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Hydrology and Earth System Sciences Discussions

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

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Response to Anonymous Referee number 3

Comment 1. The applied downscaling methodology needs to be elaborated a bit further to increase the readability of the manuscript.

Authors' response: We agree to extend the description of the climate scenarios in the manuscript.

Comment 2. In line with the two other reviewers I have concerns regarding the applied modeling approach where the results from WetSpa are fed into MODFLOW without any feedback mechanism. The combination of the WetSpa model, which, as far as the

groundwater-surface water interaction is concerned, is based on empirical and conceptual type of modeling approaches, and the physically-based MODFLOW, is a modeling approach, which I have difficulties justifying. The modeling of the interaction between subsurface and surface water is of critical importance in this study and therefore I believe that a fully integrated and physically based modeling approach using e.g. a model like MIKE SHE would have been more appropriate.

Authors' response: We are surprised about the skepticism of the referees towards the use of the distributed model to estimate groundwater recharge. We acknowledge that fully-integrated models have some advantages with regard to the simulation of groundwater-surface water interactions. However, because the WetSpa model calculates the percolation rate based on the soil moisture content we believe that the model is capable of estimating the groundwater recharge in a proper physically based way. For groundwater discharge zones the WetSpa model will simulate a groundwater recharge rate of zero and the MODFLOW model will simulate the appropriate groundwater discharge rate. Furthermore, the applied methodology has as advantage that a much better spatial and temporal discretization is possible in comparison to a fully coupled model.

Comment 3. The groundwater model seems to be overly simplified by only having two layers in the vertical. The geological settings are more complicated and I am surprised that the authors did not introduce a finer discretization such that the geological settings could be better implemented in the model. I was wondering if the simplification of the geological settings could impact the results.

Authors' response: Although the model has only two layers we do not agree that it is oversimplified. As can be seen on figure 3 the hydrogeology is mainly determined by the Miocene aquifer (HCOV 0250) and the Pleistocene and Pliocene aquifer (HCOV 0230). At some locations the Pliocene clay layer or Campine Clay-sand complex appears respectively below or above the Pleistocene and Pliocene aquifer. Therefore, the upper layer is subdivided into different zones (Figure 2). The initial horizontal and

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vertical conductivity is calculated using the weighted arithmetic and harmonic mean, respectively. Additionally the MODFLOW model integrates detailed physically based data of the surface water bodies, drainage, recharge and pumping wells.

Comment 4. The calibration of the models needs to be better described and substantiated as also stressed by the other reviewers.

Authors' response: We will include more details on the calibration procedure of the models.

Comment 5. The baseflow simulated by MODFLOW is not very accurate according to Fig. 5, which is disturbing as the MODFLOW results form the basis for the whole analysis of the manuscript. What is the reason that the MODFLOW simulations are less accurate than the results by WetSpa? I assume that the same recharge functions are applied in both cases. Why was baseflow not included in the calibration of MODFLOW?

Authors' response: Comparing the filtered baseflow with the baseflow simulated by the MODFLOW model we obtain a Nash-Sutcliff efficiency of 76%. Although this is less than the efficiency obtained by the WetSpa model there is still a very good correlation between the two baseflow series. Baseflow peaks in the filtered timeseries are shown to be often underestimated by MODFLOW. A possible explanation for the underestimation of the baseflow during winter is that the drain output simulated by MODFLOW is not added to the baseflow but is assumed to be lost by evapotranspiration. During summer it is very likely that a major part of the MODFLOW drain output is lost by evapotranspiration, however, during winter it is likely that a significant part of the drain ends up in the river. Additionally, baseflow filters generally overestimates the baseflow during peak events.

Comment 6. The interpretation of the simulations results needs to be improved and expanded and framed in relation to e.g. geology and hydrological processes.

Authors' response: As mentioned earlier we will extend the discussion on the results.

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Comment 7. In line with one of the other reviewers I have difficulties understanding Fig. 8.

Authors' response: We will extend the description of Figure 8.

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