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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.

Anonymous Referee #2

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This paper describes the application of loosely coupled WetSPA and MODFLOW models to a catchment in Belgium. The models are driven by an ensemble of 28 climate scenarios (14 GCMs and RCMs for two emissions scenarios and one timeslice) from the PRUDENCE project. Model results of groundwater discharge and discharge frequency are presented.

This paper has the potential to be a valuable contribution to the study of climate change impacts on groundwater, but is difficult to judge in its current form given the significant weaknesses. There are three main weaknesses in the current manuscript: 1) There is insufficient methodological description to understand what the authors have actually done - this is particularly the case regarding the climate inputs but also the model

linkage and calibration. The approach to climate model downscaling (particularly for GCMs) has implications for the impacts results obtained; 2) The validity of the baseline models is unclear - The authors are lucky enough to have access to a large amount of data – 10 years of flow data and over 10,000 head observations over 10 years. Despite this, the authors have not validated their model. They have fitted it to data and then assumed the model is robust to be used with driving data from outside the climatic range of the fitting data. This is a fundamental flaw in the paper; 3) There is minimal discussion of the results, to enable the reader to understand the causes of the simulated changes and thereby their significance. Section 4 is called “Results and Discussion” but there is no discussion, merely description of Results. Process-based explanations for the impacts observed must be provided for the paper to have any wider value beyond this Belgium catchment

Further specific comments âĂć P10200, L16 – what is “TAW”? âĂć P10200, L26 – are the Quaternary and Tertiary sediments actually “confined” (aquitards above and below; groundwater under pressure) or merely underlain by a low permeability clay layer as described in the text âĂć Why were the A2 and B2 scenarios, only, chosen? âĂć P10201, L14 – describes the analysis done on the RCM data. What about the GCM data? âĂć Was there a baseline assessment done on the GCM data to see if the GCMs adequately represented the baseline climatology, or required re-scaling? âĂć P10201, L20-24 – given the importance of this approach to the methodology, as it produces your changed daily time series, some description is required âĂć P10202, L1 – is WetSpa a distributed model? Equation 1 appears to have no grid-to-grid routing i.e. soil doesn’t receive runoff from upslope. From the description, the model would appear to be a grid-based conceptual model âĂć P10203, L2 – MODFLOW is set-up so that the top layer represents an amalgamation of multiple aquifers and aquitards, presumably with parameterisation representing neither (as they are means of the multiple layers). This approach needs to be justified, and the significance for the results of groundwater heads, discharge etc discussed later âĂć P10203, L23 – what is the “calibration period” – months, years. âĂć If I have understood correctly, the potential

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recharge outputs from WetSpa are used as Inputs to MODFLOW? Are there any other linkages? Figure 5 shows that both WetSpa and MODFLOW provide independent estimates of baseflow. It is unclear how the two are related, and whether the baseflow from MODLFOW has been calibrated (given that no error statistics for the baseflow are given). âĂć P10204, L5 – are these errors for Layer 1 and/or 2? Given that no groundwater heads are presented, it is difficult to judge these head errors. âĂć P10204, L8 – initial timestep are "not used" – for what? How many? âĂć Section 4.1 – the focus on PET is not necessarily helpful as it is AET that is important. PET can increase significantly, with almost no impact on AET or recharge in the situation of low Available Water (i.e. sandy) soil. The results presented in this section on PET, precipitation and recharge do not balance as a result – Precipitation decreases by 50mm; PET increases by 180mm and recharge decreases by only 20mm!! Also, there is no mention of runoff – why? This section should be re-analysed to present and describe what is actually controlling recharge/ âĂć P10205, L17 – why are the groundwater levels being given relative to the ground surface and not to a datumn such as sea level? A spatial change in groundwater head (with no change in the mean) could lead to a change in this metric. âĂć The authors average the results of their ensemble across the A2 and B2 scenarios. The authors should say why this is appropriate, given that A2 and B2 are separate Worlds – in other words, that the future impacts of climate change on groundwater is given by the average of two mutually incompatible worlds âĂć Section 4.2 – what is the reason for the spatial differences – is it merely distance from constant groundwater head cells or also a consequence of spatial recharge differences? âĂć P10207, L1-4 – relating buffering to ranges of discharge flux is interesting, but why should cells with recharge flux of between 1-10 mm/d be well buffered? âĂć L9-10 – groundwater discharge frequency – do you mean the number of days in which there is groundwater outflow? âĂć L12-14 – again an interesting observation, but why should zones with 40-90% frequency be highly sensitive? âĂć Fig 2 – this does not show the "occurrence", as layers are much more extensive. Is it showing the outcrop areas? âĂć Figure 8 – I struggled to determine what each of the lines was showing- needs clearer

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explanation âĂć Figure 9 – presumably all of the dots represent cells in groundwater discharge areas i.e. rivers, wetlands? It shows a lot of cells with low reference discharge frequency which increase – why? Where are these located?. Also shows a lot of cells with high discharge frequency which are insensitive – why? Where are these located?.

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