Resilience of the Alsatian aquifer, France to climate and anthropogenic change: Case study of the Grand Ried

EGU GENERAL ASSEMBLY 2020 - Sharing geoscience online
Session HS8.2.1: How to assess climate change impacts on groundwater and what are the tipping points in hydrogeology?
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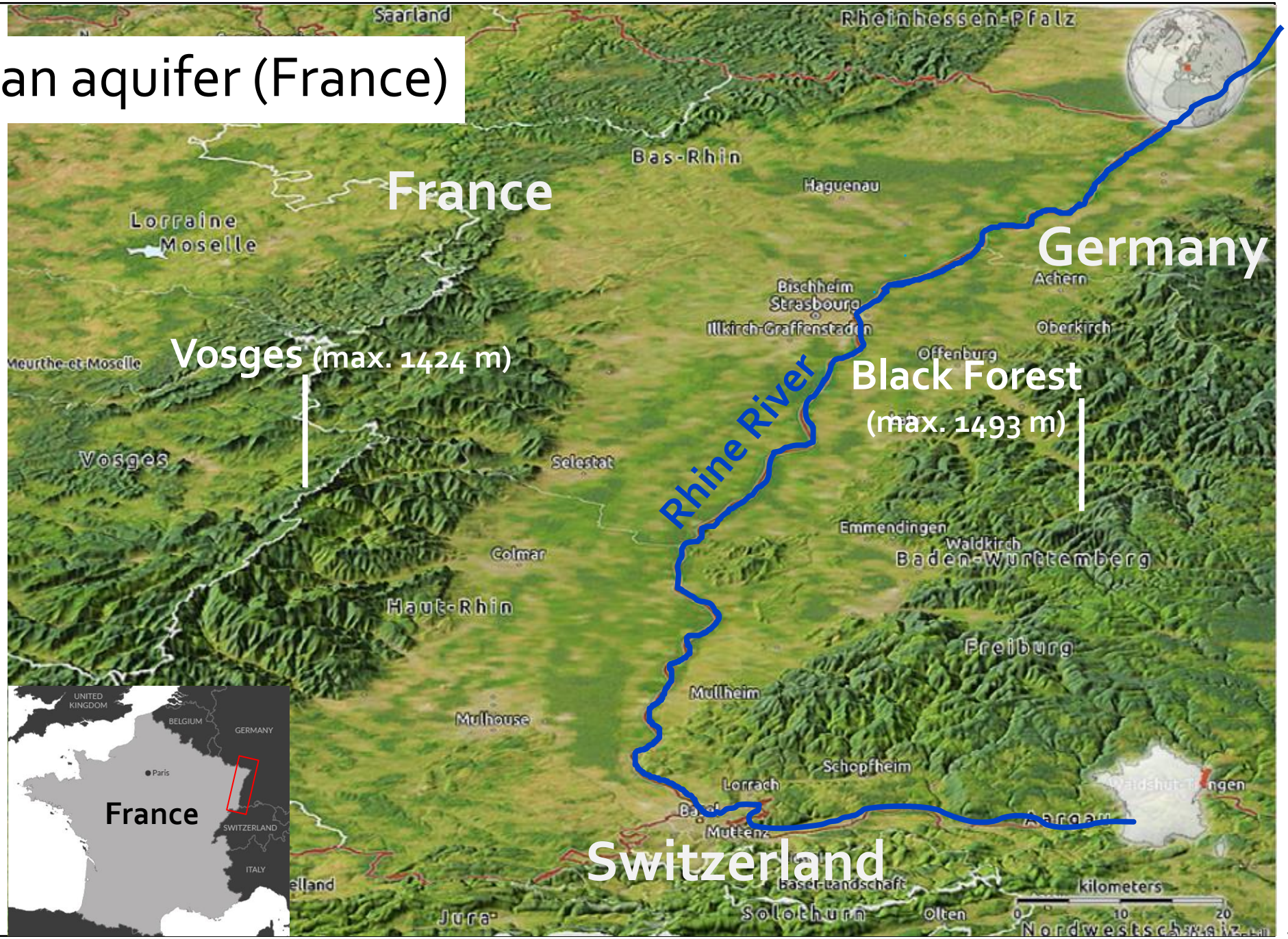
Context – Alsatian aquifer (France)

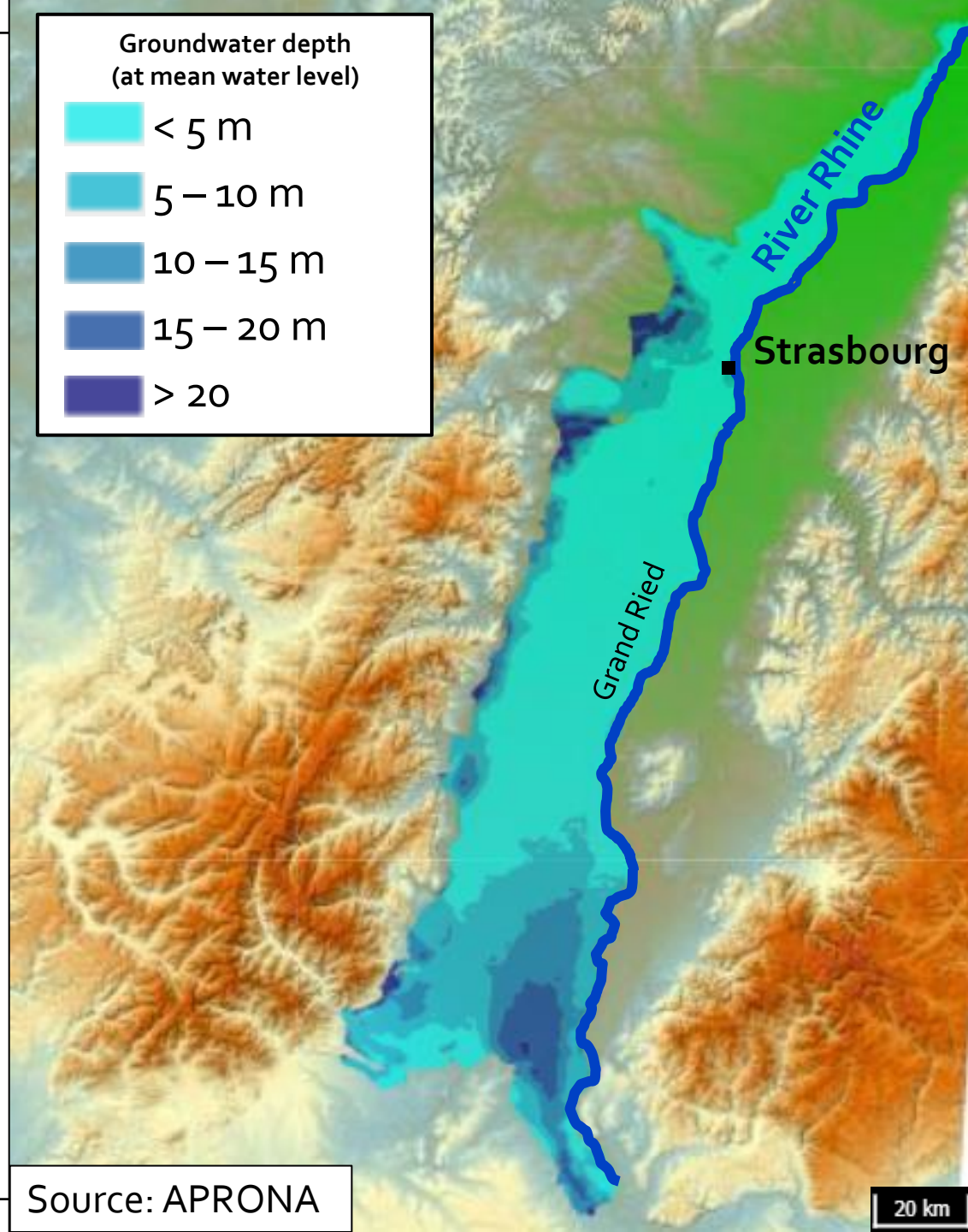
The Alsatian aquifer (Nappe d'Alsace) forms the French part of the **Upper Rhine Graben**, a transboundary aquifer (France, Germany, Switzerland)



Context – Alsatian aquifer (France)

- Quaternary alluvia
- 2850 km²
- Estimated volume of 35 billion m³
- Variable thickness from ~ 5 m to 240 m
- Variable depth from 0 m to ~ 20 m
- SouthWest-NorthEast flow
- Recharge: 1.3 to 1.5 billion m³ /year
- Abstractions: 0.5 billion m³ /year

Main resource for domestic water supply, industry and irrigation



Source: APRONA

Major issues

- Intensification of droughts and large scale, groundwater-based irrigation in summer and the subsequent need for improved water management
- Recent drying-up of small, groundwater-fed streams in the plain and the consequences for fauna and flora, such as fish mortality
- Existing regional models' resolution is too coarse for reproducing local phenomena such as drying-up streams

Objectives

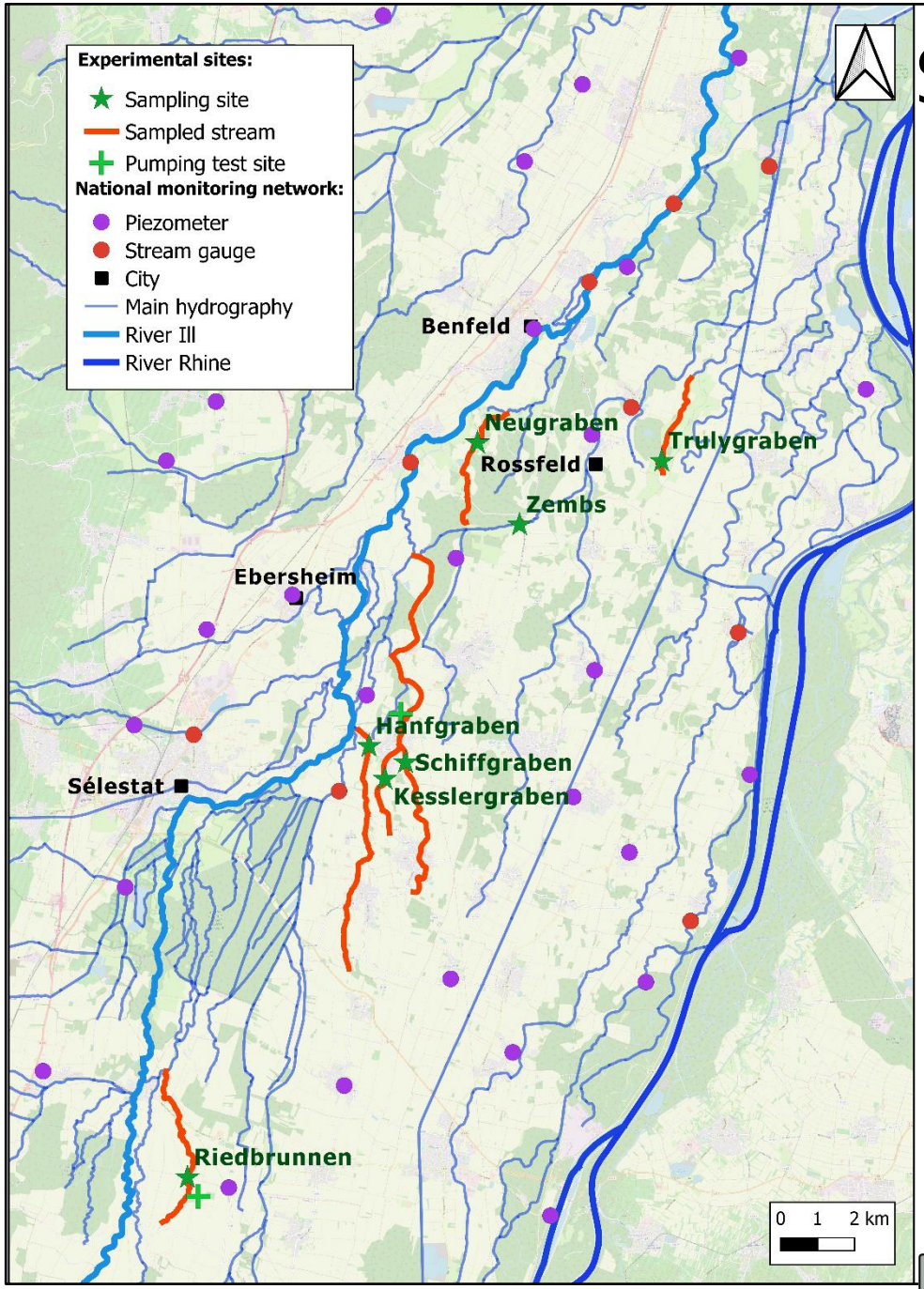
- Investigate the impacts of climate change and water abstraction, in particular pumping for irrigation, on groundwater during **low flow periods**
- Simulate the response of groundwater-fed streams to a groundwater level decrease
- Model the response of the aquifer to increased droughts and water abstraction

A better understanding of our hydrosystem functioning
helps stakeholders to make more **sustainable decisions** regarding water management

Methodology

- Comparing recent years data to the reference dry years 1976 and 2003
- Record groundwater-fed streams discharge at a 10-min resolution
- Field work at high temporal resolution to understand interactions between groundwater-fed streams discharge and groundwater levels, including manual measurements of temperature, dissolved oxygen and turbidity of the streams as well as biological observations
- Develop a local model with existing models

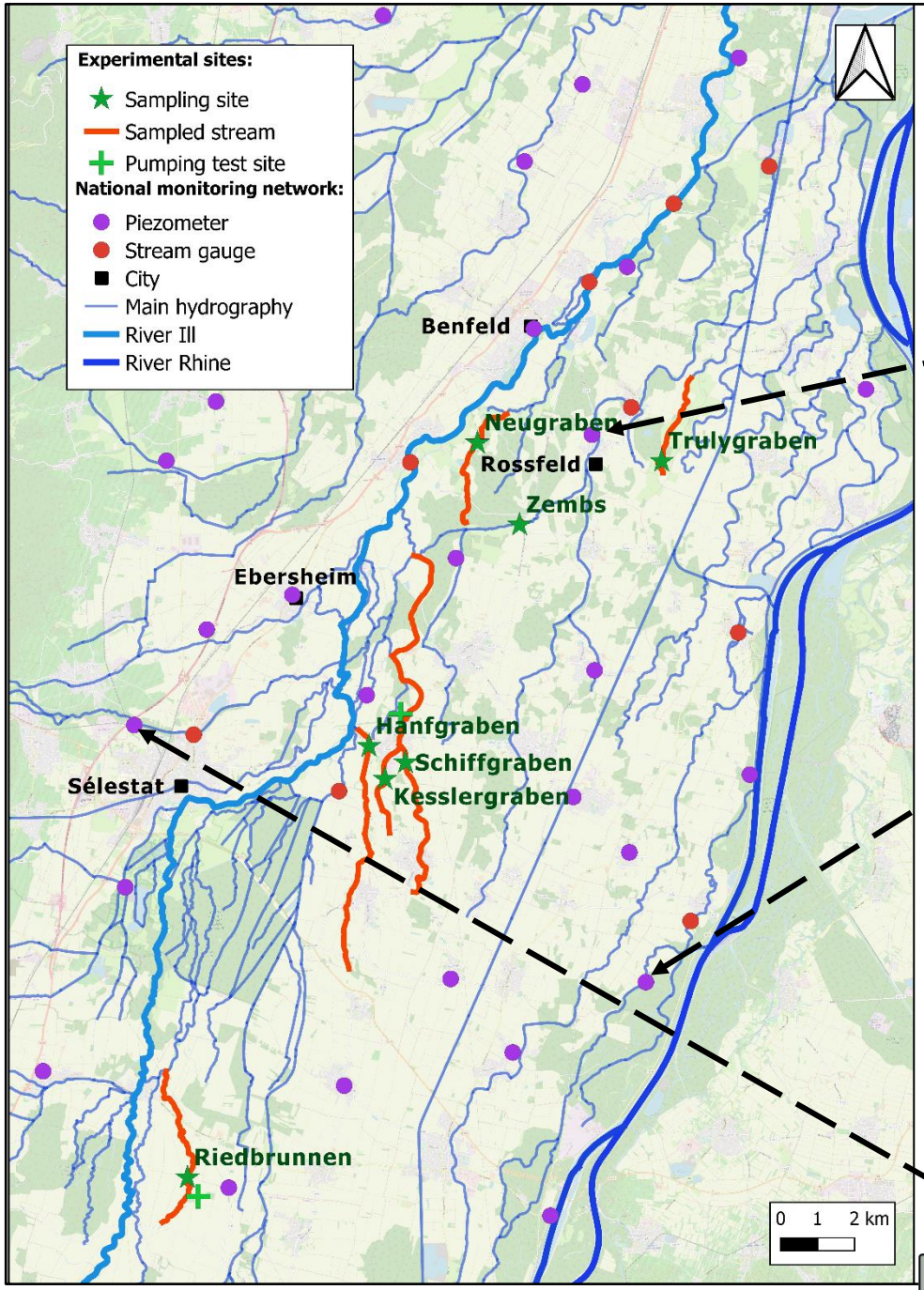
Study site: Grand Ried d'Alsace (France)

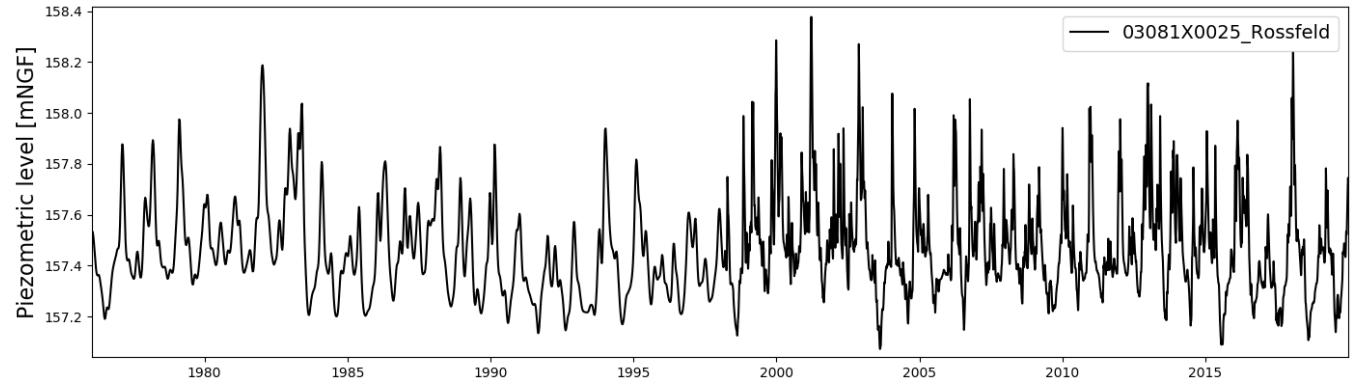


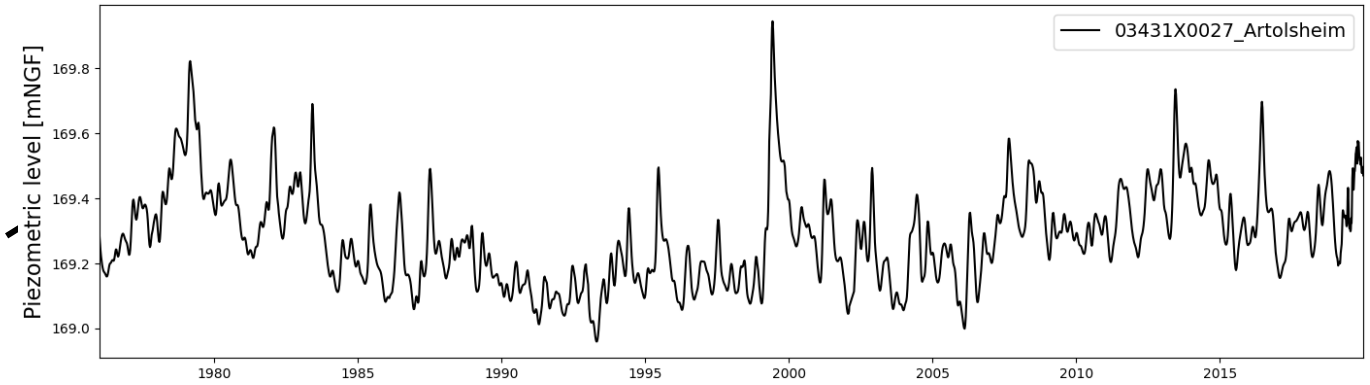
Characteristics of the Grand Ried d'Alsace:

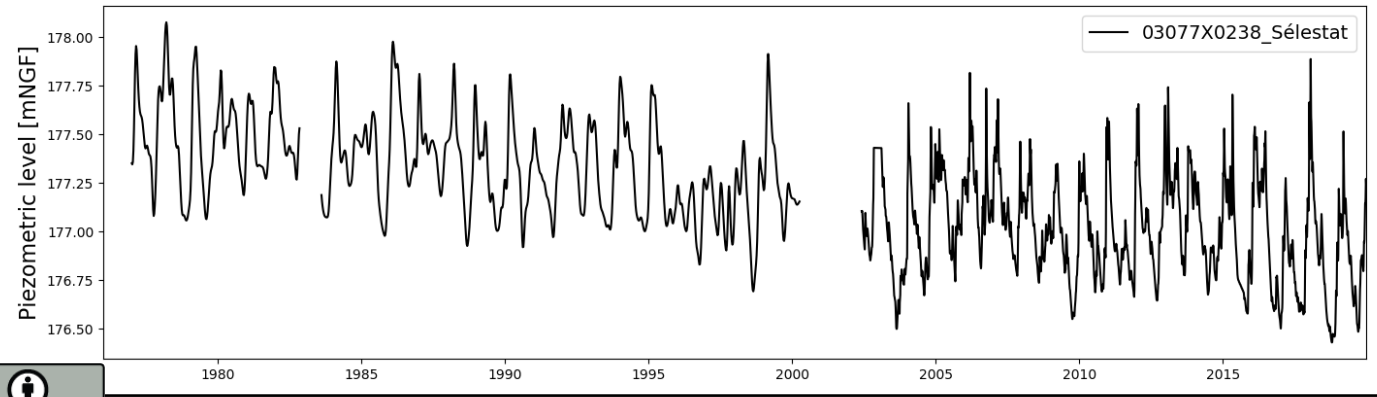
- Dense groundwater-fed stream network
- Specific fauna and flora
- Mixed agricultural and natural area
- Shallow and easily-accessible water table. Irrigation wells are therefore abundant and used alternatively, which complicates the analysis of real-time pumping effects on the local piezometry and streams

Regional differences within area

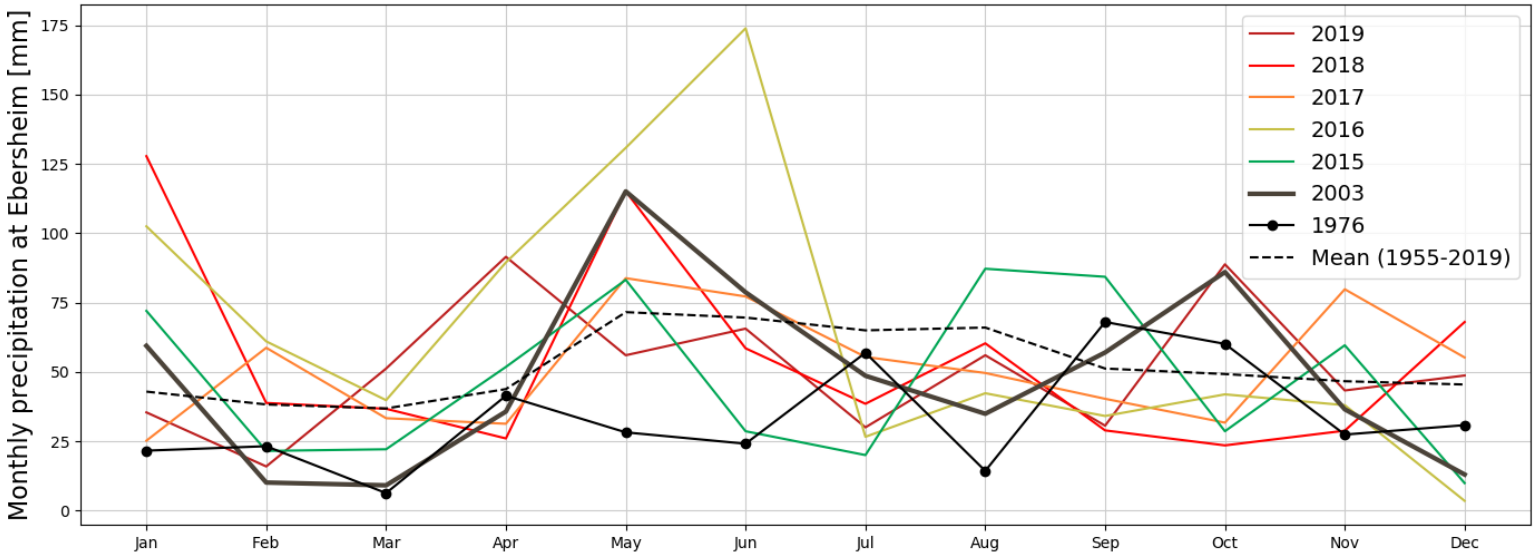


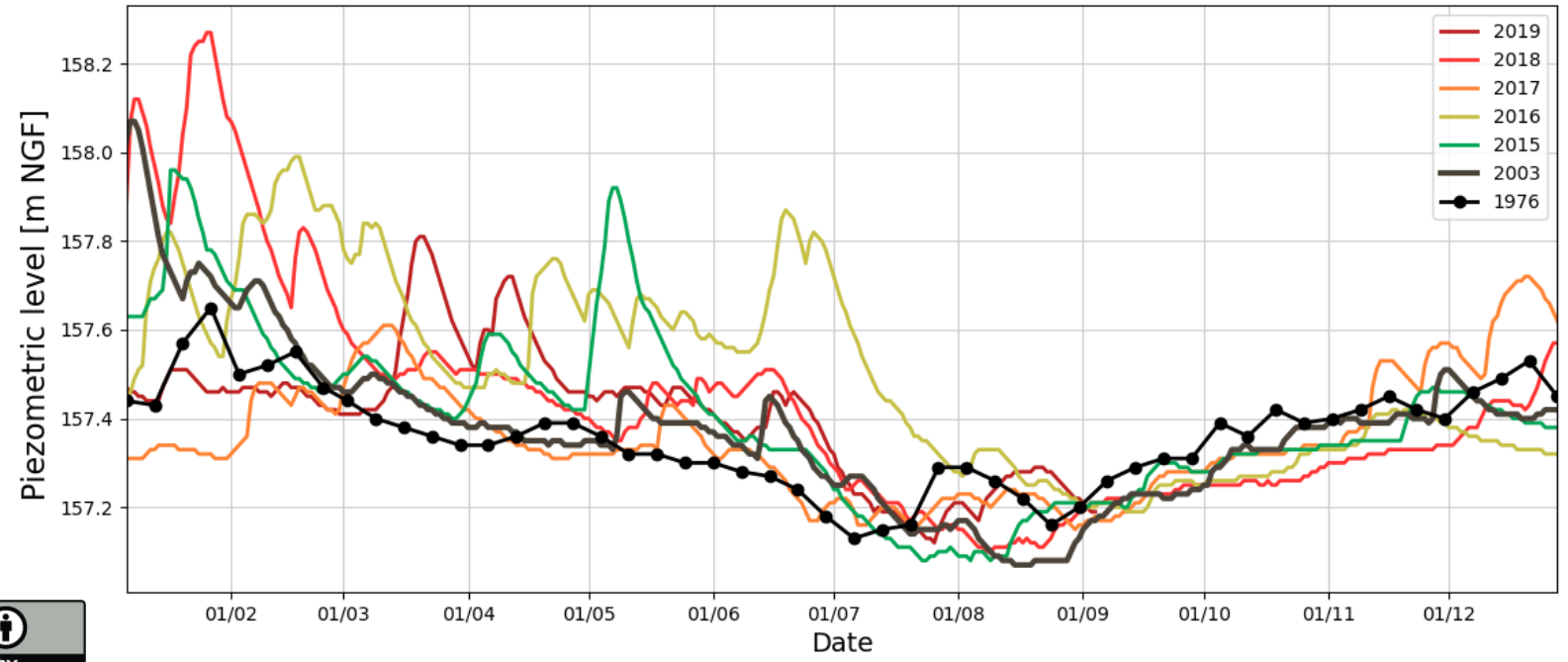






Comparison of last years' daily piezometric levels (Piezometer 03081X0024 – Rossfeld) and monthly precipitation data (Ebersheim) to the reference dry years 1976 and 2003

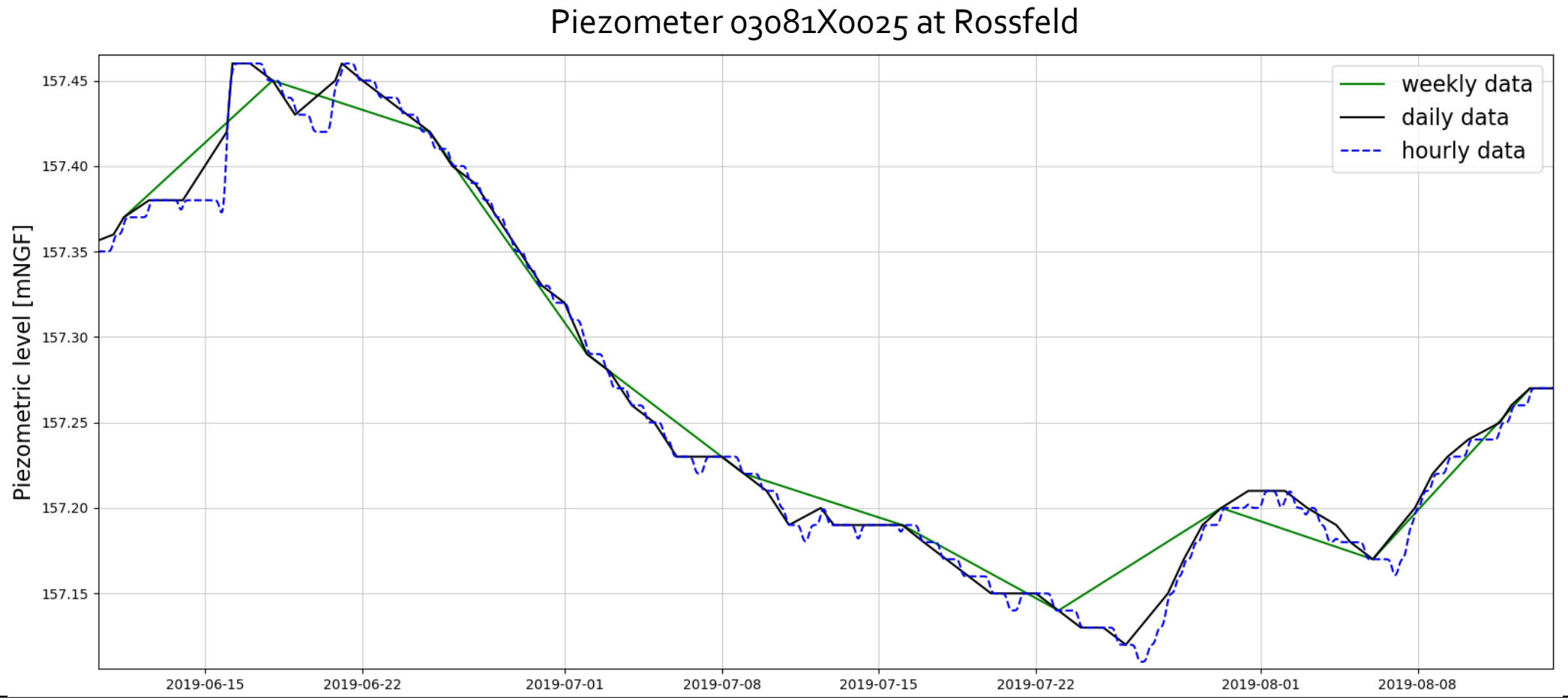




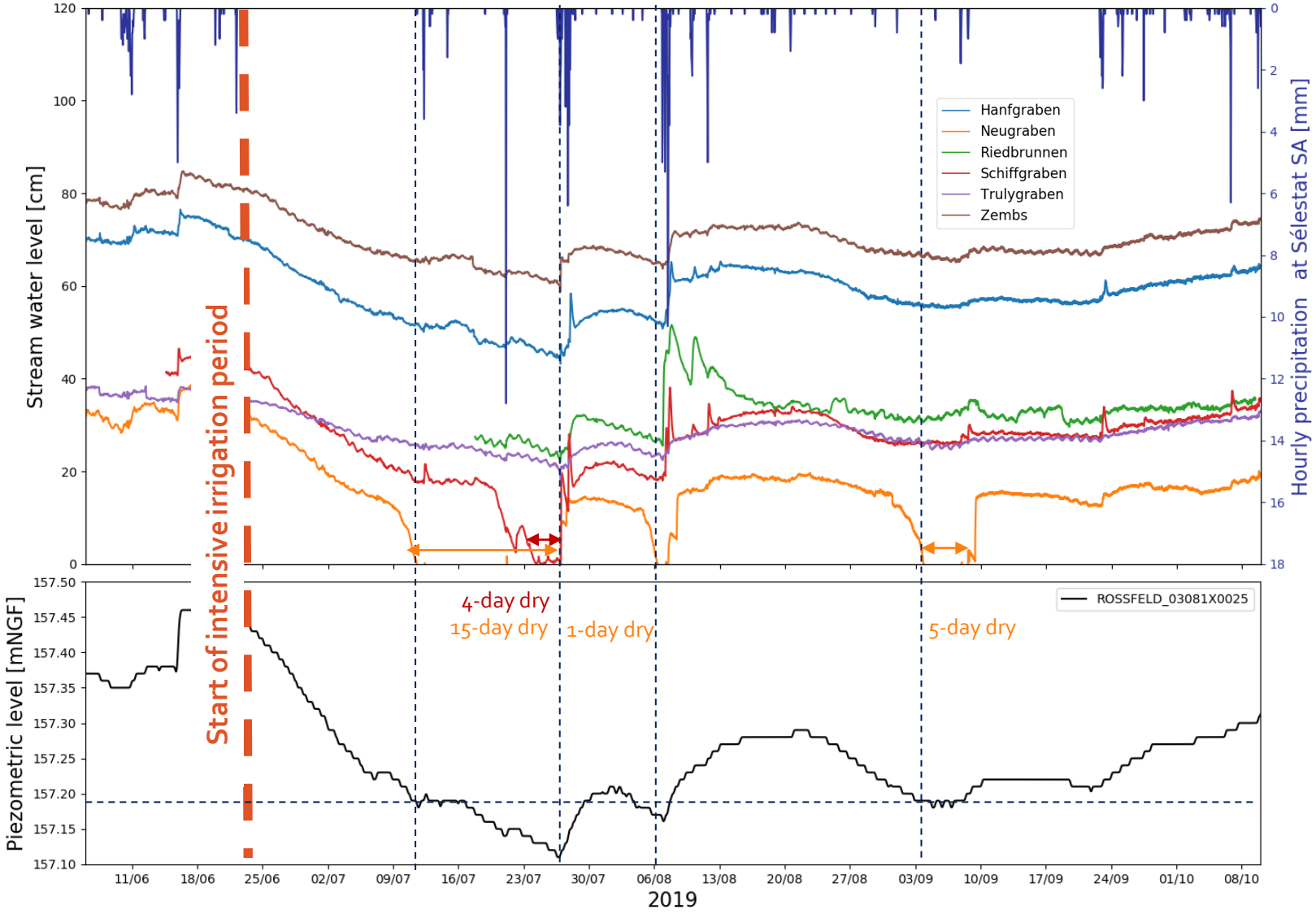
Existing bias:
Only weekly data available before 1998. Minimum values are then hardly comparable

Working at a smaller (spatio-)temporal scale

Hourly piezometric data shows intradays variations that could be human-induced (pumping) or due to evapotranspiration. Local and real-time minima are also important to improve the understanding of groundwater and river discharge relations during low flow periods



Groundwater-fed streams level variations in summer 2019

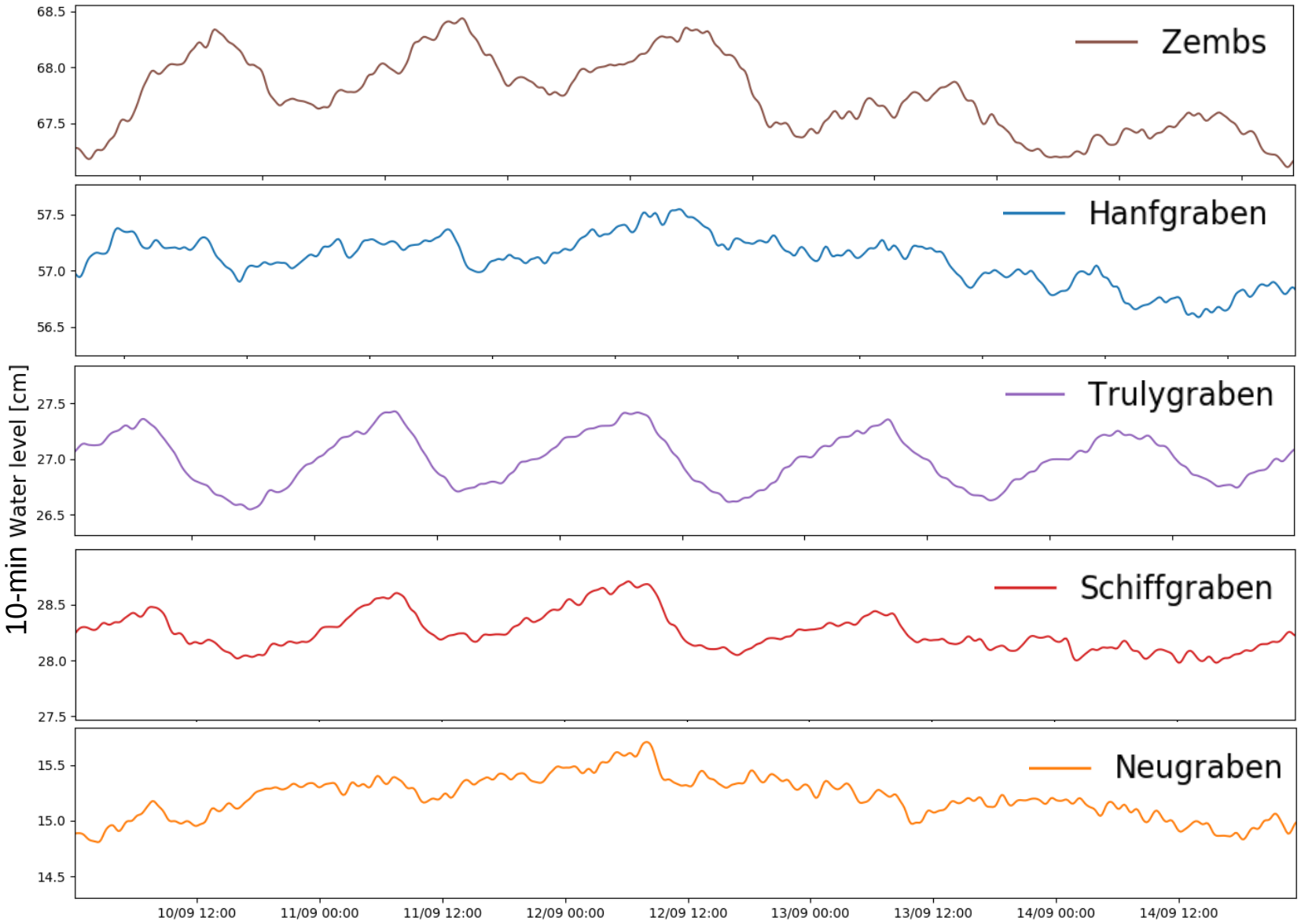


During summer 2019:

- Stream response to a piezometric level decrease differs from one stream to another
- Rapid response (< 1h) of the streams to a piezometric level increase
- Spring water level (Trulygraben) varies less significantly than other streams over time
- Intraday variations of approx. 1 cm
- Neugraben dries-up (2 times) when Rossfeld piezometric level < 157.19 mNGF[1] and (once) when <157.18 mNGF. However, due to lack of streams historic data and the piezometer being 3 kms away from the sensor, it is not yet possible to use these values as a threshold.

[1] General Levelling of France

Intraday water level variations in groundwater-fed streams



- Regular intraday variations at the source (Trulygraben):
  . No nearby pumping could explain such regular variations
  . Hypothesis: Evapotranspiration
- Intraday variations of the other streams need to be investigated

Conclusion

- Heterogeneous basin
- Necessity to work at a smaller scale to improve knowledge of local phenomena functioning
- Minor differences in groundwater level (~ a few centimetres) could be responsible for the drying-up of groundwater-fed streams in summer
- Climate change vs. Human impact: almost all piezometers are under the influence of pumping (in particular pumping for irrigation) which complicates the separation of the climate change and human impact signals on the piezometry
- Lack of data (pumping for agriculture, industry, drinking water supply)
- Intensive fieldwork completes automatic data, especially to verify hydraulic continuity in the streams and to document ecological consequences of droughts

Perspectives:

- ETP estimation at an hourly time step to explain intraday water level variations in streams
- Model of the response of the streams to a groundwater level decrease in low flow conditions

River Neugraben – summer 2019

©Serge Dumont, groundwater-fed stream Neugraben in July 2018

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THANK YOU FOR YOUR ATTENTION

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©Agnès Labarchède, Spring of the River Trulygraben in July 2019