GSSHA – Applications – Snow Modeling within GSSHA

Objectives

Learn how to set up a simulation with the snow modeling capabilities within GSSHA. In this tutorial, you learn how to accurately simulate snow within a watershed model using the data already provided within the long term simulation.

Prerequisite Tutorials

- GSSHA – Applications – Long Term Simulations in GSSHA

Required Components

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

Time

- ~ 1 hour

Contents

Introduction

In this tutorial you will see how to set up and run the snow model simulation within GSSHA. You will begin with an existing project file. The snow model runs under long-term simulations and therefore correct hydrometeorological (hmet for short) data is required. Currently there are four snow models within GSSHA to choose from: Hybrid Energy Balance (default), Energy Balance, Temperature Index, and Radiation-derived Temperature Index. The Radiation-derived Temperature Index (RTI) has shown to be most accurate, but requires some calibration. The Hybrid Energy Balance (HY) snow model is the default snow model due to limited calibration requirements.

The melt-water flow both through the snow pack and into infiltration is also modeled within GSSHA. Melt-water moves both vertically and laterally through the snow pack, essentially delaying the water as it moves through the watershed. A frozen ground simulation within the model also limits the amount of water going to infiltration by simulating when the ground is frozen and therefore cannot permit infiltration.

By accurately simulating the accumulation and melt of the snow pack as well as the melt-water transport, the GSSHA model can accurately replicate the watershed characteristics of watersheds where snow is a concerning factor.

Open an Existing GSSHA Project

Open a WMS project file for the Judy's Branch watershed. This model has been set up to simulate approximately a year of data (Sept 2009 – Sept 2010), capturing the snow accumulation and melt within the watershed. We will modify the project and perform a long term simulation with snow included.

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*|*WMS10.0*|*Tutorials*|.
3. Browse and open the file |*GSSHA Distributed Hydrologic modeling*|*SnowModel*|initial|*longterm_snow.prj*

Setting up the Hybrid Snow Model Simulation

Snow modeling support in WMS is new for v10.0 of the model.

Step 1 – Assigning the proper snow melt parameter values

Select the 2D grid module on the menu. On the top menu select "GSSHA"-> Job Control… In the dialogue next to the "snowmelt options" process select "edit parameters" and enter the following values in the dialogue box that appears:

- Make sure the "Snowmelt analysis option" is set to Hybrid energy balance/NWSRFS
- For "Vertical flow option" select Vertical snow retention.
- Set the "Hydraulic conductivity of the snow pack" to 0.00051.
- Check the "Dry adiabatic lapse rate" box and enter -5.0.
- Enter "Elevation of the HMET gage" 140.
- Check the "Base temperature to begin melt" box and enter 5.0.

Select OK to close the dialogue box.

Step 2 – Set the correct output parameters

With the GSSHA Job Control Parameters dialogue box still open, click on the "Output Control" button near the bottom center of the box. Perform the following tasks:

- Uncheck the "Surface depth" box
- Scroll down and check the "Snow water equivalent" box.
- Change the "Write Frequency" to 10,080 (weekly).

Select OK to close the GSSHA Output Control dialogue.

Select OK to close the Job Control dialogue box.

This adds the following cards in the project file (functions within parentheses):

a.	SNOW_SWE_FILE	"SWE.swe"	(snow water equivalent output file)
b.	SNOW_DARCY	0.00051	(sat. hyd. conductivity of the snow pack, mm^2)
c.	SNOW_TEMP_BASE	5.0	(temperature at which snow begins to melt -C)
d.	OROGVAR_HMET		
e.	HMET_ELEV_GAGE	140.0	(elevation of the hmet gage, m)
f.	HMET_LAPSE_RATE	-5.0	(Dry Adiabatic Lapse Rate, C / km)

```
PRECIP_FILE                "longterm_snow_mod.gag"
RAIN_INV_DISTANCE
LONG_TERM
LATITUDE                   38.769600
LONGITUDE                  270.050000
GMT                        0.000000
EVENT_MIN_Q                0.100000
HMET_WES                   "Snow_HMET.txt"
IN_HYD_LOCATION            "longterm_snow.ihl"
OUT_HYD_LOCATION           "longterm_snow.ohl"
START_DATE                 2006 10 01
START_TIME                 0 0
#
#
SNOW_SWE_FILE              "SWE.swe"
SNOW_DARCY                 0.00051
SNOW_TEMP_BASE             5.0
OROGVAR_HMET
HMET_ELEV_GAGE             140.0
HMET_LAPSE_RATE            -5.0
NWSRFS_RETENTION
```

The GSSHA model now can write temporal and spatial output data to the “longterm_snow.swd” file. The model will simulate the melt-water from the snowpack as flow through the snowpack. Melt of the snow pack will begin at 5.0-C. The GSSHA model will also account for orographic effects lowering the temperature as elevation increases.

It is important to note that the Hybrid snow model with GSSHA is automatically activated when temperatures drop below 0-C and snow is modeled within GSSHA. Output for the snow model is only activated with the inclusion of the SNOW_SWE_FILE card and associated file (in this case “longterm_snow.swd”). If the SNOW_DARCY card is not included in the project file with associated value (in this case 0.00051), the water melted within the snowpack is treated the same as overland flow, and not as flow moving through the snowpack. The default value for the temperature at which snow melts is 0-C, unless otherwise specified using the SNOW_TEM_BASE card with associated value (in this case 5.0). The GSSHA model assumes a 0.0 dry adiabatic lapse rate (no change in temperature with elevation) unless OROGVAR, HMET_ELEV_GAGE (with associated value), and HMET_LAPSE_RATE (with associated value) are all within the project file.

Step 3 – Selecting the precipitation events to use

While still in the 2D Grid Module. Select “GSSHA->Precipitation”. Check the boxes for every event, all 105 of them. Select “OK” to close the dialogue box.

Run the model

1. Save project file to your personal directory – GSSHA->Save GSSHA Project File. You can keep the name longterm_snow.prj or change it to something to let you know it’s completed. Click the “Save” button to save the project.
2. Run the model by selecting – GSSHA->Run GSSHA
3. The model will take approximately 10-15 minutes to complete.

View Results

To visualize the snow-related results do the following:

1. View your Summary file with text editor. If you scroll down through the simulation you'll see that snow accumulation begins in late October. The snow begins to melt in April and is gone by June.
2. Select the "Hydrograph Tool" from the tool bar while in the 2D Grid Module and select your outlet hydrograph. You'll see that while there are outflows up until mid October and then none again until April except for one large event caused by warm temperatures in early November. The series of events in April and May corresponds to the peak snow melt. Subsequent events are typical summer rainfall events.
3. In the 2D Grid module , select ***Display | Display Options***
4. Turn on the 2D Grid *Contours*.
5. Select OK
6. In the data tree, right click on *snow_water_equivalent* under the solution folder
7. Select *Contour Options*
8. Make sure the *Contour Method* drop-down box is set to *Color Fill*
9. Check the *Specify a range* bullet in the lower left corner of the dialogue box
10. Set the Min to 0.01 and leave the Max at the value given.
11. Uncheck the *Fill below* bullet

Setting up the Temperature-Index Snow Model Simulation

This builds upon the previous section.

Step 1 – Assigning the proper snow melt parameter values

Select the 2D grid module on the menu. On the top menu select "GSSHA"-> Job Control… In the dialogue next to the "snowmelt options" process select "edit parameters" and enter the following values in the dialogue box that appears:

- Make sure the "Snowmelt analysis option" is set to Temperature index method
- Leave all other parameters to their defaults. Do notice the Maximum melt factor and Minimum melt factor, these are often the two most important parameter when using the Temperature-Index model.
- Additional parameters (not discussed) can be found at:
  - http://www.gsshawiki.com/Temperature_Index
  - http://www.gsshawiki.com/Snow_Card_Inputs_-_Optional

Select OK to close the dialogue box.

Run the model

1. Save project file to your personal directory – GSSHA->Save GSSHA Project File. You can keep the name longterm_snow.prj or change it to something to let you know it's completed. Click the "Save" button to save the project.
2. Run the model by selecting – GSSHA->Run GSSHA
3. The model will take approximately 10-15 minutes to complete.

View Results

Do same procedure as listed above.

4. In the Properties window on the right side of the WMS application, click on the time steps and use the down arrow key (on the keyboard) to toggle through the time steps. You can see the Snow Water Equivalent contours varying in color as the time steps change.
   a. Look through some of the dates and the associated SWE maps shown in WMS.
   b. Pay attention in June when the snow begins to all melt. The spatial heterogeneity in this method is entirely based on elevation (same with the Hybrid model previously run).

Setting up the Radiation-derived Temperature-Index Snow Model Simulation

This builds upon the previous section.

Step 1 – Assigning the proper snow melt parameter values

The Radiation-derived Temperature-Index (RTI) snow model is new, and therefore not yet supported in WMS. With it's recent introduction into GSSHA 7.0, documentation of the RTI model has not yet been completed on the gsshawiki either.

The RTI snow model is built upon the TI snow model framework, with most of the complexities associated with the RTI model internal to GSSHA. Therefore, it is easy to convert an existing TI snow model to an RTI snow model:

1.) Open the "longterm_snow.prj" file within a text editor.
2.) Change Lines 50, 54, and 55
   a. "NWSRFS_SNOW_W_RAD" calls the RTI snow model instead of the TI snow model (see figure below)
   b. The RTI snow model requires only one constant melt factor ("NWSRFS_MF_CONSTANT") instead of the two melt factors required by the TI snow model.

TI SNOW MODEL

```
NWSRFS_SNOW
VERT_SNOW_RETENTION
SNOW_DARCY                0.000510
SNOW_REYNOLDS             162.000000
NWSRFS_MF_MAX             1.200000
NWSRFS_MF_MIN             0.200000
```

RTI SNOW MODEL

```
NWSRFS_SNOW_W_RAD
VERT_SNOW_RETENTION
SNOW_DARCY                0.000510
SNOW_REYNOLDS             162.000000
NWSRFS_MF_CONSTANT             1.200000
#NWSRFS_MF_MIN             0.200000
```

3.) Within the text editor save "longterm_snow.prj"

Run the model

4.) Run the model by selecting – GSSHA->Run GSSHA. UNCLICK THE TOGGLE FOR "Save file before running". This will overwrite the edits you just made in the text editor.

5.) The model will take approximately 10-15 minutes to complete.

View Results

Do same procedure as listed above.

6.) In the Properties window on the right side of the WMS application, click on the time steps and use the down arrow key (on the keyboard) to toggle through the time steps. You can see the Snow Water Equivalent contours varying in color as the time steps change.

   c. Look through some of the dates and the associated SWE maps shown in WMS.

   d. Pay attention in May when the snow begins to all melt. The spatial heterogeneity is based predominantly on elevation, but also due to slope and aspect. If the vegetation is included in the model the RTI model accounts for differences in vegetation as well.