Dear Editor and Reviewer,

Thank you for your letter and the reviewer' comments concerning our manuscript entitled "How do inorganic nitrogen processing pathways change quantitatively at daily, seasonal and multi-annual scales in a large agricultural stream" (hess-2021-615). These comments are all valuable and very helpful for revising and improving our paper, as well as providing significance to our research. We have addressed the comments carefully and made corresponding responses. The responses to the reviewer's comments are listed below.

Review Report #2

The study aims to combine high-frequency water quality measurements with a hydrochemical model to improve understanding of dissolved inorganic nitrogen dynamics in a large stream.

The presented results showing how DIN changes from daily to interannual scales together with underlying pathways are convincing and well presented.

Response: Thank you very much for the positive general comment.

What is not clear, however, is the benefit of using combined high-frequency data and a hydrochemical model. It seems to me that HF data are purely used to validate model estimates of GPP. If there is an information gain resulting from using this combined approach, it is not clear in the paper. Perhaps contrasting model validation with high- vs low-frequency data would visualize this gain?

If the model can be equally well validated using low-frequency data, what is the benefit of using high-frequency data? This point needs to be clarified by the authors.

Response: Thanks a lot for raising the point on the benefit of using high-frequency data. First of all, we have used a paragraph to discuss the value of using high-frequency data in quantifying N pathways in Section 4.3. In our study, high-frequency water quality data have been used as input of the upper boundary condition at GGL and for calibration against the simulation results at STF. There are three high-frequency water quality variables: DO, Chl-a, and NO_3^-. Also, low-frequency data can be defined by several different lower frequencies, e.g., daily, weekly, and monthly. Theoretically, we can test the benefits of using high-frequency data as input or for calibration, of each variable, against the different temporal resolutions of low-frequency data in the water quality modelling of the Lower Bode. This will create a lot of combinations of test scenarios, which will constitute a complete individual new study. But this is out of the scope of the current study. Nevertheless, we still wanted to touch on this topic in the paper.

As the reviewer has noticed, we mentioned one very important extra value of using GPP calculated from high-frequency DO data for model calibration and validation. Most important is that high frequency data of DO are simply a prerequisite to allow GPP and associated N uptake calculations. Moreover, high-frequency data allow increasing the data support for the modelling. In another study, we have proved that using 15-min interval DO sensor data can improve the identifiability and reduce uncertainties of the parameters for phytoplankton and benthic algae metabolisms using a Bayesian inference approach (Huang et al. 2021)[1]. A detailed analysis is subject of ongoing work. So far, the results of Huang et al. (2021) clearly show that the uncertainties in water quality modeling can be reduced by using high-frequency DO data. As the assimilation by algae plays such an important role in N uptake in the Lower Bode, better parameter identification of algae-related processes using high-frequency DO data supports the quantification of N uptake processes. We will include the discussion above and cite our EGU publication as evidence for the benefit of using high-frequency DO data.

Next, also the value of high-frequency NO_3^- and Chl-a data for model calibration can be tested and quantified using a similar approach done by Huang et al. (2021). However, in the current manuscript, the benefits of using high-frequency NO_3^- and Chl-a data in water quality modelling were explained with 3 arguments in Section 4.3 in a descriptive way and we will underpin this with visualisation of some more time series data showing differences between high and low frequency data. We will supplement a figure with both 15-min interval and monthly NO_3^- and Chl-a data at STF and add some discussion elements in Section 4.3 supported by the visualisation of the water quality data at high frequency and low frequency shown in Figure R9.

For supplementing the third argument about the benefit of using high-frequency Chl-a data in Section 4.3, we can see from Figure R9 clearly, that using the monthly data of Chl-a concentrations can easily miss its concentration peaks between two monthly measurements, e.g., spring blooms in 2015, 2016 and 2018. Thus, using Chl-a concertation data at monthly frequency for model calibration will cause difficulty and uncertainty in determining the phytoplankton growth and eventually quantifying its nitrogen uptake. This is, although to some lower extent, also true for NO_3^- data. The peaks between monthly NO_3^- data can be caused by storm events and short-term low values can be caused by instream biogeochemical processes; some examples are marked in Figure R9. These high frequency values are useful in determining how much NO_3^- uptake occurred during the phytoplankton bloom in the water quality model. This suggests that high-frequency Chl-a and NO_3^- data can help quantify the uptake processes. The above illustration will be supplemented to support the discussion in the revised version.

[1] 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, 13–30 April 2021, EGU2020-18622, https://doi.org/10.5194/egusphere-egu21-8936, 2021.

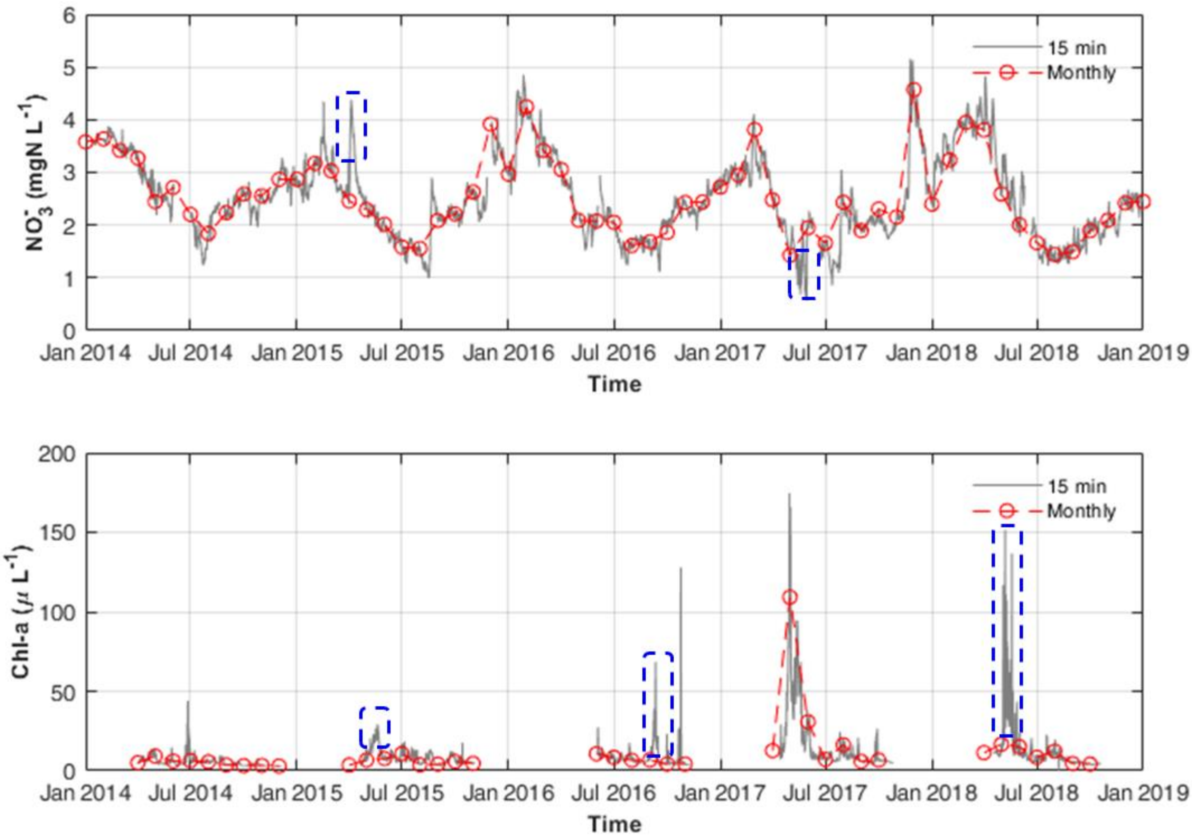

Figure R9 15-min interval and monthly NO_3^- and Chl-a measurements at STF; Cyan dotted lines illustrated the examples in the discussion Section 4.3.

Minor things:

Line 10, either stream or river

Response: Thanks! We will correct it to stream reach.

Do not use abbreviations in the abstract

Response: OK, we will avoid using abbreviations in the abstract of the revised version.

'We assume that discharge at station HAD is also valid for station GGL because no lateral flow contributes to the reach between the two stations' – how can you be sure? It is a long stretch of 2.7 km.

Response: We selected the location of the GGL station to guarantee complete mixing of upstream tributaries. Between the HAD and GGL stations, there is no tributary or drainage ditch. In the response to Reviewer 1 we already explained that the water budget is well balanced for the whole 27.4 km study reach between GGL and STF assuming the same discharge at HAD and GGL. Furthermore, calculation using the fully distributed hydrological mHM model indicated that mean yearly groundwater recharge in the lower Bode valley were always below 10 mm since 2014 (Zhou et al. in review)[2]. Therefore, it is also very unlikely that there is considerable lateral input from the 2.7 km reach. Therefore, even if we cannot completely discard lateral inflow within this 2.7 km because of missing direct measurements, lateral input can be assumed to be negligible in the water balance of the whole reach.

Discussion title Seasonal role shift and multi-annual performance – is not clear

Response: Thanks a lot for mentioning this. We will change it to “Seasonal role shift and multi-annual performance of instream N processing.”

Line 301 N has a round-trip ticket to - ?

Response: The algae biomass. This will be supplemented to the manuscript.

Once again, we appreciate the critical comments and constructive suggestions from the reviewers very much.

Jingshui Huang

Contact author behalf of all co-authors

[2] Zhou, X., Jomaa, S., Yang, X., Merz, R., Wang, Y., Rode, M.: (in review) Exploring the relations between sequential droughts and stream nitrogen dynamics in central Germany through catchment-scale mechanistic modelling (submitted to J. of Hydrol.)