Section 7-9

Evaluation of an *A Priori* Parameter Estimation Procedure

Introduction

This section illustrates how an *a priori* parameter estimation procedure can be evaluated for use in a given region. As mentioned in Section 7-5, is it important to evaluate the derived parameter values based on periods when the effects of each parameter on the hydrograph can be isolated rather than on overall 'goodness of fit' statistics. This is the only way to determine if the procedure is determining physically realistic values for the parameters. It is also helpful to determine if the *a priori* procedure can derive realistic spatial variations in parameter values over a river basin especially when some of the watersheds response quite differently than others or have significantly different values of key physiographic factors.

The Koren [2000] procedure is used in this section to illustrate the method for evaluating the derived parameter values. In this procedure total soil depth and porosity, field capacity, and wilting point information for 11 soil layers (from ground surface to 2.5 m beneath) derived from the STATSGO high resolution gridded soil data files are used to calculate estimates of 11 of the Sacramento model parameters. Tension water is determined as a function of the difference between the field capacity and wilting point and free water as the difference between porosity and field capacity, which is physically what these storages are intended to represent. The capacity of these storages are determined by dividing the soil profile depth into an upper and lower zone and further dividing the lower zone free water into primary and supplemental components. This assumes that the free water and tension water for each zone occupy the same space in the soil profile. This may not be the case. Certainly in most watersheds the primary baseflow, and probably the supplemental, aquifers are further down in the soil than the limits of the root zone which controls the lower limit of tension water storage. The free water withdrawal rates are calculated from empirical relationships. ZPERC is determined using the model percolation equation and assuming that the maximum daily percolation rate is equal to the contents of the all the lower zones, which may not be a correct assumption. The percolation curve shape parameter, REXP, is estimated using an empirical equation that produces low values, near 1.0, for sand and high values for clay soils, which are appropriate. The PFREE parameter is assumed to relate to water that follows paths through cracks, faults, etc. to escape the capillary demands of the soil and it is further assumed that clay type soils have more cracks. The PFREE parameter is actually more likely to be related to the distribution of lower zone tension water depths over the watershed and the fact that some portions of the area are saturated and thus recharging groundwater while other areas still have tension water deficits.

Evaluation

The suggested method of evaluating any *a priori* procedure for estimating model parameters is to compare the simulated hydrograph produced by the derived parameters to the observed streamflow for the watershed. The objective is then to examine the periods when the effects of each par

ameter can be isolated to determine if the derived values are reasonable. In the following illustr ation of this technique, the parameters derived using the Koren method are referred to as soil bas ed parameters.

In order to generate a hydrograph other parametric information is required in addition to the 11 S acramento model parameters produced from the soils information. For the examples in this sect ion these other parameters were determined as follows:

- Sacramento model parameters PCTIM, ADIMP, and RIVA are set to 0.0. Also RSERV is set to 0.3, its recommended default which is typically satisfactory for most watersheds, and SIDE is set to 0.0, which is the case for most areas.

- The ET-Demand curve was either obtained from a calibration of the watershed or from CA P estimates of mean monthly PE and the seasonal PE adjustment curve. If the overall bias was greater than a few percent, the PEADJ factor in the SAC-SMA operation was used to get the water balance within this limit.

- The unit hydrograph was obtained from a calibration or by estimating the channel response and then making adjustments to obtain a reasonable fit of the timing for major runoff events.

- If snow was included in the simulation, the snow model parameters were obtained from a c alibration of the watershed.

Generally when evaluating an *a priori* parameter estimation procedure for the Sacramento model , ET-Demand values would be estimated as described in Section 6-5, the initial unit hydrograph would be obtained as discussed in Section 7-6, and the initial snow model parameters would be b ased on the guidelines included in Section 7-4. In this case calibrated values were used whenev er possible to remove any variability generated by improper values of these parameters.

The first basin examined is the Oostanaula River basin in Georgia. Figure 7-9-1 shows a semi-l og plot comparison of the soil based parameter simulation to the observed flow for the Conasaug a River near Tilton (TLNG1) for a portion of the period of record. Figure 7-9-2 is an arithmetic plot for the same period. These figures indicate that at least most of the soil based parameter e stimates are quite realistic for this watershed. Some slight adjustments are probably needed to s ome of the baseflow parameters, but overall the method derives values that produce a very reaso nable simulation. In Chapter 4 a spatial assessment of hydrologic variability within the Oostan aula basin, based on hydrograph plots as shown in Figure 4-1, indicated that there were significa nt differences in how the Ellijay, Hinton, and Tilton watersheds responded. This assessment in dicated that the percolation rate for Elijay and Hinton should be greater than for Tilton as those watersheds generate much more baseflow and considerably less fast response storm runoff than t he Tilton watershed. In order to see if the soil based parameter estimation

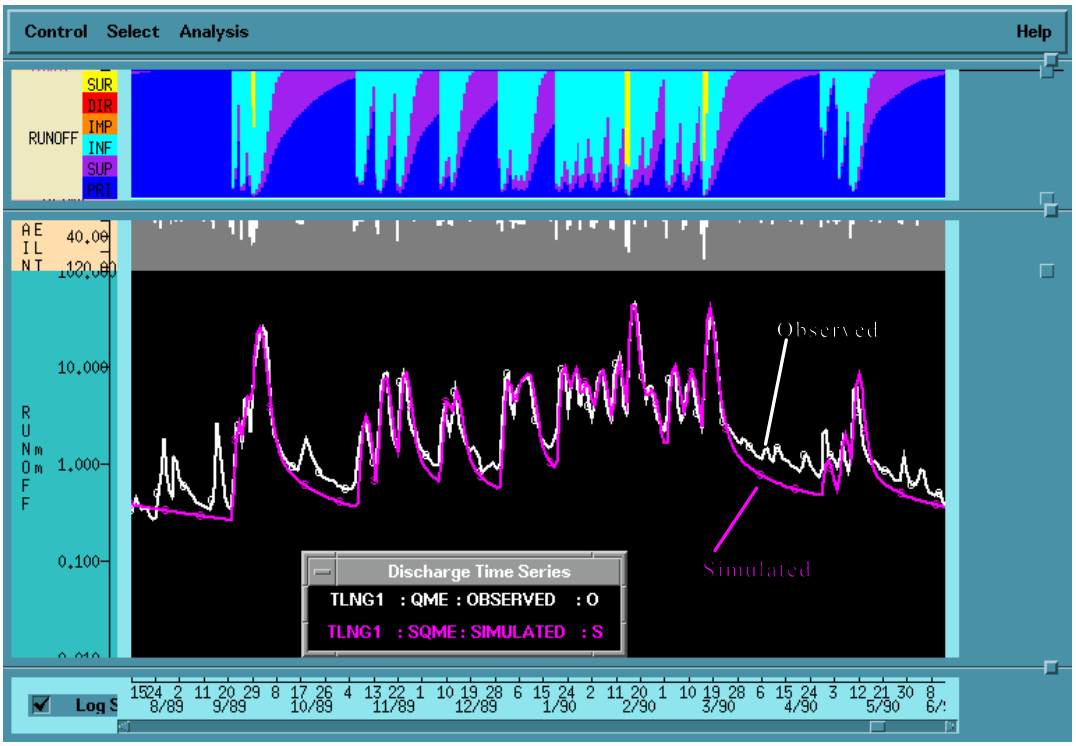
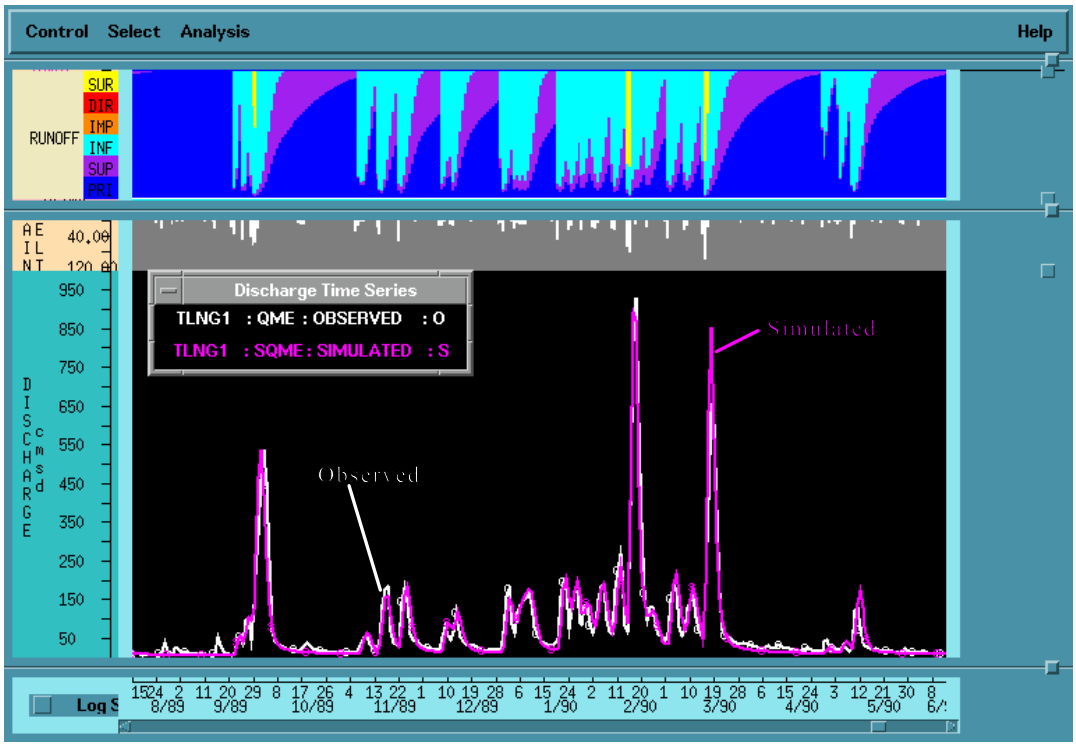


Figure 7-9-1. Soil Based Simulation for Tilton - semi-log plot.

Figure 7-9-2. Soil Based Simulation for Tilton - arithmetic plot.



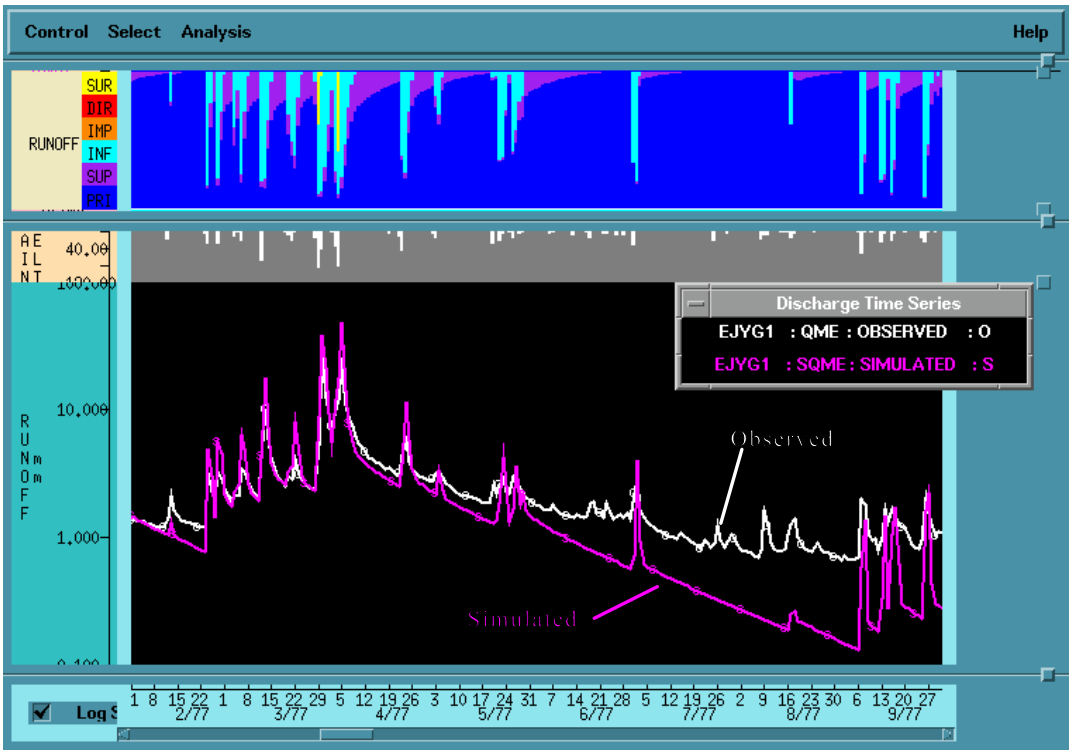


Figure 7-9-3. Soil Based Simulation for Elijay - semi-log plot.

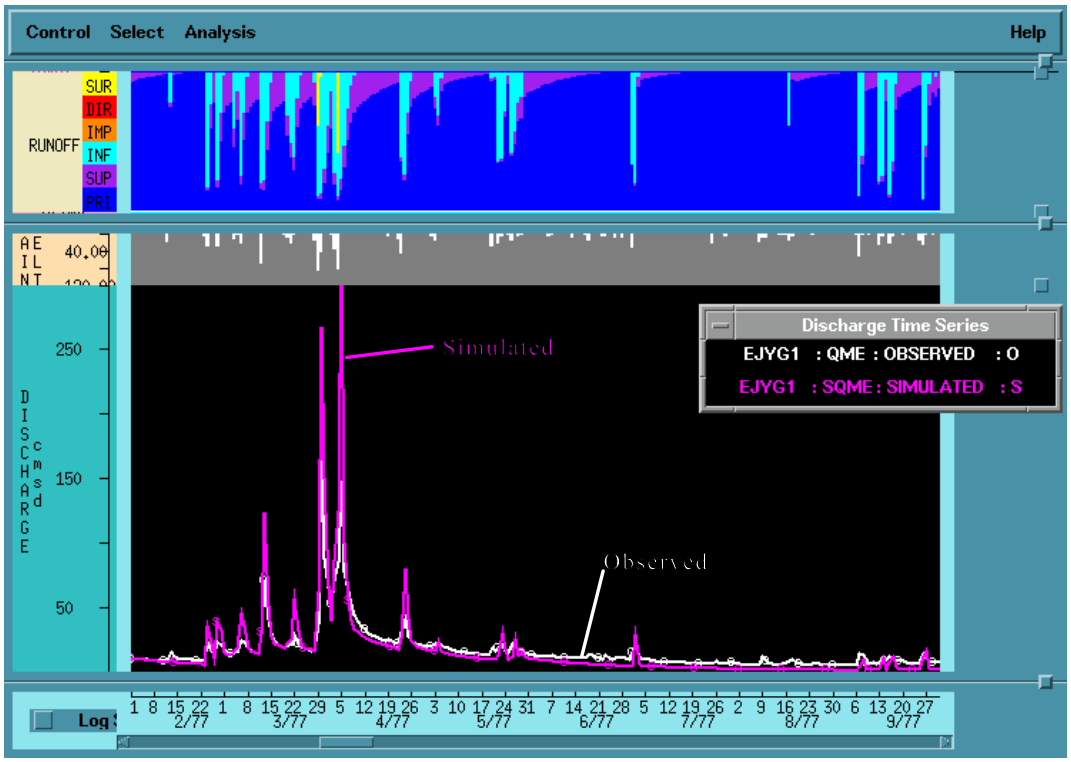
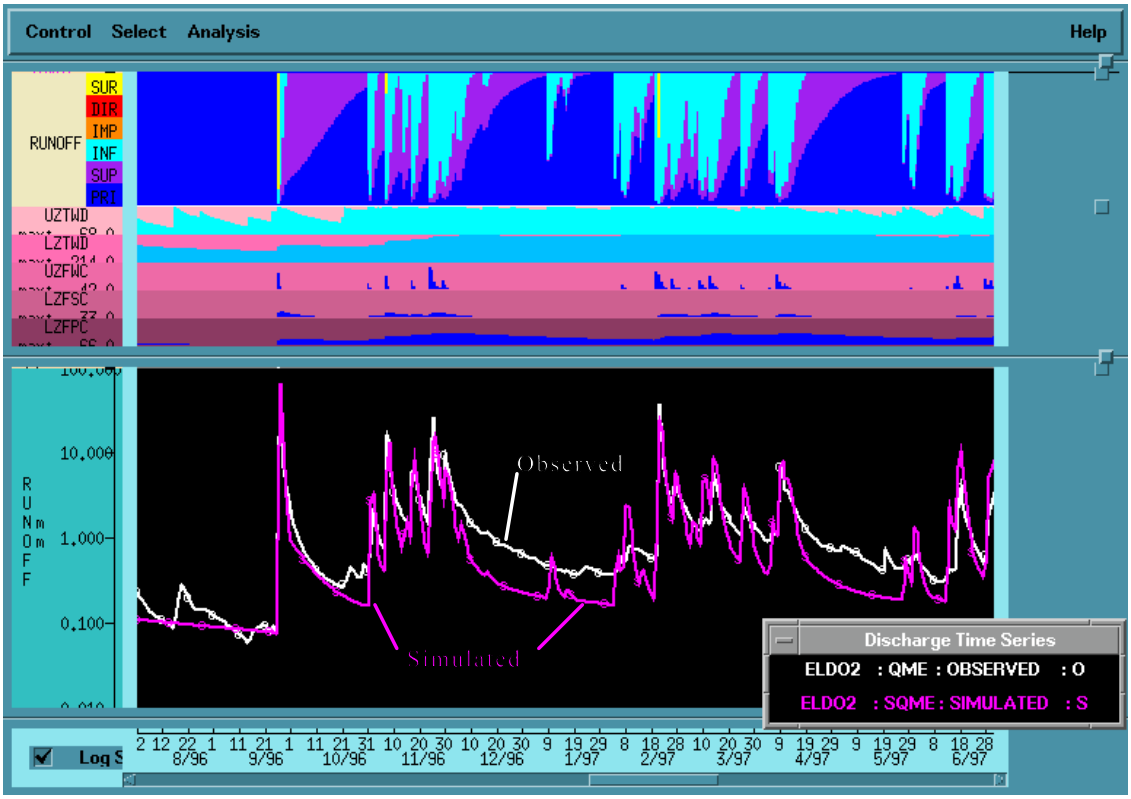


Figure 7-9-4. Soil Based Simulation for Elijay - arithmetic plot.

method could reproduce these differences, the method was applied to the Coosawattee River nea r Ellijay (EJYG1). Figures 7-9-3 and 7-9-4 show semi-log and arithmetic plots comparing the s oil based simulation to the observed flows for this watershed. These plots indicate that the soil based procedure is not able to detect the variability in hydrologic conditions that exist between T ilton and Elijay. The soil based simulation for Elijay generates too much surface runoff and not nearly enough baseflow. The primary baseflow recession is much too fast and supplemental b aseflow is practically non-existent.

The next basin examined is the Illinois River above Tenkiller Dam in Oklahoma. Figure 7-9-5 shows a semi-log plot of the soil based parameter simulation versus the observed flow for a porti on of the period of record for the Barren Fork at Eldon (ELDO2). The figure shows that the soi l based parameters are fairly reasonable and would at least be useful as initial estimates. Some adjustments are needed to the baseflow withdrawal rates and storage capacities. Also the interfl ow withdrawal rate appears to be too fast. Figure 7-9-6 shows a comparison of observed flows at Eldon and the Illinois River at Watts (WTTO2). This figure indicates that the response of the se two watersheds is very similar. Figure 7-9-7 shows a comparison of the soil based parameter simulations for the same two watersheds. The parameters and the resulting hydrographs are b asically the same. Thus, in this case where there is little difference in the response of two nearb y watersheds, the soil based method correctly indicates that conditions are similar.



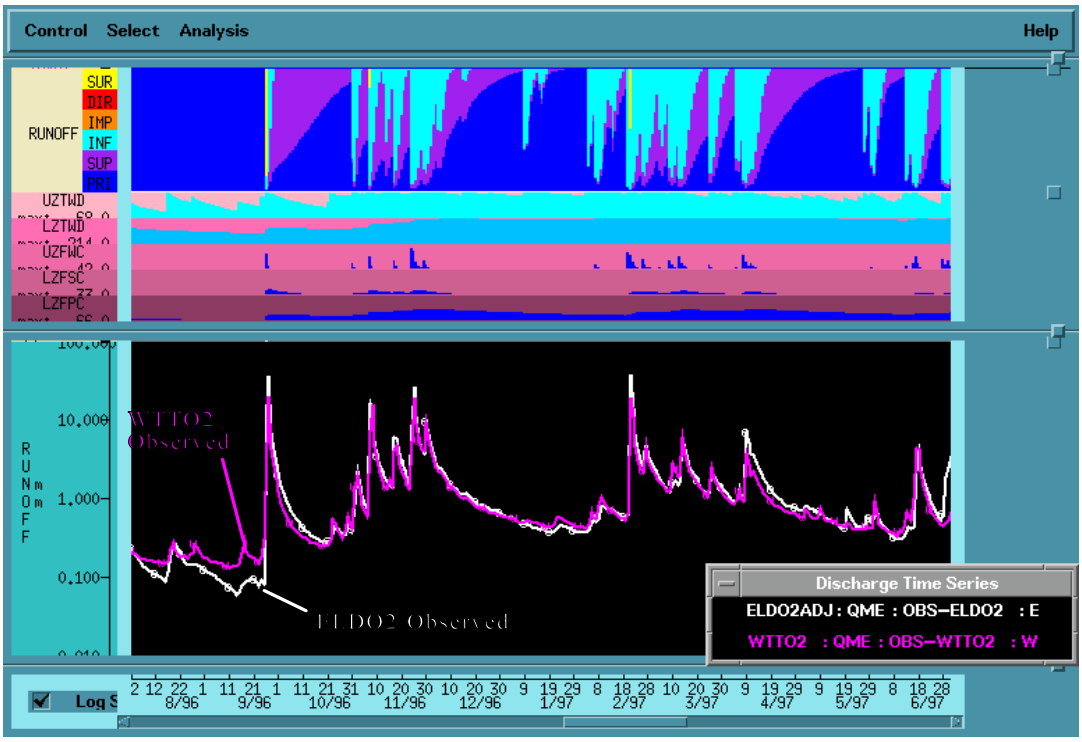


Figure 7-9-5. Soil Based Simulation for Eldon - semi-log plot.

Figure 7-9-6. Comparison of Observed Flows for Eldon and Watts.

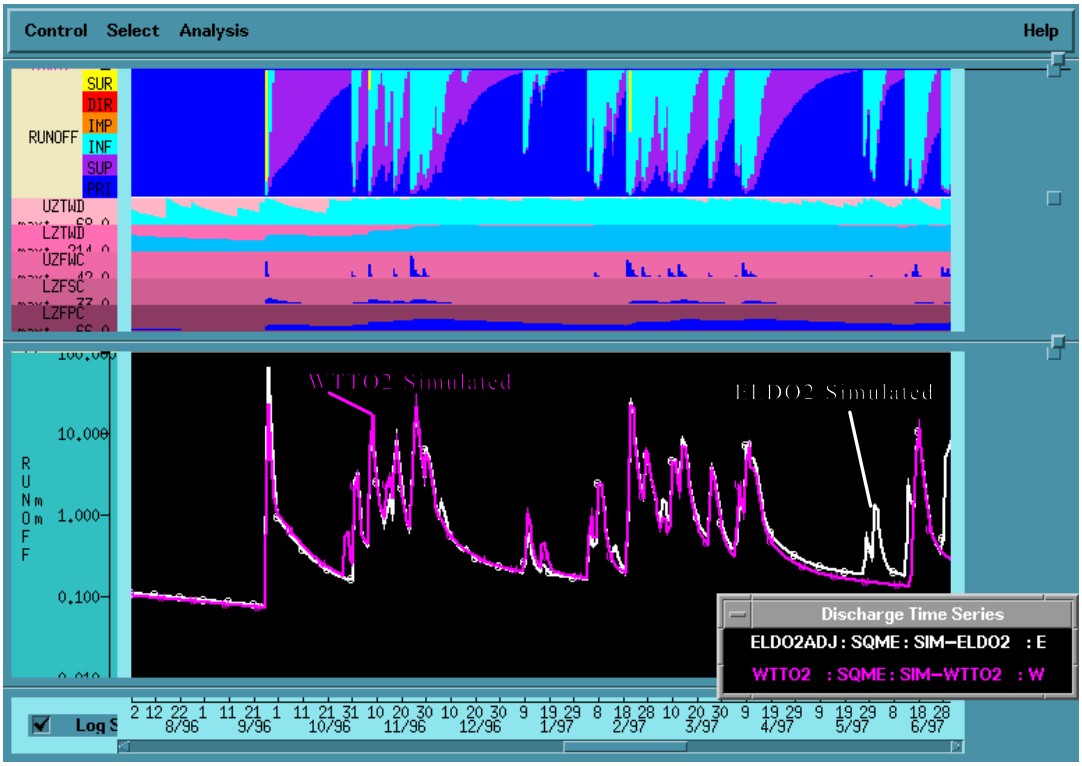


Figure 7-9-7. Comparison of Soil Based Simulations for Eldon and Watts.

The next basin evaluated was the Upper Tombigbee River in northeastern Mississippi. Figure 7-9-8 shows a comparison of the observed streamflows for Town Creek at Nettleton (NETM6) and the Tombigbee near Fulton (FULM6). The response of these two adjacent watersheds is fairly different. Town Creek is mostly within the region called the Black Belt that extends from central Alabama into northeastern Mississippi and contains very black, fertile soil. The Fulton drainage is just outside of this region. The soil based parameter estimation method recognizes that the soils are different between the two watersheds in terms of generating somewhat different values for a number of the parameters (e.g. UZTWM - 33 mm vs. 42 mm, UZFWM - 19 mm vs. 33 mm, UZK - .30 vs. .46, ZPERC - 93 vs. 66, LZFPM - 81 vs. 125, LZSK - .08 vs. .12, LZPK - .010 vs. .020, and PFREE - .37 vs. .26 – the value for Nettleton is listed first), however, as shown in Figure 7-9-9 the simulations using the soil based parameters are quite similar. The simulated hydrographs are much more like the response of the Fulton watershed than Town Creek. Thus, even though individual parameter values vary from one watershed to the other, the resulting soil based simulations do not reflect the differences between the two drainages.

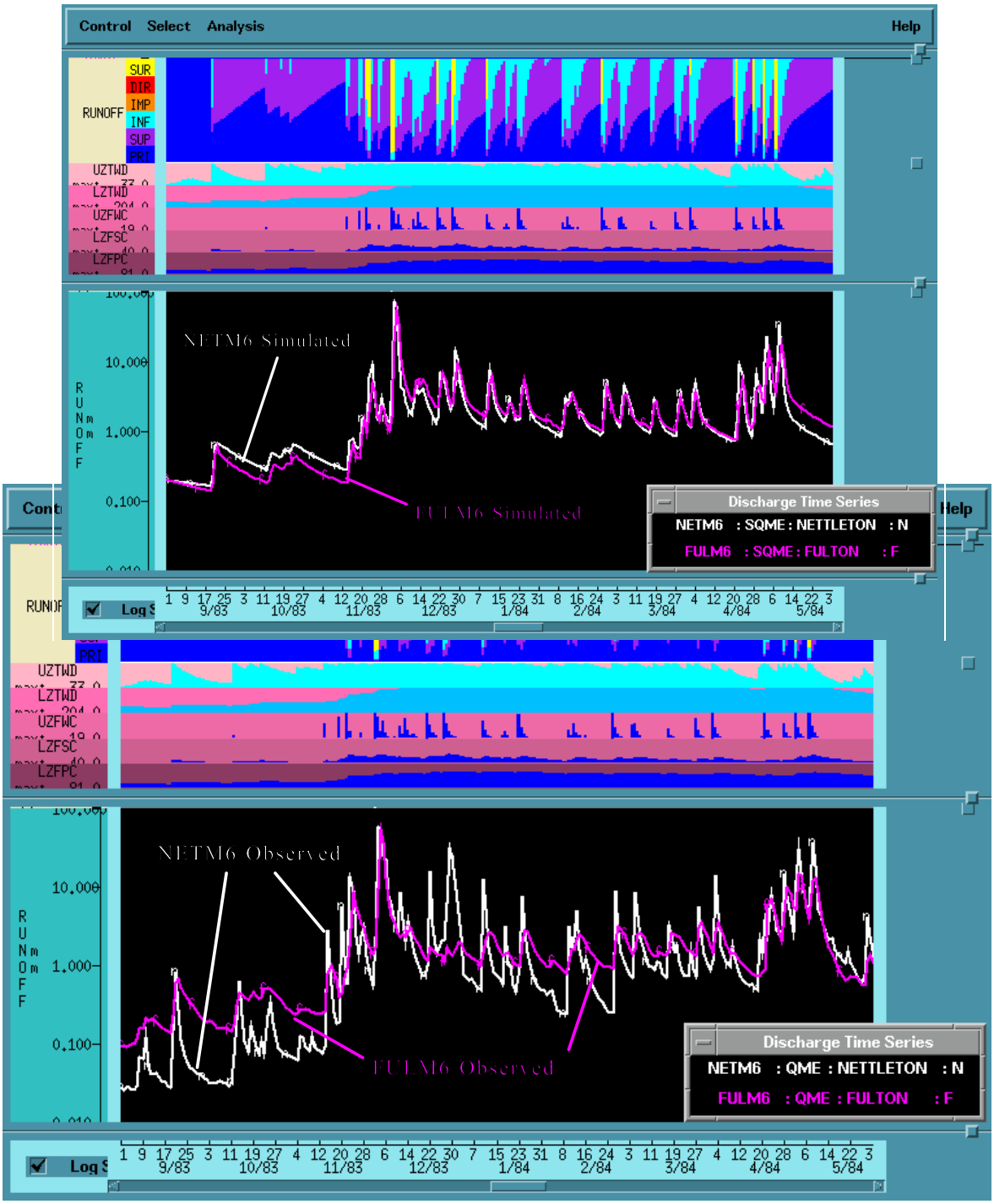
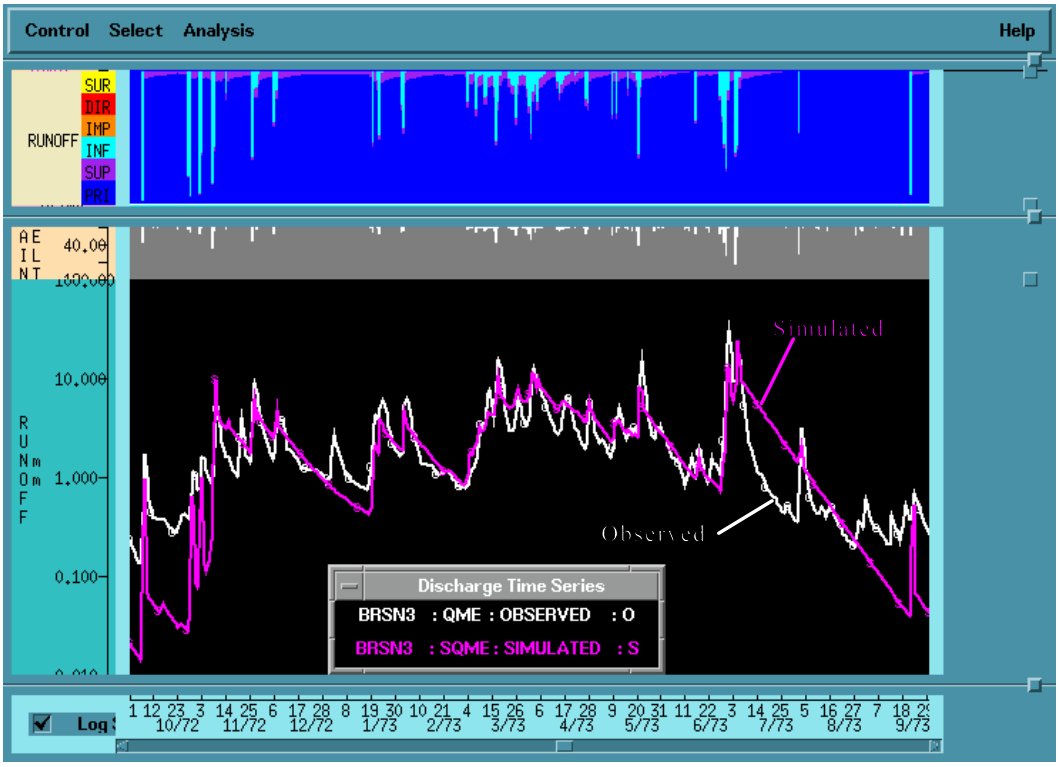


Figure 7-9-8. Comparison of Observed Flows for Nettleton and Fulton.

The next basin tested was the Merrimack River basin in New Hampshire and Massachusetts. Figure 7-9-10 shows a semi-log plot comparing soil based simulated flows versus observed values for the Smith River near Bristol, New Hampshire (BRSN3). Figure 7-9-11 shows an

Figure 7-9-9. Comparison of Soil Based Simulations for Nettleton and Fulton.



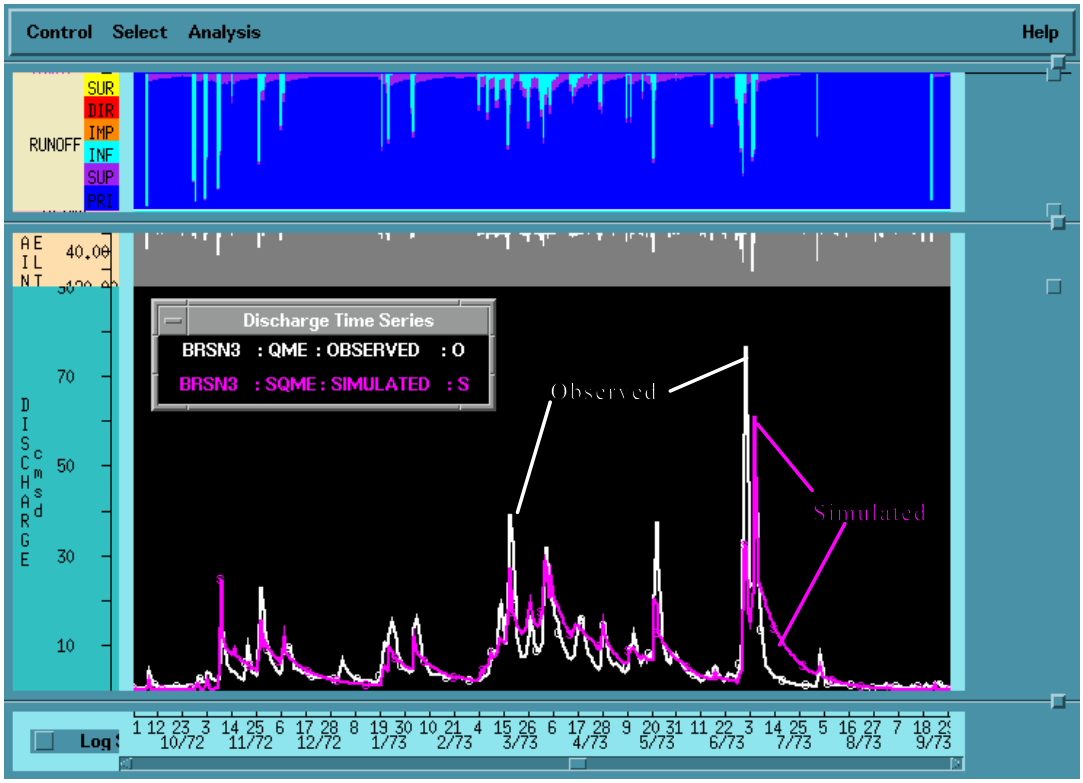


Figure 7-9-10. Soil Based Simulation for Bristol - semi-log plot.

Figure 7-9-11. Soil Based Simulation for Bristol - arithmetic plot.

arithmetic plot for the same period. For this watershed the soil based parameter values are not physically realistic. Almost all of the flow is primary baseflow with some fast interflow during storm events. In reality the primary baseflow withdrawal rate should be much slower, the suppl emental baseflow contribution should be considerable, there should be much more interflow, tho ugh at a slower withdrawal rate, and the largest events should produce surface runoff. Similar r esults were obtained when applying the soil based method to two other watersheds in the Merrim ack drainage; the Pemigewasset River near Woodstock, NH and the Assabet River near Maynard , MA. Thus, the soil based method did produce similar parameter values throughout the Merri mack basin as would be expected based on Figure 4-2, however, the values were not reasonable.

The last watershed examined was the Gallatin River near Gallatin Gateway, Montana (GLGM8). Figure 7-9-12 shows a semi-log plot of the comparison between the soil based simulation and observed flows for this two elevation zone, western, snowmelt runoff dominated drainage. Fig ure 7-9-13 contains an arithmetic plot for the same period. As for the Merrimack basin, the soil based parameters for this watershed are not physically realistic. There is too much primary ba seflow and the withdrawal rate is much too quick, there is not nearly enough supplemental basefl ow, and the amount of interflow is too great and too fast.

For these five basins the results from the Koren soil based parameter estimation procedure are

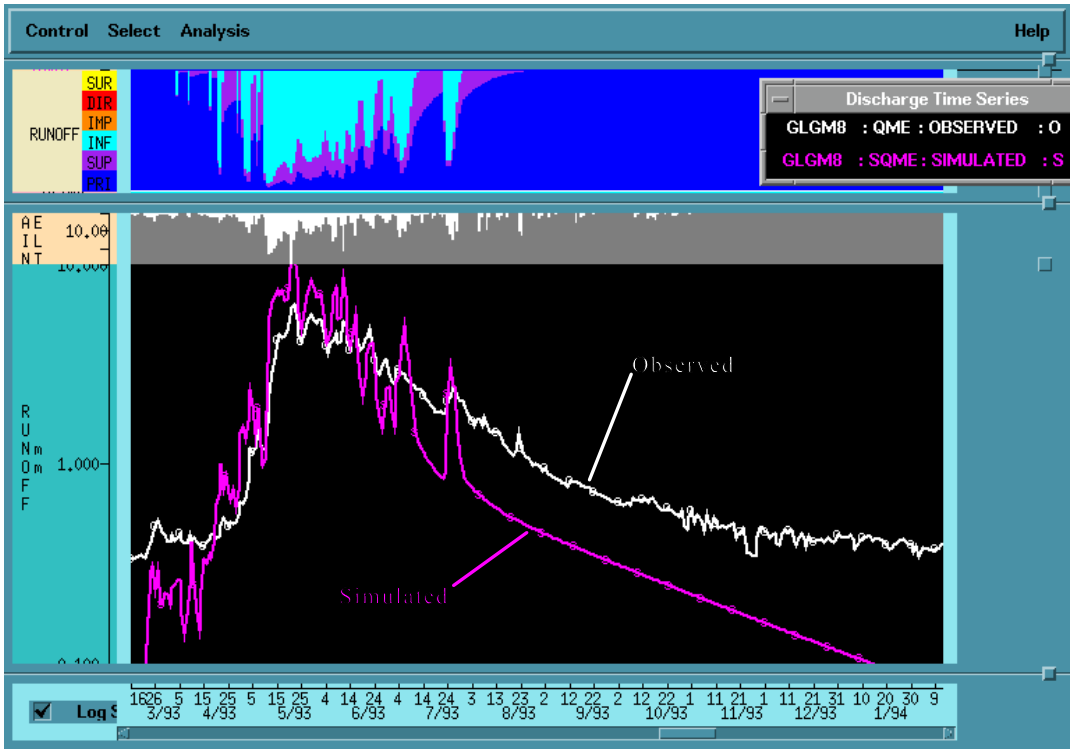
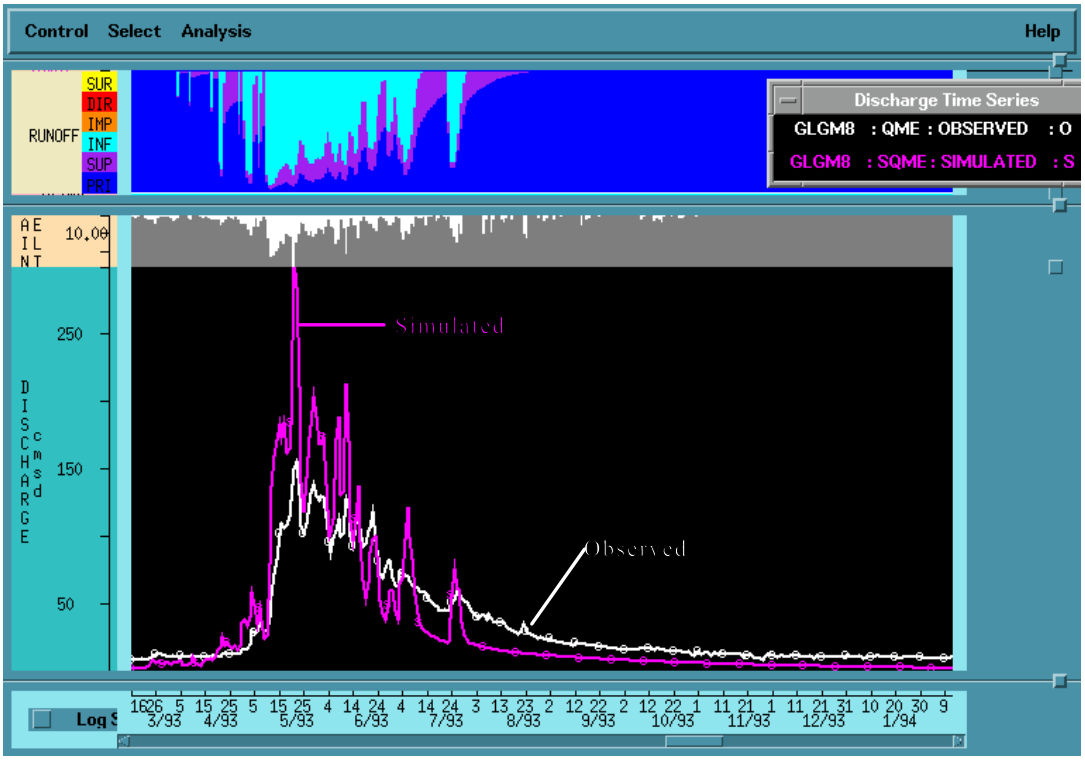


Figure 7-9-12. Soil Based Simulation for Gallatin Gateway - semi-log plot.

Figure 7-9-13. Soil Based Simulation for Gallatin Gateway - arithmetic plot.



mixed. In the three river basins scattered across the southern part of the country, the Oostanaul

a, the Illinois, and the Tombigbee, the soil based method generated values that at least for one watershed in each basin produced fairly realistic parameter values, however, in the two cases where there were differences between the response of adjacent watersheds, the simulations using the soil based parameters didn't reflect this variability. For the other two basins, the Merrimack and the Gallatin, the parameter estimates from the soil based method were not physically realistic and wouldn't be useful even as initial parameter values. It should be noted that, at least in this case, all of the watersheds that exhibited the worse results with the soil based parameters, the Gallatin, Merrimack, and Elijay, were in mountainous areas with considerable forest cover. This could just be coincidence. Overall, the greatest weakness of the soil based method seems to be in determining appropriate values for the free water storage parameters, both the upper and lower zone withdrawal rates and capacities. These are parameters for which reliable estimates can often be obtained by analyzing the observed hydrograph as described in Section 7-5.

Summary

It is critical to carefully evaluate any *a priori* parameter estimation procedure before using it in a given region. Such procedures may work well in some regions and not in others. It is also important to verify whether the procedure will serve the purpose for which it might be used. A given method might provide reasonable initial parameter values for a calibration for some watersheds, but not adequately reflect the variability in parameter values across the region. It is recommended that a given procedure be evaluated by comparing *a priori* parameter simulations to observed flows for several watersheds in the region. The emphasis of the comparisons should be to determine if the parameter values are realistic by looking at the portions of the hydrograph where each parameter can be isolated and not by comparing overall 'goodness of fit' statistics.