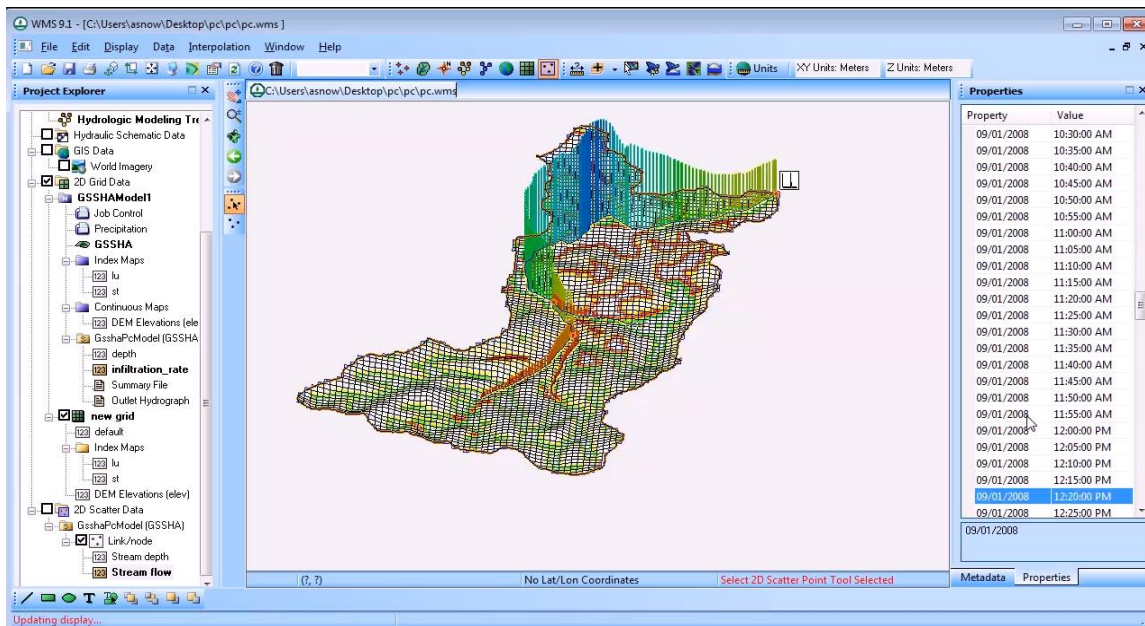


WMS 10.1 Tutorial

Spatial Hydrologic Modeling — Upgrading an HEC-HMS Model to a GSSHA Model

Learn how to convert an HEC-HMS model or any other delineated watershed to a GSSHA model using WMS



Objectives

This tutorial shows how to use WMS to convert an HMS model of a watershed near Park City, Utah to a GSSHA model. After building a GSSHA model, view the GSSHA output using the rich suite of watershed visualization tools available in the WMS interface.

Prerequisite Tutorials

- Spatial Hydrologic Modeling – Developing a GSSHA Model using the Hydrologic Modeling Wizard

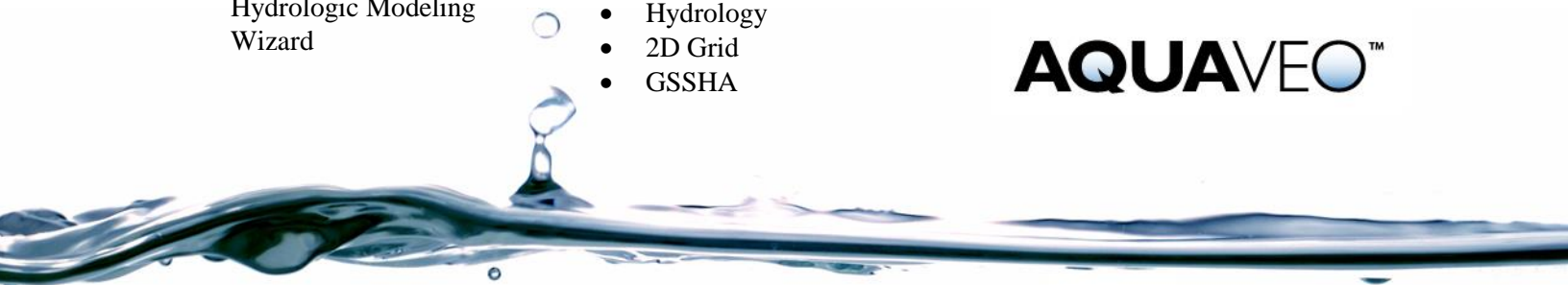
Required Components

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

Time

- 30-60 minutes

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2 Introduction


WMS supports several commonly used hydrologic, hydraulic, and storm drain models. If having built a model using one of the hydrologic models supported by WMS, save the model data to another hydrologic model by following the steps in the hydrologic modeling wizard. WMS can even be used to convert a lumped parameter hydrologic model to a distributed hydrologic model. The distributed hydrologic model GSSHA, developed by the US Army Corps of Engineers, is one of the most advanced distributed hydrologic models available and is supported by WMS.


3 Objectives

In this tutorial, convert an existing HMS model to a GSSHA model using WMS and view the GSSHA output. The model watershed is located in Park City, Utah.

4 Hydrologic Modeling Wizard

First, open the WMS project file containing the HMS watershed model. Then zoom in to view the watershed and bring up the hydrologic modeling wizard.

1. Close all instances of WMS
2. Open WMS
3. Unzip *HMSToGSSHA.zip* and select **File / Open** 
4. Select *pc.wms*
5. Select *Open*

6. In the Project Explorer, turn off *Map Data / Coverages / Soil Type*
7. In the Project Explorer, right-click on *Map Data/ Coverages / Drainage* and select *Zoom to Layer*
8. Click on the *Hydrologic Modeling Wizard* 
9. In the left window of the wizard click *Select Model*

4.1 Select Model

Select GSSHA as the model and select Initialize Model Data to begin building a GSSHA model.

1. Select *GSSHA* as the desired model
2. Select *Initialize Model Data*
3. Select *Next*

4.2 Define and Smooth Streams

GSSHA is a model that includes a 2D overland flow hydrologic model that interacts with a 1D hydraulic model. Before building the 2D grid that discretizes the hydrologic model, it's a good idea to define the attributes for the streams in the watershed and initialize the stream elevations so the 2D grid elevations correspond to the stream elevations used in the 1D hydraulic model. It's also important to define stream channel attributes such as Manning's roughness and cross section information so GSSHA can run the necessary stream hydraulic computations. Here, define the stream cross section, set the spacing between stream nodes, and initialize the stream elevations so no adverse slopes exist along the stream.



1. In the Project Explorer, turn off GIS Data
2. Click on the *Select a stream branch* tool 
3. Click on the most downstream stream arc in the model (All the stream arcs should be selected)
4. Select *Set Selected Arc Attributes...*
5. Set all the arc attributes to the following: Trapezoidal channel, Manning's $n = .04$, Depth = **1** m, Bottom width = **2** m, side slope = **2** H:1 V. Leave everything else at its default value and click *OK*
6. Select *Yes* when told about renumbering links
7. Select *All* to use all Arcs in the GSSHA coverage
8. Select *Redistribute Vertices on All Streams...*
9. Enter **60** for the spacing, select *Use Cubic Spline* and click *OK*
10. Select one continuous stream segment from the outlet to the upstream end of the stream using the *Select one or more streams* tool  as shown in Figure 4-1



Figure 4-1: Select Continuous Stream Segment

11. For each segment, click *Smooth Selected Stream Segments...* and click on *Interpolate stream elevations* until the stream has no negative or horizontal slopes. It may be necessary to click the button several times to remove all negative or horizontal slopes in the streams. If building a GSSHA model for a project, modify negative slopes manually so the stream thalweg data is not significantly modified. Click *OK* when done.
12. Continue steps 10 and 11 for each of the three continuous stream segments in the model.

The stream segment selected in Figure 4-1 should look like Figure 4-2.

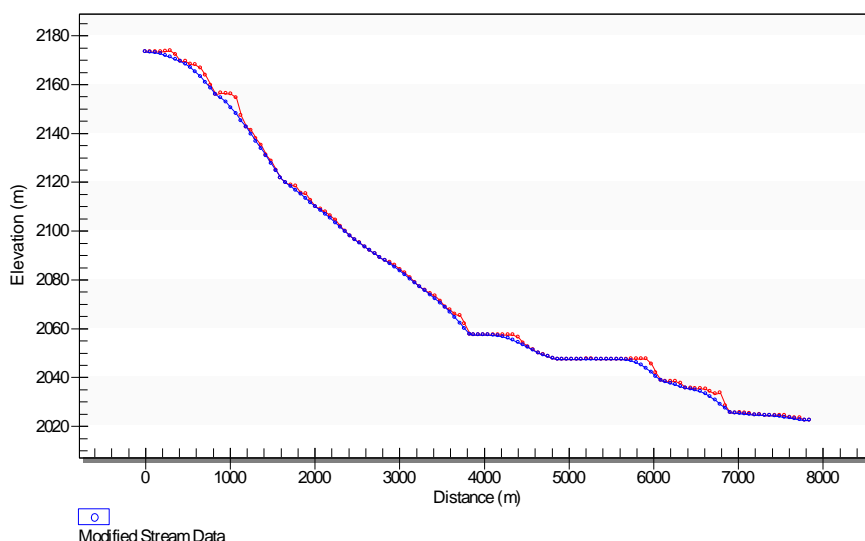


Figure 4-2: Smoothing Stream Segments

13. Select *Next*

4.3 Create 2D Grid

Next, create the 2D grid to discretize the hydrologic model domain using a 90 meter cell size.

1. Enter an X-dimension of **90** m and select *Create 2D Grid*
2. Select *OK*
3. If asked if to delete existing background DEM, select *NO*.
4. Select *Next*

The grid should look like Figure 4-3.

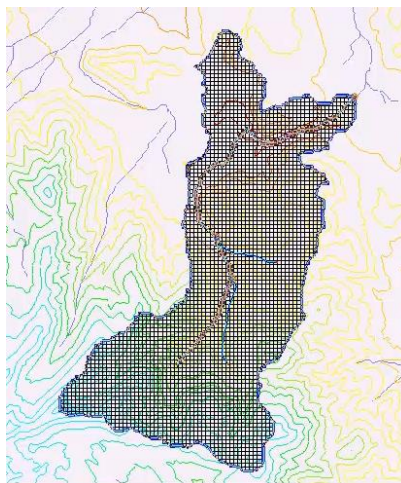


Figure 4-3: 2D Grid

4.4 Job Control

Define a start and end time for the model simulation. This model will run for two days with a 10-minute time increment.

5. Set the starting date to **9/1/2008** and the ending date to **9/3/2008**
6. Set the starting and ending times to **12:00:00 AM**.
7. Set the time interval to **2** seconds.
8. Select *Set Job Control Data*
9. Select *Next* twice

4.5 Hydrologic Computations

It's important to define land cover and soil type for each cell of the watershed so the correct Manning's roughness values and infiltration parameters can be defined for each cell. WMS has tools for assigning readily available land use and soil type information to each cell using the GSSHA Maps tool. After assigning land use ID's and soil textures to each cell, Manning's roughness values can be assigned to each of the land use ID's and infiltration parameters can be assigned to the soil textures so GSSHA can compute the amount of rainfall that infiltrates into the soil and the runoff velocities between each of the 2D grid cells.

After defining the Manning's roughness and hydrologic loss parameters, turn on channel routing in the model and turn on some additional output parameters to enhance model visualization after running GSSHA.

1. Select *Compute Index Mapping Tables...*
2. Select *Land use Grid* under *Input Coverages (1)*
3. Set the Index map name to “*Land Use*”
4. Select *Coverages→Index Map*
5. Select *Soil Type* under *Input Coverages (1)*
6. Set the Index map name to “*Soil Type*”
7. Select *Coverages→Index Map*
8. Select *Done*
9. In the Roughness tab, select *Land Use* from *Using index map*
10. Select *Generate IDs*
11. Select the Infiltration tab
12. Select *Yes* to the dialog asking to open the Job Control window to change its settings
13. Turn on *Green + Ampt with soil moisture distribution* in the Infiltration section
14. Select *OK*
15. Select “*Soil Type*” from *Using index map*
16. Select *Generate IDs*
17. Select the Initial Moisture tab and repeat steps 15-16
18. Click *Import Table...*
19. Open *gssha/GsshaPcModel.cmt* and notice the values are filled inside the tables under the previously selected tabs
20. Select *Done*
21. Select *Edit Parameters...*
22. Turn on *Diffusive wave* in the Channel routing computation scheme section
23. Select *Output Control...*
24. Turn on (under gridded datasets) *Infiltration rate*, (under link/node datasets) *Channel depth* and *Channel flow*.
25. Change the write frequency to **15** minutes and change the hydrograph write frequency to **5** minutes.
26. Change the output units to *English (cfs)*
27. Click *OK* twice
28. Click *Next* in the wizard

4.6 Define Precipitation

One last step in setting up the model is to define a storm event. This model will use a standard Type II 24-hour precipitation distribution with a precipitation depth of 3.13 inches, or 79.5 mm. This precipitation value was determined from NOAA atlas 14.

1. Click *Define Precipitation...*
2. Select *Hyetograph* under Rainfall Events
3. Select *Define Distribution...*
4. Select *typeII-24hour* under *Selected Curve*
5. Select *OK*
6. In the Average Depth (mm) row, type **79.5** mm (3.13 in)
7. Click *OK*
8. Select *Next*


4.7 Clean Up Model

The “Clean Up Model” button runs some common tasks that are often performed to clean up the display and check the model before running it. The model is cleaned up and no errors are detected in the HMS model.

1. Turn OFF the option to *Remove NULL DEM cells*
2. Select *Clean Up Model*
3. Select *Done*
4. Click *Close* when the Model Wrapper finishes
5. Select *Next*

4.8 Save and run GSSHA model

After completing the hydrologic model, save and run the GSSHA model.

1. Select *Open*  next to the input file
2. Save the model as *gssha/GsshaPcModel.prj*
3. Select *Run the Simulation...*
4. Select *OK*
5. Click *Close* when the Model Wrapper finishes (this should take about 1 minute) and wait for WMS to read the solution. If there is an error running the model, track down the error and fix the problem with the model.
6. Select *Finish* to close the wizard


5 Visualizing GSSHA Output

5.1 Visualizing GSSHA output in WMS

Once having run the GSSHA model, WMS has a rich set of tools that allow visualizing overland flow depths, infiltration rates, stream flows, and stream depths. To contour any of these computed maps at any time during the simulation, select the output map to visualize (such as the depth map) and scroll through the times in the properties window to

view the contours of overland flow depth, infiltration, stream flow, or stream depth at each time step. There are various display options that can be set to enhance the display of these dataset contours when scrolling through the time steps.

Turn on a background map and use the background map as a reference to determine where watershed phenomena occur. Also view cylindrical contours representing stream depth and view the storm flood wave along the stream.

1. Turned off the *DEM* in the Project Explorer under *Terrain Data*
2. Turn on the background image in the Project Explorer under *GIS Data / World Imagery*
3. Select *2D Grid Data / GSSHAModel1 / GsshaPcModel (GSSHA) / depth* in the Project Explorer
4. In the Properties window, step through the dataset time steps. Use the down arrows to step through the times. Notice how the contours change when stepping through the times.
5. Select *2D Grid Data / GSSHAModel1 / GsshaPcModel(GSSHA) / infiltration_rate* in the Project Explorer
6. Repeat step 4
7. Select the *Rotate* tool  from the vertical toolbar
8. Rotate the view so it looks like Figure 5-1

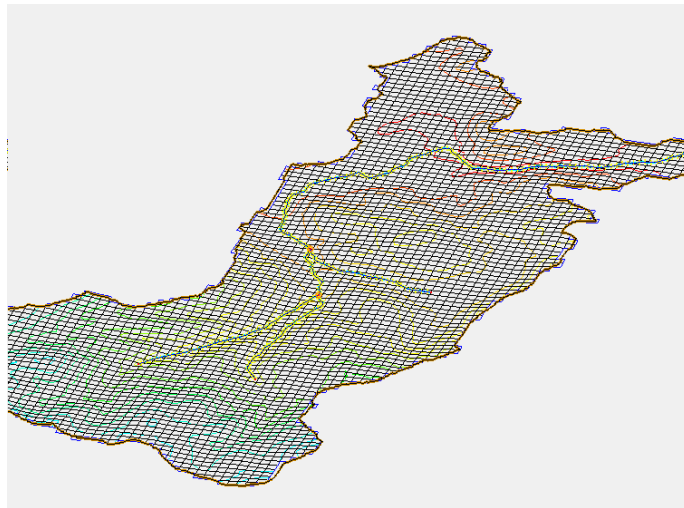







Figure 5-1: Rotated GSSHA Model

9. Click *Display Options* 
10. Select *2D Scatter Data* from the box on the left. Turn on the *2D Scattered Data contours*. Enter a Radius of **15** and a Z-magnification of **50**.
11. Select *OK*
12. In the Project Explorer, select the *2D Scatter Data / GsshaPcModel(GSSHA) / Link/node / Stream Flow* dataset and step through the times of this dataset

starting on **9/1/2008** at **10:00 AM**. Notice the cylinders representing stream water surface elevations.

5.2 Visualizing GSSHA output in Google Earth

Once having read a GSSHA solution, export an animation to a Google Earth KMZ file and view an animation of the GSSHA output in Google Earth. Viewing the output in Google Earth allows combining Google Earth's visualization capabilities with the output from GSSHA to more effectively view the watershed response to the storm event.

1. Select *Plan View*  from the main toolbar
2. In the Project Explorer, turn off *2D Scatter Data / GsshaPcModel(GSSHA) / Link/Node*
3. Turn off the background image in the Project Explorer under *GIS Data / World Imagery*
4. Click *Display Options* 
5. In Hydrologic Modeling Data deselect the *Hydrograph Icons*
6. In 2D Grid Data select *All off* and then turn on *Contours*
7. In 2D Scatter Data change the *radius* to a value of **3** and set *Z-magnification* to **200**
8. Select *OK*
9. In the Project Explorer, right-click on *2D Grid Data / GSSHAModel1 / GsshaPcModel (GSSHA) / depth* and select *Contour Options...*
10. Under the Contour Method section, select *Color Fill*
11. Turn ON *Specify a range*, turn OFF *Fill below*, and specify a minimum value of **0.001**
12. Click *OK* to close depth Contour Options
13. Select *Data / Film Loop*
14. Select *Next*
15. Select *Stream flow* from *Write this 2D Scattered Dataset to KMZ File*
16. Select *Next*
17. Click *Finish* and wait for the film loop to be generated (about 1 minute). The film loop will start up in Google Earth.
18. Select the *time options dialog* 
19. Make sure *Loop animation* is checked and the *Animation speed* is in the middle range
20. Wait for the film loop to load, then click *Play*  in Google earth and wait for the images to finish loading.
21. After the images have finished loading, zoom into the watershed and rotate the view.

22. Pan around to different locations in the watershed and notice the stream depth lines that show up as the animation progresses.

An example view of the Google Earth display is shown in Figure 5-2.

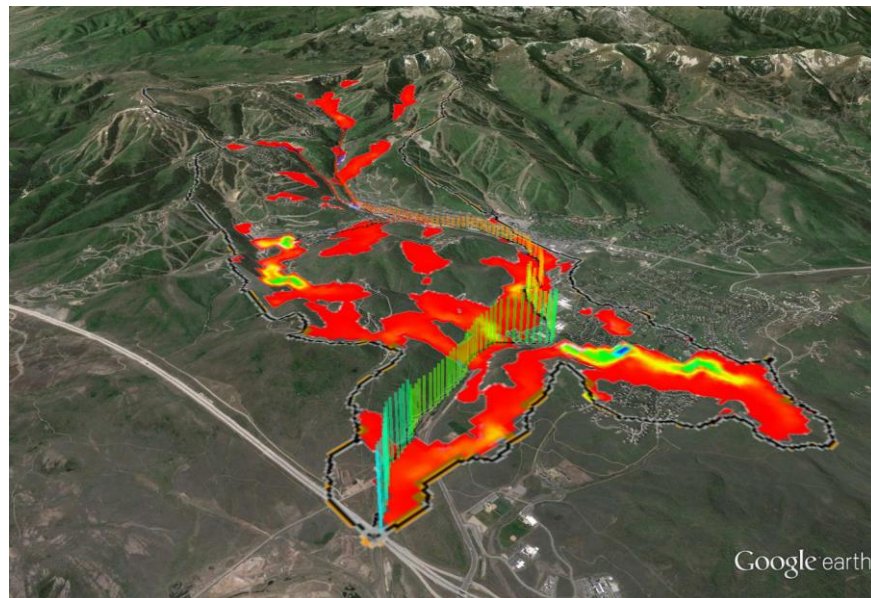


Figure 5-2: Google Model

6 Conclusion

Use the WMS Hydrologic Modeling Wizard to easily convert an HMS model to a GSSHA model. After building a GSSHA model, use WMS' powerful suite of visualization tools to visualize watershed processes anywhere in the watershed. It is also possible to export an animation of a watershed process to Google Earth.