

# USER MANUAL FOR SWATSHARE

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## INTRODUCTION

SWATShare is a cyber-enabled platform that enables users to self-publish, share, execute hydrologic models being created in Soil and Water Assessment Tool (SWAT) and visualize their outputs in spatial as well as temporal scale. Using SWATShare, modelers can choose to publish their models and share them with other users. Similarly, a user can also download any of the shared models, manipulate it and rerun for own comparison and/or analysis requirements. In addition to regular SWAT model execution, users can also run the model in calibration or sensitivity analysis mode. SWATShare can accept all the versions of SWAT model (SWAT2005 to SWAT2012), however calibration and sensitivity jobs at present are not compatible for the models created in SWAT2012 version. A brief description of how to perform each task using SWATShare is provided in this document.

## LAUNCHING SWATSHARE

A user first has to login WaterHUB at <https://mygeoHub.org/groups/water-hub/> (Figure 1). First time users need to register at the hub which is free to the public. After logging-in, click on the “TOOLS” button on the main page, and then select SWATShare. The user interface for SWATShare include five tabs: View, Upload, Edit, Run, and Visualization. The use and description for each tab is provided below.

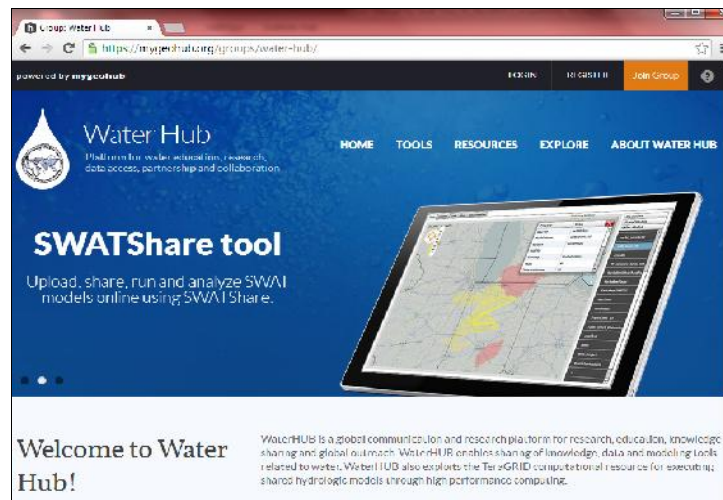
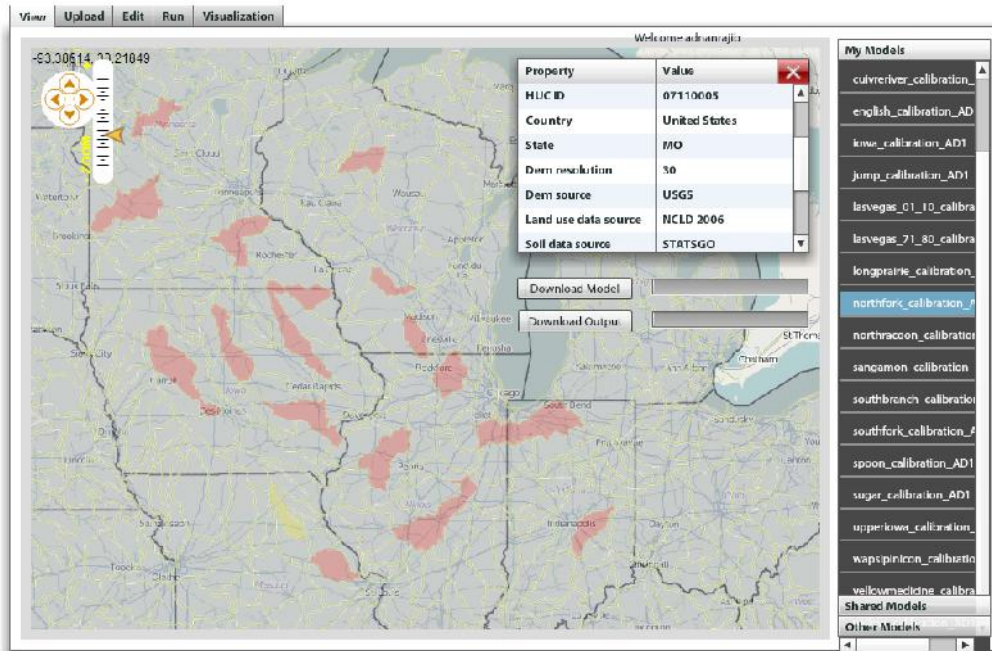


Figure 1 WaterHUB Portal

## VIEW

The main purpose of this *View* interface is to display all watershed models that are available to a user within the SWATShare interface. The models are displayed in the right panel in three groups: (i)

*My Models*: models that are uploaded by the current user; (ii) *Shared Models*: models that are shared by other users while uploading; and (iii) *Other models*: models that are uploaded by other users but not shared. The shaded portions in the map view are the 8-digit Hydrologic Unit Code (HUC) basins for which already one (or more) SWAT model is available. If a user clicks on a model name in the list, some metadata about the model setup get displayed such as the SWAT version, modeling task type (e.g. normal simulation, sensitivity analysis or auto-calibration), HUC ID of the watershed, landuse/soil data source, DEM resolution etc. (Figure 2). Alternatively, a user can click on the shaded portion in the desired region of the map view to check if there is a shared model within that HUC for the particular watershed the user wants to analyze.



**Figure 2.** SWATShare view tab components

Noteworthy that, a model is available to any user only if it is shared by the owner of the model. Users can download a model or its output files using the download links given in the *View* tab.

A major advantage of sharing watershed models is that a user can reuse other modeler's contribution multiple times in different simulation options. For example, a shared model which is originally set for normal simulation can be downloaded by another user and uploaded again, having set for a new purpose such as sensitivity analysis or auto-calibration or for a different input scenario; which of course requires some modifications in the original model. Eventually, this model will show up in the *My Models* portion of the current user's *View* tab.

## UPLOAD

This interface allows the user to upload SWAT models into SWATShare interface, listing various metadata related to the modeling processes. First, the user has to create the model in ArcSWAT and then turn only the following specific items inside a single zip folder:

1. ESRI ArcMap document that is used for creating the input files using ArcSWAT (example: WabashRiver.mxd in Figure 3).
2. Project geodatabase. This will be the Microsoft Access Database (.mdb) file which will have the same name as the ArcMap document but with an .mdb extension.
3. SWAT2009 is the geodatabase available with ArcSWAT 2009. This usually remains in user's computer directory where the ArcSWAT is installed. The geodatabase is version-specific.
4. The Watershed and Scenarios folders, RasterStore folder and its geodatabase. These are created automatically during an ArcSWAT project setup.
5. In addition, if the potential users of the model need to know some modeling information or instructions that are not obvious, inclusion of a text file containing that relevant information can be regarded customary.

As discussed, Figure 3 generically shows the contents of a typical zip folder.

Name	Type	Size
info	File folder	
RasterStore.idb	File folder	
Scenarios	File folder	
Watershed	File folder	
log	File	1 KB
RasterStore	Microsoft Access Database	1,036 KB
SWAT2009	Microsoft Access Database	14,192 KB
WabashRiver	Microsoft Access Database	11,060 KB
WabashRiver	ESRI ArcMap Document	4,618 KB

**Figure 3.** Typical components in a SWATShare model zip folder

The zip folder is uploaded in SWATShare in two-steps. First, the user has to enter the metadata associated with the model including model name and description, simulation time-step (daily/monthly) and duration, DEM source and resolution, stream network threshold (%), slope, landuse and soil threshold (%) for HRU definition, landuse and soil data source, as well as the SWAT version being used (Figure 4).

While providing a model name, it is useful to follow a self-explanatory format, such as, "watershedname\_jobtype" (example: ohioriver\_calibration). By default, the output included box is not checked, but if the output of the model is included in project folder, the user should check the 'Output Included' box. Similarly, if the user wants to share the model with others, the 'Shared' box must be checked. The default option for Model Type is 'Normal Simulation'; the other two options are 'Sensitivity Analysis' and 'Auto-calibration'. In case of model duration, put the dates including the model warm-up period (if any) in mm-dd-yyyy format.

In the second step, the model is uploaded by clicking the 'Upload' button and browsing to the computer directory where the zip folder is located. A user can track the percentage of data getting uploaded in the portal from the lower left corner of the interface window. When upload is complete, the process has to be terminated by clicking the 'Submit Model' button.

The screenshot shows the SWATShare Upload Interface with two main steps:

**Step 1: Enter model meta data** (Please start filling the model meta data)

Fields and values in Step 1:

- User Name: adnanrajib
- \* Model Name: OhcFiver\_calibration
- Description: calibrating the SWAT model for streamflow using PARASCL method. The model is made only for hydrologic analysis (no water quality)
- \* Simulation Time Step: Daily
- Country: United States, State: OH
- \* Version: SWAT2009,  Output Included:  Shared?
- HUC code: 0110005, Map button
- \* Type:  Normal Simulation,  Sensitivity Analysis,  Auto-Calibration
- \* DEM Source: JSGS
- \* DEM Resolution: 30
- \* Stream Network Threshold: 1
- \* HRU Threshold (Slope): 10
- \* HRU Threshold (Landuse): 10
- \* HRU Threshold (Soil): 10
- \* Land use data source: NCLD 2000
- \* Soil data source: STATSGO
- Date from: 01/01/2004 to 12/31/2010

**Step 2: Upload input data** (Click upload button to launch data mover tool and upload input data)

Buttons: Upload, Submit Model, Clear

Figure 4. SWATShare Upload Interface (generically filled)

Now, in order to produce a successful model execution in SWATShare, whether it is a self-created model or a shared model getting manipulated and reused by the current user, following key features has to be taken care of prior to uploading:

1. **Appropriate Method-flag in file.cio:** With the user's command of modeling type or option (normal simulation, sensitivity analysis or auto-calibration), SWATShare interacts with the model's master file *file.cio* (Arnold et al. 2011) before execution. The current version of SWATShare allows only the models being created in SWAT2005 and SWAT2009 for different automated simulation options, such as sensitivity analysis and auto-calibration. If the auto-calibration option is selected in the upload section, SWATShare specifically searches for a method-flag  $ICLB = 2$  in the *file.cio*. Likewise, sensitivity analysis and normal simulation correspond to  $ICLB = 1$  and  $ICLB = 0$ , respectively. However, currently SWATShare does not allow two cases:  $ICLB = 3$  (calibration with uncertainty analysis) and  $ICLB = 4$  (re-run of a calibrated model with best parameter set).

The concern with appropriate method-flag becomes vital when a current user tries to reuse a shared model with a different modeling option rather than that in the original. Since the *file.cio* is the master watershed file regulating modeling option, climate inputs, databases and output specification (Arnold et al. 2011), its prior modification is mandatory in such cases.

2. **Simulation Duration and Time-step:** It is recommended that a user gives input of the simulation duration and time-step, consulting with the corresponding variable values from *file.cio*. The governing *file.cio* variables for simulation duration are (i) NBYR: number of years simulated, (ii) IYR: beginning year of simulation, (iii) IDAF: beginning julian day of simulation, and (iv) NYSKIP: number of years to skip in output summarization. In SWATShare, the simulation duration should

cover the whole period including NYSKIP. The simulation time step gets decided by the variable IPRINT (IPRINT = 0 for monthly, IPRINT = 1 for daily, and IPRINT = 2 for yearly simulation). These variables get automatically printed in the file.cio while setting up a normal simulation in ArcSWAT. If required, a user can manually edit these variable values inside the *file.cio* of the desired shared model before uploading and re-running that model again in SWATShare for his/her own analysis purpose.

3. **Default Simulation Folder:** Right after running a normal simulation in ArcSWAT, simulation results gets stored in a *Default* folder under the *Scenarios* of the respective project directory. However, a user may need to run the model further with different input configurations and save in various names such as *run1*, *run2* or *sim1*, *sim2* etc. The current version of SWATShare recognizes the *file.cio* only in the *TxtInOut* from *Default*, even if there are other simulation folders having different names, each containing a *TxtInOut* and *file.cio* of its own.
4. **Setting up Auto-calibration and Sensitivity for New and Shared Models:** In order to upload a SWAT model for auto-calibration in SWATShare, a user must first run the auto-calibration using ArcSWAT2005 or ArcSWAT2009 for a very small number of trials (e.g., maximum number of trials allowed before parameter optimization is terminated, MAXN = 10). Prior to that, all other input/output parameters such as the observed data, objective function, analysis location (a particular sub-basin), as well as the calibration parameters need to be defined within the ArcSWAT's auto-calibration dialogue box following Winchell et al. (2010). Out of the available calibration methods in SWAT2005 and SWAT2009, Only PARASOL should be selected so as to make the process compatible with the current version of SWATShare. Thus, a new folder called *AutoCal* gets created in the corresponding *TxtInOut* folder. Running the auto-calibration in ArcSWAT with small MAXN will populate *AutoCal* with certain necessary files which were initially absent in the *TxtInOut* during a normal simulation. Finally, the user has to modify the *parasolin.dat* inside the newly populated *AutoCal* folder by setting a higher MAXN value (e.g. 20000); thereby completing the model preparation for auto-calibration in SWATShare.

The model preparation for sensitivity analysis is mostly the same as described above except a *Sensitivity* folder gets created instead of *AutoCal* and there is no option of setting MAXN. Hence, a user has to set and initiate running the sensitivity analysis in ArcSWAT and then manually terminate the program after a while, enabling the creation of necessary files inside the *Sensitivity* folder.

For execution, SWATShare detects only the *Default* folder and then simultaneously follows the user's command of model type in the *Upload* tab and the ICLB flag value defined in appropriate *file.cio*. For example, in case a user selects auto-calibration option while uploading, SWATShare will search for ICLB = 2 inside the *AutoCal* of the *Default* folder only, leaving other simulation folders. Failure to find either the correct folder or the ICLB value will produce a 'failed' attempt. Hence, in case of executing *run1* or *sim1* through SWATShare, a simple step for a user could be to just rename it as *Default* after following all the above preparation steps. Importantly, the name 'Default' is case sensitive. Also, keeping a copy of the original *Default* folder to any other location of user's computer directory is always recommended.

Apart from specific user-owned newly uploaded models, sensitivity analysis or auto-calibration can also be executed over any shared model through SWATShare. Whether a shared model has already been run for calibration or parameter sensitivity can be verified from the metadata displayed in *View* tab. Eventually, SWATShare calibration or sensitivity analysis of a shared model by a current user requires (i) download the model at any directory of the user’s computer, (ii) running a normal simulation with ArcSWAT, (iii) saving the simulation with a new folder name, (iv) setting up of auto-calibration/sensitivity in ArcSWAT following the exact same procedure described above, and finally (v) renaming the new simulation folder as *Default*. Users can also change any input files of the original shared model (e.g. landuse raster, reservoir location and so on) in step (ii) mentioned above. However, users need to check the version of the shared model before manipulating it in his/her own computer.

## EDIT

The *Edit* interface looks similar to that in *Upload*. It allows a user to change information related to any model already uploaded including the updating of the input zip folder (Figure 5). First the user has to select a model in the right hand column, and all the information related to the model will be displayed on the left panel. If any changes are made, clicking the ‘Change’ button will save those changes. The ‘Reset’ button will restore the original information that was saved with the original model. The ‘Delete’ button will delete the selected model from SWATShare.

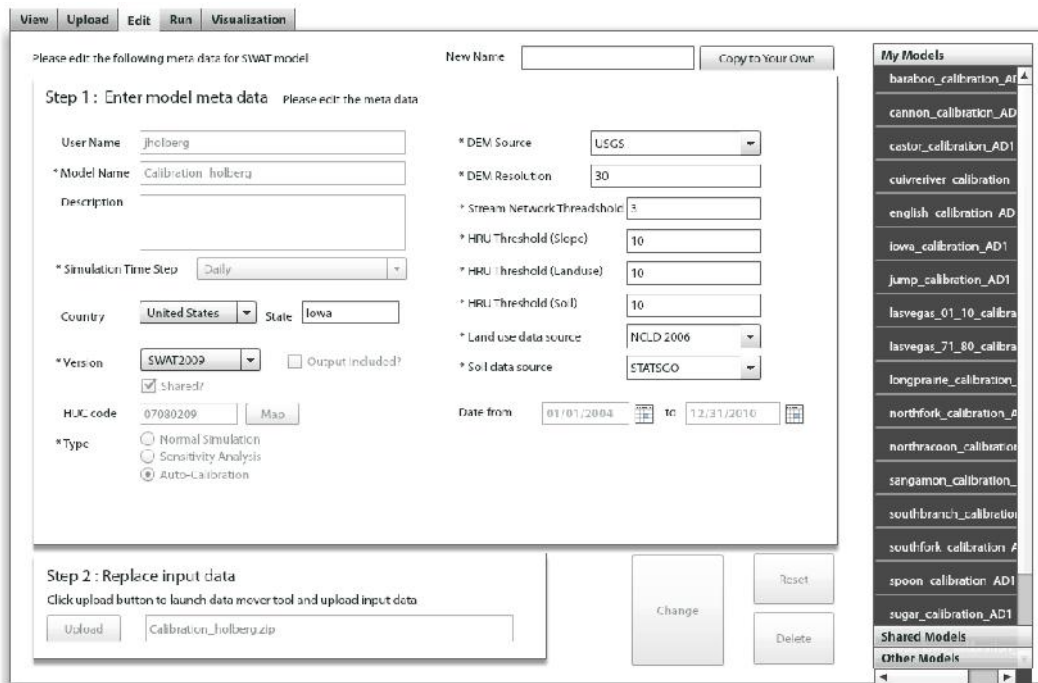


Figure 5. SWATShare Edit Interface

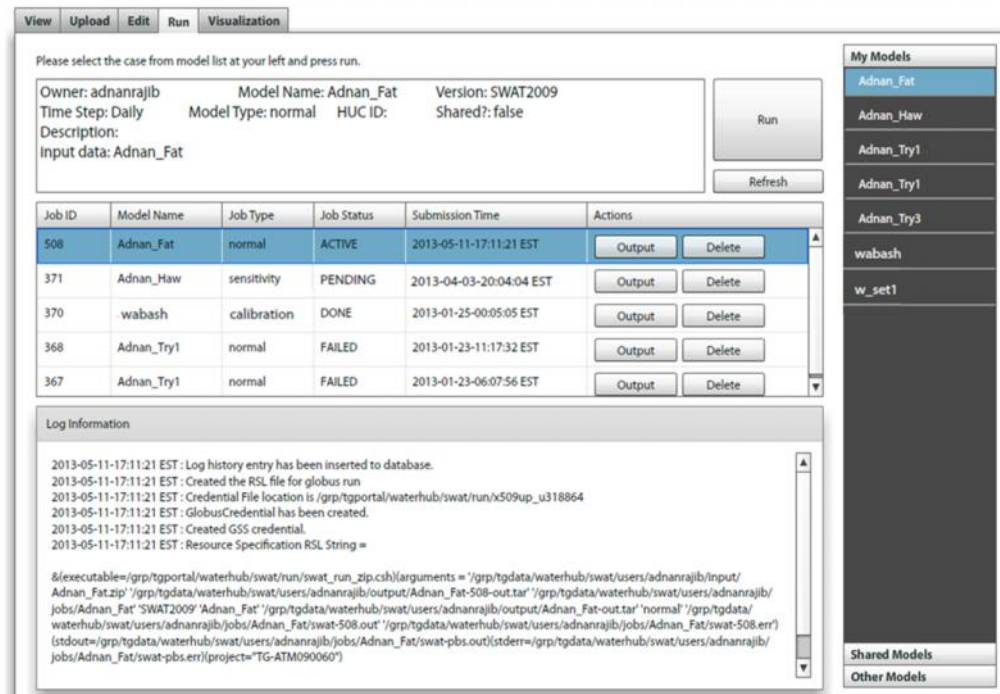
The user can change any of the information for the models from own account (*My Models*), not for the models from *Shared Models* section.

However, if a user wants simply to visualize the outputs of a shared model, that user can select the desired model, provide a *New Name* in the *Edit* interface and click on *Copy to Your Own*. This will transfer the particular shared model into user’s own account.

## RUN

The *Run* interface allows users to perform a regular SWAT simulation, sensitivity analysis, or auto-calibration depending on the option selected in ‘Model Type’ field while uploading as well as the method-flag in the *file.cio* that comes with the model input. A user can only run models that are listed in the personal account.

Figure 6 demonstrates the *Run* tab with different possible job status. First, a model is selected from the list on the right panel. Depending on the computational resource availability, the model run may start immediately after clicking the ‘Run’ button or it may be dispatched in a job queue waiting to be executed on the cluster. Each model run will be assigned a Job ID. There can be five possible job statuses as shown in Table 1.



**Figure 6.** SWATShare Run Interface with Example of Different Job Statuses

The job table allows users to monitor the status of their simulations, check the log information (by highlighting on the job row and clicking ‘Refresh’ button), download model output, as well as to delete the model runs no more necessary. If the job status of a model run is DONE, the user can proceed to view the output using the *Visualization* tab.

**Table 1.** SWATShare Job Status Table

Status	Description
NOT STARTED	The job has been submitted but the tool has not been able to get a status update from the backend computation resource
FAILED	There is some error with the job. It could be because the job failed to be submitted or the execution failed at run time
PENDING	The job has been submitted to the backend computation resource, and is waiting in the queue
ACTIVE	The job is running
DONE	The job is done

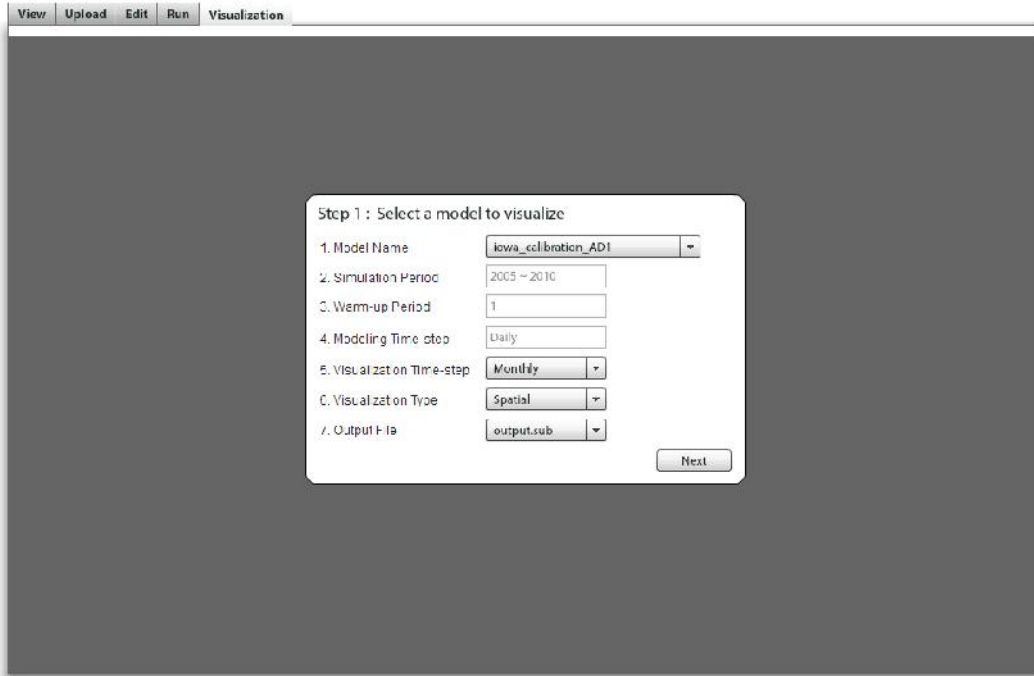
## VISUALIZATION

SWATShare's *Visualization* interface is designed to create spatial maps and temporal plots of the model outputs in a fully interactive manner. The *Visualization* interface can only be used for models from user's own account that have been executed successfully. SWAT model produces multiple output files with different extensions. The present version of SWATShare can produce visualization from the three major output files: (i) output.std (watershed-average values), (ii) output.sub (values for individual subbasins) and (iii) output.rch (values at individual reaches).

The *Visualization* tab comes with a selection menu as shown in Figure 7. Following are the instructions to create output visualizations:

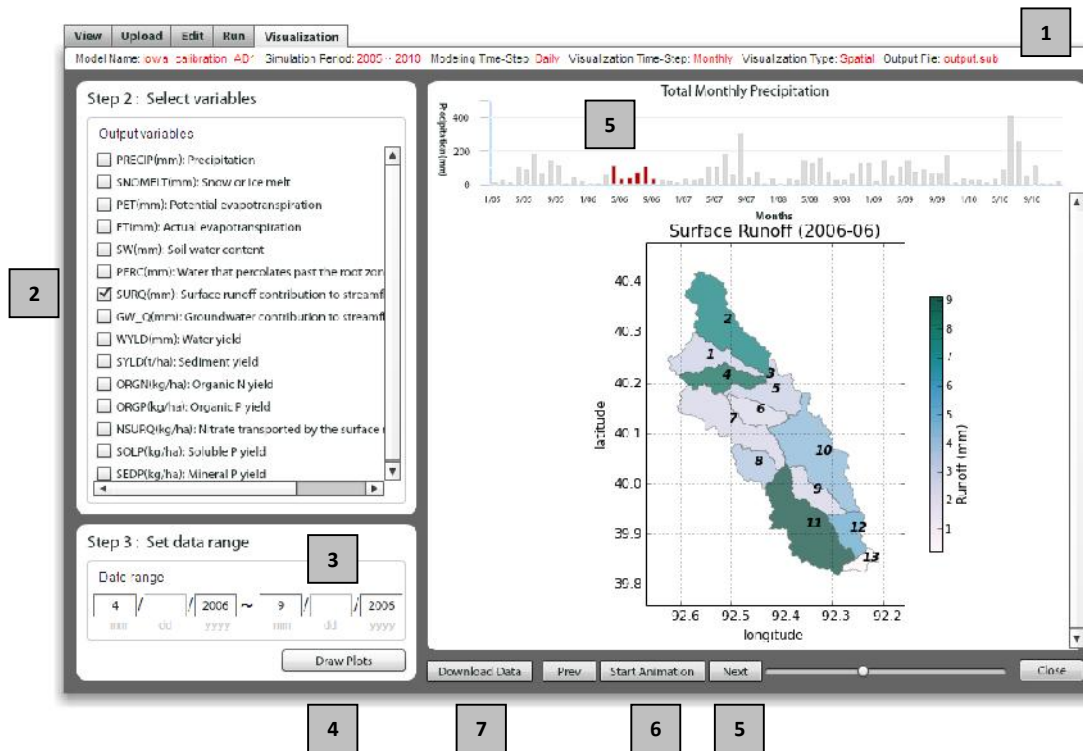
- If a user has several successfully run models in the account, any one of the models can be picked from the dropdown list in the *Model Name*.
- Once a model is selected, *Simulation Period*, *Warm-up Period* and *Modeling Time-step* fields get automatically populated from the information provided during model uploading and the corresponding *file.cio* of the model. Note that, simulation period excludes the warm-up period.
- Pertaining to the model's actual simulation time-step, SWATShare can create outputs at different temporal resolutions. For example, if a model is originally run in daily time-step, SWATShare can produce outputs at daily, monthly and yearly basis. Again, if the model's original simulation time-step is monthly, SWATShare can produce monthly and yearly outputs. User needs to select a preferred *Visualization Time-step*.
- Next, users will get to select one of the two *Visualization Types* (spatial or temporal). If the *Spatial* type is selected, SWATShare will extract only the subbasin-scale outputs and hence, the *Output File* field gets automatically populated with output.sub; in case *Temporal* visualization type is selected, users need to select either the reach-scale (output.rch) or the watershed-average (output.std) outputs from the *Output Files* dropdown menu.





**Figure 7.** SWATShare Visualization Interface (selection of visualization type)

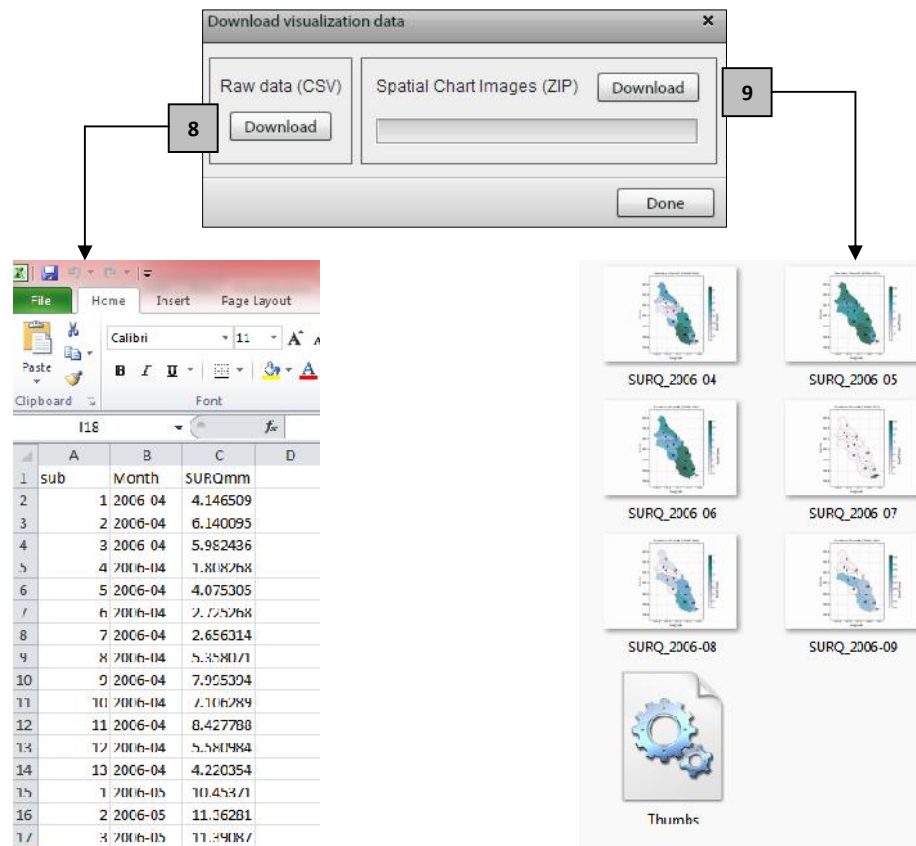
After all these selections, click on the *Next* button. This will lead to the second step of visualization (Figure 8).



**Figure 8.** SWATShare Visualization Interface (creating spatial plots)

In this step (Figure 8):

- Users can see the selections being made in the previous step (Figure 7) [1].
- From the left panel, users can select multiple variables (only SURQ is shown here as an example) [2] and set a date range for visualization [3]. Since the example shown in Figure 8 is for monthly visualization time-step, the dd (date) fields are inactive; similarly, for annual visualization, mm (month) and dd (date) fields will remain inactive. Now, clicking on *Draw Plots* [4] will create the desired visualization.
- Since precipitation is the major driving variable for all the hydrologic simulation, SWATShare shows a time-series plot of watershed-average precipitation values even in case of spatial visualization. This helps to correlate the spatial variation of different hydrologic variables with incident rainfall amount through time. Note that, precipitation values for the selected date range become highlighted [5].
- Users can see individual spatial images by clicking on the *Next* button [6] or simply run the animation [6].
- After clicking the *Download Data* button [7], following download panel will appear. SWATShare allows users to download the selected output variable values in a csv file [8] and the corresponding spatial maps in .png format [9].



Following is an example of temporal visualization (Figure 9), which is self-explanatory.



**Figure 9.** SWATShare Visualization Interface (creating temporal plots)

Here also, users can select multiple variables altogether, which enables their relative comparison in the same window. Users can interact with the plot by moving the pointer over data points to see its value and the corresponding date. Users can also download the selected output variable values in a csv file.

## References

Arnold, J.G., Kiniry, J.R., Srinivasan, R., Williams, J.R., Haney, E.B. and Neitsch, S.L. (2011) Soil and Water Assessment Tool-Input/Output File Documentation Version 2009, Texas Water Resources Institute Technical Report No. 365, Texas A&M University System, College Station, TX, USA.

Winchell, M., Srinivasan, R., Di Luzio, M. and Arnold, J.G. (2010) ArcSWAT Interface of SWAT 2009 User's Guide, Texas A&M University System, College Station, TX, USA.

**Note:** A SWATShare user is supposed to have prior knowledge on the input-output data structure of the SWAT model.