HEC-HMS Lab 9: Model Calibration

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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 manually calibrate a HEC-HMS model for streamflow hydrograph
2) How to perform auto-calibration in HEC-HMS by using the Optimization Trial menu

Student Time Required: 60 – 90 minutes

You will use your HEC-HMS model from Lab 8 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. 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).

In the case of manual calibration, you will have to manually change the parameter values based on your judgment or knowledge of what parameter values may produce the best match between the model and the observed hydrographs. For example, in the figure below for Fish Creek, the observed hydrograph has a higher peak and shorter time to peak. You have looked at the sensitivity of CN number, lag time, and Muskingum parameters on hydrograph shape in earlier labs. By using that knowledge think about how you will change the values of these parameters to match the model hydrograph with observed hydrograph. Write few lines (more than 50 words) on what your strategy is for calibrating this model (e.g., which parameters you plan to change, whether you will try to increase or decrease their values, and why)
Go ahead and play with CN values, lag time and Muskingum parameters to match the time to peak and peak value. In practice, you will have to adjust the values individually for each subbasin and reach, but to keep this relatively less tedious for this lab, use same parameter values for all subbasins and reaches. The plot below shows an example of calibrated model output and the observed hydrograph. The goal here is to try to match the peak value and the time to peak as closely as possible. Try to do better than what you see below!

In the results, you will see that there is some difference in the total volume of the observed hydrograph and the model hydrograph, but we will learn how to fix that by also including baseflow in future labs.

**Turn-in (Part 1)**

1) Average initial values for your CN, lagtime, Muskingum K and X.

2) Plot of uncalibrated model hydrograph and observed hydrograph (a good screen shot is acceptable). Report the errors (mean abs. error, RMS error and volume residual) with
correct units. Write few lines (more than 50 words) on what your strategy is for calibrating this model (e.g., which parameters you plan to change, whether you will try to increase or decrease their values, and why)

3) Average calibrated values for CN, lagtime, Muskingum K and X.

4) Plot of manually calibrated model hydrograph and observed hydrograph (a good screen shot is acceptable). Report the errors (mean abs. error, RMS error and volume residual) with correct units.

5) Compare the calibrated hydrograph and the observed hydrograph in terms of time to peak, peak value, base time and the error terms.

Part 2: Auto-calibration in HEC-HMS

Before doing this, go ahead, and reassign the default or uncalibrated values to all parameters. Copy values from excel and paste them in HEC-HMS.

Auto-calibration is possible in HEC-HMS through the Optimization trial option in the Compute menu. On the main menu bar, select Compute → Create Optimization trial. Use the default name (Trial 1), select appropriate inputs (e.g., the basin file, Meteorologic file, etc), and outlet for the last option. 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 that to see Trial 1. Trial 1 will also have optimization function as shown below.

Click on Trial 1, and you will see some information about it as shown below.
Univariate gradient 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 only 50 iterations. Make sure you use the correct date/time as per your control specification file.

Next, select the objective function to see the information associated with it as shown below.

An objective function basically is an equation such as $R^2$, Sum of Squared Errors (SSE), PBIAS or NSE that you may be familiar with. If you select the method, you will see different equations including SSE as shown below.

Keep the default 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, click on Trial 1 on 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 factor (similar to +5% and -5% that we did earlier for sensitivity analysis) 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. Similarly, we can do the same for lag time, Muskingum K and X. 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 (e.g. Lag time). For demonstration purposes, below is Muskingum K for only one reach (there is no option for selecting all Reaches!). Also, the range of Muskingum K is provided in absolute hours instead of the scale factor that we used for CN values earlier.
Go ahead and specify any parameter that you would like to include in your optimization (calibration). Make sure you use appropriate values for the range. 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).

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, Muskingum K and Lag time. Use appropriate values for defining the range based on your experience with manual calibration. If needed increase the number of iterations in your trial.

Turn-in (Part 2)

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 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. Which method you would prefer if you have to do this again in the future for another HEC-HMS model. Justify your answer.