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Hydrology and Earth System Sciences Discussions

Interactive comment on "Modelling the effects of climate and land cover change on groundwater recharge in south-west Western Australia" *by* W. Dawes et al.

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HESSD-2012-188 "Modelling the effects of climate and land cover change on groundwater recharge in south-west Western Australia" Dawes et al.

REVIEW 1

#1 Abstract is too long . . . Eliminated one paragraph; summarised the results more; moved some text to the Discussion.

#2 The authors should be more specific about the potential effects of climate change

. . . Added paragraph in the Introduction (p4 ln14) to describe general climate change effects across Australia, and in Western Australian context specifically, with references added.

#3 How much was the change in precipitation in Eckhardt and Ulbrich (2003)? I do not know. It is difficult to determine as the value for rainfall is not in the paper, only stream flow and recharge components. The catchment average is about 900 mm / year, and they made monthly adjustments from +13% in January to -23% in July. A 2005 report by the Potsdam Institute for Climate Impact Research (http://www.pik-potsdam.de/members/vtecken/lehre-uni-potsdam/projektseminar-ws-06-07-analyse-institutioneller-anpassungsstrategien/climate-change-in-germany.pdf) concluded that 2050/60 rainfall GCM predictions for Germany are for relatively small rainfall reductions on an annual basis, but stronger seasonal variations.

#4 I would not consider Australia a "small area". Point taken – removed these words.

#5 Is the VFM part of MODFLOW-96? Not as part of any standard MODFLOW96 release. As explained in the text a software engineering exercise replaced the usual MODFLOW EVT module with a VFM module. Appropriate references for this are at the end of the paragraph outlining the VFM.

#6 How was the "extra water" calculated? This was done as part of SWAMS calibration, and a reference to the work has been added.

#7 Why are these three recharge models used? These are simply the recharge models that were included in the PRAMS configuration, with the existing references sufficient.

#8 What was the reason for the different modelling methods used? The text already explains that where models existed they were used as is – conceptualised and calibrated – and in the areas without coupled and available models then a one-dimensional recharge model was used to estimate recharge.

#9 There should be more information on the future climate scenarios than "storylines".

I am quite resistant to this suggestion, as expounding on the climate input could easily add a large amount of text for those not interested in specifics of each scenario. The background and storylines are extensively described in the supplied references (Charles et al; IPCC; CSIRO and BOM; Chiew et al), and the impacts of climate change on individual climatic variables for each scenario (historical and future) is summarised in the tables in the paper. Discussing any pros and cons of the individual scenarios is beyond the scope of this work.

#10 How did you decide which GCM to use in your recharge modelling? Text added to indicate the use of GCM.

#11 Do you mean recharge under plantations is close to zero? Yes. Text changed to be clear on this point.

#12 Are these the results of your study? References to previous recharge estimates under horticulture and urban areas have been added.

#13 What do you mean "between Median and Development"? The full sentence is "Of note is the change in recharge between Median and Development." This refers to the Median and Development climate scenarios outlined in section 2.4.

#14 Why do you mention positive modelled recharge values? Are there areas of negative recharge in the study? I mention it because the SWAMS area has generally lower recharge than the PRAMS area just discussed. And yes, there are areas of net negative recharge, as seen in Figures 2 and 3, corresponding with areas of groundwater uptake by vegetation. The following paragraph already states this.

#15 You stated that WAVES was run using each of the possible variants of GCM and degree of warming assuming no surface vegetation. Here you mention various land covers. That is correct. WAVES was run without land cover for the purposes of ranking GCMs, but in the current section WAVES is used to model actual recharge, and therefore uses various land covers.

#16 If the negative values are an artefact should we ignore these results or are they telling us something about the lower boundary condition? This is a fine philosophical point, and yes it does tell us about the boundary condition, being a fixed head. It necessarily implies infinite two-way movement of water according to local gradients, as in any model using this type of boundary condition. In much of the region there is / was no groundwater table below native trees, so simulating native trees with a fixed water table introduces this artefact. It also supports the observation of a lack of water table under this vegetation. It is useful however, since in one future scenario the sign changes, and remains consistent with the other three areas.

#17 Alter reference. Done.

#18 How does an increase in soil water deficit result in an increase in recharge? Please see the text regarding winter rejected rainfall, i.e. runoff, becoming recharge due to larger soil water depletion in summer. It is counter-intuitive, but an interesting result.

#19 What is the reason for reduced recharge under trees compared to historical and future scenarios? This area has the highest rainfall and has nearly the largest changes in rainfall of any station used in the modelling. For this reason it is most controlled by rainfall.

#20 What do you mean by "as there is direct control over water table depth . . ." For the case of running WAVES stand-alone, all input conditions – most specifically water table depth – are prescribed and kept constant, or varied, as desired. In the coupled PRAMS and SWAMS models, the same vegetation / soil / climate combination can exist across a wide range of depths to water, and therefore this variable is not under direct user control.

#21A I would like to see all the data points to show the scatter. I will supply the figures in separate panels to ensure each line and its associated points are clear. I suggest that these extra graphs go into a Supplemental Section, rather than pad out the main article.

#21B I assume the relationships in Figure 4 are influenced by the groundwater tables present in the area. To what extent is the difference due to groundwater depth? Yes, I would also assume that the scatter in Figures 4 and 5 is induced by the wide variety of groundwater depths. Text should be added describing Figure 4, that the slope of the average data in all the panel is between 1 and 2, i.e. a 1% decrease in rainfall leads to a modelled decrease in recharge of 1 to 2%.

#21C Dominant control in these two regions would be different and the authors should discuss how climate soil and groundwater interact to influence recharge. This point leads from the previous #21B, and can be partially covered by discussing the similarity of the average slope. There is already discussion on the non-rainfall climatic influences in the document, however more text has been added.

#22 What do you mean by a global feature? Are you saying global rainfall is decreasing? I can see the confusion arising from my wording, and it is certainly not what I mean, although I do give context in the following sentence. The first sentence is expanded to avoid this confusion. (As I understand current global warming scenarios, the "average" is for the Earth as a whole to get somewhat hotter and overall wetter.)

REVIEW 2

#1 Abstract should be shortened. Done; also as requested by Reviewer#1.

#2 Including reference regarding recharge increasing as land-use change had a greater effect than climate change. Reference added in discussion about pine plantation removal.

#3 Including other references for human induced recharge change. References added in literature section of the Introduction.

Please also note the supplement to this comment:
http://www.hydrol-earth-syst-sci-discuss.net/9/C2829/2012/hessd-9-C2829-2012-

supplement.zip

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 9, 6063, 2012.