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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.

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In the manuscript, the authors investigate the impact of changes in climate and land use on maps of nitrate reduction in groundwater in a Danish catchment. Such maps are important tools to support management strategies that deal with nitrate pollution. Therefore it is highly relevant to investigate the potential error made in current practices that use static maps and thus neglect the effect of changes in climate and land cover.

This study compares maps of nitrate reduction in groundwater produced for different climate and land use scenarios within a modelling framework. I think that a number of point need to be clarified and examined to ensure the robustness and reproducibility of

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the results. I provide here a summary of my main concerns:

1) More information on the data and methods used is needed. In particular, the manuscript refer to numerous past studies for the data and methodology, which makes it difficult for the reader to have a clear understanding of the data and methods. The authors should provide in the manuscript a summary description of all data and method used (they can then refer to past studies for more details).

2) The calibration includes a number of 'manual' adjustments to the parameter values and identify a single parameterization. I think that it would be valuable to account for the uncertainty in the model parameter values and to determine whether the changes observed in the nitrate reduction maps due to changes in the climate are appreciable given the uncertainty due to parameter values. Given the presumably large number of calibrated parameters, the issue of equifinality is likely to arise, i.e. combinations of different parameter values could lead to the same model performances, but produce different nitrate reduction maps. In particular, only groundwater parameters are adjusted to match the Nitrate Arrival Percentage (NAP), and the value of these groundwater parameters could compensate for deficiencies in the values of the soil parameters (in particular soil denitrification parameters). I think this should be at least discussed in more details in the manuscript and I refer e.g. to Wade et al. (2008).

3) From the manuscript, I understand that, in the model, tile drains can be located in non-agricultural areas, which I find surprising. Some explanation on this are required, since tile drains appear to have a large impact on the model results.

I provide below detailed comments.

ABSTRACT

L20-22 'Th study, however, [...] in reduction capability: ' this sentence needs to be revised. 'complex interactions' is vague and the analyses presented in the manuscript do not explore the effect of model formulations on the nitrate reduction maps.

SECT. 1 (INTRODUCTION)

L42: I suggest citing and discussing the study by Knoll et al. (2020), that establishes a map of groundwater redox conditions for Germany through machine learning, and the study by Tesoriero (Tesoriero et al., 2015), that investigates the redox conditions in groundwater in the Chesapeake Bay watershed in the USA.

L59-60: 'A severe problem [. . .] resulting flow pathways.': This statement should be better explained and supported by some reference.

SECT. 2 (STUDY SITE)

L 75: Please add further details on the type, characteristics (such as frequency) of the nutrient data.

L81: A definition of the criteria to identify the redox depth (i.e. to separate aerobic from anaerobic conditions) is missing.

SECT. 3 (METHODS)

- The authors need to justify their choice of coupling the Daisy and MIKE SHE model. Why not using one model or the other? Why Daisy/MIKE SHE are particularly appropriate for this study?

- It is also not clear which parameters are calibrated and for this I think that a table that summarizes the model parameters and their calibrated value should be added (in the main text or in the supplementary information).

- What are the nitrogen inputs to the system? From L124 I understand that in cropland areas mineral fertilizers only are considered, is this correct? What about the N input for the areas with other land uses such as grass or forest? What about nitrogen biological fixation and nitrogen atmospheric deposition which can also be important inputs of nitrogen to soils?

- The grid resolution for Daisy/MIKE SHE needs to be clearly defined. Is it 200m x

200m (L 126)?

- L110-111 (and also L304-305): aren't tile drains usually located in agricultural areas? My understanding is that here tile drains are distributed uniformly independently of the land use. This is an important model assumption, since it appears that tile drainage has a large impact on the study results.

- L115 '455 groundwater wells': Which data were derived from the groundwater wells?

- L119-120 'following methods proposed by Allen et al. (1998) and Styczen et al. (2014)': it is required to add more explanation here (brief description of the methods, parameters that are calibrated with the methods). I also have the same comment regarding L128-129.

- L121 'such that they produce similar actual evapotranspiration and stream flow for the simulation period': a precise definition of what is meant by 'similar' is needed.

- L134 'the procedure described in [. . .]: Please summarize the procedure.

- L165 'compared with the measured redox depth in boreholes': a description of this comparison is missing.

- L179-181: I do not understand this statement (in particular it is not clear to me what 'direct arrival percentage' means).

- Table 1: Please define reference evapotranspiration and specify how it was calculated.

- L215-216: I would suggest to briefly summarize how these scenarios were established and to refer to Oleson et al. (2014) and Karlsson et al. (2016) for more details as currently done.

- L222 '50 model simulations': In table 3 I see only 45 and not 50 scenarios, please clarify.

SECT. 4 (RESULTS)

- L323: ‘net precipitation’ should be defined.

- L453-455: It is not clear to me how these numbers are derived from Figure 9.

SECT. 5 (DISCUSSION AND CONCLUSIONS)

- L480: replace ‘the full range’ by ‘a range’ as a limited number of scenarios were used, which cannot comprehend all possible futures.

- L515-516 ’that should be addressed along with other known sources of uncertainty such as climate model projections, land use projections and hydrological model structure uncertainty.’: This discussion needs to be expanded. In particular, uncertainty in model parameter values can also affect the results.

MINOR EDITS:

- L143 ‘section 0’: please add the correct section number. - L170 and in the figure captions: add ‘cell’ after grid. - L230 ‘no 1’: do the authors refer to scenario 1 in Table 3? Please clarify. - L236: replace ‘m^2/s’ by ‘m^3/s’. - L345: remove ‘impact’ after ‘change’. - L348: there is something wrong here. Maybe ‘different’ need to be removed? - L364-365: Please correct by ‘the change in the drain flow fraction’ (two occurrences). - L397 ‘this is also found for one of the models’: remove ‘also’ (possibly replace by ‘indeed’).

REFERENCES:

Knoll, L., Breuer, L., & Bach, M. (2020). Nation-wide estimation of groundwater redox conditions and nitrate concentrations through machine learning. Environmental Research Letters, 15(6). https://doi.org/10.1088/1748-9326/ab7d5c

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