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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 would like to thank Dr. Wang for the review of our paper and thoughtful comments. Our responses to each are below.

1. The hypothesis or the parameters to be transferred (i.e., subsurface drainage characteristics) is presented in the last paragraph of Background section. It might be better to present this earlier part so that readers can grab the key research question of this research at the beginning. The authors may consider combine the Introduction and Background sections.

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Interactive Discussion

Discussion Paper

We agree and have presented the basic hypothesis that geology can be effectively used for parameter transfer in the first paragraph of the Introduction. We have also reorganized and rewritten the Intro/Background sections based on Luce's review.

2. For the 6 calibrated parameters, gw1 and gw2 are for deep (slower) groundwater drainage. The other four parameters (k, m, po, and pa) are for soil transmissivity and holding capacity. It is understandable that gw1 and gw2 are dependent on the geologic classes. It will be helpful that the authors discuss the dependence of other 4 parameters on the geologic classes. This will explain the premise of the approach for transferring parameters.

We have expanded the discussion of parameters used in this study to justify why we might expect them to depend on geologic classes, as follows:

"We hypothesize that the younger, deeper groundwater dominated HC region will lead to higher values of gw1. We also note however that soil water-holding capacity (parameters po and pa) and shallow subsurface drainage (m and K) are also likely to depend on the time taken for soil development. Western Cascade soils are derived from bedrock that has weathered in place for up to 30 million years over which time a wide range of clay species have developed forming impervious layers and aquacludes. Infiltration rates are high with abundant residual stones and clasts (Dyrness, 1969), and soils are shallow due to mass wasting and creep. HC soils in contrast are much younger (less than 7 million years), and typically lack abundant clays and corresponding impermeable layers. They also occupy much lower gradient portions of the landscape, meaning that hydraulic gradients are gentler."

3. What's parameter(s) for the drainage characteristics for the shallow groundwater storage in the WC systems? I guess they are related to the four parameters (k, m, po, and pa). The difference between the shallow and deep groundwater systems can be discussed based on the calibrated parameters between HC and WC, or parameters in HC (k versus gw2?).

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Interactive Comment

See response to previous comment where we clarify the role of different parameters.

4. For the deep groundwater, is linear storage-discharge relation used for modeling deep groundwater drainage?

Yes, we add a line to clarify this in an expanded description of the RHESSys hydrologic process model (Methods section), as follows:

"Deeper groundwater flow of water that bypasses the shallow subsurface flow system is modeled at a coarser hillslope scale (unit draining either side of a stream reach) using a linear storage-discharge relationship."

5. For consistency among ïňĄgures, the authors can choose the best parameter set (instead of randomly selected) from each watershed or HC/WC for demonstration of ïňĄgures such as Figures 4-7.

Following the argument of equifinality by Beven and Freer (2001), we randomly select parameters from acceptable sets because we cannot really state which of the parameters in the acceptable set is actually best. Depending on how calibration is done, any of those parameters might have been selected as the “best”. For this reason we look at results from several acceptable parameter sets to ensure that results are not due to the specific parameter set selected from all possible “acceptable” ones. To further clarify we add the following two sentences:

“We argue that any of these parameter sets could be selected as the “best” parameter set in a calibration process, depending on criteria used or calibration period. We examine results from 4 parameters within the acceptable set to ensure that our results are not overly dependent on which “acceptable” parameter set is chosen”

6. It will be helpful that the authors explain the end-member parameter method in the texts. The end-member method is explicitly explained in the caption of Figure 5 (i.e.,“parameters are varied spatially according to HC/WC geologic classiïňĄcation. . .”). I fully understand this until I read Figure 5.

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We do define the “end-member” approach in the Methods section, but have added an additional line similar to Figure 5 caption for clarity:

“We use an end-member mixing approach, where drainage parameters within SF are assigned based on drainage parameters for “pure” WC and HC watersheds. In other words, parameters are varied spatially according to HC/WC geologic classification within the SF watershed. The pure “WC” and “HC” parameters are the generally acceptable drainage parameters from the calibrations of HC and WC described above.”

7. Line 14 in page 8674: exponential decay of saturated conductivity? Be specific in case the readers are not familiar with the RHESSys model.

Changed as requested: “the exponential decay of saturated conductivity with depth”

8. Table 3: Please add units for the parameters if applicable. Addressed as requested.

9. Figure 6: add a 1:1 line? A 1:1 line has been added to each graph in the figure.

10. The authors may explain the Figure 3. For example, the y-axis value corresponding to parameter m=2.0 for the watershed HORSE is around 0.2. What does that mean? Is the y-axis a cumulative probability?

We add a sentence to Figure 3 to clarify x and y axis in this Figure – note also that this method, used to examine the effect of calibration on parameter selection, is described in more detail by Thorndahl et al. (2008), which is cited in the text referencing Figure 3.

“The y-axis gives the cumulative probability of the performance measure (or parameter distribution). The x-axis gives the value of the parameter.”

11. Lines 25-26 on page 8678, “For W2, we selected parameters that met the . . .” I am confused with this sentence since parameters from W2 calibration are excluded (lines 23-25 on the same page)

We added the following to clarify approach:

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"For simulations for W2 itself, however, we use parameters that met the more stringent criteria for W2 and the initial criteria for all WC sites."

12. Line 16 on page 8680: Editing may be needed since end-member method is used only for SF watershed. For other watersheds, the parameters are based on model calibration. We removed end-member from the sentence.

13. W2 may be removed from the study watersheds due to the limitation of streamïňĆow observations. The special characteristic of W2 sometimes distracts the readers from more important discussions.

We agree (and other reviewers point to this also) – we edited to reduce confusion.

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