The ACRU Streamflow Verification Tool Guide

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DOCUMENT REVISIONS

Date	Version Number	Updated By	Document Changes
01/09/2017	0.1	Charmaine Bonifacio	Initial Draft

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1 INTRODUCTION

1.1 Scope and Purpose

This document describes the streamflow verification tool created for the Agricultural Catchments Research Unit (ACRU) agro-hydrological modelling system. This document is meant for both users of the ACRU model who wish to setup and run the ACRU model. The process of compiling and analysing data for the ACRU model can combined with either 32-bit or 64-bit Microsoft Excel® software under a Windows® operating system.

The ACRU-HYDAT Streamflow Verification Tool was developed to automate the process of verifying output data for the ACRU (v 336) model against HYDAT data from Environment Canada. The calibration and validation process of modelling are key in hydrological modelling studies. Initially, the tool was meant to automatically calculate the Nash Sutcliffe Efficiency Index. Essentially, the tool will allow the user to compare observed and simulated streamflow data (mm/day), summarize the results of the comparative statistical analysis for conservation statistics, regression statistics, error index statistics, and dimensionless statistics, create daily and monthly scatter plot graphs, create daily and monthly daily flow duration curves, create a monthly and annual seasonal flow graphs, and create a sequence of annual hydrographs for the available time period.

1.2 Tool Overview

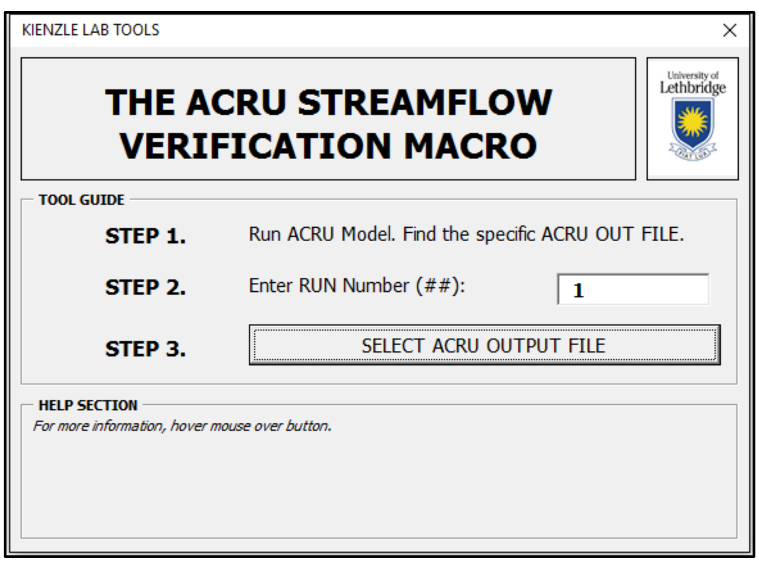


Figure 1-1 The ACRU Streamflow Verification Tool graphical user interface (GUI)

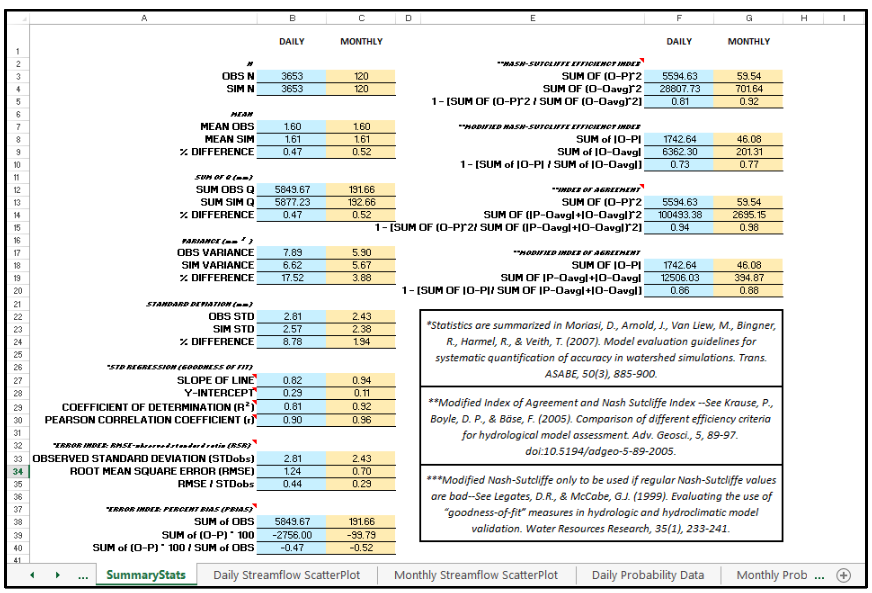
Procedure:

1. Locate the ACRU OUT file. This output file must be the outlet of a watershed, which contains observed streamflow data. If it doesn't, the tool will check and ask the user to find the appropriate file.
2. Enter the RUN Number. It is recommended to use RUN numbers as it allows the user to keep track of runs that comprise of various parameter sets.
3. Click on the button to start.

2 THE ACRU STREAMFLOW VERIFICATON TOOL

2.1 Comparative Statistical Analysis

The ACRU Streamflow Verification Tool is a comprehensive statistical analysis tool combined with graphical powers of Microsoft Excel® software under a Windows® operating system. The tool efficiently automates the comparison of observed and simulated streamflow data (mm/day) and summarizing the results of the comparative statistical analysis for verifying simulated streamflow data against observed values. Figure 2-1 shows a sample summary sheet for a specified run for the Oldman Reservoir Watershed.



	DAILY	MONTHLY
N		
OBS N	3653	120
SIM N	3653	120
MEAN		
MEAN OBS	1.60	1.60
MEAN SIM	1.61	1.61
% DIFFERENCE	0.47	0.52
SUM OF Q (mm)		
SUM OBS Q	5849.67	191.66
SUM SIM Q	5877.23	192.66
% DIFFERENCE	0.47	0.52
VARIANCE (mm²)		
OBS VARIANCE	7.89	5.90
SIM VARIANCE	6.62	5.67
% DIFFERENCE	17.52	3.88
STANDARD DEVIATION (mm)		
OBS STD	2.81	2.43
SIM STD	2.57	2.38
% DIFFERENCE	8.78	1.94
**STD REGRESSION (GOODNESS OF FIT)*		
SLOPE OF LINE	0.82	0.94
Y-INTERCEPT	0.29	0.11
COEFFICIENT OF DETERMINATION (R^2)	0.81	0.92
PEARSON CORRELATION COEFFICIENT (r)	0.90	0.96
**ERROR INDEX: RMSE-observed standard ratio (RSR)*		
OBSERVED STANDARD DEVIATION (STDobs)	2.81	2.43
ROOT MEAN SQUARE ERROR (RMSE)	1.24	0.70
RMSE / STDobs	0.44	0.29
**ERROR INDEX: PERCENT BIAS (PBIAS)*		
SUM of OBS	5849.67	191.66
SUM of (O-P) * 100	-2756.00	-99.79
SUM of (O-P) * 100 / SUM of OBS	-0.47	-0.52

	DAILY	MONTHLY
***NASH-SUTCLIFFE EFFICIENCY INDEX*		
SUM OF (O-P)^2	5594.63	59.54
SUM OF (O-Oavg)^2	28807.73	701.64
1 - [SUM OF (O-P)^2 / SUM OF (O-Oavg)^2]	0.81	0.92
***MODIFIED NASH-SUTCLIFFE EFFICIENCY INDEX*		
SUM of |O-P|	1742.64	46.08
SUM of |O-Oavg|	6362.30	201.31
1 - [SUM of |O-P| / SUM of |O-Oavg|]	0.73	0.77
***INDEX OF AGREEMENT*		
SUM OF (O-P)^2	5594.63	59.54
SUM OF (|P-Oavg|+|O-Oavg|)^2	100493.38	2695.15
1 - [SUM OF (O-P)^2/ SUM OF (|P-Oavg|+|O-Oavg|)^2]	0.94	0.98
***MODIFIED INDEX OF AGREEMENT*		
SUM OF |O-P|	1742.64	46.08
SUM OF |P-Oavg|+|O-Oavg|	12506.03	394.87
1 - [SUM OF |O-P|/ SUM OF |P-Oavg|+|O-Oavg|]	0.86	0.88

**Statistics are summarized in Moriasi, D., Arnold, J., Van Liew, M., Bingner, R., Harmel, R., & Veith, T. (2007). Model evaluation guidelines for systematic quantification of accuracy in watershed simulations. Trans. ASABE, 50(3), 885-900.*

***Modified Index of Agreement and Nash Sutcliffe Index --See Krause, P., Boyle, D. P., & Bäse, F. (2005). Comparison of different efficiency criteria for hydrological model assessment. Adv. Geosci., 5, 89-97. doi:10.5194/adgeo-5-89-2005.*

****Modified Nash-Sutcliffe only to be used if regular Nash-Sutcliffe values are bad--See Legates, D.R., & McCabe, G.J. (1999). Evaluating the use of "goodness-of-fit" measures in hydrologic and hydroclimatic model validation. Water Resources Research, 35(1), 233-241.*

Figure 2-1 Summary sheet of the statistical analysis

2.1.1 Conservation Statistics

The following statistics is calculated for daily and monthly data:

1. Number of observations, n
2. Means
3. Sum of streamflow, Q
4. Variance
5. Standard Deviation

NOTE: Percent difference is calculated between the simulated and observed streamflow data.

2.1.2 Regression Statistics

1. Slope of Line
2. Y-intercept
3. Coefficient of determination, r^2
4. Pearson correlation coefficient, r

2.1.3 Error-Index Statistics

1. Root mean square error, RMSE
2. RMSE-observed standard ratio, RSR
3. Percent bias

2.1.4 Dimensionless Statistics

1. Nash-Sutcliffe Efficiency Index, NSE
2. Modified Nash-Sutcliffe Efficiency Index, Mod NSE
3. Index of Agreement, d
4. Modified Index of Agreement, Mod d

NOTE: The modified versions were included for the dimensionless statistics

2.2 GRAPHICAL TECHNIQUES

In addition, the tool also recognizes the importance of graphical techniques used in hydrological studies. Typically, these include flow duration curves and hydrographs. However, this tool creates daily and monthly scatter plot graphs, daily and monthly flow duration curves, monthly and annual seasonal flow graphs, and a series of annual hydrographs for the available time period. The user is able to verify the streamflow data and check the magnitude and seasonality for errors.

2.2.1 Scatter Plot Graphs

The scatter plot graphs were incorporated into the tool for regression analysis. It includes the data for slope of the line, number of observations and the coefficient of determination between the simulated and observed data for daily and monthly time-steps.

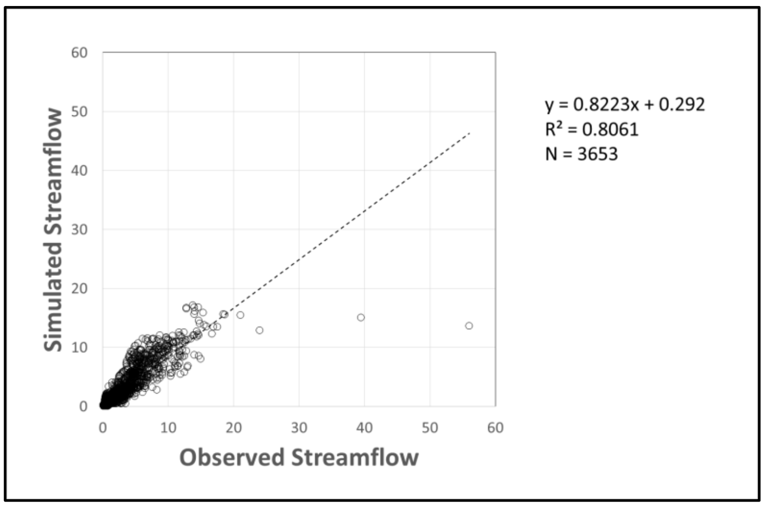


Figure 2-2. Scatter plot diagram

2.2.2 Flow Duration Curves

The flow duration curves are extremely valuable tool in hydrology. This graph illustrates how well the simulated daily flows is reproduced against observed daily flows. This is important for calibration and validation periods for distributed hydrological models like ACRU.

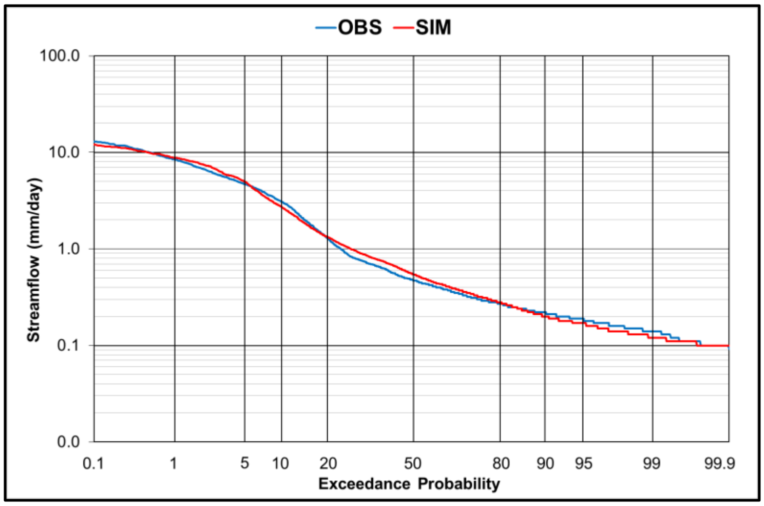


Figure 2-3. Flow duration curves

2.2.3 Seasonal Graphs

It's important to check the seasonality of the simulated data compared to the observed data. This affects the timing of precipitation of snow and rain for watershed analysis.

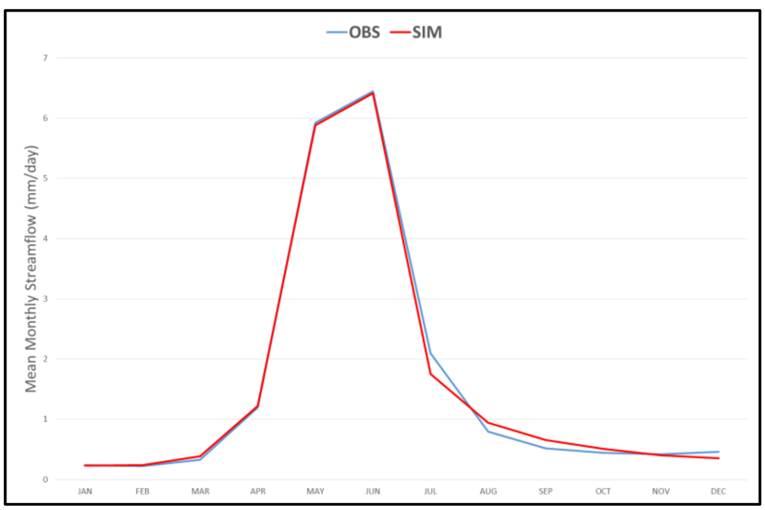


Figure 2-4. Seasonality graph for the specific time period

2.2.4 Hydrographs

The tool creates a series of hydrographs depending on the time period available in the ACRU OUT file. For instance, if the ACRU OUT file contains 1970-1980, the tool will create graphs start one year after the initial year. In this example, the tool created annual hydrographs from 1971-1980.

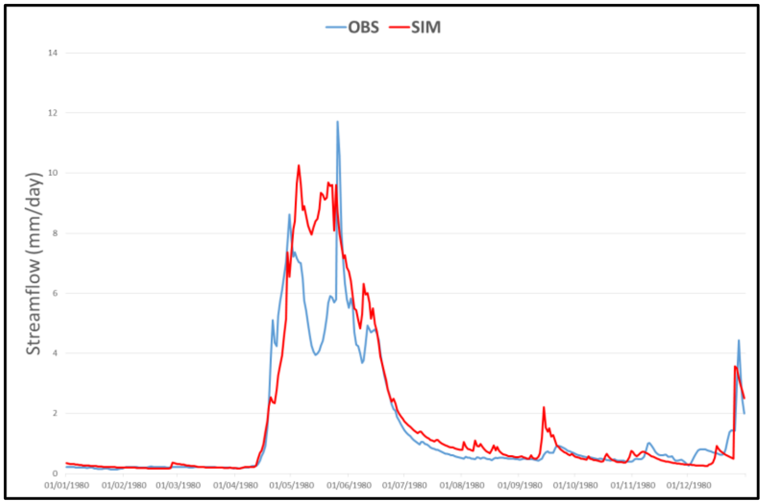


Figure 2-5. A hydrograph for the year 1980

If you encounter issues not addressed by this user guide, please contact Charmaine Bonifacio for additional support