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Hydrology and Earth System Sciences Discussions

Interactive comment on "Coupling a groundwater model with a land surface model to improve water and energy cycle simulation" *by* W. Tian et al.

Anonymous Referee #2

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General comments:

This study couples a three-dimensional groundwater model with a land surface model, and validates it over an arid region in northwestern China. The coupled model seems to produce plausible soil moisture and ET where water table is shallow, which is consistent with previous work. The authors use a coupling method that is typical in the literature: land surface model handles ET and surface hydrology, while groundwater model simulates soil moisture and water table given upper boundary condition and sink term. The coupled model could be readily implemented into climate model once its computational deficiency has been solved. This paper certainty fits the scope of HESS, and the results are interesting as they shed light on the surface-subsurface interaction over an arid region, and provide a land surface modeling framework that

considers lateral groundwater flow. However, I think it will need some work before it can live up to its potential. Also, please do not unduly extrapolate the conclusions beyond what the results can support.

Major comments:

1. One deficiency of the paper is insufficient validation. I understand that the authors only select three typical sites due to limited access to data over western China (Yuan et al. 2008a) and computation resources. To complement it, I suggest the authors conduct a set of experiments with original AquiferFlow model, and compare the simulated soil moisture and ET (could be obtained by simple algorithm based on soil moisture and potential ET, P1169) with SiB2 and the coupled model. In fact, sometimes empirical ET formulation is not bad if there is strong coupling between shallow groundwater and surface fluxes (Yeh and Famiglietti, 2009).

2. The authors offer two time coupling schemes: concurrent with land surface model and daily time step. They use the second one due to computational limitation, however, they do notice that the step change of soil moisture at the beginning of a day will affect the groundwater recharge to the surface soil, and lead to the underestimation of ET if upper soil is not wet enough. To investigate the effects of diurnal cycle of groundwater recharge on ET, I suggest the authors to select a small subdomain where water table is not too shallow or too deep within the study area, and conduct a sensitivity experiment by using two different time steps for the groundwater model. The lateral boundary conditions could be provided by the large-area groundwater simulation that has been done in this study.

3. The spin-up process is important for land surface modeling, especially for the deep soil hydrology. The authors only spin-up the model for four years. Is it enough to obtain the equilibrium of soil moisture and groundwater especially if the water table is deep (Fan et al., 2007; Yuan et al., 2008b)? How about repeatedly using the four year data for spin-up?

4. Please do not overstate your conclusions. For instance, 1) Fig. 4 could not support the authors' argument in P1182 "Furthermore, the GWSiB simulation could provide a more stable relationship between precipitation and soil moisture than the SiB2 simulation. . ."; 2) there is no "diurnal variation" (P1183) information in Fig. 5, and discussing about diurnal cycle does not make sense since GWSiB uses a daily step for groundwater in this study; 3) the attribution of underestimation of ET in YK station to the daily time step of groundwater model is questionable. The water table depth is over 70m, how can we expect groundwater could contribute to surface soil moisture and heat flux?

5. I do not think the irrigation experiment at YK station is fair to SiB2 model. Why do not the authors simply add the irrigation amount to the term "precipitation reaching the ground surface (Pg)" and then compare with GWSiB? Again, for all three sites, do the authors carry out similar spin-up procedure for SiB2 model before comparisons?

6. Since the authors are doing three-dimensional groundwater modeling, a plot showing spatial distributions of baseflow and groundwater recharge rate (flux between the third and fourth soil layer) would be helpful to identify the contributions of lateral and vertical groundwater fluxes. These could be incorporated into Fig. 10.

Specific comments:

7. The introduction includes a nearly full literature review for the coupling of groundwater model with land surface models, which indicates that the authors are very familiar with this field. However, it misses some work in China. For instance, Tian et al. (2006) implemented a subsurface runoff scheme with variable water table into CLM2; Yuan et al. (2008b) coupled a groundwater model with BATS and regional climate model RegCM3, and investigated the local and remote effects of water table dynamics on regional climate.

8. Please move the information of the thickness of three soil layers in SiB2 from section 3.2 to model description section 2.2.

9. To be consistent with SiB2 model, the authors specify the depths of the first three layers in the coupled model as 0.02, 0.48 and 1.5m (Section 2.3). However, the numerical 3-dimensinal groundwater model usually has fine vertical resolution. Is there any numerical instability in the application? The authors also mentioned in section 3.2 that the thicknesses of the lower three layers of the coupled model are determined by the aquifer information. This is reasonable and sometimes critical to land surface hydrology modeling. Yuan and Liang (2011) show the importance of bedrock data to soil moisture and water table modeling. So my question is: what if the bedrock depth is shallower than 2m? Are the specifications of three soil layer depths still valid? Perhaps it is not a problem in current study, but it will affect the application of the coupled model at large scales.

10. P1174, "Runoff is not the key hydrological process in this region; thus, the coupled model can be used here." Usually runoff consists of surface and subsurface runoff (baseflow); I guess the "runoff" in the paper only means surface runoff since the coupled model considers lateral groundwater flow which is part of subsurface runoff. So please revise it to "surface runoff" throughout the paper.

11. Fig. 1, please make the text in the flowchart more clearly.

12. Fig. 2, when validating the simulation of water table, it is better to use water table depth since the absolute value of water level is too large and it is difficult to see the difference between observation and simulation.

13. P1180, L3, it is better to use "spin-up" instead of "calibration" P1183, L5, add "the" before "same period . . ." P1186, L16, "supply" should be "supplied"

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