Multisite Rainfall Simulator Help

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1. Overview

The Multisite Rainfall Simulator is a tool that simulates the rainfall occurrence and amount by using the modified Markov model-kernel density estimate (MMM-KDE), which is a stochastic modeling framework for multisite generation of daily rainfall incorporating low-frequency variability in the simulations. This framework simulates the daily rainfall occurrences and amounts as a two stage process at each individual location. The rainfall occurrence is modeled with a Markov chain conditional on the rainfall occurrence of previous days as well as the aggregate rainfall occurrences over long time periods. The rainfall amounts on the wet days are simulated using a kernel-density estimation procedure conditional on the previous day's rainfall.

The spatial dependence across stations is simulated by making use of spatially correlated random numbers. Spatial correlation in the random numbers is introduced on the basis of the at-site observed cross correlations in rainfall occurrences and amounts. The MMM-KDE modelling framework is presented here in the form of an interactive tool and is named as Multisite Rainfall Simulator (MRS).

2. Features

The Multisite Rainfall Simulator has been tested using data from 30 raingauge stations around Sydney, Australia. The analyses of the testing results show that this modeling procedure adequately capture daily and aggregated long time period rainfall characteristics at individual locations including the spatial distribution of rainfall over the region.

Features of MRS include:

- Displays input time series and stochastically generated data graphically.
- Option to generate a matrix for each day to be used to generate spatially correlated random numbers. It requires to be generated only once for a given dataset and stations.
- Displays the statistics of observed and generated data with tabulated values and

plots (i.e. boxplots for the statistics at any individual station, and qq plots for the mean statistics of all the stations).

- All the tabulated statistics and plots can be saved to a file of various formats.

3. Data requirements

3.1 Input data files

MRS requires a continuous time series of daily rainfall observations as input data.

The supported format of input data file is written in **simple text format** (with file extension of .dat, .data or .txt) with the following sequences (Figure 1).

The first three rows record the station number, station name and station number index. **The station names should be inside the quotation marks**.

The first three columns indicate the year, month and day.

	StnNumber		70080	63039	63033	63036	63095	63224	70131	70002	70055
	"STN Name"		"TARALGA"	"KATOOMBA"	"GURNANG"	"OBERON"	"YRRNDRIE"	"LITHGOW"	"WOODHSE"		
Y	M	D	1	2	3	4	5	6	7	8	9	10
1979	1	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	
1979	1	2	.00	.00	.00	.00	.10	.00	.00	.00	.00	
1979	1	3	.20	3.00	.00	.00	2.80	2.80	.00	.00	.20	

Figure 1. The first 6 rows of a sample rainfall data file ("rain.dat" is used for demonstration purpose).

In addition to rainfall data, user is required to provide the station-distance information in a file in a simple text format. First line is distance of station 1 with all stations; second line is distance of station2 with all and so on. As distance of station with itself is zero, this matrix will have all diagonal values as zero. Station sequence will be the same as user would have in the rainfall data file. A typical distance file will look like:

0	120	80	40	15
120	0	60	72	12
80	60	0	59	8

40 72 59 0 96

15 12 8 96 0

Figure 2. A sample data format of station-distance file for five stations ("dist.dat".is used for demonstration purpose)

The data in both files is in free format i.e. only separated by spaces or comas.

3.2 Input parameters

Parameter Names	Comments
number of years (ob.)	Number of years of rainfall data from observations used for the development of model and estimation of model parameters. Maximum is 30.
start year (ob.)	Start year of observations. Can take any reasonable value.
number of stations	Number of stations used in simulation. Minimum is 1 and maximum is 30.
band	Indicating the width of moving window (i.e. band*2+1). Minimum is 1 and maximum is 21.
lag	Time lags considered by the Markovian process to generate the conditional probabilities based on rainfall state of previous time step(s). Can take either 0 or 1.

local	Representing the influence of local neighborhood during rainfall amount generation. Can take any number from 0, 1 and 2. If 0 is taken, then local influence is ignored. If 1 is taken, local wetness is considered as a conditioning variable. If 2 is taken, selected data having similar wetness is used in kernel density estimation.
nLon	Number of time periods. Maximum allowed is 3.
number of previous lags for nLon	Number of previous time lags (in days) for nLon. Maximum is 900.
number of years (sim.)	Number of years of simulations to be generated. Can take any value between 1 and 30.
start year (sim.)	Start year of simulation generated. Can take any reasonable value.
number of simulations	Number of simulations generated. Maximum is 100.
simulate rainfall occurrence only	If ticked, the rainfall amount will not be simulated.
include spatial dependence matrix	If unchecked, spatial dependence is ignored.

The input parameters and the name of files can be either provided through the interactive graphical user interface (i.e. Figure 10) or through the modification of the file "data.dat". The value of each parameters need to be **tab delimited**.

4. Technical specifications

Operating system:

Windows 7

Essential applications:

R 3.0.2 (download from http://cran.r-project.org/bin/windows/base/)

5. Running Multisite Rainfall Simulator

5.1 Getting started

1. Download the zipped folder "Multisite Rainfall Simulator", right click on it and select **Extract All…** as highlighted in Figure 2.

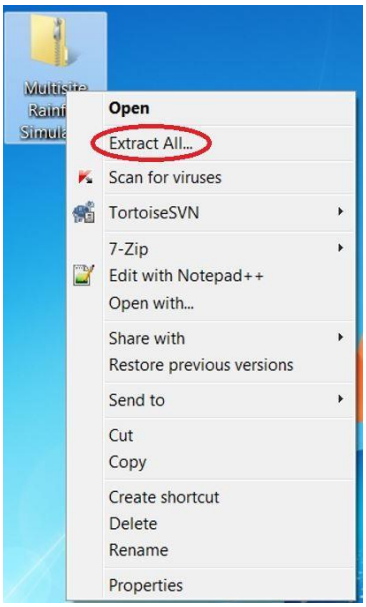

Figure 2. Extract All.

2. On the Extract Compressed (Zipped) Folder window, click **Extract**.

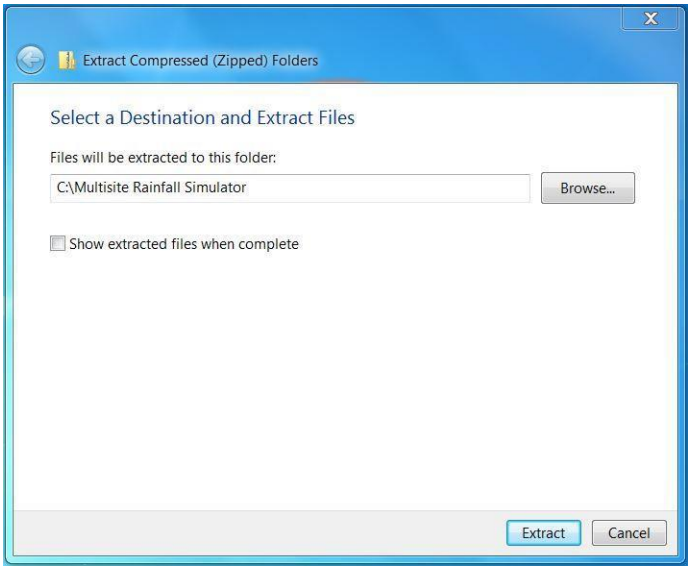

Figure 3. Extract Compressed (Zipped) Folder window.

3. Open R, click **File** on the menu bar, and click **Change dir…** as highlighted in Figure 4.

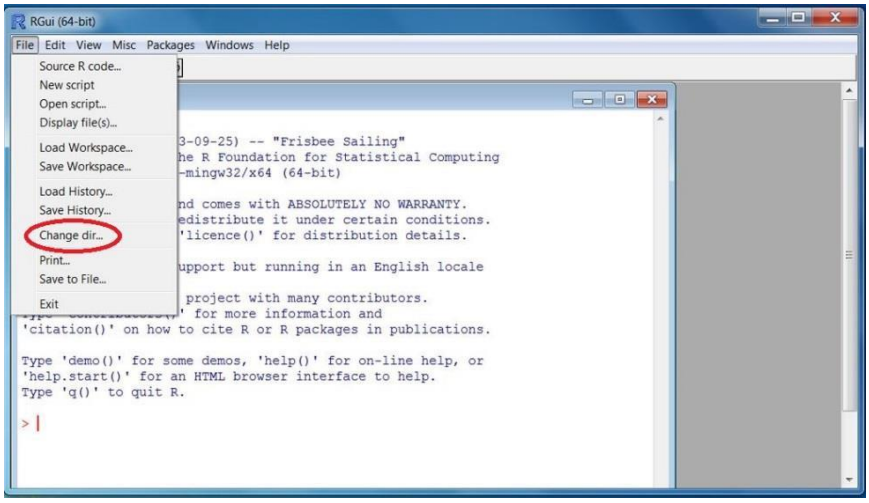

Figure 4. Change directory selection.

4. Select the extracted folder "Multisite Rainfall Simulator" as highlighted in Figure 5, and click **OK**.

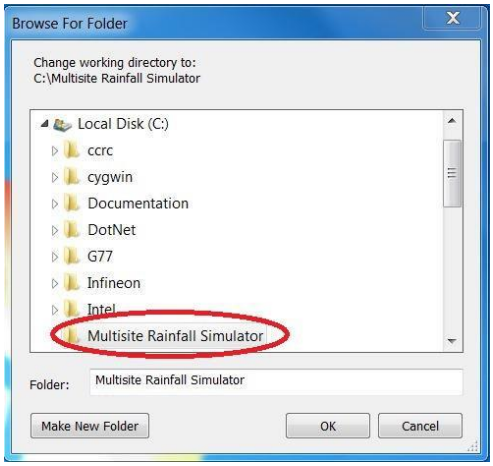

Figure 5. Browser For Folder window.

5. Click **File** on the menu bar, click **Source R code…** as highlighted in Figure 6, and click **OK**.

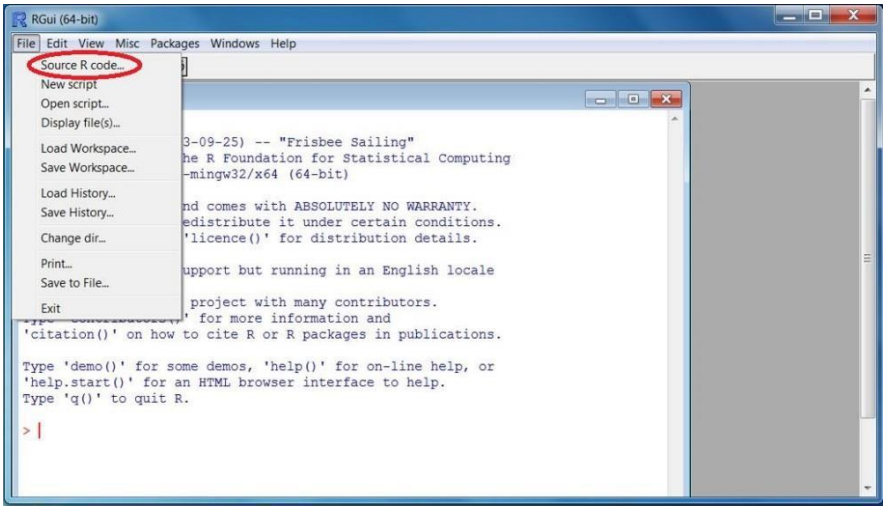

Figure 6. Source R code selection.

6. Select "simulator.r" as highlighted in Figure 7, and click **Open**.

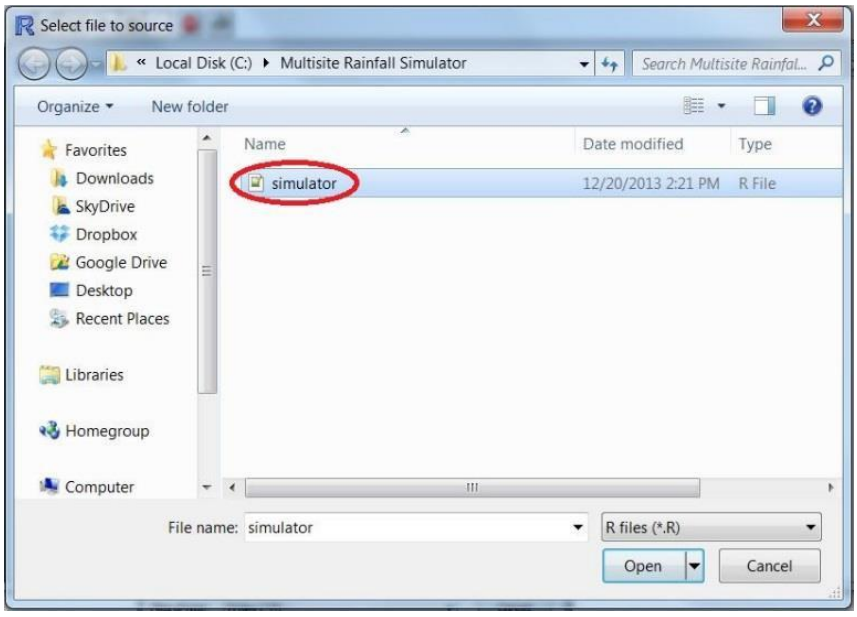

Figure 7. Select file to source window.

A graphical user interface will be generated as shown in Figure 8.

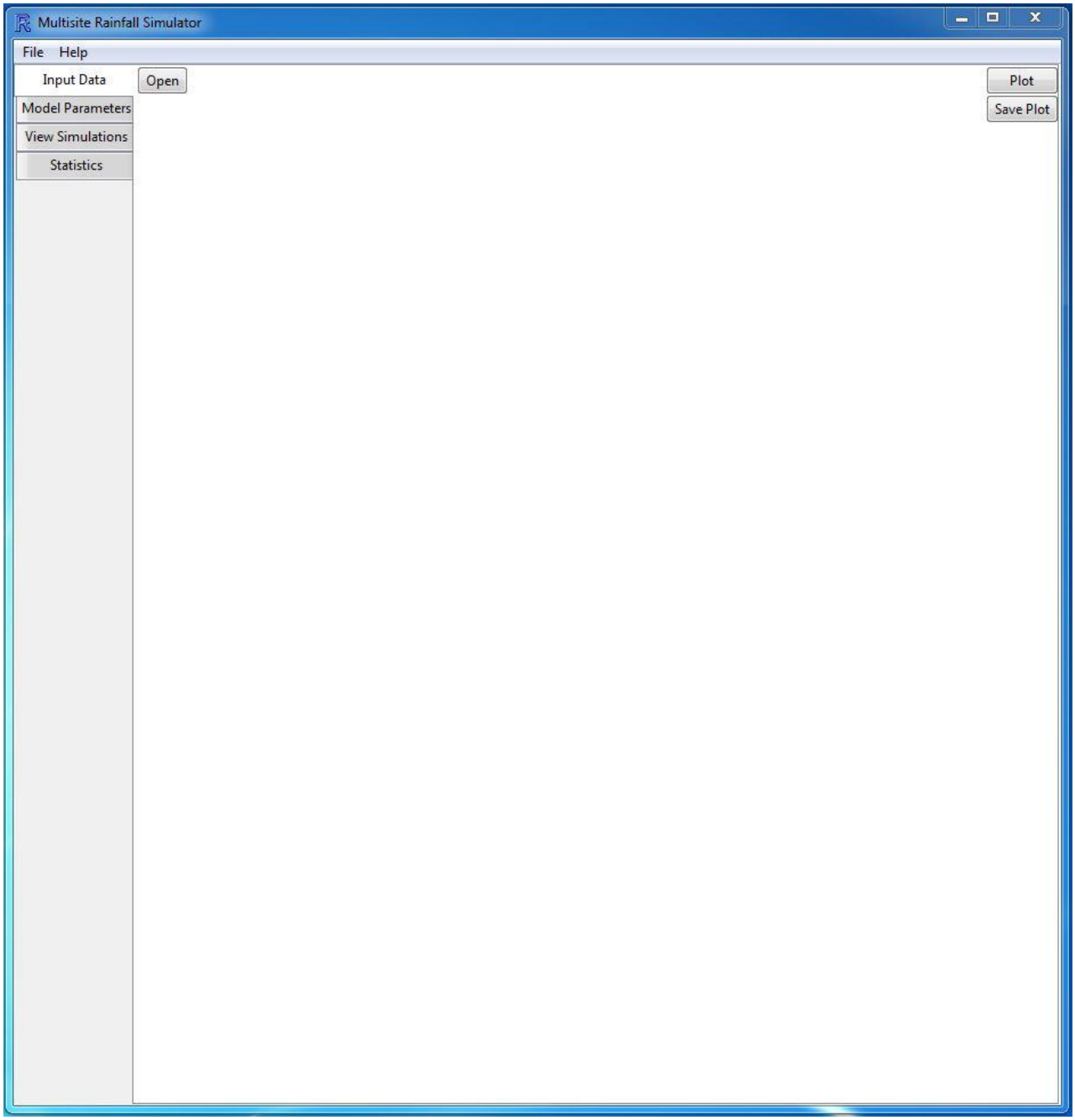

Figure 8. Initial view of the graphical user interface.

5.2 Steps in running the Multisite Rainfall Simulator

1. Click the "Open" button to select a daily observation rainfall data file with the format described in section 3.1. For the purpose of demonstration, the file "rain.dat" can be selected as the input observational rainfall data as shown in Figure 9.

2. Click the “Plot” button to plot the monthly rainfall of the input data.

3. Click the “Save Plot” button to save the graph into various formats. (Step 2 and 3 is optional.)

4. Click the “Model Parameters” tab to input parameters and then click the “Estimate” button (Figure 10). If the user wants to use their own data file, the corresponding distance file need to be provided by the user (Figure11) and should be of the same format as the file “dist.dat”.The estimation will take about 10 minutes or longer depending on the number of simulations and the computer processor.

5. Click the “View Simulations” tab to view and save each of the replicates (Figure 12).

6. Click the “Statistics” tab to select a statistic option to view as either tabulated values or plots (Figure 13 & 14). Each statistic view can be saved into a file.

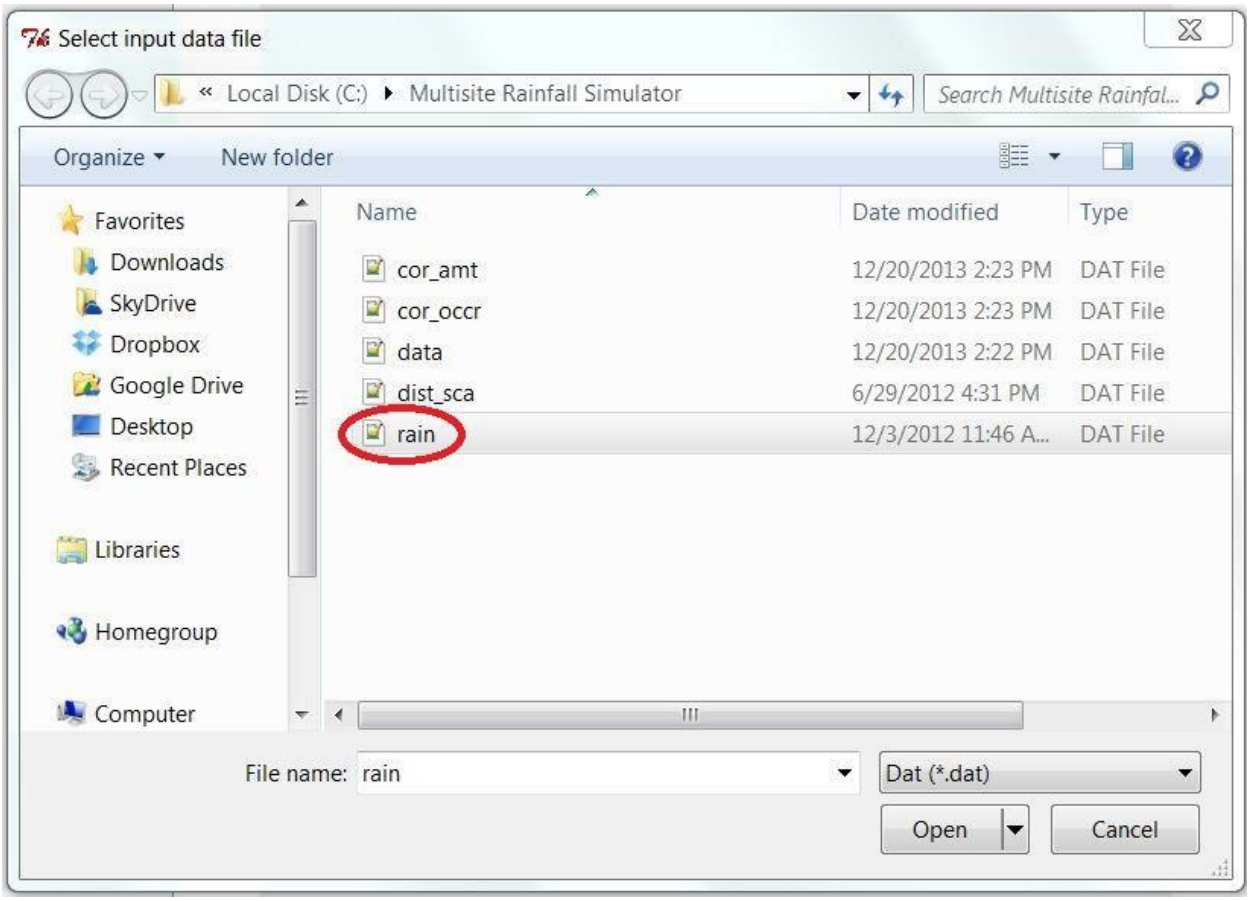

Figure 9. Select input data file.

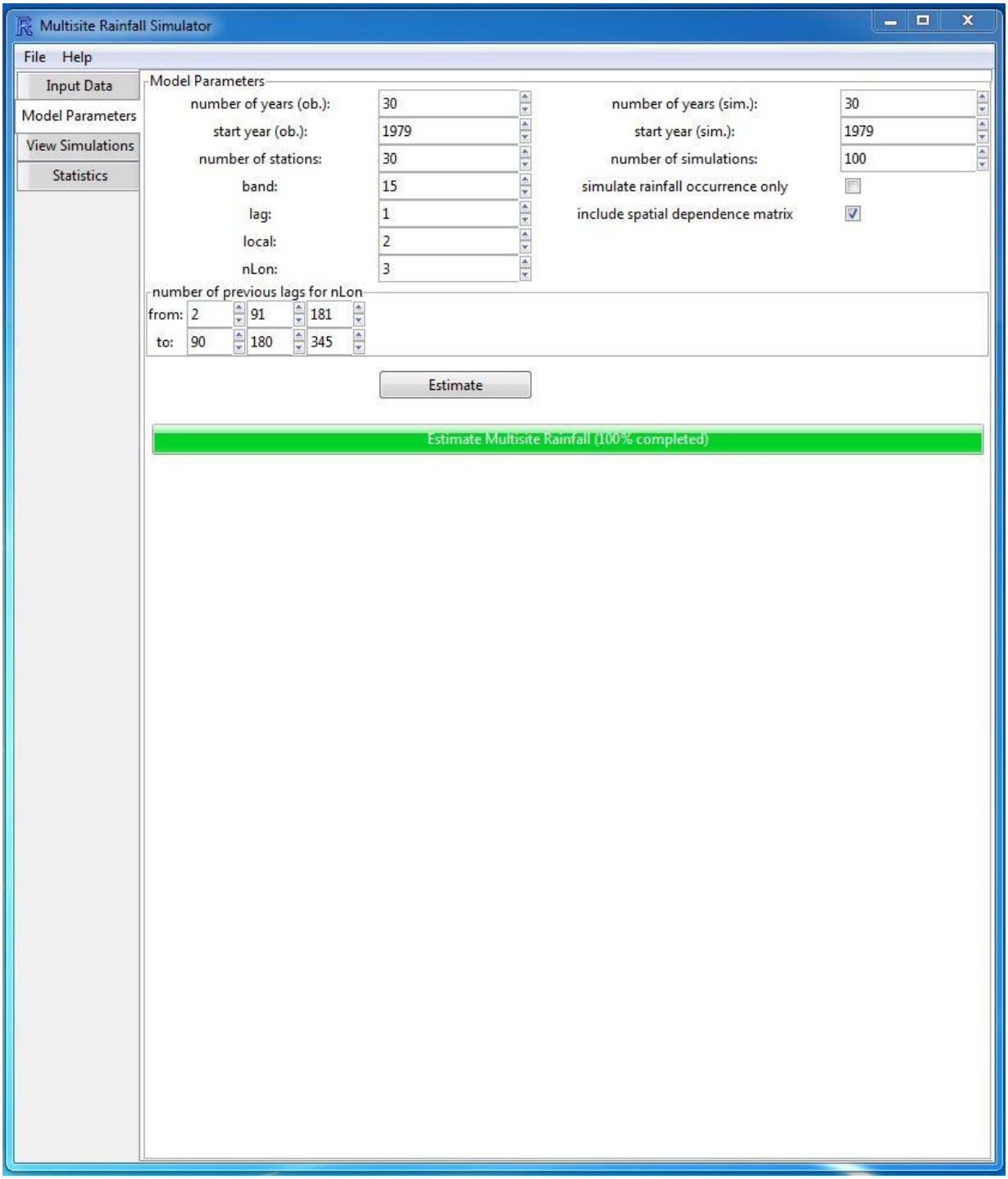

Figure 10. Model Parameters page.

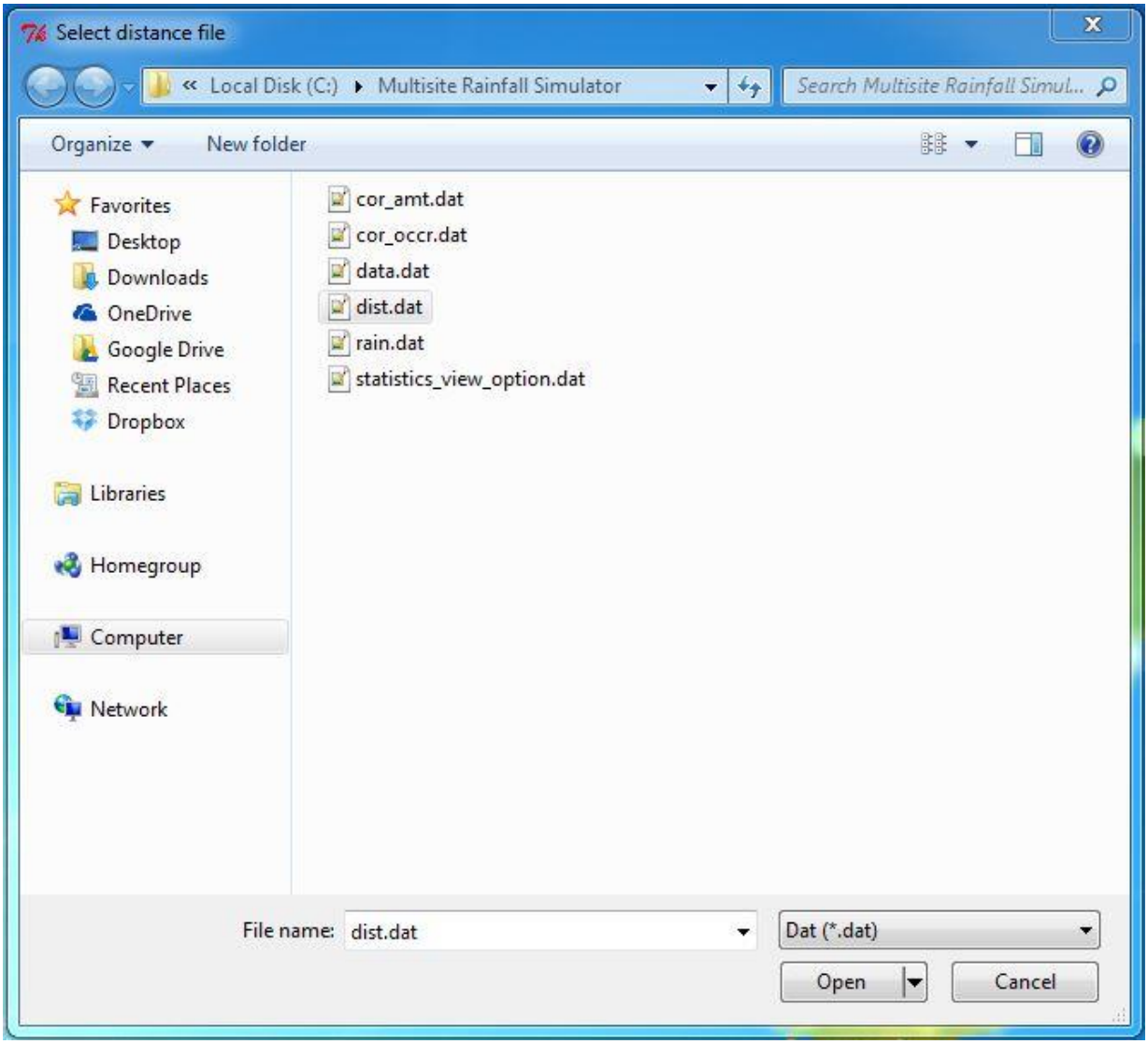

Figure 11. Select the distance file corresponding to the input rainfall data file.

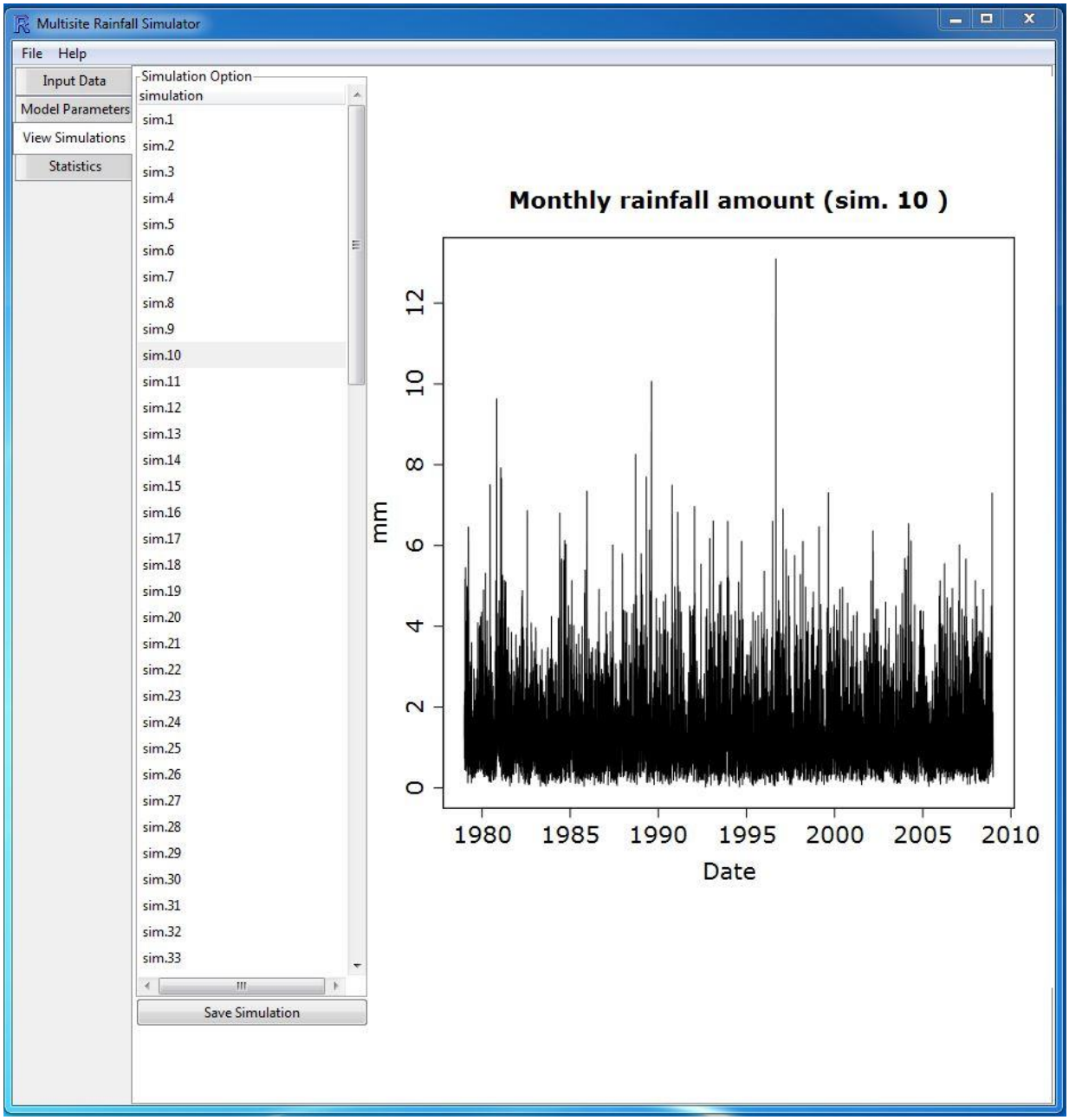

Figure 12. View Simulations page.

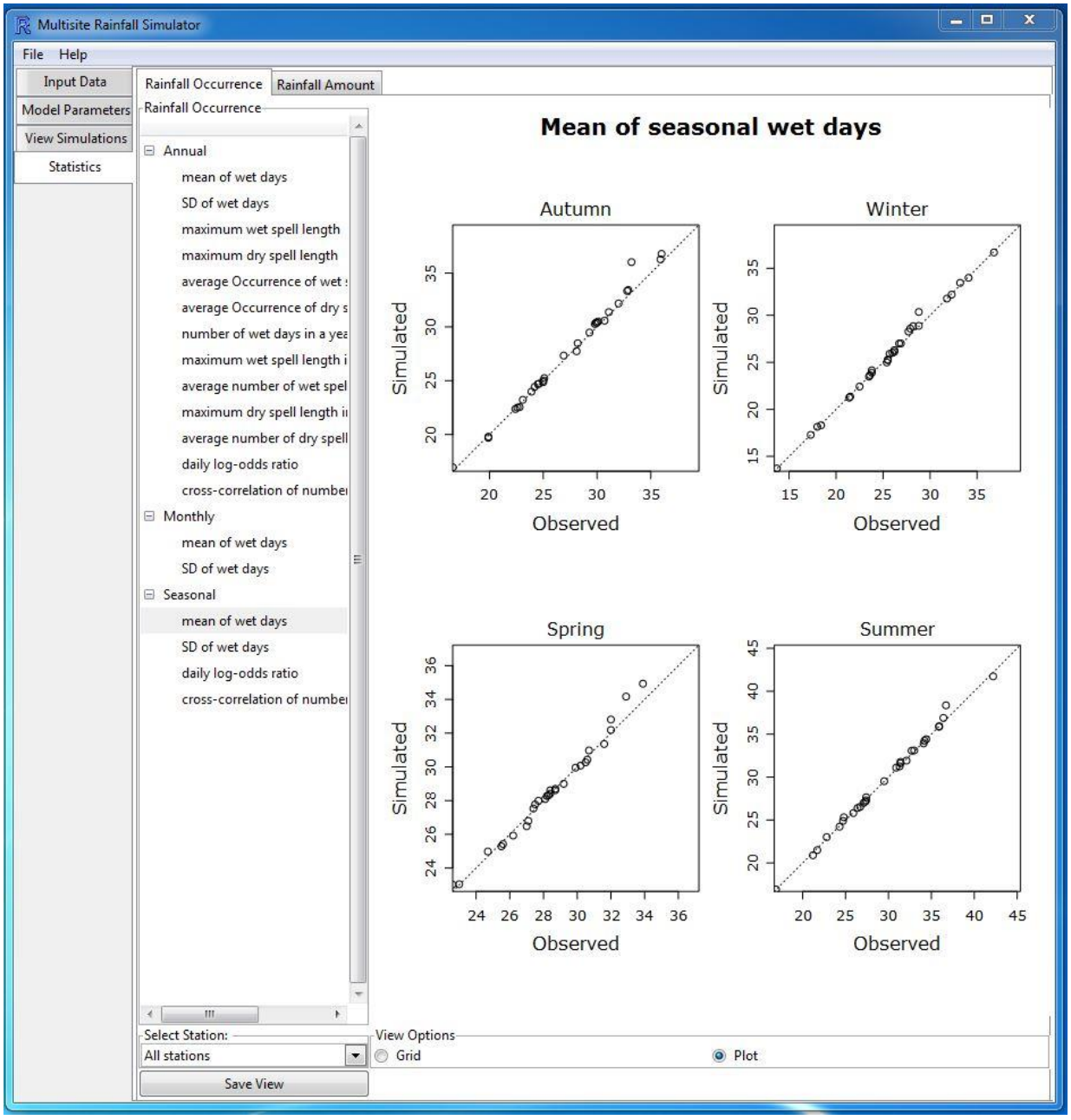

Figure 13. Graphical display of mean of seasonal wet days.

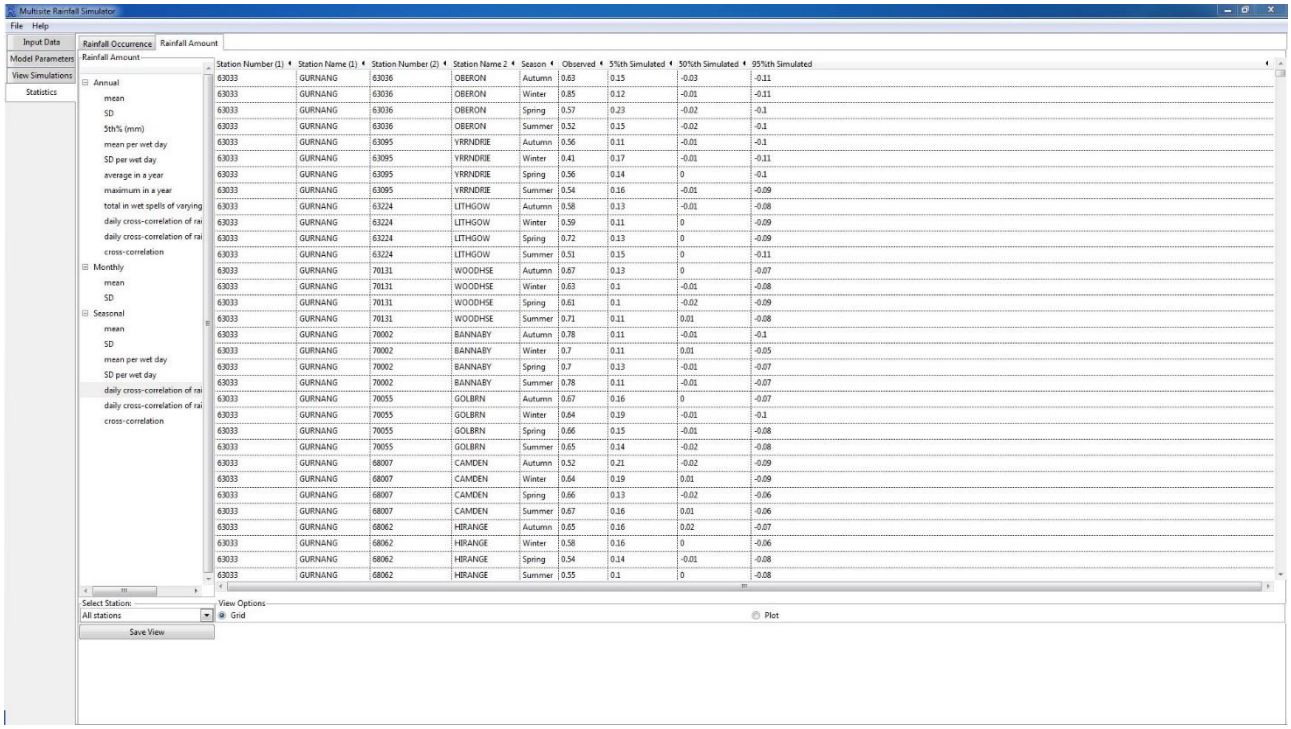

Figure 14. Tabulated display of the daily cross-correlation of rainfall in wet days on annual basis.