

Interactive comment on “Spatio-temporal impact of climate change on the groundwater system” by J. Dams et al.

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General comments

In this paper, the spatio-temporal impact of climate change on a Belgian groundwater system (Kleine Nete) is analyzed. A loose coupling between a physically based hydrological surface model and Modflow is used to evaluate the changes introduced by climate change as projected by several climate models of the PRUDENCE project. A special focus is laid on the impact on groundwater dependent ecosystems. Generally, the topic is very interesting, the manuscript well written and the research well performed. By using ensemble projections, the authors also nicely show the uncertainty related to the climate models. However, I do have some issues which should be

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clarified and commented.

Specific comments

P10200 I.10-14: How is the future water extraction (2070-2101) handled? Drier summers in future can easily lead to an increased water demand and thus to increased pumping activity. This could have a large impact on the water table projections.

P.10201 I.14-25: Although references for the downscaling approach are given, some more specific information about the downscaling would be good. As the study focuses on intra-annual changes it would be interesting to know how seasonal biases of precipitation are handled. For example, we found (Stoll et al., 2011) that it makes a huge difference if precipitation is corrected on a monthly or an annual basis.

I have some concerns about the coupling between WetSpa and Modflow. Maxwell and Kollet nicely showed the interdependence of groundwater dynamics and land-energy feedbacks (Maxwell and Kollet, 2008). If I understand it correctly, there is only a 1-way coupling between WetSpa and Modflow. The output of WetSpa is used as recharge and stream stage boundary condition for Modflow. However, there is no feedback from Modflow to WetSpa (e.g. increased groundwater tables lead to increased soil moisture and thus to increased evapotranspiration). Given the shallow groundwater tables (in average about 2m below surface) in the catchment, this might lead to an underestimation of evapotranspiration. This could also alter the spatial recharge pattern. In valley bottoms, near to the streams this effect would be more powerful than on hillslopes. Related to that: To my knowledge, certain Modflow packages allow for evapotranspiration directly from the groundwater. Are such packages used?

P.10203 I.27 - P.10204 I.5: I have some questions concerning the calibration: How many parameters (and which) are calibrated? The efficiencies are only reported for the calibration period. How is the performance of the models during the evaluation period? Is there a special reason why the models are calibrated separately and not simultaneously using a multi-objective optimization?

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P.10204 I.19-23: It would be also very interesting to see how actual evapotranspiration is changing. Summer precipitation deficits can lead to decreasing soil moisture contents and thus to decreasing actual evapotranspiration, although potential evapotranspiration is increased. Related to that, changes of soil moisture contents could be very informative (also to evaluate the impacts to the agriculture).

P.10206 I.7-10: How can the reported differences be explained? Is it solely a question of the geological properties or is it related to the recharge calculation itself (runoff processes, interception, exposition, snowmelt etc.).

P.10207 I.17-18: I don't think that this is true. Almost all groundwater impact studies are carried out with the focus on future droughts. And also for surface water, many studies have been focusing on low flow (e.g. drought related studies in the EU-WATCH project).

Small remarks

For the review about climate change effects on groundwater levels, perhaps our paper (Stoll et al., 2011) may be relevant, as we also focused on the intra-annual response.

References: Stoll, S., Hendricks Franssen, H. J., Butts, M., and Kinzelbach, W.: Analysis of the impact of climate change on groundwater related hydrological fluxes: a multi-model approach including different downscaling methods, *Hydrol. Earth Syst. Sci.*, 15, 21-38, doi:10.5194/hess-15-21-2011, 2011.

Maxwell, R. M. and Kollet, S. J.: Interdependence of groundwater dynamics and land-energy feedbacks under climate change, *Nat. Geosci.*, 1, 665–669, doi:10.1038/ngeo315, 2008.

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