APEX-CUTE 8 User Manual

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Contents

1 Program Download 2

2 Program Installation 2

3 Example Dataset 4

4 APEX Parameters available in APEX-CUTE 5

5 Observed data 6

5.1 Reach Observed Data 6

5.2 Subarea Observed Data 7

5.3 Crop Yield and Soil Organic Carbon Data 8

5.4 Crop Observed Data 9

6 APEX-CUTE 8.0 User Interface 11

Main Tab 11

7 Sensitivity Analysis 12

7.1 Select the Sensitivity Analysis Method 12

7.2 Configure Outlets 13

7.3 Select PARMs 14

7.4 Select Other and Crop Parameters 14

7.5 Configure Constraints 14

7.6 Run the Sensitivity Analysis 15

8 Sensitivity Analysis Output 16

9 Calibration 18

9.1 Configure Calibration 18

9.2 Configure Outputs and Parameters 19

9.3 Edit/build Observed data file 19

9.4 Run the Calibration 20

9.5 Calibration Output 20

10 References 22

Overview

In recent years, watershed simulation models have been used to replicate hydrological, sediment, and nutrient processes in providing scientifically credible information for engineers, scientists, and decision makers (Arnold et al., 2015). Among different models, the Agricultural Policy Environmental eXtender (APEX) was specifically initiated and developed to resolve relevant issues associated with agricultural impact on the natural environment at the field scale (Williams and Izaurralde, 2006). On the other hand, applications of APEX can be technically tedious, since a large number of corresponding model parameters may need to be predefined or calibrated to properly represent the area of interest. In considering this issue, the Agricultural Policy Environmental eXtender - auto-Calibration and UncerTainty Estimator (APEX-CUTE) was developed to facilitate the calibration and uncertainty analysis routines with a user-friendly interface (Wang et al., 2014). APEX-CUTE was developed within the framework of the Integrated Parameter and Uncertainty Analysis Tool (IPEAT, Yen et al., 2014), with the primary coding platform in Python. The current revision includes Sensitivity Analysis (SA) and the Dynamically Dimensioned Search (DDS) algorithm (Tolson and Shoemaker, 2007) for APEX auto-calibration. For the DDS optimization procedure, APEX-CUTE interacts with APEX by modifying APEX input files with a candidate solution, running APEX, evaluating model output by calculating performance statistics, perturbing the current best solution to generate a candidate solution, and iteratively repeating the process until the maximum number of objective function evaluations is completed. APEX-CUTE offers sensitivity analysis using the Sobol and FAST method (Morris, 1991; Campolongo et al., 2007).

These SA and auto-calibration tools can be used to complement users' refinement of an APEX model. Users are responsible for conducting necessary checks for model input and initial runs before conducting SA and/or auto-calibration using APEX-CUTE to make sure that the basic APEX input and setup are correct. More applications of APEX-CUTE can also be found in Wang et al. (2015).

1 Program Download

A distributable package program is available for local installation at the EPICAPEX model website. The APEX-CUTE package program is a public domain program and can be downloaded at no charge.

Program Website: http://epicapex.tamu.edu/model-executables/

Package program to download: APEX-CUTE_ver8.0_APEX1501.exe

2 Program Installation

After downloading, execute APEX-CUTE_ver8.0_APEX1501.exe to start the installation. A local directory can be selected as the destination location where the program files will be copied. It is recommended that the user install the program at the default path (C:\APEX\APEX-CUTE), though the program can be installed on any local hard drive.

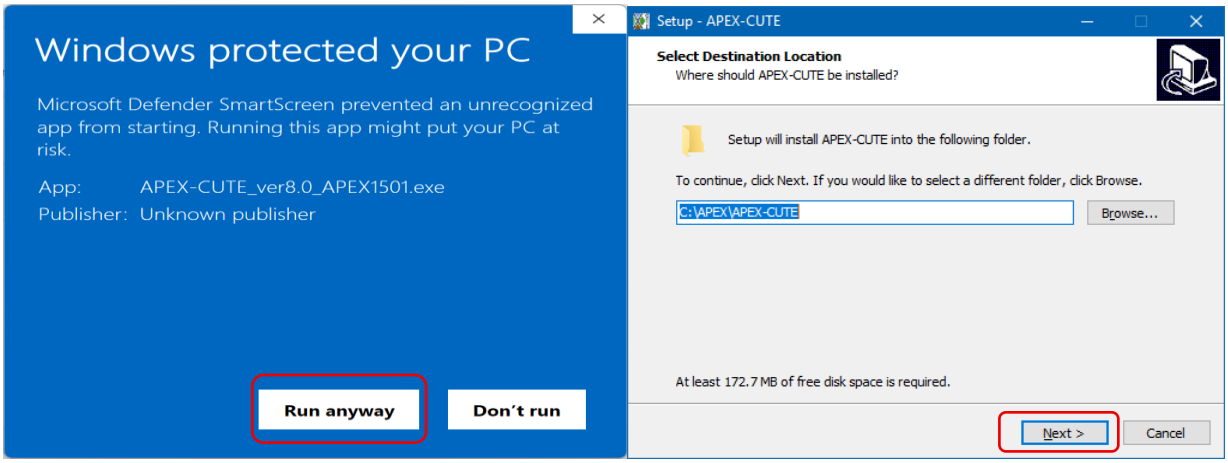


Figure 2.1. APEX-CUTE installation screen

Windows Start menu can be customized, e.g., APEX-CUTE (Fig. 1b). The start menu folder will contain a shortcut to run the program and a shortcut to uninstall the program. A user can choose to place a desktop icon for the program (Fig. 1c). Follow the in-screen instructions to complete the installation, which will copy files to the local computer.

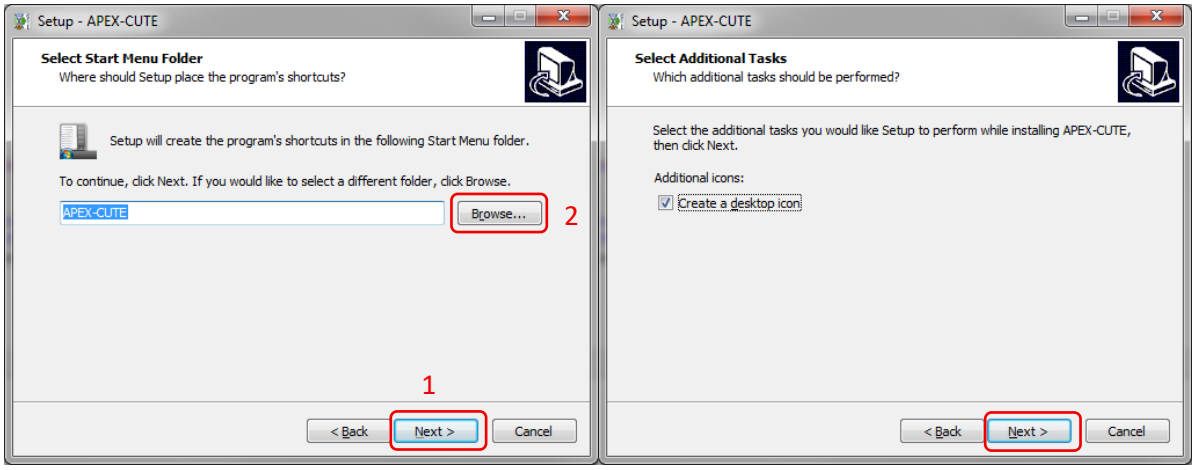


Figure 2.2. Options for Start Menu selection and desktop icon creation

Click Next (1) to continue. To select a different, Start Menu folder, click Browse (2). Follow steps to finish installation.

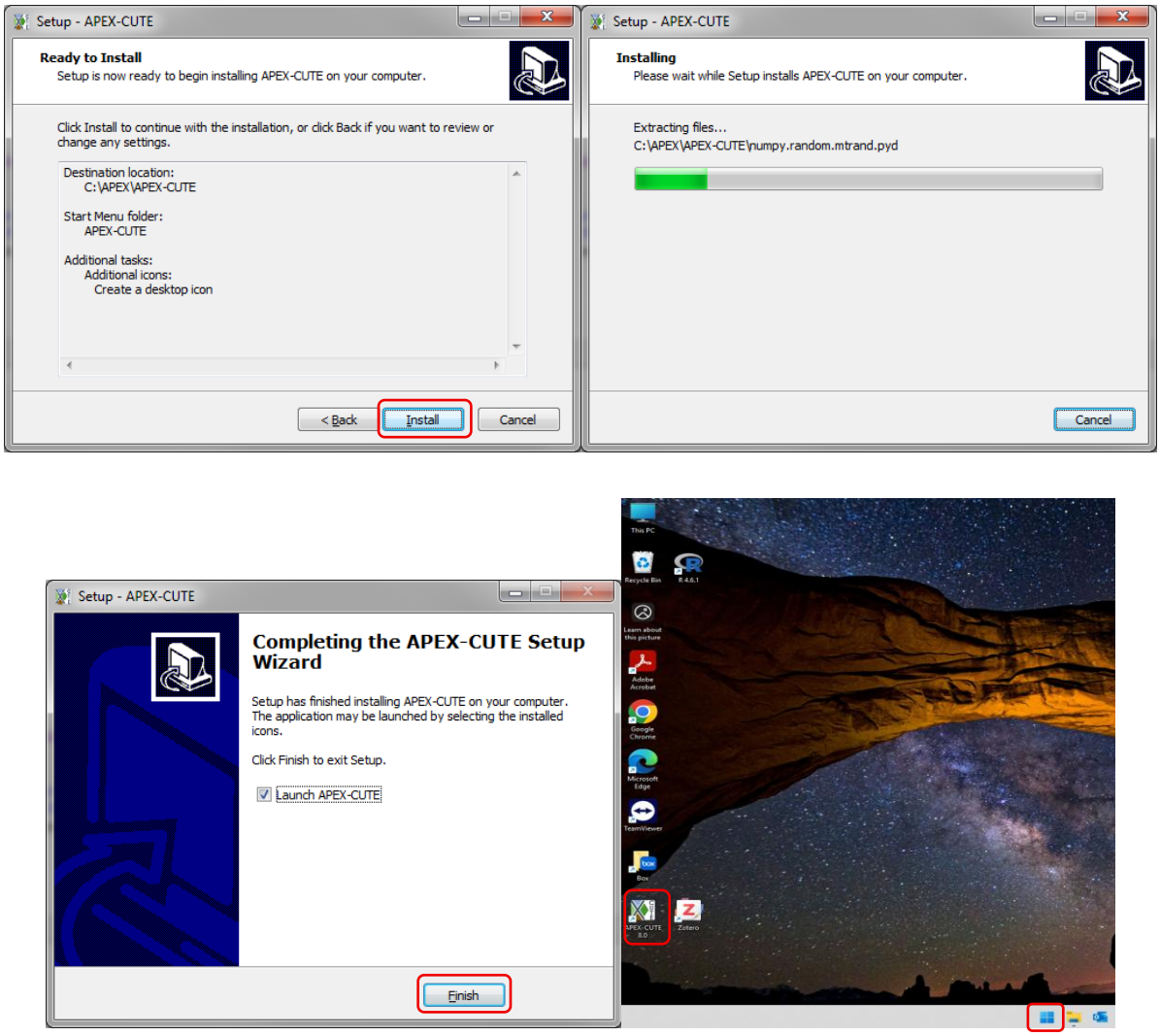


Figure 2.3. Completed APEX-CUTE installation and Windows Start Menu shortcut

At this point, the installation is completed, and the user can start APEX-CUTE either from the Windows Start menu or by double-clicking the desktop icon named APEX-CUTE 8.0.

3 Example Dataset

The installation package includes an example dataset with observed data formatted for APEX-CUTE. The example dataset is an APEX model for the USDA-ARS Riesel Y2 watershed with observed flow and water quality data formatted as daily, monthly, and annual time step data. If the user installed the program at the default path, the program files are located at C:\APEX\APEX-CUTE folder. An example dataset included in the installation package can be found in a subfolder C:\APEX\APEX-CUTE\project1501 (Figure 4). Under the project1501 folder, there are two subfolders. The folder "C:\APEX\APEX-CUTE\project1501\Obs" contains examples of observation data. The folder "C:\APEX\APEX-CUTE\project1501\TxtInOut" contains the Riesel Y2 APEX dataset.

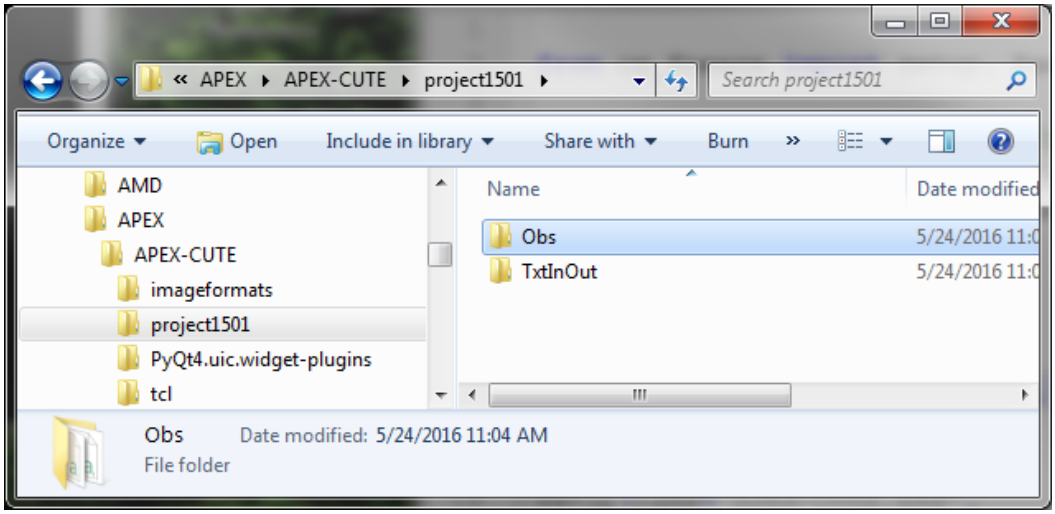


Figure 3.1 Example dataset

Detail description of the watershed is well described by Harmel et al. (2007). In addition, example observation data for daily, monthly, and annual monitoring data for streamflow, sediment, and crop yield are included in the "Obs" folder.

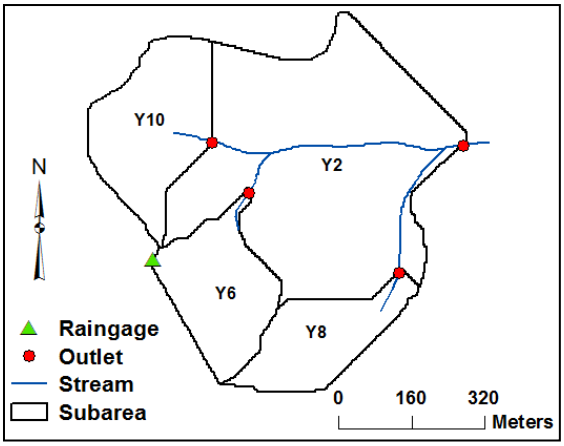


Figure 3.2. The Riesel Y2 watershed (adopted from Harmel et al., 2007).

4 APEX Parameters available in APEX-CUTE

APEX parameters (e.g., Table 1) that may be chosen to be included in SA and auto-calibration processes were based on previous APEX studies (Wang et al., 2006; Yin et al., 2009) and APEX developers' experience and recommendations, as summarized by Wang et al. (2012). APEX-CUTE 8.0 includes 110 PARMS parameters (PARM1–PARM110). The parameters can also be selected by process category, including 27 water balance/channel flow parameters, 17 soil erosion/sediment parameters, 25 nitrogen-process parameters, 9 phosphorus-process parameters, 7 carbon-process parameters, 4 pesticide-process parameters, and 17 crop-growth parameters. Users can select all the relevant parameters for the calibration, or they can conduct an SA first and then determine which parameters should be included in calibration.

Because water interacts with or drives many environmental processes within a watershed system, hydrological conditions are critical to the estimations of sediment and nutrient losses. Therefore, if the erosion/sedimentation component is to be calibrated, hydrology-related parameters should be selected for calibration. When sediment data are available, flow data are often also available for calibration. For nutrient calibration, both hydrology and sediment-related parameters should be included in the calibration (Wang et al., 2014).

5 Observed data

For calibration, observed data should be prepared following the format of the example files provided with APEX-CUTE. Observed data files should be saved in the Obs folder within the APEX-CUTE project directory, for example, C:\APEX\APEX-CUTE\project1501\Obs (Figure 3). Observed files should follow the required naming convention. The prefix "hyd_" identifies flow data and "wq_" identifies water-quality data. The filename also identifies the time interval and Subarea/Reach ID; for example, "yearly2" represents yearly data for Reach 2. Similar naming conventions are used for monthly and daily data. The ID number in the filename must correspond to the Subarea/Reach ID specified in the CUTE Setting tab (Figure 8). This allows APEX-CUTE to associate each observed dataset with the correct model output location. When multiple outlets are evaluated, separate observation files should be provided for each outlet. For a single-subarea APEX project, 1 may be used as the Subarea/Reach ID. For daily or monthly analyses, it is recommended that the observation period begin on January 1 and end on December 31. Missing daily or monthly observations should be represented by -999.

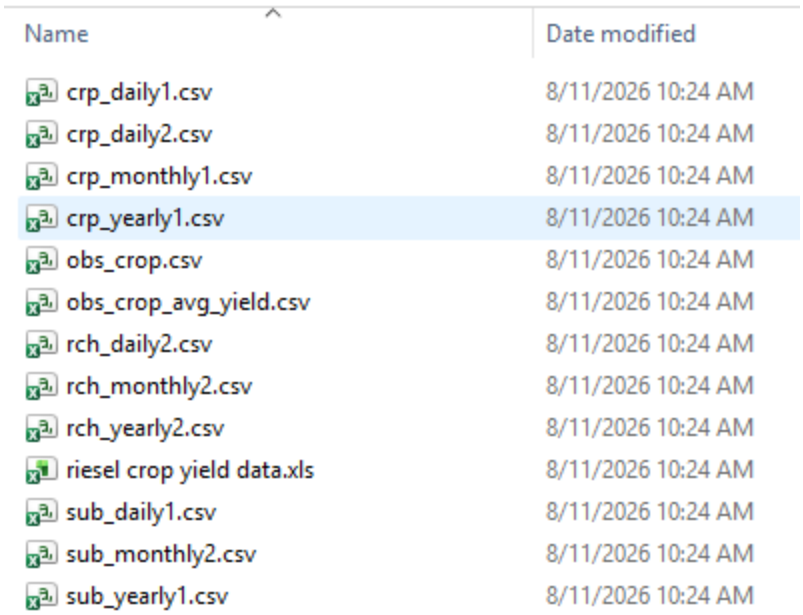


Figure 5.1. Observed data files in the Obs folder

5.1 Reach Observed Data

Reach observation files contain streamflow and water-quality variables. Daily files include Year, Month, and Day, monthly files include Year and Month, and yearly files include Year.
The supported variables are:

- **Flow (m³/s):** Streamflow rate.
- **Sed (tons):** Sediment yield.
- **TN (kg):** Total nitrogen.
- **TP (kg):** Total phosphorus.
- **MinN (kg):** Mineral nitrogen.
- **OrgN (kg):** Organic nitrogen.
- **MinP (kg):** Mineral phosphorus.
- **OrgP (kg):** Organic phosphorus.
- **Tpest (grams):** Total pesticide.

a

Year	Month	Day	Flow(m3/s	Sed(tons)	TN(kg)	TP(kg)	MinN(kg)	OrgN(kg)	MinP(kg)	OrgP(kg)	Tpest(gram
1998	1	1	0	0	-999	-999	-999	-999	-999	-999	-999
1998	1	2	0	0	-999	-999	-999	-999	-999	-999	-999
1998	1	3	0	0	-999	-999	-999	-999	-999	-999	-999

b

Year	Month	Flow(m3/s	Sed(tons)	TN(kg)	TP(kg)	MinN(kg)	OrgN(kg)	MinP(kg)	OrgP(kg)	Tpest(g)
1998	1	0.01742	12.10414	-999	-999	-999	-999	-999	-999	-999
1998	2	0.002804	1.570698	-999	-999	-999	-999	-999	-999	-999
1998	3	0.00209	1.282293	-999	-999	-999	-999	-999	-999	-999

c

Year	Flow(m3/s	Sed(tons)	TN(kg)	TP(kg)	MinN(kg)	OrgN(kg)	MinP(kg)	OrgP(kg)	Tpest(g)
1998	0.003134	19.25214	-999	-999	-999	-999	-999	-999	-999
1999	0.000147	0	-999	-999	-999	-999	-999	-999	-999
2000	0.002075	23.82669	-999	-999	-999	-999	-999	-999	-999

Figure 5.2. Examples of reach observed-data files: (a) daily, (b) monthly, and (c) yearly.

5.2 Subarea Observed Data

Subarea observation files contain hydrologic, sediment, nutrient, residue, and soil-temperature variables. Daily files include Year, Month, and Day, monthly files include Year and Month, and yearly files include Year.

The supported variables are:

- **Wyld (mm):** Water yield.
- **Runoff (mm):** Surface runoff.
- **QDR (mm):** Subsurface drainage flow.
- **RESQ (mm):** Reservoir outflow.
- **PET (mm):** Potential evapotranspiration.
- **ET (mm):** Evapotranspiration.
- **SW (mm):** Soil water content.
- **Sed (t/ha):** Sediment yield.
- **QN (kg/ha):** Nitrogen loss in surface runoff.
- **QP (kg/ha):** Phosphorus loss in surface runoff.
- **OrgN (kg/ha):** Organic nitrogen loss.
- **OrgP (kg/ha):** Organic phosphorus loss.
- **QDRN (kg/ha):** Nitrogen loss through subsurface drainage.
- **QDRP (kg/ha):** Phosphorus loss through subsurface drainage.

- **RSD (t/ha):** Crop residue.
- **SoilTmp (°C):** Soil temperature.

Missing observations should be entered as **-999**.

a

Year	Month	Day	Wyld(mm	Runoff(mr	QDR(mm)	RESQ(mm	PET(mm)	ET(mm)	SW(mm)	Sed(t/ha)	QN(kg/ha	QP(kg/ha)	OrgN(kg/h	OrgP(kg/h	QDRN(kg/	QDRP(kg/l	RSD(t/ha)	SoilTmp(C)
1998	1	1	-999	0	-999	-999	-999	-999	-999	0	-999	-999	-999	-999	-999	-999	-999	-999
1998	1	2	-999	0	-999	-999	-999	-999	-999	0	-999	-999	-999	-999	-999	-999	-999	-999
1998	1	3	-999	0	-999	-999	-999	-999	-999	0	-999	-999	-999	-999	-999	-999	-999	-999
1998	1	4	-999	6.23	-999	-999	-999	-999	-999	0.0155	-999	-999	-999	-999	-999	-999	-999	-999
1998	1	5	-999	58.75	-999	-999	-999	-999	-999	0.2385	-999	-999	-999	-999	-999	-999	-999	-999

b

Year	Month	Wyld(mm	Runoff(mr	QDR(mm)	RESQ(mm	PET(mm)	ET(mm)	SW(mm)	Sed(t/ha)	QN(kg/ha	QP(kg/ha)	OrgN(kg/h	OrgP(kg/h	QDRN(kg/	QDRP(kg/l	RSD(t/ha)	SoilTmp(C)
1998	1	-999	105.1	-999	-999	-999	-999	-999	0.2728	-999	-999	-999	-999	-999	-999	-999	-999
1998	2	-999	15.3	-999	-999	-999	-999	-999	0.0354	-999	-999	-999	-999	-999	-999	-999	-999
1998	3	-999	12.63	-999	-999	-999	-999	-999	0.0289	-999	-999	-999	-999	-999	-999	-999	-999
1998	4	-999	0	-999	-999	-999	-999	-999	0	-999	-999	-999	-999	-999	-999	-999	-999
1998	5	-999	0	-999	-999	-999	-999	-999	0	-999	-999	-999	-999	-999	-999	-999	-999
1998	6	-999	0	-999	-999	-999	-999	-999	0	-999	-999	-999	-999	-999	-999	-999	-999

c

Year	Wyld(mm	Runoff(mr	QDR(mm)	RESQ(mm	PET(mm)	ET(mm)	SW(mm)	Sed(t/ha)	QN(kg/ha	QP(kg/ha)	OrgN(kg/h	OrgP(kg/h	QDRN(kg/	QDRP(kg/l	RSD(t/ha)	SoilTmp(C)
1998	-999	222.8	-999	-999	-999	604	-999	0.4339	-999	-999	-999	-999	-999	-999	-999	-999
1999	-999	10.45	-999	-999	-999	604	-999	0	-999	-999	-999	-999	-999	-999	-999	-999
2000	-999	147.9	-999	-999	-999	604	-999	0.537	-999	-999	-999	-999	-999	-999	-999	-999
2001	-999	308.5	-999	-999	-999	604	-999	1.536	-999	-999	-999	-999	-999	-999	-999	-999

Figure 5.3. Examples of subarea observed-data files: (a) daily, (b) monthly, and (c) yearly.

5.3 Crop Yield and Soil Organic Carbon Data

Crop and soil organic carbon observations should follow the formats provided with APEX-CUTE 8.0. The following fields are used:

- **yyyy:** ear in which the observation was recorded. Use 9999 for average crop-yield observations.
- **SubID:** Subarea ID associated with the observation.
- **CROP:** Four-letter APEX crop code (e.g., CORN, WWHT, OATS).
- **Grain Yield (t/ha):** Observed dry grain yield.
- **OCPD (%):** Observed organic carbon soil content within the plow depth.

For average crop-yield observations, the following additional field is used:
Biomass (t/ha): Observed total crop biomass.

a

yyyy	SubID	CROP	Grain Yiel	OCPD (%)
1998	4	CORN	5.65	1.5
1998	3	WWHT	3.01	1.45
1998	1	OATS	3.69	1.46

b

yyyy	SubID	CROP	Grain Yiel	Biomass(t/ha)
9999	1	CORN	7	17.17
9999	2	WWHT	3.01	10.5
9999	3	OATS	3.69	12.38

Figure 5.4. Examples of observed (a) year-specific crop yield and soil organic carbon data and (b) average crop yield and biomass data

5.4 Crop Observed Data

Crop observation files contain crop growth variables used for model evaluation, calibration, or validation. Daily files include Year, Month, Day, and Cropname; monthly files include Year, Month, and Cropname; and yearly files include Year and Cropname.

The supported variables are:

- **Cropname:** Name of the crop being evaluated.
- **Biomass (t/ha):** Aboveground crop biomass.
- **STL (t/ha):** Standing live biomass.
- **LAI:** Leaf area index.
- **CHT (m):** Crop height.

Missing observations should be entered as -999.

a

A	B	C	D	E	F	G	H
Year	Month	Day	Cropname	Biomass (	STL (t/ha)	LAI	CHT (m)
1998	1	1	corn	-999	-999	-999	-999
1998	1	2	corn	-999	-999	-999	-999
1998	1	3	corn	-999	-999	-999	-999

b

A	B	C	D	E	F	G	H
Year	Month	Cropname	Biomass (	STL (t/ha)	LAI	CHT (m)	
1998	1	corn	-999	-999	-999	-999	
1998	2	corn	-999	-999	-999	-999	
1998	3	corn	-999	-999	-999	-999	

c

A	B	C	D	E	F	G	H
Year	Cropname	Biomass (	STL (t/ha)	LAI	CHT (m)		
1998	corn	-999	-999	-999	-999		
1999	corn	-999	-999	-999	-999		
2000	corn	-999	-999	-999	-999		

Figure 5.5. Examples of crop observed-data files: (a) daily, (b) monthly, and (c) yearly

Table 5.1. Selected APEX parameters in APEX-CUTE 8.0

Process impacted directly	Influential input or parameter	Description	Range	Default
Runoff CN method	CN2	Initial condition II curve number (CN2) or landuse number (LUN)	± 5	-
	Parm42 (if NVCN=4)	Curve Number index coefficient	0.5 - 2.5	0.5
	Parm92 (if NVCN=0)	Curve number retention parameter coefficient	0.8 – 1.5	1
	Parm20	Runoff curve number initial abstraction	0.05 – 0.4	0.2
Green & Ampt	SAT0	Saturated conductivity adjustment factor	0.1–10.0	1
Evapotranspiration (PET)	Parm34 (if Hargreaves PET)	Equation exponent	0.5 – 0.6	0.5
	Parm1 (if Penman-Monteith)	Canopy PET factor	1 - 2	2
ET	Parm12	Soil evaporation coefficient	1.5 – 2.5	1.5
	Parm17	Evaporation plant cover factor	0 – 0.5	0.1
Irrigation (if used)	EFI	Irrigation runoff ratio	0 -1	0

Tile/drainage flow	Parm83	Estimates drainage system lateral Hydraulic conductivity	0.1 - 10	4
Base flow	RFP0	Return flow ratio: (Return flow)/(Return flow + Deep percolation)	0.05 - 0.95	0.5
	Parm40	Groundwater storage threshold	0.001 - 1.0	0.25
	RFTO	Groundwater residence day	10 - 50	30
Erosion/ sedimentation	Parm46	RUSLE c factor coefficient in exponential residue function in residue factor	0.5 - 1.5	0.5
	Parm47	RUSLE c factor coefficient in exponential crop height function in biomass factor	0.01 - 3.0	1.0
	PEC (if having conservation practice)	Erosion control factor	0 - 1	1
	APM	Peak rate – EI_{30} adjustment factor	0 - 1.0	1.0
Routing	Parm18	Sediment routing exponent of water velocity function for estimating potential sediment concentration	1 - 1.5	1.5
	Parm19	Potential sediment concentration when flow velocity is 1.0 m/s	0.005 - 0.05	0.05
	RCCO or RCHC	Channel cover factor	0.001 - 1.0	0.7
	RCHK	Soil edibility factor	0.001 - 0.5	0.3
Nitrogen cycling Phosphorus cycling	Parm29	Biological mixing efficiency	0.1 – 0.5	0.1
	Parm8	Soluble P runoff coefficient	10 – 20	15
	Parm59	P upward movement by evaporation coefficient	1 – 30	1
	Parm14	Nitrate leaching ratio	0.1 – 1.0	0.2
	Parm35	Denitrification soil water threshold	0.9 – 1.1	0.99
	Parm7	N fixation coefficient	0 – 1	0.9
	Parm72	Volatilization/nitrification partitioning coefficient	0.05 – 0.5	0.15
Carbon Cycling	Parm70	Microbial decay rate coefficient	0.05 – 1.5	1
	FHP	Fraction of humus in passive pool	0.3 – 0.9	0.3
	FBM (.sol)	Fraction of organic carbon in microbial biomass pool	0.005-0.06	0.04

6 APEX-CUTE 8.0 User Interface

The APEX-CUTE 8.0 interface organizes the sensitivity analysis and calibration workflow into several tabs. Users generally proceed from left to right to create or open a project, configure the analysis, select parameters and outputs, provide observed data when required, and run APEX-CUTE.

Main Tab

The Main tab is used to create or open an APEX-CUTE project and link it to the required APEX input files.

Start a new project: Click New project to create a new APEX-CUTE project. Select the location and name for the project. APEX-CUTE will create the project workspace where the files and settings associated with the analysis are stored.

Open existing project: Click Browse to locate and open a previously created APEX-CUTE project. The saved project settings will be loaded so the user can continue working with the project.

Link the project to the folder location of APEX input files: Click the … button and select the folder containing the APEX input dataset that will be used for the analysis.

Copy APEX files: After selecting the APEX input folder, click Copy APEX files. APEX-CUTE copies the required APEX files into the project's TxtInOut folder. This step is required before proceeding with sensitivity analysis or calibration.

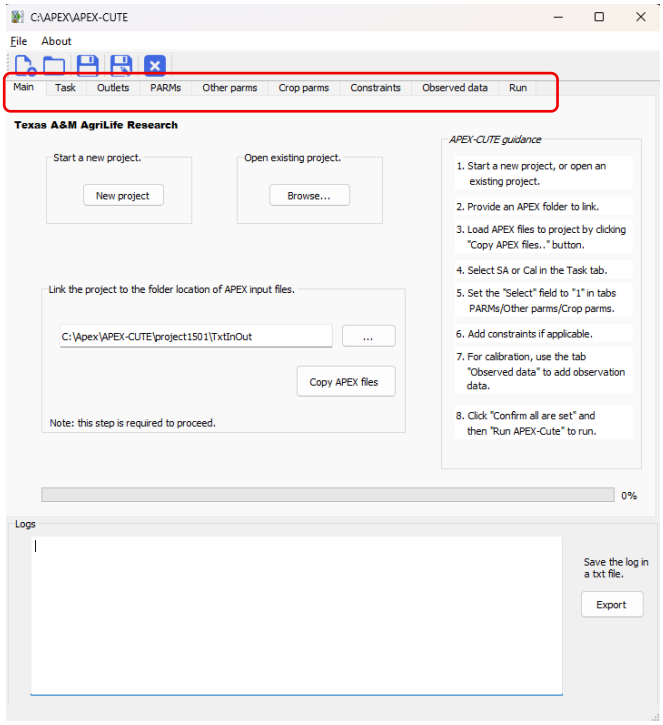


Figure 6.1. Main interface of APEX-CUTE 8.0

Task: Selects either Sensitivity Analysis or Calibration and configures the corresponding analysis settings. Sensitivity analysis can be performed using the Sobol or FAST method. Calibration settings include calibration/validation periods, number of iterations, performance indicator, calibration option, and initial conditions.

Outlets: Specifies the Subarea/Reach ID, time step, APEX output to evaluate, weighting factor, and crop name. Up to four output terms can be specified for multi-objective analysis.

PARMs: Selects parameters from PARMS.DAT. Parameters can also be selected by process category, including water balance/channel flow, soil erosion/sediment, nitrogen, phosphorus, carbon, pesticide, and crop growth.

Other parms: Selects additional parameters contained in APEX input files such as APEXCONT, SIT, and SUB.

Crop parms: Selects crop-specific parameters and their ranges for sensitivity analysis or calibration.

Constraints: Defines optional limits for baseflow ratio, PET, and crop yields. Simulations outside the selected limits can be excluded during calibration.

Observed data: Opens example observation files or imports user-provided CSV data and saves the prepared observations to the project's Obs folder.

Run: Confirms the configuration, starts or stops APEX-CUTE, displays run progress, and provides plots of sensitivity analysis or calibration results.

Logs: A log panel is available throughout the interface to display messages and run information. Logs can be exported to a text file.

7 Sensitivity Analysis

7.1 Select the Sensitivity Analysis Method

Open the Task tab, select Sensitivity Analysis, and click OK. Under Sensitivity Analysis, select either the Sobol Method or FAST Method and specify the Number of sampling intervals.

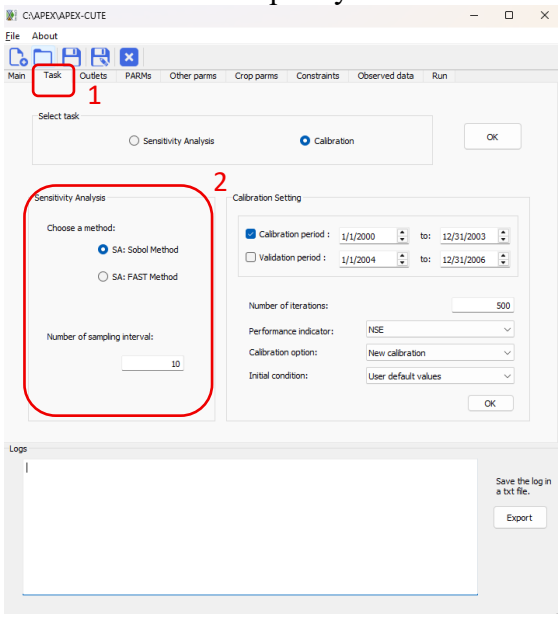


Figure 7.1. Task tab showing sensitivity analysis settings.

7.2 Configure Outlets

Open the Outlets tab and configure the model outputs to be evaluated.

a. Subarea/Reach ID: Enter the ID of the subarea or reach where the model output will be evaluated.

b. Time step: Select the evaluation interval as Daily, Monthly, or Yearly.

c. APEX output to evaluate: Select the desired APEX output from the drop-down list.

d. Weighting factor: Specify the relative weight of each output. For a single output, use the default value of 1.0.

e. Crop name: For crop-related outputs, enter the four-letter crop name used in the APEX crop table.

Up to four output terms can be specified using columns 1–4. This allows multiple model outputs to be evaluated simultaneously. Click Save after completing the settings.

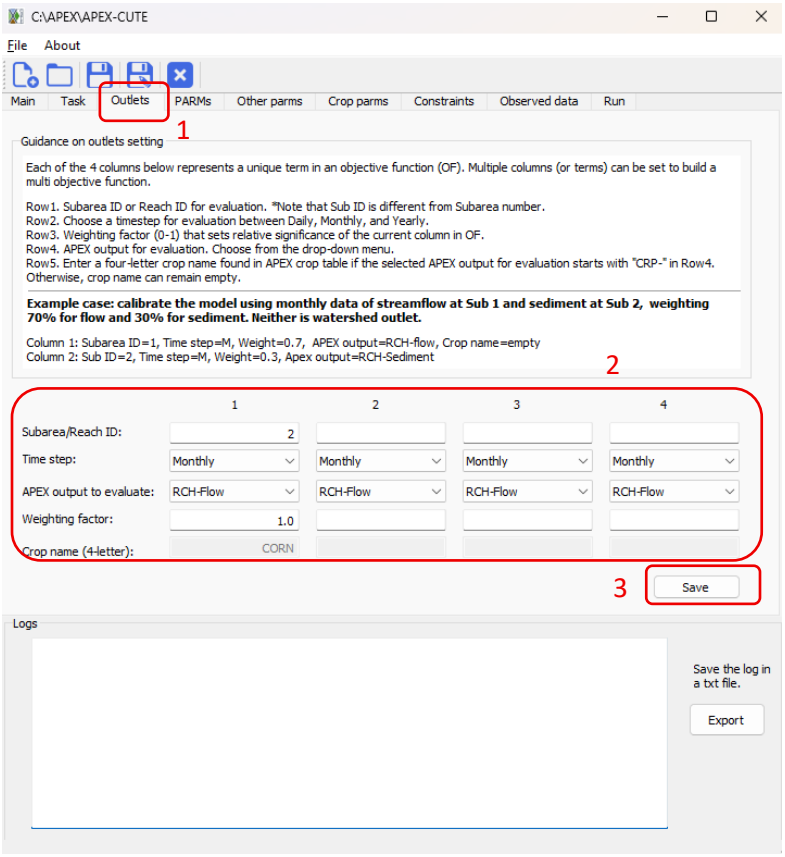


Figure 7.2. Outlets tab for configuring APEX outputs

7.3 Select PARMs

Open the PARMs tab and set the Select field to 1 for each parameter to be included in the sensitivity analysis. Parameters may also be selected by process category, including water balance/channel flow, soil erosion/sediment, nitrogen, phosphorus, carbon, pesticide, and crop growth. Click Apply after selecting a process category and Save after completing the parameter selection.

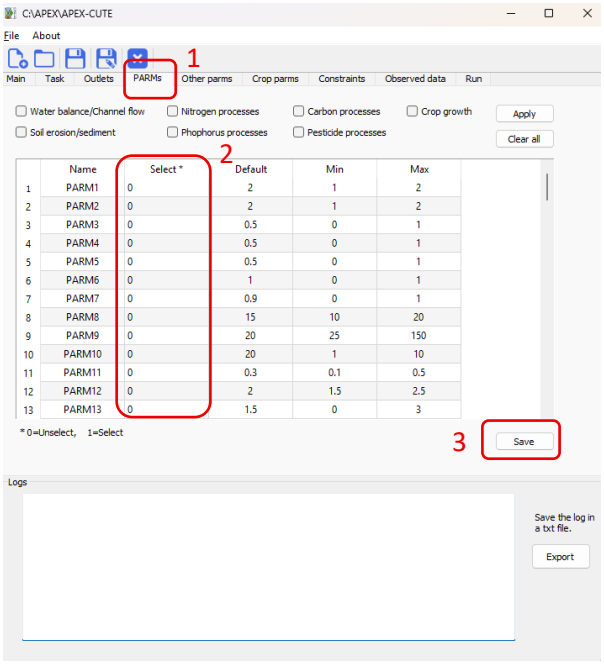


Figure 7.3. PARMs tab for parameter selection.

7.4 Select Other and Crop Parameters

Open the Other parms tab to select additional parameters contained in other APEX input files. Set Select to 1 for the parameters to be evaluated and click Save. Open the Crop parms tab to select crop-specific parameters. Set Select to 1 for the desired parameters and click Save.

7.5 Configure Constraints

Open the Constraints tab to define optional limits for model simulations. Set Select to 1 for each constraint to be applied and specify the appropriate minimum and maximum values.

For example, if rto_bf (baseflow ratio) is selected with a range of 0.5–0.8, simulation results outside this range are excluded. Constraints can also be used during calibration. Click Save after completing the settings.

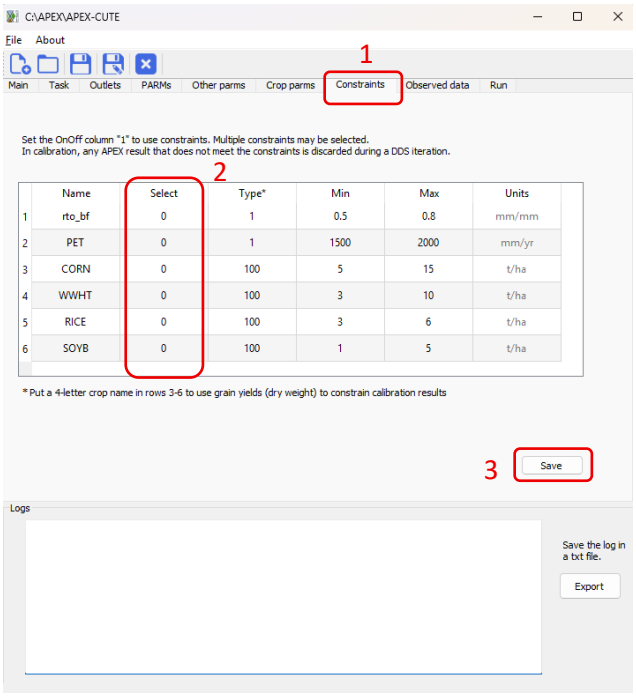


Figure 7.4. Constraints tab.

7.6 Run the Sensitivity Analysis

Open the Run tab and click Confirm all are set to verify the configuration. When the setup is complete, click Run APEX-CUTE to start the sensitivity analysis. The progress bar and log window display information during execution. After completion, sensitivity rankings can be displayed by selecting Sobol or FAST under Sensitivity Rank and clicking Update plot.

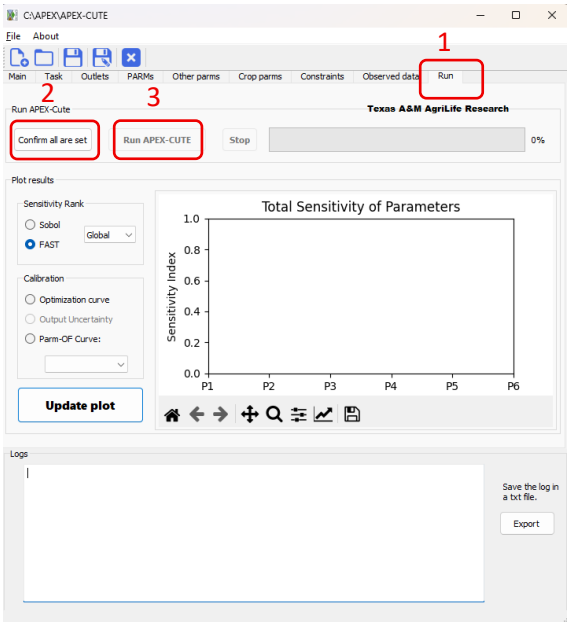
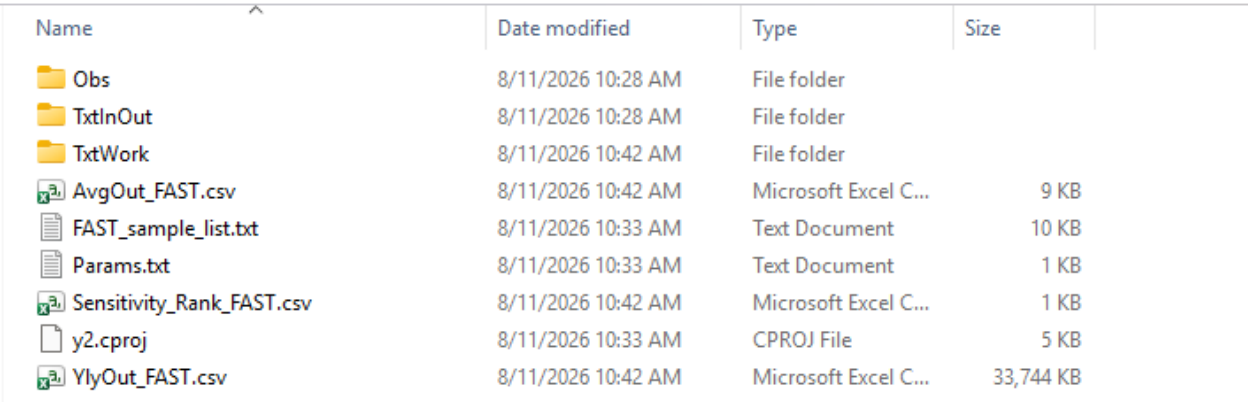


Figure 7.5. Run tab showing sensitivity-analysis results.

8 Sensitivity Analysis Output

After the sensitivity analysis is completed, APEX-CUTE generates output files containing the selected parameters, sampled parameter sets, model outputs, and calculated sensitivity indices. The output files are saved in the project folder.



Name	Date modified	Type	Size
Obs	8/11/2026 10:28 AM	File folder	
TxtInOut	8/11/2026 10:28 AM	File folder	
TxtWork	8/11/2026 10:42 AM	File folder	
AvgOut_FAST.csv	8/11/2026 10:42 AM	Microsoft Excel C...	9 KB
FAST_sample_list.txt	8/11/2026 10:33 AM	Text Document	10 KB
Params.txt	8/11/2026 10:33 AM	Text Document	1 KB
Sensitivity_Rank_FAST.csv	8/11/2026 10:42 AM	Microsoft Excel C...	1 KB
y2.cproj	8/11/2026 10:33 AM	CPROJ File	5 KB
YlyOut_FAST.csv	8/11/2026 10:42 AM	Microsoft Excel C...	33,744 KB

Figure 8.1. Output files generated after completing the sensitivity analysis

AvgOut_FAST.csv – Stores the average APEX output obtained for each FAST simulation.

FAST_sample_list.txt – Stores the sampled parameter values used in the FAST sensitivity analysis. Each row represents one parameter set used in an APEX simulation, and each column corresponds to a selected parameter.

Params.txt – Lists the APEX parameters selected for sensitivity analysis.

Sensitivity_Rank_FAST.csv – Stores the first-order (SI_First) and total (SI_Total) sensitivity indices for each selected parameter.

YlyOut_FAST.csv – Stores the yearly APEX output generated for each FAST simulation.

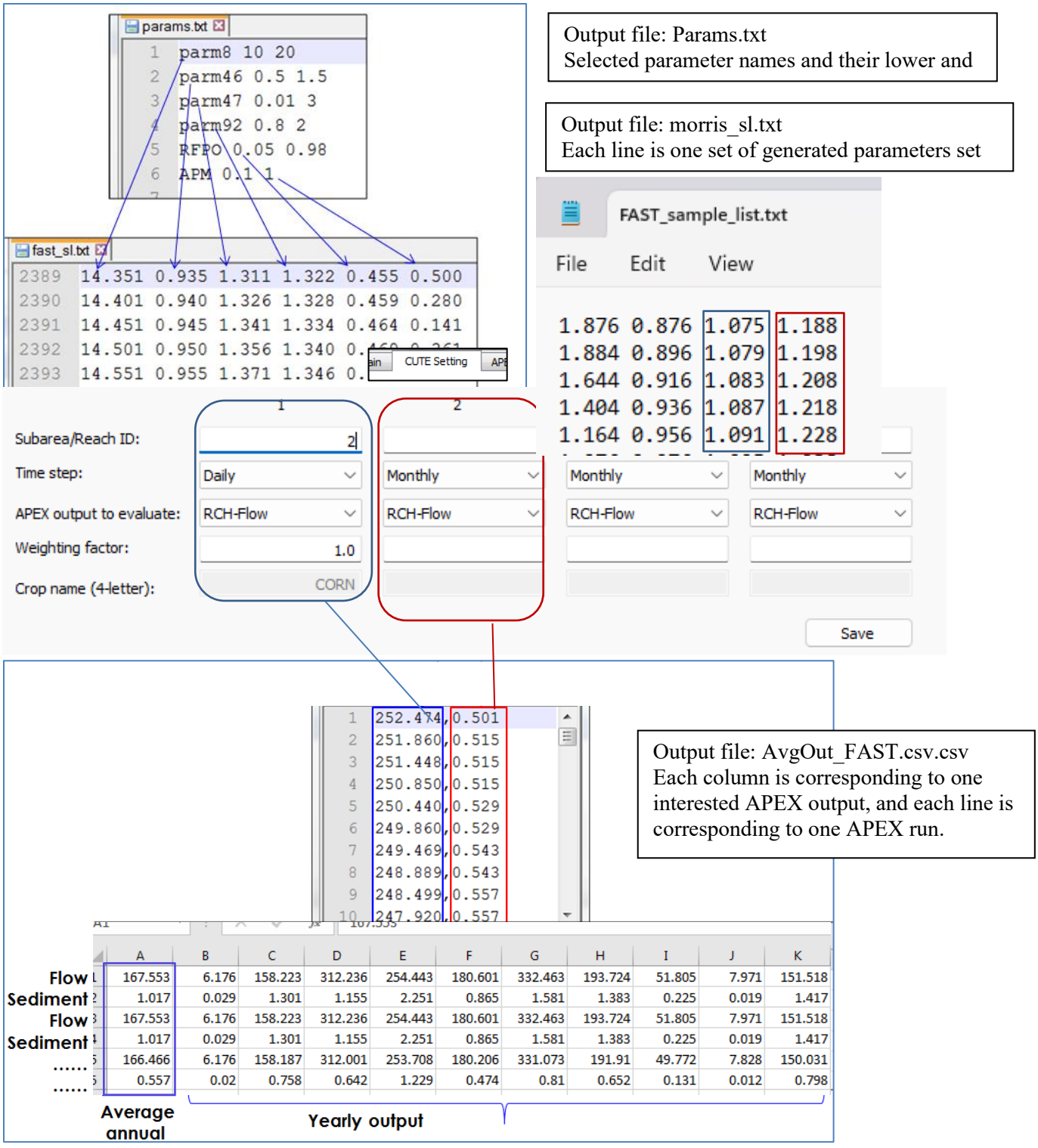


Figure 8.2. Example sensitivity analysis output files.

9 Calibration

9.1 Configure Calibration

Open the Task tab, select Calibration, and click OK. Configure the calibration settings in the Calibration Setting panel.

Calibration period: Select the beginning and ending dates for the calibration period.
Validation period: If validation is performed, enable this option and specify the beginning and ending dates for the validation period.

Number of iterations: Specify the total number of calibration iterations. A range of 500–5000 iterations is generally recommended in the existing APEX-CUTE guidance.
Performance indicator: Select the model performance statistic to be used as the calibration objective.

Calibration option: Select either New calibration or Continuing from previous run.

- New calibration: Starts a new calibration using the specified settings.
- Continuing from previous run: Continues an incomplete calibration from the previous stopping point.

Initial condition: Select the method used to initialize the calibration.

- User default values: The calibration starts using parameter values specified in the Default columns of the parameter tabs.
- Random Sampling: APEX-CUTE performs initial runs using randomly generated parameter values and uses the best-performing parameter set to initialize the calibration.

Click OK after completing the calibration settings.

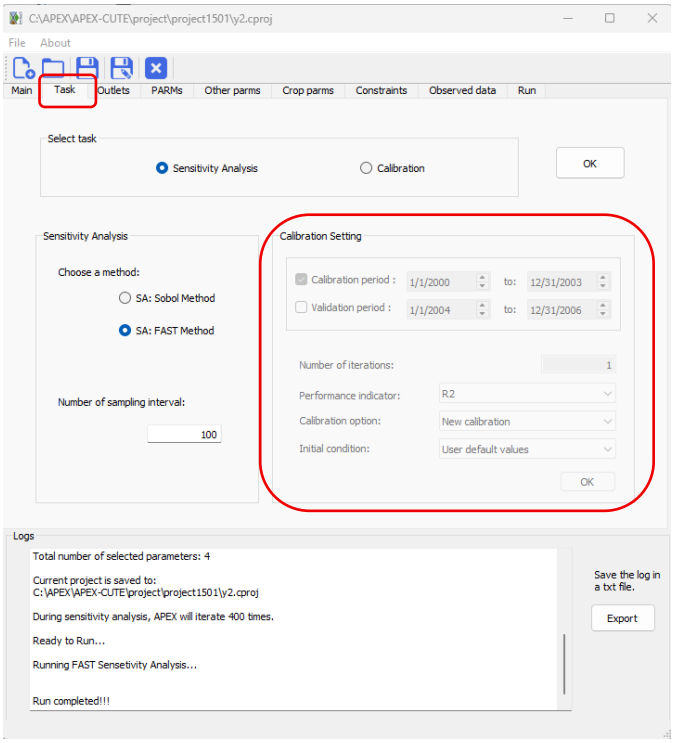


Figure 9.1. Task tab showing calibration settings.

9.2 Configure Outputs and Parameters

Open the *Outlets* tab and specify the Subarea/Reach ID, time step, APEX output, weighting factor, and crop name, as applicable. Multiple outputs may be specified for multi-objective calibration.

Select the parameters to be calibrated from the PARMs, Other parms, and Crop parms tabs. Set Select = 1 for each parameter to be included and click Save. If required, configure acceptable simulation limits in the Constraints tab. Observed data required for calibration should be prepared using the Observed data tab and saved in the project's Obs folder.

9.3 Edit/build Observed data file

Click the *Observed data* tab to add or edit observation data files. Create a folder named "Obs" under your project folder. APEX-CUTE will not perform automatic calibration if the Obs folder does not exist in your project folder or no observation data file exists in it.

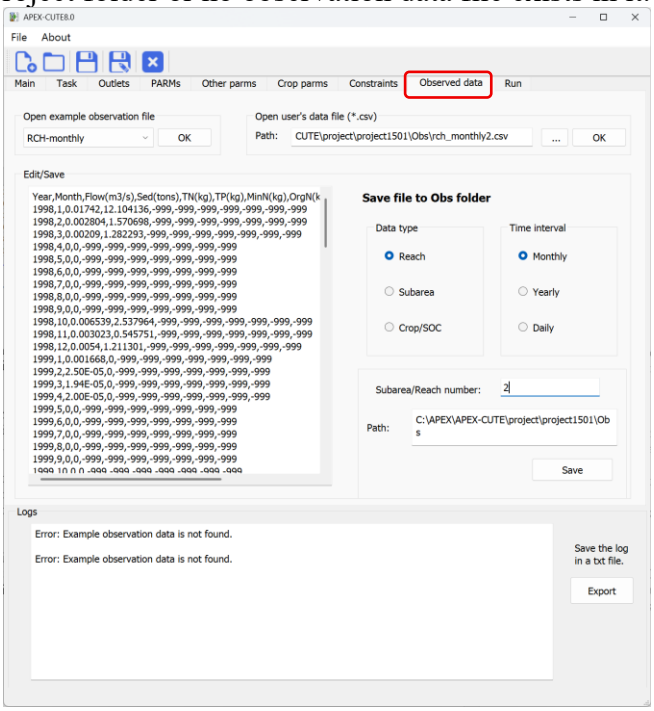
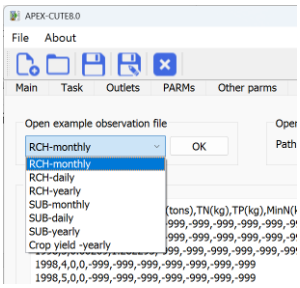


Figure 9.2. Configuration for observed data files in the APEX-CUTE interface.

To create a new observation data file, one can use example files as a template. To do this, choose a type of example observation data from the dropdown menu on the top left of the Observed data tab and click the OK button. The user can now see comma-delimited observation data in the editor window and edit the dates and values.



Alternatively, the user can open a custom observation file. Choose the data type by clicking "Open user's data file" on the top right side of the *Observed data* tab.

When editing is finished, the new data can be saved in the Obs folder. Select data type (Reach, Subarea, or Crop/SOC) and time interval (Monthly, Yearly, or Daily). Enter a subarea/reach number for which the observed data were measured and provide the path to the Obs folder. Click the Save button to save the file. This way, the file is named specifically following the naming convention that APEX-CUTE requires for observed data files. Input "-999" for any data type on a given day in the observation file when no data is available.

9.4 Run the Calibration

Open the Run tab and click Confirm all are set. After the configuration has been successfully confirmed, click Run APEX-CUTE to begin calibration. The progress bar and log window display information about the calibration while it is running. After completion, calibration results can be examined using the plotting options available on the Run tab.

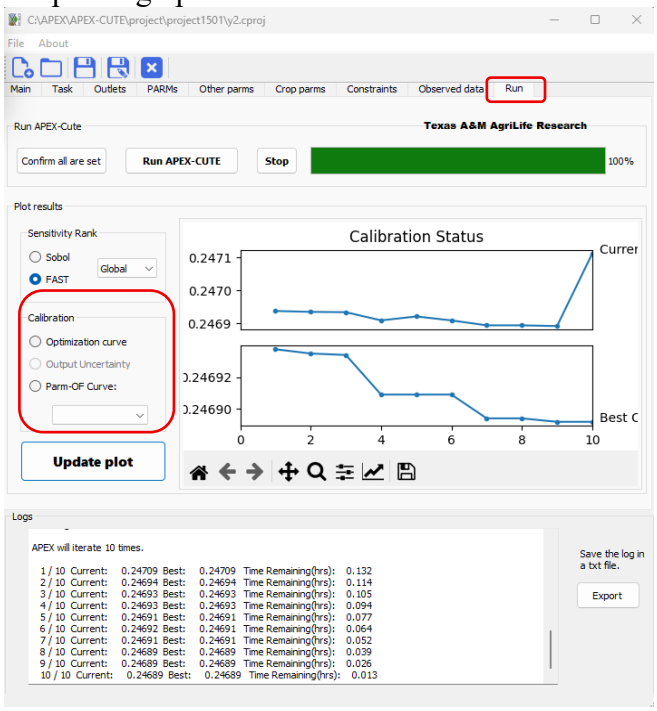


Figure 9.3. Run tab for APEX-CUTE calibration and result visualization.

9.5 Calibration Output

After the calibration is successfully completed, APEX-CUTE generates three output files in the project folder (Figure 9.4).

a. The dds.out (Figure. 9.4a) contains:
   - Iteration run number (Run#);
   - Corresponding parameter set values (e.g., parm12, parm18, etc.);
   - Calculated objective function value (Test_OF) for this run; and
   - The best objective function value (Best_OF) identified so far.

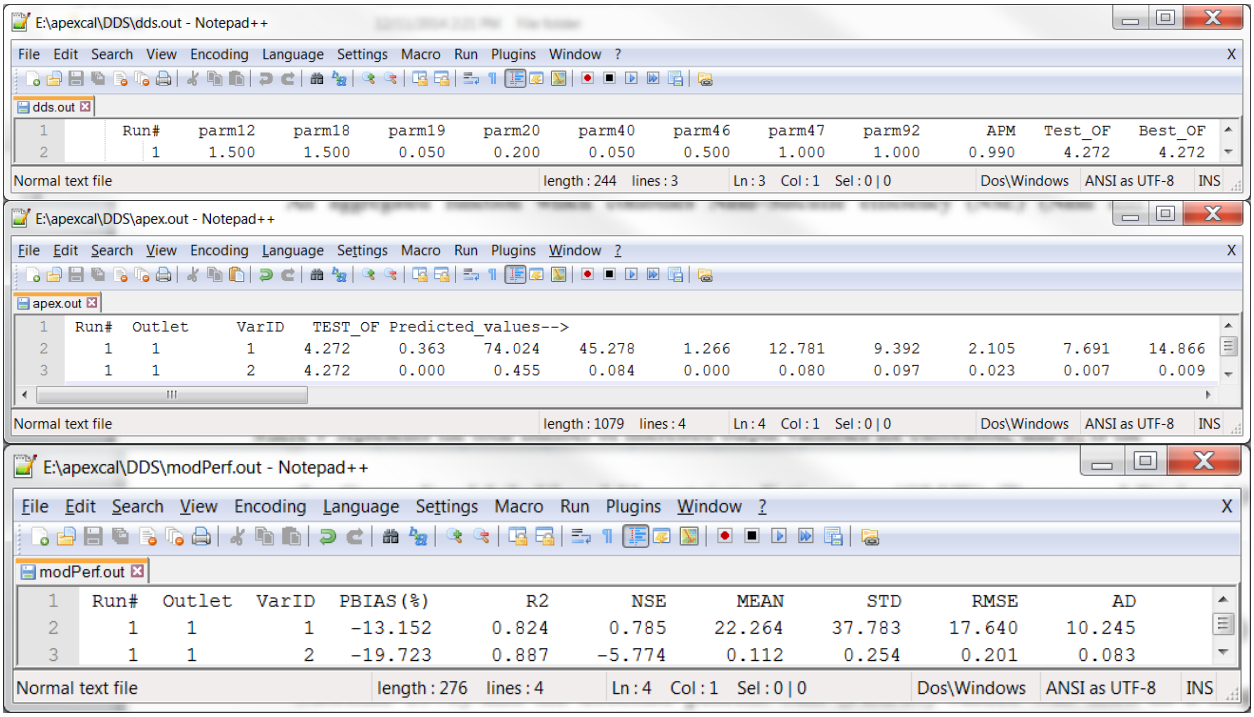
b. The apex.out (Figure 9.4b) saves:

- Iteration run number (Run#);
- Outlet ID
- Output variable ID (VarID) where "1" represents flow, "2" represents sediment, etc. as described in the config.dat file line 4;
- Objective function value of the run (Test_OF); and
- The corresponding predicted output variable values (by day, month, or year depending on user's choice of calibration time step as indicated in config.dat file line 8).

c. The modPerf.out (Figure 9.4c) provides:

- Iteration run number (Run#);
- Outlet ID
- Output variable ID (VarID) where "1" represents flow, "2" represents sediment, etc. as described in the config.dat file line 5;
- Model performance statistics for each calibration output (e.g., flow and/or sediment) in each APEX iteration.

a



b

c

Figure 9.4. Calibration output files: (a) dds.out, (b) apex.out, and (c) modPerf.out.

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