A Geospatial Modeling Interface (GMI) for SWAT Model Deployment and Evaluation

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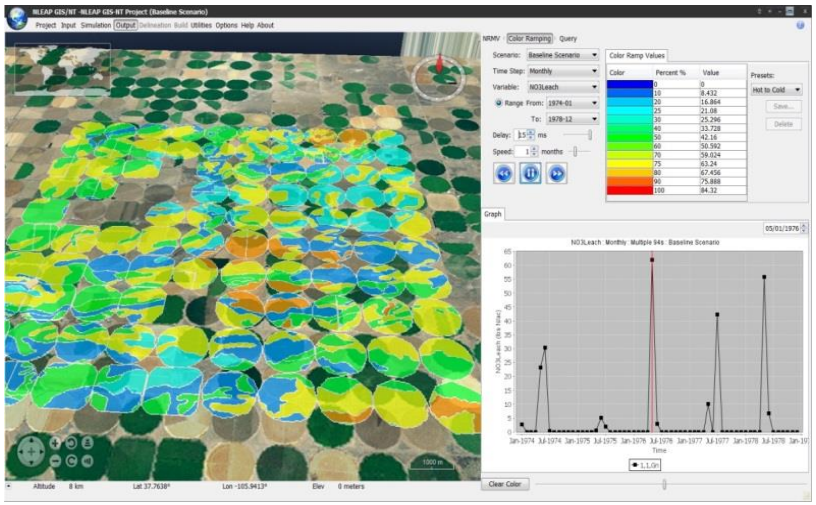


Impetus for GMI Development

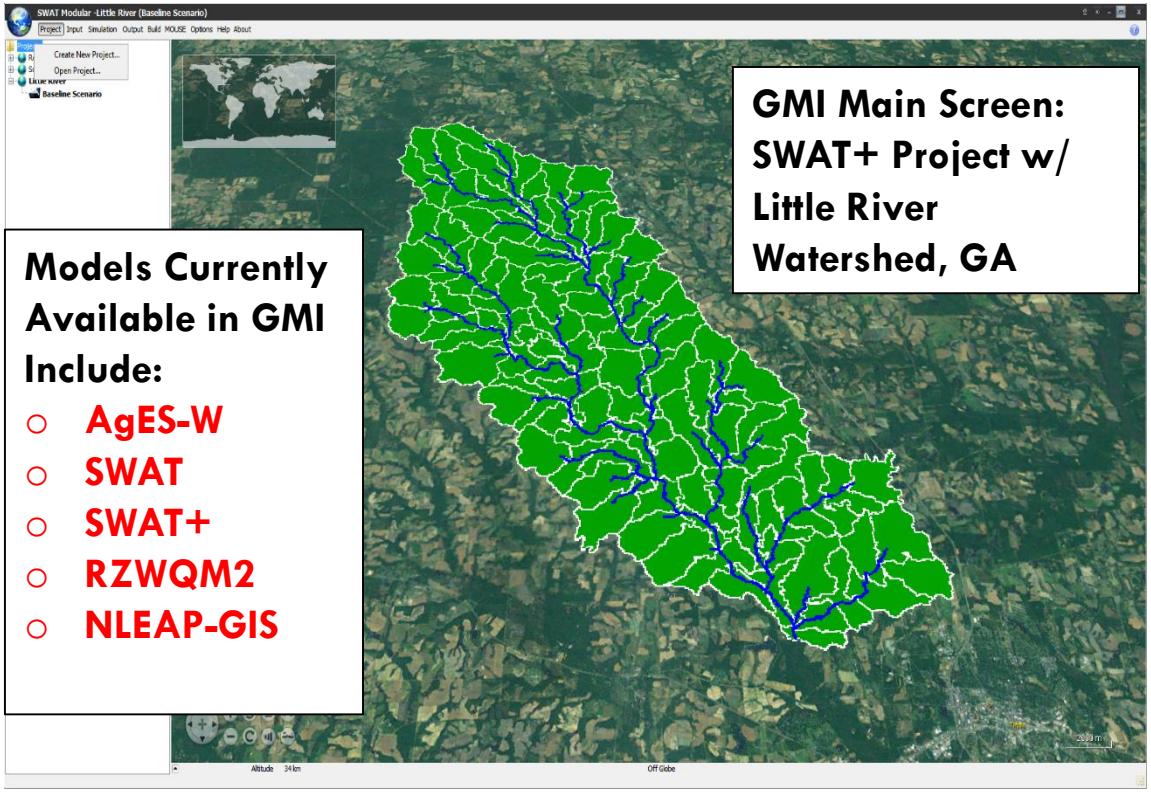
The GMI Tool Was Developed To:

- Provide "common" access (in terms of project management, file handling, spreadsheet operations, geospatial data management, report writing, visualization, etc.) to environmental models that operate at different temporal and spatial scales
- Create a geospatial modeling system that is entirely open source, compatible with commonly available GIS data layers, useful for scenario development/assessment at multiple scales, and able to render geospatial model resources in a contemporary "real-world" presentation

The overall vision of the GMI development effort is the creation of a geospatial modeling framework that allows rapid integration of environmental models such as SWAT/SWAT+ and enables/enhances the scientific modeling process through state-of-the-art geospatial visualization components

GMI Overview

- The GMI geospatial simulation system was developed using Java 8 and the NetBeans™ 8.0 Integrated Development Environment (IDE)
- GMI leverages NASA's World Wind™ Java SDK and employs nearly 180 custom Java libraries to provide functionality for various system features

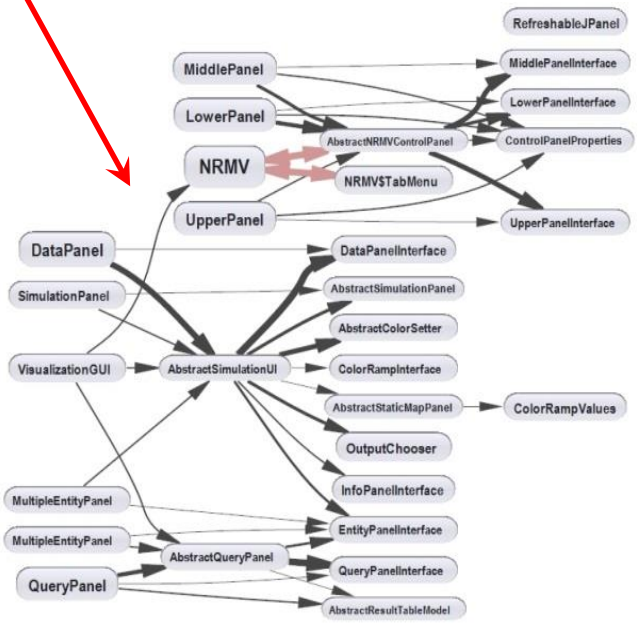


GMI Main Screen: SWAT+ Project w/ Little River Watershed, GA

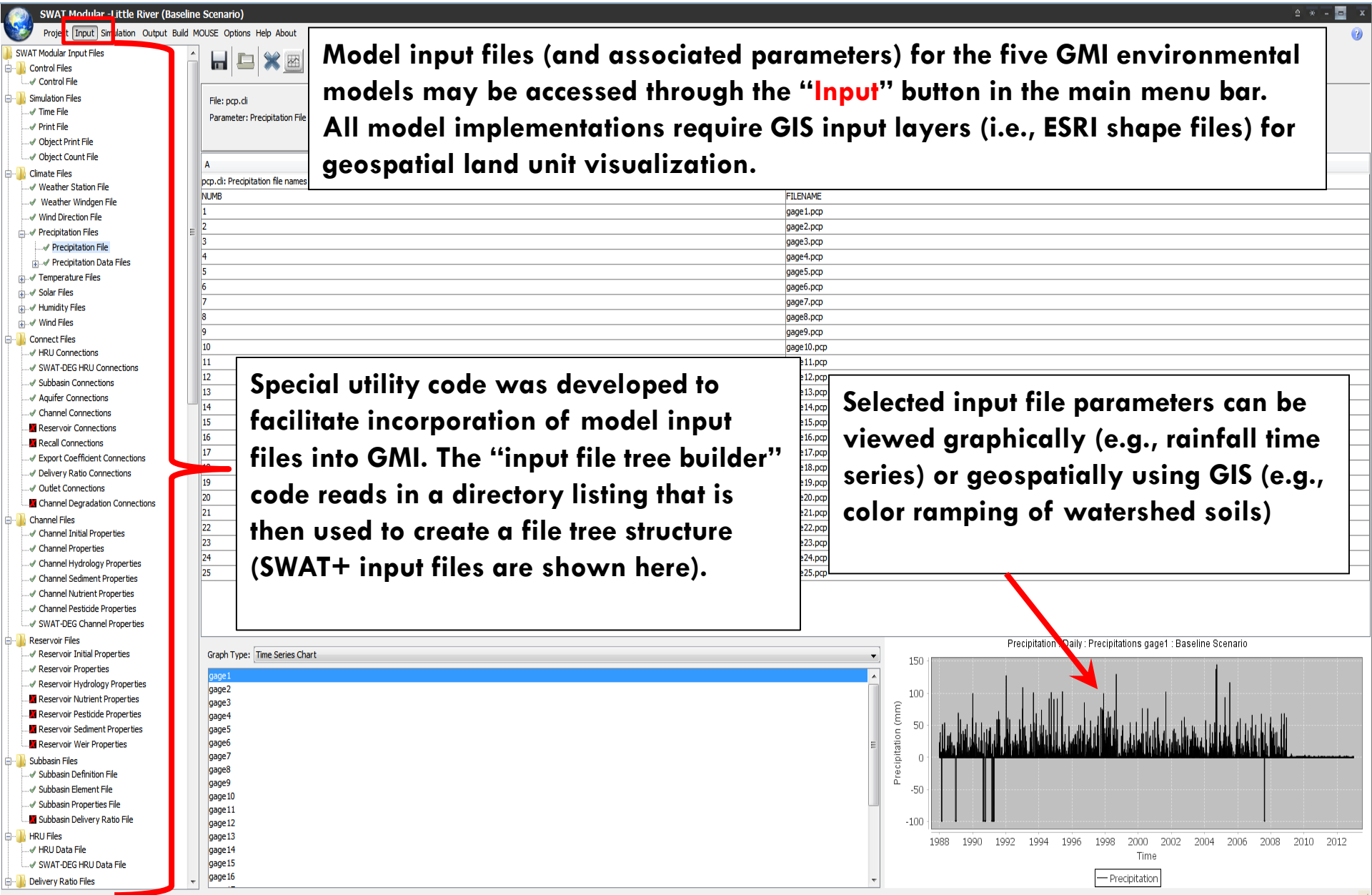
Models Currently Available in GMI Include:

- AgES-W
- SWAT
- SWAT+
- RZWQM2
- NLEAP-GIS

Overview of Major GMI Java Classes for Output Visualization



GMI Input Screen – SWAT+ and Little River Watershed (LRW) Example

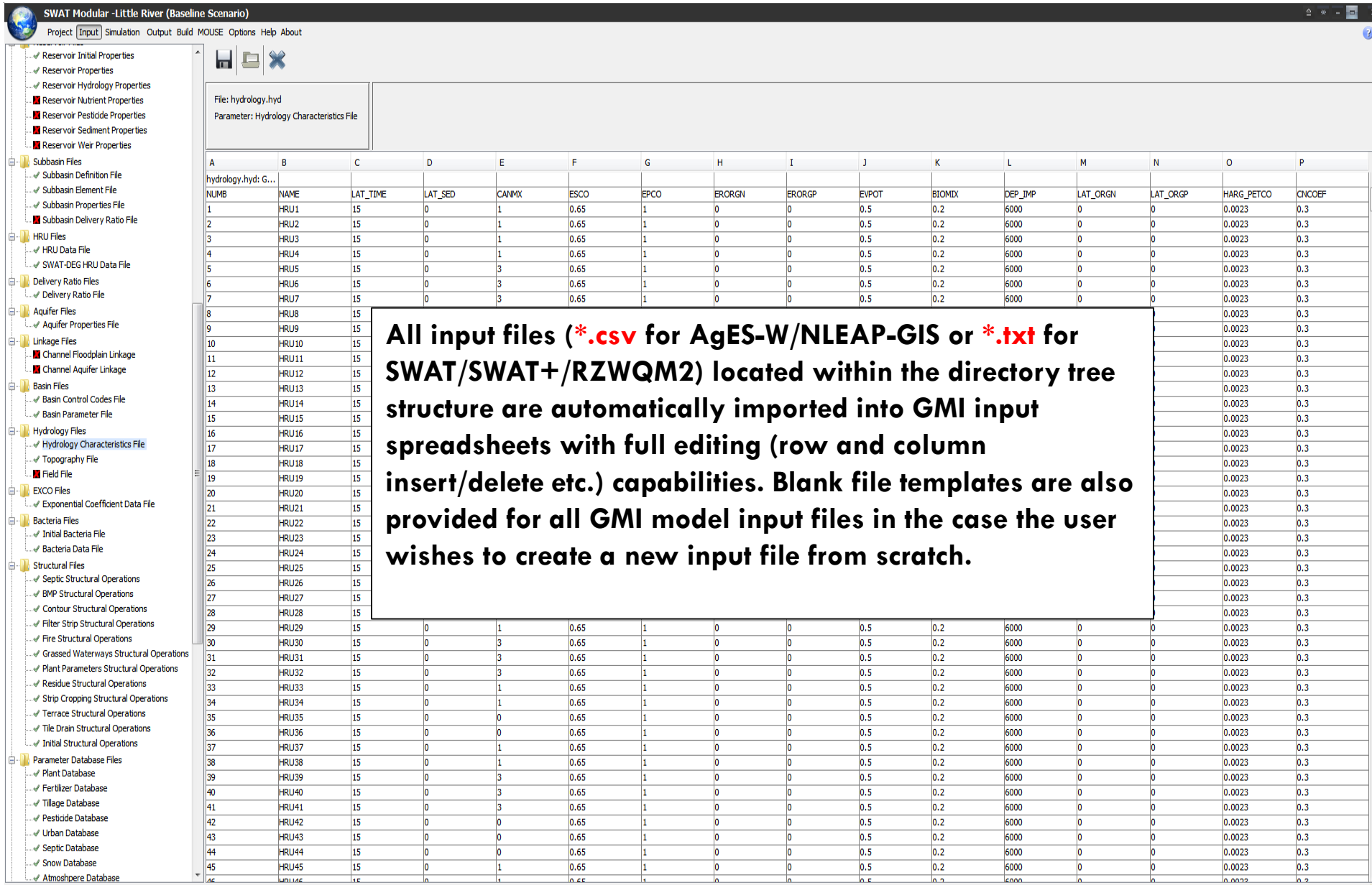


Model input files (and associated parameters) for the five GMI environmental models may be accessed through the "Input" button in the main menu bar. All model implementations require GIS input layers (i.e., ESRI shape files) for geospatial land unit visualization.

Special utility code was developed to facilitate incorporation of model input files into GMI. The "input file tree builder" code reads in a directory listing that is then used to create a file tree structure (SWAT+ input files are shown here).

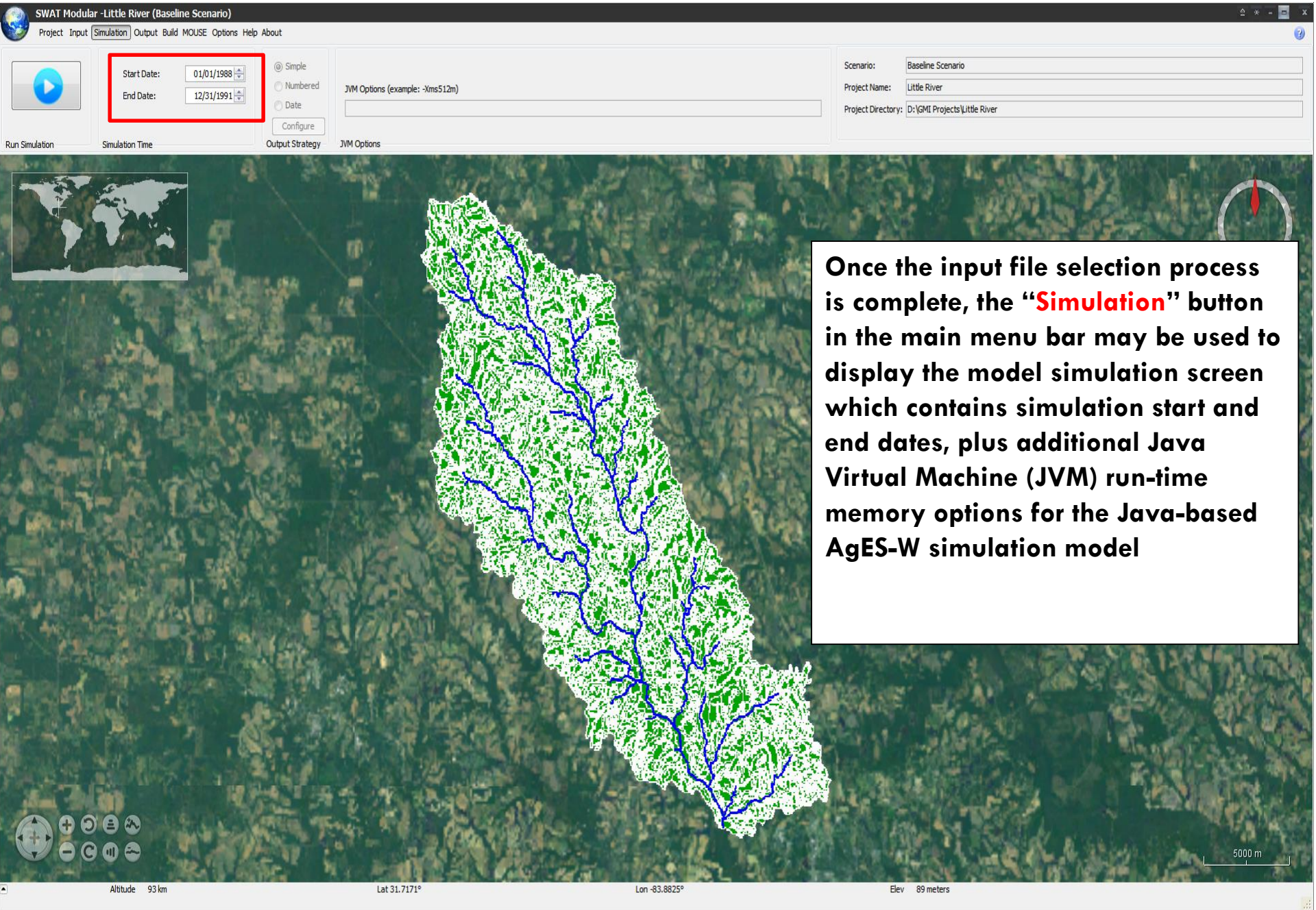
Selected input file parameters can be viewed graphically (e.g., rainfall time series) or geospatially using GIS (e.g., color ramping of watershed soils)

GMI Input Screen – SWAT+ and Little River Watershed (LRW) Example



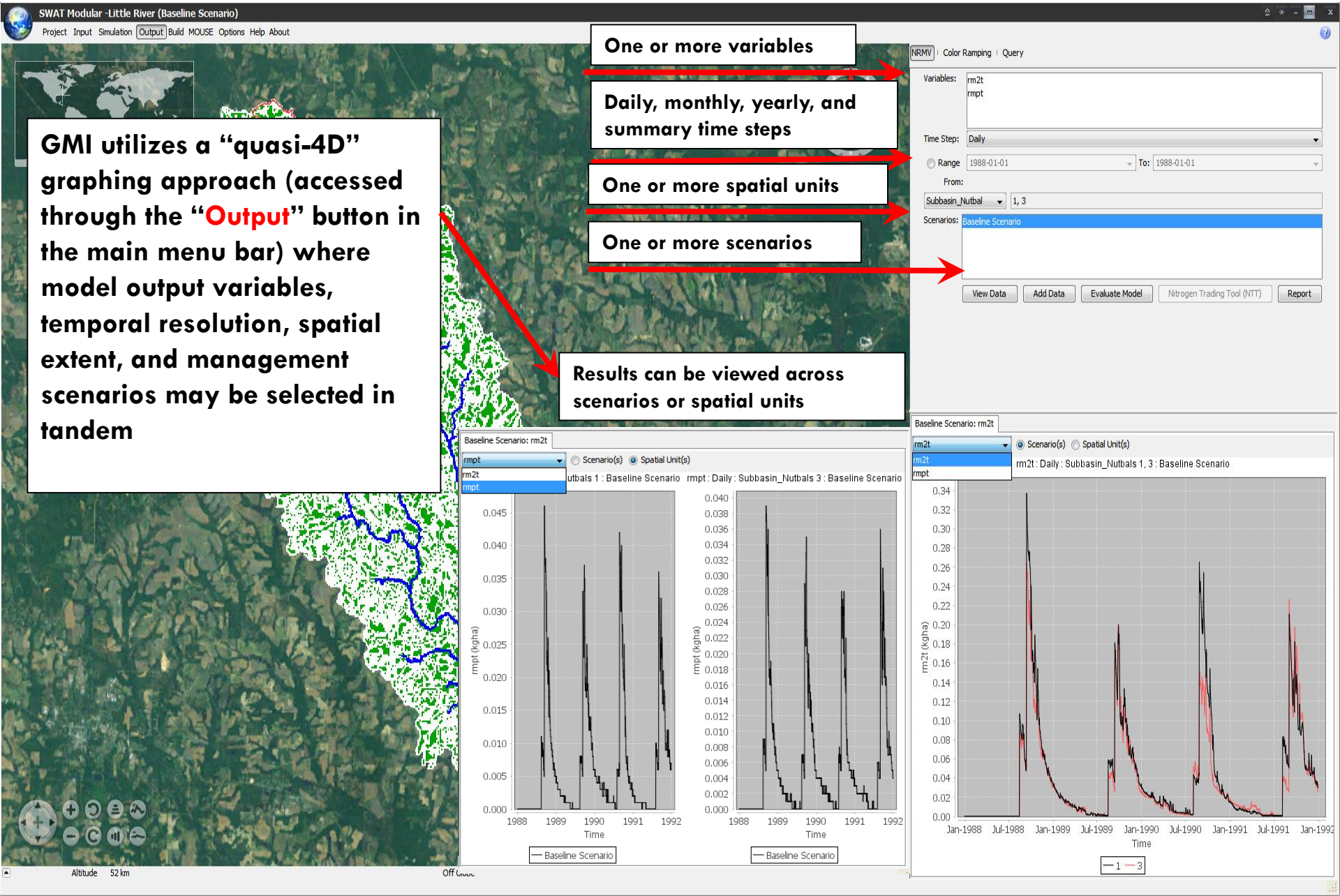
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
hydrology.hyd: G...															
NUMB	NAME	LAT_TIME	LAT_SED	CANMX	ESCO	EPCO	ERORGN	ERORGP	EVPOT	BIOMIX	DEP_IMP	LAT_ORGN	LAT_ORGP	HARG_PETCO	CNCOEF
1	HRU1	15	0	1	0.65	1	0	0	0.5	0.2	6000	0	0	0.0023	0.3
2	HRU2	15	0	1	0.65	1	0	0	0.5	0.2	6000	0	0	0.0023	0.3
3	HRU3	15	0	1	0.65	1	0	0	0.5	0.2	6000	0	0	0.0023	0.3
4	HRU4	15	0	1	0.65	1	0	0	0.5	0.2	6000	0	0	0.0023	0.3
5	HRU5	15	0	3	0.65	1	0	0	0.5	0.2	6000	0	0	0.0023	0.3
6	HRU6	15	0	3	0.65	1	0	0	0.5	0.2	6000	0	0	0.0023	0.3
7	HRU7	15	0	3	0.65	1	0	0	0.5	0.2	6000	0	0	0.0023	0.3
8	HRU8	15												0.0023	0.3
9	HRU9	15												0.0023	0.3
10	HRU10	15												0.0023	0.3
11	HRU11	15												0.0023	0.3
12	HRU12	15												0.0023	0.3
13	HRU13	15												0.0023	0.3
14	HRU14	15												0.0023	0.3
15	HRU15	15												0.0023	0.3
16	HRU16	15												0.0023	0.3
17	HRU17	15												0.0023	0.3
18	HRU18	15												0.0023	0.3
19	HRU19	15												0.0023	0.3
20	HRU20	15												0.0023	0.3
21	HRU21	15												0.0023	0.3
22	HRU22	15												0.0023	0.3
23	HRU23	15												0.0023	0.3
24	HRU24	15												0.0023	0.3
25	HRU25	15												0.0023	0.3
26	HRU26	15												0.0023	0.3
27	HRU27	15												0.0023	0.3
28	HRU28	15												0.0023	0.3
29	HRU29	15	0	1	0.65	1	0	0	0.5	0.2	6000	0	0	0.0023	0.3
30	HRU30	15	0	3	0.65	1	0	0	0.5	0.2	6000	0	0	0.0023	0.3
31	HRU31	15	0	3	0.65	1	0	0	0.5	0.2	6000	0	0	0.0023	0.3
32	HRU32	15	0	3	0.65	1	0	0	0.5	0.2	6000	0	0	0.0023	0.3
33	HRU33	15	0	1	0.65	1	0	0	0.5	0.2	6000	0	0	0.0023	0.3
34	HRU34	15	0	1	0.65	1	0	0	0.5	0.2	6000	0	0	0.0023	0.3
35	HRU35	15	0	0	0.65	1	0	0	0.5	0.2	6000	0	0	0.0023	0.3
36	HRU36	15	0	0	0.65	1	0	0	0.5	0.2	6000	0	0	0.0023	0.3
37	HRU37	15	0	1	0.65	1	0	0	0.5	0.2	6000	0	0	0.0023	0.3
38	HRU38	15	0	1	0.65	1	0	0	0.5	0.2	6000	0	0	0.0023	0.3
39	HRU39	15	0	3	0.65	1	0	0	0.5	0.2	6000	0	0	0.0023	0.3
40	HRU40	15	0	3	0.65	1	0	0	0.5	0.2	6000	0	0	0.0023	0.3
41	HRU41	15	0	3	0.65	1	0	0	0.5	0.2	6000	0	0	0.0023	0.3
42	HRU42	15	0	0	0.65	1	0	0	0.5	0.2	6000	0	0	0.0023	0.3
43	HRU43	15	0	0	0.65	1	0	0	0.5	0.2	6000	0	0	0.0023	0.3
44	HRU44	15	0	0	0.65	1	0	0	0.5	0.2	6000	0	0	0.0023	0.3
45	HRU45	15	0	1	0.65	1	0	0	0.5	0.2	6000	0	0	0.0023	0.3

GMI Simulation Screen

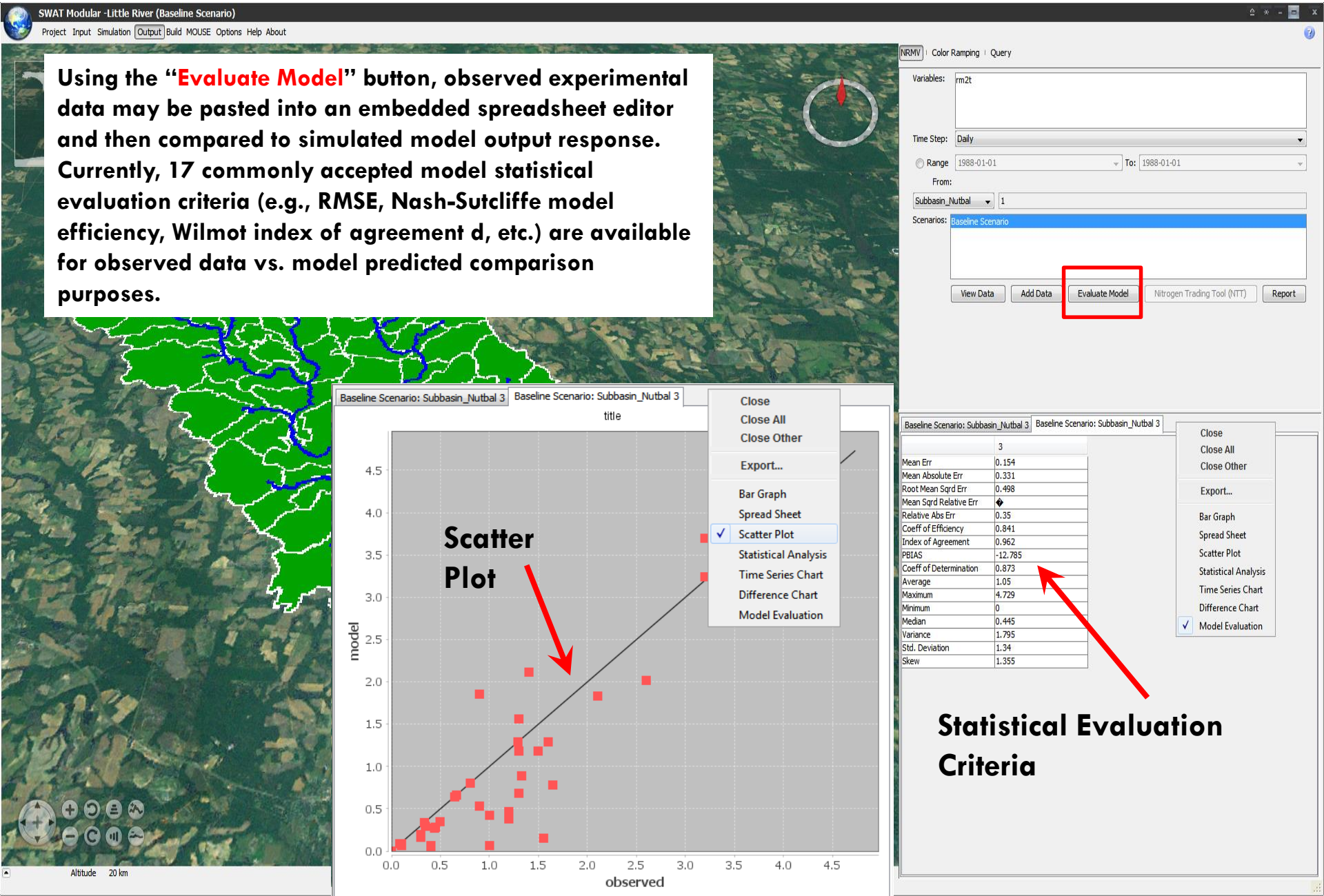


Once the input file selection process is complete, the "Simulation" button in the main menu bar may be used to display the model simulation screen which contains simulation start and end dates, plus additional Java Virtual Machine (JVM) run-time memory options for the Java-based AgES-W simulation model

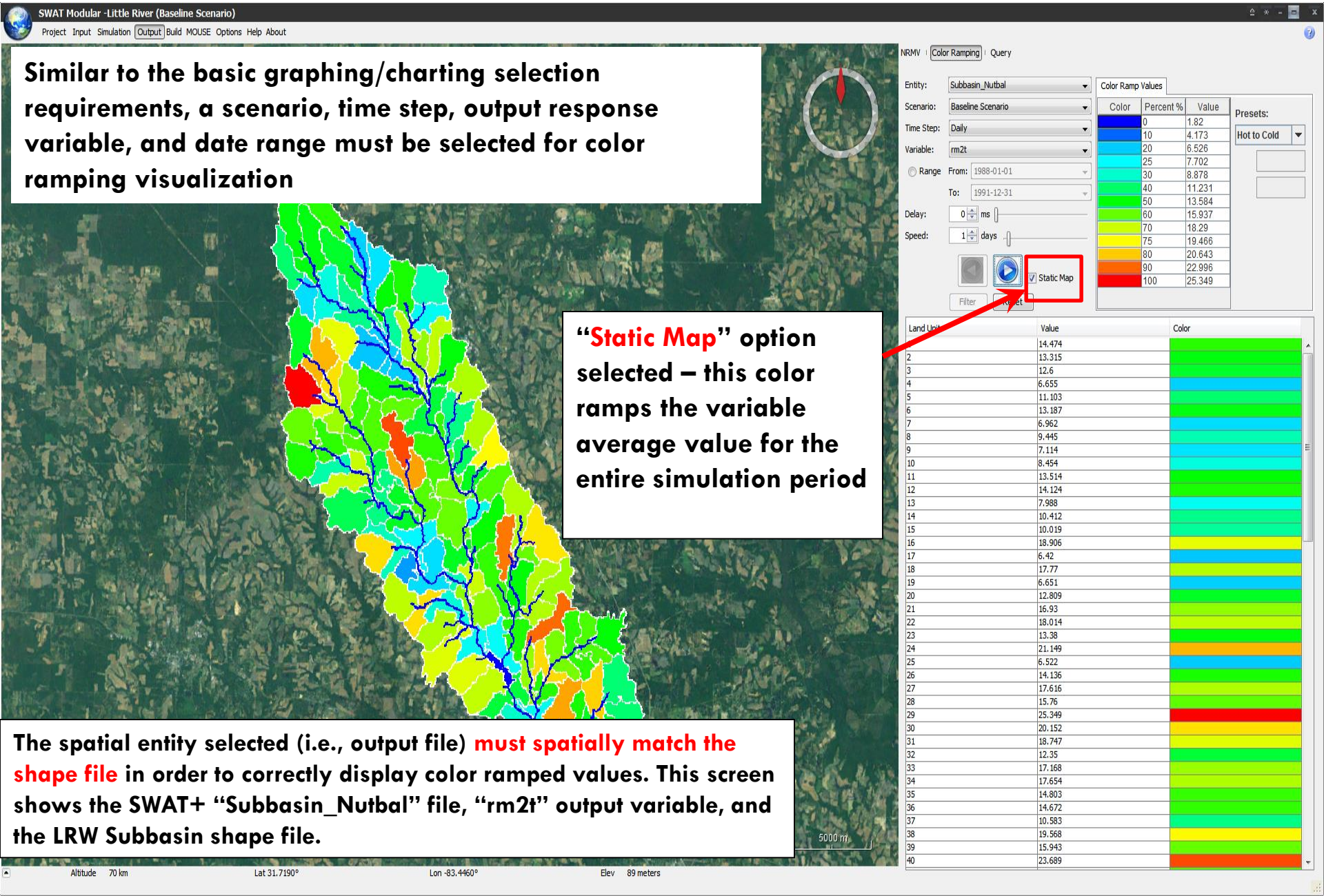
GMI Output Visualization – Graphing/Charting



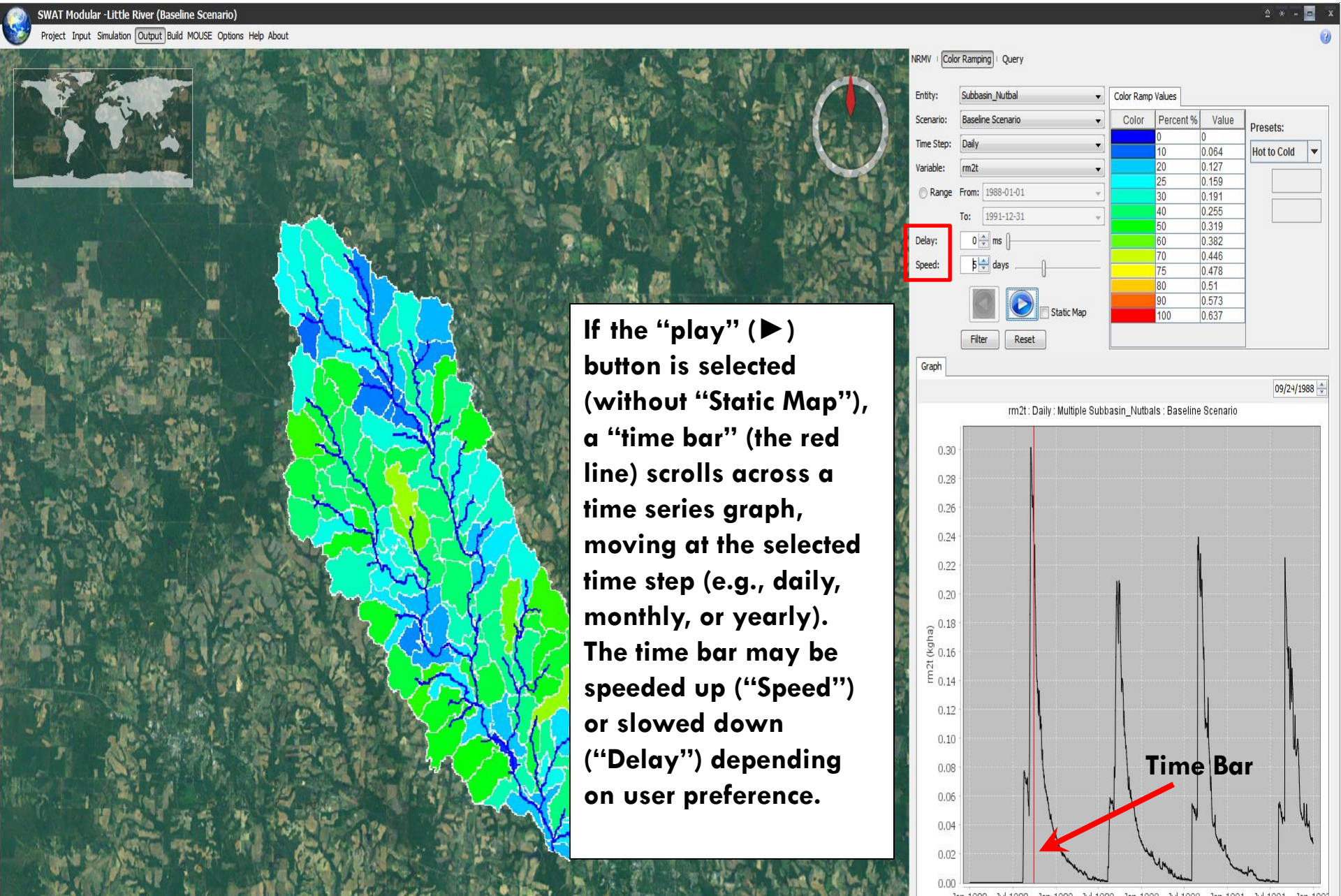
GMI Output Visualization – Graphing/Charting



GMI Output Visualization – Color Ramping

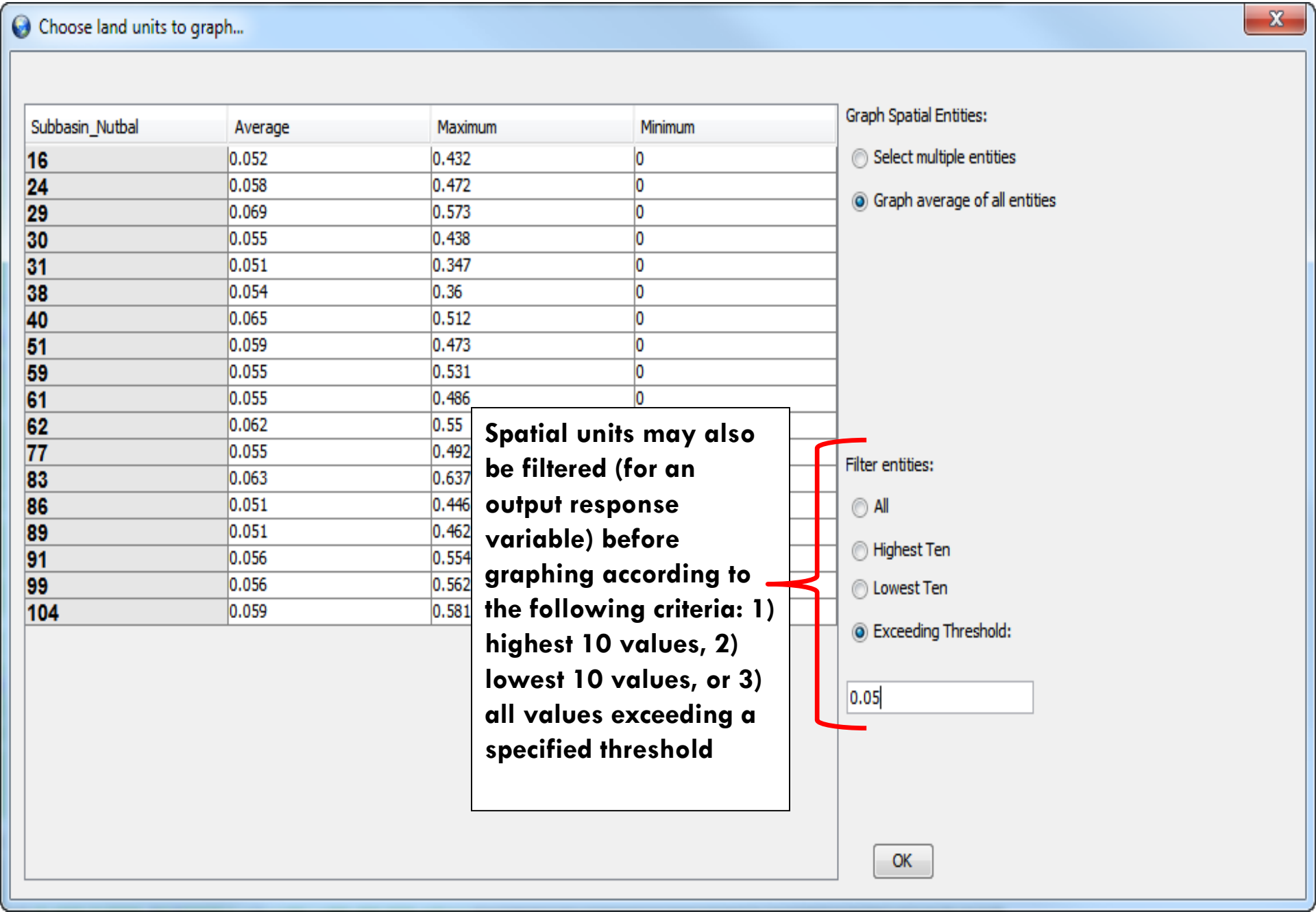


GMI Output Visualization – Color Ramping



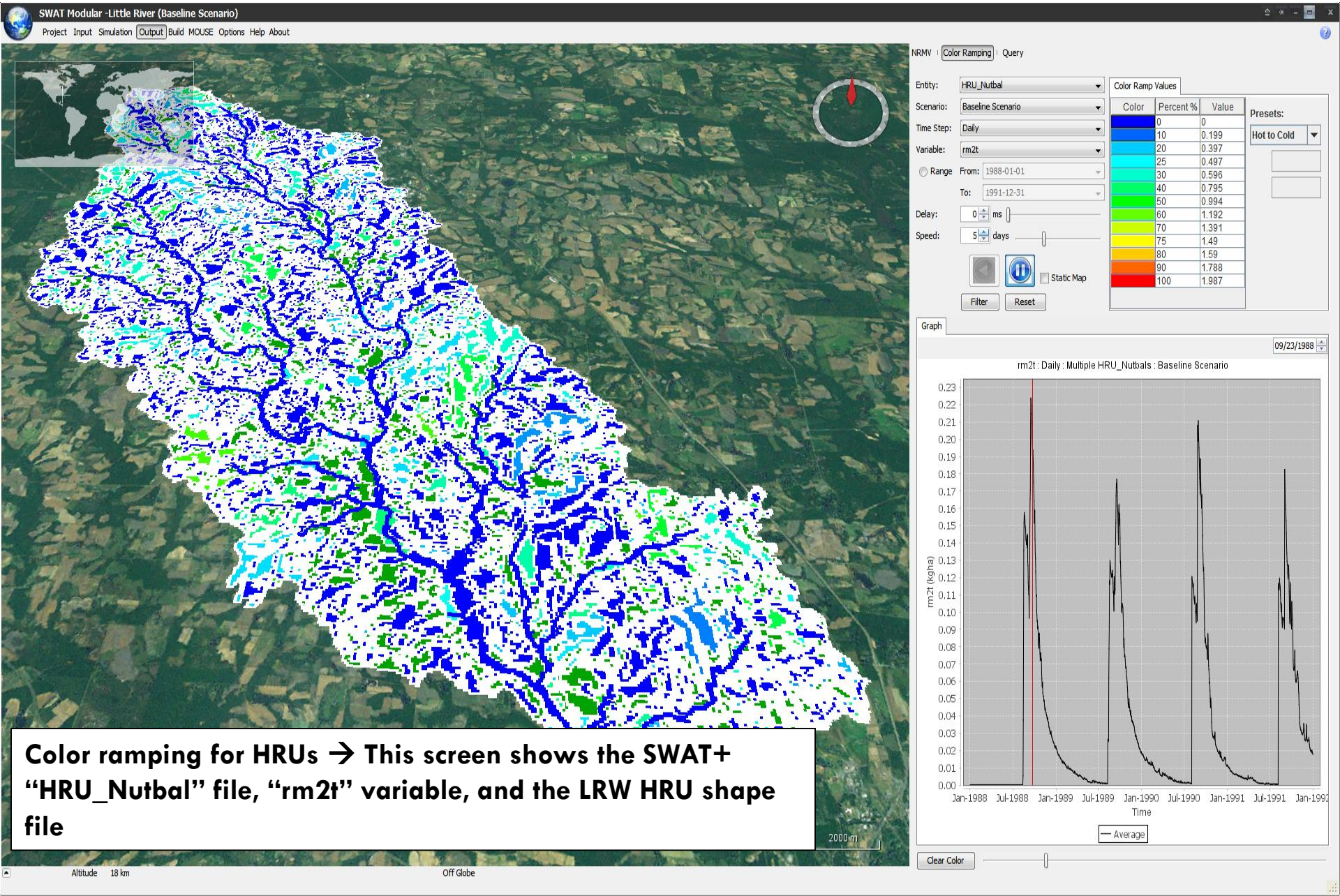
If the "play" (►) button is selected (without "Static Map"), a "time bar" (the red line) scrolls across a time series graph, moving at the selected time step (e.g., daily, monthly, or yearly). The time bar may be speeded up ("Speed") or slowed down ("Delay") depending on user preference.

GMI Output Visualization – Color Ramping Filter



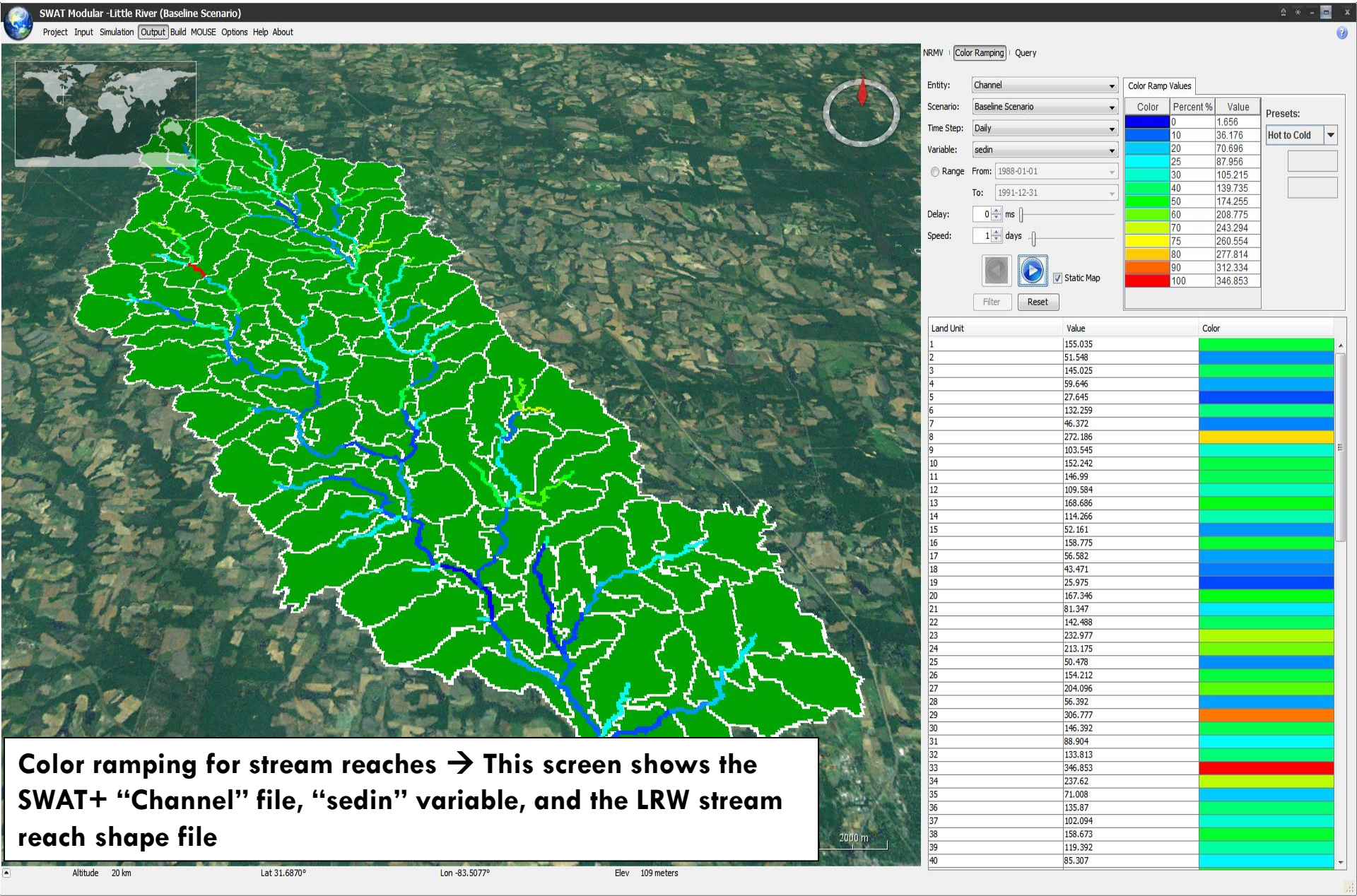
Spatial units may also be filtered (for an output response variable) before graphing according to the following criteria: 1) highest 10 values, 2) lowest 10 values, or 3) all values exceeding a specified threshold

GMI Output Visualization – Color Ramping



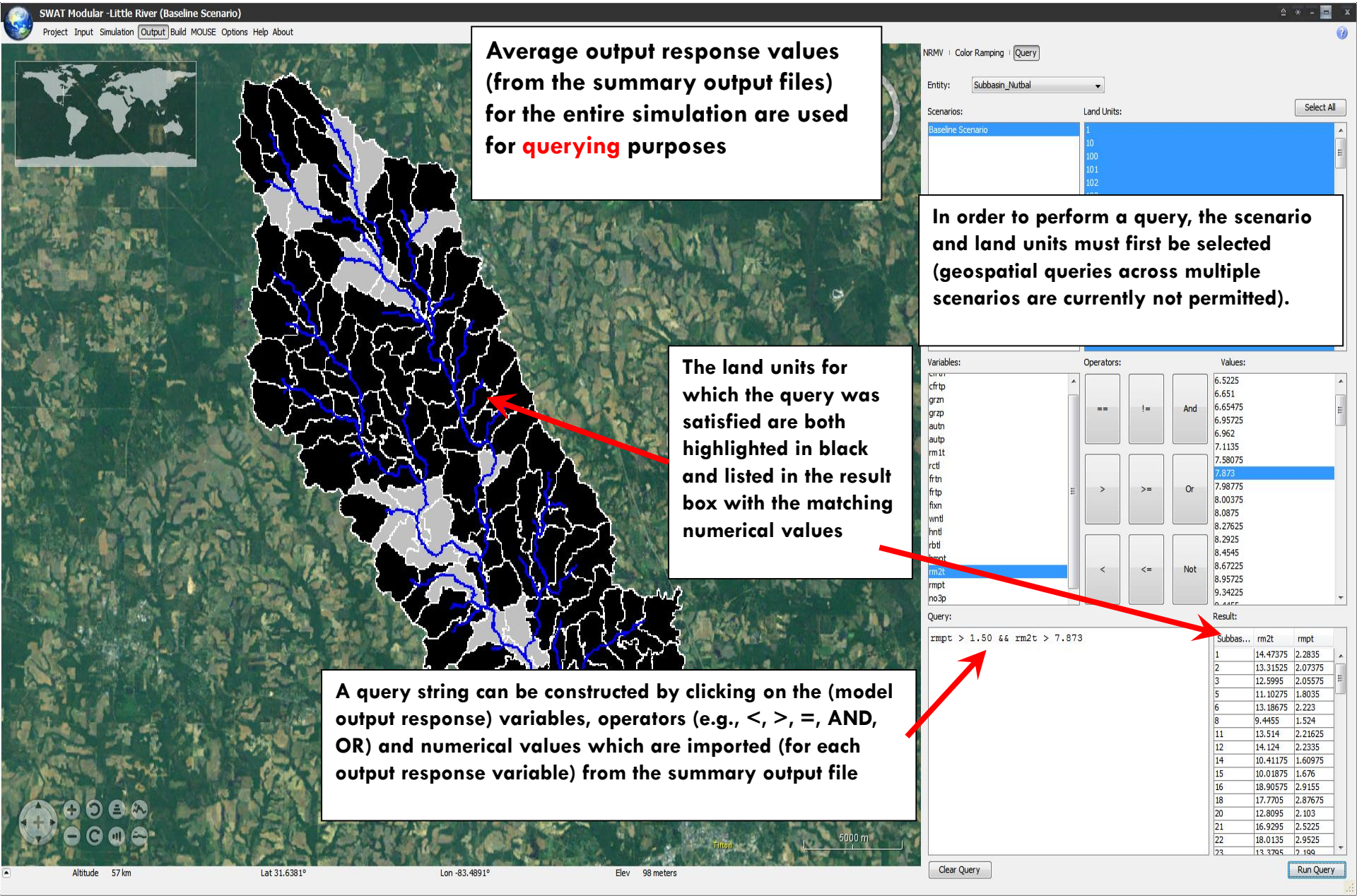
Color ramping for HRUs → This screen shows the SWAT+ "HRU_Nutbal" file, "rm2t" variable, and the LRW HRU shape file

GMI Output Visualization – Color Ramping

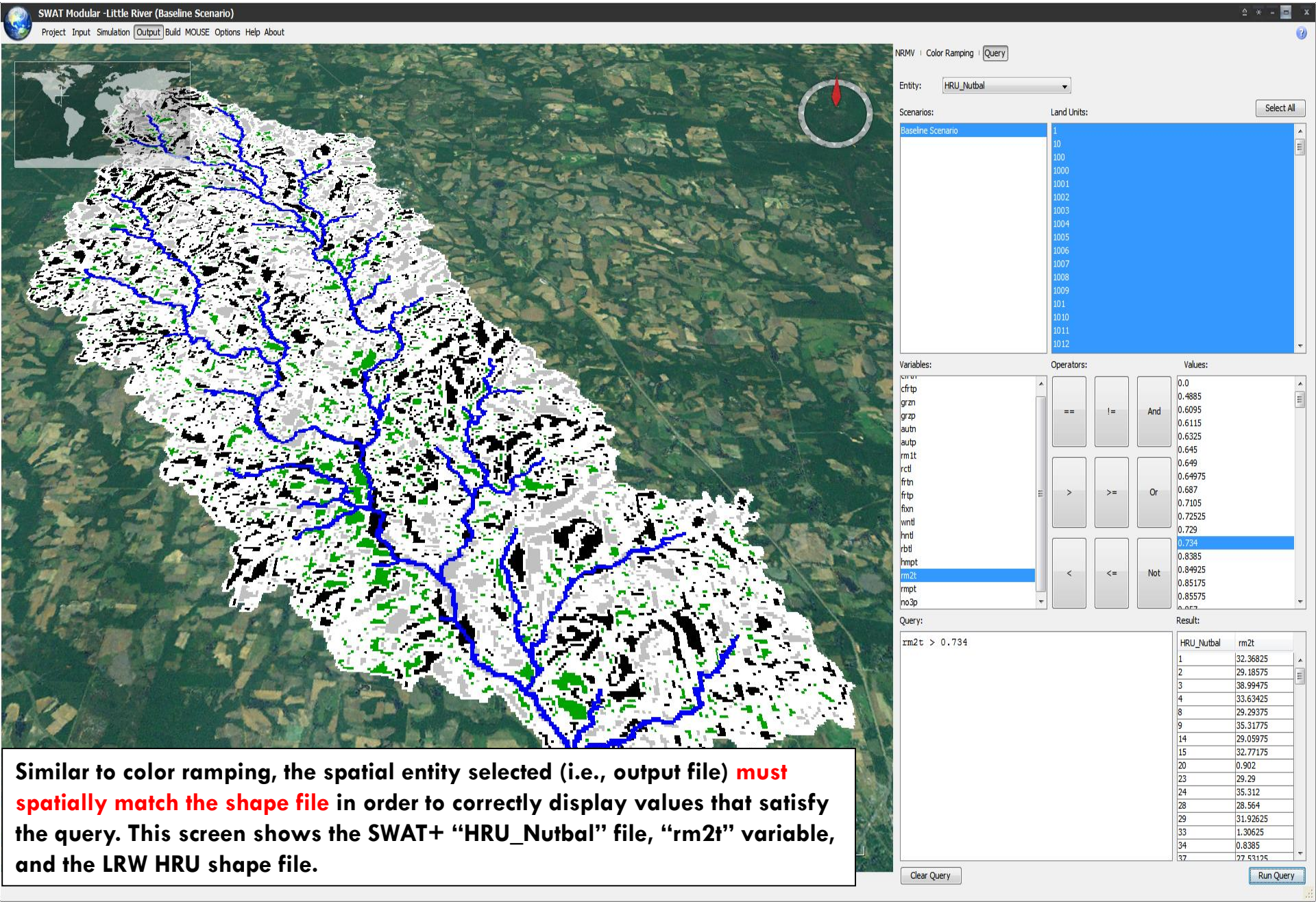


Color ramping for stream reaches → This screen shows the SWAT+ "Channel" file, "sedin" variable, and the LRW stream reach shape file

GMI Output Visualization – Querying

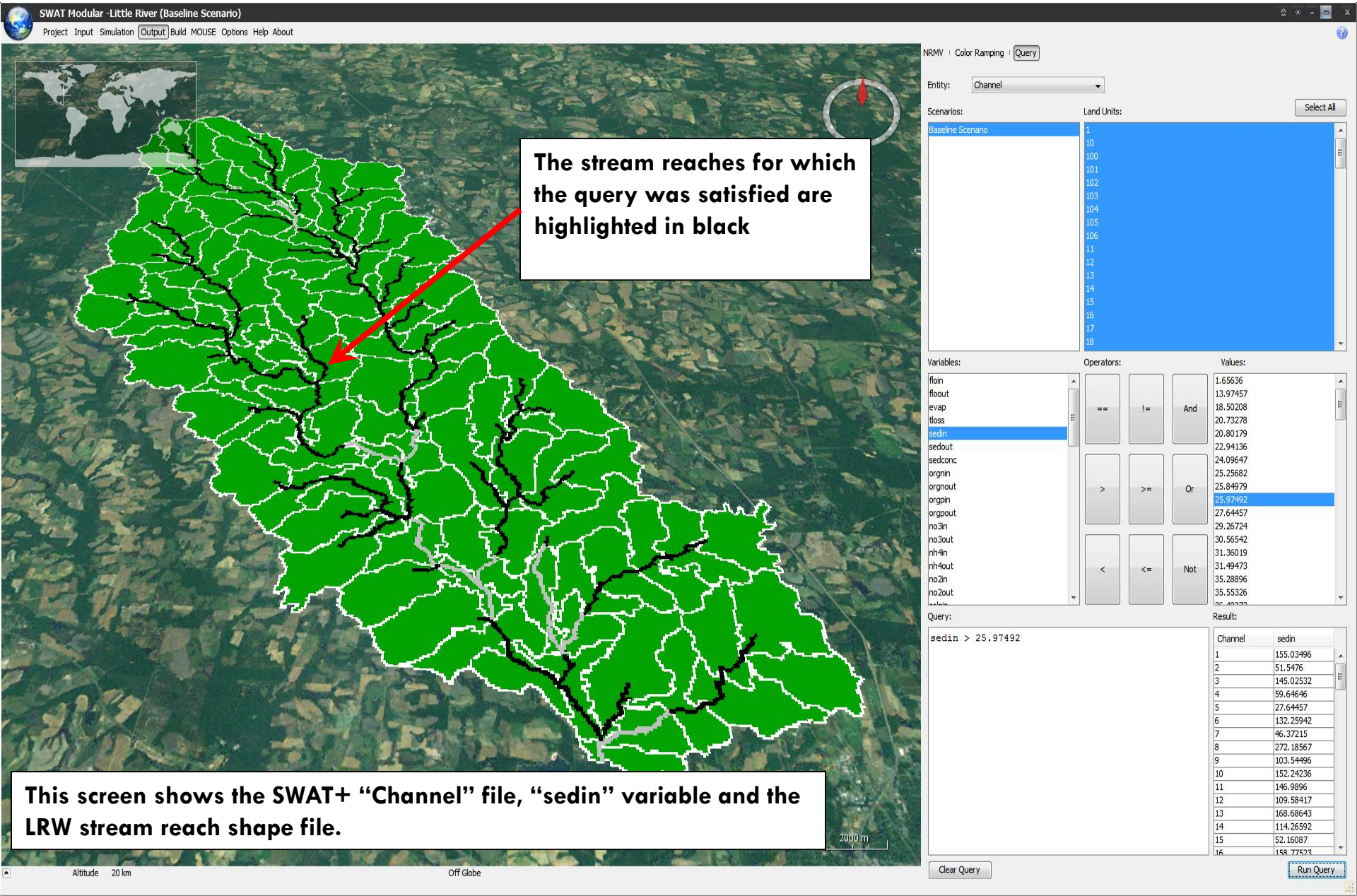


GMI Output Visualization – Querying



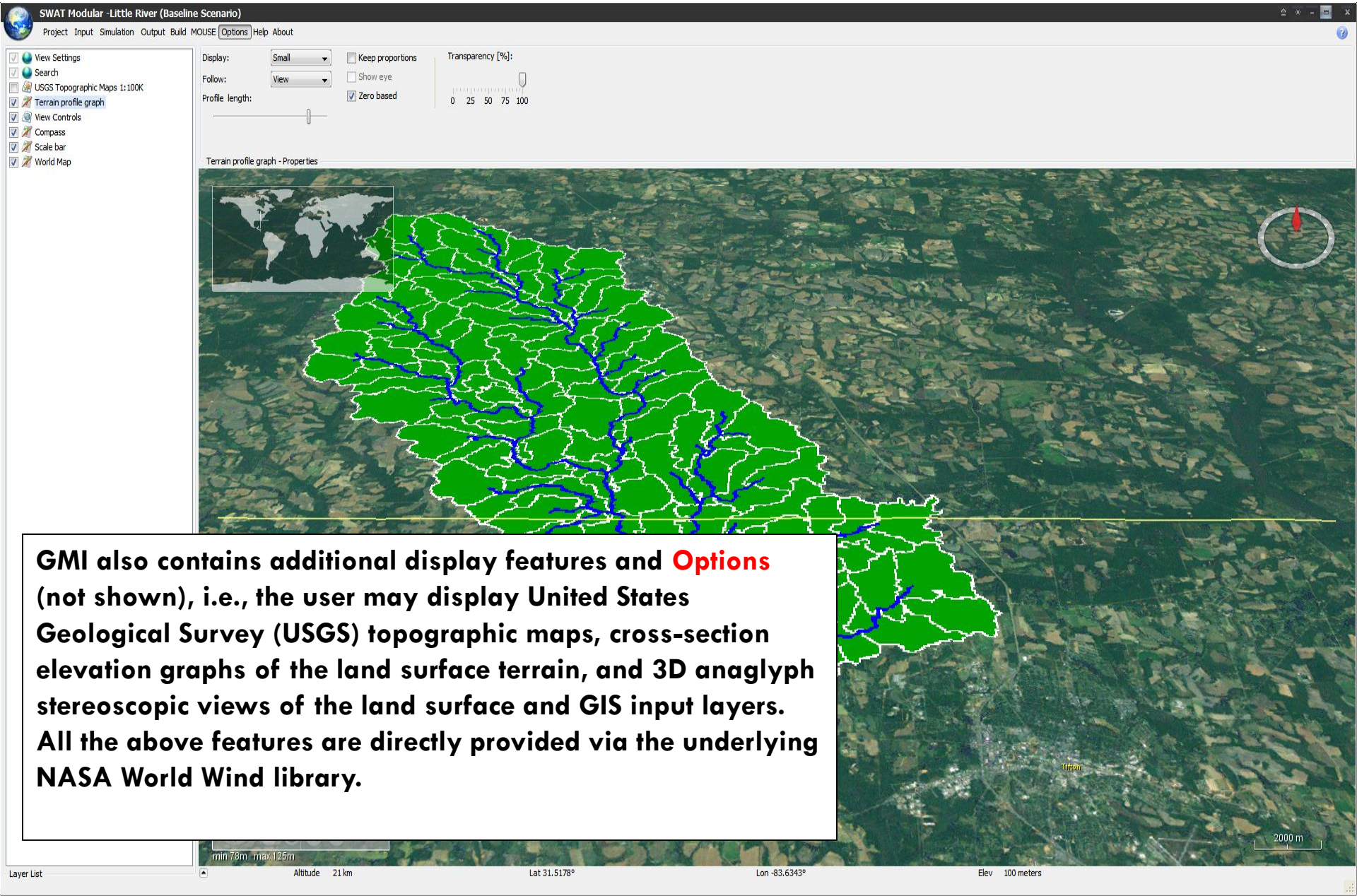
Similar to color ramping, the spatial entity selected (i.e., output file) must spatially match the shape file in order to correctly display values that satisfy the query. This screen shows the SWAT+ "HRU_Nutbal" file, "rm2t" variable, and the LRW HRU shape file.

GMI Output Visualization – Querying



This screen shows the SWAT+ "Channel" file, "sedin" variable and the LRW stream reach shape file.

GMI Options Menu Button



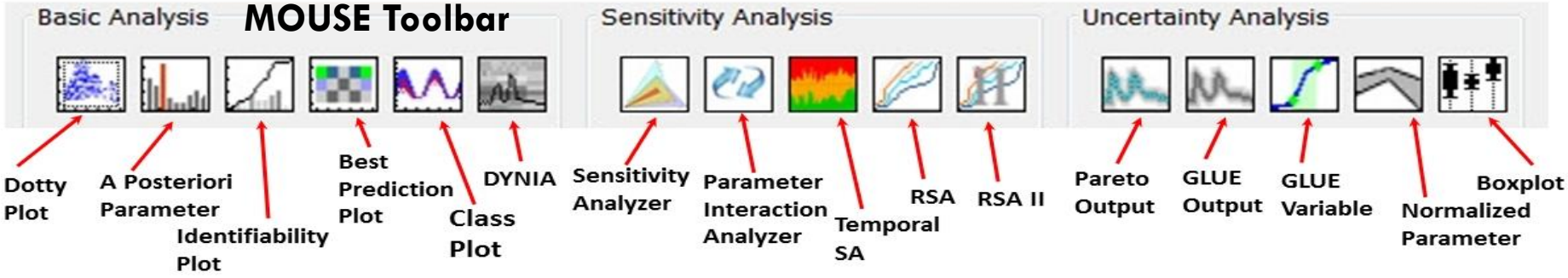
GMI also contains additional display features and Options (not shown), i.e., the user may display United States Geological Survey (USGS) topographic maps, cross-section elevation graphs of the land surface terrain, and 3D anaglyph stereoscopic views of the land surface and GIS input layers. All the above features are directly provided via the underlying NASA World Wind library.

Summary

- The GMI project was initiated after conducting an extensive review of geospatial model interfaces (appropriate for multi-scale H/WQ modeling) and determining that none of the existing GIS tools provided a suitable interface for research/application development
- GMI currently provides access to five H/WQ environmental models: 1) AgroEcoSystem-Watershed (AgES-W), 2) Nitrate Leaching and Economic Analysis-GIS (NLEAP-GIS), 3) Soil and Water Assessment Tool (SWAT), 4) Soil and Water Assessment Tool Modular (SWAT+), and 5) Root Zone Water Quality Model 2 (RZWQM2)
- GMI has robust data processing and visualization features including:
  - ⇨ Editing and visualization of geospatial model input data;
  - ⇨ The ability to input measured experimental data for robust statistical model evaluation; and
  - ⇨ Geospatial output visualization across time, space, and modeling scenarios including capabilities for real-time post-processing (e.g., on-the-fly color ramping) and querying

Conclusions and Future Research

- GMI was designed primarily as a model simulation/visualization tool and currently does not offer the advanced model development features typically found in dedicated environmental modeling frameworks.
- Currently, GMI models do not exchange data, i.e., each model is treated as a separate and independent entity in the system. However, a comprehensive data provision tool is under development that will provide a "one-stop" repository for data commonly required by environmental models (e.g., climate, soils, management, elevation, land use, etc.).
- Future GMI enhancements include the addition of a standalone watershed delineation tool (currently being developed separately) and integration of the Model Optimization, Uncertainty, and SEnsitivity Analysis (MOUSE) tool for model autocalibration and sensitivity/uncertainty analyses.



THANK YOU FOR YOUR ATTENTION!

For more information on evaluating the GMI and SWAT/SWAT+ integration, please contact Jim Ascough at:

jim.ascough@ars.usda.gov