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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Are maps of nitrate reduction in groundwater altered by climate and land use changes?" *by* Ida Karlsson Seidenfaden et al.

Anonymous Referee #1

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Summary

This study explores how different land use and climate scenarios influence nitrate reduction maps in a catchment in Denmark. Nitrate reduction maps are routinely used in Northern Europe but they are usually considered as constant in time. Because changing land use and climate will affect flowpaths and therefore the amount of nitrate crossing the redox interface, we can expect that the assumption of a constant nitrate reduction map may be wrong. This study uses a coupled model DAISY + MIKE SHE to quantify expected changes in nitrate reduction % under several scenarios. The results show that nitrate reduction maps are more sensitive to changes in the climate than

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changes in land use.

General comments

This study definitely addresses an important question in the context of Northern Europe, and provides an interesting answer: catchment-scale change in nitrate reduction can reach 10% and climate changes have a greater effect compared to land use changes.

I suggest four main improvements to the manuscript:

- Place the study in a more international context. Most references are from Denmark, where the same models and maps are used. What about other countries in the Baltic area? Although I understand that nitrate reduction maps may not be common in other regions of the world, it would be interesting to do a literature review on nitrate retention and changes in flowpaths as a result of a changing climate and land use. This would greatly improve the introduction and the discussion.

- Improve the calibration strategy. This study uses a parameter-rich model, which is calibrated in one single catchment and with a poor evaluation of how the model is simulating interannual climate variability. This type of model is subject to equifinality, and it is important to evaluate it properly to make sure that it provides the right answer for the right reason. For example, would it be possible to evaluate the model in different sub-catchments with different land use % before testing land-use change scenarios? In the same way, evaluate the model in different climatic conditions during the calibration period (making the most of the past interannual climate variability) before testing future climate scenarios?

- Show time series of river discharge and nitrate concentration + model fit.

- Spatial variability and representativeness of the study area. Why only studying one catchment and not the entire country? Is it a problem of data availability, computation time? If studying more catchments is not possible, I would suggest to present the

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results in different subcatchment with different land use / soil types to see if they have similar responses (preferably subcatchments with a nitrate monitoring station). This would also help assess whether the <10% change in nitrate reduction is big or not compared to current spatial variability.

Specific comments

L9: “Nitrate reduction maps have been used routinely in Northern Europe for calculating efficiency of remediation measures and impact on climate change on nitrate leaching and are as such valuable tools for policy analysis and mitigation targeting.” This sentence is too long. L11&14 “Nitrate maps . . .” -> “nitrate reduction maps” L20 “The study, however, also showed that the reductions maps are products of a range of complex interactions and that the combination of the choices made for selected scenarios, model formulations and assumptions are critical for the resulting span in reduction capability.” Sentence too long and unclear. Suggest to discuss whether these differences <10% are important to consider for management. How big is this 10% difference in comparison to the spatial variability across different regions of Denmark? L29 “depending on the actual hydrobiogeochemical conditions the removal may mainly occur in groundwater or in surface water systems such as lakes or wetlands” Reference needed. Please add a paragraph with references showing that the retention process studied in this paper is a dominant process in the context of the study. L75 “one of the best nutrient time series in Denmark, providing a long and near-complete data set” Please specify length, frequency. L76 “The average discharge amounts to 4.4m3/s and the load is approximately 14 kg NO3-N/ha/year” what period? Any trend? L 77 “The geology is mainly a result of previous glaciations like till deposits. Aquifers are generally confined and the phreatic groundwater tables are shallow.” Move next to the sentence about soil types. L79 “There were 226 measurements of the redox depth in the area” Please briefly present the method to measured redox depth. L114 “Calibration was carried out against data from four discharge stations and 455 groundwater wells from the period 2004-115 2007, see Karlsson et al. (2016) for details” please present the

calibration strategy, objective function, parameter exploration algorithm, etc. did you calibrate Daisy and MIKE SHE together or separately? L139 “Each time the accumulated input of nitrate reach 0.5 kg N” is it 0.5 kg/ha, or kg/km^2? L 165 “subsequently compared with the measured redox depth in boreholes” where is this comparison? L215 “More information on the land use scenarios can be found in Olesen et al. (2014) and Karlsson et al. (2016).” Please provide a summary how these scenarios were built. l241 “For all the crops in the region the DAISY model is able to reproduce the observed harvested N” performance in evaluating the spatial variability in harvested N? l251 “To select the most appropriate combination, the cumulative distribution of the resulting redox depth of a given parameter combination is plotted against the distribution of observed redox depths. The observed redox depth is both compared to the simulated values at the actual point of observational measurement as well as to the total fractional distribution of the whole catchment (not shown). Based on this analysis the best combination with the correct NAP was found to be f=0.01yr and min.redoxdepth=3m.” I found this difficult to understand, add a figure in SI? This paragraph should be moved to Materials & methods section l255 “the depth to the redox interface is fairly shallow” avoid “fairly” in a technical paper. L480 “also worth noting, that all combinations of land use and climate change scenarios may not be equally likely or even plausible in the future” Interesting remark. Please add a reference. L511“The indication that errors can be up to 10% is based on only a single case study with one catchment”. Wasn’t it possible to do the same study in several catchments of DK? If not, is it an issue of data availability? Computation time? If doing the same analysis in other catchments is not possible, I would suggest presenting the N retention in different subcatchments with different land use / soil type / topography.

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