Improvement of SWAT Auto-Calibration for Accuracies in High and Low Flow Regime using K-means Clustering Algorithm

Improvement of SWAT Auto-Calibration for Accuracies in High and Low Flow Regime Using K-means Clustering Algorithm

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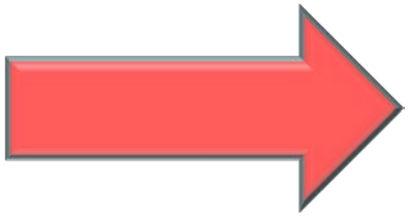
❑Introduction

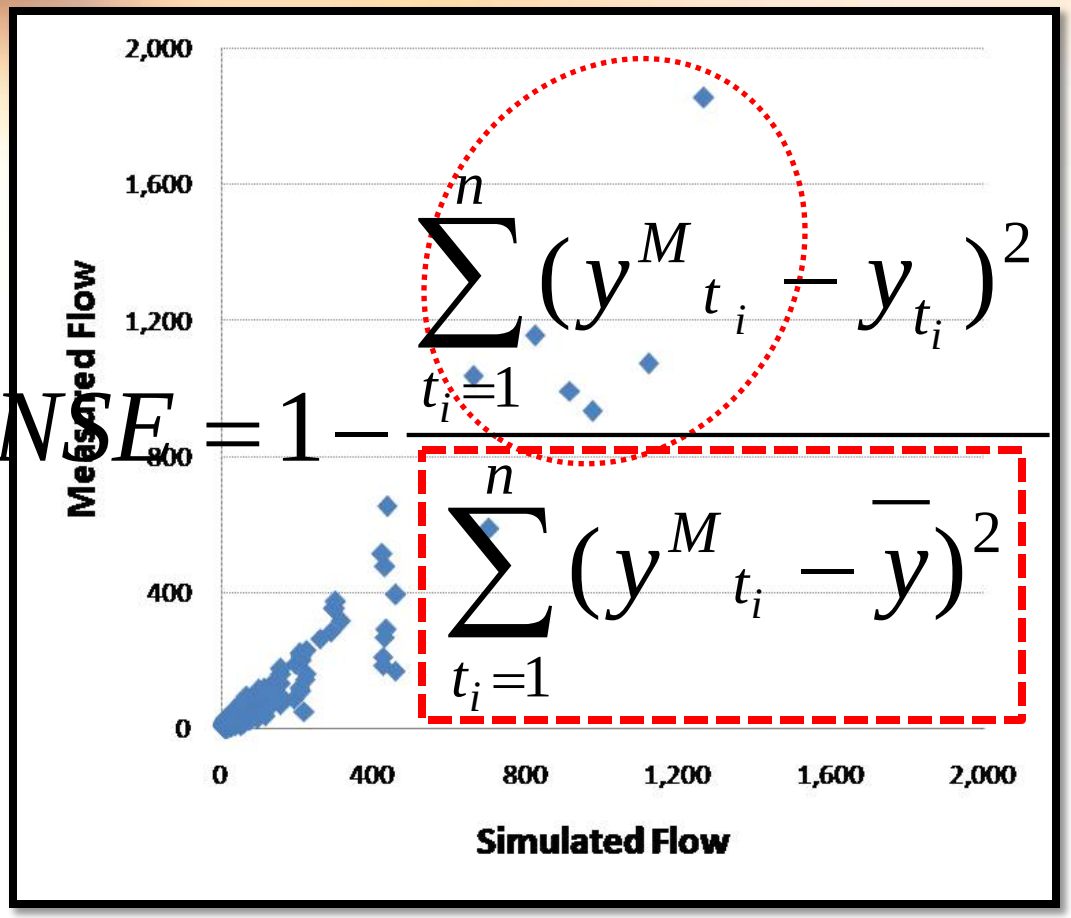
Nash and Sutcliff coefficient = NSE

NSE = 1



Perfect match

Introduction

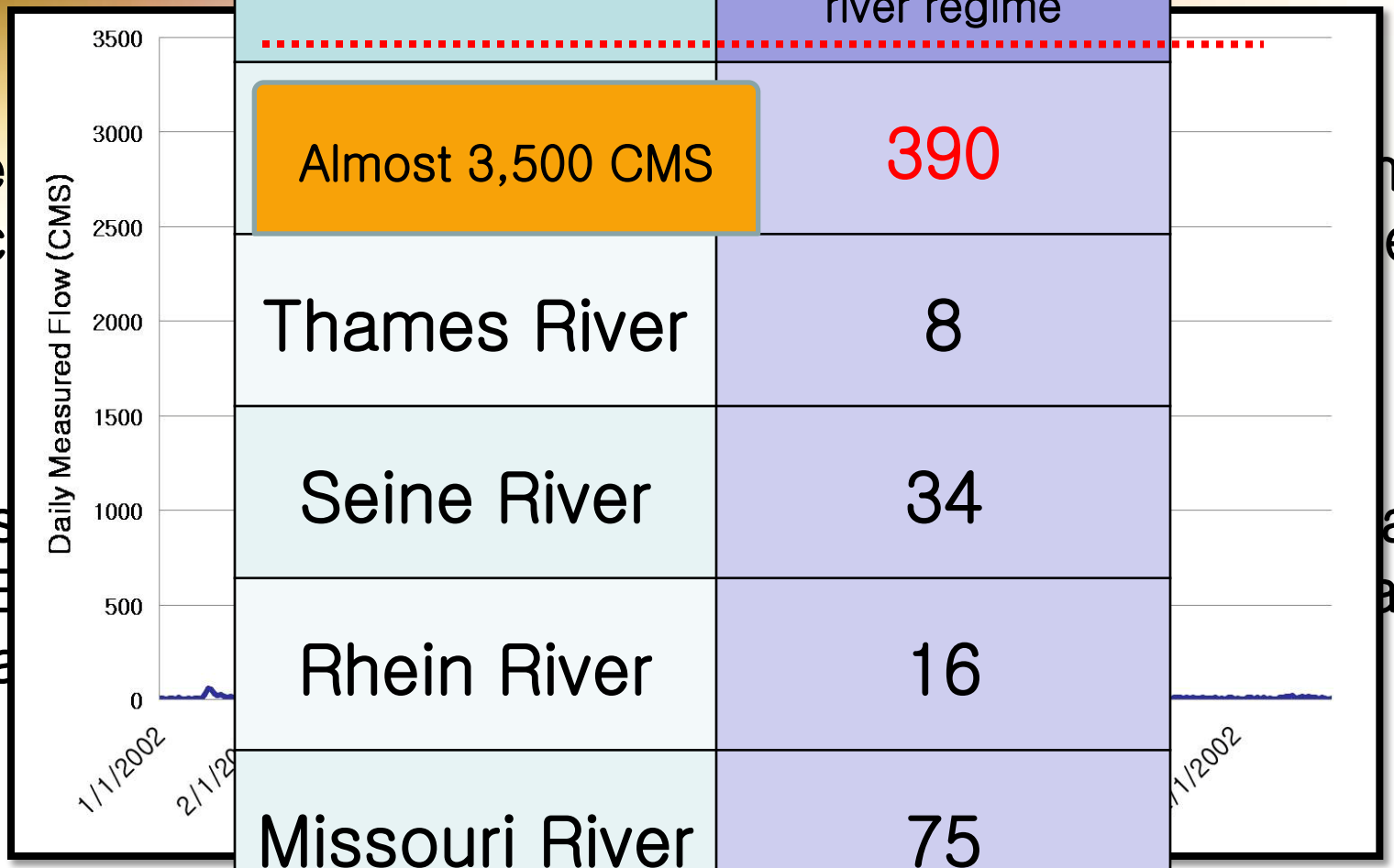


$$NSE = 1 - \frac{\sum_{t_i=1}^{n} (y^{M}{}_{t_i} - y_{t_i})^2}{\sum_{t_i=1}^{n} (y^{M}{}_{t_i} - \bar{y})^2}$$

❑ Introdu

K-Water(Korea Water Resources Corporation) (1996)

Name of river	The coefficient of river regime
Almost 3,500 CMS	390
Thames River	8
Seine River	34
Rhein River	16
Missouri River	75



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❑Introduction

SWAT auto-calibration

Parameter solution (Parasol)

Best parameter

❑Introduction

Parameter solution (Parasol)

Goal function = NSE

It has a many chances to make a problem!!

❑ Introduction

K-means clustering algorithm

Simplest algorithm that solve the well known clustering problem

❑Objectives of this study

- To modify SWAT Auto-calibration using K-means clustering algorithm to improve accuracy in flow estimation for all flow regime

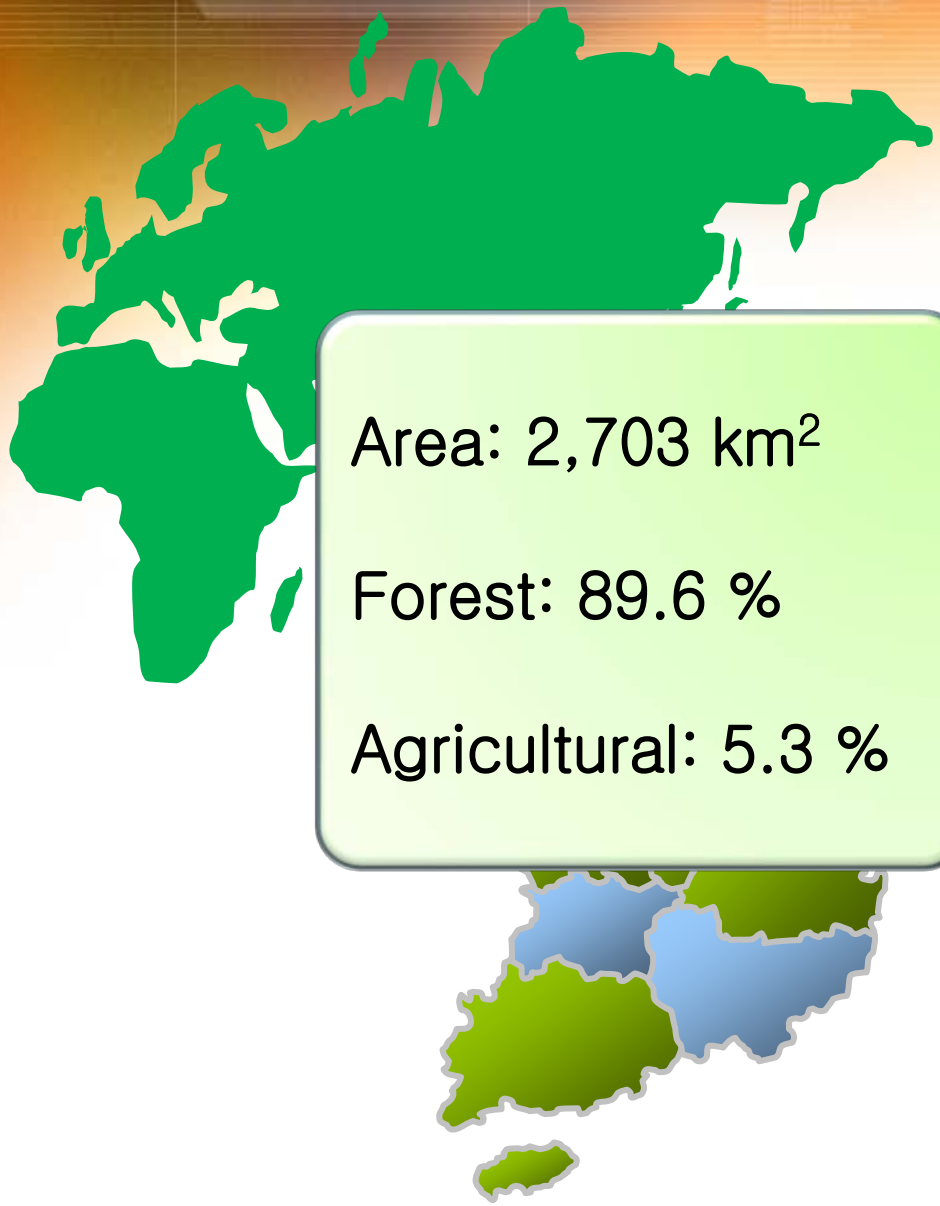
- To evaluate enhanced SWAT Auto-calibration module developed with K-means clustering algorithm by applying it to study watershed

❑ Two SWAT auto-calibration modules

- SWAT auto-calibration using Parameter Solution (Parasol) in current SWAT 2005 engine
  -> Original auto-calibration

- Enhanced SWAT Auto-calibration module using K-means algorithm -> K-means auto-calibration

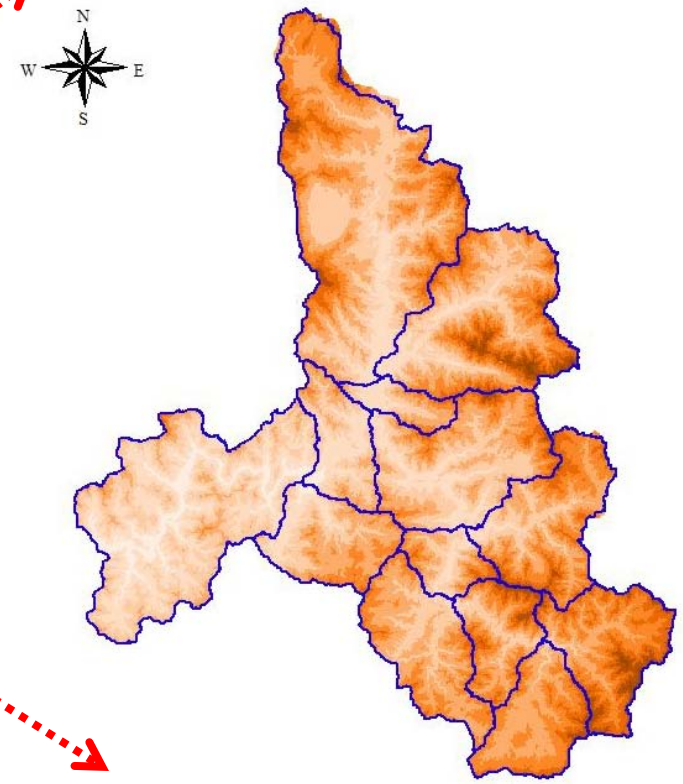
❑Study area



Area: 2,703 km^2

Forest: 89.6 %

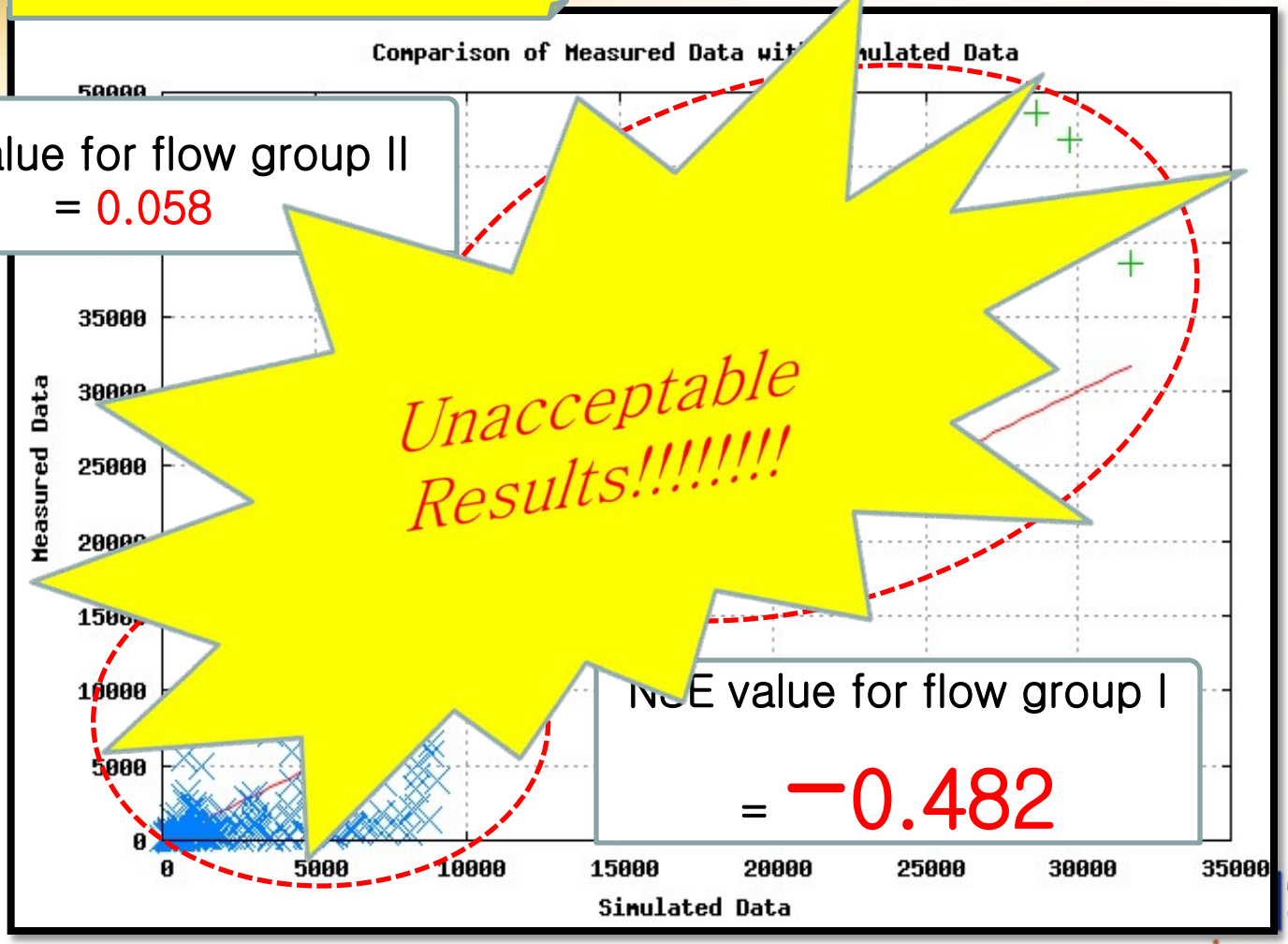
Agricultural: 5.3 %



Development of K-means auto-calibration module and simple GIS interface

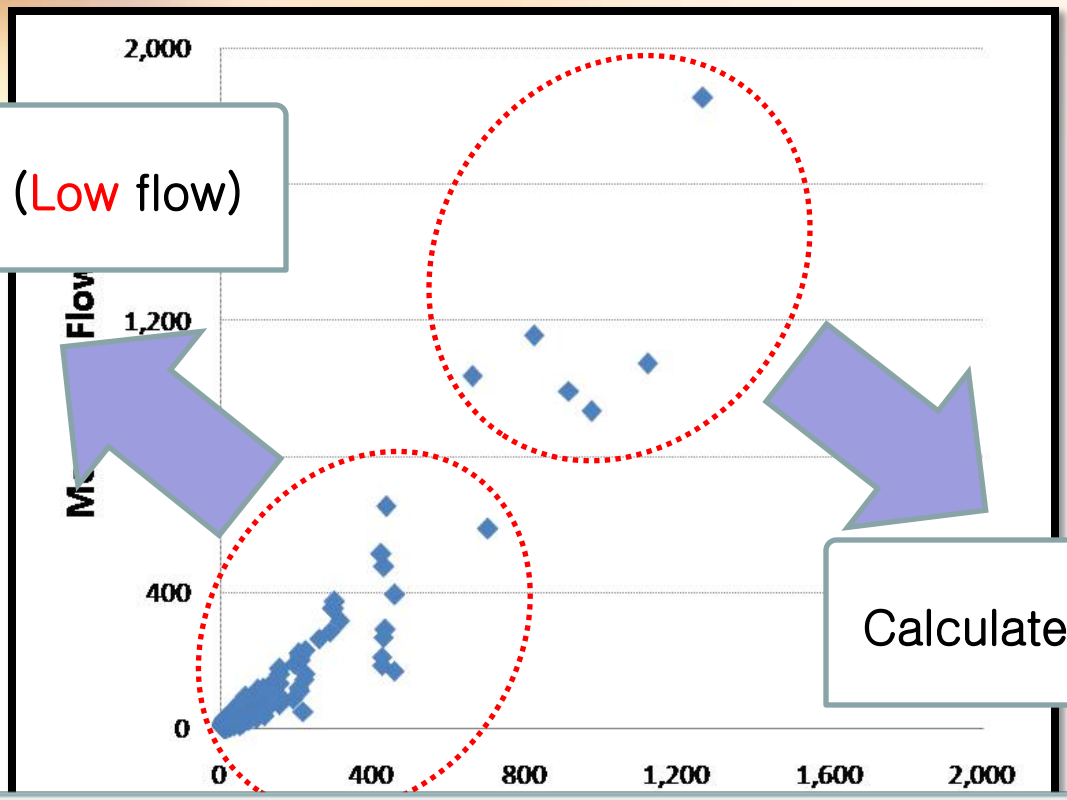
❑Weakness of Nash-Sutcliffe coefficient in evaluating flow simulation

Park et al.,(2007)



❑Modification of auto-calibration using K-means algorithm

Calculate NSE (Low flow)



Calculate NSE (High flow)

Validation of High and Low flow separately

❑Objective function in Parasol

Parameter Solution (Parasol)
Objective function => Sum of the squares of the residuals(SSQ)

$$SSQ = \sum_{t_i=1}^{n} (y^M{}_{t_i} - y_{t_i})^2$$

$$NSE = 1 - \frac{SSQ}{\sum_{t_i=1}^{n} (y^M{}_{t_i} - \bar{y})^2}$$

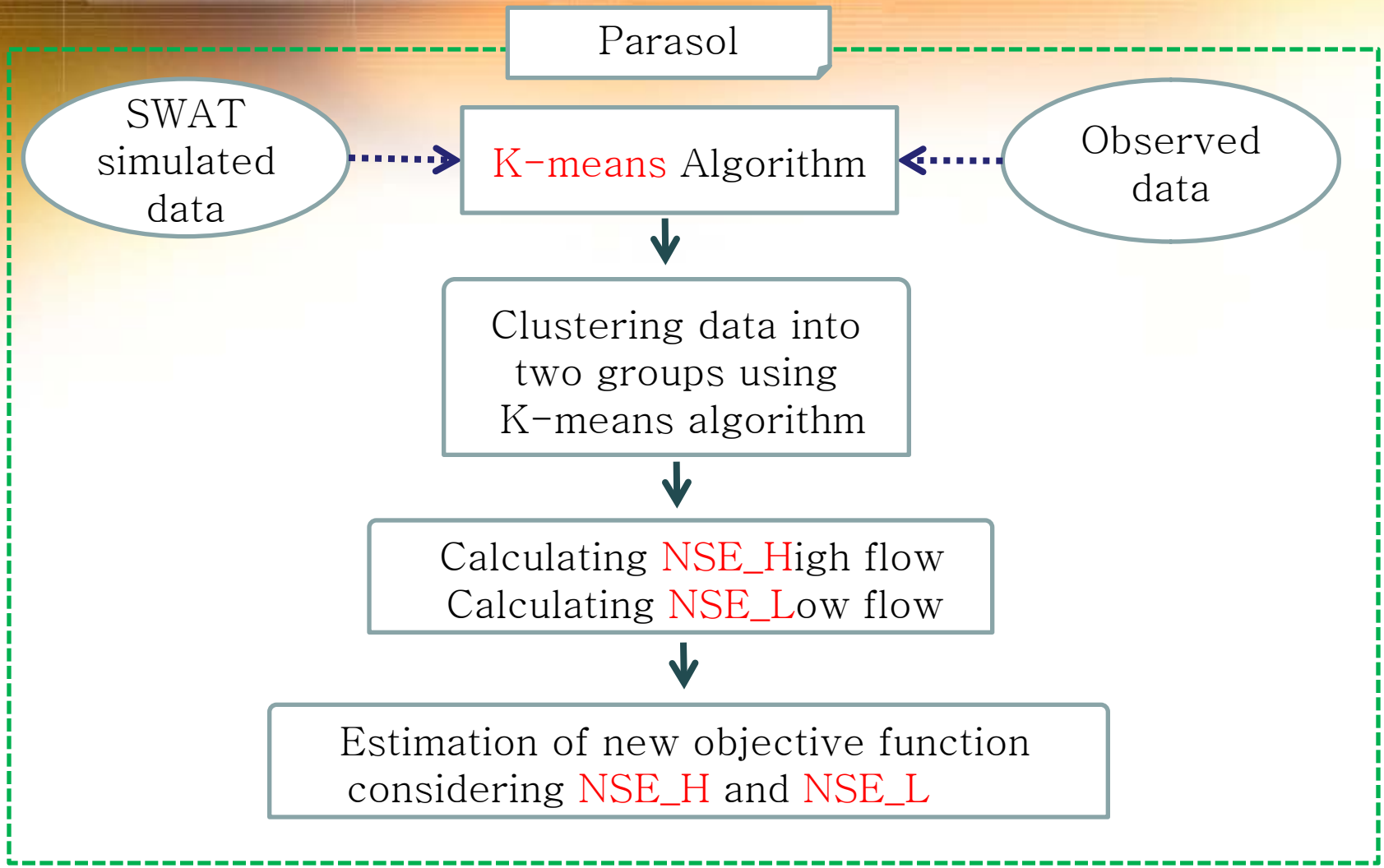
$y^M{}_{t_i}$ = *Measured Data*

y_{t_i} = *Simulated Data*

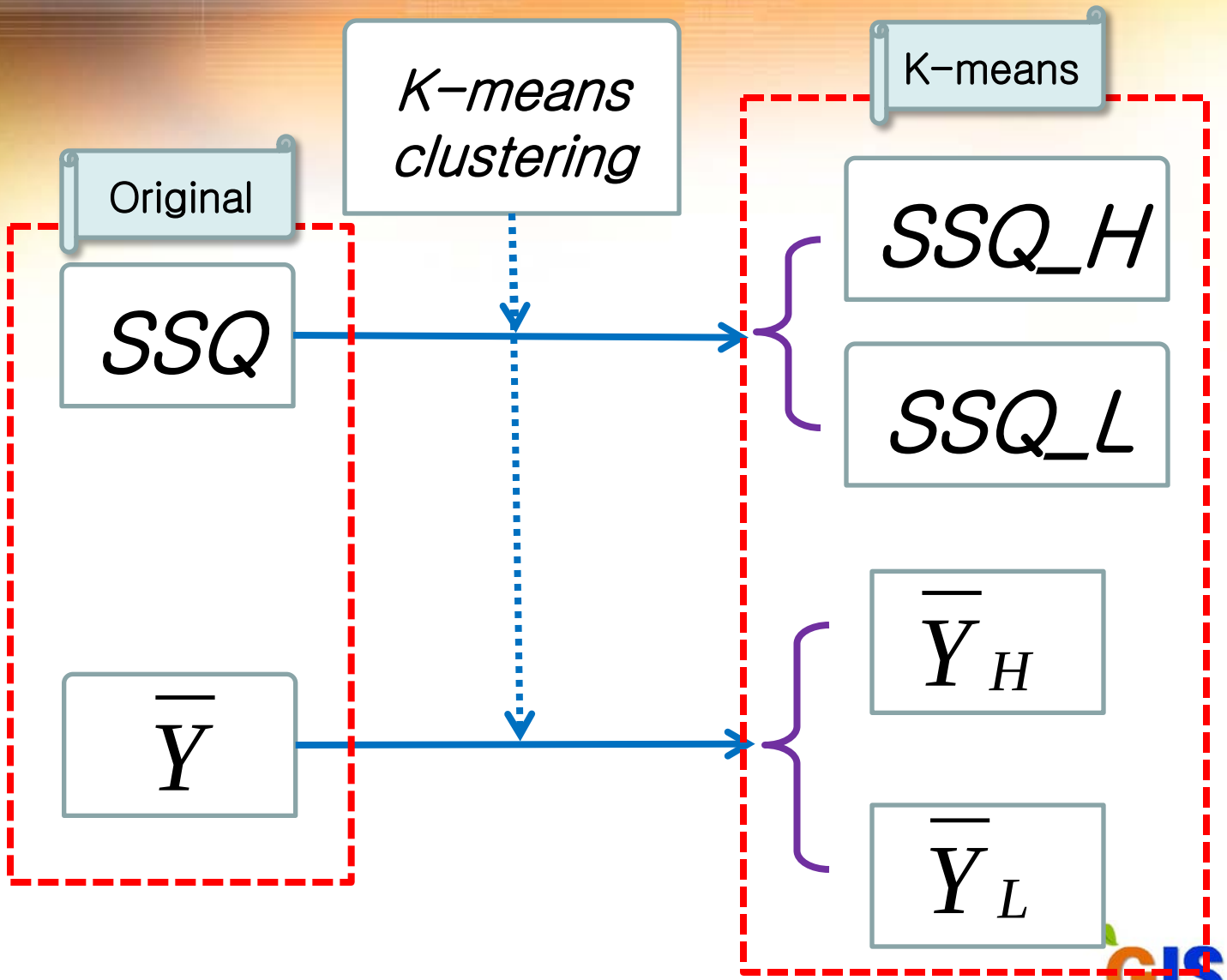
$\bar{y}$ = *Average of measured Data*

$$\sum_{t_i=1}^{n} (y^M{}_{t_i} - \bar{y})^2 = \bar{Y}$$

❑ Enhancement of Parasol algorithm using K-means clustering



❑Substitution of objective function considering NSE_H and NSE_L



❑Substitution of objective function considering NSE_H and NSE_L

$$\frac{SSQ\_H}{\overline{Y}_H} < NSE\_H = 1 - \frac{SSQ\_H}{\overline{Y}_H} > 0.6$$

&

$$\frac{SSQ\_L}{\overline{Y}_L} < NSE\_L = 1 - \frac{SSQ\_L}{\overline{Y}_L} > 0.6$$

ept

Donigan and Love (2003)

	Poor	Fair	Good	Very Good
NSE for Daily Simulation	**< 0.60**	**0.60 ~ 0.70**	**0.70 ~ 0.80**	**> 0.80**

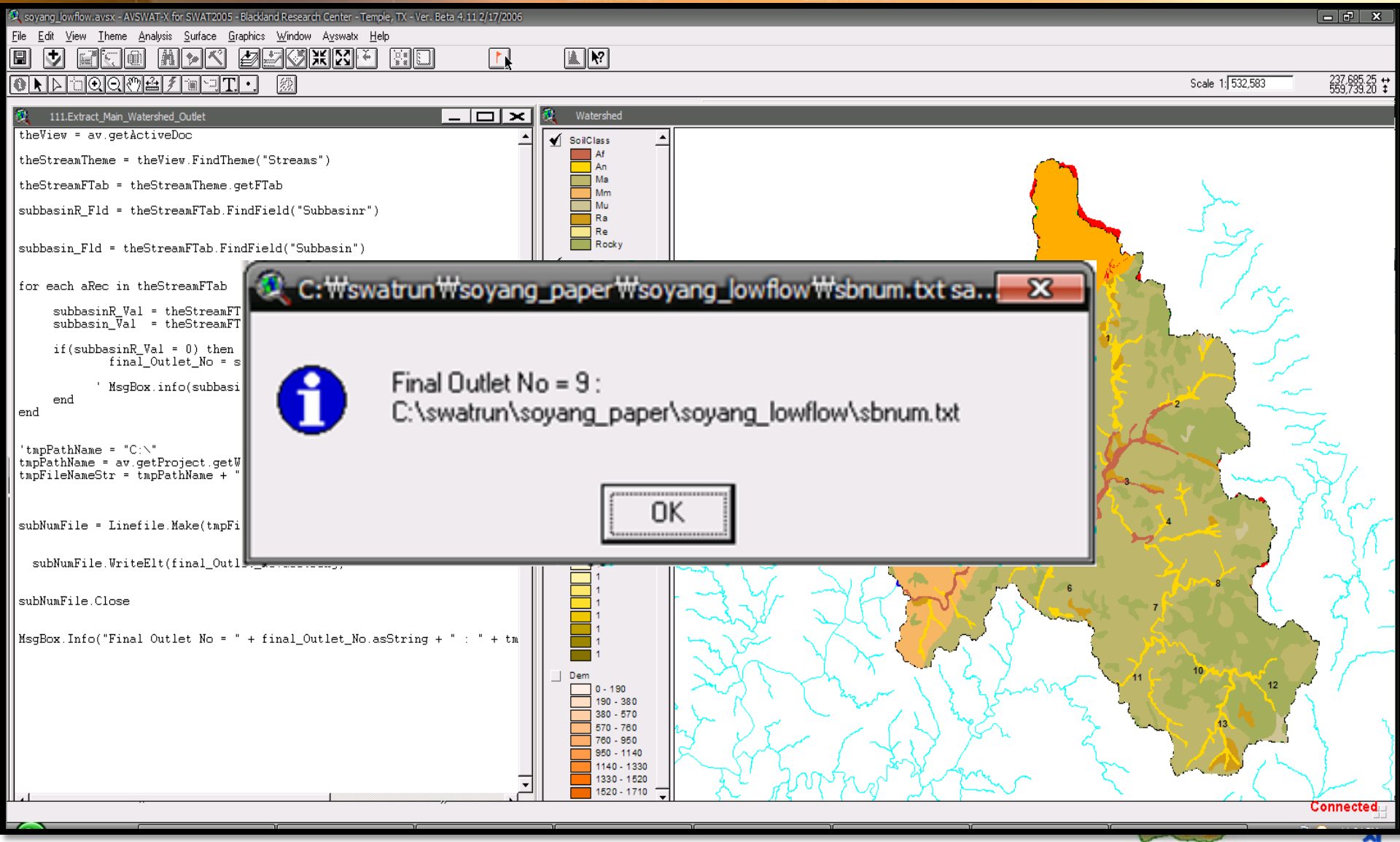
❑Substitution of objective function considering NSE_H and NSE_L

New objective function

$$\frac{SSQ\_H}{\overline{Y}_H} + \frac{SSQ\_L}{\overline{Y}_L}$$

NSE_H and NSE_L together

❑ Determination of the number of main outlet in watershed automatically



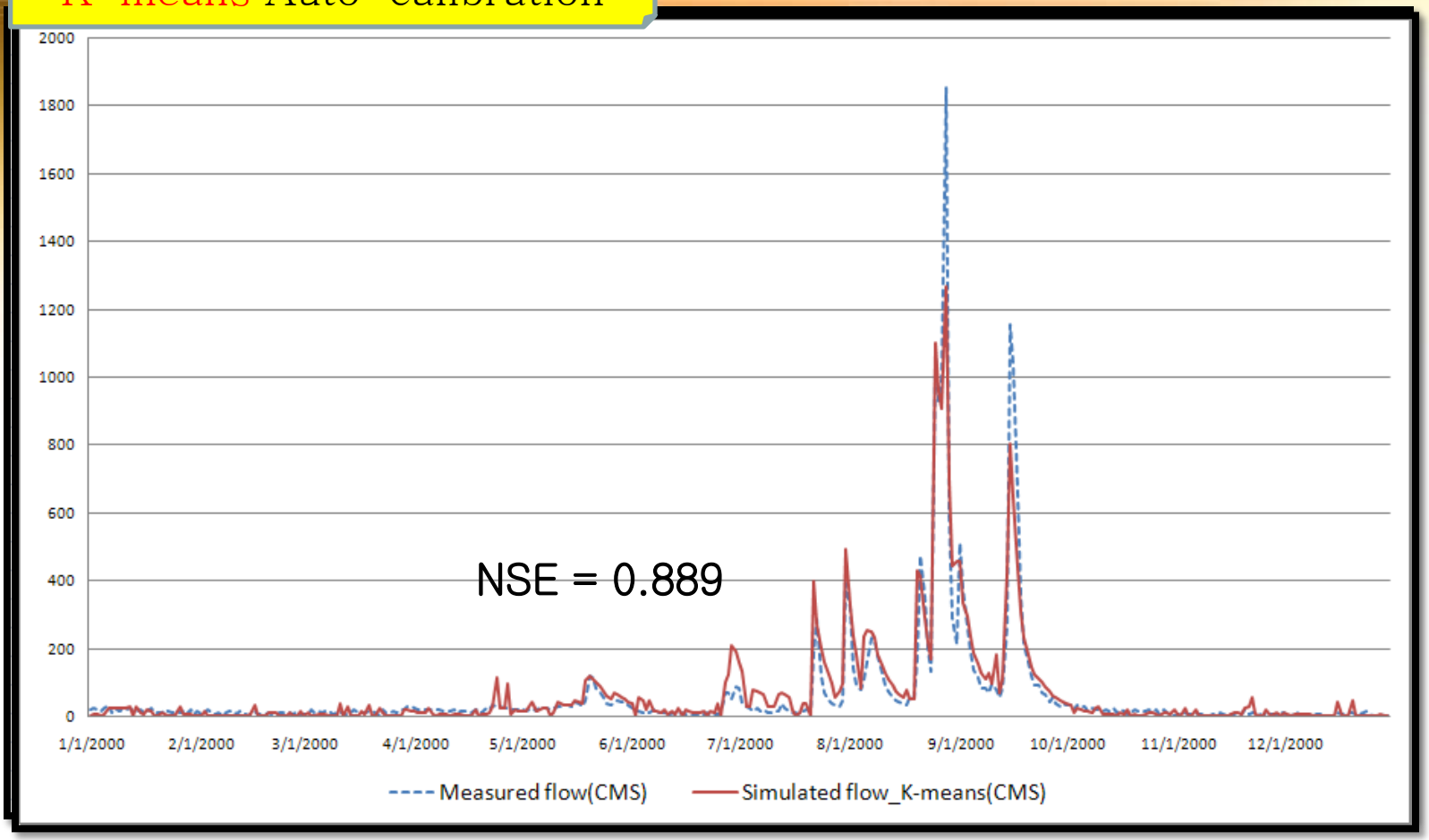
Application of K-means auto-calibration

❑ The parameters used in auto-calibration

Parameter	Description	Range
CN2	SCS runoff curve number for Moisture condition II	35 ~ 98
AHPAH_BF	Baseflow alpha factor	0 ~ 1
SURLAG	Surface runoff lag time	1 ~ 24
CH_N	Manning's "n" value for the main channel	-0.01 ~ 0.3
CH_K2	Effective hydraulic conductivity in main channel alluvium	-0.01 ~ 150
GW_DELAY	Groundwater delay	0 ~ 500
GW_REVAP	Groundwater "revap" coefficient	0.02 ~ 0.2
GWQMN	Threshold depth of water in the shallow aquifer required for return flow to occur	0 ~ 5000
SOL_AWC	Available water capacity of the soil layer	1 ~ 24

❑Comparison of SWAT auto-calibration

K-means Auto-calibration



The NSE values of Total flow are similar.

❑Comparison of SWAT auto-calibration

Type of Auto Calibration	NSE - Total Flow	NSE - Low Flow	NSE - High Flow
Donigan and Love (2003)		0.699	0.460
	Poor	**Fair**	**Good**	**Very Good**
ıtion	0.889	0.608	0.604
NSE for Daily Simulation	**< 0.60**	**0.60 ~ 0.70**	**0.70 ~ 0.80**	**> 0.80**

❑ Conclusions

- The NSE values from K-means auto-calibration are 0.608 and 0.604 for low and high flow regimes.

- However the NSE value for high flow from original auto-calibration is 0.460 (Poor calibration result).

Donigan and Love (2003)

❑ Conclusions

- SWAT simulated flow using original auto-calibration may not match measured flow data because objective function in original auto-calibration is affected by big number.

- With K-means auto-calibration, developed in this study, would provide better estimation for all flow regimes.

Thank you for your Attention!!

Flow duration curve