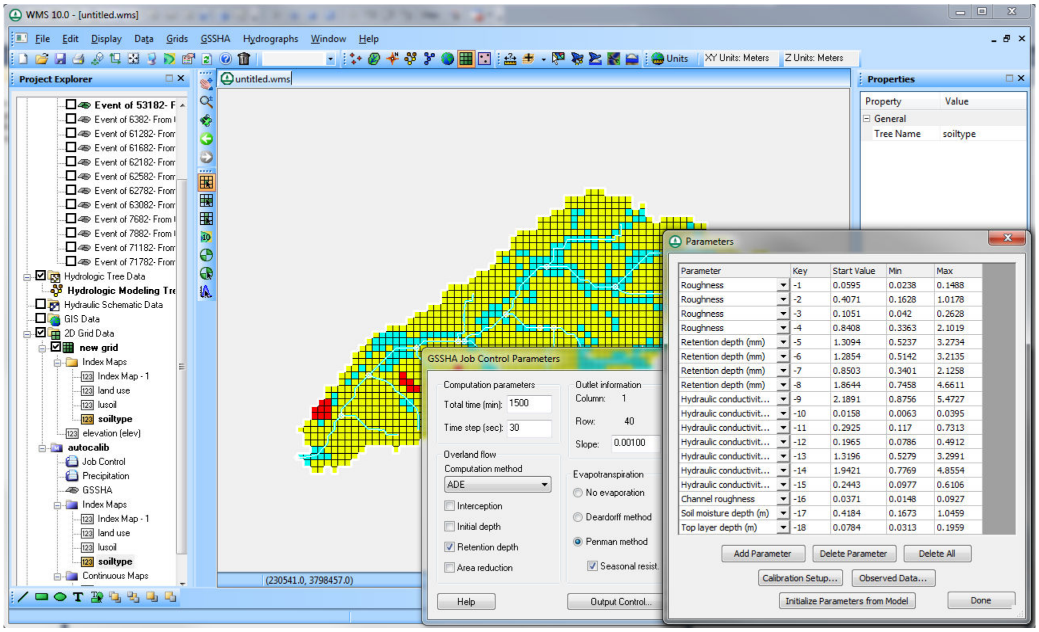
v. 10.0

WMS 10.0 Tutorial

GSSHA – Calibration – Computer-based Calibration of GSSHA models

Define parameters to be specified as adjustable, the objective function to be used to support their estimation, and automatically calibrate a GSSHA model



Objectives

This tutorial shows you how to set up and run a GSSHA model that automatically calibrates specified adjustable parameters using a documented efficient local search method.

Prerequisite Tutorials

- GSSHA – Calibration – Stochastic Simulations of GSSHA models

Required Components

- Data
- Drainage
- Map
- Hydrology
- 2D Grid
- GSSHA

Time

- 20-40 minutes

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2 Open an Existing GSSHA Project

Open the GSSHA model for Goodwin Creek Watershed

1. In the *2D Grid Module* select ***GSSHA | Open Project File…***
2. Locate your tutorial files.
3. Browse and open the file ***Calibration\Automated\goodwin.prj.***
4. Select ***GSSHA | Save Project File*** to save the base project with a different name, so that the original project remains unchanged. Save your project as ***\Personal\Calibration\Automated\autocalib.prj.***
5. Turn off the display of all the coverages except the *GSSHA coverage.*

3 Creating Calibration Runs

Here you will select the simulation that you want to calibrate and run an initial forward simulation. The initial simulation is run so WMS can determine the begin and end time for the simulation and so an initial objective function value can be determined for the calibration run.

1. Before we create a calibration run, we need to make sure all the Rainfall events that will be used in the forward model simulation are selected. Select ***GSSHA | Precipitation…*** and toggle on all of the events (Event 52282 – Event 71782). Click *OK.*
2. We also need to run the simulation once in the forward simulation mode not only to make sure the model runs but also to create a hydrograph file that will be used to support determination of the calibration parameters. Select ***GSSHA | Run GSSHA…***. Click *OK* to accept the default run parameters. After the run is completed, click *Close* on the model wrapper window and wait for the solution to be read.

3.1 Assigning keys to map tables and other parameters

You will need to use the WMS GSSHA interface to indicate which parameters you want to specify as adjustable calibration parameters. Generally, the calibration parameters are those which involve uncertainty in measurement or the ones that affect the outflow hydrograph the most. This is done by defining negative "key" values for each of the parameters you want to calibrate.

1. Select ***GSSHA* | *Map Tables…*** and switch to the *Roughness* tab.
2. Enter the keys -1, -2, -3 and -4 for the roughness values shown below. Entering a negative numbers tells WMS that these are the calibration parameters. WMS then associates the values we will define in the calibration dialog (in a future step) with these parameters.

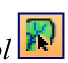
Roughness					
ID	1	2	3	4	5
Description1	pine 27% ...	water 0.3% ...	cotton 14% ...	pasture 42%...	gullied land ...
Description2	...	...	...	...	...
Surface roughness	-1.000000	0.358000	-2.000000	-3.000000	-4.000000

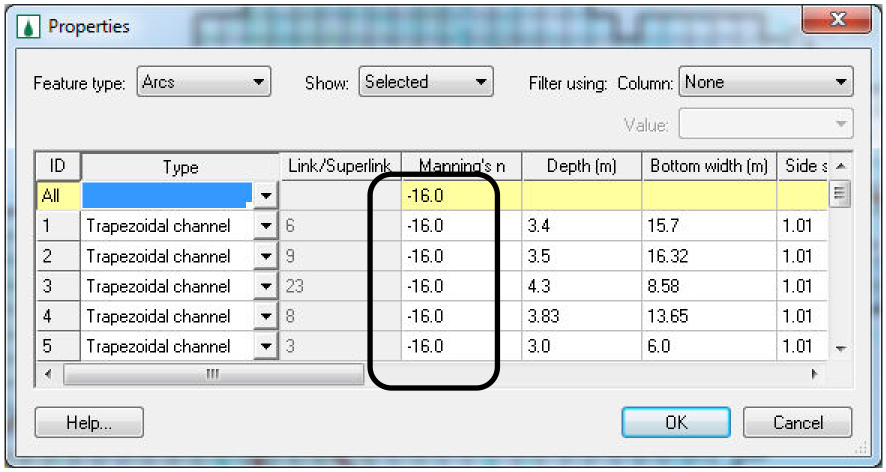
3. In the *Retention* tab, enter the following keys:

Retention					
ID	1	2	3	4	5
Description1	Pine 27% ...	Water 0.3% ...	Cotton 14% ...	Pasture 42%...	Gullied land ...
Description2	...	...	...	...	...
Retention depth (mm)	-5.000000	1.300000	-6.000000	-7.000000	-8.000000

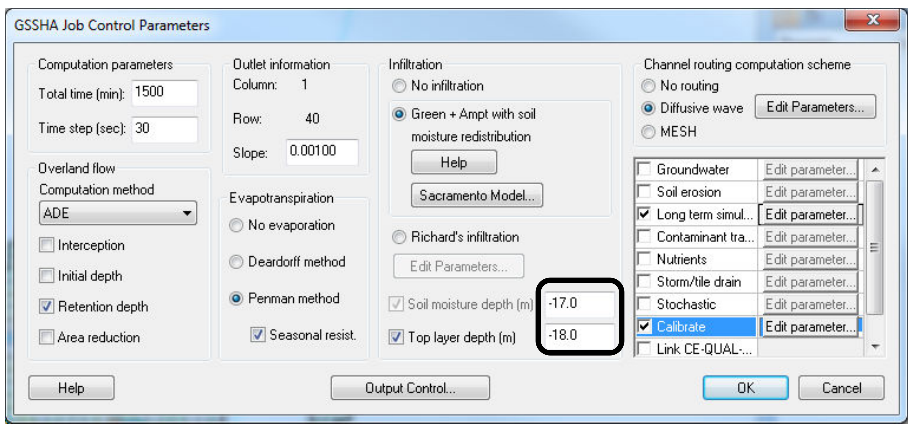
4. Switch to the *Infiltration* tab and enter the following keys for *Hydraulic Conductivity*.

Infiltration									
ID	1	2	3	4	5	6	7	8	9
Description1	gullied-land-...	gullied-land-...	water-.3% ...	pasture-clay...	cotton-clay-l...	pine-clay-loa...	pine-silt-loa...	cotton-silt-lo...	pasture-silt-l...
Description2		...	...	...	...	...	...	...	...
Hydraulic conductivity (cm/hr)	-9.000000	1.410000	0.003000	-10.000000	-11.000000	-12.000000	-13.000000	-14.000000	-15.000000
Capillary head (cm)	16.680000	4.950000	0.003000	20.880000	20.880000	20.880000	16.680000	16.680000	16.680000
Porosity (m^3/m^3)	0.486000	0.437000	0.582000	0.464000	0.464000	0.464000	0.486000	0.486000	0.486000
Pore distribution index (cm/cm)	0.234000	0.694000	0.001000	0.242000	0.242000	0.242000	0.234000	0.234000	0.234000
Residual saturation (m^3/m^3)	0.015000	0.020000	0.015000	0.075000	0.075000	0.075000	0.015000	0.015000	0.015000
Field capacity (m^3/m^3)	0.330000	0.091000	0.436500	0.318000	0.318000	0.318000	0.330000	0.330000	0.330000
Wilting point (m^3/m^3)	0.133300	0.033000	0.133300	0.133300	0.133300	0.133300	0.197000	0.133000	0.133000

5. The last column in the *Hydraulic Conductivity* field should be -15. Click *Done* to close the *Job Control* dialog.
6. In the *Map module* , click on the *Select feature line branch tool*  and double click on the downstream most channel arc (the one closest to the watershed outlet) which will open the *Properties* dialog.
7. Enter -16 for Manning's n for all arcs and click OK.



8. Select the *2D Grid* module, select ***GSSHA* | *Job Control***, and enter -17 for *Soil Depth* and -18 for *Top Layer Depth*. Click *OK* to close the Job Control dialog.

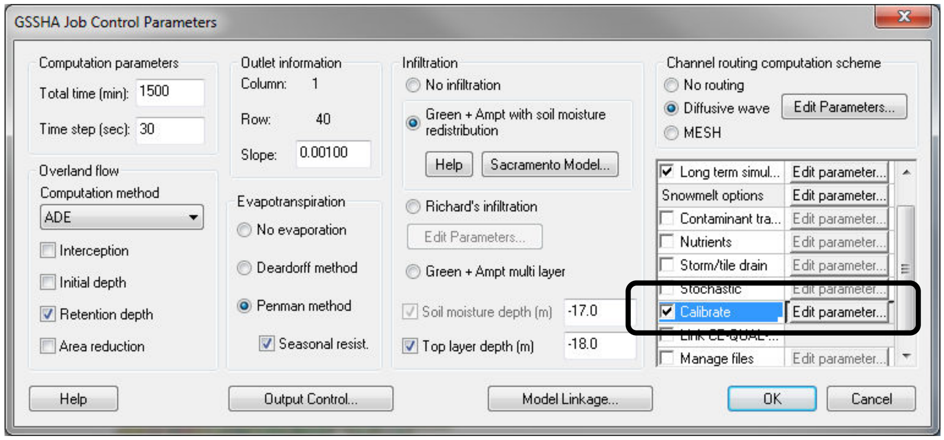


So, altogether there are 18 parameters that will be used in the automated calibration for this tutorial example problem.

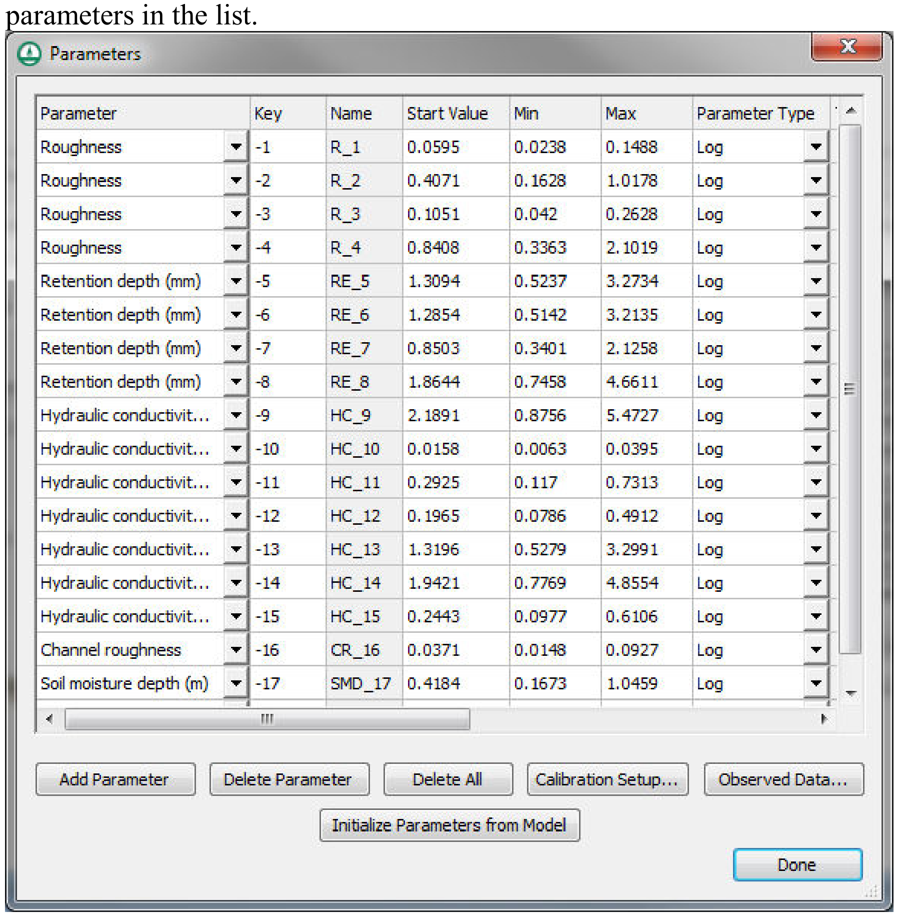
3.2 Defining calibration parameters

We need to define lower and upper bounds for the parameters whose values can vary during the calibration run.

1. Select ***GSSHA* | *Job Control…*** and select the *Calibrate* Option (See the following figure)



2. In the *Job Control* dialog, click on the *Edit Parameter* button for calibration option.
3. Select the *Initialize Parameters from Model* button so that you have 18 parameters in the list.



4. Enter the *Starting, Minimum and Maximum* values shown in the figure above by copying and pasting the values from the file ***\Calibration\Automated\InitialParams.txt.*** Guidance for parameter estimates can be found on http://gsshawiki.com.

Do not close this dialog yet.

3.3 Defining the Observed Data for Model Calibration

A quantitative measure of closeness of fit is called an objective function, and it is an important component of the automatic calibration process. For this example GSSHA problem, the objective function will be defined by comparing observed flow data at the Goodwin Creek watershed outlet with their model simulated counterparts. The best set of parameters corresponds to the lowest objective function value.

For this example problem, we are calibrating the GSSHA model for a long term event where there are multiple storm events.

1. In the *Parameters* dialog, click on the *Observed Data…* button to bring up the *GSSHA Observations* dialog.
2. Click the *Add* button.
3. Click on the *Define* button under the *Observed Data* column and select *Define Series….*
4. With Show Dates turned off, copy and paste the values from the file ***\Calibration\Automated\observed.txt*** into the XY Series Editor.
5. Turn on Show Dates and define a starting date and time of 5/23/1982, 12:59:00 AM.
6. Select *OK* and *Done*. Click on the Define Weights button and notice an XY Series has been defined to correspond to the observation data. These weights could be edited to put a greater emphasis on peak values if desired. Select *Cancel* and then *OK* to close the GSSHA Observations.

3.4 Defining Levenberg-Marquardt (LM)/Secant LM (SLM) data

1. In the *Parameter* dialog, click on the *Calibration Setup…* button which will open the *Calibration Setup* dialog.
2. Notice that you can choose from several calibration methods. The default LM/SLM methods are recommended for routine use. However, if sufficient time is available for a more exhaustive exploration, then of the three global optimization methods (Multistart, TR, and MLSL), the MLSL method is recommended. Use the *LM/SLM* calibration method with the *Run Secant LM (SLM) method* toggle turned on for this simulation. The SLM calibration option will compute a set of optimum values using a local search. If you are able to leave the model running for several hours, you might want to select *MLSL* for the calibration method. The MLSL option computes a set of optimum values using a global search, but will require more time than the SLM method. Do not modify any of the calibration setup parameters at this time.
3. Click *OK*.
4. Click *Done* to close the *Parameters* dialog.
5. Click *OK* to close the *Job Control*.

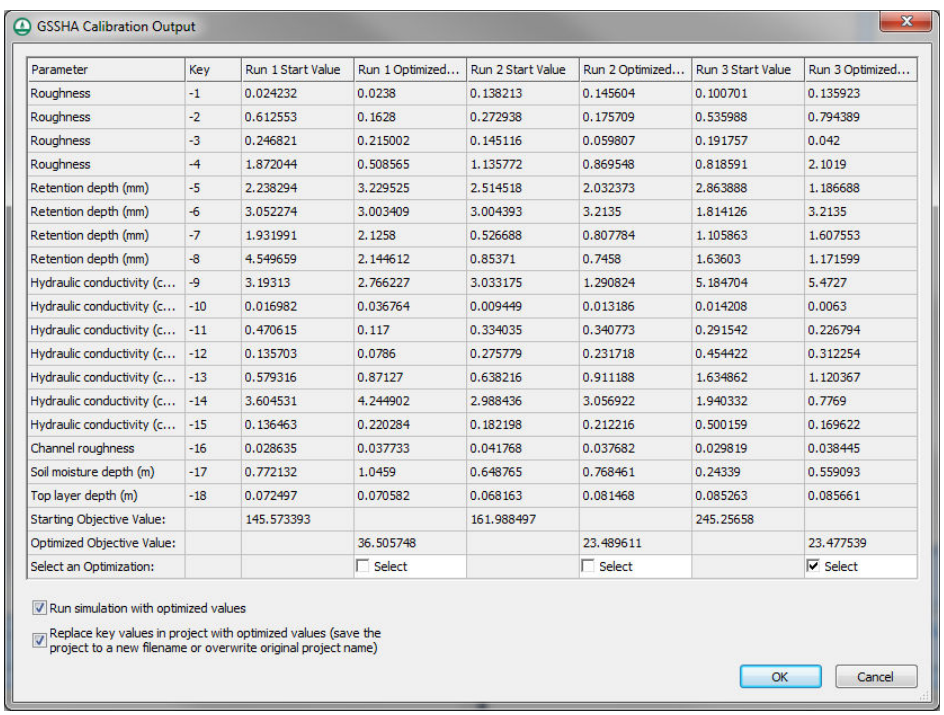
4 Save and Run the Model

1. Save the GSSHA project as ***Personal\Calibration\Automated\autocalib.prj***.
2. Select ***GSSHA | Run GSSHA…***
3. This run will take some time to finish. We recommend running the calibration overnight or in the background while you are working on other tasks.

5 Run the Forward Simulation with the Optimized Parameters

Once the calibration completes, GSSHA writes the best set of parameters (the set of parameters which produce minimum cost function). WMS can read the best parameters; then you can save your file using a new filename so you do not overwrite your calibration input file. You can also modify some of the input or output control data and run a new forward simulation with the calibrated parameters.

1. The GSSHA model wrapper displays an evolution of the automatic calibration. It indicates if the maximum number of specified optimization iterations was met or if the local (global, if such a method is chosen) search terminated by virtue of other specified stopping criteria.
2. Close the model wrapper after the calibration completes. The *GSSHA Calibration Output* dialog shows the starting and optimized parameter values along with the starting and optimized objective function values.



GSSHA Calibration Output

Parameter	Key	Run 1 Start Value	Run 1 Optimized...	Run 2 Start Value	Run 2 Optimized...	Run 3 Start Value	Run 3 Optimized...
Roughness	-1	0.024232	0.0238	0.138213	0.145604	0.100701	0.135923
Roughness	-2	0.612553	0.1628	0.272938	0.175709	0.535988	0.794389
Roughness	-3	0.246821	0.215002	0.145116	0.059807	0.191757	0.042
Roughness	-4	1.872044	0.508565	1.135772	0.869548	0.818591	2.1019
Retention depth (mm)	-5	2.238294	3.229525	2.514518	2.032373	2.863888	1.186688
Retention depth (mm)	-6	3.052274	3.003409	3.004393	3.2135	1.814126	3.2135
Retention depth (mm)	-7	1.931991	2.1258	0.526688	0.807784	1.105863	1.607553
Retention depth (mm)	-8	4.549659	2.144612	0.85371	0.7458	1.63603	1.171599
Hydraulic conductivity (c...	-9	3.19313	2.766227	3.033175	1.290824	5.184704	5.4727
Hydraulic conductivity (c...	-10	0.016982	0.036764	0.009449	0.013186	0.014208	0.0063
Hydraulic conductivity (c...	-11	0.470615	0.117	0.334035	0.340773	0.291542	0.226794
Hydraulic conductivity (c...	-12	0.135703	0.0786	0.275779	0.231718	0.454422	0.312254
Hydraulic conductivity (c...	-13	0.579316	0.87127	0.638216	0.911188	1.634862	1.120367
Hydraulic conductivity (c...	-14	3.604531	4.244902	2.988436	3.056922	1.940332	0.7769
Hydraulic conductivity (c...	-15	0.136463	0.220284	0.182198	0.212216	0.500159	0.169622
Channel roughness	-16	0.028635	0.037733	0.041768	0.037682	0.029819	0.038445
Soil moisture depth (m)	-17	0.772132	1.0459	0.648765	0.768461	0.24339	0.559093
Top layer depth (m)	-18	0.072497	0.070582	0.068163	0.081468	0.085263	0.085661
Starting Objective Value:		145.573393		161.988497		245.25658	
Optimized Objective Value:			36.505748		23.489611		23.477539
Select an Optimization:			☐ Select		☐ Select		☑ Select

☑ Run simulation with optimized values

☑ Replace key values in project with optimized values (save the project to a new filename or overwrite original project name)

OK Cancel

3. If you have run the SLM local optimization method, you will only see a single set of optimized values. If you have run the MLSL method

described above, you will see multiple sets of optimized values. Select the desired set of optimized values from the dialog.

4. Turn ***off*** both options: *Run simulation with optimized values* and *Replace key values…*. Click *OK* or *Cancel* to close the *GSSHA Calibration Output* dialog. If, at a later time, you want to access this window to replace the key values in your simulation, select the ***GSSHA | Read Calibration Output…*** menu command.
5. Select ***GSSHA | Read Solution…*** to read the calibration results.

6 Observe the Full Calibration Results

GSSHA writes several calibration files during and after a calibration run. Here are a couple of files that you can look at:

1. Scroll down in the project explorer and double-click or right-click to open the ***Calibration Record (.rec) File.*** This file shows detailed results for the calibration run.
2. Double-click or right-click to open the ***Parameter Estimate (.par)*** and ***Parameter Sensitivity (.sen)*** files. These file show additional parameter information about the calibration run.
3. If you have run an MLSL calibration, you may want to open the ***Optimization File (slm_chl_mlsl.rec)***. This file contains overview information about the global optimization method.