HEC-HMS Lab 7: Auto-Calibration of Fish Creek

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Learning outcomes

The objective of this lab is to learn how to calibrate a HEC-HMS model. By the end of the exercise, students will know:

1) How to perform auto-calibration in HEC-HMS by using the Optimization Trial menu

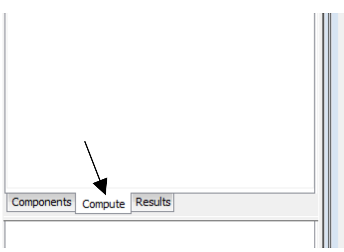
Student Time Required: 60 – 90 minutes

Instructions

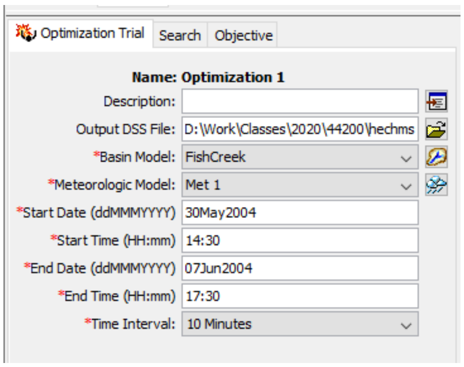
You will use your HEC-HMS model from the previous lab to complete this lab. Before we calibrate the model, change the routing method in your model from Lag to Muskingum. Use K value of 1 hr and X value of 0.5 for all reaches. Also change the CN value and the lag time for the SCS CN and the Unit hydrograph methods to 75 and 2500, respectively for all sub-basins.

Take a screen shot of the HEC-HMS results showing both simulated hydrograph at the outlet and the observed hydrograph. Also look at the errors (mean abs. error, RMS error and volume residual).

Auto-calibration is possible in HEC-HMS through the Optimization trial option in the Compute menu. On the main menu bar, select Compute→ Optimization Trial Manger. Select New and use the default name (Optimization 1), and select appropriate inputs (e.g., the basin file, Meteorologic file, etc) to create the optimization trial. Once this is done, you can click on the Compute tab in the components window (shown below) to see a folder named "Optimization Trials". Expand the folder to see Optimization 1.

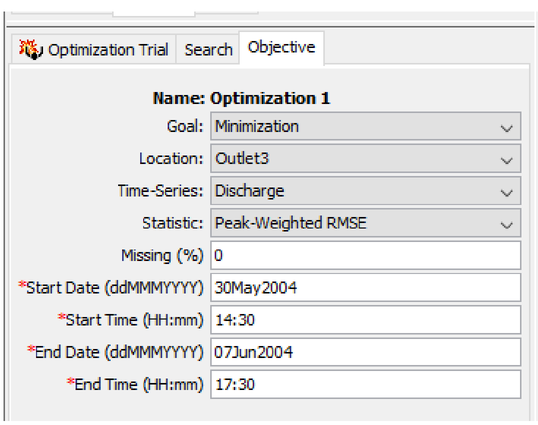


Click on Optimization 1, and you will see some information about it as shown below. Make sure you add the correct start and end date based on your control specification file.



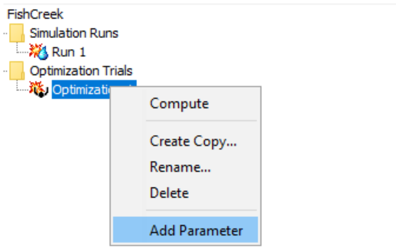
Next Click on the Search Tab. Use default options. Simplex is one of the methods used for optimization of functions. You can find more information about it online if you are interested. Max iterations specifies the number of iterations that the program will conduct in finding the optimized solution. We may want to increase this later if we are not able to get the optimized value with 100 iterations.

Next, click on the Objective tab to see the objective function and the information associated with it as shown below. Our goal is the minimize the objective function (similar to what we tried to do with manual calibration – minimize SSE, MSE or NSE). Location gives information about where the observed data are recorded (Outlet in this case). Start date/end date should match with your control specification file or the observed data file. The statistic option includes multiple functions, including the ones you used for manual calibration. You can drop down to see what is available. Lets use Peak-Weighted RMS error.

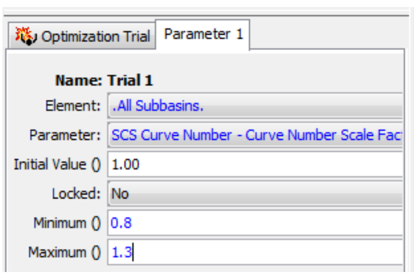


The goal of the optimization trial is to find optimized (or calibrated) values for the parameters to produce the optimum value for the objective function. For example, in the case of SSE or any function that represents the error function, the goal would be to minimize (optimum value = 0) the value of the objective function.

Now that you know little bit about optimization, lets go ahead and add some parameters. To do this, Right click on Optimization 1 in the components window and select add parameter as shown below.

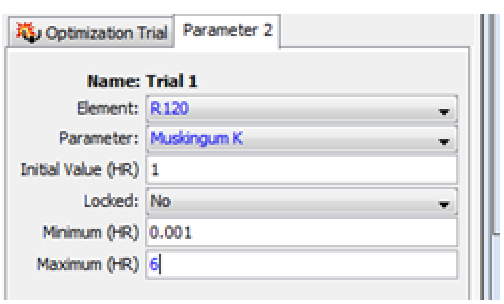


You will see that Parameter 1 will be added after the objective function. Click on parameter 1, and use the information given below for CN number.



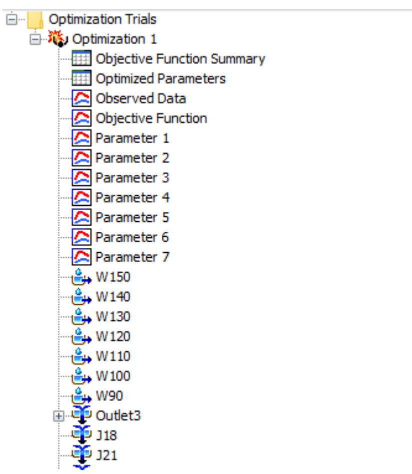
What we have done above is asked the program to modify the CN value using a scale (minimum is some percent of the initial value and maximum is also some percent of the initial value) to find the optimum value. We have asked the program to find the optimum or calibrated CN value for each sub basin (by including All sub-basins in the Element box) by changing it between 0.8 to 1.3 times its default value. Since CN cannot be greater than 100, make sure upper bound for the scale factor does not make CN greater than 100. For example, if your initial CN value is 90, using a scale factor of 0.8 – 1.2 is not reasonable. 1.2 will make the higher value for CN as 108. (90 x 1.2). Locked: No means that this parameter is not locked and can be changed. If for some reason you do not want to change any parameter then you should specify Locked = yes for that parameter. Here we are changing CN for all sub-basins. You will see that you also have the option of specifying parameters for individual sub-basins separately for calibration. For example, you cannot select all elements for lag time! You have to do it individually.

After we include the CN value in the optimization trial, we can add lag time lag time, Muskingum K and X. Also, the range of Muskingum K is provided in absolute hours instead of the scale factor that we used for CN values earlier. The lag time also needs to be specified in terms of absolute values instead of scale factor. For demonstration purposes, below is Muskingum K for only one reach (there is no option for selecting all Reaches!).



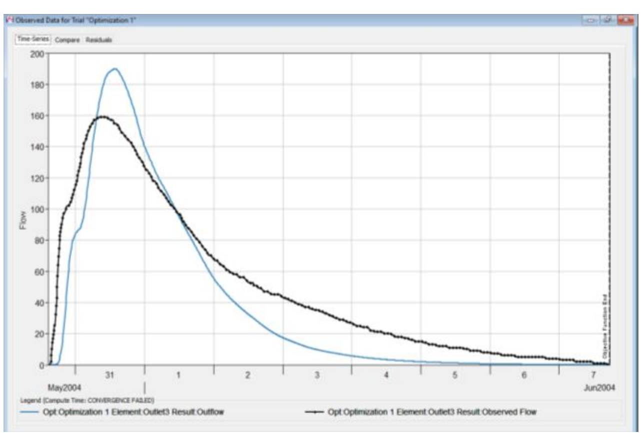
Go ahead and specify any parameter that you would like to include in your optimization (calibration). Including more parameters in auto-calibration will provide more flexibility for the model to change the values for these parameter and provide a better fit with observed data. Make sure you use appropriate values for the range (you should have gotten some idea on the range after doing manual calibration). I suggest you at least try Muskingum K for all reaches and Lag time for all sub-basins. Once you are done specifying the parameters, it is time to run the optimization. Running an optimization is similar to running a simulation. You go to the compute menu, select your trial, and then run your trial (Compute Trial[Optimization 1]).

The trial will take longer than a normal simulation so be patient! Once the trial is finished, looking at the results is similar to the simulation results. You will go to the results tab and select Trial 1 from Optimization trials as shown below.



The critical information to look for is the optimized parameter values and the hydrograph comparison. You are free to explore the results for each reach and sub-basins.

The comparison between observed and calibrated hydrographs are shown by changing CN and lag time.



Now that you know how auto-calibration works in HEC-HMS, go ahead and auto calibrate your model by using CN, Lag time, and Muskingum K. Use appropriate values for defining the range based on your experience with manual calibration. Play with parameters and also with different objective functions to get you the best fit possible. If needed increase the number of iterations in your trial.

Turn-in (March 13 by 1:30 PM)

1) A table from HEC-HMS that shows the calibrated values for your parameters.
2) Four plots (hydrograph comparison, flow comparison, flow residuals and objective function) from your Optimization Trial 1 in HEC-HMS and a brief explanation for each plot.
3) A brief write-up of what you learned from manual calibration and auto-calibration. Summary of options, including the parameters, their range and the choice of objective function/statistic used in the auto calibration. Which method you would prefer if you have to do this again in the future for another HEC-HMS model. Justify your answer.