QSWAT+ Workflow v1.5.8

User Manual Manual (v1.0)

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Contents

Introduction

SWAT is a time-continuous, semi-distributed hydrological model that has been widely used in various hydrological studies across the world. There are several options for interfaces for setting up SWAT model application. QSWAT is a more popular option since it has more features and does not require GIS software licences by using QGIS, unlike ArcSWAT which uses ArcGIS.

Reproducibility of science has come under scrutiny recently (Marcus, 2015) as it has been discovered that a large proportion of science is not reproducible (McNutt, 2014; Vasilevsky et al., 2013). In hydrology, modelling work is often not reproducible because of missing details on model setup. This software uses a namelist, which is a settings file, to build and run SWAT models. Users can share the namelist along with their published works to promote transparency as all model options are well documented in the file. Sharing the namelist and data also allows others to reproduce the models from scratch.

Setting up software

Download and install QGIS 2.6 – 32-bit version from QGIS website (http://qgis.org/downloads/QGIS-OSGeo4W-2.6.1-1-Setup-x86.exe). Note: you must open QGIS at least once after installation!

Download and install QSWAT Workflow using default settings. The installer can be found on the repository (https://github.com/VUB-HYDR/QSWAT_Automated_Workflow/releases/download/v1.5.8/QSWAT.Workflow.v1.5.8.msi)

Data

The data requirements for the QSWAT Workflow are the same as data requirements for QSWAT or ArcSWAT interfaces. Thus, users can use the same data formats as the GUI counterparts. For more information on SWAT data formate refer to QSWAT guide (Dile, Srinivasan, & George, 2017)

There is a need, however, to organise the data in a predefined structure within the directory where the model will be created. Figure 1 shows the file structure for the *Data* directory

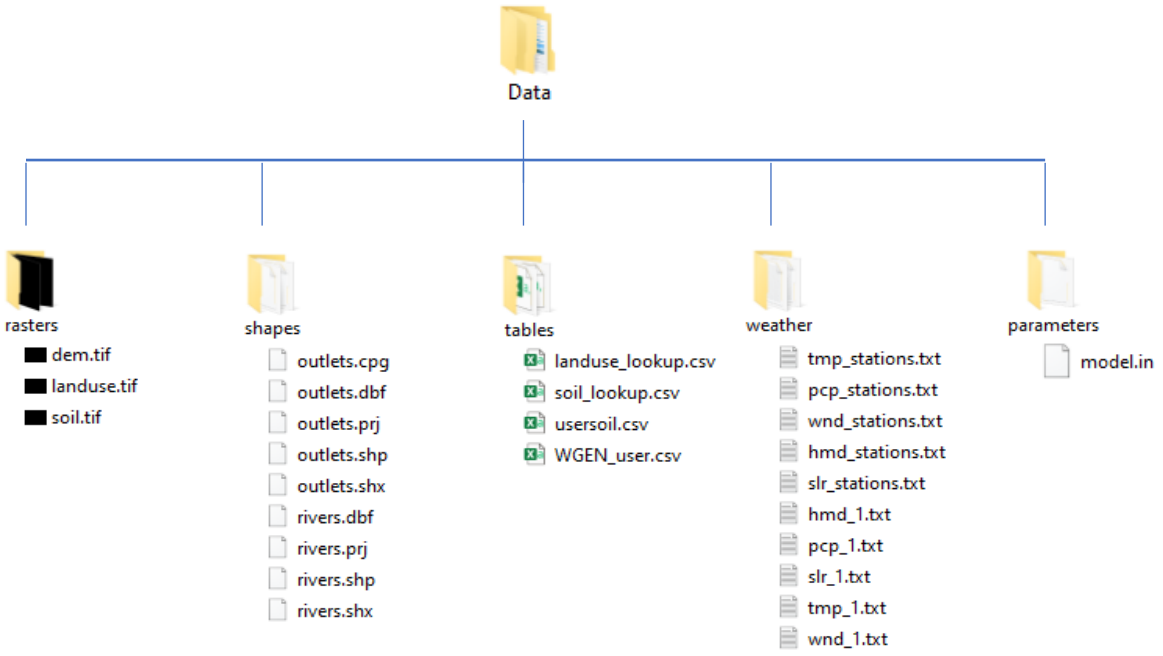

Figure 1: Structure of the Data Directory

Rasters files. i.e. Digital elevation model (DEM), land use map and soil map should be placed in the *rasters* directory within the *Data* folder.

All shapefiles. i.e. outlet shapefile and river shapefile for 'burn in' should be placed in *shapes* directory

Files that have information that needs to be imported into project databases later should be placed in the *tables* directory. These files include land use and soil lookup tables, soil properties table and weather generator table.

All weather files should be placed in the *weather* directory.

If the user wants to include calibrated parameters that should be applied to the model after set up, they should include the parameters file in the *parameters* directory. Note that you can use the model.in file from SWATCUP or the user can create their own. However, It should be formatted as the *model.in* file present in the example that comes with the QSWAT workflow.

Setting up the namelist

The configuration information for setting up the model is in a settings file called 'namelist.py'. Users can open and make changes to this file in any text file editor such as Notepad, Notepad++, Visual Studio Code (recommended).

Go to https://github.com/VUB-HYDR/QSWAT_Automated_Workflow/blob/master/test_data/namelist.py to view an example of a filed namelist file. The following is a description of each section and how to fill it.

Project identification

This section identifies the name and type of the project (Figure 2). The project name should be filled on Project_Name. Model_2_namelist option identifies what type of project it is. If the SWAT model was set up in the QSWAT GUI and the user wants to retrieve a namelist and dataset that will reproduce that model, the Model_2_namelist option should be set to *True*. To go from namelist and data to a SWAT model, set this option to *False*.

```
"""----------------------QSWAT Workflow v1.5.2 Settings File---------------"""
# Project Identification
Project_Name     = "working_example"
Model_2_namelist = False         # True = get settings from existing model
                                 # False = get model from current settings

"""--------------------------   File Names  -------------------------"""
# Raster files (Should be projected with the same projection)
Topography         = "dem.tif"
Soils              = "soils.tif"
Land_Use           = "landuse.tif"


# LookUp Files
soil_lookup        = "soil_lookup.csv"
landuse_lookup     = "landuse_lookup.csv"
# Database table files
Usersoil           = "usersoil.csv"
WGEN_user          = "WGEN_user.csv"


# Shape Files
Outlet             = "outlet.shp" # it should have same format as in the exampl


# Weather stationinformation files
Precipitation      = "pcp_stations.txt"
Temperature        = "tmp_stations.txt"
Rel_Humidity       = "hmd_stations.txt"
Solar_Radiation    = "slr_stations.txt"
Wind               = "wnd_stations.txt"
```

Figure 2: Project identification and file names sections in namelist.py

File names

In this section, all files that are to be used in the model setup are listed. This includes the soil, land use and DEM raster files present in rasters directory (Figure 1). Note that file names should include file extensions, as shown in Figure 2.

Lookup files contain the soil type or land use classes represented by the values in the soil and land use raster files. The lookup files are contained in the tables directory (Figure 1) and should be listed in the soil_lookup and landuse_lookup lines for soil lookup file and land use lookup file respectively.

Database table files are the files that the user would otherwise have to import into Microsoft Acess databases for the project. However, the Workflows does this automatically if the user lists the files in this section, as demonstrated in Figure 2.

The user should also list the name of the file that contains locations where outlets should be created within the model in the *Outlet* line under Shape Files section.

Files that list weather stations for precipitation, temperature, relative humidity solar radiation and wind should be listed in their respective lines under the *weather station information files section* as shown in Figure 2.

For watershed delineation, users should specify the threshold area for delineating sub-basins and creating a stream network. Maximum distance for snapping outlets to streams should also be entered in metres in the *OUT_Snap_threshold* line under *Watershed Delineation* section (Figure 3).

```
"""--------------------------  Project Options  ----------------------"""
# Watershed Deliniation (1 = Cells)
WS_thresholds_type    = 1
WS_threshold          = 792
OUT_Snap_threshold    = 300               # metres
Burn_in_shape         = ""                # leave as "" if none

#  -------------------  HRU Definition  ------------------
Slope_classes         = "0, 10, 42, 9999"

# HRU creation method   (1 = Dominant landuse, soil, slope , 2 = Dominant HRU,
#                        3 = Filter by Area,                 4 = Target Number of HRUs,
#                        5 = Filter by landuse, soil, slope)

HRU_creation_method   = 5

# Thresholds           (1 = Total Area , 2 = Percent)
HRU_thresholds_type   = 0

HRU_thres_LandUse     = 12             # Only used if HRU_creation_method 5 is selected
HRU_thres_Soil        = 10             #        can be set to "" if 5 is not selected
HRU_thres_Slope       = 7

Target_Value          = None           # used if HRU_creation_method 3 and 4 are selected

# Routing and ET and infiltration
ET_method             = 3           # 1 = Priestley-Taylor, 2 = Penman-Monteith,   3 = Har
Routing_method        = 1           # 1 = Muskingum,        2 = Variable Storage
Routing_timestep      = 1           # 1 = Daily,            2 = Hourly
Rainfall_timestep     = 1           # 1 = Daily,            2 = Sub-hourly timestep (works
Run_off_method        = 1           # 1 = SCS Curve Number, 2 = Green & Ampt

# model run settings
cal_file              = "model.in"           # a model.in file (format of swatcup) with pa
                                             # leave as "" if there is no file to be used.
Model_Run_period      = "1990 - 2013"# e.g. "1975 - 1980". period to run the simulation fr
                                             # leave as "" to run whole period where weather data
Warm_up_period        = 0             # the number of years for running the model without p


# Log progress or not? If yes, you will not see updates
log                   = False         # True or False
"""--------------------------  Settings End  ----------------------"""
```

Figure 3: Project options section in namelist.py

The HRU Definition section offers options to be used for creating HRUs. Slope classes for model setup can be specified in *Slope_classes* line. Separate slope demarcation values by commas as shown in Figure 3.

The user can specify one of different HRU creation methods (1 through 5) that are also available in ArcSWAT and QSWAT. For more information on how they work, refer to QSWAT guide #Ref!. The HRU creation methods are listed in Table 1:

Table 1: Available HRU creation options

Number	Method
1	Dominant land use, soil, slope
2	Dominant HRU
3	Filter by Area
4	Target Number of HRUs
5	Filter by land use, soil, slope

If HRU creation method 4 is selected, *Target_value* line should be set to a value. The QSWAT Workflow will create the number of HRUs specified in the *Target_value* line.

If method 5 is selected, the user should also specify the threshold for land use, soil and slope for *HRU_thres_LandUse* , *HRU_thres_Soil* and *HRU_thres_Slope* respectively.

If method 3 or 5 is selected, set HRU threshold type to either 1 or 2 to interpret threshold values as areas (hectares) or per cent of sub-basin respectively. Note that if method 3 is selected, *Target_value* will be used as the area threshold.

Routing, ET calculation method and Infiltration options can be filled as shown in Figure 4 with reference to options presented in Table 2.

Table 2: Routing Options, ET calculation method and Infiltration options

Setting	Options
ET_method	1 = Priestley-Taylor 2 = Penman-Monteith 3 = Hargreaves
Routing_method	1 = Muskingum 2 = Variable Storage
Routing_timestep	1 = Daily 2 = Hourly
Rainfall_timestep	1 = Daily 2 = Sub-hourly timestep (works with Green & Ampt infiltration)
Run_off_method	1 = SCS Curve Number 2 = Green & Ampt

For model run options, there are three settings. Firstly, specify the name of the parameter file in the *cal_file* line to apply provided parameters before running the model or leave “” if the user does not want to apply parameters.

Secondly, specify the duration of the run period in the *Model_Run_period* line and finally set the model warm up period in the *Warm_up_period* line, as shown in Figure 3.

Running the workflow

Setting up the model

Once the namelist has been filled, it should be placed in the same directory as the *Data* directory

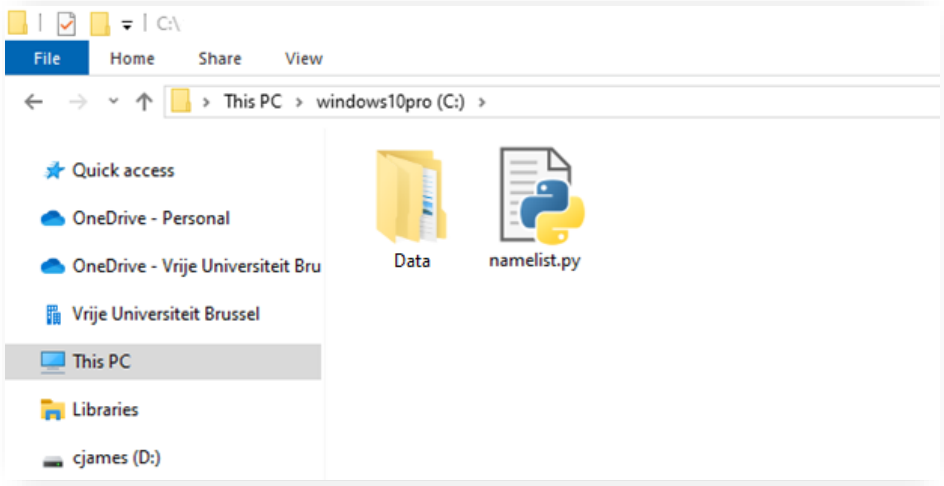

Figure 5: Directory for Setting up model

User can run the workflow using Command Prompt or Powershell by following these steps

1. Open the directory where the data directory and namelist are located.
2. Click the address bar and type ‘cmd’ or ‘powershell’ (Figure 6)

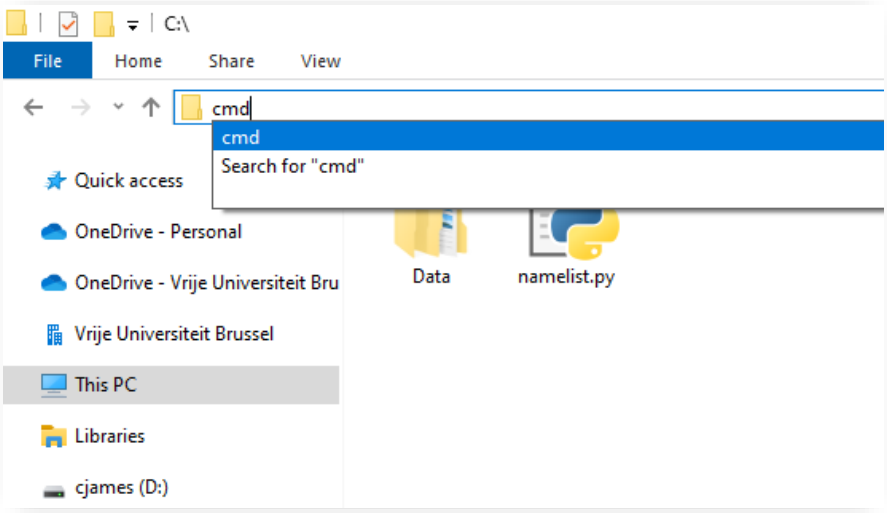

Figure 6: Opening Command Prompt in the current directory

3. Press the ENTER key to open the Command Prompt window in the current directory (Figure 7). Note that the user can open Command Prompt outside the current directory from the start menu, but the directory needs to be changed to the location of the namelist using the CD command.

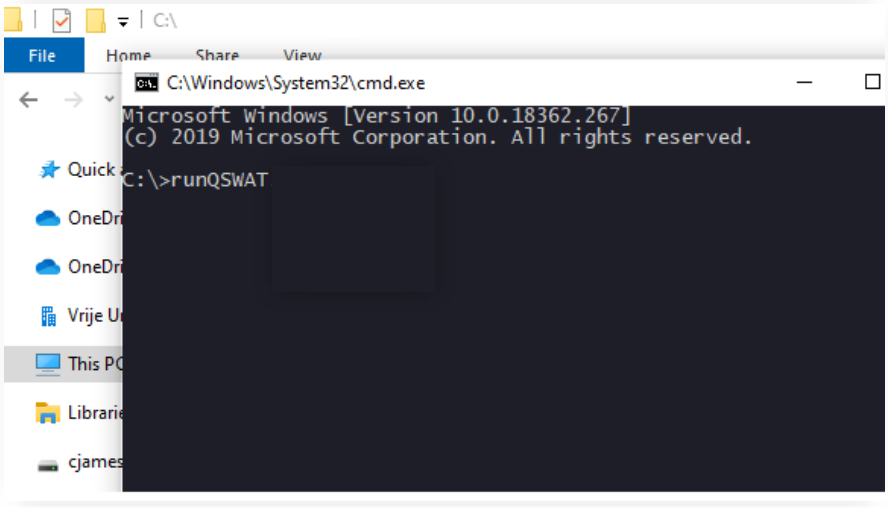

Figure 7: Running the QSWAT Workflow

4. Type runQSWAT and press Enter to start running the QSWAT Workflow. The Workflow will set up the model based on the settings specified in the namelist (Figure 8).

A new directory, *'model'* will appear, and the model that has been set up will be inside. If the user changes a setting in the namelist, they must change the name of the project too; otherwise, the current project will be overwritten.

Once the model setup finishes, the user can open the model in QSWAT for visualisation. The model project files that are created by the workflow are fully compatible with the GUI, and further changes can be made in the GUI.

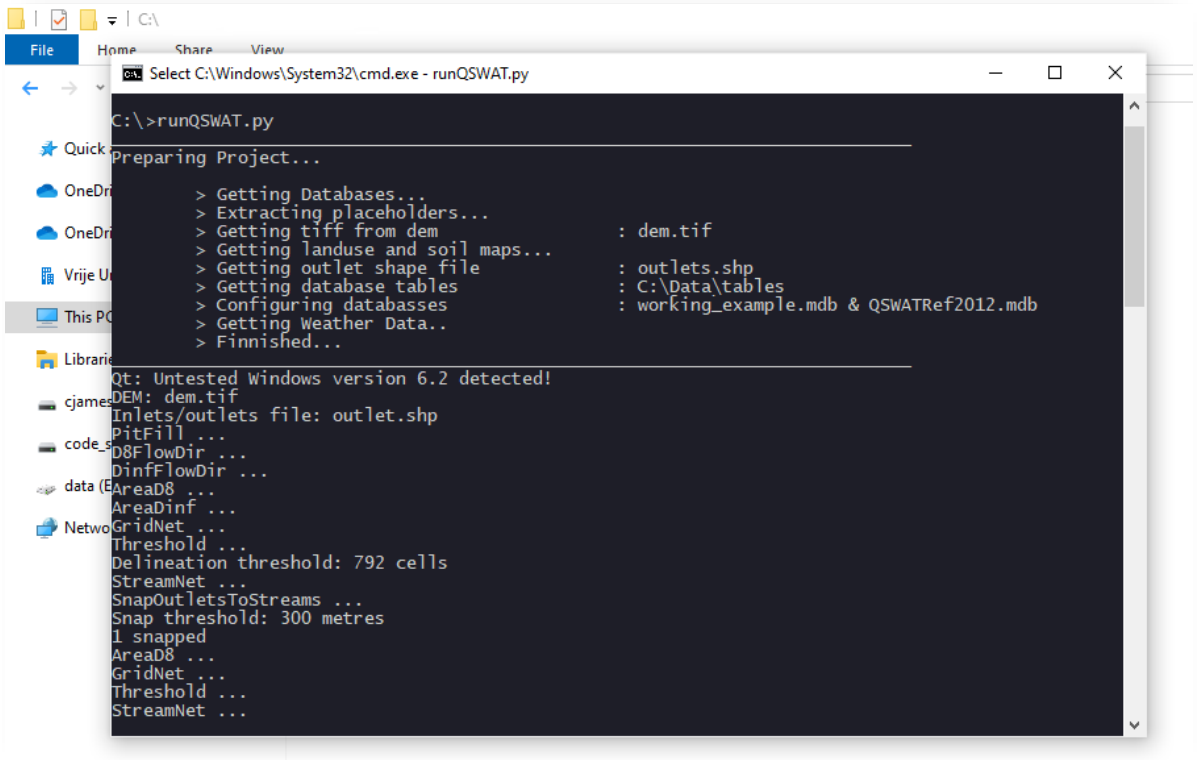

Figure 8: Workflow Running based on namelist

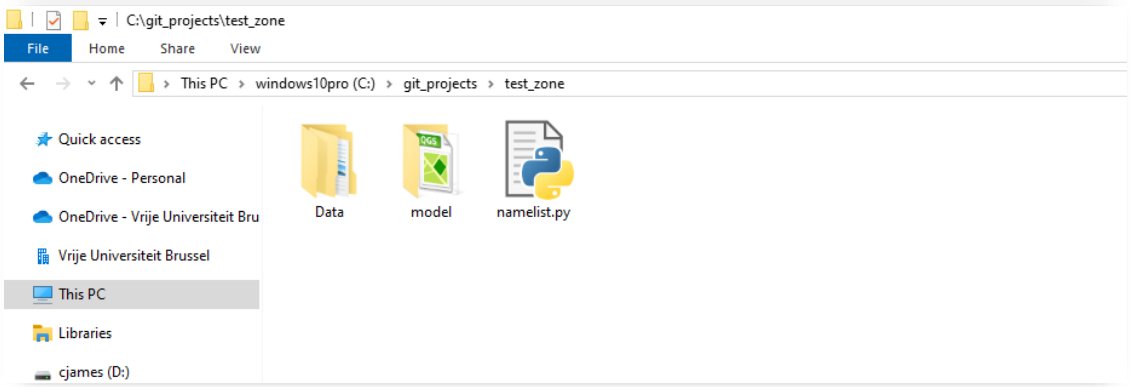

Figure 9: model directory contains models that have been set-up

Retrieving namelist and data from existing model

The procedure for retrieving the namelist and data is the same as for setting up the model. The only difference is that the user has to set the *Model_2_namelist* setting to True. Be sure to move or rename the existing Data directory as it will be overwritten in the process.

The namelist used to retrieve the namelist from the existing model is saved into a directory called old_namelists. Thus the user can use previously used namelists later.

References

Dile, Y., Srinivasan, R., & George, C. (2017). QGIS Interface for SWAT (QSWAT), *February*(v 1.4), 77. https://doi.org/10.13140/RG.2.1.1060.7201

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McNutt, M. (2014). Reproducibility. *Science*, *343*(6168), 229–229. https://doi.org/10.1126/science.1250475

Vasilevsky, N. A., Brush, M. H., Paddock, H., Ponting, L., Tripathy, S. J., LaRocca, G. M., & Haendel, M. A. (2013). On the reproducibility of science: unique identification of research resources in the biomedical literature. *PeerJ*, *1*, e148. https://doi.org/10.7717/peerj.148