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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Modeling groundwater responses to climate change in the Prairie Pothole Region" *by* Z. Zhang et al.

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Zhang et al. use a land surface model coupled to a two-way groundwater dynamics model to explore the response of groundwater to climate change in the Prairie Pothole Region (PPR) of North America. The main research objectives of this study were to simulate two-way exchange in the subsurface, characterize groundwater response to climate change, and identify the major processes controlling this response in the region. The novel methodological components of this study include the application of a two-way groundwater exchange module coupled to a land surface model and the use of regional scale WRF CONUS model outputs with a scheme that treats convective precipitation. The authors point out that there is a need to explore hydrologic response to climate change at the regional scale, of which there is currently a gap, and so this

study is a timely and important addition to that area of research.

My main comments are:

1. The authors need to introduce their research objective earlier in the introduction, and better organize the following paragraphs around the background and motivation for the study. In particular, I would like to see more motivation for the methodological set up of the study. For example, if prairie pothole hydrogeology is so complex at the local scale (lines 70-83), why is a coarse regional model appropriate? Second, since the freeze thaw process is a key requirement for PPR hydrogeology, I would like to see more background (including references) of how this process has been treated in various LSMs and also more information in the methods section of how NOAH-MP represents it.

2. More information is needed on the criteria for selecting wells, such as required length of record and how anthropogenic effects were minimized. Further, comparing a coarse land surface model covering a large total area (the model area is not reported) to only 11 wells is concerning. From Fig. 1 it appears that quite a large portion of the PPR does not have any well coverage. I think it would be worth revisiting the criteria and including a few more wells out of the 160. If that's not possible, then more discussion regarding potential uncertainty in capturing groundwater dynamics in PPR subregions without wells (e.g. the southwest portion) is warranted.

3. More information is needed on the climate change scenarios such as what emissions scenario was used and what sort of temperature increase does that roughly translate to?

4. If the REP model performed better against observational data, then why didn't the authors choose to run the climate change scenario using that parameterization? Including such a simulation would give the reader a sense of how sensitive projections are to model parameterization. If including this simulation is too computationally expensive, then at least some discussion of how the climate projections might be sensitive to

model parameterization is warranted.

5. There is a fairly major typographical error in the text and figure captions. Delta S should be equal to R + Qlat – Qr (according to equation 4), but it is repeatedly written as R + Qlat + Qr (equation 10, for example) in the paper. This is hopefully only typographical, as that would result in large errors in reported changes in storage.

6. The figure captions in the text often do not match the figure captions associated with the figures. Further, the authors should write out fully descriptive figure captions, including defining acronyms, such that the figures would be able to be read on their own. There are currently several figure captions that simply say “same as Fig. xx.”

7. Finally, the timing and amount of thaw is a key control on recharge projections, but the authors do not explore or discuss how well their model captures freeze-thaw dynamics at the regional scale. This is related to my earlier comment, that the authors need to explain how this process is represented in their model. Some discussion of how future studies could improve upon this methodology to capture this important and heterogeneous process would also add strength to the paper.

Specific comments:

There were quite a number of typographical errors, a few of which I will list here, but I do recommend the authors go back over the manuscript with a closer eye for spelling and grammatical errors.

Line 55: use a different acronym for precipitation- PR is too close to PPR

Lines 64-65: rewrite for grammar

Line 76: provide citation for recharge estimate

Line 77: rewrite for grammar

Line 80: rewrite for grammar

Lines 93-94: studies of regional climate change impacts to hydrology in N. America: Niraula et al., 2017a,b, Christensen et al., 2004

Line 148: Observational data

Line 181: define offline mode

Lines 341 and 350: under current/future climate conditions

Line 372: what is Qdrain?

Line 474: include citation

Lines 520-522: rewrite for grammar

Table 1: either use descriptive column names or define any abbreviation used. Add units where needed.

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