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Interactive comment on "Global riverine N and P transport to ocean increased during the twentieth century despite increased retention along the aquatic continuum" *by* A. H. W. Beusen et al.

Anonymous Referee #1

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GENERAL COMMENTS

The study by Beusen et al. explores nutrient retention (N and P) and export to the ocean by the world's freshwater systems, giving estimates of the total riverine transport and assessing the main contributing factors to these global fluxes. The authors analyze long-term changes using a worldwide, spatially explicit model, and discuss the shift in nutrient sources and in-stream dynamics in relation with the changes in human activities throughout the 20th century. I believe it is a valuable paper, and it represents a relevant scientific contribution within the scope of Biogeosciences. I therefore recommend its publication with a few minor corrections.

Positive aspects of the manuscript are:

- The model analyzes nutrient dynamics taking into account hydrological changes, land-use factors, wastewater discharge, and in-stream processes. This allows for a good critical analysis of the impact of major human transformations over the past century.

- As stressed by the authors, the model considers the in-stream dynamics of P, something that is seldom, if ever, considered in similar modeling studies.

- Estimates on global N and P retention and export to the ocean are provided for the whole 20th century. Although modeled data is approximate and it should be further tested in many different freshwater systems, these integrated values are very useful for discussing changes in global biogeochemical cycles and in budget calculations.

There are a few issues that may need further discussion, or clarification:

- I understand that the model is described in full length in Beusen et al. (2015), and the information provided in the supplementary material is fairly complete, so there is no point repeating all such information in the manuscript. Some particulars, however, are required to understand how the model works and what computation is behind the results. In this regard, some brief details on how the two models (IMAGE-GNM and PCR-GLOBWB) are coupled would be welcome.

- Given that the model uses a 0.5° by 0.5° grid, I agree with the authors that there is no point including small rivers in the analyses. They set the threshold in rivers < 10000 km2 (page 20129, line 3), but I wonder whether this may be a huge constraint in certain areas of the world, such as the Mediterranean, where the hydrological system is composed of many small streams, in most cases much smaller than the 10 000 km2 here established. Could the authors please discuss what might be the effect of neglecting such small rivers?

- In my opinion, a more in-depth comparison between some of the results of the model

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and actual data provided in other studies would be desirable. References could be given, for instance, to support the observed decrease in the N:P soil molar ratio (page 20129), the global increase in point sources (page 20131), the large nutrient retention in the Mediterranean and the Black Sea with regard to other areas (pages 20132-33), etc. This would actually serve as an additional model validation.

- I understand that long time series of riverine nutrient concentrations are not easy to find, yet it seems to me that validating world simulations with just three rivers, all of them located in the northern hemisphere and with similar climatological conditions (Fig. 2) is too limited. Have the authors tested some other rivers? If so, could them include them in the supplementary materials?

SPECIFIC COMMENTS and TECHNICAL CORRECTIONS

Abstract, Page 20124, Lines 8, 9, 14: Please correct the P units (5 to 9 Tg P yr-1; 3 to 5 Tg P yr-1; 2 to 4 Tg P yr-1).

Page 20127, Lines 12-17: Is ammonia volatilization considered among the N outputs? Is it assumed to be globally offset?

Page 20127, Lines 22-23: the "memory" or retention time of groundwater, does it change much between world areas? (Groundwater represents a big share of the nutrient sources in Fig. 3, so I wonder whether there are important geographical differences)

Page 20127, Line 26: Wouldn't it be better to validate the model sensitivity for the year 1975 instead of the 1950, taking into account that it was mostly in the 70s when the largest nutrient increases, mainly from agricultural sources, took place (the steepest increasing slopes in Figs. 3-4-5 occur around the 70s)?

Page 20134: The authors compare the influence of the different factors for the N and P budgets over time. The discussion is somewhat vague, though: they say that the influence of this or that factor became important after a certain year, but how important?

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could they be more specific and broadly quantify such importance (e.g. did it represent over 30% of the total sources? half of the inputs?)?

Page 20136, Lines 7-9: Do you mean that desorption processes are not considered at all? not even as a percentage? Do the authors think that including desorption processes would change much the P export values to the sea?

Interactive comment on Biogeosciences Discuss., 12, 20123, 2015.