

## ***Interactive comment on “Multi-criteria parameter estimation for the unified land model” by B. Livneh and D. P. Lettenmaier***

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We thank Referee 2 for the positive, constructive review and we agree with most of his or her recommendations made. We respond below in the order they were raised. Major comments: 1. We have expanded slightly our discussion on equifinality and model evaluation. We have also cited additional literature and included a statement describing why the performance measures were selected, given the question of how best to calibrate multiple criteria (Q, ET, TWSC), via the use of multiple objective functions. 2. We have included some additional description of our chosen method (MOCOM-UA) in contrast with other methods, and have indicated as well which specific parameters were calibrated, how they were constrained, and how single-criterion Pareto fronts

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were used in comparison with multi-criteria optimization. 3. Point taken. However, we disagree that adding additional model benchmarks fits within the scope of this paper, namely comparing simulated components of the terrestrial water budget with observational data. In fact, the referee's suggestion of using daily/monthly flows is already part of the analysis (for small and large scale optimizations, respectively). We have added a clearer description of this to assure that this isn't missed by the reader. The objective functions include not only a difference in means (as the referee suggests), but also range-shift (difference in standard deviations) and correlations. In our opinion, the use of empirical ET equations or outside hydrologic simulations as additional benchmarks would shift the focus of the paper in a way that we find undesirable, since they bring their own unique set of additional questions (assumptions/limitations of the empirical equations and assumptions/simplifications related to further hydrologic simulations). 4. We have added a more comprehensive discussion of the issue of structural error, our approach is to dealing with these errors, which regions we suspect the model is most susceptible, and whether a single structure is realistically able to represent all the (hydro-climatically diverse) catchments considered in this study. Other comments: 4420, 21. We have added Sac nomenclature . 4420, 23-24. We have added an explanation of why these observations were selected, as well as an explanation for why certain parameters were not selected for calibration. 4423, 24. We have added an additional description of the precipitation gridding algorithm. We did not use any multipliers to adjust precipitation in this analysis and for the interest of space, must refer the reader to the appropriate citation for complete details on the gridding algorithm. 4425, 10. We have added a statement explaining how TWSC was calculated from model outputs. 4426, 13. We have added the other physically based Noah LSM parameters to the table. 4427, 9. The referee's comment is noted. We did not compare the calibration to other methods such as the KGE statistic. This is something we may investigate in future work, but we don't think that it is central here. 4427, 18. We have addressed these comments in our response to major comment 2, above. The number of objective functions was held constant at 3 for all cases in order to preserve the cal-

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ibration algorithm and to facilitate consistency in comparing different (criterion) cases. We now include this point in our updated description of the calibration methodology. 4428, 13. We agree that for flood forecasting, more emphasis on the hydraulics component is needed, in addition to finer temporal resolution of precipitation observations and an ability to assimilate current conditions into the model at the time of forecast. For this reason, we have changed the text from “flood forecasting”, to read “hydrologic forecasting”. 4430, 9. The units of ETsat are mm/month and this has been clarified in the text 4430, 21. We thank you for noting this and have since recomputed the NDVI (shown previously was a VI composite value) such that the values are between -1 and 1. 4432, 18. We have made this change.

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