

Author's response to:

Interactive comment on "Detection and attribution of global change effects on river nutrient dynamics in a large Mediterranean basin" by R. Aguilera et al.

Anonymous Referee #2

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This manuscript deals with river nutrient dynamics in the Ebro basin, and attempts to link nutrient variations in the river and its tributaries to a number of environmental and anthropogenic factors. For this study, the authors use data from public databases, from which they extracted nitrate and phosphate concentrations, and are using the data from 50 sampling locations where they were able to construct a 31-year time series.

They are also using water discharge time series for 37 of these 50 sampling locations. They are using a number of statistical tools, in conjunction, to highlight trends and patterns, in order to identify interannual or seasonal cycles, and to associate them with the external factors considered. I appreciated the fact that the authors do point out that public databases and time series often are poorly maintained and lack data.

Overall, the manuscript is well written, the description of the tools used, and why, is helpful and clear. The topic is within the Biogeosciences scope. I would only suggest minor revisions, mostly clarifications on some points I will go over below.

We thank Referee #2 for their constructive criticism and for providing specific comments below, these are dealt with in the revised version of the manuscript and we provide here the corresponding specific answers to each of the Referee's suggestions.

The main issue for me here is the use of the term "global change". We are all aware that global change does not exclusively mean climate change, and I understand that the external factors taken into account in this study can fall within the "global change" category. However, I would like to see a short paragraph defining what exactly the authors mean by global change in this instance, and why these particular factors were chosen and relate to that definition. The reason why I mention this is that the notion of global change appears early in the manuscript, and then in the conclusions, but we lack insight so as to what it really means here. "Global change effects" or "global change impacts" is an extremely broad notion.

Global change in our paper includes anthropogenic activities such as land use and water management practices, as well as changes in climatic conditions. There is a brief description of the concept of global change in Page 2 of the revised manuscript.

The spatial component of the variability studied also could benefit from extra space in the manuscript. In section 3.7 it is said that for each sampling point, mean values and percent areas were calculated considering 2 regions: is this for all potential explanatory variable listed above between lines 17 and 25, or only some of them? Were you able to get complete time series for ALL these variables? And what of their location (reservoirs, WWTPs: :), this could be useful to know. If I understand correctly, the spatial distribution of patterns/explanatory variables is computed from the patterns themselves found through DFA? I had a hard time picturing spatial distribution from the manuscript alone, even though the figures are good. Figure 5 is a good attempt at putting together explanatory variable and affected clusters, but if the colored circles refer to clusters in Fig. 3 and Fig 4., how can we know if red circles are Cluster 1 from fig. 3 or Cluster 1 from fig. 4. Same thing with blue circles (Cluster 4 from fig. 3 or cluster 2 from fig. 4?). The clustering and conclusions drawn from explanatory variables identified should be discussed more in depth in section 5. All in all the "spatial" talk is very technical, and adding a paragraph in the discussion regarding this would make it easier to understand.

The spatial distribution of the relevant patterns was identified by the magnitude of the factor loading for each pattern, and these magnitudes are defined by DFA results. The values for explanatory variables represented averages at each particular sampling point location. The main objective here was to find any relationship between the factor loading magnitude

distribution and the relevant explanatory variables identified by regression models. The average values for explanatory variables for the two regions (total upstream and local buffer) were computed for all variables. Further clarification is now provided in Section 3.7 in the revised manuscript.

Regarding Fig. 5, the clustering colors belong to the corresponding nutrient, i.e, Fig.3 cluster colors for nitrate appear in Figure 5 in the NO₃ sub-figure and Fig.4 cluster colors for phosphate belong in the PO₄ sub-figure in Fig. 5. Nevertheless, to avoid confusion, we have clarified the origin of the cluster coloring in Fig. 5 in the revised version of the manuscript by assigning capital letters to the nutrient sub-figures (A for nitrates and B for phosphates), and by explicitly specifying their link to clusters Figs. 3 and 4.

The clustering and conclusions drawn from explanatory variables have been further discussed in Section 5 of the revised manuscript.

Section 4.1: Are the 3 extracted patterns common to all 50 times series?

Yes, the 3 extracted patterns are common to the set of 50 time-series, and this has been emphasized in the revised manuscript (Page XXX). The relevance of each pattern at each monitoring point is indicated by the magnitude of the factor loading obtained at that point.

Section 3.1: - "collected from public databases": did you use multiple different databases to construct the time series? If so, were the measurements made the same way at each sampling site, maybe they were automated? Were they all comparable? - "some unreasonable values were manually removed": did you try to link these values with land use data? How unreasonable? Were they measurement errors?

The 50 time-series for nitrate and phosphate concentration, as well as streamflow values, were obtained from the same database of water quality monitoring carried out by the Ebro Basin Authority (CHE; <http://www.chebro.es/>). The same measurement methodology, specific to each variable, was applied throughout the entire network of monitoring points.

Unreasonable values were mainly outliers and those derived from the inappropriate use of characters such as decimal commas instead of decimal points, which could be grouped as recording errors. The sentence has been modified to include this information in the revised manuscript (Page 5).

Streamflow time series: I was a bit confused with the streamflow time series. Were you able to get complete streamflow time series for 37 sampling sites? Why reconstruct it? Maybe a sentence could be added in section 3.3 explaining this further?

As stated in the text (Pages 5-6 of the revised manuscript), we used the DFA resulting streamflow patterns to enhance the signal to noise ratio of the measured streamflow time-series, which in turn facilitated the identification of characteristic oscillations and potential relationships between streamflow and other variables.

The 37 streamflow time-series contained data gaps, for this reason we obtained the reconstructed continuous streamflow time-series based on DFA resulting patterns and factor loadings. This information has been added to this section to provide further clarification.

References: In the manuscript you cite (Caille, 2009) but in the reference list we find Caille et al., 2012. Please correct. P 5274, line 2: Gonzalez et al., 2012 does not appear in the reference list

The reference should read (Caille, 2012), this has been corrected in the revised manuscript. Also, the reference related to González (2012) has been included in the reference list.

p. 5275, section 5.1, lines 1-13: ENSO discussion/oscillation pattern: Is there also a similar pattern affecting precipitation? Or air temperatures? Could this further link your findings with ENSO? On the same page, line 15, I would replace "in our view", maybe with "in our opinion"?

We observed that both nutrient and streamflow patterns in the basin showed oscillations coherent with those of the ENSO and NAO, which are known to modify the magnitude and frequency of precipitation. In this case, we used streamflow as a surrogate variable for precipitation. Looking at the air temperature patterns in the Ebro basin, we can add that they also present the supra-annual frequencies characteristics of the above mentioned climatic modes. Specifically, air temperature patterns had significant frequencies of 2.2, 2.7, 3.3 and 5.7 yr. This information has been added to Section 5.1 (Page 17) in order to provide further evidence of the link to ENSO and NAO.

Line 438 in Page 17 of the revised manuscript now starts with the phrase "in our opinion".

Typos: P 5272, line 18 "showed the largest relevance of pattern 1": please replace "of" with "for"

The typo has been corrected. The line 350 (Page 14) now reads "showed the largest relevance for Pattern 1".