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Geoscientific Model Development Discussions

Interactive comment on "Beyond the bucket – Developing a global gradient-based groundwater model (G^3M v1.0) for a global hydrological model from scratch" *by* Robert Reinecke et al.

Anonymous Referee #2

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Review of "Beyond the bucket . . ." by Reinecke et al

This work presents a global groundwater model, coded based on the MODFLOW formulation to couple to WaterGAP. Model formulation is presented. Steady state simulations driven by recharge were conducted and are compared to observations and other models (which I applaud). This work is interesting, as global groundwater stores are of tremendous scientific importance to the hydrologic community and the paper is generally clearly written. I have listed several points below that I think need to be addressed before suitability for publication can be assessed. Hopefully these points help the authors focus this work and improve the clarity and quality.

Bigger picture, conceptual questions:

1. Is 5' an appropriate resolution at which to simulate groundwater flow? The analysis by Krakauer et al may be useful in determining the appropriate resolution.

2. The work is coupled to WaterGap at 0.5deg, this is a really large scale discrepancy âĂŤ how do you think this might alter the model results?

3. The comparisons between this study and Fan et al and Maxwell et al are interesting. While pressure head is important, I think the bias from these scatterplots, basically water table depth, is more meaningful (as plotted in Fan et al / Maxwell et al too). The statistics will really be driven by topography which can occlude model performance and differences.

4. The diagram for how the model handles topographic breaks (Fig 1) is super confusing. Basically is water moved between cells even if there is a disconnect?

5. The assumption of confined conditions really seems hard to justify. This is effectively what de Graaf et al (2015, 2017) do with their two layer MODFLOW model with a stream package connection to PCRGLOB. There are so many assumptions present I think more careful discussion of how sensitivities in these assumptions (e.g. parameters in what amounts to the stream package used here) and feedback back to the WaterGap (which I think is just one-way at this point) would be really important.

6. From Figure 2 it appears that not all the features are implemented in this model, or perhaps not all the features are activated except for recharge. Since the abstract discusses capillary subsides for plant water use but this feature is not described (nor is it entirely clear how that would be implemented as a simple flux), I think a thorough re-working of this discussion and assumptions are needed. Unfortunately, this figure begs the question why is a methods paper in GMD incomplete and not presenting all the model features?

7. The maps of water table depth seem to have a tremendous shallow bias. It is

hard to say because of low figure resolution, but perhaps most of Eastern N America, most of Australia, half of Europe and all of Tropical Africa are under water. I think additional discussion is needed here at least. Could this be due to the steady state assumptions? Confined conditions? The stream aquifer package? Resolution and slope? ET feedbacks?

8. It's hard to tell what the difference is here between the PRCGlob-MODFLOW model and this current model. More discussion is needed to clarify this distinction. I actually feel it's okay if there are many similar models out there (and both can be good models or bad models, it's not a competition), I would like more dissection of the differences in approach.

9. The current model is also completely different from the Central Valley model. This strikes me as odd too. Is it water use? Boundary conditions?

References Krakauer et al Groundwater flow across spatial scales: importance for climate modeling, ERL (9), 2014

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