Review HESS-2015-69

Phosphorus dynamics in lowlands streams as a response to climatic hydrological and agricultural land use gradients

General response to Editor and Reviewers:

We would like to thank both reviewers and editor for their thorough comments to our manuscript. Several concerns have been raised. In light of these comments, we agree to conduct major changes to the organization and logic of the article.

We are aware about our dataset is limited and restricted to only four watersheds varying in a series of characteristics. This is a weak point that is hard to overcome in any field study of this nature and conducted at the watershed level. However, each catchment can be considered as a representative of its type regarding contrasting climate-hydrologic scenarios. We also consider than our dataset has other strengths given by the high frequency monitoring strategy. In this line, we decided to center the new version of the ms in the comparison of monitoring strategies for stream phosphorus considering the contrasting climate driven flow regimes as main factor. Land use intensity (please see below) will become considered as contrasting conditions for each climatic/hydrologic scenario. We aim at focusing on the overall behavior of these watersheds in the dynamics of nutrients, not necessarily on the specific mechanisms within each of them. Therefore we will now focus on monitoring strategies for nutrients, in the line of the special issue of HESS, describing the observed patterns and highlighting the potential of our results to generate hypothesis for future works, down toning the extent of our conclusions. These changes will cause modifications in the overall structure of the ms.

Henceforth: R2: reviewer 2; A: authors.

R2: Unfortunately, to encompass the variation of climate, hydrology and land use in only four watersheds is extremely limited by insufficient replication due to all four watersheds having very different land use and subsequent management (cropland drained by tiles vs forage crops and dairy farms without tiles and forest vs Pampa grasslands (used as pasture)). Furthermore, there was little to no description of topography and slope or even the spatial distribution of the different land uses across each of the watersheds. The mechanisms for runoff generation and nutrient transport could be drastically different between these watersheds. Therefore, large uncertainties due to these variations are likely in the results.

A: Please see General response to Editor and Reviewers. Given the recognized limitations, we will moderate the degree of certainty used in our previous conclusions. As the reviewer states and we agree, we will expand the rational of the choice taken and operational definitions, adding more information about aspects as cropping systems, livestock type and density, kind and use of fertilizers and tillage operations and other

relevant variables. The use of “agricultural intensification” concept in the ms will be changed by “land use intensity” (LUI). We are aware that LUI is a complex, multidimensional term, and measure the intensity of land use is not a trivial issue. We have selected really contrasting LUI conditions, and we are able to classify they in a robust way using LUI categorical descriptors such as fertilization, mowing, and livestock following the concepts of a big number of previous works (e.g. Blüthgen et al., 2012; Brown and Vivas, 2005). In this context, we will use the term LUI as synonymous with farming intensity, integrating all the productive set and management activities in each climatic scenario (country).

At the same time, we intend to characterize real and typical productive systems representative from the each selected country/climatic-hydrologic condition, and will contribute to generate basic knowledge about consequences of LUI over water quality. Even though intensive land use is a worldwide phenomenon (Alexandratos and Bruinsma, 2012; Foley et al., 2005), the knowledge about the relationships between LUI and environmental consequences, has not been homogenously generated. Most of the studies has been conducted in Europe and USA, and within these, in developed countries and temperate climatic conditions. Otherwise, a low number of studies were generated in developing countries, with warmer and wetter conditions as Uruguay. In this context, what are the environmental consequences of the farming intensity in subtropical South America constitute still an open question.

R2: More complications from uncertainty arise considering only the outlet was monitored. Field-level (or even hillslope) management effects on water quality cannot be inferred adequately from outlet monitoring only. This can also be true for the particular processes driving runoff generation and other important hydrological processes affecting nutrient transport. While septic and wastewater effluents were estimated for the appropriation model, are there particular differences in animal units and/or manure management that could be described for each watershed. Other particular field management differences (manure and fertilizer use, grazing intensity, etc.) in the agricultural watersheds were described only very limitedly. Only livestock access to streams in Uruguay was discussed to any degree. In Denmark, was animal production focused on confined animal operations or others?

A: Regarding the uncertainty arisen by monitoring the outlets only, we would like to stress that in this article we aim at focusing on the overall behavior at the watershed level rather than on the local mechanisms (despite we do recognize their relevance for developing local, field-level models). On the other hand, we agree on the fact that the information on some uses in the agricultural watersheds was limited in the original version. More information on animal production and use of manure (e.g. used as fertilizer only in Denmark, while it is left on the fields by the grazing cattle in Uruguay) will be added in the next version.

R2: On the modeling front, upstream and field or hillslope monitoring would be very important to serve as corroboration of processes in any continued modeling efforts as suggested in the last paragraph of section 4.4. Calibration can easily allow the model to match measured flows, but the particular processes driving the processes could likely be overshadowed by excessive calibration. The particular hydrological processes determined from both outlet and upstream evaluation, however, can facilitate parameterization and allow better representation of the processes. Therefore, the suggestion to use models to select management (“Strategies that allow to generate scientific based management actions which maximize agronomic productivity while reducing environmental concerns include the development of catchment models (e.g. SWAT; Gassman et al., 2007),. . .”) for these watersheds would require broad familiarity with the watershed and its various processes together with direct management input from the farming communities in order to

indicate management strategies with any degree of certainty. In my experience in modeling, watershed models are not given the “benefit of the doubt” by most, and it would require some strong convincing.

A: Indeed! We agree that models recommended for management need to be strongly supported by local data (including farming practices and field-level data) before they are taken by managers and decision makers or even the academic community coming from different fields. In the next version of the draft we will explicitly mention the variables that need to be measured and incorporated to build relevant models at the local level.

R2: It is apparent there was a large effort involved in the study. However, there are some critical concerns in connecting the results of four very dissimilar watersheds to the expansive conclusions on agricultural intensification offered in the Discussion and the Conclusions. The Uruguayan dairy farming systems were condemned and the Danish farming systems were applauded for being “properly managed”. However, there are no results from other agricultural watersheds in each country to indicate a range of water quality expected from agricultural watersheds, or in o words, a comparison of other subtropical watersheds was not available to indicate the extent of impairment of this study’s particular intensive agriculture watershed. Indeed, eutrophication issues in Uruguay, as in other countries across the world, do need to be addressed in order to secure clean water for the populace; however, the regulations on farming will need to truly impact nutrient losses, fit within the capabilities of the farming community, and continue to allow them to meet market demands and their needs.

A: We agree that we might have extended our discussion and conclusions too far given the low number of watersheds included in this study. Our knowledge on the management practices in both countries surely influenced our conclusions. Considering that both reviewers highlighted this weakness (and that we agree upon re-reading our ms), we have decided to remove the section that discusses the “goodness” of different farming systems and their implications for management in the next version.

PARTICULAR COMMENTS AND QUESTIONS

R2: I would suggest a more in-depth discussion on fertilizer and/or manure application rates and timings, especially in the intensive watersheds. A map of the land use around each watershed would be helpful as well. Topography and other watershed characteristics could be presented.

A: We will include topography as well as other watershed characteristics in either the text or a table. Also we will add the relevant information and discuss the differences in fertilizer and manure application in each location and more details on the land use in each watershed. In view of the extension of the new version, we may include such information as a map or other format.

R2: In the high frequency composite sampling, how many samples were generated within a fortnight and what duration of time did they represent? Or was a single sample of all the composites collected together for the full two weeks? Besides refrigeration, was there any processing of composite samples soon after collection?

A: The composite and grab samples were collected fortnightly on the same date. The composite sample was a single bottle that integrate all the water subsamples collected every 4 hours for a 2 weeks period.

Original, lines 135-138: “The samplers were programmed to collect an equal water volume every four hours, and the composite samples were collected following a fortnightly sampling programme. The final phosphorus concentration in the sampler carboy represents a time-proportional average for the complete sampling period.” There was no processing of the samples besides immediate refrigeration.

R2: While the ratio of runoff to precipitation is an important aspect to consider in hydrologic assessments and has been used as a “proxy of catchment water balance”, it clearly is not the only means of characterizing hydrological processes between watersheds. It may also be quite variable within a year and over several years. Are there any discharge gages available near to any or all of the watersheds that may provide some indication of the variation of this ratio?

A: The comment is indeed appropriate. However, and as said in the reply to Reviewer 1, climate characteristics of the studied lapse could be considered as typical or “average” both in Denmark and in Uruguay. Therefore, we would prefer to clearly state that data can be considered representative in this respect without include more analysis about it.

R2: In the appropriation model, was there any work to corroborate some of the point source wastewater estimates that were used as input to the model?

A: No, unfortunately we could not corroborate such estimates in Uruguay. We therefore used published coefficients as the best surrogates (Vinnerås, 2002), multiplying such coefficients by the number of people in each watershed as done elsewhere in similar studies. In Denmark such data was generated after a model (Wiberg-Larsen et al., 2013). Despite the potential errors involved in these approaches, the estimations for both countries are within the same order of magnitude and far from the estimations of the other nutrient sources; so we are pretty confident on them.

References

Vinnerås, B.: Possibilities for sustainable nutrient recycling by faecal separation combined with urine diversion, PhD, Acta Universitatis Agriculturae Sueciae, Agraria 353, Swedish University of Agricultural Sciences, Uppsala, 2002.
Wiberg-Larsen, P., Windolf, J., Bøgestrand, J., Baattrup-Pedersen, A., Kristensen, E. A., Larsen, S. E., Thodsen, H., Ovesen, N. B., Bjerring, R., Kronvang, B., and Kjeldgaard, A.: Vandløb 2012. NOVANA, Aarhus Universitet, DCE - Nationalt Center for Miljø og Energi, 84 s. - Videnskabelig rapport fra DCE - Nationalt Center for Miljø og Energi nr. 75. http://dce2.au.dk/pub/SR75.pdf, 2013.