Author's response

egusphere-2025-656

Dear Reviewer,

Thank you very much for your valuable comments. The point-by-point responses to your comments are listed below.

RC1

This paper provides an evaluation of the effects of droughts on water quality with a special focus on oxygen and nitrogen processing. This contribution can be valuable to the field, after the authors carry out a major revision. Please follow my suggestions and comments below:

- The title seems incomplete, e.g., "detected with high-frequency sensors"?

Response: Thank you for the comment. We will modify the title accordingly.

- Higher temperature will enhance stream metabolism and nutrient uptake but also dissolution of compounds in stream water – have you corrected these metrics for temperature effects before comparing them with 2014-2017 values? Specifically, have you corrected DO concentrations for temperature? Have you used flow-weighted concentrations for comparison? Please clarify.

Response: Thank you for this valuable comment. This is a very good observation. Indeed, we have considered the temperature effect on DO concentrations for comparison. As you can see in Table 1 in the manuscript, we have introduced daily DO saturation (DO_S) and daily DO deficit (DO_D) to consider the effect of temperature on DO dissolution. Stream metabolism calculations incorporated temperature-corrected saturated DO concentrations. However, we did not use flow-weighted concentrations for comparison.

- Line 33 grammar

Response: Thank you for the comment. We will change the sentence to „Drought events are a key driver to low-flow conditions in rivers and streams (Van Loon, 2015)."

- Sentence in lines 39-40 – logic is missing, "While the impacts of extreme low flows on water quantity are well-documented, there are still knowledge gaps regarding the effects on water quality…" – so are they well documented or are there still knowledge gaps?

Response: Perhaps there is a misunderstanding. The impact on water **quantity** is well-documented; however, the impacts on water **quality** are still facing knowledge gaps.

- Lines 50-60, please support with appropriate references

Response: Thank you for your suggestion. More references will be added.

- Line 58 wording error

Response: Thanks for the comment. We will revise the sentence to "This fine-scale temporal resolution is crucial for understanding how ecosystems respond to transient events, such as extreme **high** flows, **during which** rapid changes can significantly influence water quality and ecosystem processes."

- Line 65 your list of publications covering the topic seems incomplete, please identify other publications. In general, there have been more publications coming out on these topics in the last years, please update your references as they seem a bit outdated.

Response: Thank you for your suggestion. We have checked more recent publications on the topics and will update them in the revised version.

- Line 269 logic again – "As a lowland agricultural stream, the Lower Bode is not heavily influenced by point sources" – one can expect a strong impact of point sources in an agricultural setting, please clarify your reasoning here

Response: We appreciate this insightful comment and agree that agricultural streams can often be affected by point-source pollution. However, in the Lower Bode, our findings indicate that non-point sources (particularly agricultural runoff) dominate nutrient inputs, as supported by long-term water quality monitoring and modeling studies (e.g., Yang et al., 2018).

Key evidence for minimal point-source influence:

1. Low BOD inputs: Water quality data show consistently low biochemical oxygen demand (BOD) levels, inconsistent with significant point-source discharges.
2. DO patterns under low flow: If point sources were dominant, we would expect sustained oxygen depletion. Instead, we observe:
    - Pronounced diel DO cycles (elevated daytime peaks from photosynthesis, nighttime declines from respiration)
    - No systematic oxygen depression characteristic of point-source pollution (e.g., downstream of wastewater inputs)

This aligns with our revised text (Lines 269–270): "As a lowland agricultural stream with minimal point-source inputs, the Lower Bode's DO dynamics are primarily governed by ecosystem processes (photosynthesis/respiration)."

We're happy to provide additional data (e.g., BOD time series, correlation analyses) if helpful.

- And the following sentence "Instead, its DO balance is governed by ecosystem processes such as photosynthesis and respiration." – do you have any evidence to support these two claims? How about groundwater influxes, have you accounted for them in your study?

Response: We thank the reviewer for these insightful questions regarding DO dynamics in our study system. Our conclusion about the dominance of ecosystem processes is supported by multiple lines of evidence:

1. Diurnal DO variability: High-resolution sensor data (see Fig.) show clear diurnal fluctuations—a hallmark of biologically driven DO cycling (e.g., peak DO during daylight hours due to photosynthesis, and nighttime declines from respiration).

2. We have done a parameter sensitivity of dissolved oxygen (DO) dynamics during the low-flow (LF) period in 2016 using the same model setup as this study using Elementary Effect (EE) method. This analysis revealed that benthic algae-related parameters (e.g., growth and respiration rates) exhibited the highest sensitivity, indicating their dominant influence on DO processes (Huang et al., 2021). These findings were initially presented in our EGU General Assembly poster contribution in 2021. A detailed ranking of all parameters, along with their definitions and units, is provided in the figure and table below.

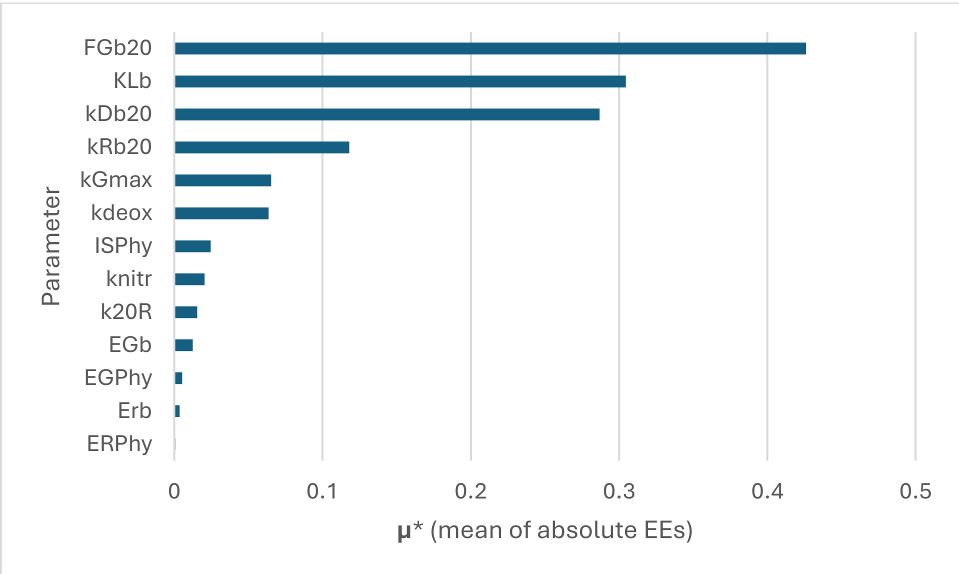

Fig. 1 Parameter sensitivity ranking for DO concentration under low flow

Table 1 Top 6 sensitive parameters for DO concentration under low flow

Para.	**Definition**	**Units**	**Range**
F_{Gb20}	Benthic algae maximum growth rate	gD m^{-2} d^{-1}	5 – 100
K_{Lb}	Light constant for benthic algal growth	Ly d^{-1}	50-300
k_{Db20}	Benthic algae death rate	d^{-1}	0.001-0.2
k_{Rb20}	Benthic algae respiration rate	d^{-1}	0.05 – 0.2
k_{Gmax}	Phytoplankton maximum growth rate at 20 C	d^{-1}	0.5 – 4.0
k_{deox}	Carbonaceous deoxygenation rate at 20 C	d^{-1}	0.05 – 0.4

Regarding groundwater influences, we specifically analyzed water balance during the extreme summer low-flow period of 2018. Our calculations revealed a minimal water balance imbalance of just +0.59% (the positive value means that discharge at the outlet was lower than the input). This provides direct evidence that the direct exchange with groundwater of the main stem of the study reach in the Lower Bode is therefore very limited.

- I am not a big fan of mixing results with their discussion, please separate these to streamline the manuscript in a better way. At the moment, it is quite difficult to follow. Perhaps, more meaningful and less cheesy headings would be more suited. Please avoid using comparisons like "slight" or "slightly" – they dilute your message.

Response: We sincerely appreciate the reviewer's valuable feedback regarding manuscript organization. While we acknowledge that the traditional separation of Results and Discussion sections often enhances readability, we intentionally adopted an integrated approach for this study due to the following considerations:

1. Interpretational Complexity: Our findings require immediate contextualization with process explanations and direct comparisons to existing literature to prevent potential misinterpretation of non-intuitive patterns. Maintaining these elements together reduces the need for excessive cross-referencing between sections and helps preserve the logical flow of our arguments.

2. Synthesis Section: We have included Section 3.7 specifically to integrate all water quality parameters and ecosystem processes into a comprehensive discussion, providing readers with a holistic understanding of our findings.

To address the reviewer's valid concerns, we propose:

1. Revising section headings to be more precise.
2. Adding a brief rationale in the last paragraph of the Introduction justifying the integrated structure.
3. Eliminating vague terms like "slight/slightly" as suggested, to strengthen messaging.

We believe this approach balances the need for clear presentation with the study's analytical requirements. We would be happy to make additional adjustments if the reviewer identifies any remaining passages that require clarification.

- Finally, what was truly novel about your approach? You simply repeat the same approach as in your 2016 paper. I am not convinced that extending your analysis to an extreme drought of 2018 is enough of a novelty.

Response: We appreciate the reviewer's attention to the methodological connections between this study and our earlier work (Huang et al., 2022). While both studies leverage some overlapping datasets and modeling foundations, the scope, focus, and advancements of this work are distinctly different:

1. Expanded Scope: Unlike our 2022 study, which focused solely on nitrate processes, this work systematically examines multiple water quality parameters (e.g., temperature, dissolved oxygen, Chl-a) and ecosystem processes during an unprecedented extreme event—the 2018 drought. This broader perspective reveals interactions and responses that were not previously investigated.

2. Different Focus: In our 2022 study, we were interested in the seasonal variations of the nitrogen processes. As we were interested in the average changes, we did not separate 2018 extreme low flow from the results and analysis. In this study, we only focus on the summer low flows and extremes.

3. New Analysis: The data comparison using Kruskal–Wallis test including all water quality, environmental conditions, ecosystem processes were conducted newly only in this study.

4. Unique Findings: The water quality responses observed in 2018 could not have been extrapolated from our earlier work. Without the targeted reanalysis conducted here, these insights would remain inaccessible.

We acknowledge that some methodological continuity exists, but the combination of expanded parameters and tailored analysis provides novel contributions to understanding drought impacts on water quality.

References

Yang, X., Jomaa, S., Zink, M., Fleckenstein, J. H., Borchardt, D., & Rode, M.: A new fully distributed model of nitrate transport and removal at catchment scale. *Water Resources Research*, 54, 5856–5877, https://doi.org/10.1029/2017WR022380, 2018.

Huang, J., Merchan-Rivera, P., Chiogna, G., Disse, M., and Rode, M.: Can high-frequency data enable better parameterization of water quality models and disentangling of DO processes?, EGU General Assembly 2021, online, 19–30 Apr 2021, EGU21-8936, https://doi.org/10.5194/egusphere-egu21-8936, 2021.

Huang, J., Borchardt, D., and Rode, M.: How do inorganic nitrogen processing pathways change quantitatively at daily, seasonal, and multiannual scales in a large agricultural stream?, Hydrol. Earth Syst. Sci., 26, 5817–5833, https://doi.org/10.5194/hess-26-5817-2022, 2022.