

## ***Interactive comment on “Comparing sensitivity analysis methods to advance lumped watershed model identification and evaluation” by Y. Tang et al.***

**Y. Tang et al.**

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Note to the Editor: The results presented in our original manuscript were based on model runs which utilize uniform potential evapotranspiration (PE) throughout the year. In order to improve the quality and generality of our sensitivity results, the updated manuscript has been amended to show results based on monthly average PE data. Although the new PE data resulted in very minor shifts in parametric sensitivities, these edits did not significantly impact any of the overall findings or conclusions for the original study. These changes and those requested by referee # 1 will be reflected in the final submitted manuscript.

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In the text below, we provide a detailed list of the editorial changes made to our new manuscript based on referee #1's requests.

#### Technical Edits Suggested by Referee #1:

1. 3334 Abstract lines 1-5. First sentence too long and cumbersome. Separate setting down of the 4 methods from the broad intent of the study.

Authors' Edits: The suggested edit has been made. The long sentence has been broken into two sentences as shown below. This study seeks to identify sensitivity tools that will advance our understanding of lumped hydrologic models for the purposes of model improvement, calibration efficiency and improved measurement schemes. Four sensitivity analysis methods were tested: (1) local analysis using parameter estimation software (PEST), (2) regional sensitivity analysis (RSA), (3) analysis of variance (ANOVA), and (4) Sobol's method.

2. 3335 Section 1 lines 5,6. water management studies

Authors' Edits: The suggested edit has been made.

3. 3335 Section 1 line 14. Is it too bold to suggest move towards highly complex models of the Duffy type? Suggest moderate this statement.

Authors' Edits: The sentence has been revised as follows. Hydrological models vary in complexity from lumped conceptual models to distributed models that include close coupling of surface and groundwater flow processes, feedbacks with the atmosphere, transport of water and solutes, and spatially explicit representations of system characteristics and states (e.g., Duffy 1996, 2004; Koren et al. 2004; Panday and Huyakorn 2004).

4. 3336 Section 2.1. line 13. "changes in model inputs" not clear at this stage this includes model parameters.

Authors' Edits: Two sentences have been added to clarify that this study only focuses

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on analyzing the sensitivities of model parameters. The added sentences are shown below. Model inputs include model parameters, forcing, initial conditions, boundary conditions, etc. In this study, we focus on analyzing the sensitivities of model parameters.

5. 3337 Section 2.1 line 26. In presenting the 4 approaches for the first time, it would be useful to clarify what method group each belongs to.

Authors' Edits: In the first sentence in the last paragraph of Section 2.1 on page 3337, we have modified the sentence as follows. The four sensitivity analysis approaches include one local method termed PEST and three global methods consisting of RSA, analysis of variance (ANOVA), and Sobol's method. These sensitivity analysis methods were selected for comparison due to their popularity and their common application in a variety of scientific domains.

6. 3339 Section 2.2.1 line 6. Style of introducing equation is poor. Introduce equation in sentence with punctuation. For example: "The composite sensitivity of parameter  $i$  is defined as" and then present equation (1) in line below.

Authors' Edits: The suggested edit has been made.

7. 3340 Section 2.2.2 line 10. "If the ten lines with  $\check{E}$ " - this needs to be expressed more clearly.

Authors' Edits: The sentence was clarified as shown below. The ten lines in the RSA plot represent the cumulative distributions of a parameter with respect to ten sampled sub-ranges. If the lines are clustered, the parameter is not sensitive to a specific model performance measure.

8. 3340 Section 2.2.2 line 18. It is poor practice to point forward to figures (Fig. 5 and 6). Consider revising/rephrasing.

Authors' Edits: The suggested edit has been made. "(e.g., see Figs. 5 and 6)" was removed from the sentence.

9. 3341 Section 2.2.3 line 1,2. Can evidence be presented that supports a normal distributed model response assumption?

Authors' Edits: The normal distribution assumption is implicit in the formulation of the ANOVA method. In this study, we used the root-mean-square-error (RMSE) and the Box-Cox transformed RMSE to measure the model's responses. Histograms of these measures based on 10,000 Monte-Carlo experiments show that they are approximately normally distributed as would be expected from large sample theory.

10. 3341 Section 2.2.3 line 8. The meaning of "objective values" is unclear here.

Authors' Edits: "objective values" has been changed to "model response measures such as the RMSE of streamflow predictions used in this study".

11. 3341 Section 2.2.3 line 17,18. Style of introducing equation is poor. Delete "is shown in Eq. (2):" and rephrase sentence to define variable  $Y_{ijk}$  explicitly; also  $k$  needs to be defined.

Authors' Edits: The suggested edit has been made.

12. 3342 Section 2.2.3 line 3. The coefficient of determination is usually denoted as  $r^2$  (the square of the correlation coefficient), not  $R^2$  which is normally reserved for the  $R^2$  efficiency statistic (that can take on negative values).

Authors' Edits: The suggested edit has been made.

13. 3343 Section 2.2.4 line 11. Style of introducing equation is poor. Delete "shown in Eq. (3):"

Authors' Edits: The suggested edit has been made.

14. 3343 Section 2.2.4 line 17. Replace "shown below in Eq. (4)-(5)" by "as".

Authors' Response: The suggested edit has been made.

15. 3344 Section 2.2.4 line6,7. Rephrase introduction of equations. " The Monte Carlo

È are given below as presented in Sobol' (1993, 2001) and Hall et al. (2005):” Also define the function  $f(\cdot)$  explicitly.

Authors' Edits: The suggested edit has been made.

16. 3346 Section 3.1 line 22,23. Is parameter SI not an areal depletion curve parameter?

Authors' Edits: “SI” is not an areal depletion curve parameter but the “mean water-equivalent above which 100% cover exists” as clarified in table 2.

17. 3348 line 1. “temporal impervious area” - should this be “additional impervious area”?

Authors' Edits: “temporal impervious area” has been changed to “additional impervious area” in this sentence.

18. 3348 line 15 Figure 5 (not Figure 4)

Authors' Edits: The suggested edit has been made.

19. 3352 line 11. Forward reference to Fig. 10a poor style - consider rephrasing.

Authors' Edits: We have removed “(e.g., see Fig. 10a)”.

20. 3352 line 12 then they should be

Authors' Edits: “Than” has been changed to “then”.

21. 3352 line 18 “Sections 6.1-6.4” - consider improving style.

Authors' Edits: We would prefer to keep the original text due to its conciseness.

22. 3354 line 10 Clarify whether parameter SI is invoked if partial cover curve is not invoked.

Authors' Edits: “SI” is not an areal depletion curve parameter but the “Mean water-equivalent above which 100% cover exists”. It is invoked in this study.

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23. 3355 line 19,20. Does normal distribution assumption hold?

Authors' Edits: The RMSE/TRMSE results are approximately normally distributed as expected from large sample theory.

24. 3355 22,23. ..pairwise &#711; E. was fitted to the model.

Authors' Edits: The suggested edit has been made.

25. 3355line 26. coefficient of determination r2

Authors' Edits: The suggested edit has been made.

26. 3356 line 20. most of the SAC-SMA

Authors' Edits: The suggested edit has been made.

27. 3357 line 5. pairwise (and elsewhere)

Authors' Edits: The suggested edit has been made.

28. 3362 line 19,20. between a model's output

Authors' Edits: The suggested edit has been made.

29. 3363 line 10. ..model see Tonkin and Doherty (2005)]

Authors' Edits: The suggested edit has been made.

30. 3364 line 29. ..sample size. Our use of 8192

Authors' Edits: The suggested edit has been made.

31. 3373 Table 1 Meaning of LHS and IFFD acronyms are not known at this stage. Quasirandom

Authors' Edits: The suggested edit has been made to show the full names for LHS and IFFD. "sequence" has been deleted.

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32. 3374 Table 2. MFMIN Minimum melt factor. SI appears to be part of partial cover curve definition.

Authors' Edits: The suggested edit has been made. The "SI" and "Depletion Curve" are separate parameters.

33. 3381 Table 9. pairwise

Authors' Edits: The suggested edit has been made.

34. 3386 Fig. 1. mme/degc/6hr poor notation. Use SI notation: mm \_C-1 6h-1. What is mme?

Authors' Edits: The suggested edit has been made. "mme" should be "mm".

35. 3388 Fig. 3. Omit "The United States Ë names."

Authors' Edits: The suggested edit has been made.

36. 3390 Fig. 5 RSA (Regional Sensitivity Analysis) plot for

Authors' Edits: The suggested edit has been made.

37. 3391 Fig. 6 RSA (Regional Sensitivity Analysis) plot for

Authors' Edits: The suggested edit has been made.

38. 3395 Fig. 10. Change R to r and define as the correlation coefficient.

Authors' Edits: The suggested edit has been made.

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 3, 3333, 2006.

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