Hydraulic and Hydrologic Modelling Tool

HHMT

User's Manual

March 2017

UNESCO-IHE

Institute of Water Education

Water Science & Engineering

Hydroinformatics department

Module 5: Modelling Systems Development

Mostafa Farrag

No: 53699

Locker No:31

Contents

1. Introduction

The objective of this software tool is to develop a modelling system that can solve several hydrological problems and set up certain kinds of conceptual and physical-based models. The modelling system consists of three part, Backwater Curve Calculator, HBV Modeller and Free Surface Flow Simulator. Each of the system allows you to input parameters and obtain the results of the model in the form of plots as well as tables. It also allows you to save the results in files.

2. Programme Specifications

This software tool was coded in the Matlab programming language using Matlab version 2016, this code may be incompatible with older or newer versions of Matlab

3. Working with HHMT- An overview

HHMT is an integrated package of hydraulic and hydrologic analysis tools, in which the user interacts with the system through the use of a graphical user interface (GUI). The system is capable of performing steady and unsteady flow water surface profile calculation and several hydraulic computations

4. Starting HHMT

When you first start the HHMT, you will see the main window as shown in figure 4.1

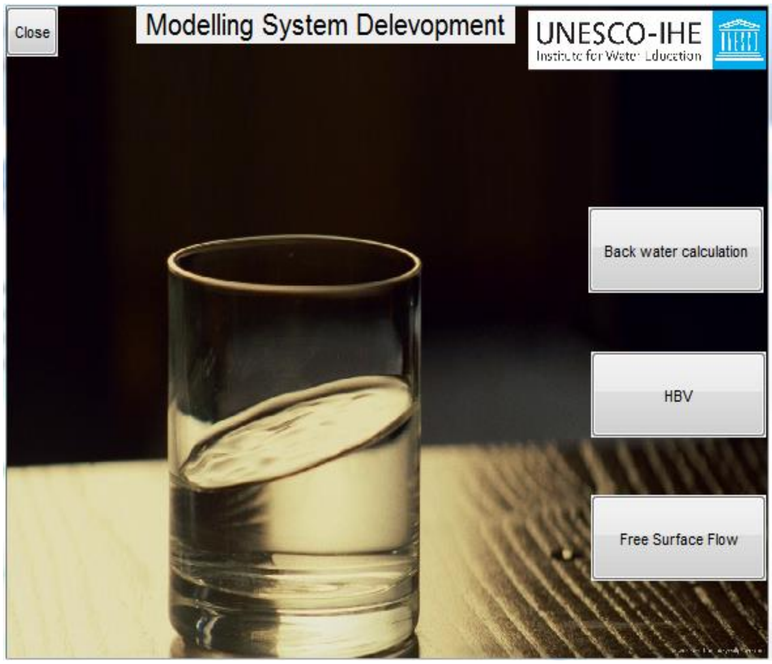


figure 4.1 main window interface

figure 4.1 HHMT Main window

at the left of the HHMT main window user will find the tools included in the package

1- Back water curve
2- Hydrologic modelling calculation
3- Free surface flow calculation
4- Help
5- Developer

5. Back water curve

The backwater curve tool has been coded to calculate the water depth along a channel knowing the water depth at the downstream end of the channel and the characteristics of the channel Such that length, slope, width, chezy coefficient, discharge

And the results will be presented on a graph showing the water level, ground level, along the length of the channel also these data will be presented in a table

5.1. Assumptions

The modelled channel was assumed to be rectangular, the flow is steady, low velocities all of these assumptions was assumed to simplify the numerical calculation.

5.2. BWC interface

The following figure represents the interface of the BWC, to the left of the window user will find all the channel properties with predefined values

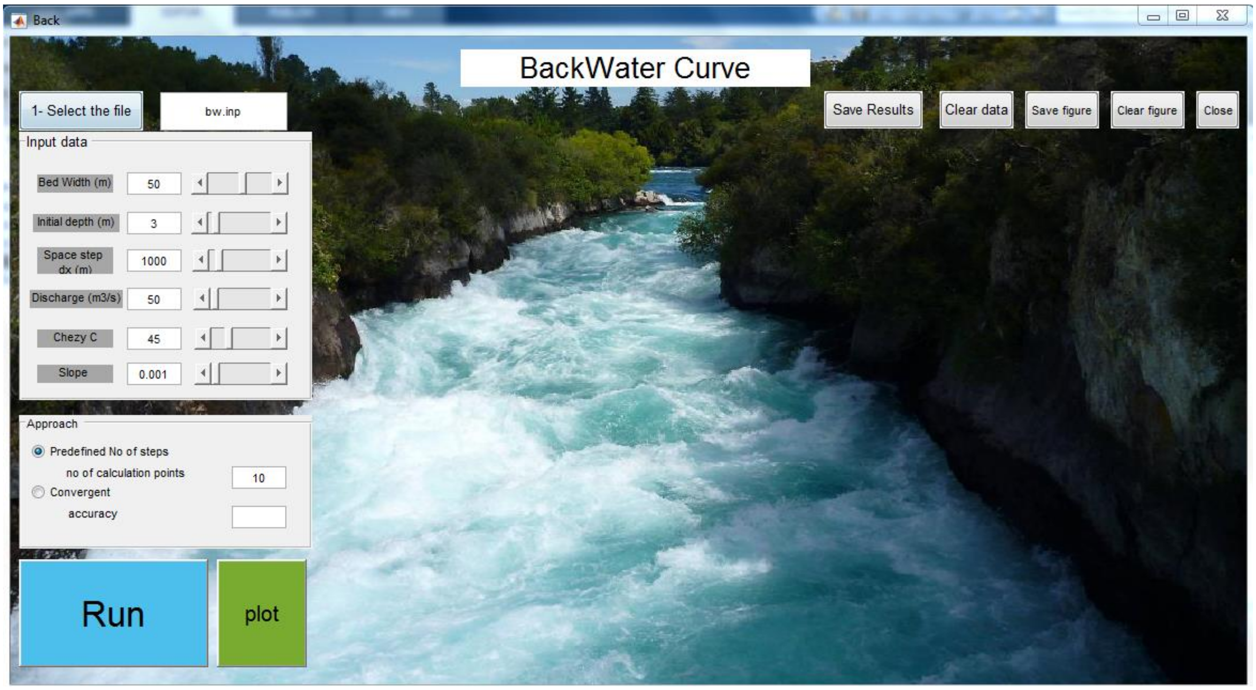


Figure 5.1 interface of the BWC

5.3. Methodology of the code

The code has been designed in a way that every button will validate all the data that will be included in the calculation process inside such that if the user pressed plot before running the calculation process then the code will send an error message

Here is a flow chart of the methodology of calculation & validation for all the buttons in the GUI

Mostafa Farrag
No: 53699 Locker No: 31

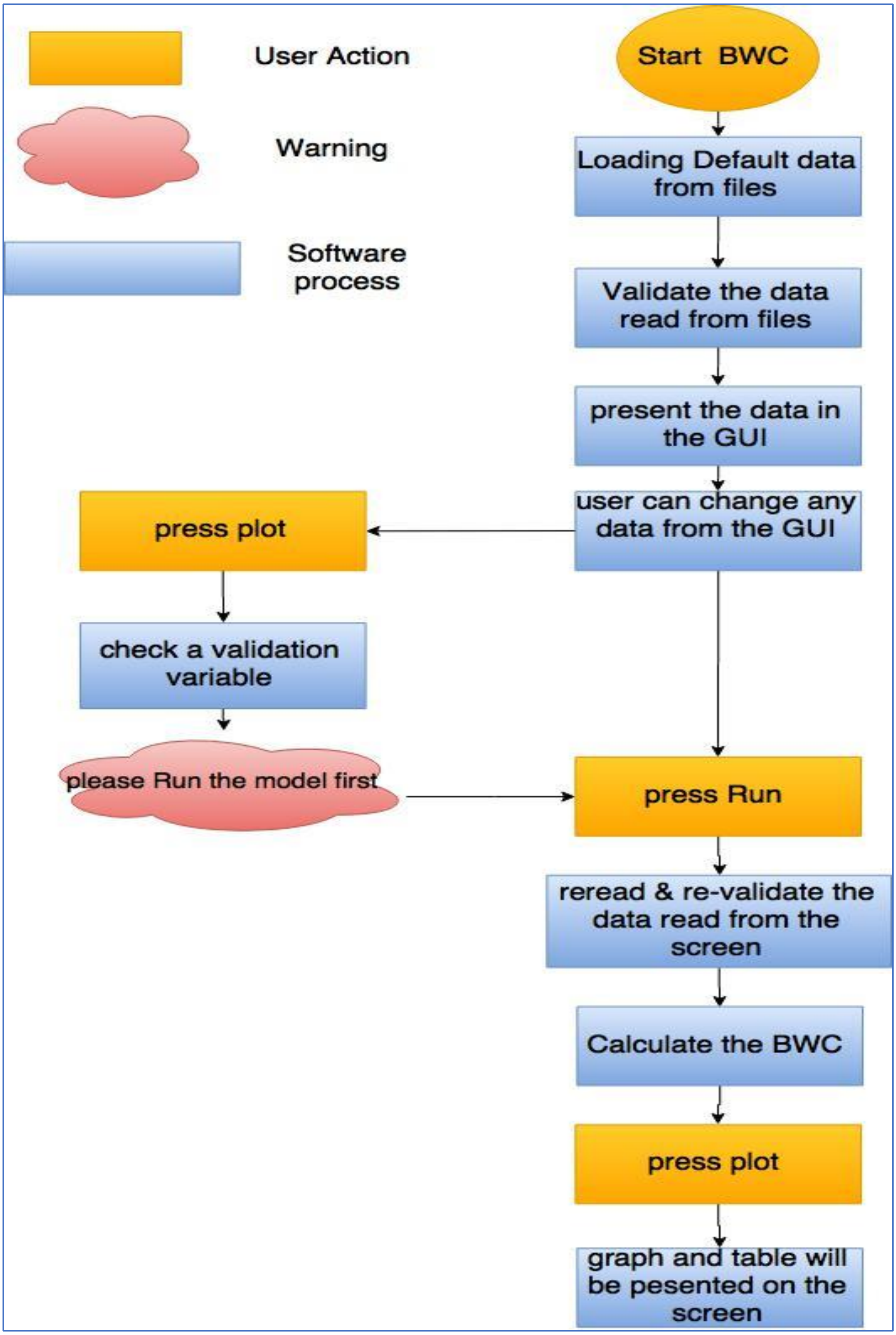


Figure 5.2 flow chart of the methodology of calculation & validation

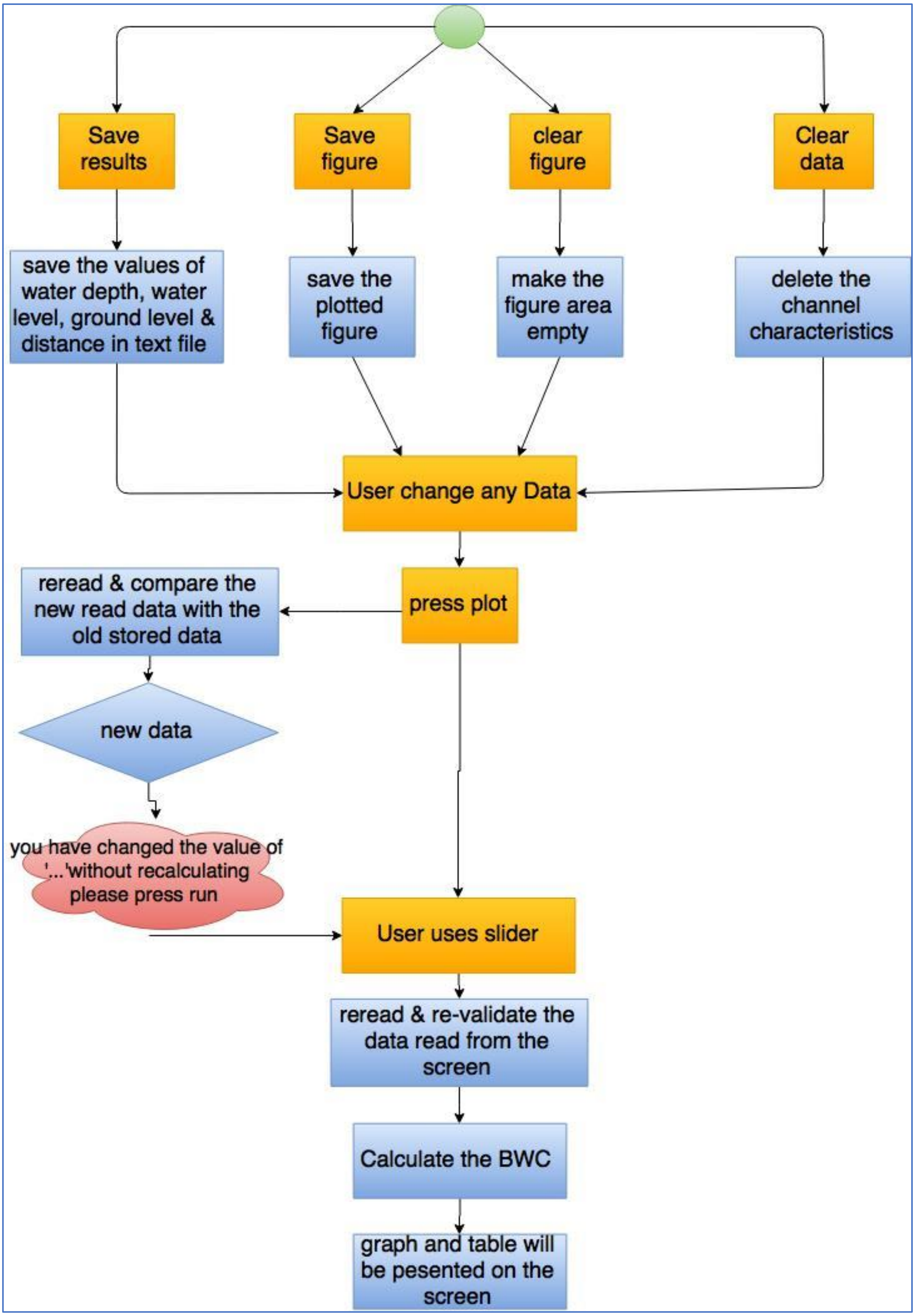


Figure 5.3 flow chart of the methodology of calculation & validation

5.4. Step-by-Step Procedure

Whoever if the user has tried to use the interface without knowing the procedure the messages from the program will be a guide to get a result but it in this section the logical procedure of using the BWC interface will be listed

5.4.1. Input data

As mentioned before the interface is usually opened with default values that are read from attached text file

If the user wants to read the data from a file data should be stored in a text file in the same arrange and style as shown below in figure 5.5

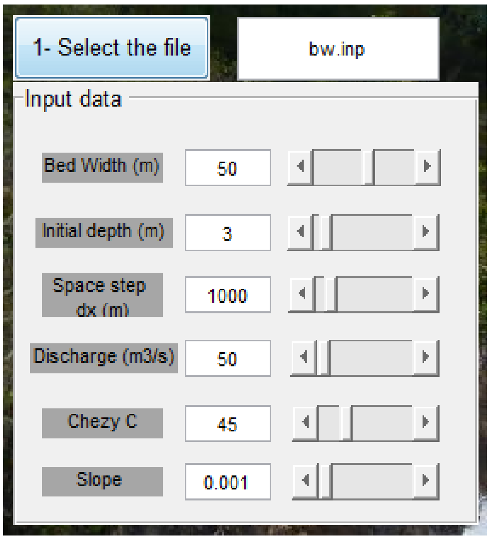
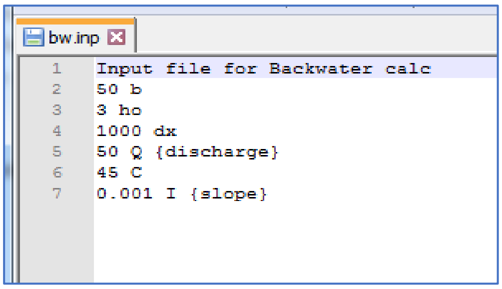


Figure 5.4 input data



```
Input file for Backwater calc
50 b
3 ho
1000 dx
50 Q {discharge}
45 C
0.001 I {slope}
```

Figure 5.5 input data file

5.4.2. Calculation Approach

User should choose a calculation approach either to calculate the water level for a specific number of points or run the calculation till the water depth becomes equal to the normal depth

The numerical method used in both approaches to calculate the water depth at every point is the implicit method (with accuracy 10^{-5}) more information about the numerical method Can be found in the following link

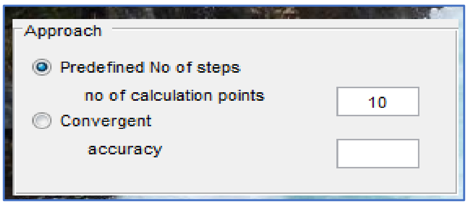
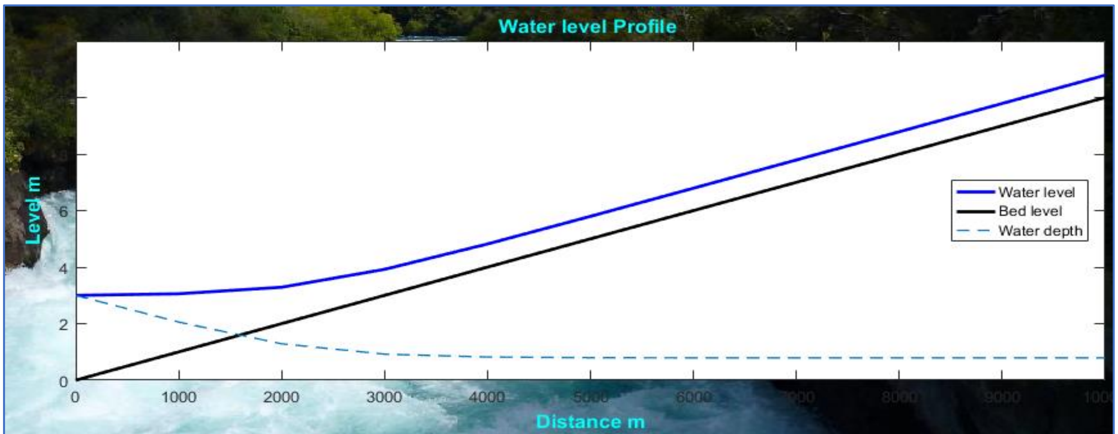


Figure 5.6 calculation approach

5.4.3. Results

User should press on run then plot, then Results will be presented on a form of table and figure



	1	2	3	4	5	6	7	8	9
Points	0	1	2	3	4	5	6	7	8
Distance	0	1000	2000	3000	4000	5000	6000	7000	8000
Depth	3	2.0570	1.2880	0.9210	0.8190	0.7970	0.7920	0.7910	0.7900
Elevation	0	1	2	3	4	5	6	7	8
Water level	3	3.0570	3.2880	3.9210	4.8190	5.7970	6.7920	7.7910	8.7900

Figure 5.8 results

5.4.4. Sliders

sliders buttons are included in the interface to enable the user from assessing the sensitivity of the calculation to each parameter

also, slider buttons work as independent calculator that will read all the parameters from the screen and validate all the data and print the results

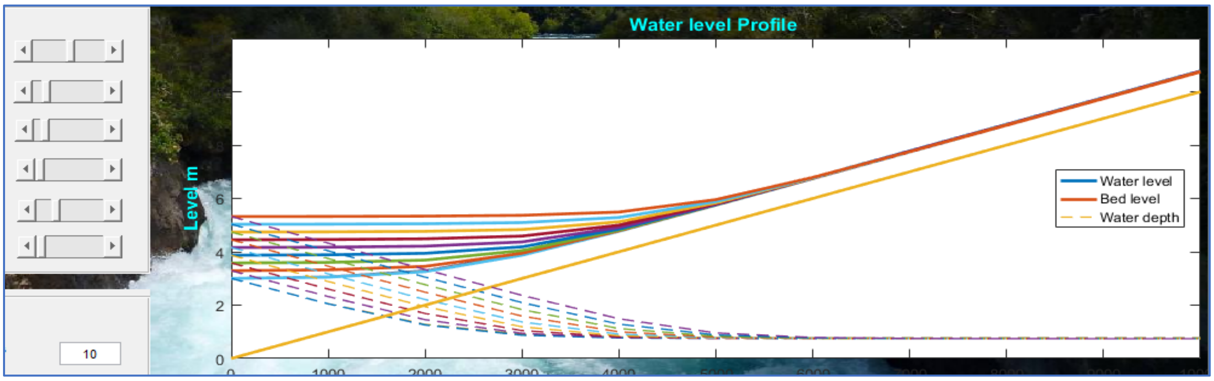


Figure 5.8 Sliders

5.4.5. Optional buttons

User can save figures or results also can clear the panel of data or the figure area from the plots

Figure 5.9 optional buttons

6. HBV

- The HBV tool has been coded to run and evaluate the hydrologic process in the catchment using the observed values of precipitations, Evapotranspiration, temperature and run off Recalculating any of the observed variables using the catchment parameters enable us to use these data to calibrate the parameters and also to measure the uncertainty in each parameter
- The catchments used are described with 18 parameters to describe the water process during the whole water cycle
- HBV model takes into account the catchment area & the time basis of the observed data either it is in hourly basis or in daily basis
- HBV model includes Calibration process, validation, Monte Carlo, and Tank simulation process
- Accuracy of the calibration process is assessed based on three types of errors

  A- Nash-Sutcliffe Efficiency (NSE)

  NSE = 1 means that the modelled data perfectly matches the measured data. A NSE = 0 means that the modelled data is as accurate as the mean of the observed data. An NSE < 0 means that the observed mean is a better predictor than the modelled data. The user should try and maximize the NSE through parameter calibration, either manually or using the automatic calibration.

  B- The Root Mean Squared Error (RMSE)

  It measures model performance. RMSE is a measure of difference between the measured and simulated discharge values. The units RMSE are in the units of measure for discharge. The ideal calibrated value of RMSE is 0.

  C- Percent Bias (PBIAS)

  It measures the tendency of the modelled values to be larger or smaller than the measured values. The ideal calibrated value of PBIAS is 0.

  D- The RMSE-observation standard deviation ratio (RSR)

  The ideal calibrated value of RSR is 0.

6.1. Assumptions

- all parameters and variables represent average values over the entire catchment
- the equations are semi empirical, but still with a physical basis
- model parameters cannot usually be assessed from field data alone, but have to be obtained through the help of calibration.

6.2. HBV interface

The following figure represents the interface of the HBV, to the left of the window user will find all the catchment properties with predefined values and in the bottom at the left

The calibration parameters (calibration equation, percentage of the data used in the calibration process & and number of iterations)

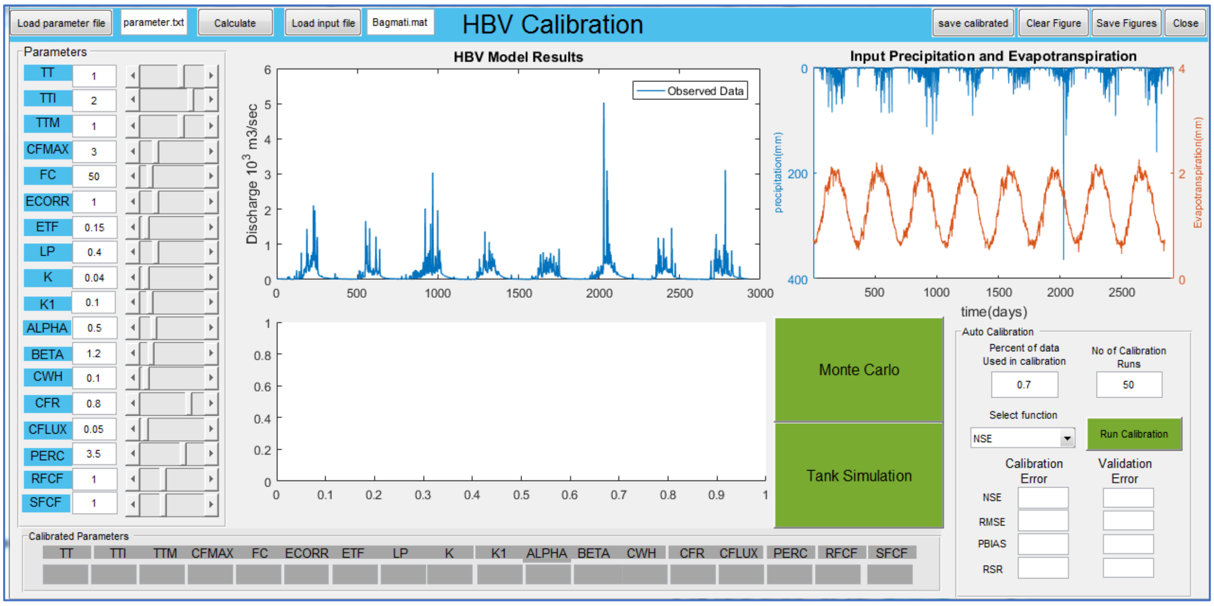


Figure 6.1 interface of the HBV

6.3. Methodology of the code

The code has been designed in a way that every button will validate all the data that will be included in the calculation process inside, such that if the user pressed plot before running the calculation process then the code will send an error message

Here is a flow chart of the methodology of calculation & validation for all the buttons in the GUI

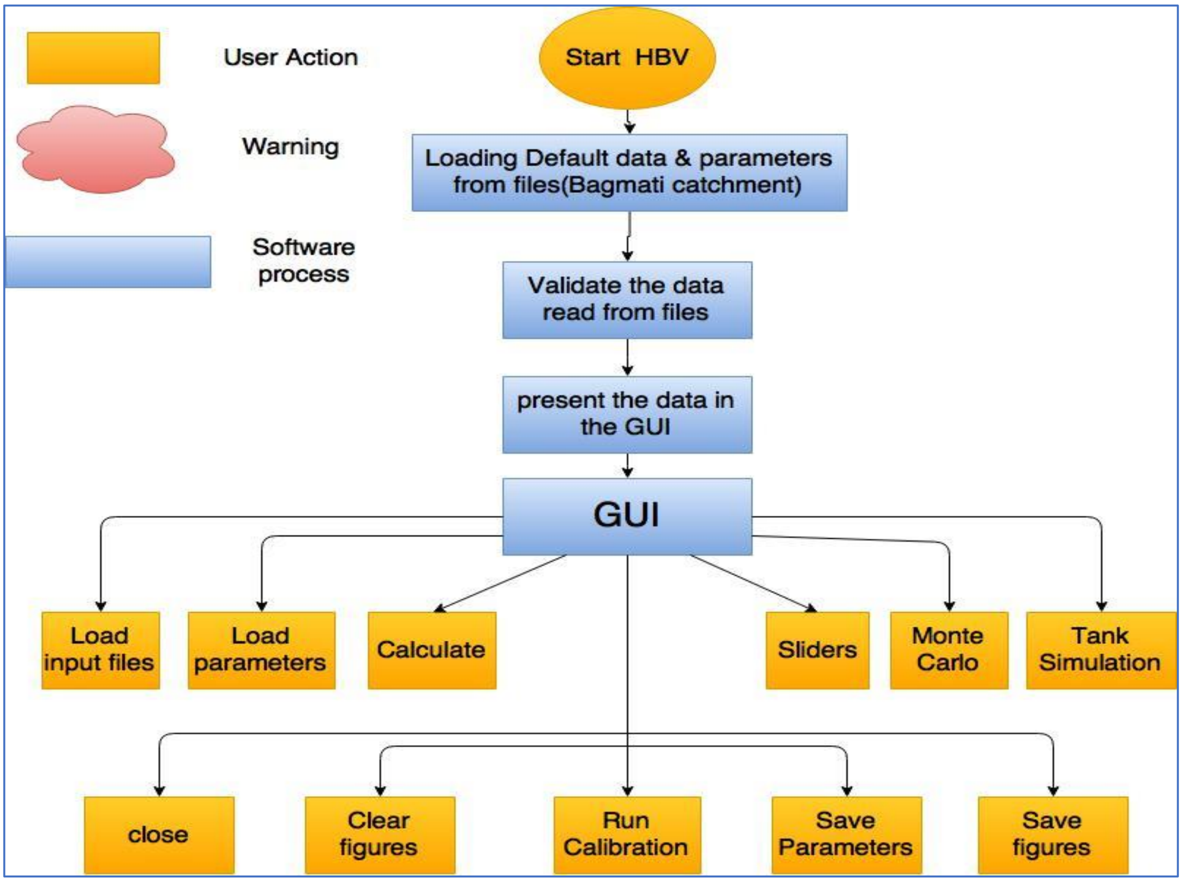


Figure 6.2 Structure of buttons in the GUI

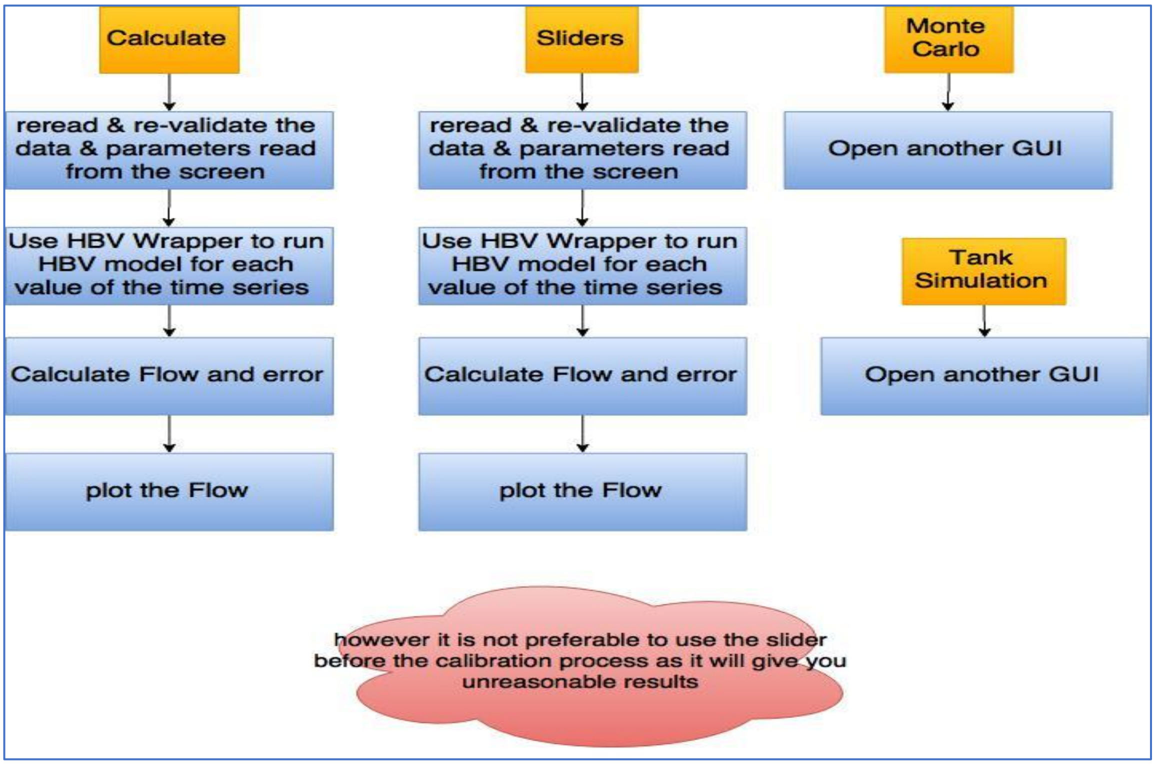


Figure 6.3 Procedures of calculate, sliders, Monte Carlo & Tank simulation buttons

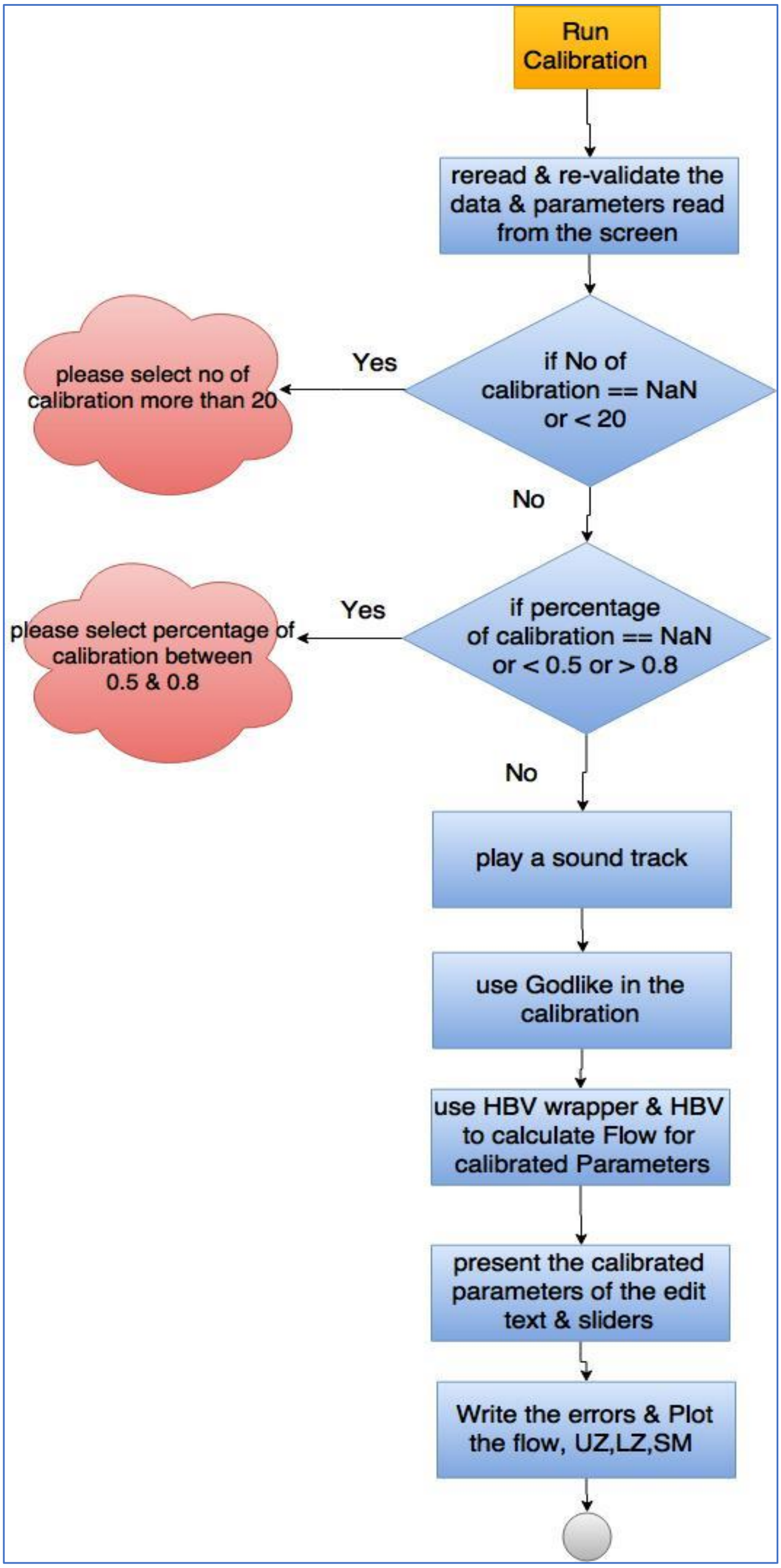


Figure 6.4 procedures of Run calibration

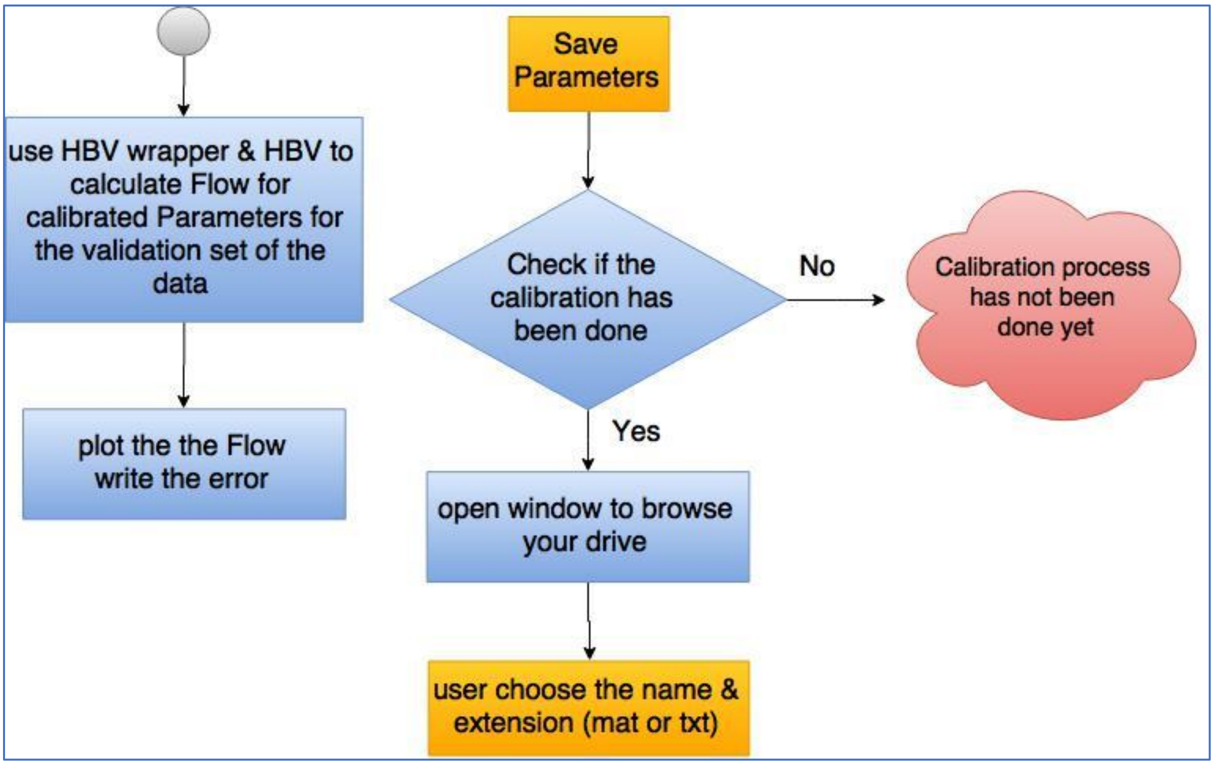


Figure 6.5 procedures of Run calibration & save parameters buttons

6.4. Step-by-Step Procedure

6.4.1. Input data

As mentioned before the interface is usually opened with default values that are read from attached text file

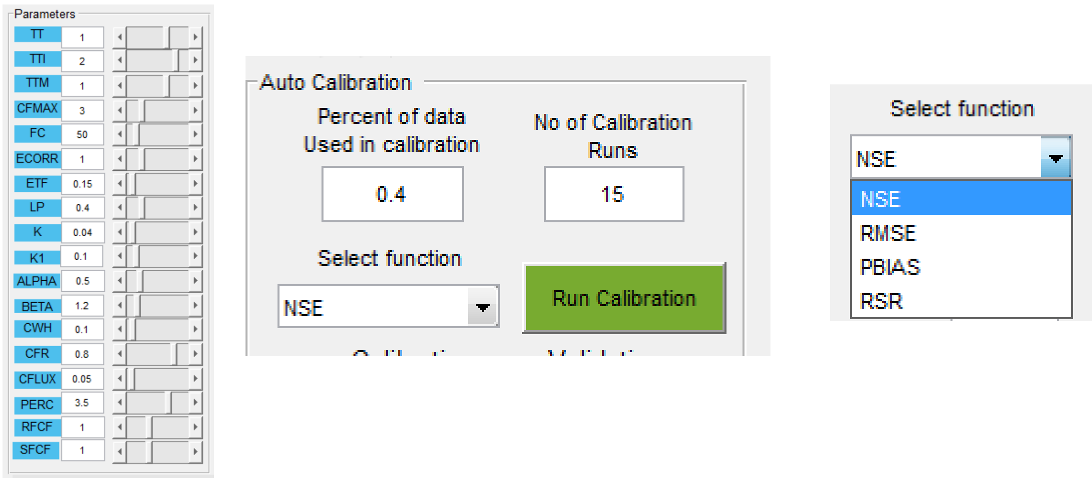
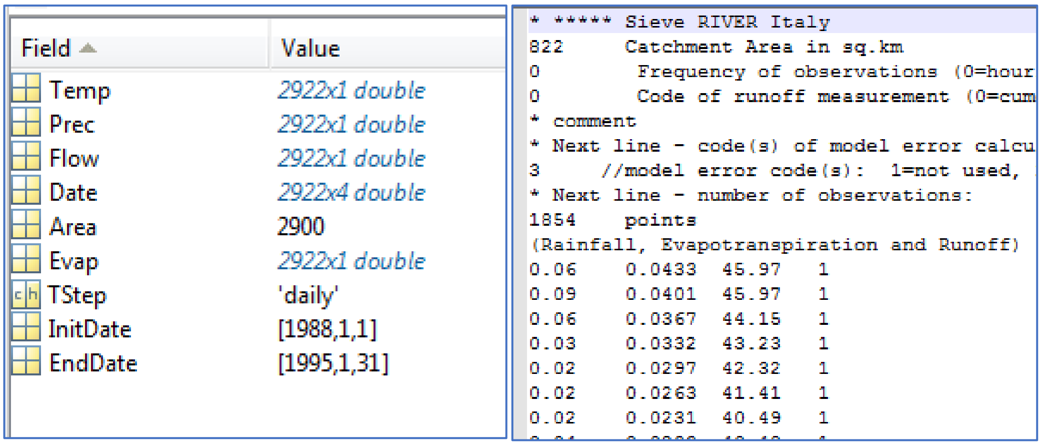


Figure 6.6 input data

If the user wants to read the data from a file data should be stored in a text file in the same arrange and style as shown below in figure 6.5



Field	Value
Temp	2922x1 double
Prec	2922x1 double
Flow	2922x1 double
Date	2922x4 double
Area	2900
Evap	2922x1 double
TStep	'daily'
InitDate	[1988,1,1]
EndDate	[1995,1,31]

```
* ***** Sieve RIVER Italy
822      Catchment Area in sq.km
0         Frequency of observations (0=hour
0         Code of runoff measurement (0=cum
* comment
* Next line - code(s) of model error calcu
3      //model error code(s):  1=not used,
* Next line - number of observations:
1854     points
(Rainfall, Evapotranspiration and Runoff)
0.06     0.0433  45.97    1
0.09     0.0401  45.97    1
0.06     0.0367  44.15    1
0.03     0.0332  43.23    1
0.02     0.0297  42.32    1
0.02     0.0263  41.41    1
0.02     0.0231  40.49    1
```

Figure 6.7 input data file

6.4.2. Results

User should press on run calibration, then Results will be presented on the figure

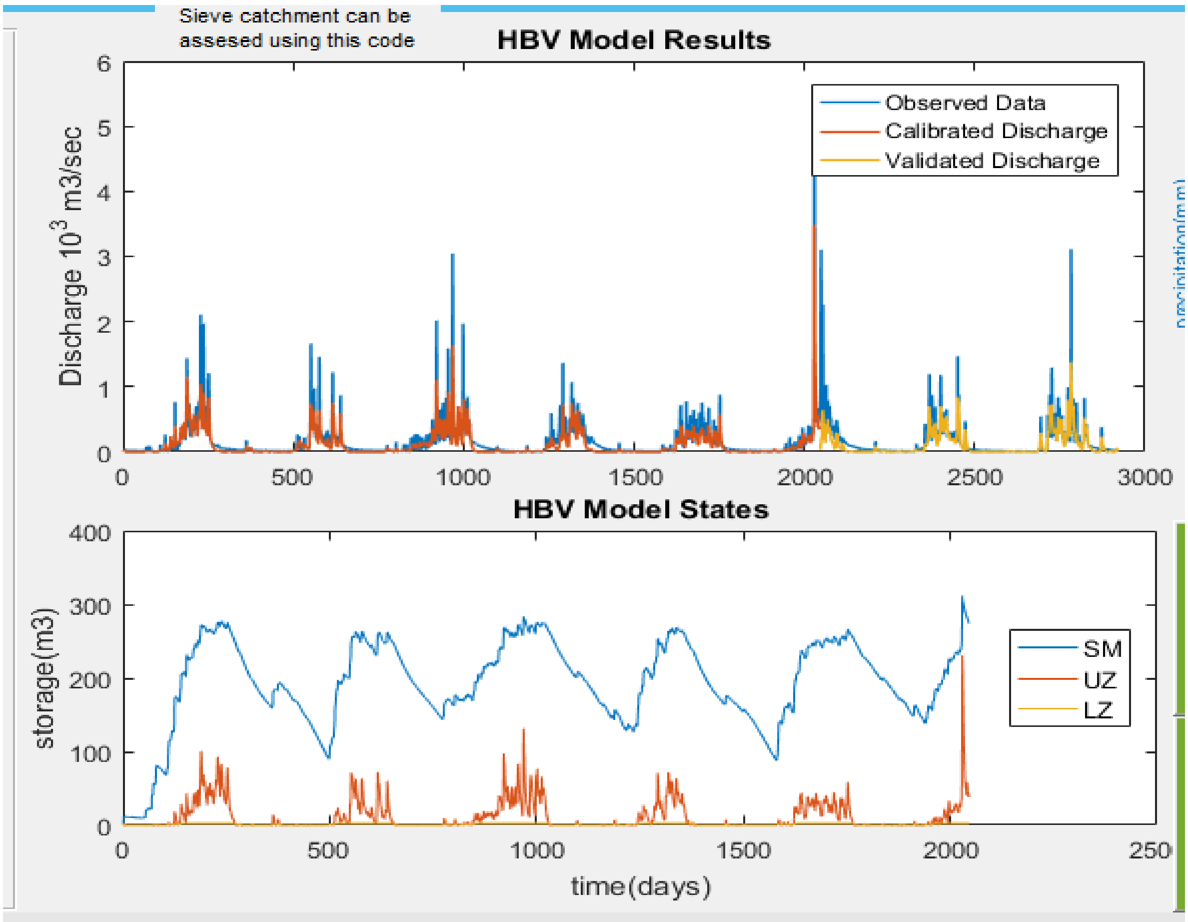


Figure 6.8 Results

6.4.3. Sliders

sliders buttons are included in the interface to enable the user to use manual calibration of the parameter also, slider buttons work as independent calculator that will read all the parameters from the screen and validate all the data and print the results

6.4.4. Tank Simulation

Using the tank simulation user will be able to visualise and interpret the results got from the calibration process and would also be able to change them according to the physical understanding of the catchment properties as the percolation parameters results from the calibration process might be to high which will lead to ground water recharge with low values of surface runoff

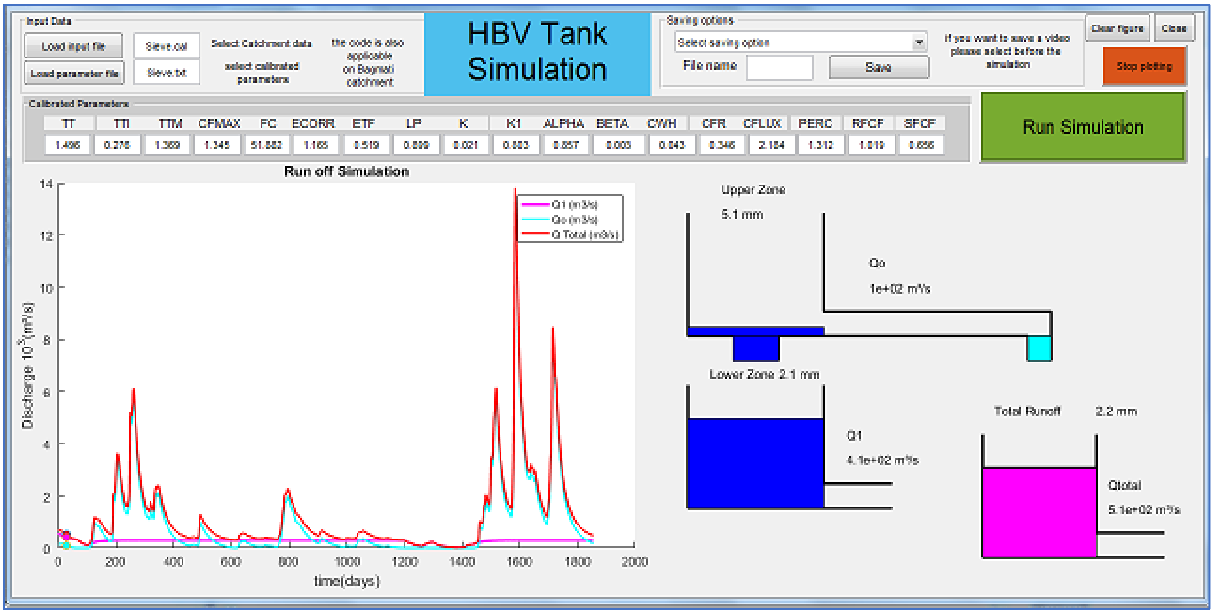


Figure 6.9 Tank Simulation

6.4.5. Monte Carlo Simulation

Using monte Carlo simulation user would be able to determine who much the certainty in the results at high or low flow values

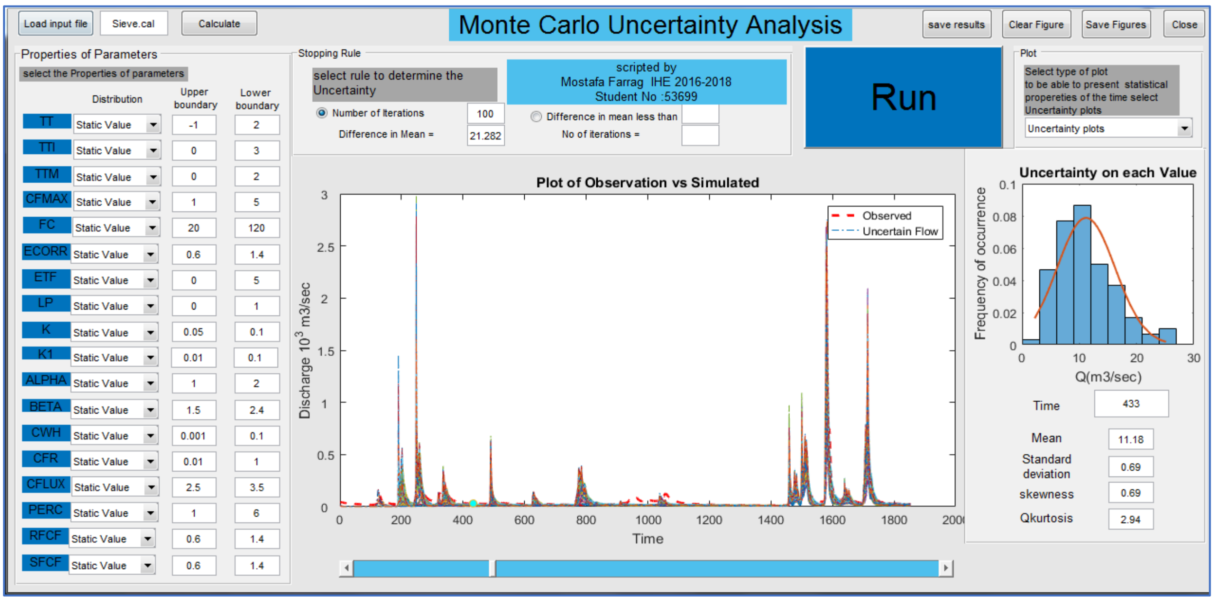


Figure 6.10 Tank Simulation

6.4.6. Optional buttons

User can save figures or results also can clear the panel of data or the figure area from the plots

It worthy to mention that in order to be able to use the Tank simulation user should use the calibrated parameters saved from this model also user can input all the parameters manually from the screen

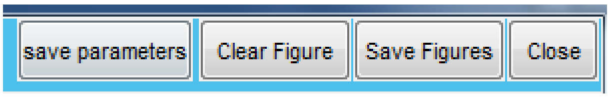
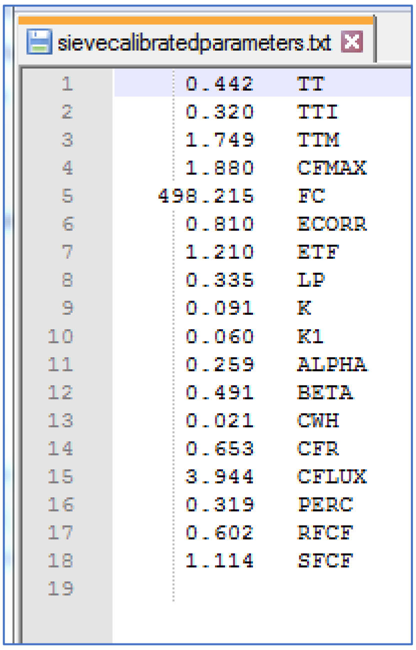


Figure 6.11 optional buttons


sievecalibratedparameters.txt

```
  0.442   TT
  0.320   TTI
  1.749   TTM
  1.880   CFMAX
498.215   FC
  0.810   ECORR
  1.210   ETF
  0.335   LP
  0.091   K
  0.060   K1
  0.259   ALPHA
  0.491   BETA
  0.021   CWH
  0.653   CFR
  3.944   CFLUX
  0.319   PERC
  0.602   RFCF
  1.114   SFCF
```

Figure 6.12 Saved file from save parameters button

7. Free Surface Flow Simulation (FSF)

The Free Surface Flow (FSF) uses Preissmann numerical scheme to solve one-dimensional Saint Venant equations for continuity and momentum.

This code could be used to simulate the steady and unsteady free surface flow in channel

7.1. Assumptions

The assumptions adopted in the numerical method (Preissmann scheme) has the same assumption of 1D Venant equations

- Water surface is horizontal across any section perpendicular to the longitudinal axis.
- Flow is gradually varied with hydrostatic pressure prevailing at all points in the flow.
- Longitudinal axis of the channel can be approximated by a straight line.
- Bottom slope of the channel is small, i.e., tan h = sin h. (h =10 yields 1.5% variation).
- Bed of the channel is fixed, i.e., no scouring or deposition is assumed to occur.
- Resistance coefficient for steady uniform turbulent flow is considered applicable and an empirical resistance equation such as the Manning equation describes the resistance effect.
- Flow is incompressible and homogeneous in density

7.2. FSF interface

The following figure represents the interface of the FSF, to the left of the window user will find all the channel properties, the numerical parameters & test cases with predefined values

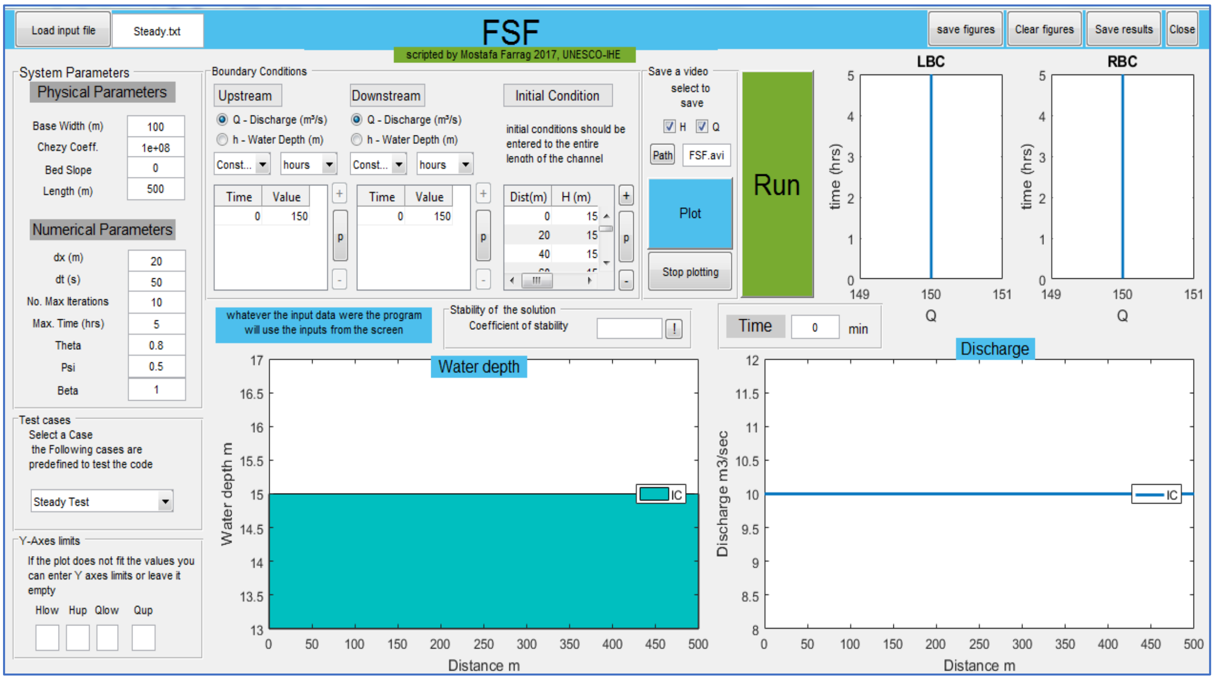


Figure 7.1 interface of the FSF

Mostafa Farrag
No: 53699 Locker No: 31

7.3. Methodology of the code

The code has been designed in a way that every button will validate all the data that will be included in the calculation process inside, such that if the user pressed plot before running the calculation process then the code will send an error message

Here is a flow chart of the methodology of calculation & validation for all the buttons in the GUI

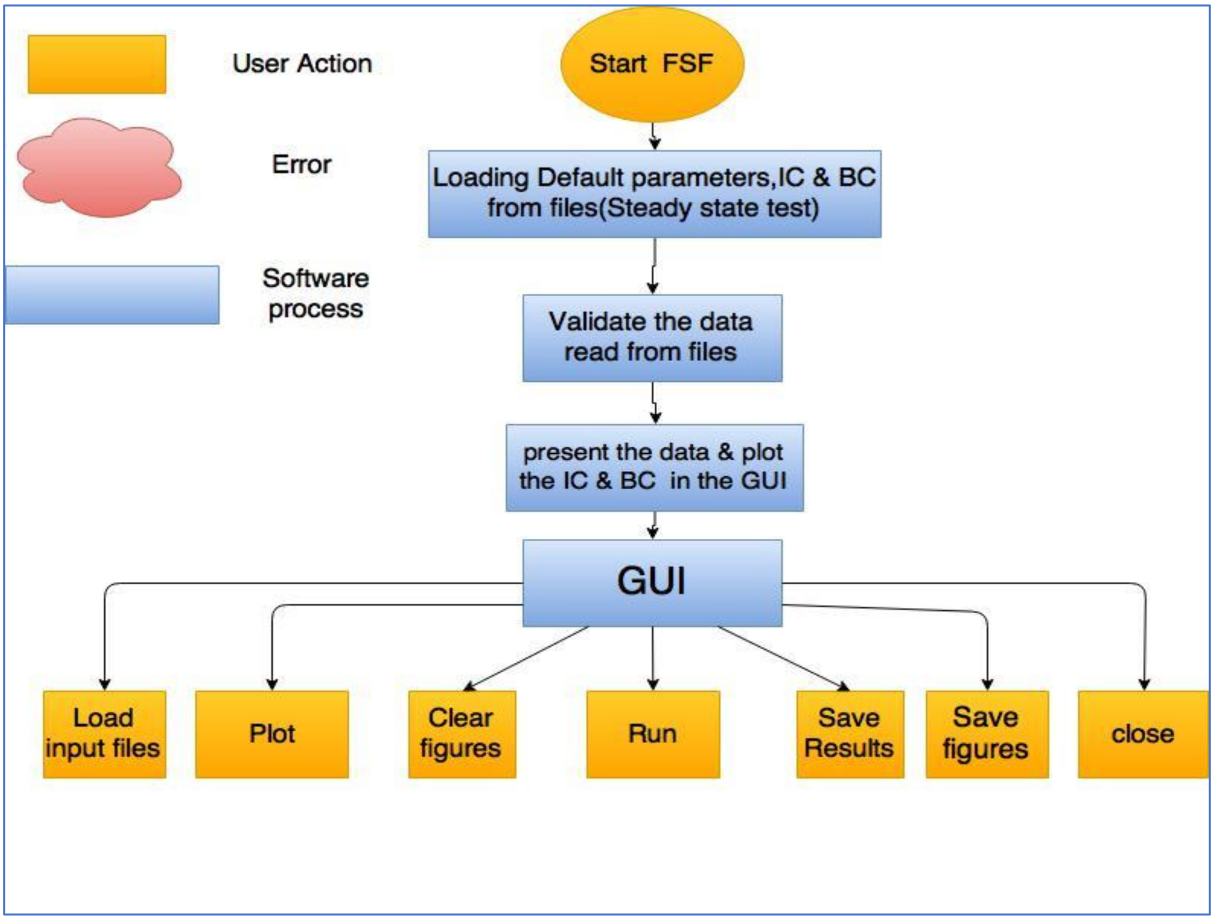


Figure 7.2 Structure of buttons in the GUI

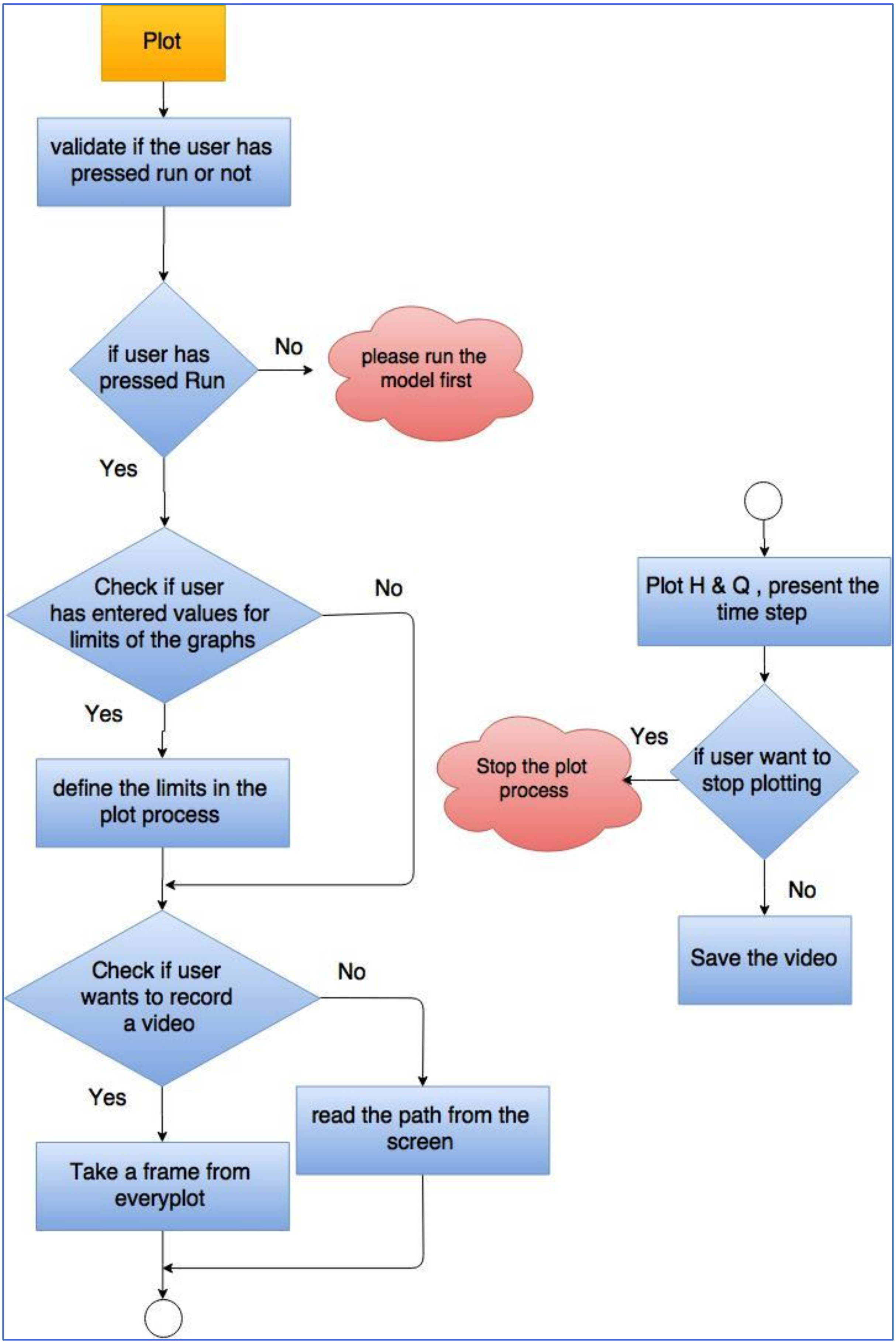


Figure 7.3 procedures of plot button

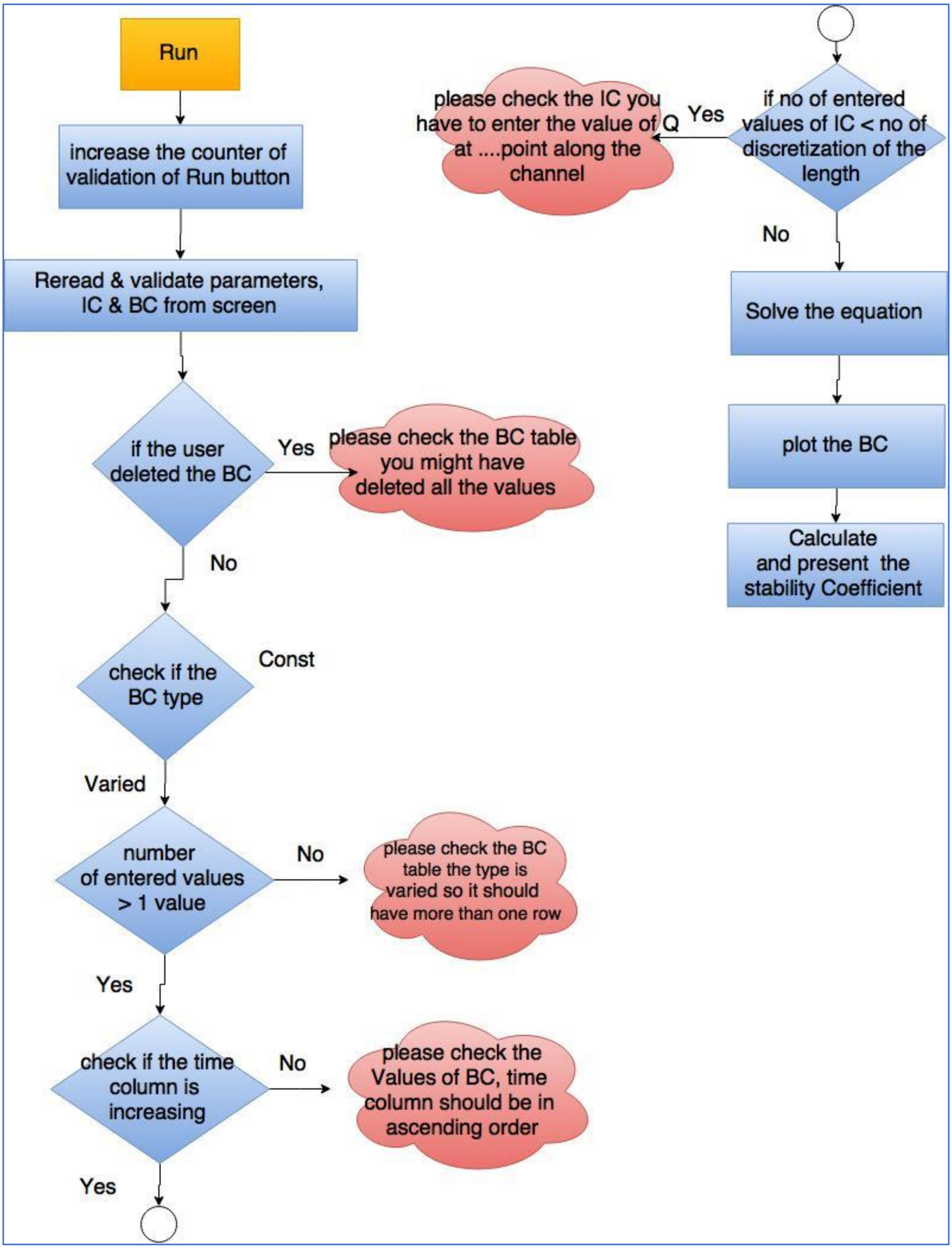


Figure 7.3 procedures of Run button

7.4. Step-by-Step Procedure

7.4.1. Input data

As mentioned before the interface is usually opened with default values that are read from attached text file

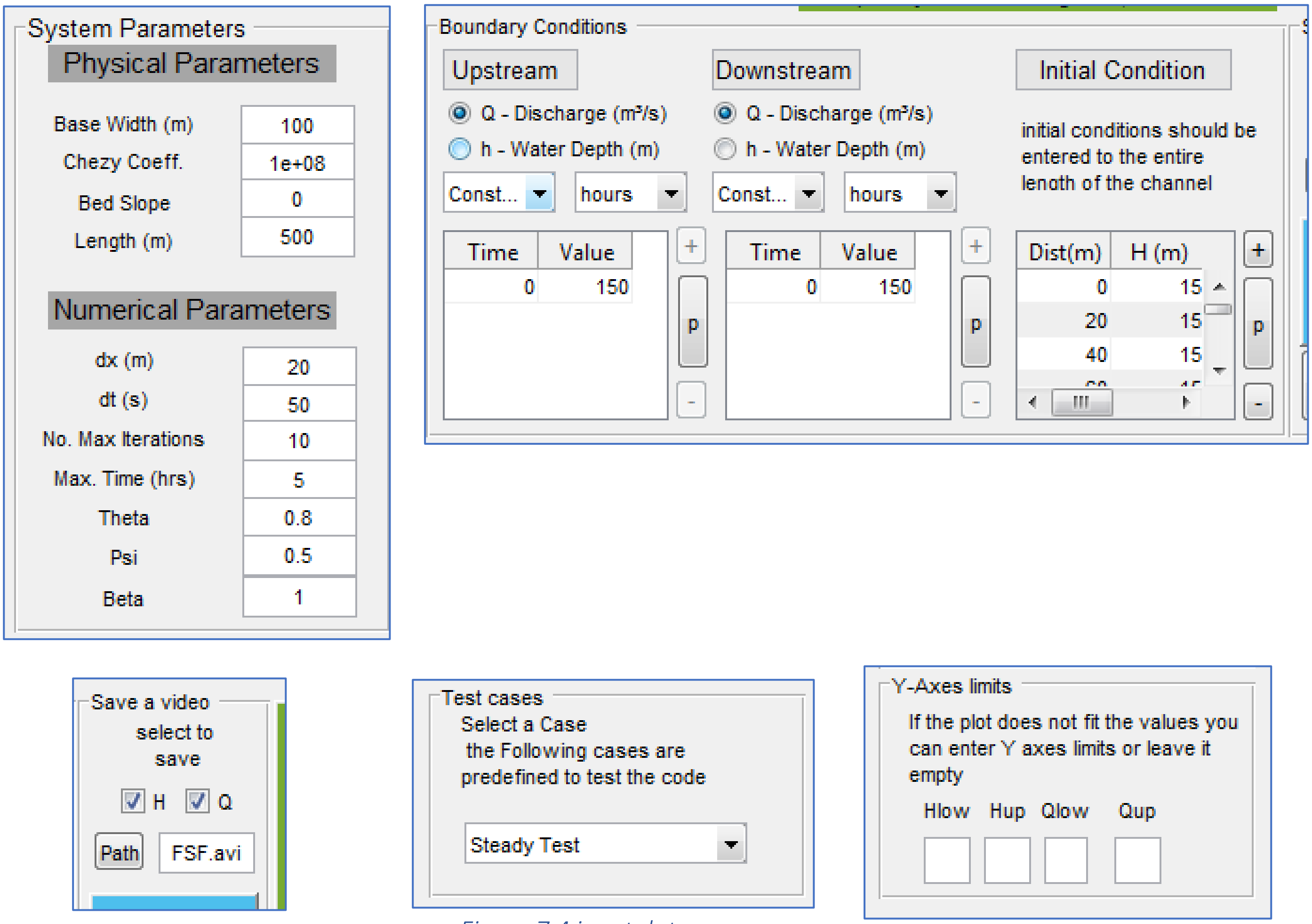


Figure 7.4 input data

If the user wants to read the data from a file data should be stored in a text file in the same arrange and style as shown below in figure 7.5

Mostafa Farrag
No: 53699 Locker No: 31

```
# steady
#geometry
500 - length of the channel
100  - width of the channel
100000000 - chezy coefficient
9.81 - gravity acceleration
0 - slope
#Numerical parameters
20 - deltax
50 - deltat
0.8 - theta
0.5 - epsi
10 - max no of iterations
5 - hours of max
#IC & BC
Qhinitialsteady.txt
LBCsteady.txt
RBCsteady.txt
#results file
Qoutsteady.txt
houtsteady.txt
```

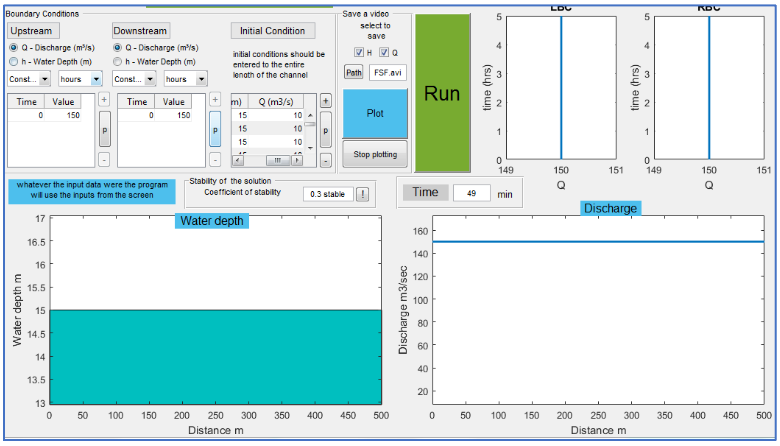
```
#QH initials
10  15
10  15
10  15
10  15
10  15
10  15
10  15
10  15
```

```
#right Boundary conditions
Q
hours
0 0
24 0
```

Figure 7.5 input data file

7.4.2. Results

User should press on run, then press plot will be presented on the figure



7.4.3. Optional buttons

User can save figures or results also can clear the panel of data or the figure area from the plots

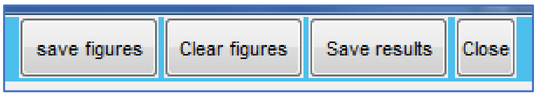


Figure 7.6 optional buttons

FSFH.txt

1	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000
2	15.055	15.050	15.045	15.041	15.036	15.032	15.028	15.023	15.019
3	14.997	14.998	14.999	15.000	15.000	15.000	15.001	15.001	15.001
4	14.994	14.994	14.994	14.994	14.994	14.995	14.995	14.996	14.996
5	15.002	15.002	15.002	15.002	15.002	15.001	15.001	15.001	15.001

FSFQ.txt

4	150.000	149.339	148.818	148.414	148.106	147.876	147.709	147.591	147.511
5	150.000	149.776	149.509	149.217	148.915	148.614	148.328	148.064	147.832
6	150.000	150.112	150.236	150.367	150.498	150.623	150.741	150.847	150.939
7	150.000	150.019	150.034	150.047	150.057	150.067	150.075	150.083	150.090
8	150.000	149.974	149.950	149.927	149.906	149.885	149.866	149.849	149.834
9	150.000	150.004	150.008	150.012	150.016	150.019	150.023	150.026	150.029
10	150.000	150.003	150.005	150.008	150.011	150.013	150.015	150.017	150.018

Figure 7.7 Saved file from save parameters button