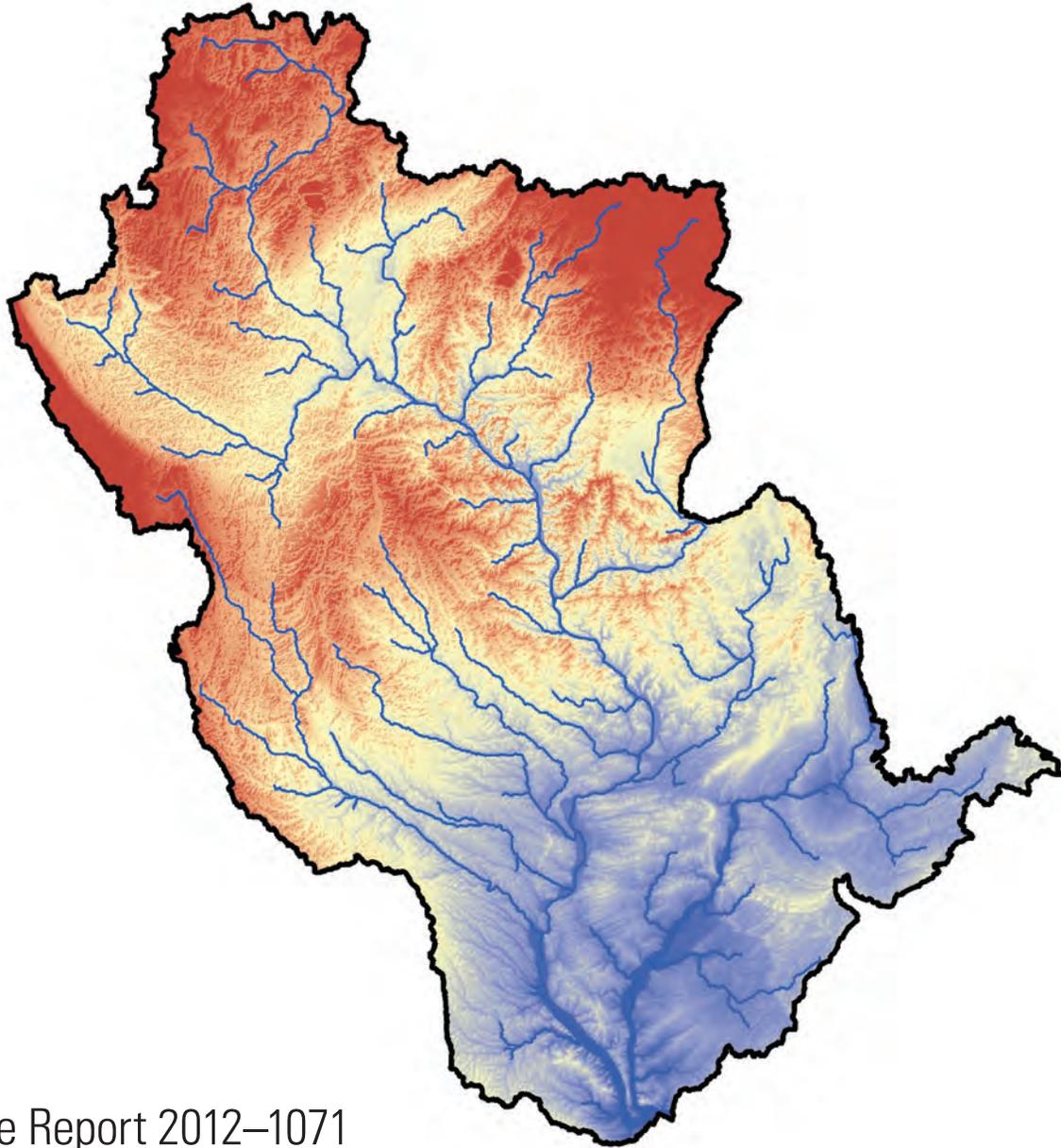


# R-SWAT-FME User's Guide



Open-File Report 2012–1071



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By Yiping Wu and Shuguang Liu

Open-File Report 2012–1071

**U.S. Department of the Interior**  
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# R-SWAT-FME User's Guide

By Yiping Wu<sup>1</sup> and Shuguang Liu<sup>2</sup>

## Introduction

R program language-Soil and Water Assessment Tool-Flexible Modeling Environment (R-SWAT-FME) (Wu and Liu, 2012) is a comprehensive modeling framework that adopts an R package, Flexible Modeling Environment (FME) (Soetaert and Petzoldt, 2010), for the Soil and Water Assessment Tool (SWAT) model (Arnold and others, 1998; Neitsch and others, 2005). This framework provides the functionalities of parameter identifiability, model calibration, and sensitivity and uncertainty analysis with instant visualization.

This user's guide shows how to apply this framework for a customized SWAT project. Users have two ways to execute this modeling framework: (1) run the executable (RSWATFME.EXE), which is supported by the RFortran (Thyer and others, 2011) and Open Multi-Processing (OpenMP), or (2) run the R script (yp\_SWATDLL\_FME.R), which calls RSWATFME.DLL, in the R prompt window. Users that have access to the developed R function, R-SWAT, could also use other potential R packages for SWAT by simply calling functions R-SWAT(pars) or R-SWATcost(pars).

## Quick Start

The development of R-SWAT-FME is based on the SWAT built-in auto-calibration procedure and uses the same input files. Therefore, a SWAT project, prepared for the model's auto-calibration with the Shuffled Complex Evolution (SCE) algorithm (Duan and others, 1992; Green and van Griensven, 2008; van Griensven and others, 2006), is also ready to use the R-SWAT-FME framework. R-SWAT-FME users need to follow the procedures in this section to avoid possible errors.

## Use the ArcSWAT Auto-calibration Tool

It is highly recommended to use the existing auto-calibration tool available in the ArcSWAT interface (Winchell and others, 2009) to prepare input files (such as changepar.dat, objmet.dat, responsmet.dat, ObsData.dat) required by R-SWAT-FME. Detailed information about these files can be found in the SWAT 2005 auto-calibration manual (van Griensven, 2006).

Users need to make sure the model print time step (iprint=0/1/2 in "file.cio") agrees with the print time step for calibration and observation data. Before running the framework, users need to run the officially published SWAT model (SWAT2005.exe) with auto-calibration activated (icl=2 in "file.cio") to verify it works. If it does work, then users complete the following steps:

1. stop SWAT2005.exe with ctrl+C,
2. manually change icl to 0 and run SWAT2005.exe (required only if RSWATFME.DLL is the user's option),
3. manually change icl to 11 if RSWATFME.EXE is the user's option (denoted as option 1 hereafter) or 12 if RSWATFME.DLL is the user's option (denoted as option 2 hereafter).

If the user's system supports OpenMP, then SWAT2005.exe can also be replaced by RSWATFME.EXE when implementing steps 1 and 2.

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### Copy Files

Copy the following files from the released package of the framework to the user's local project directory:

1. RSWATFME.EXE

This file is only required for option 1.

2. RSWATFME.DLL

This file is only required for option 2.

3. yp\_FME\_Func.R

This file contains some basic R functions required for both options 1 and 2. Changes to this file can only be made if users understand the purpose of each function.

4. yp\_SWAT\_FME.R

This file is only required for option 1 and demonstrates how the R-SWAT-FME works through calling some major FME functions. Users can modify the file, as needed, to use other R packages or functions. The R-SWAT function is named SWAT(pars) for option 1 and RSWAT(pars) for option 2.

5. yp\_SWATDLL\_Func.R

This file is only required for option 2 and contains some extra R functions used for the framework. Changes to this file can only be made if users understand the purpose of each function.

6. yp\_SWATDLL\_FME.R

This file is only required for option 2 and shows how the R-SWAT-FME works through calling some major FME functions. Users are encouraged to modify the file, as needed, to use other R packages or functions.

7. LOG.IN

This file is required for both option 1 and 2. Users are not allowed to change this file as the parameters inside it are not related to the framework and they can only be recognized by the developers.

### Set Parameters

- mxNiter: maximum iterations.

This parameter is defined by the user (default = 1000) in yp\_SWAT\_FME.R and yp\_SWATDLL\_FME.R and used by functions: yp\_FME\_pseudoOptim and yp\_FME\_MCMC.

- cmeth: code for the optimization method.

This parameter is defined by the user (default = "Pseudo") in yp\_SWAT\_FME.R and yp\_SWATDLL\_FME.R. More methods are available in the FME package, but Pseudo is recommended and has been tested successfully (Wu and Liu, 2012).

### Create Plotting Directory

Users need to make a directory called "Figures" directly under their SWAT project directory to save the figures generated by the framework.

## Run R-SWAT-FME

Users can run the R-SWAT-FME framework in two ways: (1) execute RSWATFME.EXE or (2) execute yp\_SWATDLL\_FME.R in the R window. Figure 1 and figure 2 show the screenshots of the R-SWAT-FME run with option 1 and option 2, respectively. For option 2, users need to read the short instruction given in the first few lines of the R script. Option 1 is recommended as it shows the progress of the model run and the R script run; however, the user's system must support OpenMP. A detailed comparison of the two options was given by Wu and Liu (2012).

```

RGui
File Edit View Misc Packages Windows Help

R Console

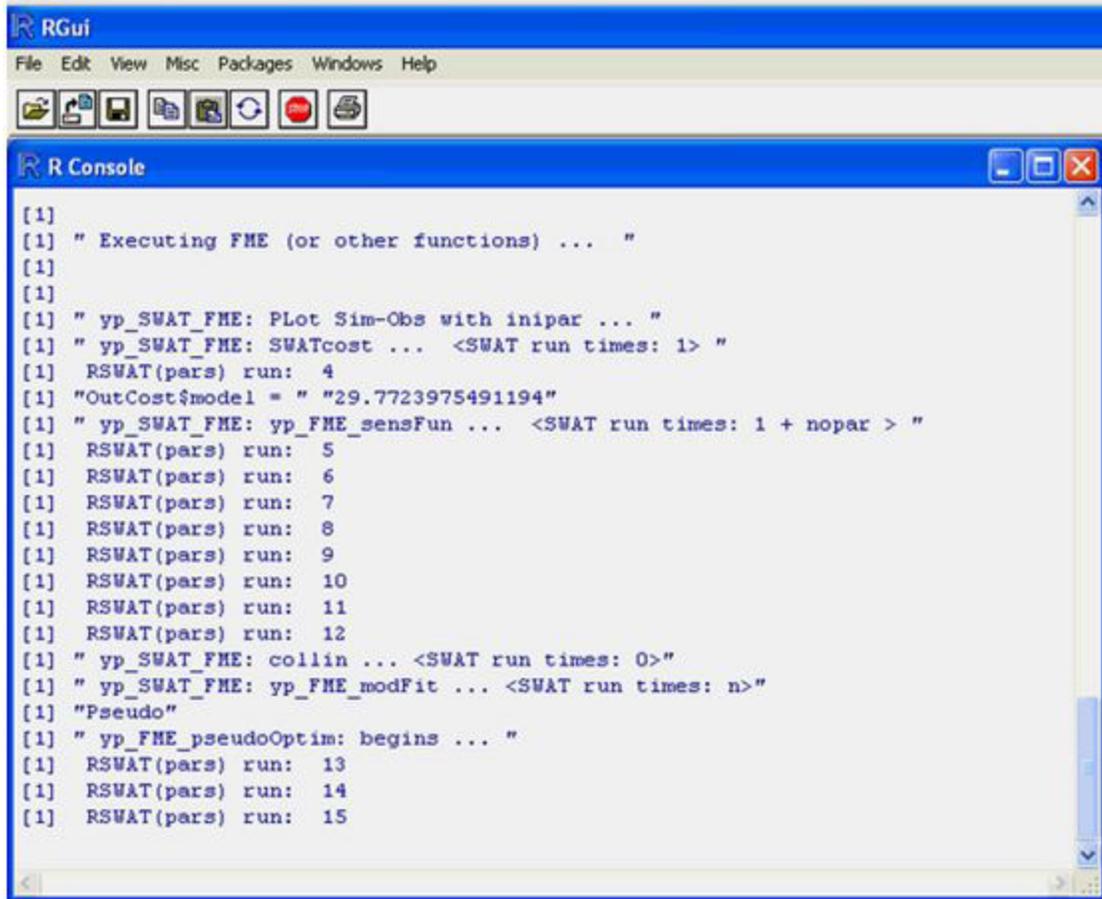
[13] solP          sobP          pbac          lbac
[17] mt11          mt12          mt13          Temp
[21] TKN           Total N      Total P
[1] VarUnit[:] = (cms) (mg/L) (mg/L) (mg/L) (mg/L)
[6] (mg/L) (mg/L) (mg/L) (mg/L) (mg/L)
[11] (mg/L) (ug/L) (mg/L) (mg/L) (ct/L)
[16] (ct/L) (mg/L) (mg/L) (mg/L) (degC)
[21] (mg/L) (mg/L) (mg/L)
[1] nmobjf = 1
[1] idobjf[:] = 1
[1] ObjNam[:] = Flow
[1] iuobjf[:] = 1
[1] " yp_SWAT_FME: Plot Sim-Obs with inipar ... "
[1] " yp_SWAT_FME: SWATcost ... <SWAT run times: 1> "
[1] SWAT(pars) run: 1
[1] "OutCost$model = " "29.7723975491194"
[1] " yp_SWAT_FME: yp_FME_sensFun ... <SWAT run times: 1 + nopar > "
[1] SWAT(pars) run: 2
[1] SWAT(pars) run: 3
[1] SWAT(pars) run: 4
[1] SWAT(pars) run: 5
[1] SWAT(pars) run: 6
[1] SWAT(pars) run: 7
[1] SWAT(pars) run: 8
> |

D:\MrcSWATProject\CEDR_1\Test\R-SWAT-FME.exe

atnofile =
ICLB = 11
NWSKIP = 2
[4 readbsn]: My CHANGES cancelled !
Cha_cCO2 = n
Cha_LAI = n
Cha_vCO2 = n
Cha_CCrf = n Cha_CCtp = n Cha_CCr = n Cha_CCrh = n frn:(N/S/R)
Cha_ANFT = y
PERT_co(:) = 0.00
Co_ANFT = 1.00
Init_shaq = 300.00 use
changing parameters
hru_dafrc(i) is calc in [13.3 Soil_phys]
Executing year 1 / 5
Year = 1999
Executing year 2 / 5
Year = 2000
Executing year 3 / 5
Year = 2001
Executing year 4 / 5
Year = 2002
Executing year 5 / 5
Year = 2003

```

Figure 1. Screenshot of the R-SWAT-FME run with option 1.



```

[1]
[1] " Executing FME (or other functions) ... "
[1]
[1]
[1] " yp_SWAT_FME: Plot Sim-Obs with inipar ... "
[1] " yp_SWAT_FME: SWATcost ... <SWAT run times: 1> "
[1] RSWAT(pars) run: 4
[1] "OutCost$model = " "29.7723975491194"
[1] " yp_SWAT_FME: yp_FME_sensFun ... <SWAT run times: 1 + nopar > "
[1] RSWAT(pars) run: 5
[1] RSWAT(pars) run: 6
[1] RSWAT(pars) run: 7
[1] RSWAT(pars) run: 8
[1] RSWAT(pars) run: 9
[1] RSWAT(pars) run: 10
[1] RSWAT(pars) run: 11
[1] RSWAT(pars) run: 12
[1] " yp_SWAT_FME: collin ... <SWAT run times: 0>"
[1] " yp_SWAT_FME: yp_FME_modFit ... <SWAT run times: n>"
[1] "Pseudo"
[1] " yp_FME_pseudoOptim: begins ... "
[1] RSWAT(pars) run: 13
[1] RSWAT(pars) run: 14
[1] RSWAT(pars) run: 15

```

Figure 2. Screenshot of the R-SWAT-FME run with option 2.

## Summary

The R-SWAT-FME is free and users may modify the R scripts as needed. Users may contact the developers for trouble shooting or sharing their improvements to these scripts. In addition, to wrap the FME package with other Fortran or C/C++ based environmental models, we suggest users see Wu and Liu (2012) for help. More information about FME functions is available from the Comprehensive R Archive Network at <http://CRAN.R-project.org/package=FME>, and information about using RFortran is available at <http://www.rfortran.org>.

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