streamflow of the river Rhine and its tributaries. CHR report no. I 28. International Commission for the Hydrology of the Rhine basin (CHR), Lelystad.



Published 2017

1st Phase: the past

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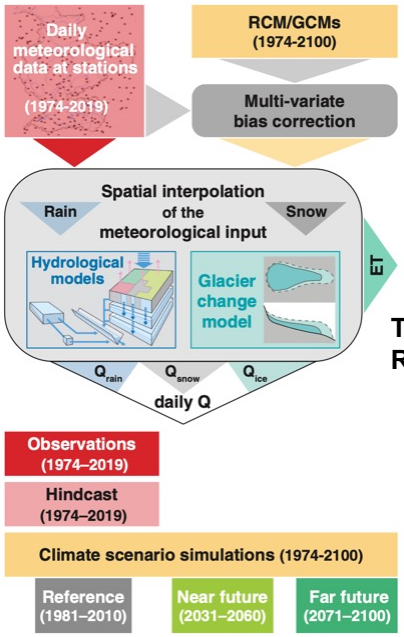
Forthcoming 1. June 22

2nd Phase: the future

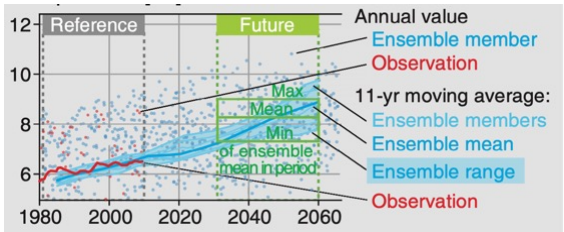
1

The model approach



- RCP8.5
- 7-member ensemble (EURO-CORDEX: 5GCMs, 2 RCMs)

Transient Runs!



- Daily streamflow components for climate change scenarios
- Analysis: annual, seasonal, extremes & upstream to downstream

2

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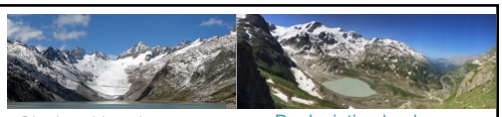
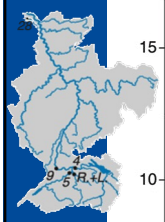
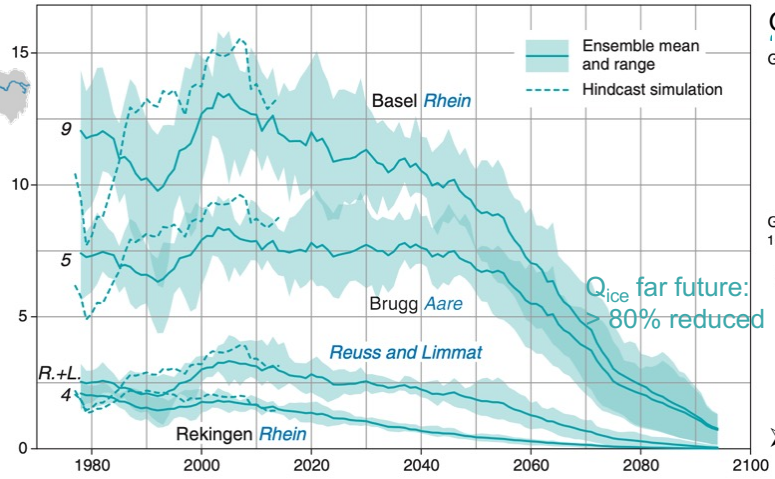
Modelled transient change in Qice



Glaciated headwaters | Deglaciating landscape

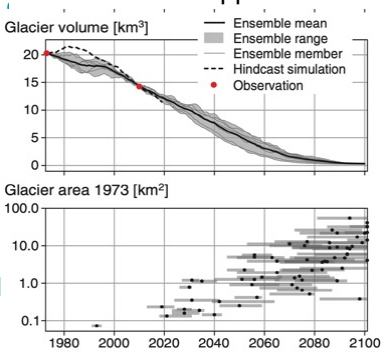
Mean annual Q_{ice} [m^3/s]





Q_{ice} far future: > 80% reduced

Glacier vol. & disappearance



➢ Basel: Qice declines from early 2000s

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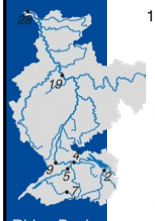
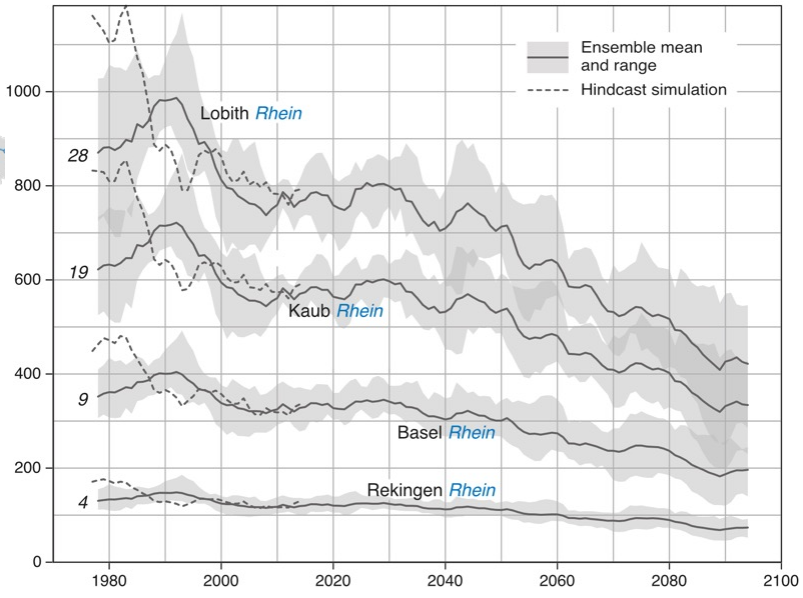
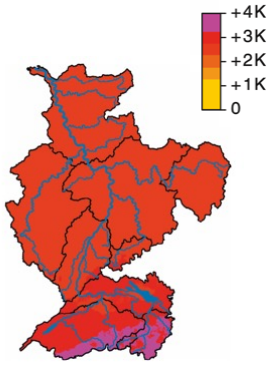
Modelled transient change in Qsnow

Mean annual Q_{snow} [m^3/s]



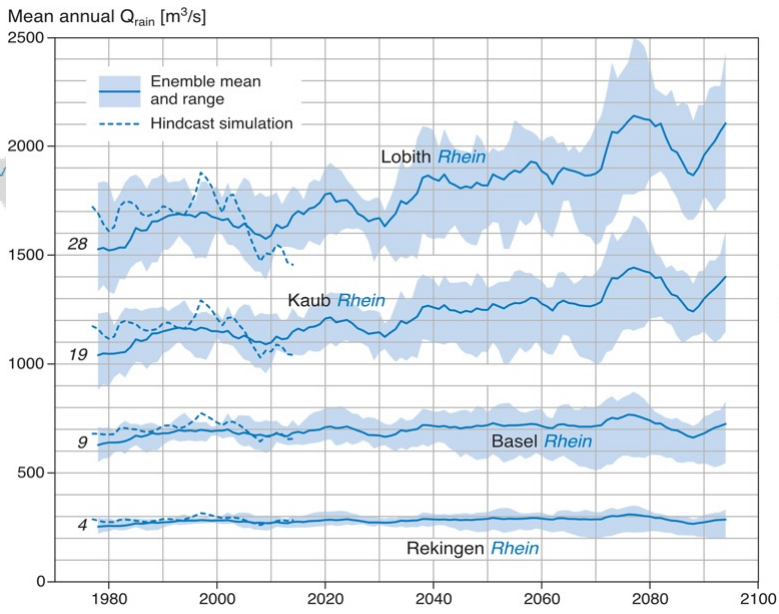


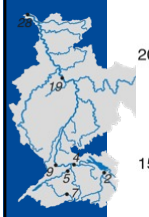
Temperature change:
Far future
(2071-2100 to 1981-2010)



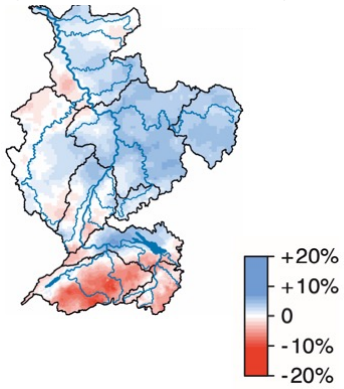
4

Modelled transient change in Qrain





Precipitation change
Far future
(2071-2100 to 1981-2010)



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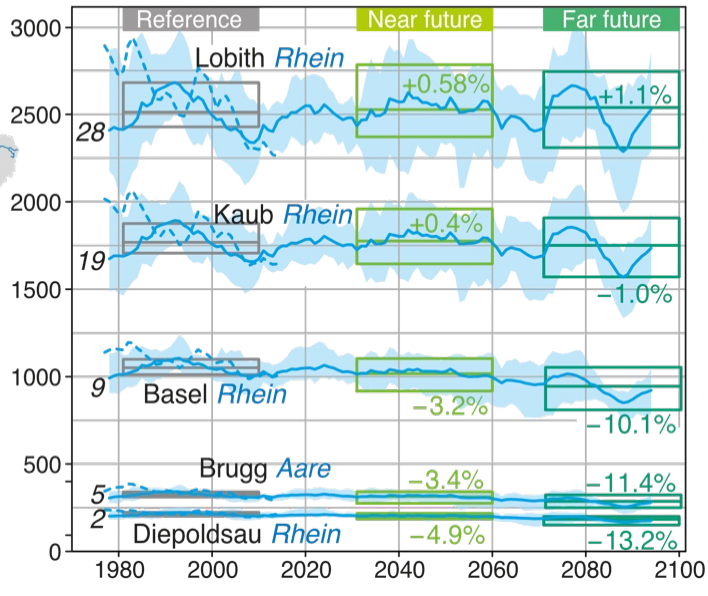
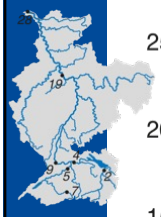
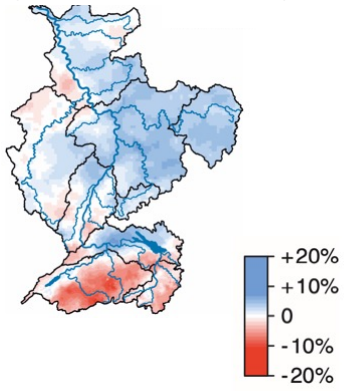
Modelled transient change in total Q

Mean annual streamflow [m³/s]

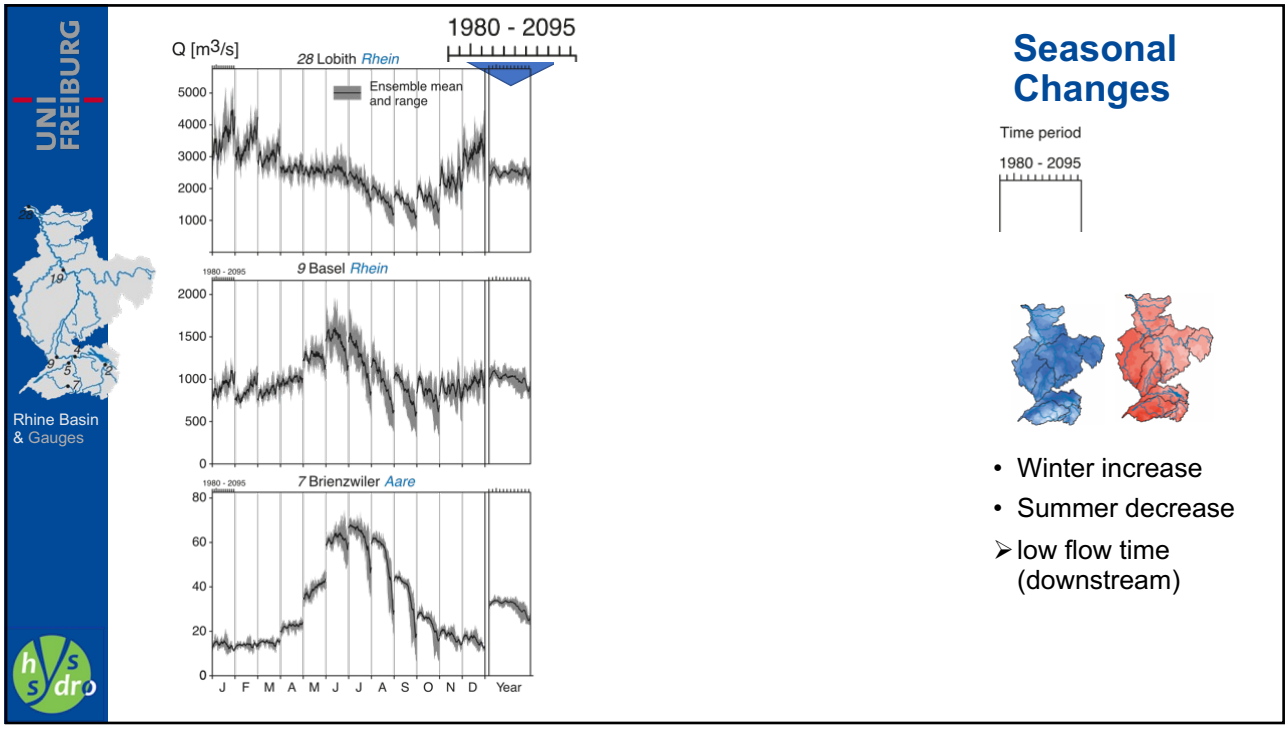




Precipitation change
Far future
(2071-2100 to 1981-2010)



6


UNI FREIBURG
Rhine Basin
& Gauges
1980 - 2095
Q [m3/s]
28 Lobith Rhein
Ensemble mean and range
9 Basel Rhein
7 Brienzwiler Aare
J F M A M J J A S O N D Year
Seasonal Changes
Time period
1980 - 2095
• Winter increase
• Summer decrease
➢ low flow time (downstream)

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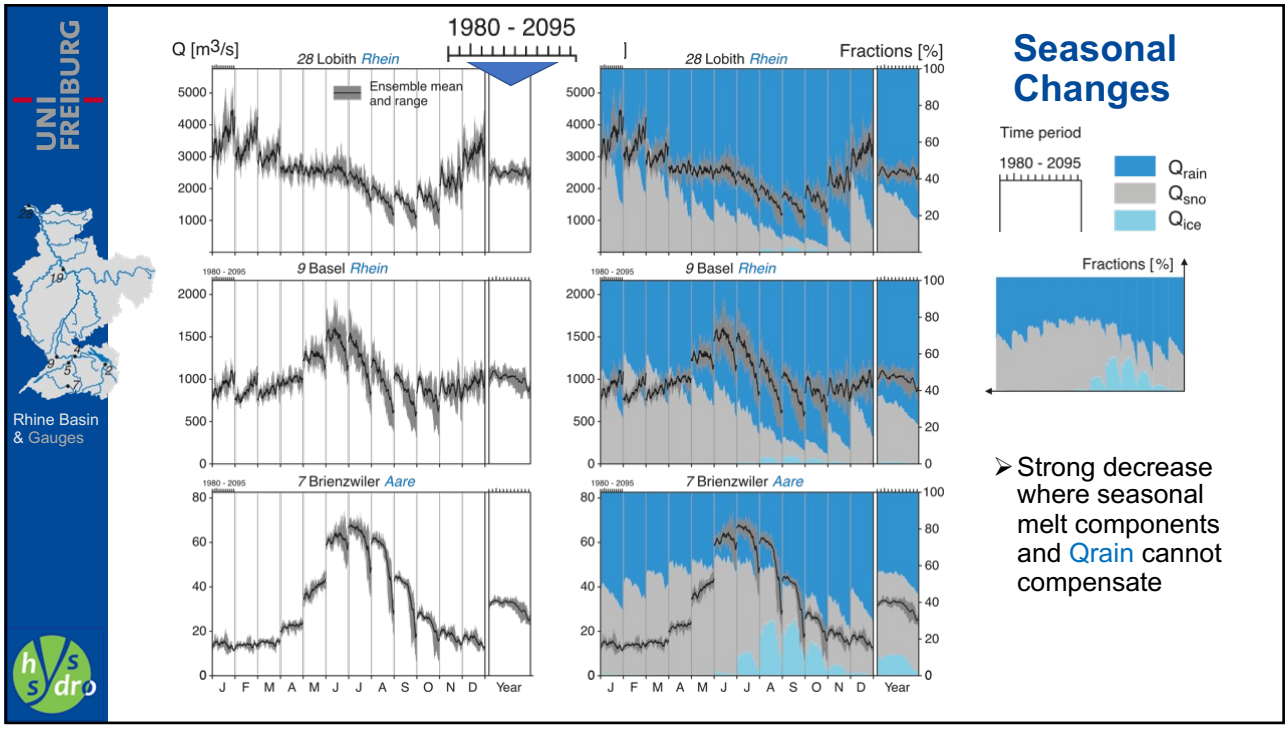
UNI FREIBURG
Rhine Basin
& Gauges
1980 - 2095
Q [m3/s]
28 Lobith Rhein
Ensemble mean and range
9 Basel Rhein
7 Brienzwiler Aare
Fractions [%]
J F M A M J J A S O N D Year
Seasonal Changes
Time period
1980 - 2095
Qrain
Qsno
Qice
Fractions [%]
➢ Strong decrease where seasonal melt components and Qrain cannot compensate

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Implications for operational Q-thresholds

Navigation

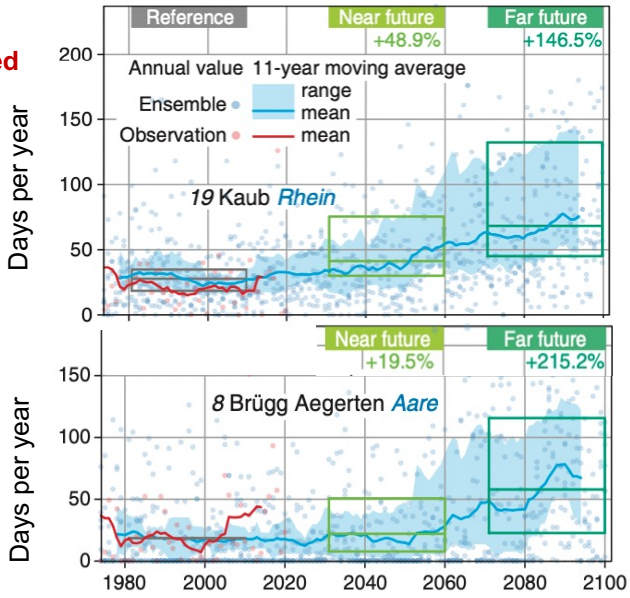
Navigation on the river Rhine near Oberwesel during the low flow situation in November 2015 (photo: Jörg Belz).

Impaired

Environmental flow $Q_{347}/Q95$

Lake run brown trout (Seeforelle) in the stream Urbachwasser (photo: Matthias Meyer, 2014).

Below



Rhine Basin & Gauges

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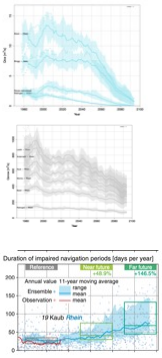
Conclusion

Model experiments indicate:

- declines in Qice and Qsnow with consequences for future summer drought situations
- compensation by the rain component downstream

➢Summer use restrictions will exacerbate



Rhine Basin & Gauges

More !

EGU22-7345 | Presentations | HS2.4.4

Stress-testing the buffering role of glaciers in the Rhine basin: How much worse could summer low flows get under future glacier retreat?

Marit Van Tiel, Markus Weiler, Daphné Freudiger, Greta Moretti, Irene Kohn, Kai Gerlinger, and Kerstin Stahl
Fri, 27 May, 10:37–10:44 **Room B**

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