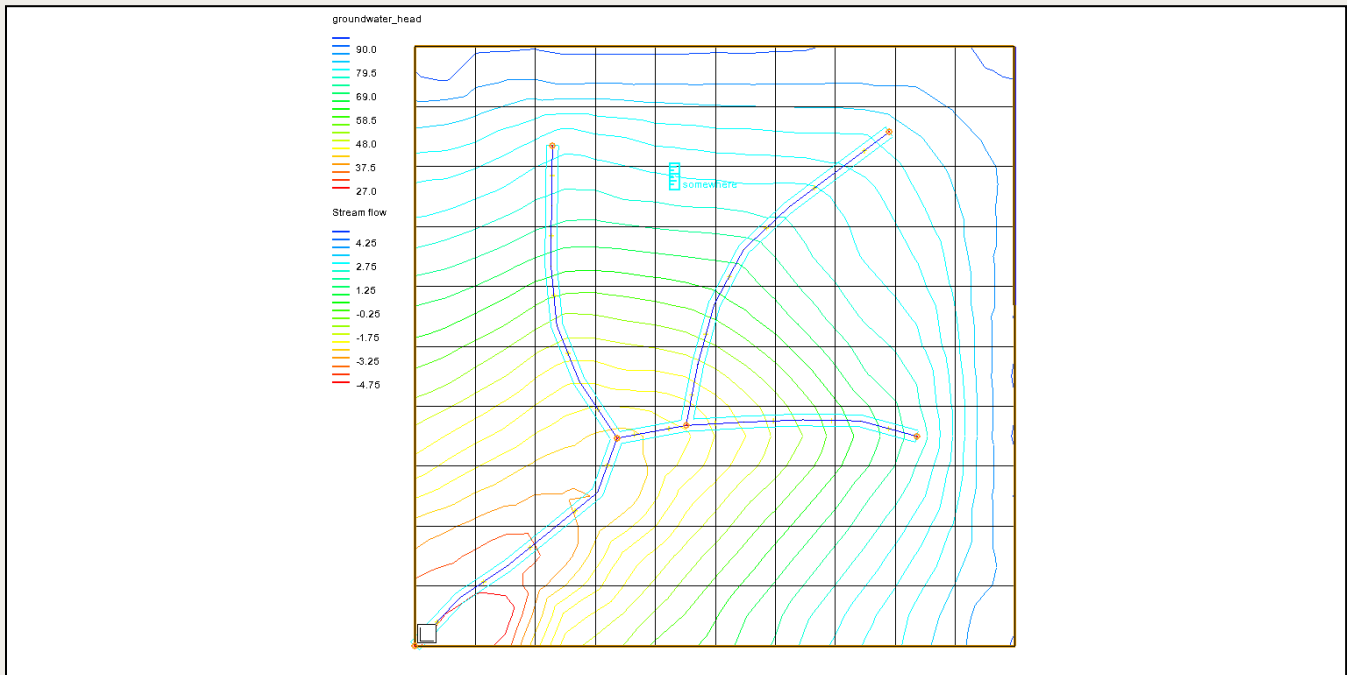*WMS 11.2 Tutorial*

Permafrost in GSSHA
Modeling permafrost in GSSHA

Objectives

Build on a long-term GSSHA model to simulate permafrost.

Prerequisite Tutorials
- Long-Term Simulations in GSSHA

Required Components
- WMS Core
- GSSHA Model

Time
- 20–30 minutes

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1   Introduction

The tutorial illustrates modeling permafrost using the Geophysical Institute Permafrost Laboratory (GIPL) coupled with GSSHA. This simplified example is conceptual, but the permafrost parametric values represent Alaskan woodland and tundra ecosystem sites in a permafrost active region. This tutorial begins with a surface and subsurface runoff model where the infiltration component is turned on. The soil moisture and soil physical state are defined by the Richards Equation.

1.1   Getting Started

To begin the tutorial, do the following:

1. Start WMS, or click **New** if WMS is already open.

2. Switch to the **2D Grid Module**.

3. Select *GSSHA | Open Project File...* to bring up the *Open* dialog.

4. Browse to the *Permafrost* folder for this tutorial.

5. Select "gw.prj" and click **Open** to exit the *Open* dialog.

6. Select *File | Save As…* to bring up the *Save As* dialog.

7. Enter "permafrost.wms" as the *File name* and click **Save** to save the project under the new name and close the *Save As* dialog.

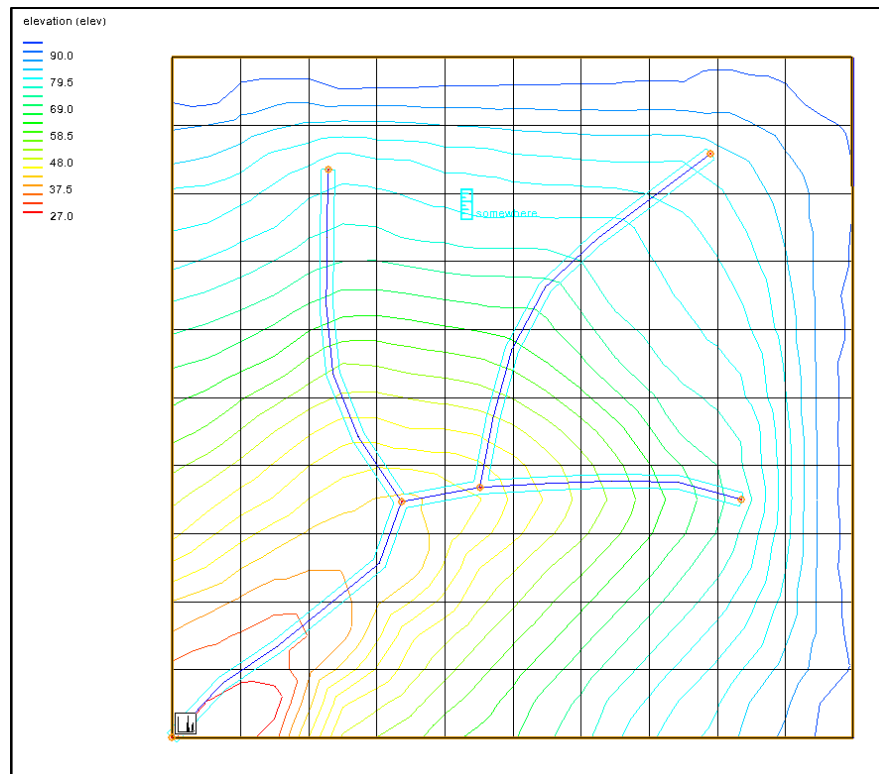The project should appear similar to Figure 1.

Figure 1   Initial GSSHA project

2   Adding Permafrost Parameters

This section will demonstrate turning on the permafrost option in the *GSSHA Job Control Parameters* dialog. Then, it will demonstrate defining a mapping table containing the required permafrost parameters.

2.1   Turning on Permafrost in Job Control

1. Select *GSSHA | **Job Control…*** to bring up the *GSSHA Job Control Parameters* dialog (Figure 2).

2. In the list on the right, turn on the *Permafrost* option.

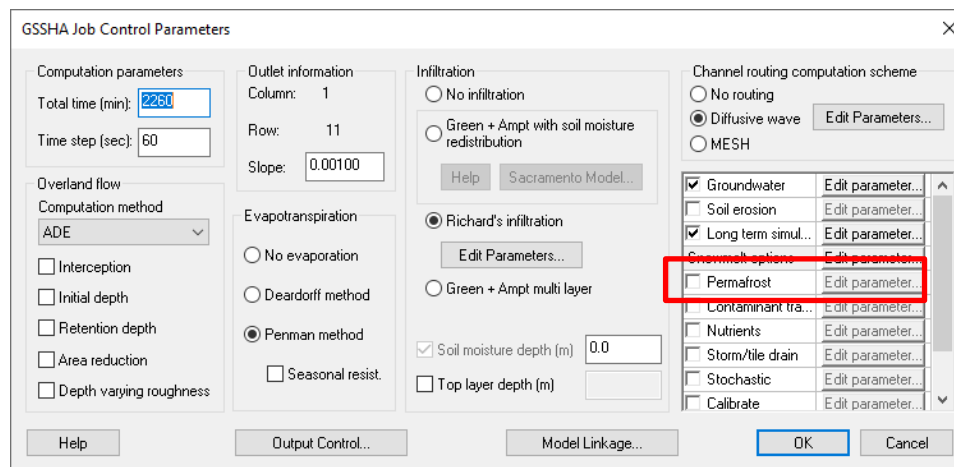3. Click **OK** to close the *GSSHA Job Control Parameters* dialog.

Figure 2   GSSHA Job Control Parameters dialog

2.2   Defining a Mapping Table

Define the Permafrost parameters in the mapping table dialog.

1. Select *GSSHA | **Map Tables…*** to bring up the *GSSHA Map Table Editor* dialog.

2. Select the *Permafrost* tab.

3. For *Using index map*, select "soil".

4. Change *Number of layers* to "7".

5. Click **Generate IDs**.

6. Enter the following parameters for each layer into the mapping table or copy/paste them from the "mapping_tables.xlsx" spreadsheet. The same parameter values should be entered for each soil ID.

Layer	1	2	3	4	5	6	7
ID	1 and 2	1 and 2	1 and 2	1 and 2	1 and 2	1 and 2	1 and 2
Thickness of soil layer (m)	0.08	0.22	0.32	0.38	0.5	3.5	5
Phase change temperature (C)	0	0	0	0	0	0	0
Volumetric soil water content	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Volume of unfrozen water	0.1077	0.0274	0.0537	0.0143	0.0727	0.0144	0.0213
Unfrozen water parameter "A"	0.0345	0.0231	0.0461	0.0128	0.0643	0.0134	0.0155
Unfrozen water parameter "B"	-0.321	-0.235	-0.275	-0.237	-0.294	-0.137	-0.104
Unfrozen water parameter "C"	0	0	0	0	0	0	0
Thawed soil thermal conductivity	3.901	3.901	3.901	0.0145	0.0145	0.0145	0.0145
Frozen soil thermal conductivity	3.001	3.001	3.001	0.019	0.019	0.019	0.019
Volumetric heat capacity	2800000	2900000	2700000	2800000	2700000	2800000	2800000

7. Under *ID 1*, next to the *Initial temperature plot* option, click the **Define** button to open the *XY Series Editor* dialog.

8. Select the **Import** button to open the *Open File* dialog.

9. Select the "temp.xys" file and click **Open** to close the *Open File* dialog.

10. Select the **OK** to close the *XY Series Editor* dialog.

11. Under *ID 2*, next to the *Initial temperature plot* option, click the **Define** button to open the *XY Series Editor* dialog.

12. For the *Selected Curve* option, select "temp".

13. Select the **OK** to close the *XY Series Editor* dialog.

14. Under *ID 1*, next to the *Computational node depths* option, click the **Define** button to open the *XY Series Editor* dialog.

15. Select the **Import** button to open the *Open File* dialog.

16. Select the "temp.xys" file and click **Open** to close the *Open File* dialog.

17. Select the **OK** to close the *XY Series Editor* dialog.

18. Under *ID 2*, next to the *Computational node depths* option, click the **Define** button to open the *XY Series Editor* dialog.

19. For the *Selected Curve* option, select "depths".

20. Select the **OK** to close the *XY Series Editor* dialog.

21. Click **Done** to close the *GSSHA Map Table Editor* dialog.

2.3   Defining Solution Points

Define locations, depths, and other information so soil temperatures are output and plotted.

1. In the Project Explorer, select the "🔵 GSSHA" coverage to make it active.

2. Using the **Create Feature Point** ⋮• tool, click on the Graphics Window to create a point at the following location: 755.8, 942.3

3. Using the **Select Feature Point/Node** 🢒 tool, right-click on the newly created point and select **Attributes…** to open the *Properties* dialog.

4. Scroll to the right and turn on *Permafrost output*.

5. Under *Permafrost output depths*, click the button to open the XY Series Edior.

6. Select the **Import** button to open the *Open File* dialog.

7. Select the "output_depth.xys" file and click **Open** to close the *Open File* dialog.

8. Select the **OK** to close the *XY Series Editor* dialog.

9. Select the **Import** button, select output_depths.xys, and select **Open**.

10. Select **OK** to close the *XY Series Editor*.

11. For the *Permafrost map table ID,* enter "1".

12. Click **OK** to close the *Properties* dialog.

13. Repeat steps 2–12 to add another feature point with the following information:

    a. Location: 44.6, 144.9

　　　　　　　　b. *Permafrost output*: ON

　　　　　　　　c. *Permafrost output depths*: Select the output_depths XY series from the *Selected Curve* drop-down box.

　　　　　　　　d. *Permafrost map table ID*: 2

2.4　　Saving and Running the Model

Before running the model, the project should be saved.

1. Switch to the **2D Grid Module** ⊞.

2. Select *GSSHA* | **Save Project File...** to bring up the *Save GSSHA Project File* dialog.

3. Enter "permafrost.prj" as the *File name*.

4. Click **Save** to save the project under the new name and exit the *Save GSSHA Project File* dialog.

5. Select *GSSHA* | **Run GSSHA…** to bring up the *GSSHA Run Options* dialog.

6. Notice that "permafrost.prj" is listed in the *Location* section.

7. Click **OK** to close the *GSSHA Run Options dialog* and bring up the *Model Wrapper* dialog.

GSSHA may take some time to complete its run.

8. When GSSHA finishes running, turn on *Read solution on exit* and click **Close** to exit the *Model Wrapper* dialog.

3　　Visualizing the Results

This section will discuss how to visualize the soil temperatures.

3.1　　Temperature Plots

The GSSHA permafrost module outputs the soil temperature at the depths defined in the "output_depths" XY series. These temperatures are read into WMS with the solution and can be displayed in a plot window as follows:

1. Select the **Select hydrographs** 🔺 tool in the 2D Grid Module.

2. To bring up a temperature plot, Double-click the plot icon located near the feature point at the following location: 755.8, 942.3

Note the plots of temperature vs time for air temperature and each of the soil depths and close or minimize the plot window.

3. Double-click the plot icon located near the feature point at the following location: 44.6, 144.9

Note the plots of temperature vs time for air temperature and each of the soil depths at this second location and close or minimize the plot window.

3.2   Temperatures Output file

To view the permafrost temperature file, do the following:

1.   Double-click on " Permafrost Temperature File" in the Project Explorer to bring up the *View Data File* dialog. If *Never ask this again* was previously turned on, this dialog will not appear. In this case, skip to step 3.

2.   Select the desired external text editor from the *Open With* drop-down and click **OK** to close the *View Data Files* dialog and open the summary file.

3.   Review the permafrost temperature file and note that this information can be copied and plotted in a spreadsheet.

4.   When finished, exit the text editor and return to WMS.

3.3   Summary File

To view the summary file, do the following:

1.   Double-click on " Summary File" in the Project Explorer to bring up the *View Data File* dialog. If *Never ask this again* was previously turned on, this dialog will not appear. In this case, skip to step 3.

2.   Select the desired external text editor from the *Open With* drop-down and click **OK** to close the *View Data Files* dialog and open the summary file.

3.   Review the summary file.

4.   When finished, exit the text editor and return to WMS.

4   Conclusion

This concludes the "Permafrost in GSSHA" tutorial. Feel free to continue to experiment, or exit the program.