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Hydrology and Earth System Sciences Discussions

Interactive comment on "Modeling and measurement of two-layer-canopy interception losses in a subtropical mixed forest of central-south China" *by* G. Zhang et al.

G. Zhang et al.

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Dear Prof. M. Bierkens,

We highly appreciate the detailed comments. The suggestions are quite helpful for us and we shall incorporate them in the revised paper. As below, on behalf of my co-authors, I would like to clarify some of the points raised by the Editor.

1. From the introduction it is not clear what the novelty is of the authors' contribution. Application of a model to a new location by itself is not enough to warrant publication in HESS. Possibly the combination of the Gash-model and the spare Gash-model is novel. The authors should then say so and support this first application of the dual model by references.

Response: The comments are valuable to improve the structure of our paper. The novelty of this paper will be addressed in the section of introduction in the revised version.

2. The Discussion part is overly long and often reads like a review. The authors should keep to their own results and only refer to the literature when relevant.

Response: We shall carefully check and concise the discussion part in revision.

3. The English should definitely be improved, i.e. by letting a native speaker look at the paper. Furthermore, to improve the readability the authors are encouraged to not repeat all figures that are already in table, but only mention the main results.

Response: We shall take the Editor's comments into account in revision.

When considering the content of the paper I share the three major concerns of the reviewers:
1. What is the reason for application of the sparse model to the under story and the original one for the top canopy, while the gap fraction of the top canopy is larger?

Response: This question is the similar to that of the Reviewer #1. And we answer it as following:
There was a serious mistake in the expression of the canopy coverage for each layer in the original text. The projected top-canopy coverage of the stand is about 82% and that of the sub-canopy coverage is 41%.
The original Gash model described by Gash (1979) demonstrated that the evaporation of rainfall intercepted by forest canopies can be estimated form the forest structure, the mean evaporation and rainfall rates, and the rainfall pattern. Although the model has been used with some success over various different forests, the model has the weakness in application in sparse forest (Lankreijer et al., 1993; Gash et al., 1995).
The original Gash model tends in theory to overestimate the interception loss from sparse forests as they assume that the evaporation area (canopy and trunks) extends

to the whole plot area, whereas the actual evaporating area (canopy and trunks) is much reduced in these types of forests (Teklehaimonot and Jarvis, 1991). With regard to the sparse forest, the revised Gash model (Gash et al. 1995) can give more accurate estimates of canopy interception loss than the original one.
In our study, the top-canopy coverage is 82%, but the sub-canopy is relatively sparse compared with that of top-canopy, with the coverage of 41%. Therefore, we use the original Gash model to estimate the canopy interception loss in the top-canopy and use the revised Gash model to predict the loss in the sub-canopy. The predicted results estimated by using the different Gash model have been discussed in the original text, but we shall improve the statements in the revised manuscript by taking the Reviewer's comments into consideration.

2. The authors should not only report the average observations, but also the variability between individual gauges and plots.

Response: The throughfall coefficients of variability (CV) are shown in Figure 7 in the revised manuscript. The coefficient of variability of throughfall for all events averaged 11.2$\pm$2.4% and ranged from 6.8$\pm$1.1% to 81.3$\pm$3.7%. The CV of sub-throughfall for all events were estimated to be 5.5$\pm$3.7% and ranged from 2.1$\pm$1.7% to 10.7$\pm$4.6%. The CV values for small events were generally much larger than that for large events. The CV values for $\sim$90% of events, especially for the event precipitation higher than 10 mm, were less than 25%.
For the large events (precipitation $>=$10 mm) in the Shaoshan forest stand, throughfall accounted for higher than 85% of the incident precipitation, and ranged from 74.1$\pm$1.5% to 93.4$\pm$2.1% (Figure 6 in the revised manuscript). The proportion of incident partitioned into throughfall for smaller events (precipitation $<$10 mm) increased in a linear fashion from 14.1$\pm$1.1% for events ranged from 0.4 to 2.0 mm to 74.8$\pm$3.3% from events ranged from 3.4 to 9.4 mm. The statistical difference of the throughfall depths between the gauges was averaged to be 7.2$\pm$3.4% and ranged from 3.5$\pm$2.7% to 18.6$\pm$4.1%. The variability of throughfall between the measured 10 plots was esti-

mated at 12.7±3.5%, ranging from 5.6±3.2% to 20.8±6.4%.

Figure 6. Throughfall as a percentage of incident precipitation in the study site during the observe year of 2003.
Figure 7. Throughfall coefficients of variation (CV) (%) as a function of the throughfall (% of incident precipitation).

3. The authors calibrate and verify an event-based model on time-averaged observations, while previous literature (mentioned by reviewer # 2) has analyzed the problems with that. The authors should thus analyze the uncertainties involved, possibly recalibrate their model on time series (perhaps they have these) and analyze the degree of uniqueness of their estimated parameters.

Response: Error in the field determination of interception losses was estimated assuming that (a) a random error of 5% in incident event measurement throughout the study year (Gash et al. 1995), giving a total error of 61.3 mm for top-canopy and 51.2 mm for sub-canopy, (b) an error of 11.2% for throughfall and 5.5% for sub-throughfall, estimated on the basis of its spatial variability, and giving a total error of 19.5 mm for throughfall and 10.0 mm for sub-throughfall, and (c) an error of 20% in stemflow (see Gash et al. 1995) giving a total error of 1.1 mm. The quadratic sum of these errors gives a total error of 64.3 mm, i.e. 5.2% of rainfall or 37.0% of the top-canopy interception losses, and a total error of 52.1 mm, i.e. 5.0% of rainfall or 28.6% of the sub-canopy interception losses. Note that his error translates to error in the estimation of canopy parameters, notably S (Gash and Morton, 1978; Lloyd et al. 1988).
Error in the prediction of the top-canopy interception losses with the original Gash model, estimated following the procedure used by Lloyd et al. (1988), was dominated by the errors in S, p, pt, and E, which assumed to be ±0.1 mm, 0.5, 0.01, and 0.02 mm h^{-1}, respectively. And error in prediction of sub-canopy interception losses was dominated by errors in Sc, E and c, which assumed to be ±0.1 mm, 0.01 mm h^{-1} and 0.10, respectively. The method of Rosenbluth (1975) was used to derive an estimated error of ±13.7 mm for top-canopy interception losses and ±11.2 mm for sub-canopy

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losses, respectively.

Some specific remarks of Editor:
1. Page 1999: the 12 throughfall collectors are 1 m above ground. Does this mean that they are at located without sub-canopy?

Response: The throughfall collectors are placed 1 m above the forest ground avoiding the sub-canopy.

2. Rutter et al, 1975 and van Dijk and Bruijnzeel, 2001 are not in the references.

Response: The two references have been listed on Page 2012, line 24-26 and Page 2013, line 14-19 in the original text, respectively.

3. Page 2002, line 19: should it be C$=$S instead of C$>$S, as C$<$A at all times?

Response: We have referred to some published literatures again and revised the expression as following:
Evaporation rate (E) for the saturated canopy of a sparse forest can be estimated as Ep when C$>=$S, or as E$=$Ep$\times$C$/$S, when C$<$S (C is the actual canopy storage and S is canopy storage capacity) (Teklehaimonot and Jarvis, 1991; Domingo et al. 1998; Schellekens et al. 1999; Aboal et al. 1999).

4. Table 5: difficult to read; it would be better to replace it by a Figure.

Response: The selected data in Table 5 is to compare the simulated results in our present case study with the published values derived from the similar Gash models. Table 5 has been revised to improve its readability.

Table 5. Partitioning of interception loss components (Ic, %) into the five stages of rainfall events estimated by the original and revised Gash models.

5. Page 2008, lines 2 to 8: this is a puzzling paragraph, because I would think that if canopy evaporation E is under-estimated, canopy interception will be under-estimated

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as well, not overestimated as stated here?

Response: We thank the Editor for his comment on the canopy evaporation in our original text: "There is a growing number of studies report that wet canopy evaporation rates inferred from throughfall measurements is much higher than that suggested by Penman-Monteith theory, particularly under wet maritime climatic conditions (Rowe, 1983). The overestimate of the interception of storms around the saturation point (when PG is close to PG') by the Gash models can be explained by using of the "waterbox" concept. When the shower is too small to saturate the canopy (PG$<$PG'), the estimated interception is dependent on E and linear with rainfall, and the canopy drip is neglected." But, we think that "the overestimated canopy evaporation rate results in the overestimation of the canopy interception loss" in the original text is not different from the Editor's comment, "if canopy evaporation E is under-estimated, canopy interception will be under-estimated as well".

6. Page 2008, line 23-end page: this is the first time that it is mentioned that in theory the Gash model will overestimate interception. If this is the case, than this should be mentioned already in the introduction.

Response: We agree with the suggestion on the statements in the original text. In fact, we have mentioned the original Gash model tends to significantly overestimate the canopy interception loss in the sparse forests in Page 2001 line 2-4.

7. 2010, last line: The authors claim that canopy structures strongly influence Shaoshan forest hydrology cycle. They cannot make this claim, as they have not related discharge, groundwater recharge and transpiration in relation to canopy properties.

Response: We are in agreement with the comment of the Editor and shall revise the conclusion in the revised manuscript.

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