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

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Session HS8.2.1: How to assess climate change impacts on groundwater and what are the tipping points in hydrogeology?
7TH MAY 2020

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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
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

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

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
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

Study site: Grand Ried d’Alsace (France)
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 intraday 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.

Piezometer 03081X0025 at Rossfeld
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
More and more streams are drying up in recent years with severe impacts on aquatic fauna, such as fish mortality. Such observations in remote sites are only possible via regular field visits.
THANK YOU FOR YOUR ATTENTION

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