Hydrol. Earth Syst. Sci. Discuss., 8, C1432–C1436, 2011
www.hydrol-earth-syst-sci-discuss.net/8/C1432/2011/

Hydrology and Earth System Sciences Discussions

Interactive comment on "Spatial and temporal connections in groundwater contribution to evaporation" *by* A. Lam et al.

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Received and published: 12 May 2011

We thank you for your comments, that certainly will improve our paper. We will clarify sentences that you found strenuous, in spite of the compliments that referee ♯1 paid for the style and language of our manuscript. However, we prefer to revise rather than to resubmit our manuscript.

Specific comments:

RC: To the benefit of the Authors, I have listed page/line numbers where necessary revision is highly recoomended (only until p. 1546, I hope the Authors will find them useful....) (line numbers omitted)

Authors reply: Thank you, we will seek to improve all of those.

RC: P 1543, lines 18-20: This argument is strong. Can the Authors cite some references to support the argument?

Authors reply: Certainly. We will add some references in the revision, that we also list here:

- LSMs underestimate long-term temperature memory: Joanna Syroka, Ralf Toumi, 2001, Scaling and persistence in observed and modelled surface temperature, GEOPHYSICAL RESEARCH LETTERS, VOL. 28, NO. 17, PAGES 3255-3258, SEPTEMBER 1, 2001.
- LSMs underestimate long-term soil moisture variability: Katul, G. G., A. Porporato, E. Daly, A. C. Oishi, H.-S. Kim, P. C. Stoy, J.-Y. Juang, and M. B. Siqueira (2007), On the spectrum of soil moisture from hourly to interannual scales, Water Resour. Res., 43, W05428, doi:10.1029/2006WR005356.
- CMs not able to replicate interannual persistence: Martin Hirschi and Sonia I. Seneviratne, 2010, Intra-annual link of spring and autumn precipitation over France, Climate Dynamics Volume 35, Numbers 7-8, 1207-1218, DOI: 10.1007/s00382-009-0734-1
- Memory improvement by hydrological processes in LSM helps predictability of heatwave: Weisheimer, A., F. J. Doblas-Reyes, T. Jung, and T. N. Palmer, 2011, On the predictability of the extreme summer 2003 over Europe, Geophys. Res. Lett., 38, L05704, doi:10.1029/2010GL046455. .

RC: P 1544, lines 11-15: Questions 1 and 3 are partially overlapped, aren't they? suggest to clarify.

Authors reply: Agreed. We will clarify by targeting question 1 at average contributions in time and space, and question 3 at persistence, as we already do.

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RC: P. 1544, lines 18-20, Please explain quantitatively the contrast between the "meso-scale" and "regional climate scale".

Authors reply: Any quantitative division would be rather arbitrary, but let us say that meso-scale is in the order of tens of kilometers, while regional scale would be in the order of hundreds of kilometers. We'll add this in our revision for clarification.

RC: P. 1546, line 4 - why 7-day timestep was used? Can it capture the dynamics? I seriously doubt. Land surface use 30-min to 3 hrs timesteps in order to calculate the flux exchanges between different reservoirs, how can it be done using 7-day timestep? Need a strong justoification.

Authors reply: As the referee implies, the 7-day timestep is too long to mimick fluctuations in ET on an hourly or similar timescale. We agree with that. On the other hand, the seconds-to-hourly timescale of ET fluctuations does not correspond well with the daily resolution of the forcing data. The Penman-Monteith equation that we employ is a standard approach to estimate daily average ET. Once the timescale permits (or forces) to omit diurnal fluctuations, the upscaling to 7 days is not nearly as problematic, as the diurnal variation of E is much larger than the variation of daily average ET between consecutive days. In other words, the approximation $f(\bar{x}) \approx f(\bar{x})$ is much better for a daily-to-weekly upscaling than for an hourly-to-daily one. The weekly timescale is sufficient to mimic seasonal variation in ET and groundwater contribution to E, which is the purpose of this study. We will augment the discussion with these issues.

RC: Second, the introduction of background information takes 9 pages (p. 1942-p. 1950), but the presentation & discussion of results are only 4 pages. This ratio is not acceptable. Suggest to shorten the background information, and enhance both the contents and quality of discussion on the results and well spell out the implication and shortcoming of this study. None of them have been reached in its present form.

Authors reply: We concede that we can improve on the discussion as it is. Referee ♯1 has several suggestions towards improvement that we can apply.

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RC: Third, the objective of the manuscript seems rather vague to me. Some key statements read contradictory to each other such that I was really confused about the clear idea the authors would like to express. An example is from p. 1554, line 24 to p. 1555, line 2. So, what is the main point here? Latral groundwater flux is not neccessary to be included, but it helps to close water balance? Difficult to understand indeed.

Authors reply: The main difference between our model and usual LSMs is the inclusion of groundwater bodies and rivers. The groundwater and river compartments in our model produce both local (vertical) and lateral (horizontal) mass fluxes, fluxes that are absent in usual LSMs. When we explore whether or not our extension is useful, we find that the additional vertical exchange (groundwater-river interactions included) is necessary for the surface climate and the horizontal exchange is not necessary for the surface climate. Given that our extension produces both, we will express more clearly that land surface modelers can reap some minor benefits from our extension.

RC: Further, although the Authors repeatedly argued that considering groundwater processes will help close water balance, but has this been demonstrated in this paper? I am afraid not at all.

Authors reply: We offer to give a better description of our goal. Adding transport of runoff by rivers and transport by aquifers mends a gap in the modelled hydrological cycle, and is instrumental to represent essential timescales / memory in land surface modelling. In our frame of mind, the water balance equation in many LSMs lack some essential terms, and are not necessarily in error in other aspects. The description alone of previously ignored processes in LSMs helps to close this gap, but admittedly does not necessarily achieve water balance closure.

RC: Same thing apllies to their statement that "Goal of this research was to investigate the importance of groundwater and groundwater convergence to the regional scale evaporation and through this on regional climate."

Authors reply: If the referee argues that we did not find and present results pertain-

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ing to the importance of groundwater and groundwater convergence to the regional scale evaporation, we obviously disagree. We do show that groundwater is important as a source for dry season evaporation and we show that, at the scale of GCMs or RCMs and in flat terrain, groundwater convergence is not important as a source for evaporation.

RC: Finally, some relevant reference have not been adequatedly cited. A quick search over the WRR, JH, JHM using the key words such as "groundwater-vadose zone interactions", "groundwater evapotranspiration" or "Groundwater-supported evapotranspiration" will come out some more references not cited yet in the manuscript -

Authors reply: There are indeed a few papers that we missed, and some of those will prove useful to support the narrative of our revised manuscript.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 8, 1541, 2011.