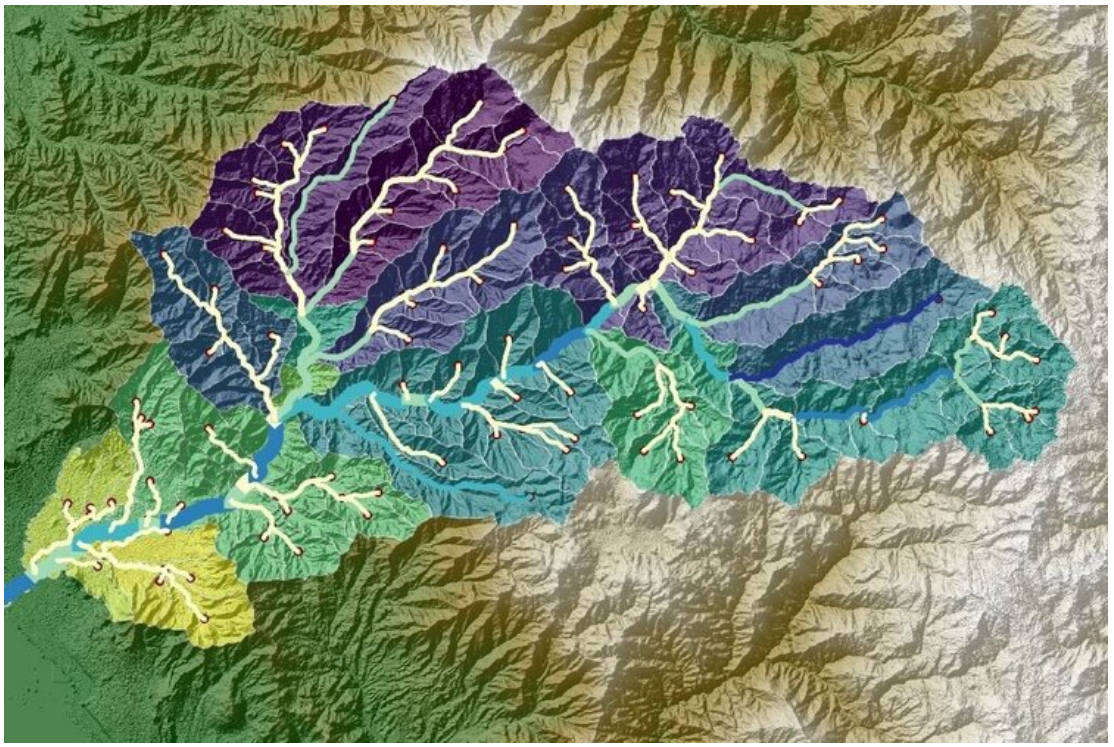
Hydrological Modeling Program with SWAT+ and QGIS - Asynchronous and Offline



2023

1. Description

Hatarilabs presents the educational program to master SWAT+ (Soil Water Assessment Tool), which is a tool that allows soil and water evaluation for hydrographic basins based on Hydrological Response Units (HRU's). SWAT+ is used to predict the long-term impact of land use on the generation of water, sediments, among others, and also integrates a variety of models, with the water balance being the driving force of the model.

This program is designed from the most basic and according to this, it will advance to higher topics that allow knowledge in the development of hydrological models using the SWAT+QGIS interface, allowing sensitivity analysis, calibration and validation using versatile tools such as SWAT+ Toolbox, SQLite and Python.

This program is developed in asynchronous mode that allows students to be more flexible in their schedule and enjoy of instructional materials during 06 months.

Note: This diploma is the recorded version of our last synchronous diploma.

Objectives

This program is designed to provide you with the following capabilities:

- Know the SWAT+ and QGIS environment
- Understand the SWAT+ data entry mechanism and its databases.
- Carry out the correct data processing.
- Implement essential meteorological variables for the model.
- Present the data obtained in the model and compare the results with real data.
- Obtain experience in the application of SWAT + in numerical modeling.

2. Content

The program is divided into 03 modules, each module is divided into 6 sessions. The content of each module and the description of each session are described below:

Module 01: Introduction to Hydrological Modeling with SWAT+ and QGIS

This course develops the key concepts to understand hydrological modeling using SWAT+ and QGIS, introductory topics will be addressed and a pre-established model to understand the operation of SWAT +, the procedure for the processing of data required in a hydrological model will also be explained.

Session 01: Introduction to Hydrological Modeling

A session dedicated to the introduction of basic concepts of hydrological modeling to use SWAT+ under the QGIS environment.

- Basic Concepts: Hydrologic Processes, SWAT Watershed, and Water Balance.
- Scope of hydrological modeling.
- Introduction to SWAT+
- Installation QGIS 3.22 and SWAT+2.1
- Introduction to QGIS and handling of files in QGIS

Session 02: Components of SWAT+ Part I

A review of the climatic variables that allows evaluating the changes of the hydrological cycle at the scale of the hydrographic sub-basin at the level of SWAT and source data structure management will be addressed.

- SWAT+ climatic variables
- Global climate data
- Structure and Location of Data Sources
- SWAT+ Environment: Configuration of sub-basins and rivers.
- First review of a hydrological model: Basin configuration

Session 03: SWAT+ Components Part II

This session addresses the handling of output data and the continuation of the review of the model focused on the definition of Hydrological Response Units (HRU's)

- Structure and Location Output Data
- SWAT+ Environment: Hydrological Response Units (HRU's).
- Second review of a hydrological model: Creation of HRUs: Land
    - and land use coverage.
    - Report reading.
    - HRU generation.

Session 04: Components of SWAT+ Part III

Based on the pre-established model, the climatic data that are necessary inputs for the simulation will be reviewed. The results will also be displayed using the tools that SWAT + has.

- Review of climate input data editing.
- Tools for the execution of a model:
    - Simulation period.
    - heating period.
    - Verification of output parameters
- Visualization of Outputs: Static, animation and plot.

Session 05: Preparing spatial data for a model

This session covers the processes for preparing spatial input data such as shapes and rasters that are necessary to build a SWAT+ model with QGIS.

- Review of the main platforms that allow downloading spatial data.
- Download of Digital Elevation Models (DEM), Ground Cover and Soils.
- Spatial data processing using tools such as projection and clipping with QGIS.
- Obtaining water networks based on a DEM.

Session 06: Preparation of tabular data for a model

For this session, global climate data will be downloaded and students will learn to organize the data from the weather stations and the monthly statistics of the climatological variables required by SWAT+.

- Climate data review for SWAT+
- Global climate data download.
- Preparation of tabular data using Excel.

Module 02: Hydrological Modeling with SWAT+ and QGIS

Once the concepts have been covered and the operation of SWAT+ is understood, hydrological models will be developed with daily rainfall data, since they are the basis of the entire model, thus being the basis for the generation of future variables such as outflows or runoff.

Session 01: Construction of a hydrological model

For this session, a model with SWAT+ and QGIS will be developed in detail from the configuration of basins to the creation of Hydrological Response Units (HRU's).

- Delimitation of sub-basins and creation of rivers.
- Import of entry and exit points.
- Introduction of land and soil cover maps.
- Generation of the HRU's.
- Visualization of reports generated by SWAT +.

Session 02: Simulation of a hydrological model

We are going to continue with the development of the model following the guidelines of the incorporation of climatic variables, simulation, analysis of results and visualization of simulated data.

- Incorporation of weather station files and monthly weather statistics.
- Configuration to run the model.
- Confirmation of the output parameters.
- Analysis and visualization of simulated data.

Session 03: Development of a hydrological model with SWAT+ and QGIS.

For this session, a model will be built and simulated with SWAT+ and QGIS where the outflows will be estimated and compared with observed values.

- Implementation of the SWAT+ model
- Insertion of digital elevation models.
- Preparation of data on the use of land cover, soil.
- Visualization and analysis of model results.
- Comparison of observed and simulated data.

Session 04: Construction of a hydrological model

For this session, the construction of a model with SWAT+ and QGIS will begin, where the sub-basins will be delineated and a "landscape" will be created using various SWAT+ methods, after which it will be defined the Hydrological Response Units (HRU's) that allow grouping areas of the sub-basins with similar physical characteristics.

- Development of a SWAT+ model with completed data.
- Definition of capacity points in SWAT +.
- Creation of landscape units using SWAT+ methods.
- Fractionation of land use.
- Analysis of HRUs report.
- Visualization of the routing.

Session 05: Simulation of a hydrological model

Execution of the simulation of the model based on the insertion of data from the climatological stations using the preset parameters that SWAT+ has.

- Definition of climatic data.
- Review of simulation parameters.
- Hydrological balance analysis.
- Visualization of static data.

Session 06: Analysis of model results

In this session we will analyze and visualize the results in an animated way of different output variables from the SWAT+ interface in QGIS. The statistics of the simulated and observed output streams with Python will also be obtained.

- Generation of animated maps of the output variables.
- Plotting of simulated flows.
- Analysis of observed and simulated data from the SWAT+ interface.
- Realization of scripts in Python to obtain runoff graphs.
- Analysis of statistical parameters with Python.

Module 03: Advanced modeling applications with SWAT+, QGIS and SQlite

In this last section the sections of validation, calibration, and sensitivity analysis will be developed using various tools that SWAT+ Toolbox has. The hydrological and sediment balances of a calibrated model will also be evaluated and then graphs will be made by connecting the database of a model with Python and SQlite.

Session 01: Manual Calibration of a hydrological model

This session will address an introduction to the calibration process and its parameters to analyze a first approximation of the model results.

- Introduction to model calibration.
- Review of the main calibration parameters I.
- Configuration of parameters with SWAT + Editor.
- First approximation of the model calibration.
- Analysis of statistical parameters with Python.

Session 02: SWAT+Toolbox Automatic Calibration Tool

For this session, the main technical aspects about automatic calibration in a model using compatible tools such as SWAT+Toolbox will be completed.

- Review of the main calibration parameters II.
- Download and install SWAT+Toolbox.
- Description of how SWAT+Toolbox works.
- Import and simulation of a model to SWAT+Toolbox.

Session 03: Sensitivity analysis and calibration - Part I

The sensitivity analysis of a model that allows evaluating the effect produced by certain SWAT+ parameters on a measured variable such as flow will be developed.

- Scope of sensitivity analysis concepts.
- Sensitivity analysis to determine the most sensitive parameters of the model.
- Selection of parameters to calibrate.
- Execution of the model in SWAT+Toolbox.

Session 04: Validation and analysis of model results.

For this session, the main technical aspects about validation in a model using SWAT+ compatible tools will be completed and the optimal calibration parameters for the validation of the results will be configured.

- Appearance of the validation of a model.
- Configuration of the optimal calibration parameters in SWAT+.
- Validation of the results.
- Obtaining statistical parameters with Python.
- Visualization of the results.

Session 05: Evaluation of outflows and sediments in the SWAT+QGIS model.

With the calibrated model, the outflows and the sediment production provided by the basin under study will be analyzed based on the pre-established parameters of the software, the scope of the main parameters will be provided.

- Definition of applications of hydrological and sediment models.
- Review of the hydrological balance and its parameters.
- Review of the sediment balance and its parameters.
- Analysis of flow and sediment results in the SWAT+ and QGIS platform.

Session 06: Visualization of results with SQLite in Python

In this session we will learn to connect the SQLite database from Python and the hydrological simulation of a SWAT+ model will be carried out in an automated way in order to generate interactive graphics.

- Creating a database connection using the pandas library.
- Checking of meteorological variables
- Reading of specific columns as output stream.
- Obtaining statistical parameters of a river.
- Visualization of the simulated flow in time series.

4. Trainer

Saúl Montoya M.Sc. - Hydrogeologist - Numerical Modeler

Mr. Montoya is a Civil Engineer graduated from the Catholic University of Lima with postgraduate studies in Water Resources Management and Engineering (WAREM Program) from the University of Stuttgart - Germany with a mention in Groundwater Engineering and Hydroinformatics . Mr. Montoya has strong analytical skills for the interpretation, conceptualization, and modeling of the surface and groundwater cycle and their interaction.

He is in charge of numerical modeling for contaminant transport and contaminated site remediation systems. Within his hydrological and hydrogeological investigations, Mr. Montoya has developed a holistic understanding of the water cycle, understanding and quantifying the main hydrological dynamic processes of precipitation, runoff, evaporation and recharge of the groundwater system.

Over the last 9 years, Saul has developed 2 websites to share knowledge on water resources: www.gidahatari.com (Spanish) and www.hatarilabs.com (English) that have become relevant due to their applied tutorials on water modeling underground, spatial analysis and computational fluid mechanics.

5. Methodology / Exam

Mode: Offline - Asynchronous

Some details about the methodology of the diploma:

- Manuals and files for the exercises will be delivered on our online platform.
- The course will be developed by video recorded videos and will be available on our elearning platform.
- There is support for questions regarding the exercises developed through the forum/email.
- Video of the classes will be available for 6 months only for students registered in **https://shop.hatarilabs.com/**

The certification exams are organized as follows:

- The program consists of 02 exams.
- Digital certificate available at the end of the program with the approval of the exam.
- To receive the digital certificate you must take the exams.