Calibration SWAT Model

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Outline

- Introduction
- Calibration
- SWAT Parameter
- Technique for SWAT Calibration

Hydrological Calibration

To calibrate water balance and stream flow we need to have some understanding of the actual conditions occurred in the watershed:

- Data of the stream flow located at the outlet of your model sub basin
- Quality check on the observed flow data
- Compare hydrograph of your model result with the observed flow at selected gauge site , and trial to match with calibration criteria (Volume ratio and COE)

Calibration and Validation

Calibration : Model testing with know input and output used to adjust or estimate factors

Validation : Comparison of model results with an independent data set

(without further adjustment)

How to Calibration ?

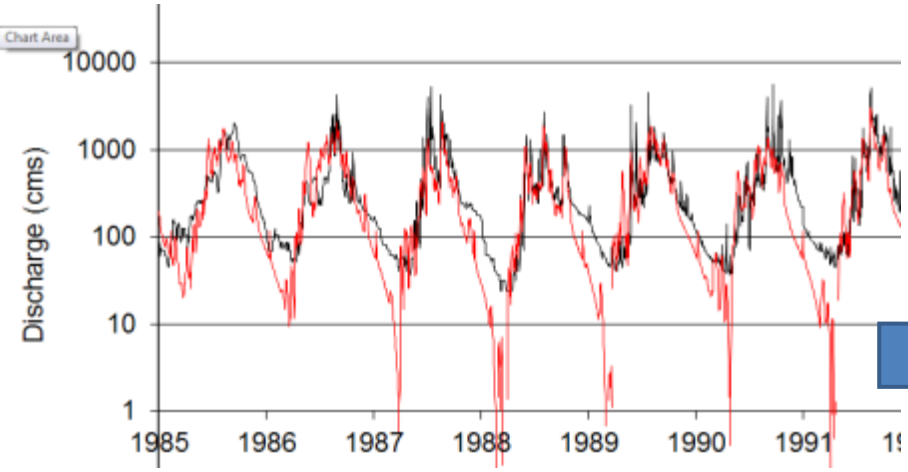
Compare Simulated data with Observed data

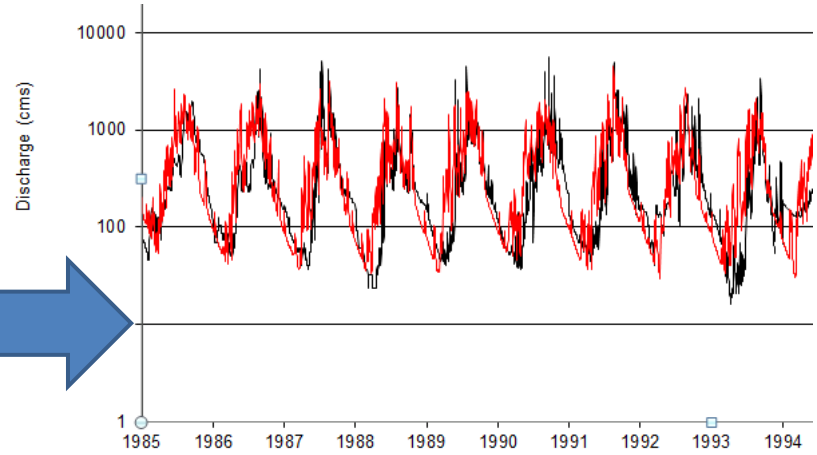
- **Look into sequence**
  - annual water balance
  - Seasonal variability
  - Base flow
  - Overall Time Series
- **Statistics**
  - Mean & Standard deviation
  - Coefficient of Efficiency (COE)
  - Volume Ratio

Calibration criteria

Look into sequence

Simulated data with Observed data





Calibration criteria

Compare Simulated data with Observed data

1. Achieve Mass Balance

   Good comparison of volume ratio
2. Match Flow hydrograph (Yearly, monthly and daily)

   Good comparison of hydrograph shape
3. Match Flow Distribution Patterns

   Good comparison of flow duration curves

Calibration criteria

Statistics

1. Assessment of preservation of mass
(Error of Volume Ratio, %)

$$V_r = \left(1 - \frac{\sum_{i=1}^{n} S_i}{\sum_{i=1}^{n} O_i}\right) * 100\%$$

90 - 110

$O_i = Observed\ \ flow\ at\ day\ i$
$S_i = Simulated\ \ flow\ at\ day\ i$
$i = Day\ no.\ i$
$n = Number\ of\ \ days$
$\overline{O} = Mean\ of\ \ observed\ \ \ flows$

2.Assessment of preservation of daily and monthly flow peaks

(Coefficient of Efficiency, Nash-Suttcliffe)

$$CE = 1 - \frac{\sum_{i=1}^{n} (O_i - S_i)^2}{\sum_{i=1}^{n} (O_i - \overline{O})^2}$$

> 0.65

Evaluate the efficiency of model

Coefficient of efficiency

Value	Performance Rating	Modeling Phase	Reference
> 0.65	Very Good	Calibration and validation	Saleh et al.(2000)
0.54 to 0.65	Adequate	Calibration and validation	Saleh et al.(2000)
> 0.50	Satisfactory	Calibration and validation	Santhi et al. (2001); adopted by Bracmort et al. (2006)
< 0.65	Satisfactory	Calibration and validation	Santhi et al. (2004); adopted by Narasimhan et al. (2005)

After D.N.Moriasi et al. (2007)

Calibration Method

- Optimization Method (Auto-Calib.)

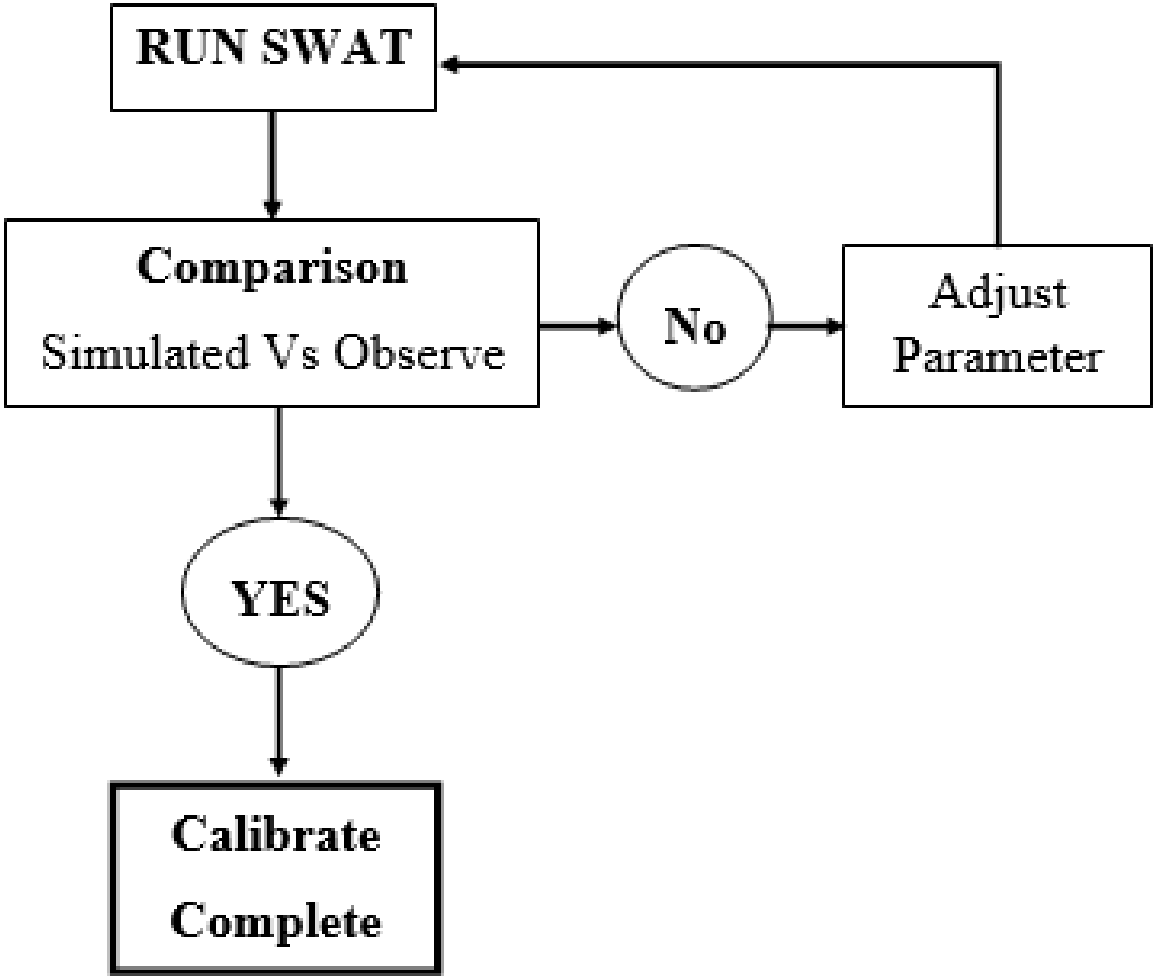
  → SWAT CUP

- Manual Method (Trial & Error)

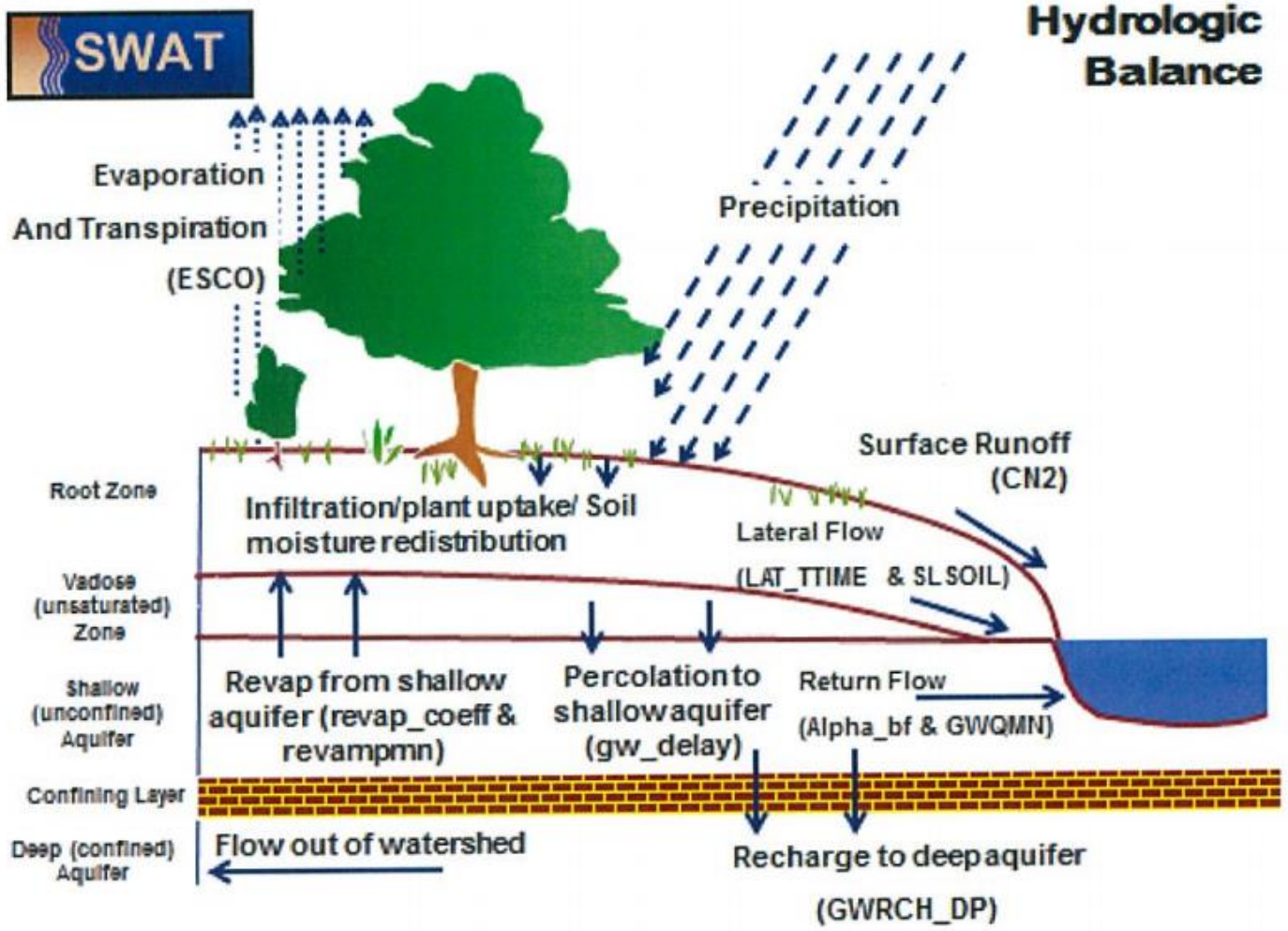
Calibration steps

1. **Separate base flow (using base flow filter program)**
2. **Extract result from the model for comparison**
3. Check compared values then select parameters for calibration
4. Adjust Parameters

Calibrate flowchart



Parameter for SWAT Calibration



Parameter for SWAT Calibration

Group	Parameter	Description	Value	Sensitive
GW	AlPHA_BF	Base flow recession factor, days	0.02 - 0.8	low
	REVAPMN	Threshold depth for revaporation to occur, mm	0 - 1500	low
	GWQMN	Threshold depth for ground water flow to occur, mm	0 - 500	low
	GW_DELAY	Ground water deleys, days	0 - 150	high
	RCHRG_DP	Deep aquifer recharge fraction	0 - 0.4	high
	GW_REVAP	Ground water revaporation coefficient	0.02 - 0.2	low

Technique for SWAT Calibration

Check Surface Runoff

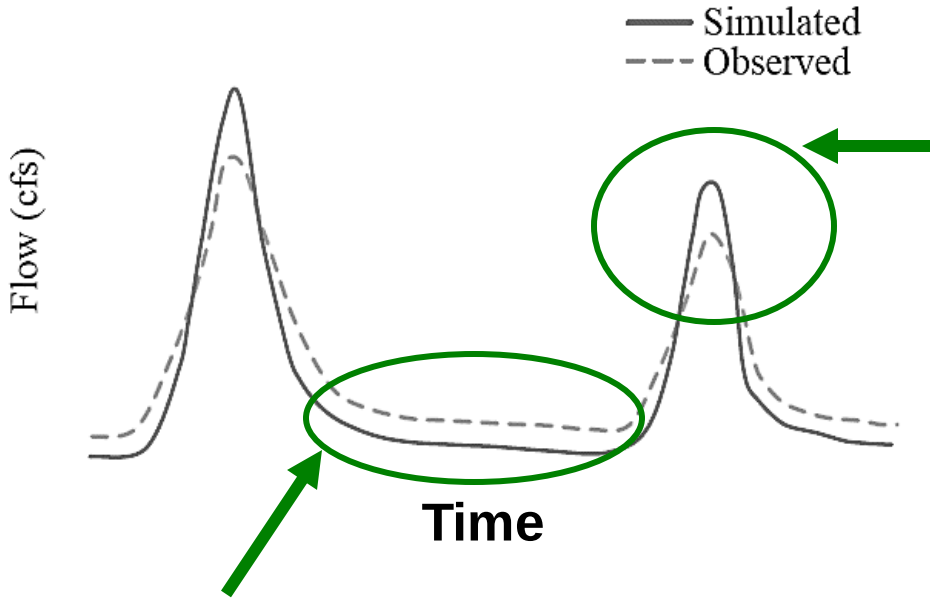
Surface	Parameter		
	CN	Sol_AWC	ESCO
Too high	decrease ↓	increase ↑	decrease ↓
Too low	increase ↑	decrease ↓	increase ↑

Check Subsurface Runoff

Subsurface (Baseflow)	Parameter		
	GW_REVAP	REVAPMN	GWQMN
Too high	increase ↑	decrease ↓	increase ↑
Too low	decrease ↓	increase ↑	decrease ↓

Technique for SWAT Calibration

Example 1



1. High Surface flow

   Adjust :

   CN (*.mgt)

   SOL_AWC (*.sol)

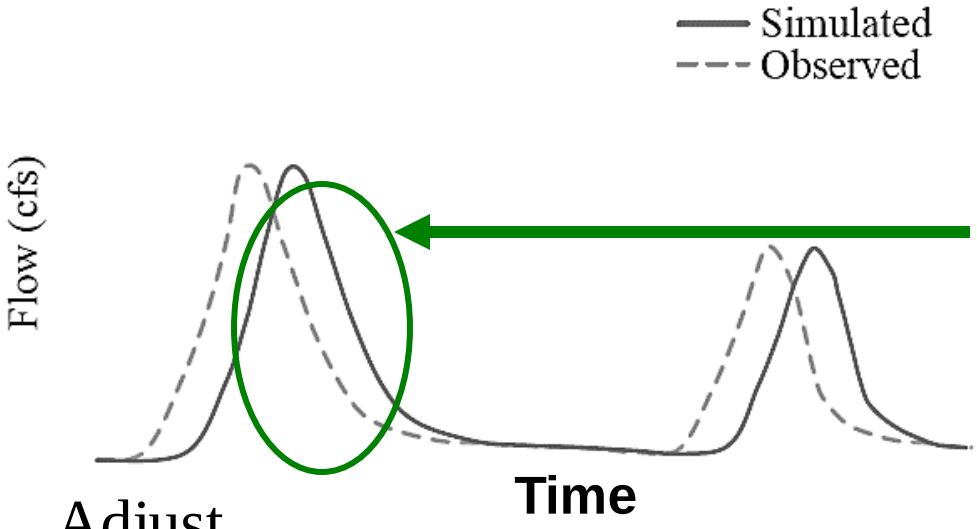
   ESCO (*.sub)

2. Little Base flow

   Adjust：GW parameter (*.gw)

Technique for SWAT Calibration

Example 2



Lag Time

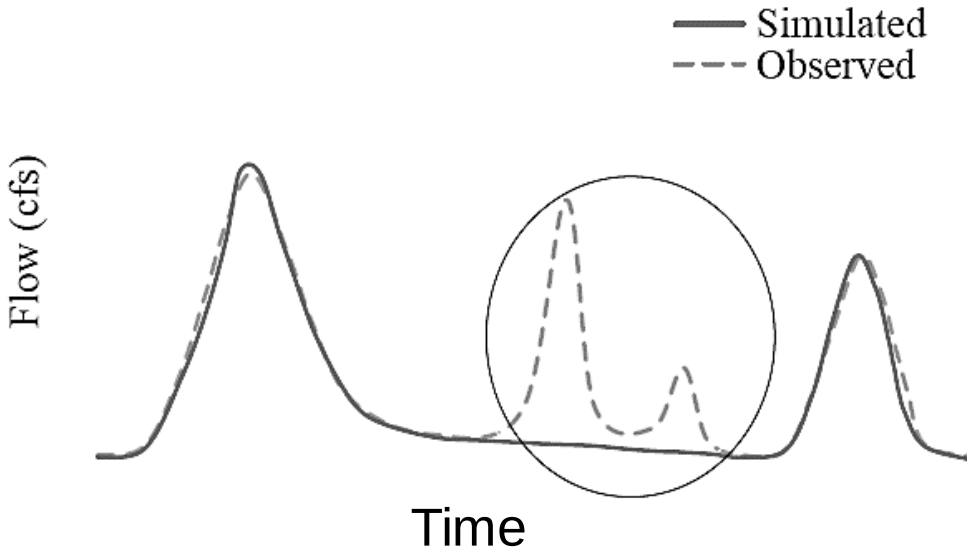
- Tc is too long
- Less than actual slope for overland flow
- Over estimated surface roughness
- Flood routing coefficients

Adjust

- Increase slope for overland flow (SLOPE)
- Manning's roughness coefficient , lower it after checking OV_N tables (OV_N)
- The value of overland flow length- lower to 5-10m, if necessary (SLSUBBSN)

Technique for SWAT Calibration

Example 3



Flow missing

Rainfall data is not represent or missing

Common Problems on Calibration

- Too little data or monitoring period too short
- No observed data
- Prediction of future conditions which are outside the model conditions
- Adjustment of the wrong parameter
- Adjustments destroy physical representation of system by model

Output SWAT model

- rch
- tblDepDef
- tblHruDef
- tblMgtdef
- tblPotDef
- tblRchDef
- tblRsvDef
- tblSedDef
- tblSnuDef
- tblSnwDef
- tblSubDef
- tblSwrDef
- tblVelDef
- tblWqlDef
- tblWtrDef

SUB	YEAR	MON	AREAkm2	FLOW_INcm	FLOW_OUTc
1	1985	1	1560	38.1	38.82
2	1985	1	2520	65.6	65.51
3	1985	1	3038	77.7	76.14
4	1985	1	4016	96.0	99.78
5	1985	1	195.2	6.40	6.403
6	1985	1	5204	130.2	130
7	1985	1	627.9	26.4	26.37
8	1985	1	5861	148.5	146.7
9	1985	1	258.9	6.35	6.344
10	1985	1	146.1	6.30	6.292
11	1985	1	6496	180.7	180.5
12	1985	1	1074	36.7	36.67
13	1985	1	267.7	16.2	16.28
14	1985	1	1937	77.1	77.09
15	1985	1	173.3	4.59	4.591
16	1985	1	1452	36.3	36.27
17	1985	1	302.3	9.50	9.373
18	1985	1	2430	98.5	98.41
19	1985	1	9120	234	232.9
20	1985	1	501.7	9.80	9.844
21	1985	1	261.5	5.00	5.01

SWAT Calibration

Simulation Flow out

Date	Obs	FLOW	Tcms	<-- Result put here	Calibration Performance Evaluation				
1-Jan-85	109.0		125.4		Period	COE	Vol. Ratio		1-6,8,10-11,16-17
2-Jan-85	7.0		211.1		1985-2000	0.54	87		,19-21,25,28
3-Jan-85			97.3		2001-2005	0.64	89		
4-Jan-85			86.2						
5-Jan-85			175.7		Statistic	Average	Max	Min	
6-Jan-85			67.3		Observed 1985-2000	412	10,068	16	
7-Jan-85			159		1985-2000	357	3,356	19	
8-Jan-85			152		Observed 2001-2007	468	7,495	52	
9-Jan-85			146.3		2001-2007	416	3,103	35	
10-Jan-85			141.2						
11-Jan-85			136.9	1985-2000	% Time Exceed	Observed	Modelled	% difference	Criteria
12-Jan-85			132.6	1%	99%	24.0	29.1	21%	
13-Jan-85			129.5	5%	95%	45.0	38.2	-15%	Lau Flow - 10%
14-Jan-85			126.4	10%	90%	56.0	47.8	-15%	
15-Jan-85			123.6	25%	75%	93.0	77.9	-16%	10%
16-Jan-85			121.1	50%	50%	205.0	175.3	-14%	10%
17-Jan-85			118.7	75%	25%	463.5	501.8	8%	10%
18-Jan-85			116.9	90%	10%	975.4	916.5	-6%	
19-Jan-85			114.8	95%	5%	1516.1	1213.2	-20%	Peak Flow - 10%
20-Jan-85			113.6	99%	1%	2929.6	1887.7	-36%	
21-Jan-85			111.6						
22-Jan-85			109.3		High	2,098,301	1,767,497	84.2	+- 10%
					Lau	306,107	316,926	103.5	+- 10%

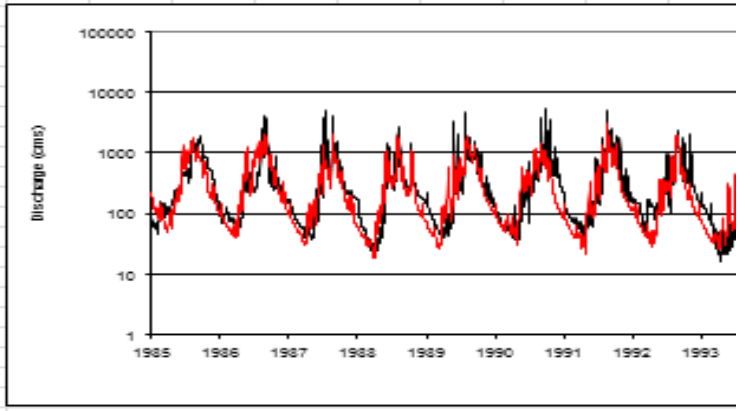


Figure : Calibration Period 1985 - 2000 a

Observe Flow out

Date	Obs	FLOW	Tcms		% Time Exceed	Observed	Modelled	% difference	Criteria
28-Jan-85	56.0		122.3	10%	99%	59.0	42.1	-29%	
29-Jan-85	51.0		120.1	25%	95%	62.0	50.5	-19%	Lau Flow - 10%
30-Jan-85	51.0		116.3	50%	90%	72.0	60.7	-16%	
31-Jan-85	46.0		112.5	75%	75%	99.0	89.6	-9%	10%
1-Feb-85	46.0		109	90%	50%	229.0	176.4	-23%	10%
2-Feb-85	46.0		105.1	95%	25%	616.0	575.8	-6%	10%
3-Feb-85	46.0		101.8	99%	10%	983.5	1154.0	17%	
4-Feb-85	46.0		98.15		5%	1636.5	1403.3	-14%	Peak Flow - 10%
5-Feb-85	46.0		96.01		1%	3092.3	2238.8	-28%	
6-Feb-85	56.0		93.51						
7-Feb-85	62.0		91.39		High	746,632	636,653	85.3	+- 10%
8-Feb-85	62.0		89.27		Lau	106,013	120,819	114.0	+- 10%

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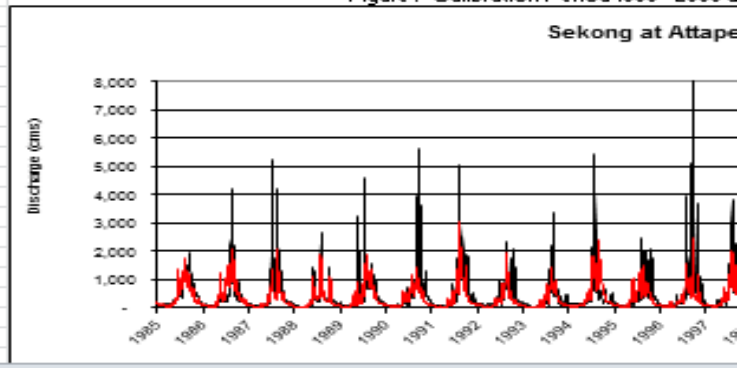

Exercise

- Calibration and see results

Contract
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