USER MANUAL FOR SWATSHARE

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INTRODUCTION

SWATShare is a cyber-enabaled 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 enabling SWATShare for performing calibration jobs with SWAT2012 version are currently under development. A brief description of how to perform each task using SWATShare is provided in this document.

SWATSHARE INTERFACE

A user first has to login WaterHUB at https://mygeohub.org/groups/water-hub/. 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.

VIEW

The main purpose of this *View* interface (**Figure 1**) is to display all the SWAT models stored in the SWATShare platform. In order to help users discover models in their regions of interest, center points of the watersheds with existing SWAT models are geo-referenced and shown as blue circles. The models are categorized 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) *Private models*: models that are uploaded by other users but not shared. If a user draws a bounding box over the map or clicks on only one blue circle using the cursor, the selected model(s) get highlighted (red) and a list of information with model name, availability of the model (shared or private), modeling task type (e.g. normal simulation, or calibration), date of last modification etc. appear on the interface.

There can be several SWAT models (with different objectives, with/without calibration etc.) for the same watershed. If a user clicks on a model name from this list, a new window appears with detail metadata associated with the selected model (**Figure 2**). These metadata help a user to decide which of the shared models is useful for his/her research objectives.

A selected model (either from *My Models* or *Shared Models* section) can be downloaded, edited, re-run or analyzed by output visualization using the icons shown at the bottom of **Figure 2**. Noteworthy that, a model is available (for download, re-run, output visualization) to any user only if it is shared

by the owner of the model. 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 simple streamflow simulation can be downloaded by another user and uploaded again, having set for a new purpose such as land use/climate change impact analysis; which of course requires some offline modifications in the original model. Eventually, this model will show up in the *My Models* portion of the current user's *View* tab.

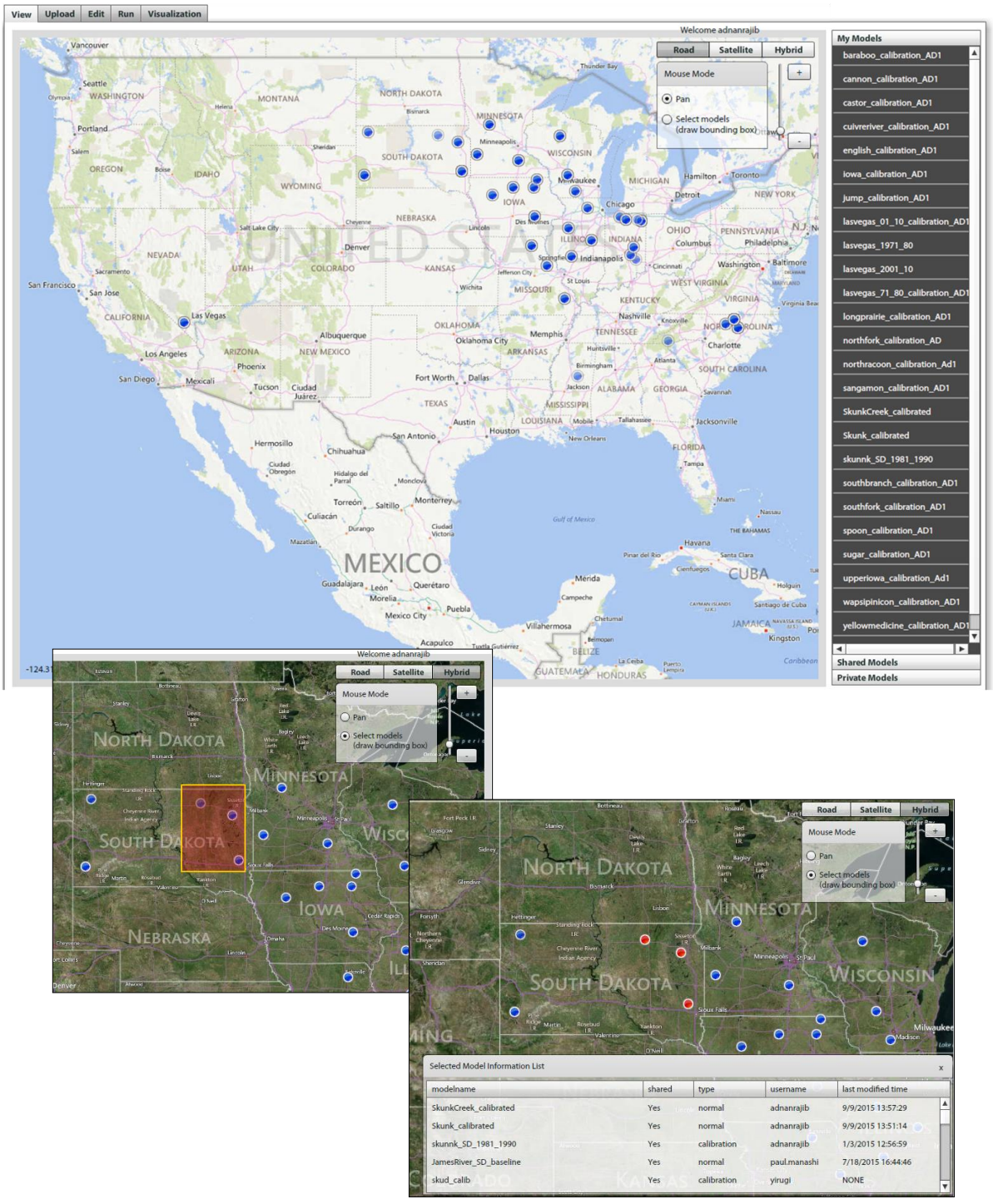


Figure 1. SWATShare *View* tab components

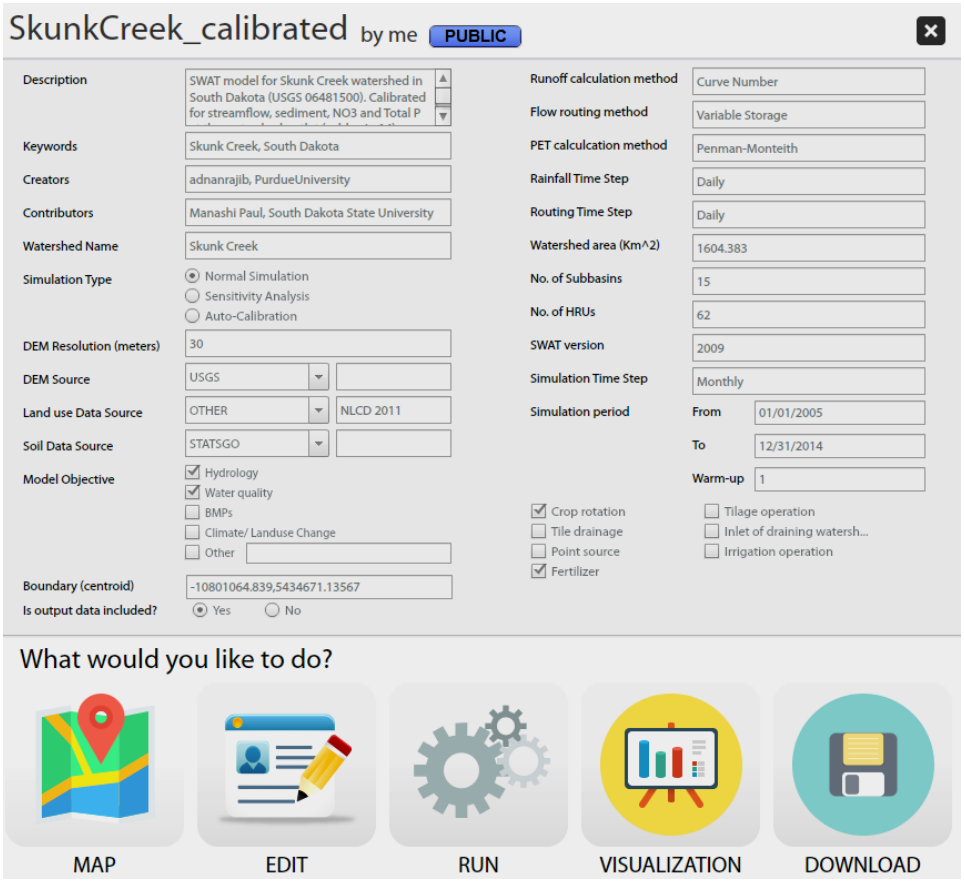


Figure 2. Metadata associated with a selected model in the *View* tab

UPLOAD

This interface allows the user to upload SWAT models into SWATShare interface, listing various metadata related to the model. The user has to create the model in ArcSWAT and then turn only the following specific items inside a single zip folder (**Figure 3**):

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 the first step, an appropriate model name needs to be entered without spaces and special characters. The name should be self-explanatory for other users to understand, for example, a calibrated SWAT model on the Cedar Creek watershed in Indiana, USA can be named as

'CedarCreek_calibration'. The given name needs to be checked for availability by clicking 'Check Available' button. Upon availability of the name, the 'Browse' icon will be activated through which the zip folder can be uploaded either from user's local system, idata or HydroShare.

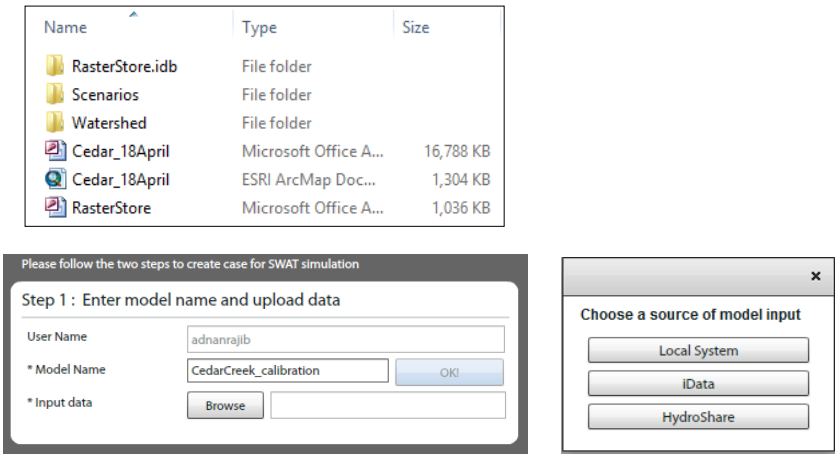


Figure 3. Typical components in a SWATShare model zip folder and model upload (step 1)

Once the model is uploaded, SWATShare automatically extracts many of the metadata associated with the modeling processes (runoff calculation, flow routing, PET calculation), duration of simulation, rainfall/routing/simulation time step and number of sub-basins/HRUs in the model.

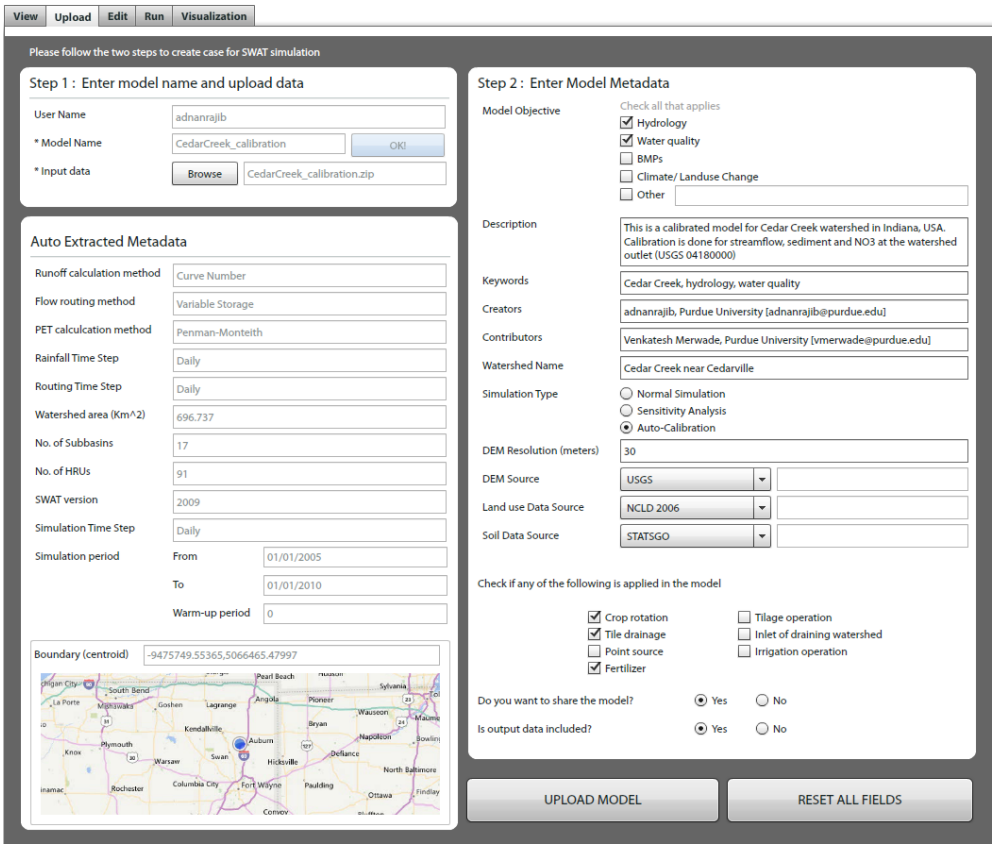


Figure 4. SWATShare *Upload* interface with example of metadata (step 1: automatically extracted metadata and step 2: metadata needing user input)

In the second step, the user has to populate some of the metadata fields including

- model objective (example: hydrology, water quality, climate change or all);
- a brief description of the model/study, which can include an URL as well, leading towards more information, references and related publications;
- Keywords (related to the watershed's location, study objective etc.);
- watershed name (standardized name is preferable, for example, name/ID given by the USGS for the gauged watersheds in USA);
- sources of the geo-spatial data layers (DEM, land use, soil) and spatial resolution (DEM only);
- management operations such as crop rotation or tile drainage (if applied).

Since a 'shared' model in SWATShare will continue to grow based on multi-user inputs/modifications, names of the creators/contributors is a required input to maintain provenance of individual model instances.

In the current version of SWATShare, there are three options for Simulation Type including ' Normal Simulation', ' Sensitivity Analysis' and 'Auto-calibration'. By default, the output included box is not checked, but if the output of the model is included in project folder (inside TxtInOut), 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. Clicking the 'UPLOAD MODEL' button will complete the uploading procedure.

Now, in order to produce a successful metadata extraction and subsequent model execution in the current version of SWATShare, following key features has to be taken care of prior to uploading:

1. **Default Simulation Folder*:*** After setting up a SWAT model in ArcSWAT, input/output files get stored in a *Default* folder under the *Scenarios* of the respective project directory. However, a user may also have other simulation runs with different input configurations and save in various names such as *run1*, *run2* or *sim1*, *sim2* etc. The current version of SWATShare needs to interact with the master file (*file.cio*, Arnold et al., 2011) only in the *TxtInOut* from the *Default* folder, even if there are other simulation folders having different names, each containing a *TxtInOut* and *file.cio* of their own.

2. **Appropriate Method-flag in file.cio**: With the user's command of simulation type (normal simulation/ auto-calibration), SWATShare interacts with the model's master file *file.cio* (Arnold et al. 2011) before execution. The current version of SWATShare allows sensitivity analysis and auto-calibration only for the models being created in SWAT2005 and SWAT2009. 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 a different modeling option rather than that fixed inside *file.cio*. 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.

EDIT

The *Edit* interface looks similar to that in *Upload*. It allows a user to change information related to any existing model (**Figure 5**). Once the user selects a model from the right hand panel, all associated metadata (which was originally input during the model upload step) get displayed. The information that are automatically extracted from the model (step 1 in **Figure 5**) cannot be changed within this interface; only the information in step 2 can be modified, including the updating of the input zip folder.

The user can change any of the information for the models from own account (*My Models*), not for the models from *Shared Models* section. Clicking the 'MODIFY METADATA' button (red arrow) will save the changes. User can remove a model from SWATShare by clicking the 'DELETE MODEL' button.

Figure 5. SWATShare *Edit* interface

Although any shared model can be directly downloaded to local directory from the *View* interface (**Figure 2**), if a user wants simply to visualize the outputs of a shared model before downloading, that user can select the desired model, provide a *New Name* (red arrow) in the *Edit* interface and click on *Make my own copy*. This will transfer the particular shared model into user's own account.

RUN

A user can only run (normal simulation, sensitivity analysis or auto-calibration) SWAT models that are listed in the personal account (*My Models*). **Figure 6** demonstrates the *Run* interface with

different possible job status. The model can be selected either from the list on the right hand panel in **Figure 6** or directly clicking the 'RUN' icon as shown in **Figure 2**.

The next step is to initiate the online simulation by clicking the 'Run' button in **Figure 6**. Depending on the computational resource availability, the model run may start immediately 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.

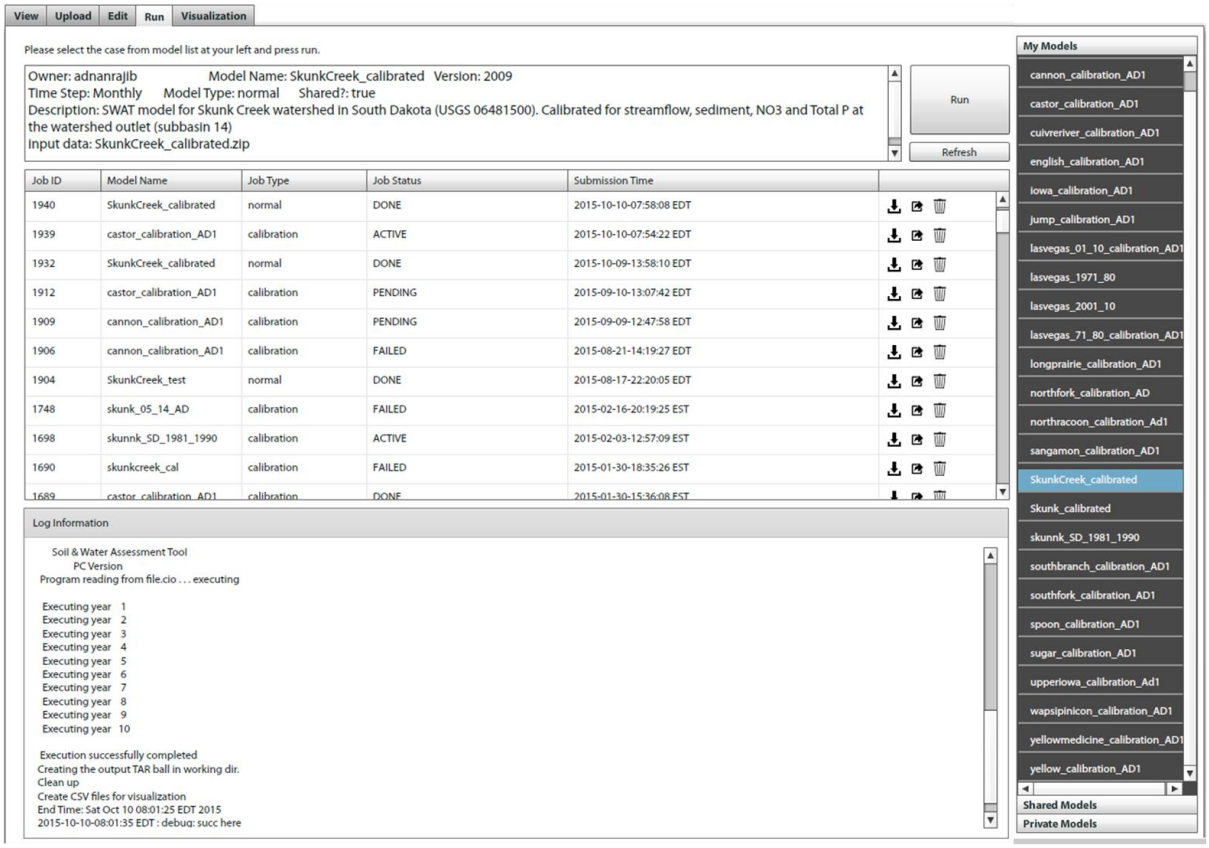


Figure 6. SWATShare *Run* interface with examples of different job status

Table 1. SWATShare job status

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

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 if 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.

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 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 Type*s (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 File* dropdown menu.

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

- 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].

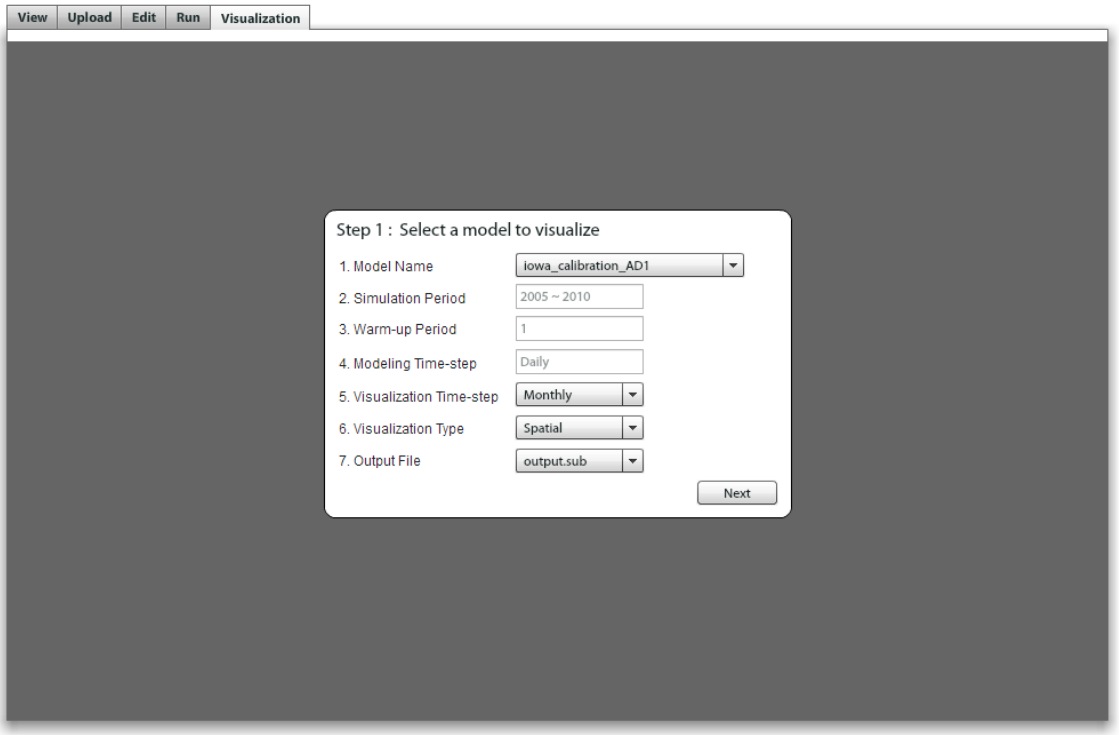


Figure 7. SWATShare *Visualization* interface (selection of visualization type)

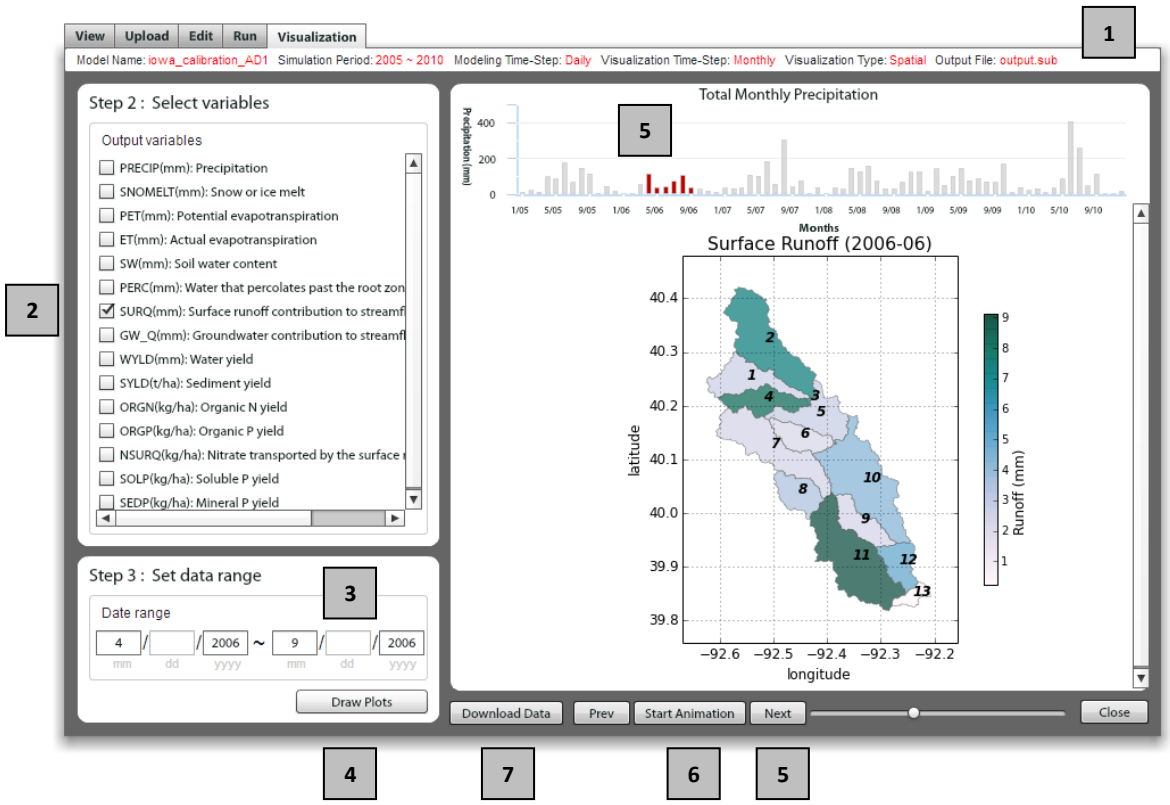
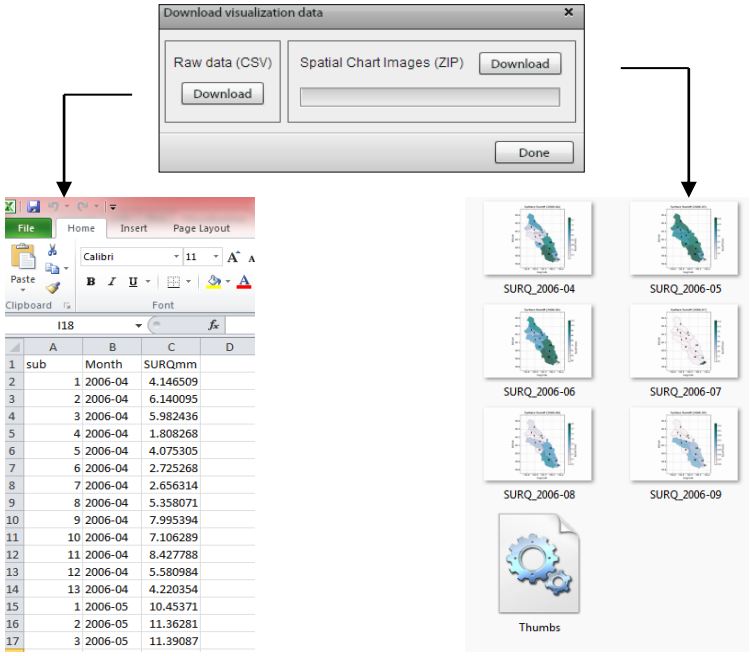


Figure 8. SWATShare *Visualization* interface (creating spatial plots)

- 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.

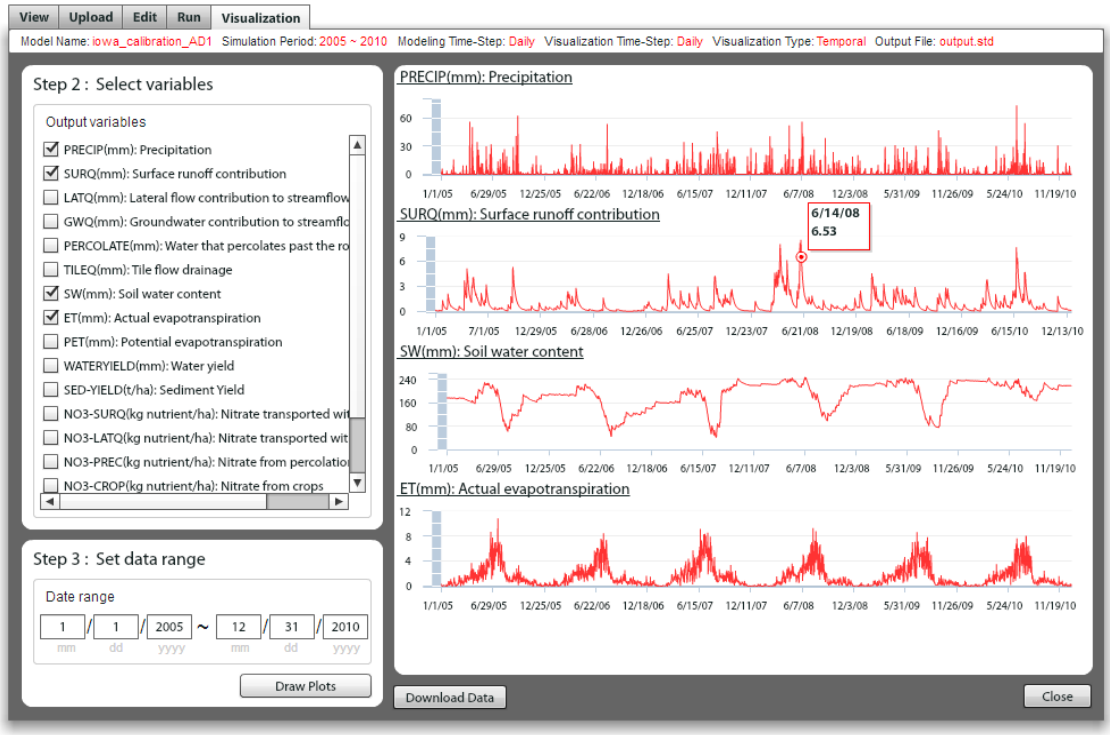


Figure 9. SWATShare *Visualization* interface (creating temporal plots)

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.

SETTING UP AUTO-CALIBRATION AND SENSITIVITY

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.

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.

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