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Interactive comment on "Groundwater nitrate concentration evolution under climate change and agricultural adaptation scenarios: Prince Edward Island, Canada" *by* D. Paradis et al.

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Review of Âń Groundwater nitrate concentration evolution under climate change and agricultural adaptation scenarios: Prince Edward Island, Canada" by Paradis et al.

General remarks

Groundwater remains the most important natural resource exploited on Earth, and many groundwater systems are already subjected to pollution pressure of nitrates. Climate change and associated changes of land use are likely to modify these pressures even more, which jeopardizes long term exploitation. This is also the case for the groundwater body of the Prince Edward Island (PEI) in Canada.

In their study, the authors assess possible impacts of climate and agricultural land use change on the groundwater concentration of the PEI groundwater body. For doing this, the authors implement a classical and straightforward hydrological modelling impact study. They set up local climate change scenarios (projection period 2050) for the PEI, considering 4 GCM scenarios that were appropriately downscaled using local meteorological data. The 4 GCM scenarios were forced by the IPCC 2001 A2-B2 emission scenarios. They also set-up a single land use change scenario. Subsequently they process the local CC and land use scenarios with a physical based recharge (HELP) and groundwater flow and transport model (FEFLOW). The model was designed and calibrated for PEI, using available historical groundwater head data, river flow recession flow data, and nearly 17000 nitrate concentration data observed in different wells. The processed CC and land use change scenarios allows elucidating possible evolution of the PEI groundwater body in terms of nitrogen loadings and the impact of the different forcing terms of these nitrogen loadings.

This study is a very nice example of a detailed and high quality groundwater impact modelling study, encompassing many different modelling steps. The overall modelling framework is well designed and uses state-of-the-art submodels and very detailed historical and projected data of the PEI groundwater system and its environment.

Evidently, many hypothesis and conceptual choices are made by the authors for implementing the modelling study. These hypothesis and conceptual choices are subjective. They are therefore the major weak points of the study. Authors try to incorporate uncertainty about some aspects of the impact modelling (e.g. the global climate evolution by considering 4 downscaled GCM – emission scenarios), but fully ignore uncertainty about other aspects (e.g. they consider only a single agricultural land use scenario). Also, there are only few efforts made by the authors to quantify and propagate rigorously the uncertainty (although I fully acknowledge the challenge of quantifying uncertainty in these complex impact studies). In any case, after reading the manuscript, I'm left with a "so-what" feeling, and it is very difficult for me to appreciate what are the

ESDD
6, C550–C553, 2015

impacts of the subjective choices and hypothesis on the obtained results. I'm puzzling with the following questions: What would be the effects if the authors would use the updated emission and GCM scenarios as published in the IPCC 2014 report rather than the 'old' 2001 emission scenarios? What would be the impacts if the agriculture land use scenario would be different than projected by the authors? What would be the impacts if the soil organic matter was not at steady state, as considered by the authors, but be strongly affected by change of soil temperature? What would be the impacts if RSN would not be nitrified completely during a growing season? What would be the impacts if denitrification in groundwater would occur? What water servicing measures and infrastructure would be needed to mitigate to the predicted adverse trends?

Another major weak point of the study is that the modelling results as such are not fully discussed. Issues related to uncertainty and perspectives for improving the impact modelling study (conceptual choices, modelling data, ...) are not addressed. Also, a comparison with similar modelling studies (e.g. De Jong et al., 2008; Ducharme et al., 2007) would be appreciated. I therefore suggest adding a discussion section after the results section where uncertainty issues and comparison with similar studies can be appropriately discussed. I think both major concerns above should be considered in a major revision of this manuscript.

Specific remarks

P8, Line 9. Reference to Fig. 3b is wrong.

P16,line 11. During the calibration of HELP, the initial water content was calibrated. This is very surprising given the fact that initial water content is not sensitive (page 14, line 25). Can this contradiction be resolved?

P16, line 23. The correlation coefficient is used here as a model performance indicator. Also this parameter is rather low (64%). Can the authors justify the use of the correlation coefficient as performance indicator and explain what threshold should be considered as appropriate.

ESDD
6, C550–C553, 2015

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ESDD

6, C550–C553, 2015