Interactive comment on “Bi-criteria evaluation of MIKE SHE model for a forested watershed on South Carolina coastal plain”

Anonymous Referee #1

Received and published: 10 February 2010

Page 181 line 26: consider "good candidate" to "important hydrologic variable". Page 181 line 25 to 28: Water table depth is not surrogate of soil moisture. It is true that evapo-transpiration and discharge rate (particularly base flow) depend on subsurface water level, vegetation types, and geology type and structure (e.g. cracked hard rock).

RESPONSE: Good point. The necessary editorial change has been made as follows: “Water table depth may be one of the good candidates of measurable variables to be used for distributed model calibration and validation because it is an important hydrological variable that affects hydrological processes, such as discharge, particularly subsurface drainage, and evapotranspiration and because it varies largely in space and time within a watershed, especially in large river catchments or the watersheds with a low-relief landscape.”

Page 184 lines 5 to 10: The weather station is 3 km away from the study site. Have you checked that there is minimum difference in weather between the study site and weather station particularly precipitation, PET, and wind data. If the all are in the coastal plain and there is no barrier (e.g.) between the study site and the weather station, then there should not be any difference else there should be difference in weather values. In such case how do you relate? Page 184 lines 5 to 10: Has any previous research compared the PET estimated using Penman-Monteith method with measured data?

RESPONSE: There are four stations within the Santee Experimental Forest (SEF), of which three are within the 500 ha second-order watershed (WS79) containing a paired watershed system (WS77 and WS80) and measure only precipitation, air and soil temperatures. The forth station is at the SEF Headquarters (SEFH), 2.8 km away from the study site (WS80) that measures complete weather variables including humidity, wind speed and radiation. All stations are in open areas within the Francis Marion National Forest and there is no barrier as such that could have significant effects on the measured weather data. Therefore, their environments are very similar, including approximate height of measurements, soil, vegetation type and tree age, and their data are comparable. However, there is a small spatial variability in summer precipitation, especially during large storm events. Therefore, on-site temperature and precipitation were used for the model input. However, full weather parameters measured at the SEFH were used to estimate the Penman-Monteith based PET that was input into the model. There is no study yet that compared the Penman-Monteith PET with measured data except for a previous study that compared the estimates of Penman-Monteith based PET with the simple temperature-based Thornthwaite and Hamon PET methods for this site (Harder et al., 2007). However, similar data were used by Harder et al. (2006) and Lu et al. (2006) for their hydrological simulations for this site.

Page 190 line 25 to 28: Have you considered the rooting depth and density based on plant growing and dying stages?

RESPONSE: Yes, both rooting depth and density of plants are very important parameters to simulate forest hydrology, especially transpiration rates. Because this is a mature forest and the total simulation period is only a 5-year span, the rooting depth change was not considered. However, the root density varied spatially and temporally based on vegetation types.

Page 191 line 25 to 29: Did you use spatial distributed horizontal hydraulic conductivities or weighted average? The sentence is confusing the use of the distributed hydraulic conductivity.

RESPONSE: Yes, the horizontal hydraulic conductivities were based on the distribution of soil types on the watershed. This paragraph has been revised to improve clarity:
"Horizontal hydraulic conductivity affected both streamflow and water table depth. However, different optimal values of horizontal hydraulic conductivity were observed for the two calibrated variables due to large spatial differences in soil properties; for example, using a soil-area-weighted average to represent the spatially distributed horizontal hydraulic conductivity, we observed the optimal values of 0.00008 m/s for streamflow (*E* of 0.77, RMSE of 2.53) and 0.00001 m/s for water table depth (*E* of 0.46, RMSE of 0.18). Thus, a spatial range of 0.00001–0.0001 m/s for horizontal hydraulic conductivity was used in simulation based on topography and spatial distributions of soil type and texture."

page 192 line 24: have you considered the rooting depth and density for each vegetation types? If plant rooting depth and density is important for water table estimation, then it is also important for stream baseflow during summer. Baseflow depends on the water level of the area near to the streams during continued sunny days.

RESPONSE: Yes, please also see the response for Page 190 line 25 to 28. Rooting depth is important for water table depth, ET, and stream flow estimation during summer and low precipitation periods, but unimportant during wet periods in this catchment because the water table this time is very shallow or near surface resulting in saturated or even ponded topsoil with unlimited soil moisture to meet ET demands. However, the line 24-25 was revised to improve clarity:
"For example, the calibration results showed that, the plant rooting depth was not important to streamflow during wet periods (for example in 2003) but became important during low precipitation periods like in 2004, whereas plant rooting depth was a significant factor to water table depth with an optimal value."

Page 193 line 8 to 16: Have you checked the water level in saturated zone during these period. If the model is predicting higher water level, then the model also overestimates the streamflow during these period. If the water level is lower than the stream bed, then there should not be any flow. I can see from Figure 7c that model over-predicts water level. I do not think over-prediction of MIKE SHE is an artifact, because Figure 6a and 7a shows that there is zero stream flow during some months.

RESPONSE: Yes. Water table in saturated zone was checked. It was much lower than the elevation of the stream bed (<50 cm on average) during dry and low precipitation periods. Over-prediction of water table level was observed mainly during wet periods. The statistical result for water table can be found in Table 4a and 4b. The water table level was under-predicted for most wells, especially for dry periods.
Fig.6a and 7a may seem to show zero simulated flow for dry periods in this site. However, zero flow was not allowed by MIKE SHE in any period. The simulated minimum flow was >0.1 mm per day for no-flow periods in this study site. The problem is that the size of the figures is too small to explicitly display very small flow values. Although the simulated minimum flow for no-

flow periods is very small, it can produce a large error for total flow in a dry year. Because this catchment is a first-order headwater watershed, the flow depends heavily on precipitation. For example, 2004 is a dry year; the simulated flow for no-flow periods produced an error of over 30% of the total annual flow. The simulated water table level, showing good agreement with the observation, was much lower than the stream bed for the no-flow periods because this site has a very shallow stream, <50 cm on average.

Figure 6a and 7a: show rainfall in bar chart. It is not continuous, Rainfall events are instantaneous. Figure 7a: it is not that clear. Make thick continuous line for simulated scenario and continuous measured line on it, so that one can see how both overlap each other. Figure 7b: Please take out the error bars because there are lots of points and the error bars does not provide any information anyway.

RESPONSE: Those figures will be replaced by the ones below as suggested.

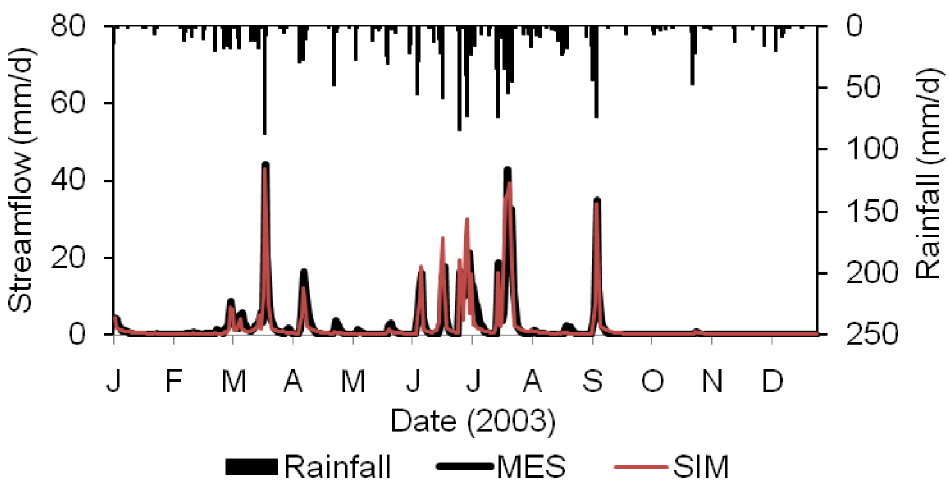

Fig.6a Measured vs. simulated daily streamflow in 2003
(MES = measurement, SIM = simulation)

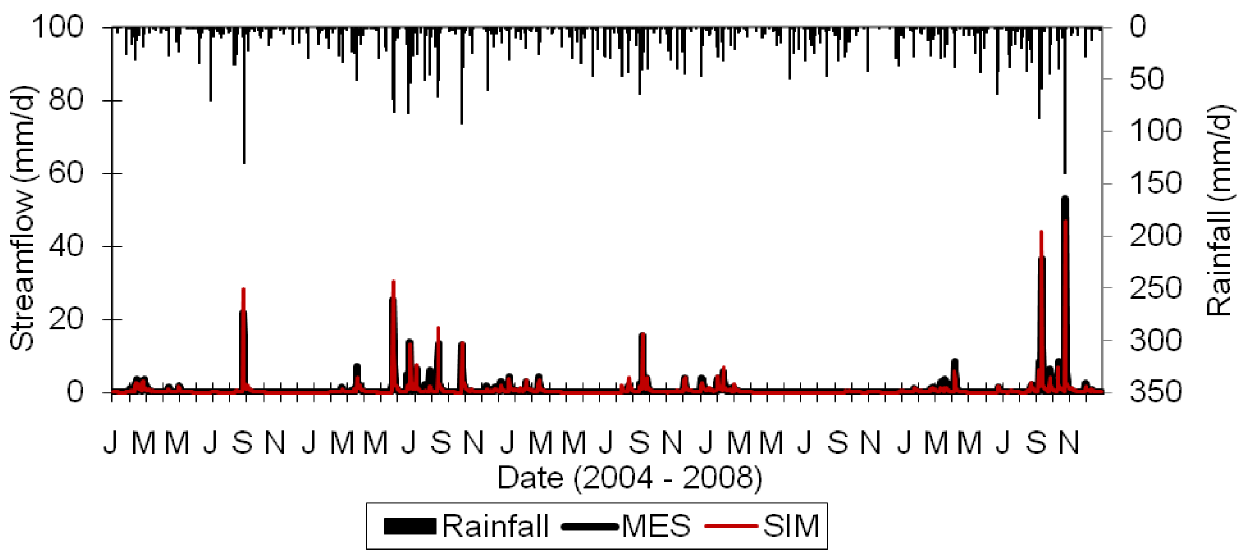

Fig.7a Daily streamflow simulated vs. observed in 2004-08
(MES = observation; SIM = simulation)

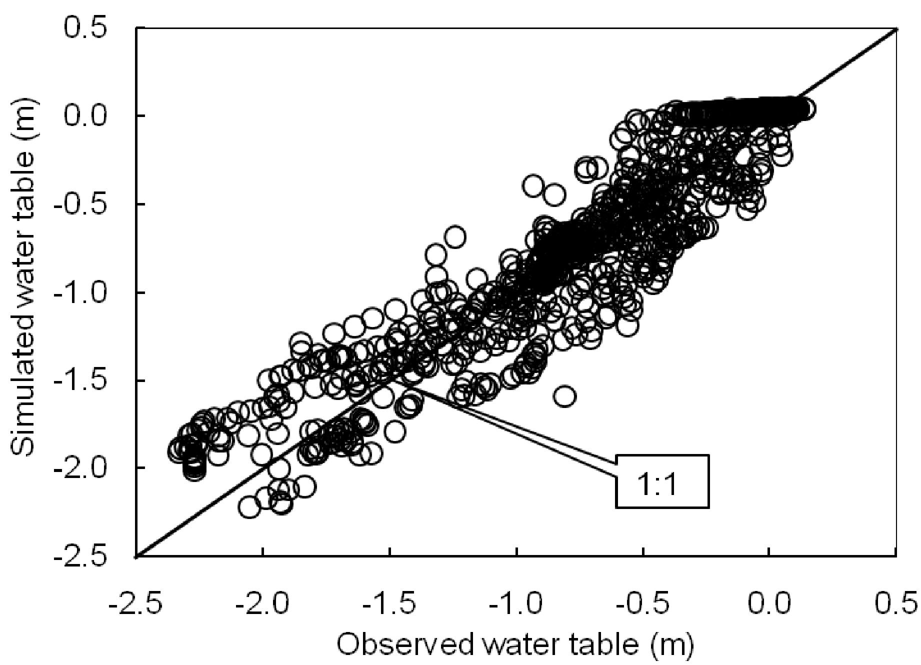

Fig. 7b Water table depth observed vs. simulated at well W3 and W7 in 2004-05