Assessing the impact of climate change on water quality and quantity in the Elbe catchment

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Motivation: Climate change and water quality

- Even though much work has been done to investigate the impacts of human-induced climate change on water supply, its effects on water quality remain highly uncertain (Whitehead et al., 2019)

➢What effects on nitrate concentrations and discharge in the Elbe catchment can we already observe as a consquence to the warm last decade and the 2018 drought?

Figure 1: Map of the transboundary Elbe catchment. The green shape is the federal state of Saxony-Anhalt.

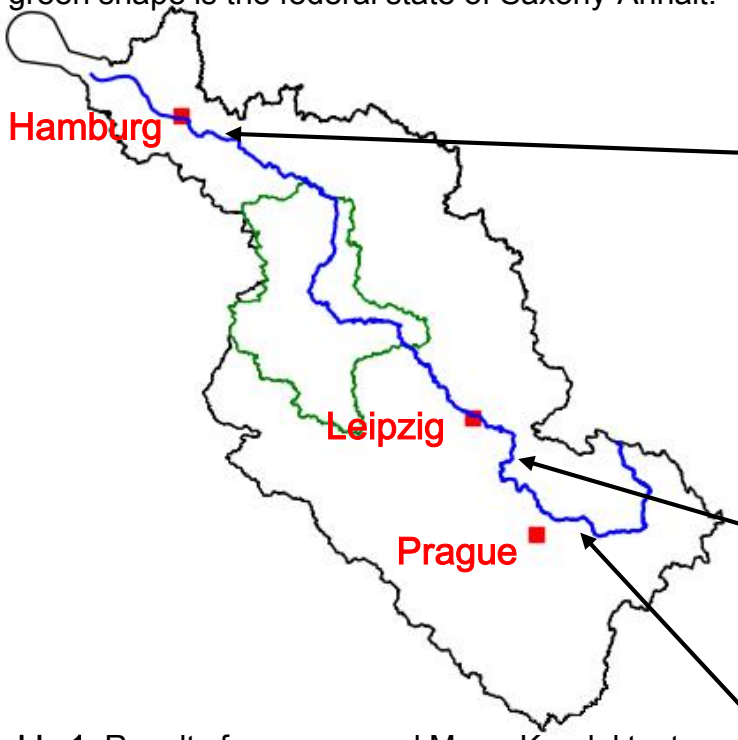

Table 1: Results from seasonal Mann-Kendal test on monthly nitrate-N and discharge time series. Slopes with $p < 0.05$ are highlighted.

Discharge trends				
	2000-2009		2010-2019	
	p	sen slope	p	sen slope
Geesthacht	0.860	3.34	8.5E-06	-29.17
Schmilka	0.110	-3.72	3.3E-11	-23.14
Litol	0.710	-0.17	1.2E-04	-3.45
Nitrate-N trends				
	2000-2009		2010-2019	
	p	sen slope	p	sen slope
Geesthacht	0.006	-0.10	0.034	-0.05
Schmilka	0.000	-0.08	0.000	-0.11
Litol	0.738	0.00	0.000	-0.20

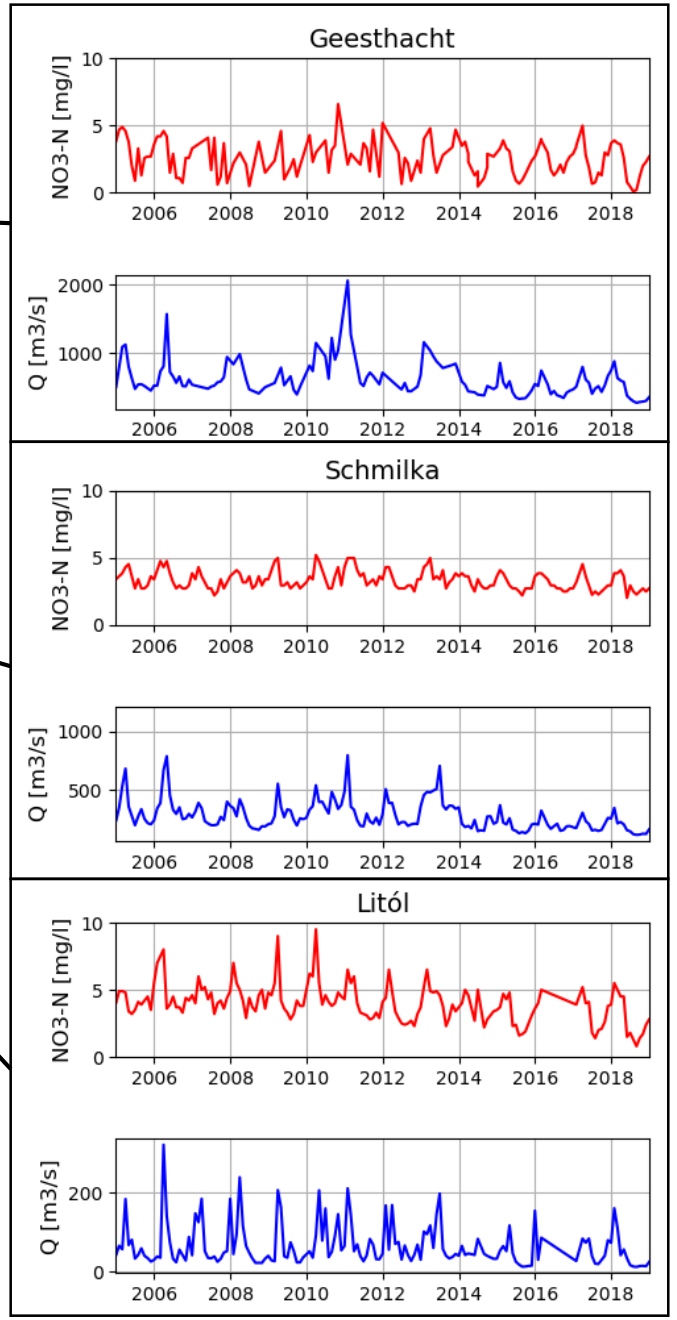

Figure 2: Monthly time series of discharge and nitrate-N along the Elbe main stream, shown from 2005-2019.

How did discharge evolve along the Elbe in the past 20 years?

- No significant ($p < 0.05$) discharge trends in the period of 2000-2009 were detected among the 3 gauging stations
- All 3 gauging stations show a significant decrease in discharge from 2010-2019
- Since 2015, especially the high flows seem reduced at the gauging stations Schmilka and Geesthacht

How did nitrate-N concentration evolve along the Elbe in the past 20 years?

- In the period 2000-2009, only the German stations showed decreasing nitrate-N concentrations
- From 2010-2019, all stations showed decreasing nitrate-N concentrations
- The strongest decrease is observed at Litól between 2010 and 2019 (table 1)
- In Litól, summer nitrate-N concentrations are decreasing strongly

Nitrate-N concentrations in ground- and surface waters of Saxony-Anhalt

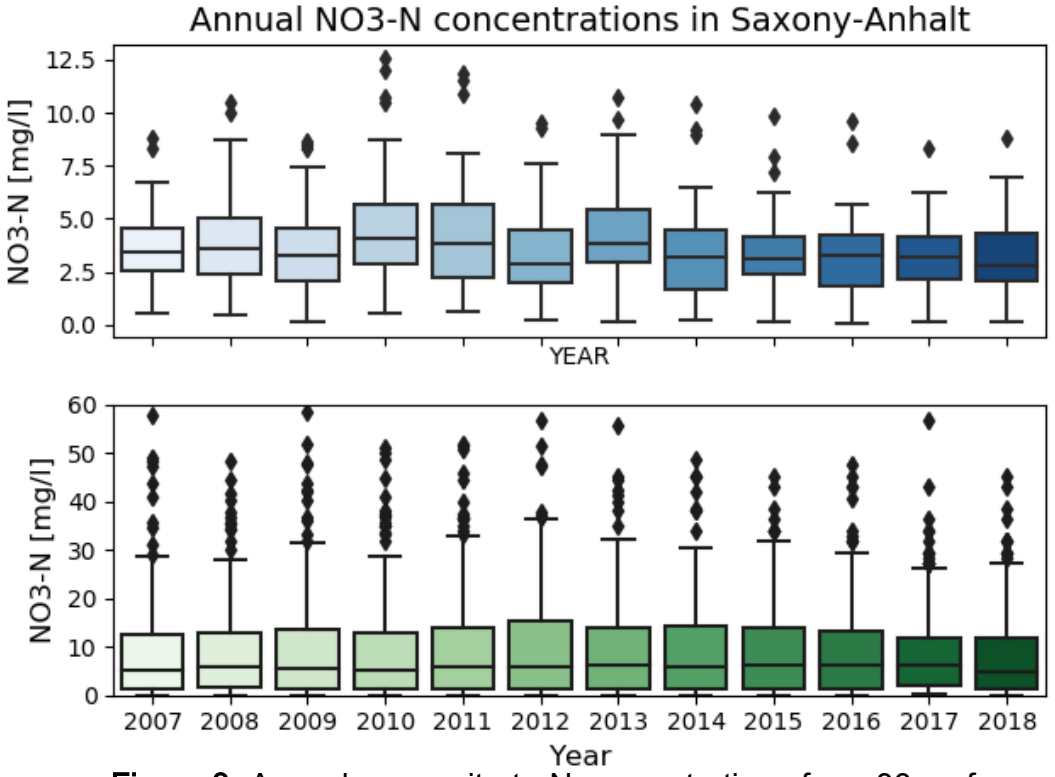

Figure 3: Annual mean nitrate-N concentrations from 86 surface water sampling sites (blue) and 452 groundwater wells (green) in Saxony-Anhalt. Only sampling sites with at least 10 years of min. bi-monthly sampling were considered.

- To investigate the effect of the warm 2010-2020 decade and the 2018 drought on water quality besides the main stream of the Elbe, data from 86 surface – and 452 groundwater sampling sites were used.
- Overall, surface- and groundwater nitrate-N concentrations seem constant over the observed period.
- Heterogenous sampling frequencies impede individual time series analysis.

Decadal trends:

I. In the german part of the Elbe catchment nitrate-N concentrations have been decreasing throughout the entire investigated time series (2000-2019). This trend seems to be unrelated to discharge trends which were detected later.

II. Negative discharge trends were detected for all three gauging stations from 2010-2019.

III. Riverine nitrate-N concentrations in the Czech part of the Elbe catchment have only been decreasing in the period 2010-2019.

➢ What were the effects of the 2018 drought on nitrate-N concentrations along the Elbe main stream?

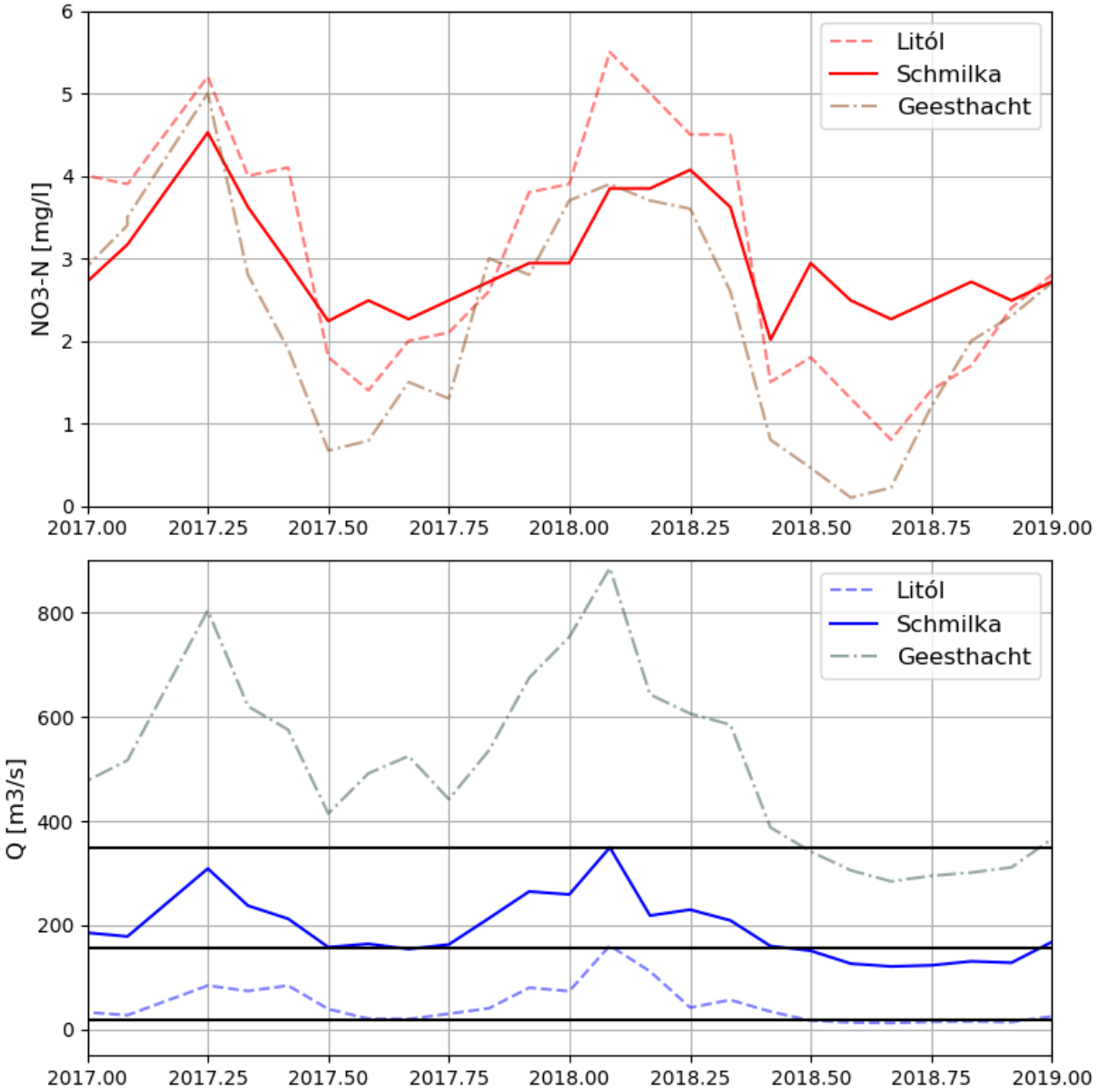

Figure 4: Monthly nitrate-N and discharge values along the Elbe mainstream for 2017 and 2018. Black solid lines in the lower figure represent the 5 % percentile of flow (p5) calculated from the time series 2000-2019.

What was the impact of the 2018 drought on discharge and nitrate-N along the mainstream of the Elbe?

- From June to Dezemeber 2018, the flow at Geesthacht and Schmilka was below the 5 % percentile which was not undershot in 2017
- Even though both stations were affected by the 2018 drought, there was no response in nitrate-N concentrations at Schmilka, which are noticeably higher than the values at Geesthacht and Litól during the summer months
- Nitrate-N variability across the time series (2000-2018) is the lowest at Schmilka (annual mean standard deviation 0.6 mg/l versus 1.2 mg/l (Geesthacht) and 1.1 mg/l (Litól)

➢ What is causing the low annual variation and weak response to the 2018 drought of nitrate-N at Schmilka?

Discussion

Decreasing nitrate concentrations in Litól (2010-2019):

- Occur in the same decade as decreasing discharge is detected
- Between 2000 and 2008, the number of waste water treatment plant in the Czcheck Republic has doubled (Mayo et al., 2019)
- Increasing air temperature is believed to increase denitrification thereby limiting nitrate input into streams (Barclay, 2015)

➢ The observed effect could be a combination of transport limitation, increased denitrification and point source control

Decreasing nitrate concentrations in Geesthacht and Schmilka (2000-2019):

➢ Water quality improvements for many parameters since 1990 due to decrease of industrial contaminants and fertilizer reduction are well documented in the Elbe catchment (e.g. Lehmann and Rode, 2010; Hesse and Krysanova, 2015)

➢ It is possible that increased denitrification (due to temperature increase) contributes to the trend

Responses to the 2018 drought:

- Nitrate concentrations at Schmilka show no fast response to the 2018 drought
- Throughout the entire time series, nitrate concentrations at Schmilka show a comparatively small annual variation, indicating a chemostatic behaviour
- It cannot be assessed yet if the 2018 drought will have a lagged effect on the concentrations (e.g. due to longer travel times from the dominating nitrate source)

Literature & Data

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