Hydrol. Earth Syst. Sci. Discuss., 5, S1396–S1401, 2008
www.hydrol-earth-syst-sci-discuss.net/5/S1396/2008/

Hydrology and Earth System Sciences Discussions

Interactive comment on "Constraining model parameters on remotely sensed evaporation: justification for distribution in ungauged basins?" *by* H. C. Winsemius et al.

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Received and published: 3 October 2008

We thank dr. Immerzeel for his useful comments. The comments offer us the opportunity to clarify the focus of the paper in this discussion and to critically review how we brought forward the focus of the research in the manuscript. We will make sure this is absolutely clear in the final manuscript. Below, we address the comments brought forward. We are happy to further discuss in this HESSD issue if necessary.

Referee: 1.To focus of the paper is on the procedure that constrains the parameter distributions. I would suggest adding more information on the hydrological and physical functioning of the basin. To assess the results it would be useful if a monthly water

balance for each major land use would be included. I understand this information is not readily available, but I believe that even by using public domain data a general overview could be presented. This would facilitate interpretation of the results.

Authors: To make a monthly, or even annual water balance, at least long-term estimates of rainfall and either evaporation or discharge are needed over the different land covers. Although long-term rainfall may be retrieved from for instance the Global Historical Climatology Network or Climate Research Unit, information about other water balance terms is simply not available, not even in extensive databases such as the Global Runoff Data Center and RivDIS. The Luangwa river is a truly ungauged basin with its related problems. On p. 2298. l. 15-17, we show the annual water balance of the whole basin, by mentioning that on average, about 15 % of annual rainfall runs off. This is the best we can do at this stage and we hope that our modelling efforts can reveal more information about the water balance.

Referee: 2.The conceptual model is a simplified version of the HBV model. To my opinion the model and the stratification is oversimplified. Only two model parameters (Ip and Smax) are used and a basin covering an area of 150 000 km2 is stratified in only five zones. The strength of RS algorithms such as SEBAL is foremost the high spatial resolution, which is not optimally used when only five zones are used. I understand the risk of equifinality, however constraining more parameters at a higher spatial resolution would be legitimate to my opinion. I would suggest to evaluate whether this is feasible and if not I would suggest to devote a substantive part of the discussion to this topic.

Authors: this is a critical point and the authors would like to stress that the choice of treatment of the SEBAL evaporation was a very careful one. Let us explain it in further detail: indeed SEBAL has a high spatial resolution, which may seem to be a justification for introduction of a wide amount of parameters. However, it remains a difficult comment, because the referee assumes that SEBAL is highly deterministic and not subject to a lot of noise. The authors already presented an overview of a number of possible sources of noise on p. 2298, l. 25-29 that will emerge especially over highly

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heterogeneous regions. This makes the validity of using SEBAL as a 1×1 (km)^2 calibration data source in natural areas highly doubtful and can be the reason of serious bias in parameter values due to over-conditioning of the model parameters. In fact, in the theoretical case that noise is completely uncorrelated in space, by spatial averaging the effect of noise would decrease by the square root of the amount of pixels averaged. In the true case, this noise decrease may be less, but it will for sure decrease. This is exactly the reason why the authors have chosen a 'soft' approach in the use of this data source and selected larger regions with a dominating land cover to constrain parameter distributions. Furthermore, the scientific issue of this paper is exploration of the information content of the data without looking for the optimal model and for this purpose, introduction of numerous parameters in the soil routine has no added value: it would result in equifinality as the referee already pointed out and as a result, ill-identifiable parameter response surfaces, which would compromise our ability to interpret the results. Some of these issues have been explained in section 3.2. We were now able to physically interpret the results of the response surfaces which we describe in section 4.2. I hope we've clarified our purpose but the authors are very happy to further discuss this debate in this HESSD interactive discussion.

Referee: 3.The authors have used SEBAL evapotranspiration to constrain model parameters for transpiration. How did the authors take into account the evaporation component?

Authors: This is a terminology problem. Literally, evaporation is the process, where water transfers from the liquid to the gas phase. Whether in the form of soil evaporation, open water, or transpiration, it is all evaporation. We make reference to (Brutsaert, 1982) for this term. We'll add a short description of our interpretation of the term evaporation.

Specific comments

Ref: P2293 The title is not clear. I suggest changing to justification for distributed

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parameters *Auth*: Ok, we will add 'parameters' to the title.

Ref: P2294 l8 Precipitation is the largest water balance term *Auth*: of course true, we will change the sentence.

Ref: P2294 l9-10 How to the model results provide better understanding of the information density of RS ET? *Auth*: This is the case if the use of this information reveals identifiable parameters and if there is physical reasoning in the posteriors. It becomes clear in the results and discussion.

Ref: P2294 l15-20 It seems strange that wetlands are suffering from moisture stress *Auth*: Not the wetland as such, but the vegetation in the wetlands suffer from stress, because of their shallow rooting. This is explained in a later section but indeed not entirely clear in the abstract. We will revise the sentence.

Ref: P2293 l27 Replace 2 with two. *Authors*: Ok.

Ref: P 2297 l21-25 Major issue in this study was that streamflow was regulated mainly by reservoirs and thus unsuitable for calibration of natural hydrological processes. *Auth*: We will revise this.

Ref: P2298 l3 Replace space with remote sensing. *Auth*: Ok.

Ref: P2299 l1-3 I would suggest adding a number of references that show validation results for SEBAL. *Auth*: Ok.

Ref: P2299 I suggest adding water balance information on the major zones here. *Auth*: We have dealt with this comment above.

Ref: P2300 l1 Rephrase a great deal with large amounts. *Auth*: Ok.

Ref: P2300 l2 carrying capacity of the rivers. *Auth*: Ok.

Ref: P2300 l8 This is a METRIC publication. *Auth*: We agree with the referee, however metric is largely equal to SEBAL and this reference is one of the most recent and

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complete state of the art descriptions of the SEBAL procedure. Therefore we would like to keep this reference (also agreed upon by the 3rd author who is the founding father of SEBAL)

Ref: P2300 l5 An error has been made H = 0 is true for the cold (wet extreme) pixel. *Auth*: True! This will be altered in the final manuscript of course

Ref: P2302 l5-10 There must be public domain data sources available that provide better land use information (e.g. AfriCover)? This is true. We've considered the use of GLCC or IGBP land cover. On some of our field trips, we found that many areas, given as 'savannah' in these maps, were actually covered with forest. Therefore we were not entirely convinced if these maps were appropriate in some of the unique environments of Eastern Zambia. It is maybe a somewhat subjective decision, but this is why we decided to do a land cover analysis ourselves, based on our field expertise.

Ref: P2302 l19-31 This sentence is confusing. What do you mean with information density of evaporation data? *Auth*: It means that we want to answer the question: to what degree can evaporation estimates explain land surface behaviour. See our earlier comment. We will revise this sentence to make it more clear.

Ref: P2302 l23 an should be and. *Auth*: Ok

Ref: P2303 Although very important the physical meaning of parameter Ip is not described in the manuscript. *Auth*: this was also pointed out by referee Laguardia. We will extend the model description and add a table with the physical meaning of the parameters.

Ref: P2306 There is a very clear bi-modal distribution of Ip for the riverine land use. This is however not discussed. *Auth*: Also pointed out by the other referees. We will add this to the discussion points.

Ref: P2306 l15-25 A more likely explanation for the high Smax is that SEBAL consistently overestimates evapotranspiration over forested areas. This has been found

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in earlier studies and this should at least be discussed here. *Auth*: This could be a reason although in these earlier studies, this is hypothesized, while there could also be other reasons for water balance closure problems (e.g. consistent error in rainfall, unaccounted reservoir releases, etc.), but nevertheless, as referees Laguardia and Immerzeel point out, it could be a reason, which we will add in our discussion, by showing the sensitivity of posteriors for bias in the explanatory data.

Ref: P2307 l15 How does RS ET constrain the model structure? *Auth*: This is indeed perhaps a bit overstated. We have at least not done model structure conditioning. We could change it into: 'can both condition model parameters and reveal model structural deficiencies'. We have seen that model constraints on evaporation lead in some areas to physically unrealistic parameters, which is a hint of model structure problems.

Ref: P2308 l8 distributed instead of distribute. *Auth*: 'evaporation is one of the few opportunities to justifiably distribute parameters', sentence is correct.

Figures *Ref*: Fig 2. The figure is unclear. I suggest a raster image of the DEM with the isohyets superimposed. The overview map of Africa can be smaller. *Auth*: This is a good idea.

Ref: Fig 3. I would suggest splitting the figure in two figures and enlarging both. *Auth*: Ok, We will split the figure in the final manuscript.

Ref: Fig 4. Discuss bi-modal distribution in top right figure. *Auth*: Ok. See our comment above.

References

Brutsaert, W., 1982. Evaporation into the Atmosphere. Reidel, Dordrecht.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 5, 2293, 2008.

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