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Hydrology and Earth System Sciences Discussions

Interactive comment on "Parameterizing sub-surface drainage with geology to improve modeling streamflow responses to climate in data limited environments" *by* C. L. Tague et al.

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We appreciate the comments here regarding how applicable might this work be to other regions. We think this is a very interesting question and certainly the subject of future work. We add some additional discussion in several sections throughout this paper to both a) expand on our description of the geology of the region and in particular its likely link with the hydrologic parameters used in our model, and b) some thoughts in the conclusions on how regions with less clear contrasts in geology might be dealt with.

Regarding the reviewers specific comments:

1. In the first sentence of the Methods section, the RHESSys model is described as spatially distributed. It would be helpful to include a sentence describing the spatial structure of the model so the reader doesn't have to search out the provided reference.

We added the following description of RHESSys spatial objects:

"As a spatial model RHESSys discretizes the landscape into a hierarchy of spatial objects including watersheds, hillslopes that drain to either side of a stream reach, zones which are areas of similar meteorological forcing within hillslopes and finally patches which are typically 30m to 90m scale modeling units. Most vertical hydrologic and carbon cycling processing is done at the patch scale; while shallow subsurface moisture redistribution occurs between patches at the hillslope scale and a deeper groundwater store is also modeled at the hillslope scale."

2. Regarding the RHESSys model parameter descriptions on page 8673, it would be good to provide dimensional units for the parameters. This is particularly important for"m" and others critical to later parts of the discussion. Does a large value of "m" mean that K diminishes more rapidly with depth?

We have added units and also explicitly show how m and K are related by adding in equation 1 to the paper (as other reviewers were also confused about the use of "m")

3. Line 17, p 8674 – What criteria were used to select the four calibrated parameter sets from the generally acceptable dataset?

We have added: "Parameter sets were selected to cross a range different parameter values, but all gave model results within the acceptable performance criteria".

4. Last sentence of p 8675 uses the term "sensitivity" where the ïňĄgure caption uses the term "preference".

We changed the text to match the caption.

5. Results section top of page 8676 – It would be good to add discussion relating the

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results back to the hydrogeology of the WC and HC landscapes. For example, the finding that the CLEAR (HC) watershed showed improved performance with lower values of K and higher values of m (which I assume means that K decreases more rapidly with depth) relative to the WC watersheds seems counterintuitive. I would expect HC watersheds to have thinner and less well-developed (i.e. more permeable) soils than WC watersheds.

We agree that more detailed discussion was needed here (and other reviews had similar concerns), therefore, to address these we added:

"Improved performance for WC watersheds occurred with lower values of m relative to HC watersheds. Lower values of m denote a steeper decline in hydraulic conductivity with depth; and are consistent with shallower hydrologically active soils. This result is consistent with the more well-developed clay and bedrock confining layers associated with the older WC geology."

6. Line 15, p 8677 – Begins the sentence: "Thus, for the HC watershed a deeper groundwater store must be included based either on the initial or more stringent criteria for parameter selection." But according to table 2 it appears that no HC watersheds met the more stringent criteria.

We removed "based either…", and rewritten as: "Thus, for the HC watershed a deeper groundwater store must be included."

7. Second paragraph of page 8878 – The 20 percent bias in the simulated streamïňĆow is attributed to error in precipitation inputs. Could the bias possibly be related to the commonly poor correspondence between groundwater and surface water catchment areas and the tendency for subsurface ïňĆow between drainages in the High Cascades? This would be worth mentioning I think.

Good point – we added the following:

"Further work using improved precipitation input estimates will also test whether under

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prediction reflects geologic controls. In particular the disorganized drainage of the HC portion of SF may in some cases lead to inter-basin subsurface water transfers. This effect was shown to be small for the CLR watershed and we do not expect it to be a significant loss here but further work would be needed to confirm this."

8. Line 4, p 8682 – It would be worth pointing out that the results described mirror the findings of Mayer and Naman (2011) based on analysis of historic data.

Thanks for pointing this out! We added this in:

"These results are consistent with empirical findings (Mayer and Naman, 2011) on the sensitivity of streamflow to temperature in this region."

9. Finally, I found figure 3 to be not very intuitive and difficult to understand. An expanded discussion on how this figure was generated (and addition of units) would be helpful.

We re-worded the description as follows:

"Calibration preference (or improved performance) for particular parameter value is demonstrated by a shift of the cumulative distribution of NSE or NSElog for that parameter relative to its cumulative distribution within the calibration set (shown in Figure 3 as a solid black line – this can be interpreted as the reference distribution). Generally departures above the reference distribution indicate preference for parameter values in that range and vice-versa."

We agree that this approach to describing parameter sensitivity is not particular intuitive, however, it has been used in a variety of papers – and its actually one of the clearest ways that we know of to show how calibration influences parameter selection.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 9, 8665, 2012.