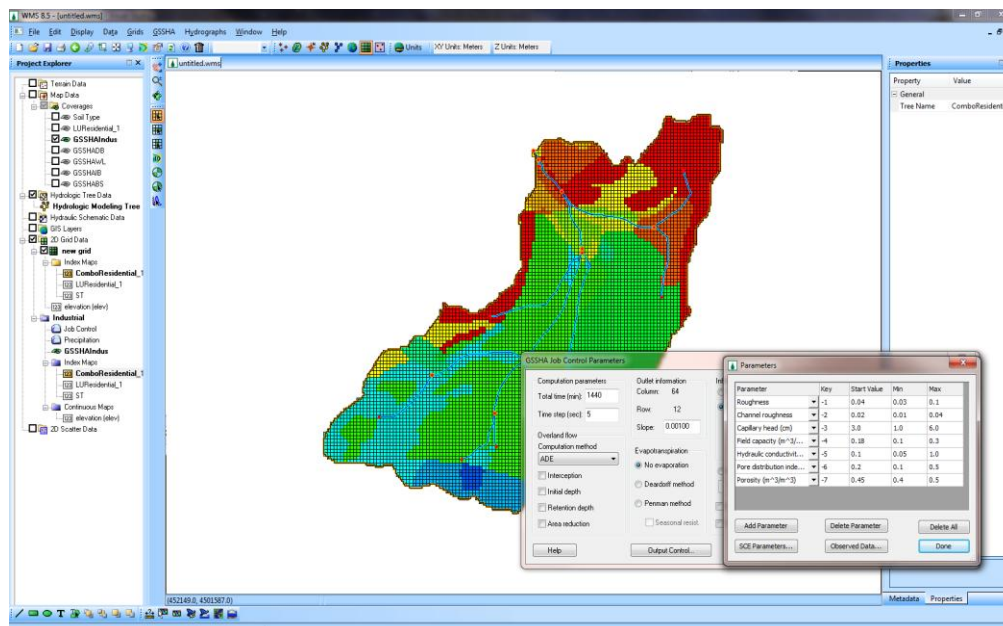


## WMS 9.1 Tutorial

# GSSHA – Calibration – Automated Calibration of GSSHA models

Define required parameters to automatically calibrate a GSSHA model



## Objectives

This tutorial shows you how to set up and run a GSSHA model that automatically calibrates specified input parameters.

## 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

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Open the GSSHA model for Goodwin Creek Watershed

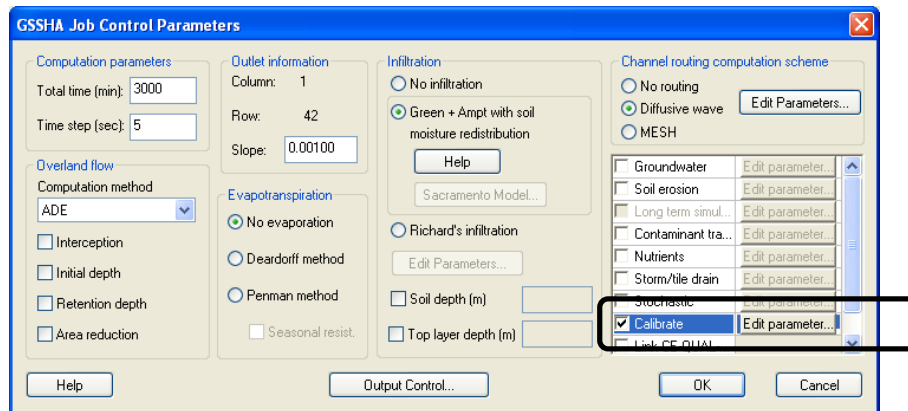
1. In the *2D Grid Module*  select **GSSHA | Open Project File...**
2. Locate the **GSSHA Distributed Hydrologic modeling** folder in your tutorial files. If you have used default installation settings in WMS, the tutorial files will be located in `|My documents|WMS 9.1|Tutorials|`.
3. Browse and open the file `|GSSHA Distributed Hydrologic modeling|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 `|GSSHA Distributed Hydrologic modeling|Personal|Calibration|Automated|autocalib.prj`
5. Turn off the display of all the coverages except the *GSSHA coverage*.

## 3 Creating Calibration Runs

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Here you will select the parameters that you want to calibrate and also define the SCE calibration parameters.

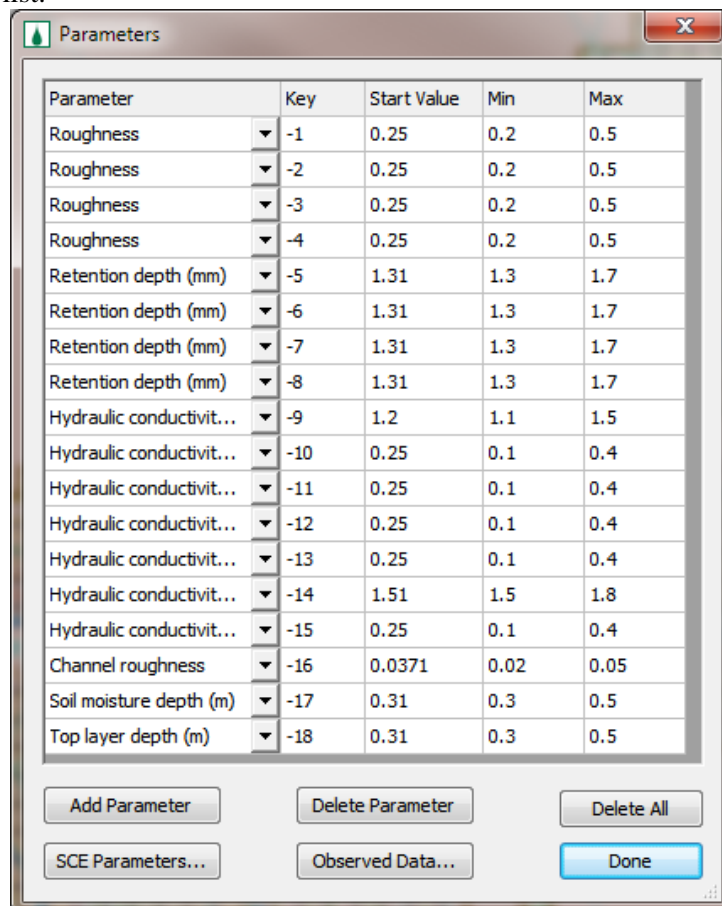
1. Before we create the calibration runs, we need to make sure all the Rainfall events that will be used in the simulations are selected. Select **GSSHA / Precipitation...** and toggle on all of the events (Event 52282 – Event 71782). Click *OK*
2. Select **GSSHA / Job Control...** and select the *Calibrate* Option (See the following figure)



### 3.1 Defining calibration parameters

We need to setup the parameters whose values can vary during the calibration run. Generally, the calibration parameters are those which involve uncertainty in measurement or the ones that affect the outflow hydrograph the most.

1. In the *Job Control* dialog, click on the *Edit Parameter* button for calibration option.
2. Select the *Add Parameter* button 18 times so that you have 18 parameters in the list.



- Define the parameter names from the drop down boxes for each parameter. See the above figure for reference.
- Similarly, enter the *Starting*, *Minimum* and *Maximum* values shown in the figure above or copy and paste from the file `\GSSHA Distributed Hydrologic modeling\Calibration\Automated\InitialParams.txt`.

Do not close this dialog yet.

### 3.2 Defining the Observed Flow Data

GSSHA needs observed peak and volume flow data to compare calibration runs for a closeness of fit. A cost function is computed for each calibration run to check how close to the observed flow GSSHA computes in the simulation results. The best set of parameters corresponds to a the lowest cost function, which should be close to zero.

Since we are calibrating the model for a long term event, there are multiple storm events and corresponding peak flows and volumes.

- In the *Parameters* dialog, click on the *Observed Data...* button to bring up the *GSSHA Observations* dialog.
- Click *Setup All Precip Events* button which will populate all storm events (there are 14 defined in this model). These events are read from the precipitation data that was already defined for this simulation.

	Observation Type	Observed Data	Precip Event	Auto-Calibration	Peak Weight	Volume Weight
1	Outlet Hydrograph	Define...	Event of 5/22/82- From ...	<input checked="" type="checkbox"/>	0.0	0.0
2	Outlet Hydrograph	Define...	Event of 5/24/82- From ...	<input checked="" type="checkbox"/>	0.185	0.08
3	Outlet Hydrograph	Define...	Event of 5/31/82- From ...	<input checked="" type="checkbox"/>	0.0	0.0
4	Outlet Hydrograph	Define...	Event of 6/3/82- From G...	<input checked="" type="checkbox"/>	0.125	0.075
5	Outlet Hydrograph	Define...	Event of 6/12/82- From ...	<input checked="" type="checkbox"/>	0.0	0.0
6	Outlet Hydrograph	Define...	Event of 6/16/82- From ...	<input checked="" type="checkbox"/>	0.09	0.05
7	Outlet Hydrograph	Define...	Event of 6/21/82- From ...	<input checked="" type="checkbox"/>	0.0	0.0
8	Outlet Hydrograph	Define...	Event of 6/25/82- From ...	<input checked="" type="checkbox"/>	0.0	0.0
9	Outlet Hydrograph	Define...	Event of 6/27/82- From ...	<input checked="" type="checkbox"/>	0.0	0.0
10	Outlet Hydrograph	Define...	Event of 6/30/82- From ...	<input checked="" type="checkbox"/>	0.125	0.075
11	Outlet Hydrograph	Define...	Event of 7/6/82- From G...	<input checked="" type="checkbox"/>	0.0	0.0
12	Outlet Hydrograph	Define...	Event of 7/8/82- From G...	<input checked="" type="checkbox"/>	0.0	0.0
13	Outlet Hydrograph	Define...	Event of 7/11/82- From ...	<input checked="" type="checkbox"/>	0.0	0.0
14	Outlet Hydrograph	Define...	Event of 7/17/82- From ...	<input checked="" type="checkbox"/>	0.12	0.075

- Click on the *Define* button under the *Observed Data* column and enter the following peak and flow volumes.

**Note: You do not have to define the peak and volumes**

- If the values are 0 for both peak and volume as they are zero by default.
- If the weights for both peak and volumes are zero

S No	Peak Flow (cms)	Volume (m <sup>3</sup> )	Peak Weight	Volume Weight
1	0	0	0	0
2	23.818	202577	0.185	0.08
3	0	0	0	0
4	12.925	271593	0.125	0.075
5	0	0.1	0	0
6	0.9796	17956	0.09	0.05
7	0	0	0	0
8	0	0	0	0
9	0	0	0	0
10	15.772	119761	0.125	0.075
11	0	0	0	0
12	0	0	0	0
13	0	0	0	0
14	6.06	35419.2	0.12	0.075

**Note:** The observed flow data can also be defined as a hydrograph by selecting *Use XY Data* option and then clicking *Define Series* button.

4. Once you are done defining the peak flows and volumes, enter the Peak and Volume Weights using the above table. Make sure that the sum of the peak and volume weights is equal to 1.0.

### 3.3 Defining SCE (Shuffle Complex Evolution) Flow data

1. In the *Parameter* dialog, click on the *SCE Parameters...* button which will open the *Shuffle Complex Evolution* dialog.
2. Change the *Maximum number of iterations* to 500.
3. Click OK.
4. Click *Done* to close the *Parameters* dialog.
5. Click OK to close the *Job Control*.

**Note:** GSSHA might not calibrate well within 500 runs, but we will see how the automated calibration works

## 4 Changing the map tables

Once you defined the SCE parameters, you will need to tell GSSHA (mapping table) which parameters you want to use as the calibration parameters. This is done in the mapping table.

1. Select **GSSHA | map Tables...** and switch to the *Roughness* tab.
2. Enter the keys -1, -2, -3 and -4 for the following roughness. Entering a negative numbers tells WMS that these are the calibration parameters. WMS then associates the values we defined in the calibration dialog (previous 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

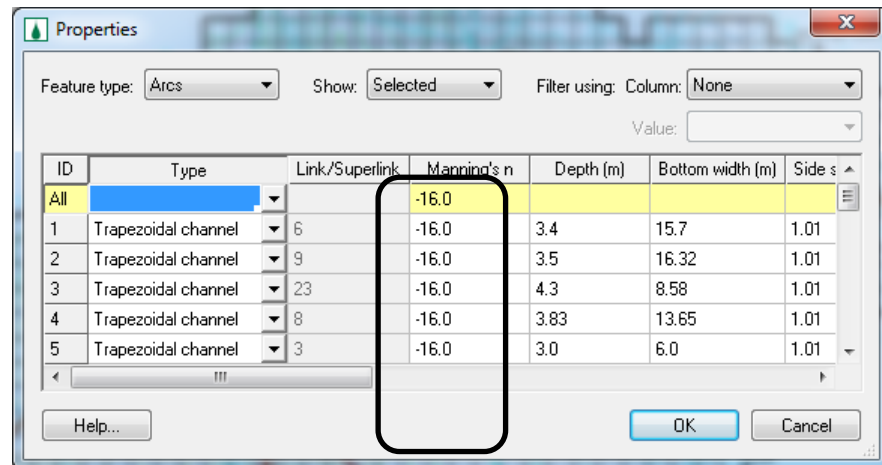
3. In the *Retention* tab, enter the following keys

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

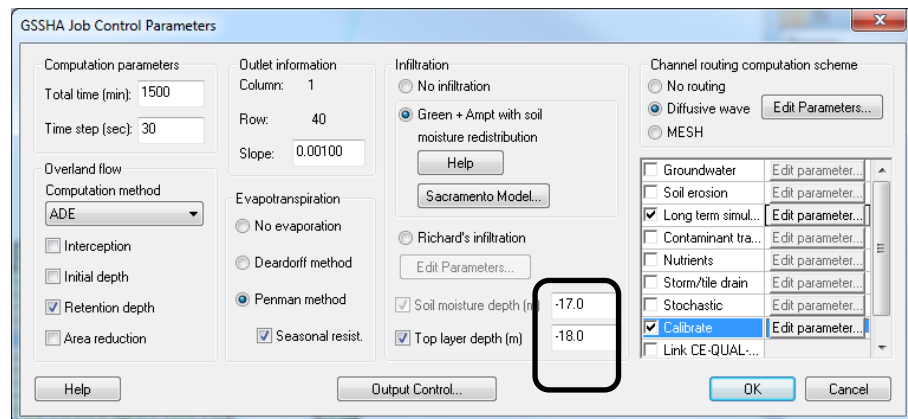
4. Switch to the *Infiltration* tab and enter the following keys for *Hydraulic Conductivity*.

Infiltration									
ID	1	2	3	4	5	6	7	8	9
Description1	gullied-land-...	gullied-land-...	water-3% ...	pasture-clay-...	cotton-clay-...	pine-clay-loa...	pine-silt-loa...	cotton-silt-lo...	pasture-silt-l...
Description2	...	...	...	...	...	...	...	...	...
Hydraulic conductivity (cm/hr)	-9.000000	0.410000	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 <sup>3</sup> /m <sup>3</sup> )	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 <sup>3</sup> /m <sup>3</sup> )	0.015000	0.020000	0.015000	0.075000	0.075000	0.075000	0.015000	0.015000	0.015000
Field capacity (m <sup>3</sup> /m <sup>3</sup> )	0.330000	0.091000	0.436500	0.318000	0.318000	0.318000	0.330000	0.330000	0.330000
Wilting point (m <sup>3</sup> /m <sup>3</sup> )	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. Click **OK**.
9. Select **GSSHA / Job Control**, and enter -17 for *Soil Depth* and -18 for *Top Layer Depth*.



So, altogether there are 18 parameters that will be used in the automated calibration, we have 14 storm events and we will let GSSHA run a maximum of 500 simulations. The model is all set up to run an automated calibration.

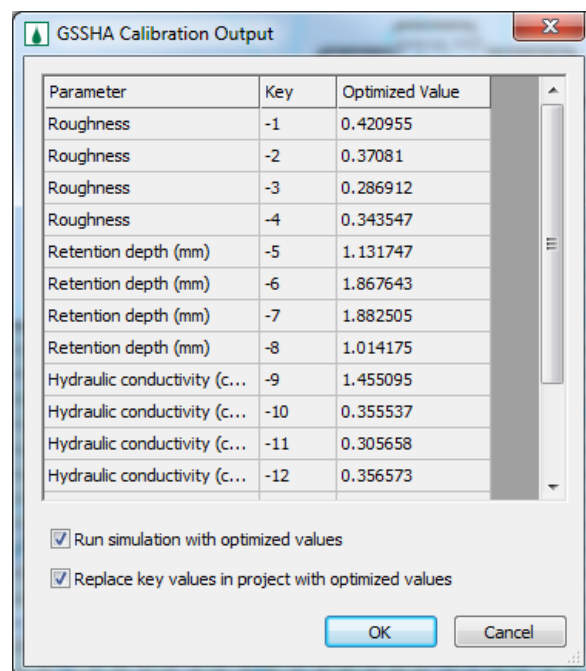
## 5 Save and Run the Model

1. Save the project as **Personal\Calibration\Automated\autocalib.prj**.
2. Select **GSSHA / Run GSSHA...**
3. This run will take several hours to finish. We recommend running the calibration overnight. If the calibration does not run to completion, the calibration project file with its output is located in **Calibration\Automated\autocalib.prj** directory. You can read these output files using the **GSSHA / Read Calibration Output** menu command.

## 6 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, plug in back to GSSHA input files and perform a forward simulation. Doing that helps you see the results of your calibration.

1. The model wrapper displays the results of the calibration. It indicates if the maximum number of iterations was met or if the cost function converged first.
2. Close the model wrapper as the calibration completes which will open the *GSSHA Calibration Output* dialog. Your parameters will be different from what is shown in the following sample image.



3. Click OK to replace the key values for calibration (all the negative numbers) with the optimized parameters and run GSSHA.
4. Once done, view the model results.

## 7 Observe the Full Calibration Results

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

1. **0000\_sce\_best.out:** Browse to and open the file `|GSSHA Distributed Hydrologic modeling\Personal\ Calibration\ Automated\0000_sce_best.out` in a text editor. This file populates the best set of values for the calibration parameters.
2. **sce\_output.out:** Browse to and open the file `|GSSHA Distributed Hydrologic modeling\Personal\ Calibration\ Automated\sce_output.out` in



a text editor. This file populates the all the SCE parameters that were used during the calibration runs.

3. ***0000\_sce\_log\_file.txt***: Browse to and open the file ***\GSSHA Distributed Hydrologic modeling\Personal\ Calibration\Automated\0000\_sce\_log\_file.txt*** in a text editor. This file populates the results from all the calibration runs. You can access this file even when the calibration is running and check the progress of the calibration.