Simulating Frozen Soil Using Simple Options in GSSHA

In this tutorial you will modify an existing GSSHA model to simulate the effects of frozen soil utilizing the different methods outlined in the lecture and with varying input parameters. To do this exercise you will have to learn a few new things since the frozen soil options used here are not currently supported in WMS. You have to manually edit files and run GSSHA from the command line. It'll be good for ya. I promise.

Step 1 - Edit Your Input Files

1. Find the directory FrozenSoilStudent.
2. Open the file longterm_snow.prj in a text editor by selecting the file and right clicking and select to "Open With" a text editor, such as Wordpad.
3. When you open the project file you'll see something like this.

```
GSSHAPROJECT
WMS WMS 10.0.10 (64-bit)
WATERSHED_MASK        "longterm_snow.msk"
#PROJECT_PATH         "C:\temp\snow\"
#LandSoil             "C:\temp\snow\longterm_snow.lsf"
#PROJECTION_FILE      "C:\temp\snow\longterm_snow_prj.pro"
NON_ORTHO_CHANNELS
FLINE                 "longterm_snow.map"
METRIC
QOUT_CFS
GRIDSIZE              90.000000
ROWS                  70
COLS                  75
TOT_TIME              2880
TIMESTEP              60
OUTROW                64
OUTCOL                1
OUTSLOPE              0.001000
MAP_FREQ              720
HYD_FREQ              720
MAP_TYPE              1
ELEVATION             "longterm_snow.ele"
DEPTH                 "longterm_snow.dep"
CHAN_DEPTH            "longterm_snow.cdp"
CHAN_DISCHARGE        "longterm_snow.cdq"
DIFFUSIVE_WAVE
CHANNEL_INPUT         "longterm_snow.cif"
STREAM_CELL           "longterm_snow.gst"
```

```
OVERTYPE              ADE
ET_CALC_PENMAN
SEASONAL_RS
INF_REDIST
SOIL_MOIST_DEPTH       0.500000
#INDEXGRID_GUID        "C:\temp\snow\Soil.idx" "075149ba-8214-44ec-be55-1e1d12571f43"
#INDEXGRID_GUID        "C:\temp\snow\LandUse.idx" "ca5d7bec-c528-4657-b175-0d1bacf52268"
#INDEXGRID_GUID        "C:\temp\snow\Combined.idx" "6f1b8f24-a1fc-4a5c-a445-f33759b5c34b"
MAPPING_TABLE          "longterm_snow.cmt"
ST_MAPPING_TABLE       "longterm_snow.smt"
SUMMARY                "longterm_snow.sum"
OUTLET_HYDRO           "longterm_snow.otl"
QUIET
PRECIP_FILE            "longterm_snow.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"
SNAP_RETENTION
SNOW_DARCY             0.005550
SNOW_REYNOLDS          162.000000
IN_HYD_LOCATION        "longterm_snow.ihl"
OUT_HYD_LOCATION       "longterm_snow.ohl"
```

4. Scroll down to the bottom of the page hit return to add a new a new line and type the card "SNOW_NO_INFILTRATE". This will evoke the SNOW_NO_INFITRATE option in GSSHA.
5. You'll want to change the names of your output files so you can compare results. Find the project card SUMMARY (highlighted above), change the name of the summary file output from longterm_snow.sum to longterm_sni.sum. You should see the OUTLET_HYDRO card right above or below. Change the name of the outlet hydrograph file to longterm_sni.otl.
6. Save the project file with a new name, longterm_sni.prj.
7. Now change the frozen soil option. Change the line SNOW_NO_INFILRATE to GTFSM. Now you have specified to use the ground temperature frozen soil model. Again, you'll want to change the output file names, longterm_gtfsm.sum and .otl, and rename the project file, longterm_gtfsm.prj.
8. Now change the frozen soil option again, but this time to "CFGI", the continuous frozen ground index model. Change you output file names, longterm_cfgi.sum and longterm_cfgi.otl, and save your project as longterm_cfgi.prj.

9. Now you are going to vary the parameters for the CFGI model. When you specify just CFGI you are taking the default values. Here, you will vary the default values by including additional cards and parameter values in your project file. You will start with the index. The index control the values of negative degrees days that must occur before the ground is considered frozen. The default is 83. You'll try increasing and decreasing the value to see the effects.
10. Go to the bottom of the page and add a new line. In this line type GFGI_INDEX followed by the value 120. So you should now have this in your project file.

    CFGI
    CFGI_INDEX 120

    Repeat steps 5 and 6 using the name "longterm_cfgi120".

11. Now change the index to 40, repeat steps 4 and 5 - change the output names, and save the project file using the name "longterm_cfgi40".
12. Now you will modify the K value. The K value is the exponent for the effect of snow. The default value is 0.5. You'll try increasing and decreasing this value to see the effects.
13. Change the line CFGI_INDEX to CFGI_K and change the value from 120 to 1.0. Your file should look like this.

    CFGI
    CFGI_K 1.0

14. Repeat steps 4 and 5; rename your output files "longterm_cfgiK1.sum" and "longterm_cfgiK1.otl", and save your project file with the name "longterm_cfgiK1.prj".
15. Now change the value of K to 0.25. Repeat steps 4 and 5; rename your output files "longterm_cfgiKp25.sum" and "longterm_cfgiKp25.otl", and save your project file as "longterm_cfgiKp25.prj".

You should now have 7 new project files in your folder. Now you'll run these project files and plot the results.

<u>Step 2 – Run GSSHA with your files</u>

For this exercise you are going to run with GSSHA from the command line. To facilitate this you need to have a copy of GSSHA within our directory. You should have a copy of GSSHA in the FrozenSoilStudent directory. The GSSHA v7.0 executable is gssha70.exe. If not, or it doesn't work, search your drive for the gssha70.exe and copy it to your FrozenSoilStudent directory.

Now that you have the GSSHA executable in your directory with your files you'll run GSSHA in one of two ways, from a batch file, or from the command line.

There is a file in the FrozenSoilStudent directory called "frozen.bat". This is a batch file. If you double click on this file it will launch GSSHA 7 times in a row and run all your simulations. The batch file will only work if you have used the suggested names for the project files above. If you have not, you can edit the batch file in a text editor and change the names of the files. Be aware, if you click on the .bat file and try to open it, it will launch. You'll need to open Word Pad or other editor and then open the file from there. Be sure to save the file with extension .bat, or it won't function as a batch file.

The second option is run GSSHA repeatedly from the command prompt.

1. Open a command prompt by clicking on the Windows icon on your computer toolbar and selecting the command prompt icon.
2. You'll have to move to the directory where your files exist. Use the command "cd" followed by the directory name to move forward. To move backwards type "cd.." To see what is in the current directory type "dir".
3. Once you get to your directory, you can launch the GSSHA executable by typing gssha70 followed by the name of your project file, such as

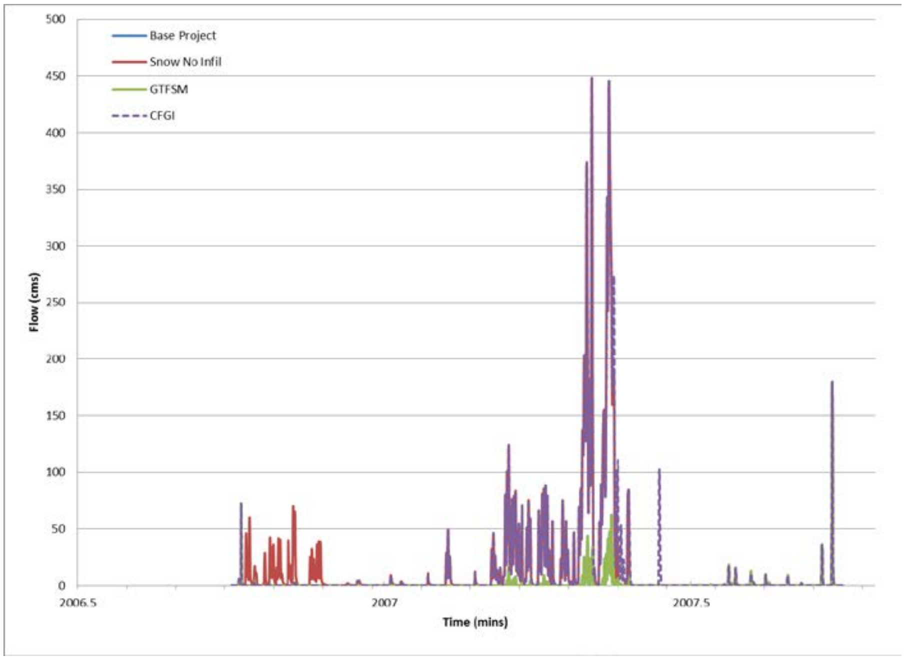
   gssha70 longterm_sni.prj

4. Repeat step 3 for all of your project files. Allow each simulation to run to completion before trying to type the command in the command prompt.

<u>Step 3 – Visualize Results</u>

Now that you have all of your simulations completed, open spreadsheet "4 FrozenSoils". Open all your outlet hydrograph output files. "*.otl" and paste them in the correct columns in the "Data" sheet. If you had trouble getting any or all of your files to run, you can find the various "*.otl" files in the "Frozen Soil" directory.

The results of using different methods are shown in the "Methods" page. You'll see that the SNOW_NO_INFILTRATE and the CFGI methods greatly increase runoff over the base, while the GTFSM increasing runoff more modestly. Look at the summary files, "*.sum" to see the net effect on runoff and infiltration for the simulation. Open the .sum files in a text editor and scroll to the bottom of the page to see the simulation totals. How do runoff, infiltration, and ET vary between simulations? If you look at the pages "CFGI" and "CFGI(2)" you can see the effects on runoff caused by changing the parameter values in the CFGI model for the index and the snow K, respectively. What effect do these parameters have? How are the simulation totals in the summary file different?



SIMULATION TOTALS
GLOBAL MASS BALANCE CALCULATIONS
All volumes are in cubic meters

Initial volume on surface=	0.00
Initial volume in channels=	0.00
Initial volume in soil over simple soil depth	1119420.00
Initial volume in groundwater=	0.00
Final volume on surface=	187.72
Final volume in channels=	54.49
Final volume in soil over simple soil depth	4569248.55
Final volume in groundwater=	0.00
Final volume of snow=	0.00
Final volume of melt water =	0.00
Total amount of precip=	27545567.94
Total amount of interception=	0.00
Total amount of canopy sublimation=	0.00
Total amount of infiltration=	10784693.12
Total amount of evaporation=	1534579.47
Total direct evaporation=	84645.90
Total amount of exfiltration=	0.00
Total downward flux from unsaturated zone=	5884930.99
Total flux of gw across bounds=	0.00
Total overland point sources=	0.00
Total channel point sources=	0.00

Total lateral inflow into channels=	16669529.62
Total amount of discharge=	16669475.13

Mass balance error of surface components = 0.023639 percent

Overall mass balance error = .022716 percent

Simple soil moisture mass balance = 0.000000 percent