MRCS
IKMP-Modelling Team
Sediment Workshop 21-22 Oct 2008

Application of SWAT model for Erosion and Sediment Transportation in the LMRB

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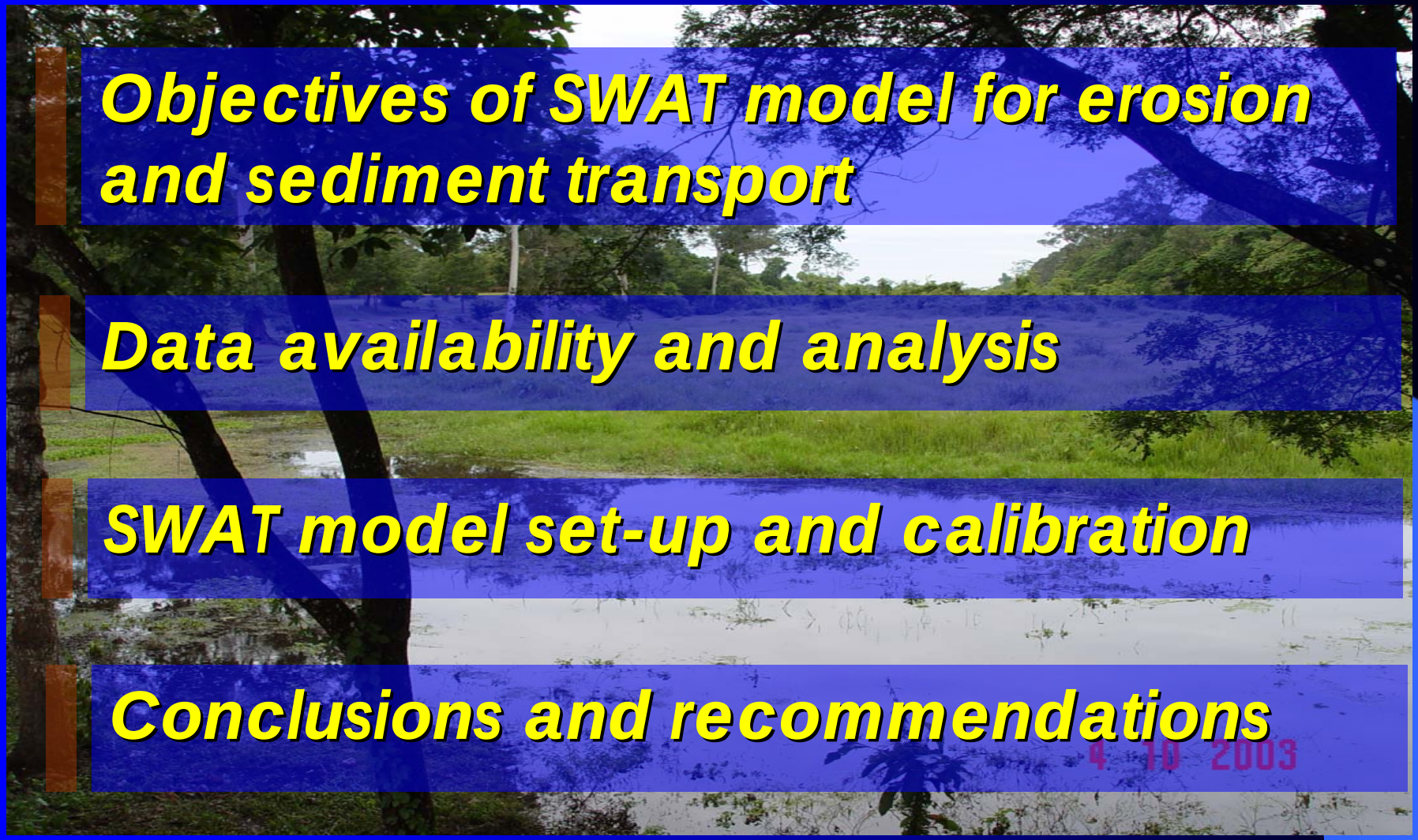
Water Resources Modelling Expert

TOPICS



- *Objectives of SWAT model for erosion and sediment transport*
- *Data availability and analysis*
- *SWAT model set-up and calibration*
- *Conclusions and recommendations*

Objectives of SWAT Model for erosion and sediment transport

- *To understand more on SWAT Model capabilities for erosion and sediment transport;*
- *To start-up model set-up for water quality of Mekong River Basin;*
- *To investigate the status of sediment data available inside MRCS;*
- *To gradually build-up the experience of MRCS Modeling Team on erosion and sediment modelling;*
- *The study can be extended to meet the future needs of other programmes on the issue of erosion and sedimentation.*


Data availability and analysis
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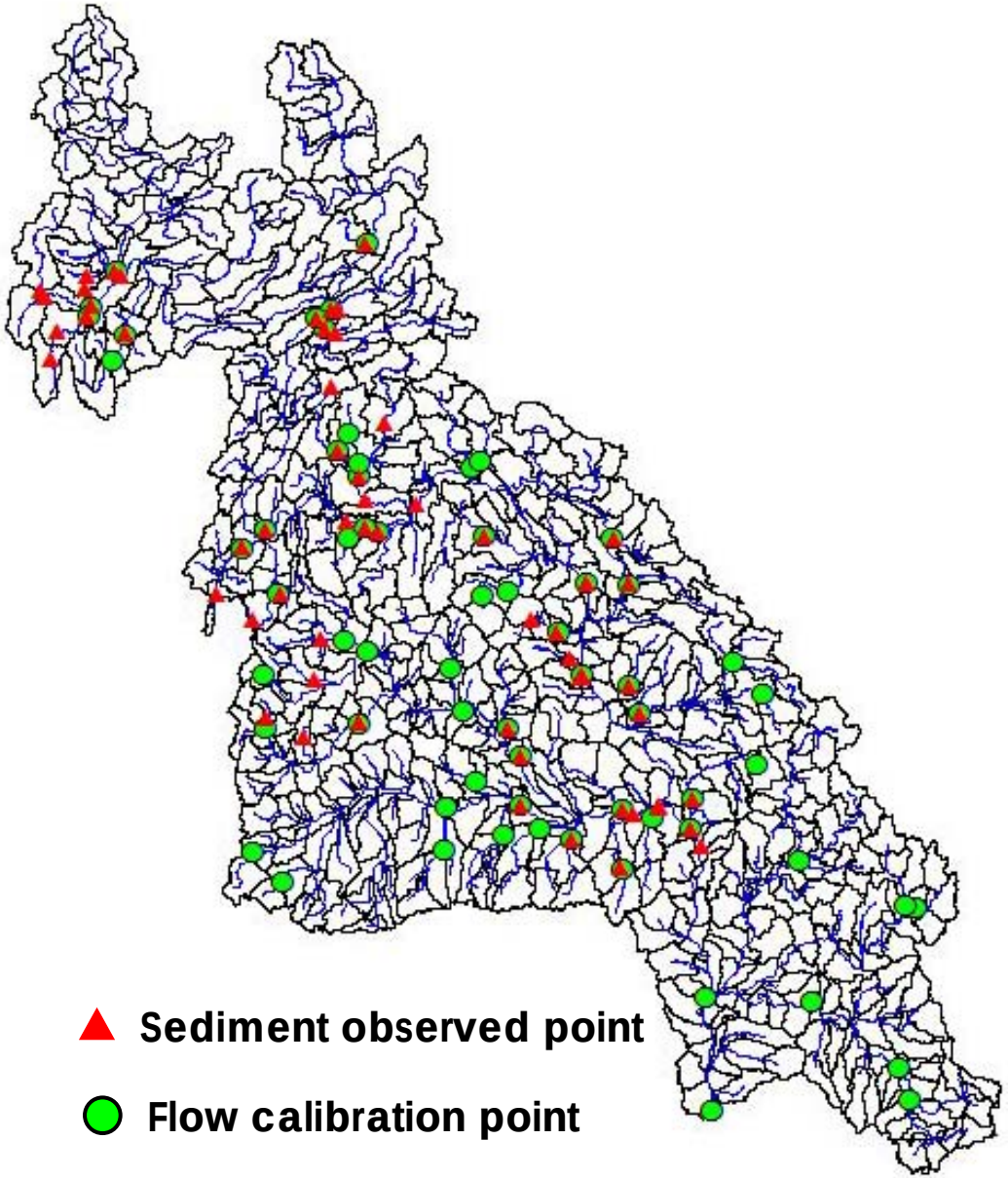
MRCS

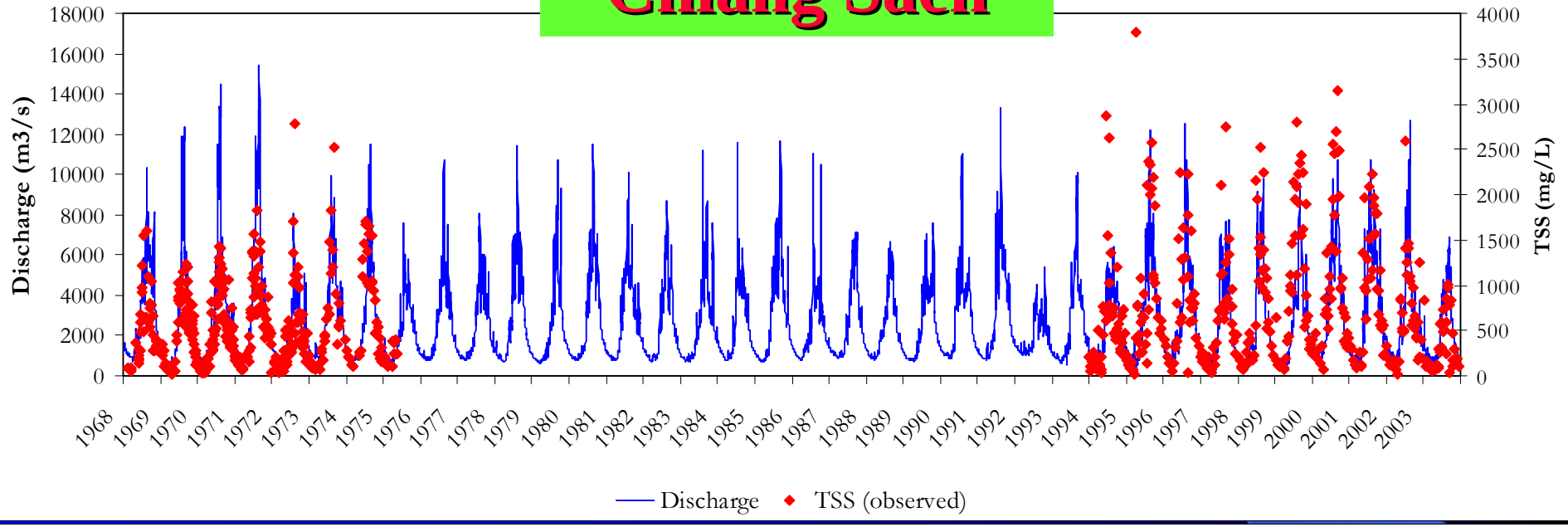
HYMOS

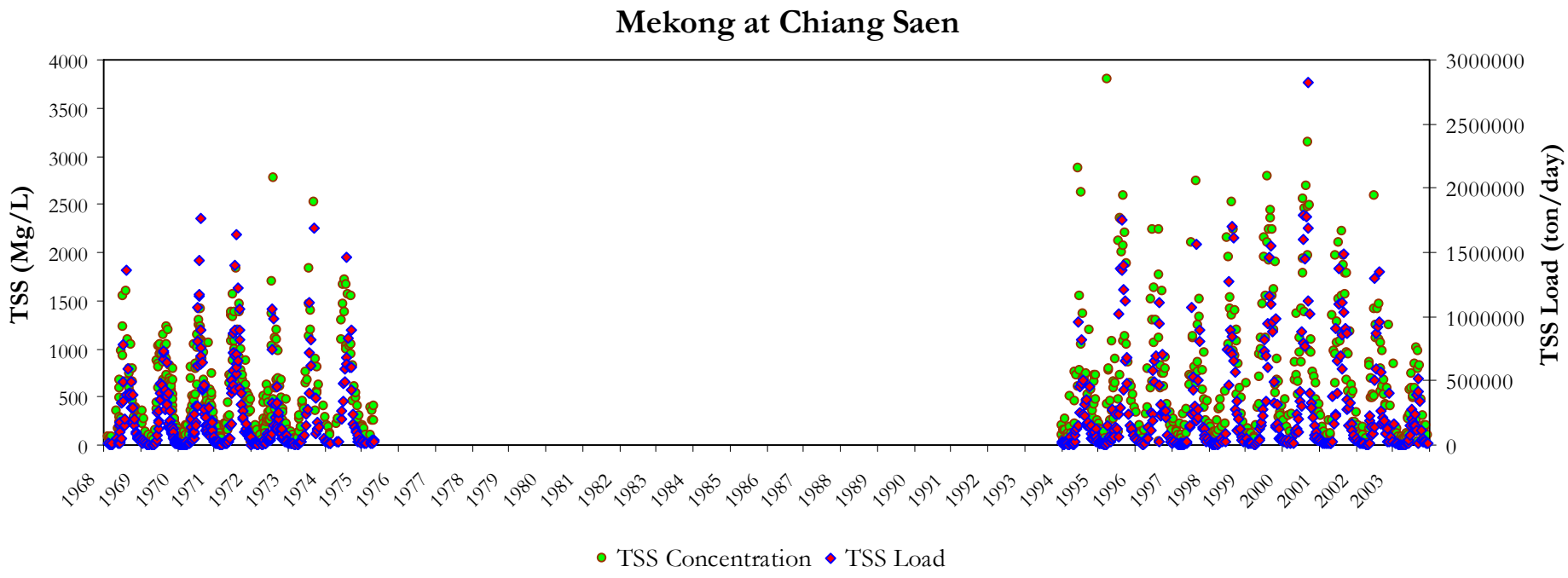


Sediment Sampling & Flow Measurement Points

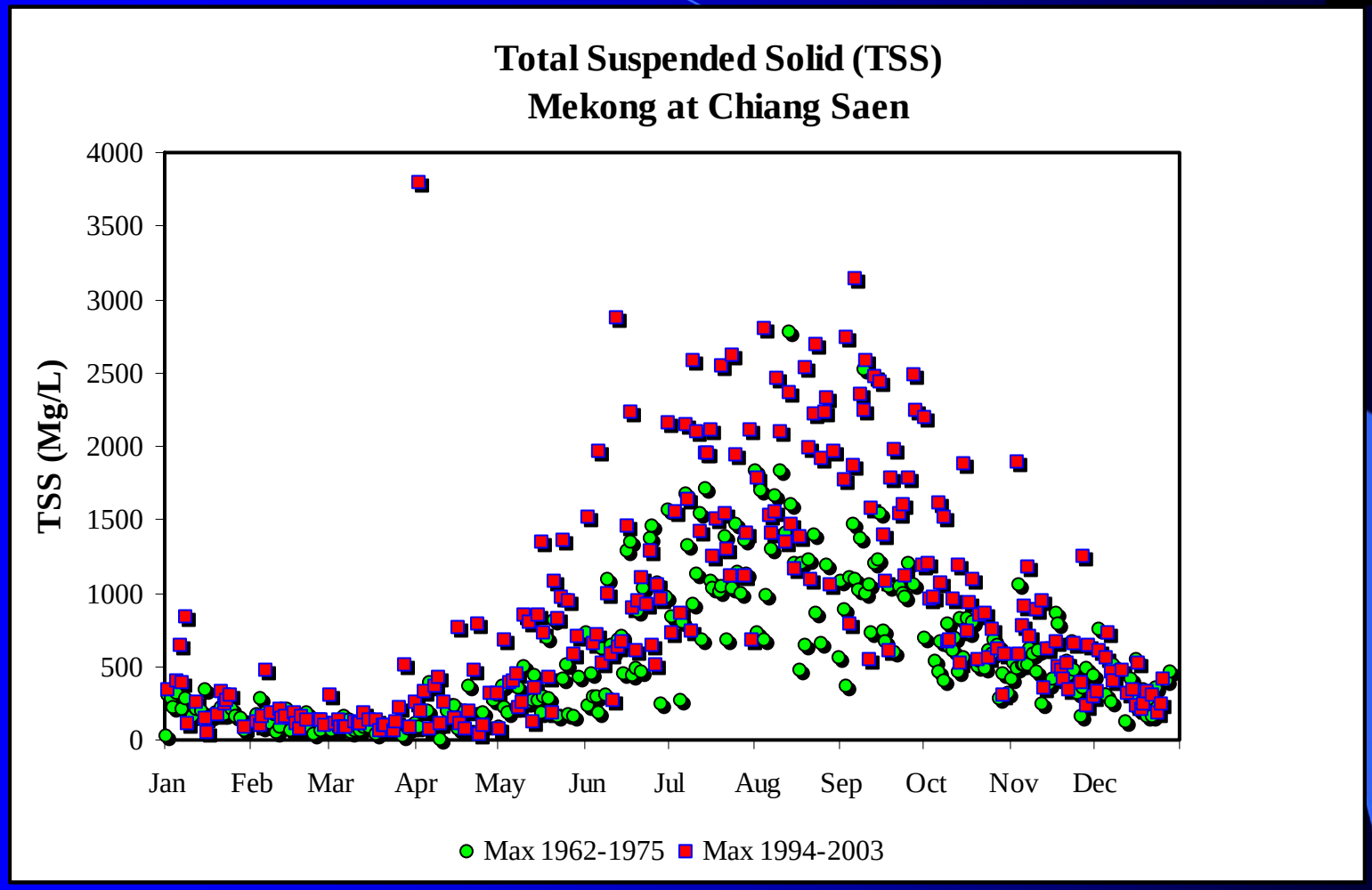
NO.	STNID	STNAME	RIVER	COUNTRY	LAT	LON	Data Availability	Sub-model
1	11201	Luang Prabang	Mekong	Laos	19.89	102.14	62;85-92;97-02	2
2	10501	Chiang Sean	Mekong	Thailand	20.27	100.08	62,68-75, 94-03	2
3	70103	Thoeng	Nam Mae Ing	Thailand	19.69	100.19	69-03	2
4	50104	Chiang Rai	Nam Mae Kok	Thailand	19.92	99.85	77-81;85-94	2
5	50301	Ban Tha Sai	Nam Mae Lao	Thailand	19.85	99.84	72-03	2
6	100102	Muong Ngoy	Nam Ou	Laos	20.70	102.76	90;96-02	2
7	110101	Ban Sibounhom	Nam Suong	Laos	19.97	102.27	91;	2
8	150101	Wang Saphung	Nam Loei	Thailand	17.30	101.78	68-87;89-03	3
9	12001	Nong Khai	Mekong	Thailand	17.88	102.72	72-78,81-92,94-04	4
10	13402	Mukdahan	Mekong	Thailand	16.54	104.74	62-82, 84-04	4
11	310102	Nam Kae	Nam Kam	Thailand	16.96	104.51	75-00	4
12	230201	Ban Hin Heup	Nam Lik	Laos	18.66	102.36	67;90-93;97-02; 05	4
13	230101	Ban Pak Kanhoung	Nam Ngum	Laos	18.42	102.55	93;97-02; 05	4
14	270903	Ban Signo	Nam Theun	Laos	17.85	105.05	96-02; 05	4
15	320107	Mahaxai	Se Bang Fai	Laos	17.41	105.20	90-92;96;98-02; 05	4
16	381206	Ban Huai Khayuong	Huai Khayuong	Thailand	15.01	104.64	79-03	5
17	381503	Ban Fang Phe	Lam Dom Yai	Thailand	14.69	105.16	69-99	5
18	13901	Pakse	Mekong	Laos	15.12	105.80	62;90;97-02	5
19	380103	Ubon	Nam Mun	Thailand	15.22	104.86	62-03	5
20	350101	Ban Keng Done	Se Bang Hieng	Laos	16.19	105.32	62;91-92;97-00	5
21	350601	Kengkok	Se Champhone	Laos	16.45	105.20	97-00	5
22	390104	Souvanna Khili	Se Done	Laos	15.40	105.83	93;96-02; 05	5
23	371101	Ban Nong Kiang	Huai Rai	Thailand	16.13	101.67	75-78;81-03	7
24	370104	Yasothom	Nam chi	Thailand	15.78	104.14	62-03	7
25	370122	Ban Chot	Nam Chi	Thailand	16.10	102.58	75-03	7
26	371509	Ban Na Thom	Nam Yang	Thailand	16.06	104.04	79-03	7
27	380134	Rasi Salai	Nam Mun	Thailand	15.34	104.16	79-03	8

Chiang Saen

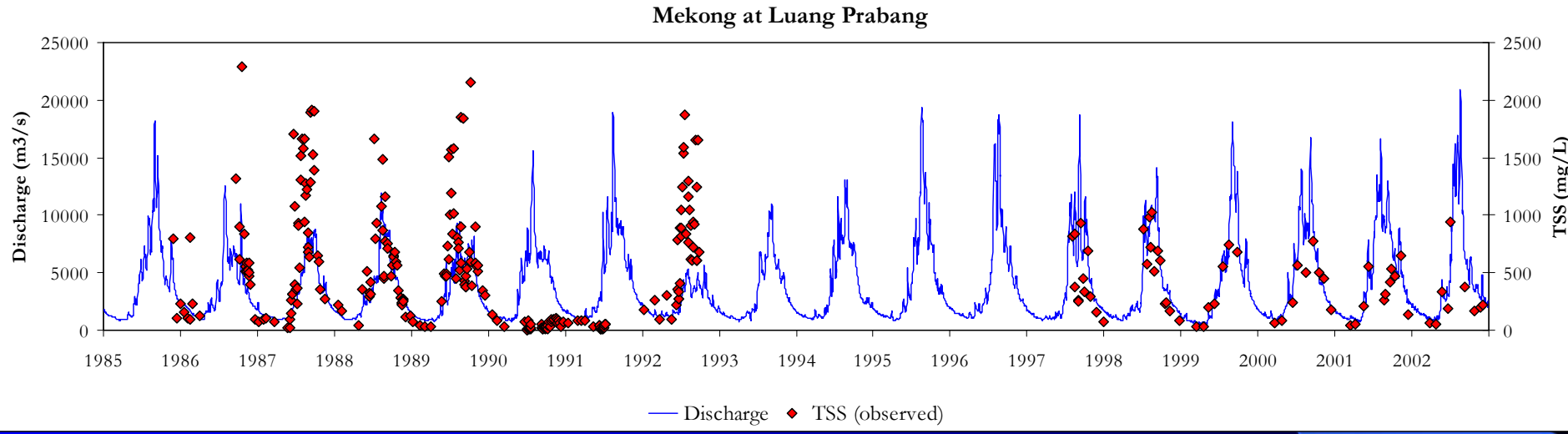

Discharge (m3/s)
TSS (mg/L)
Discharge
TSS (observed)

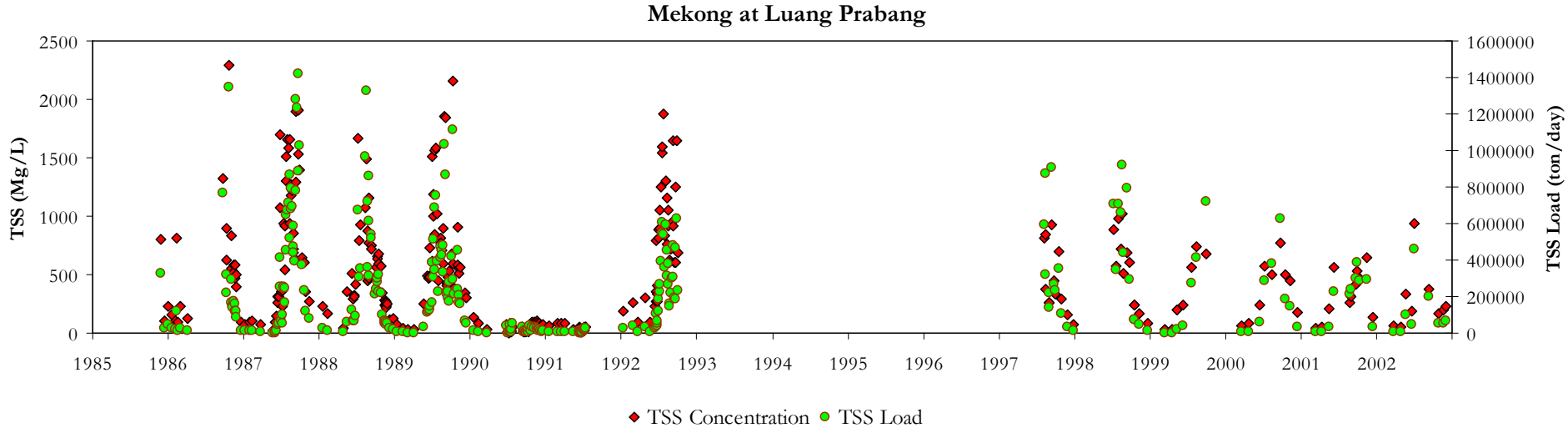

Mekong at Chiang Saen
TSS (Mg/L)
TSS Load (ton/day)
TSS Concentration
TSS Load

Chiang Saen

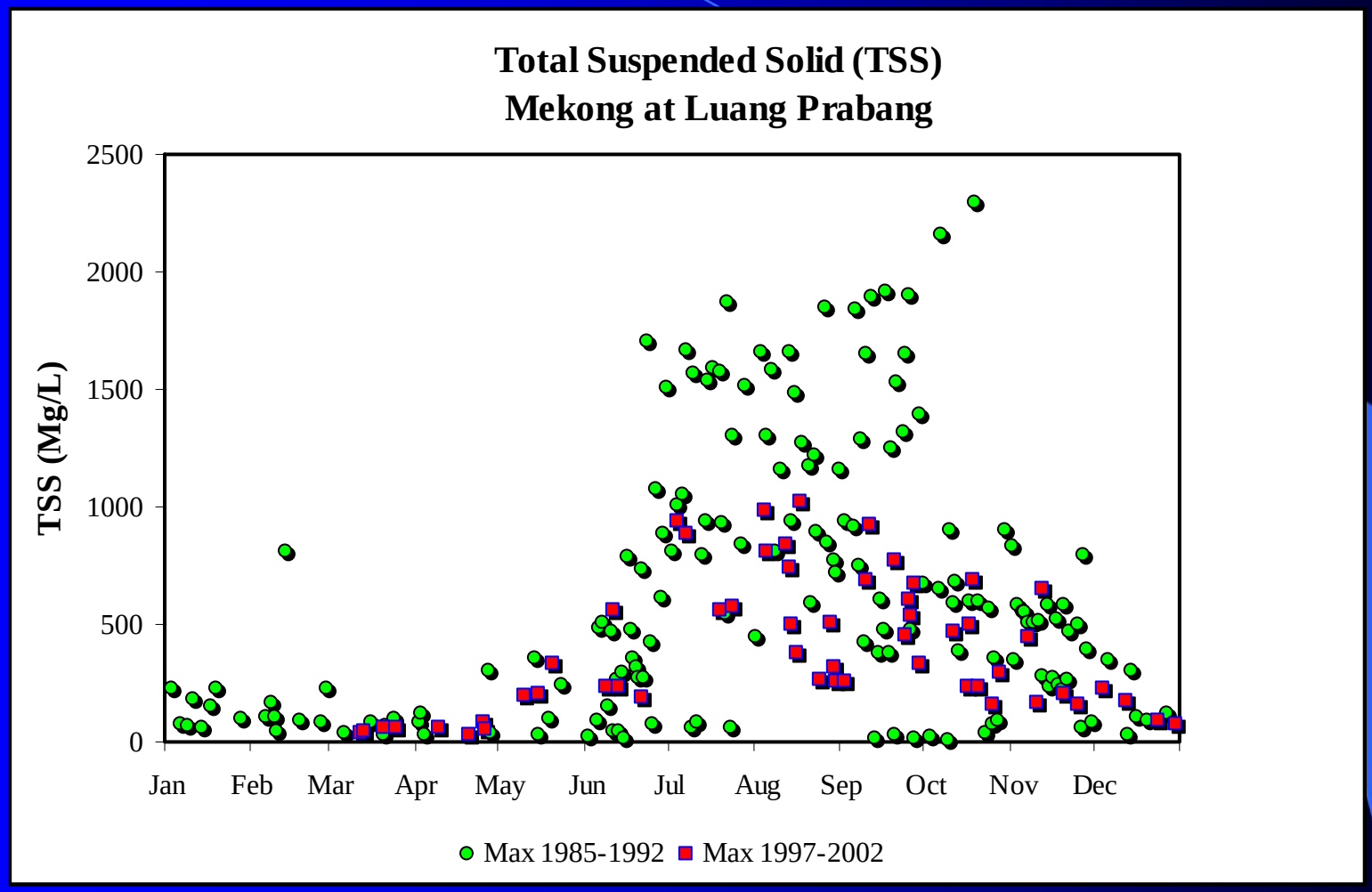

Total Suspended Solid (TSS)
Mekong at Chiang Saen
TSS (Mg/L)
4000
3500
3000
2500
2000
1500
1000
500
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Max 1962-1975
Max 1994-2003

Luang Prabang

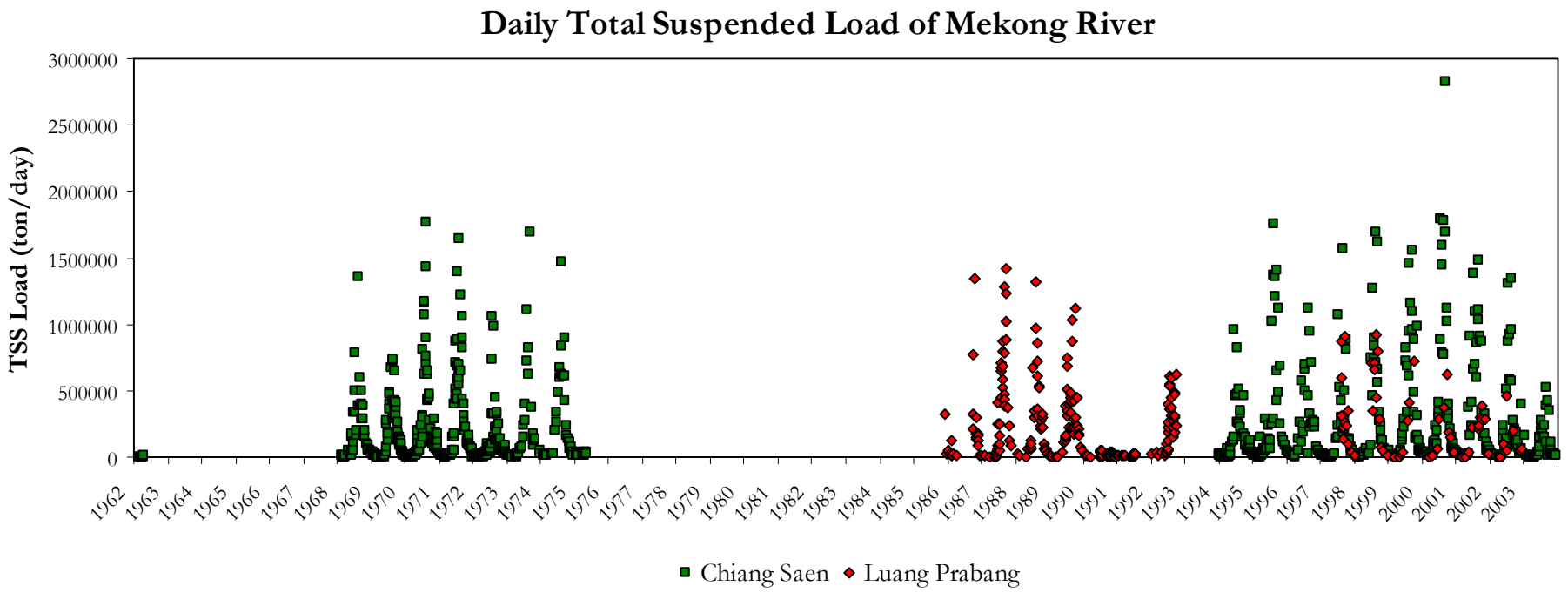


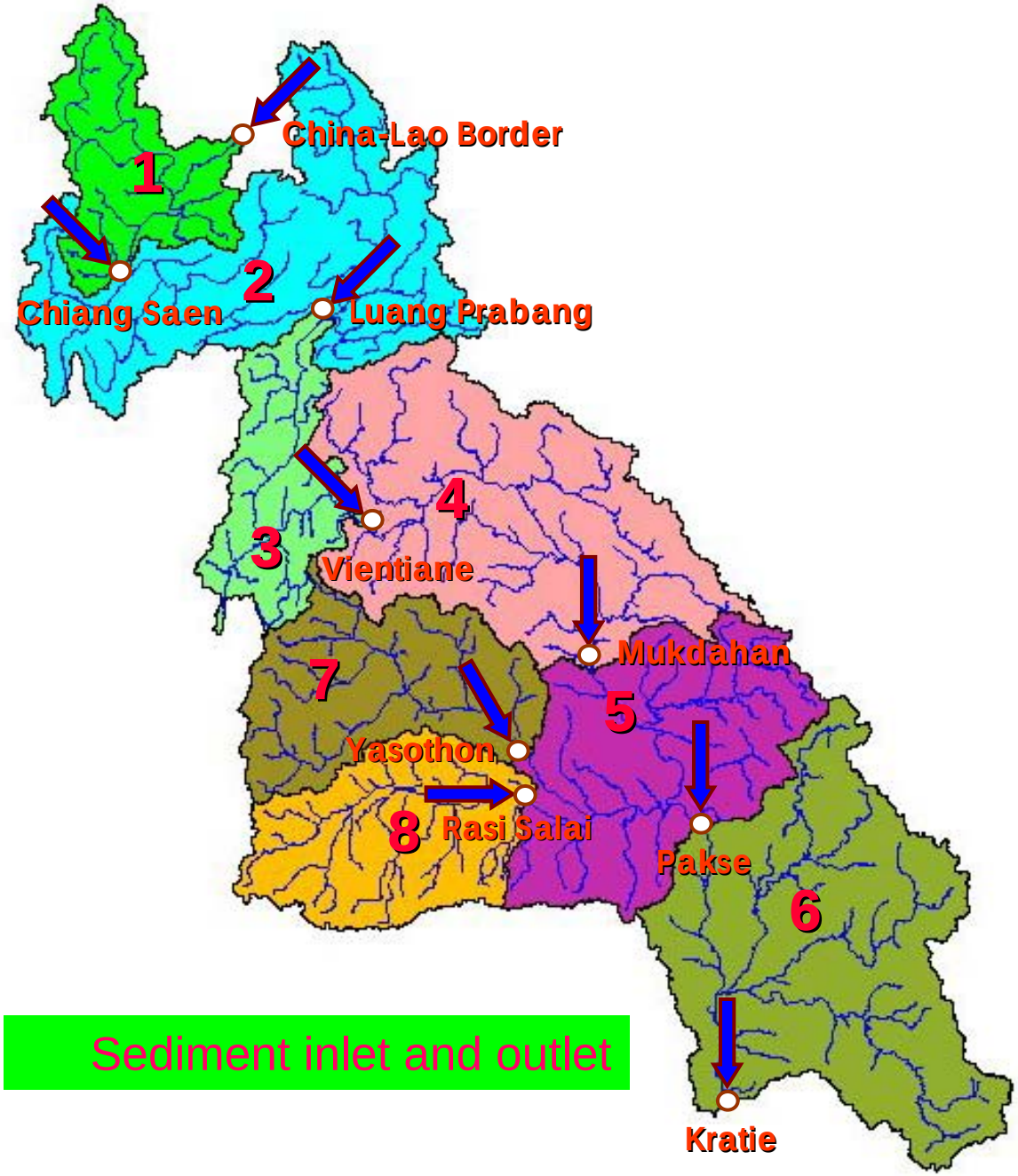


Luang Prabang



Sediment Load
Chiang Saen VS. Luang Prabang





Sediment inlet and outlet

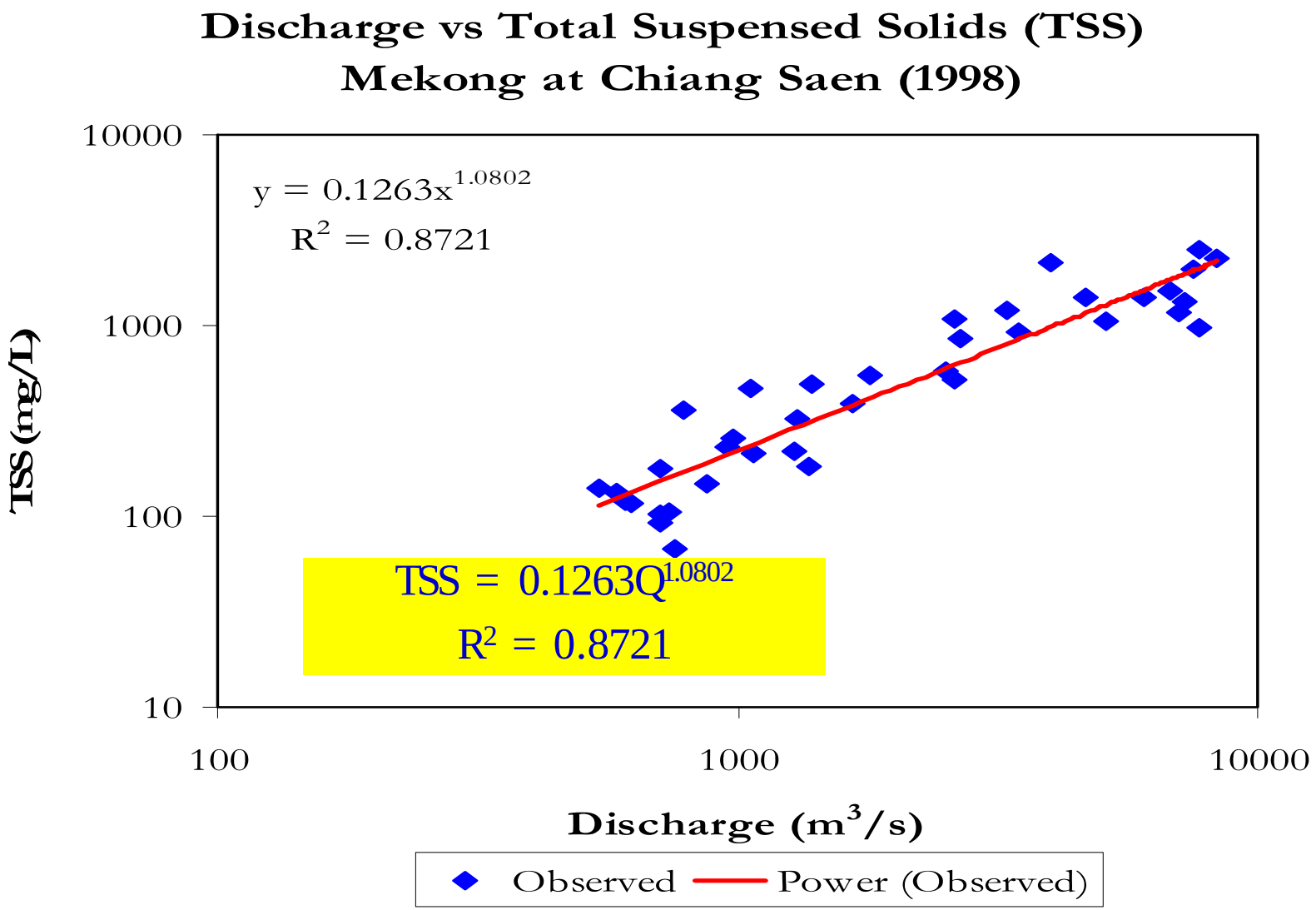
Sediment Rating Curves

- Applied for generating sediment concentration from daily observed flow and subsequently calculating daily sediment load;
- Derived year-by-year using regression analysis of flow vs TSS concentration;
- If the regression analysis for a year does not provide a good relationship, the analysis for multiple-year or whole data will be carried out;

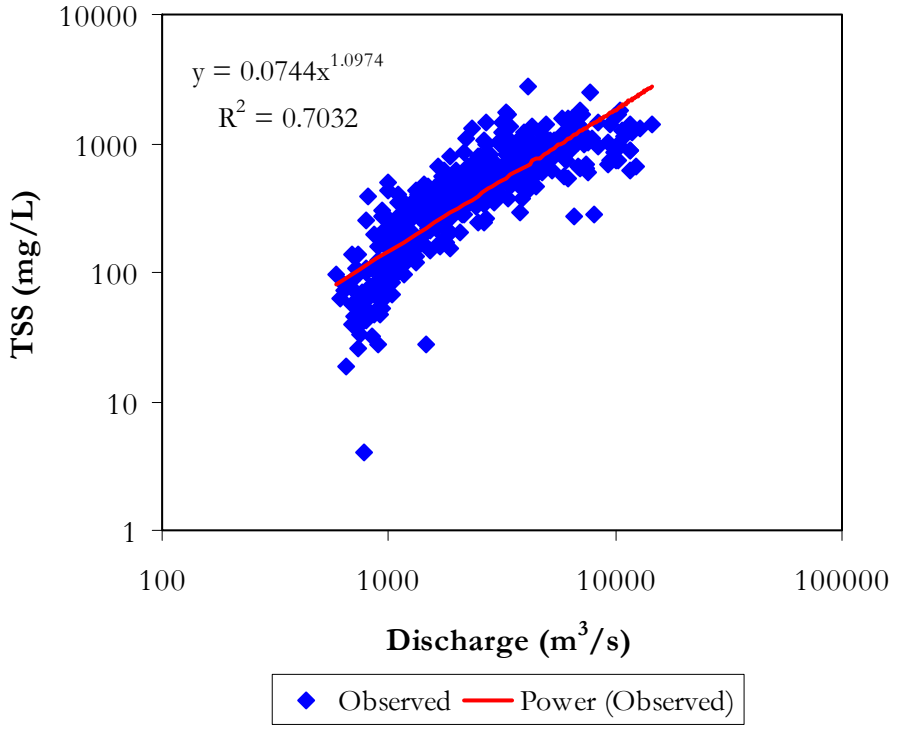
Daily Inlet Sediment Load

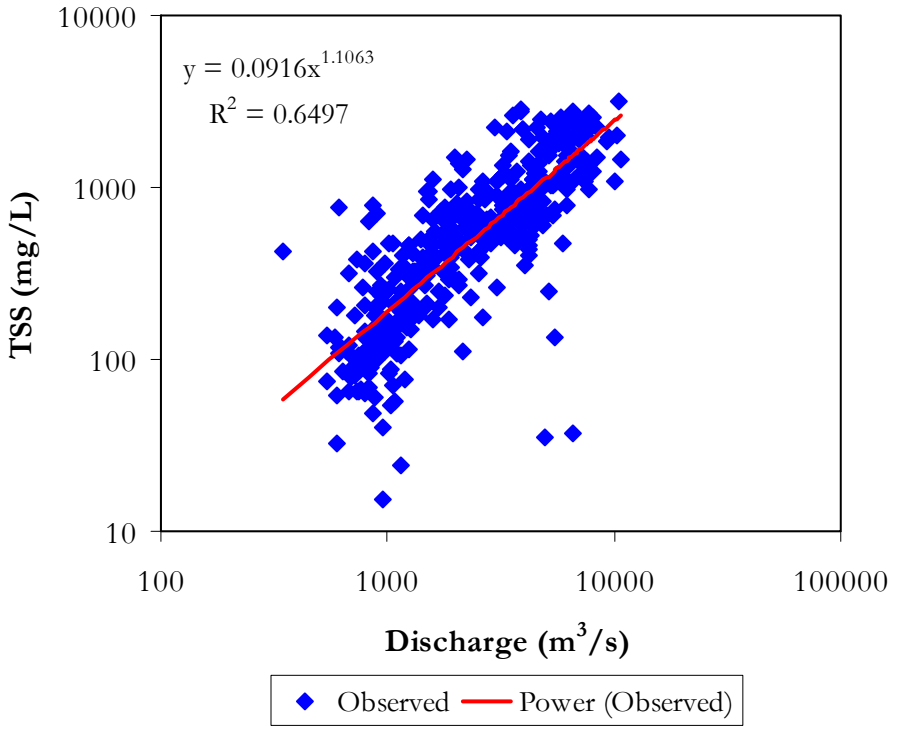
- TSS concentration (Mg/L) is calculated from daily observed flow and a rating curve;
- To maintain the observed TSS, the generated TSS concentration values had been used only for the data missing days;
- The obtained merged TSS (observed and generated) used to estimate daily sediment load at each SWAT inlet point;
- The obtained daily time series of inlet sediment load will be used for simulations of SWAT Sediment Model.

Sediment Rating Curves: Chiang Saen (1/2)



Sediment Rating Curves: Chiang Saen (2/2)





$TSS = 0.0744Q^{1.0974}$

$R^2 = 0.7032$

$TSS = 0.0916Q^{1.1063}$

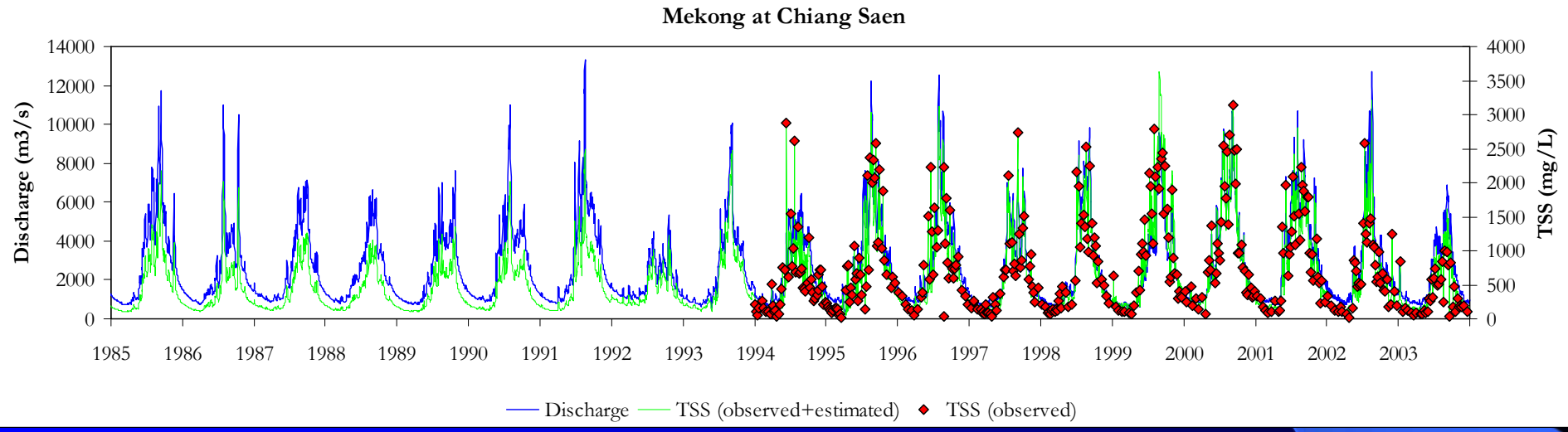
$R^2 = 0.6497$

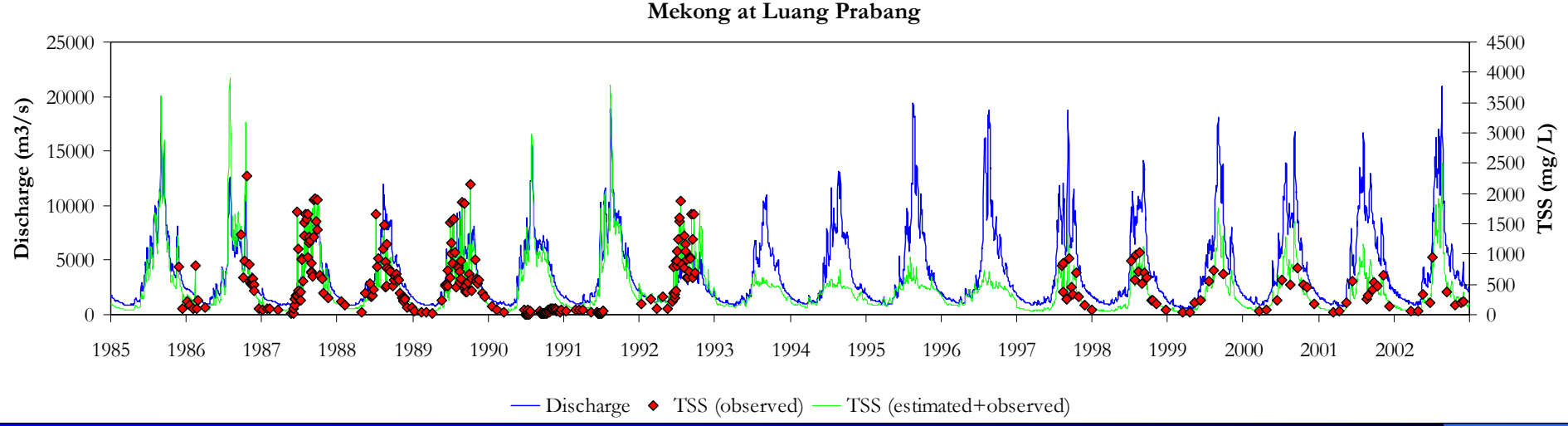
Year	Mekong at Chiang Saen		Mekong at Luang Prabang		Mekong at Nong Khai		Mekong at Mukdahan		Mekong at Pakse	
	Current Calculation	Prof. Walling (2005)	Current Calculation	Prof. Walling (2005)	Current Calculation	Prof. Walling (2005)	Current Calculation	Prof. Walling (2005)	Current Calculation	Prof. Walling (2005)
1960										
1961		71.3		112.4				144.5		165.8
1962	78.0						126.9	129.1		180.0
1963	69.4						148.4	140.2		
1964	84.5						112.8	96.9*		
1965	83.7						107.6	112.1		
1966	200.7						174.8	183.2		
1967	52.4						73.5	60.8*		
1968	70.7	59.1					77.6	77.6		
1969	70.8	60.6					87.4	87.6		
1970	95.6	76.6					123.8	110.8		
1971	126.6	98.2					140.5	117.3		
1972	35.7	45.2			58.8	85.0	70.4	69.6		
1973	66.9	85.4			122.3	113.6	99.1	97.0		
1974	69.7	80.8			83.4	72.2	82.3	81.5		
1975	34.3				62.8	57.5	101.9	98.8		
1976					51.3	67.9	70.3	71.3		
1977					54.2	56.5	48.7	47.3		
1978					76.6	77.5	105.0	102.4		
1979					50.1		57.2	56.5		
1980					106.7		66.6	73.2		
1981					70.7	78.3	54.1	48.9*		
1982					87.0	60.3	59.6	69.2		
1983					71.0	83.4	75.8			
1984					93.4	87.6	73.3	79.0		
1985	82.8		163.1		115.9		105.9		68.8	
1986	49.7		129.0	106.6	61.1	56.9*	84.1	84.0	50.5	
1987	48.4		83.5	86.7	50.7	47.1*	72.2		44.3	
1988	40.9		61.2	62.7	76.2	79.0	69.1		35.0	
1989	43.9		73.2	74.9	79.8	80.5	105.7	111.2	45.7	
1990	65.8		120.1		96.2	100.3	158.4	160.3	63.2	
1991	87.5		175.3		92.1	105.3	151.1	147.6	80.2	
1992	30.5		58.4	62.0	38.8	42.5	44.8	48.7	31.9	
1993	77.8		44.1		56.1		71.7	71.1	45.0	
1994	57.3	58.3	52.4		82.3	84.4	108.9	118.9	84.1	
1995	113.1	119.9*	67.5		62.9	78.5*	117.6	113.4	75.4	
1996	103.8	97.2*	61.4		79.2	79.9	85.6	80.6	80.1	
1997	70.4	69.7	58.4	59.5	56.5	54.7	91.9	81.7	79.7	
1998	98.0	94.8	59.1	55.4	55.1	51.0	100.7	95.2	40.9	
1999	128.2	122.6	92.9		68.7	62.8	165.9	157.8	67.2	74.6
2000	145.6	147.0	91.7		81.3	78.4*	228.7	199.1	122.5	121.4
2001	127.3	127.0	80.8	71.2	87.3	81.7	225.8	216.3	153.7	168.0
2002	92.4	81.1	121.8		40.1	29.9*	235.1	237.8	157.3	174.6
2003	45.6	30.5								

Comparing TSS calculation with previous study

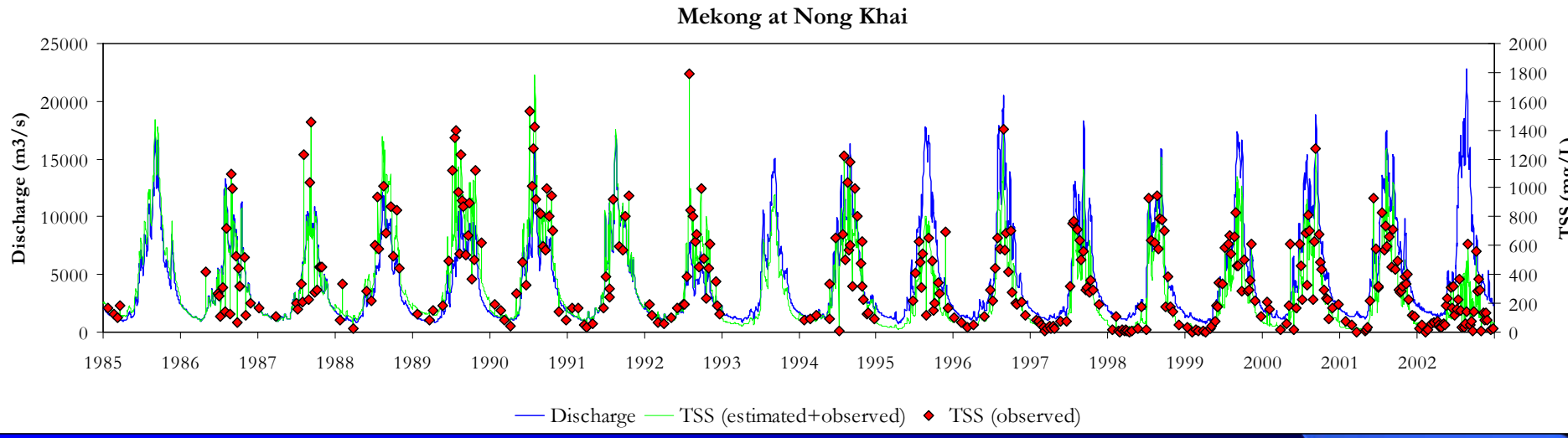
* include greater uncertainty

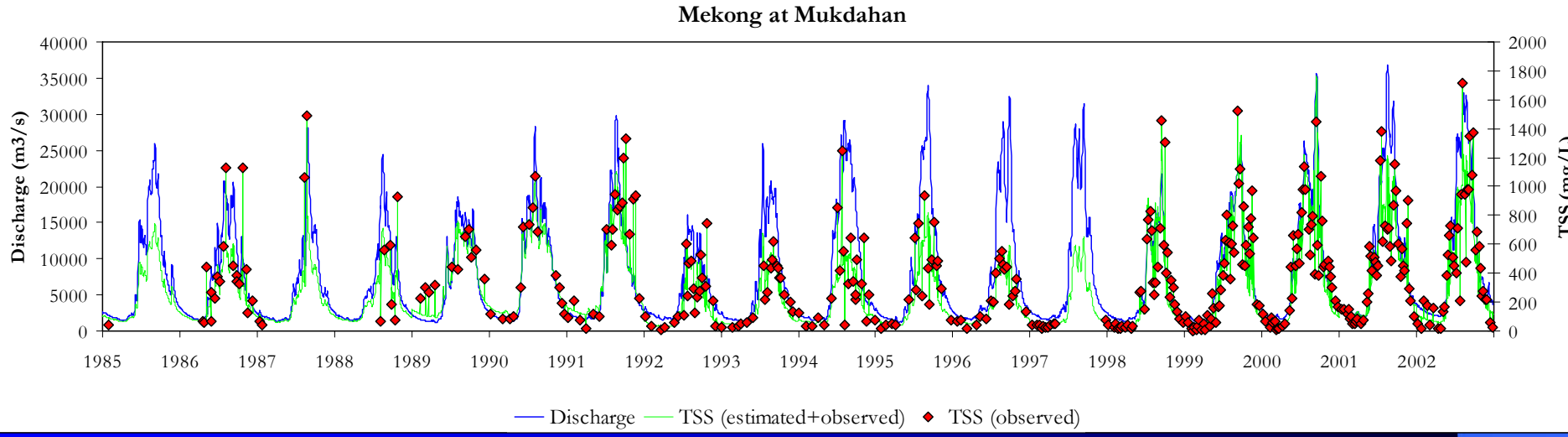
Daily Time Series of TSS Concentration (1/3)



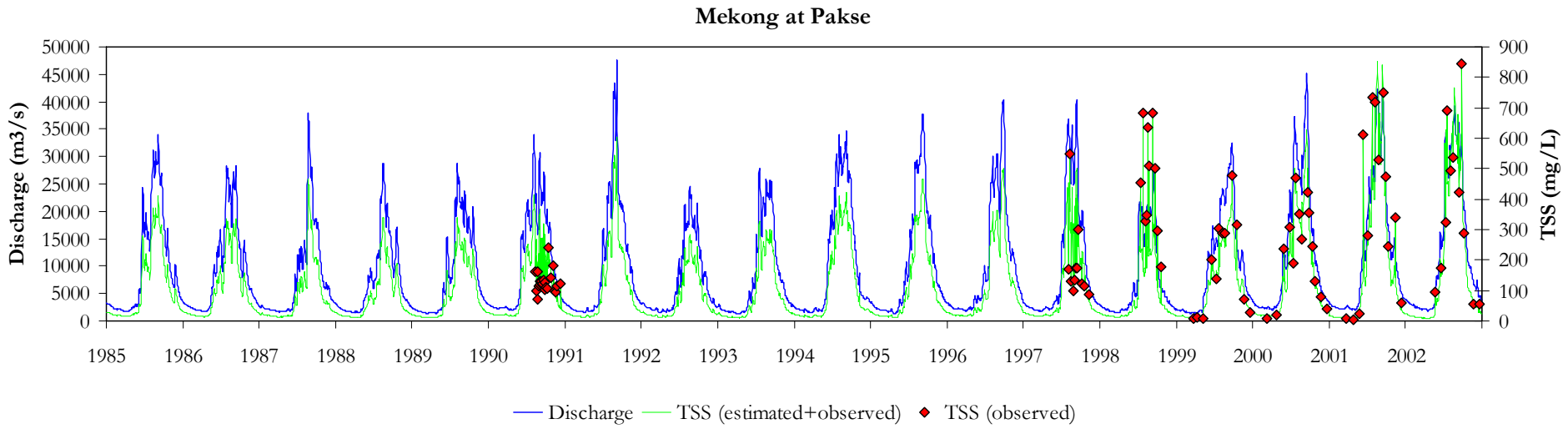


Daily Time Series of TSS Concentration (2/3)





Daily Time Series of TSS Concentration (3/3)



SWAT model set-up and calibration

Minimum data requirements for current model:

- Time series of daily sediment loads at SWAT model inlet estimated from observed point TSS data merged with estimated values obtained from sediment rating curves and observed daily flow;
- Point sediment loads calculated from observed point TSS data and daily observed flows. The calibration of sediment model will be carried out against point sediment loads;
- Existing reset-up and recalibrated SWAT models.

Parameters for model calibration:

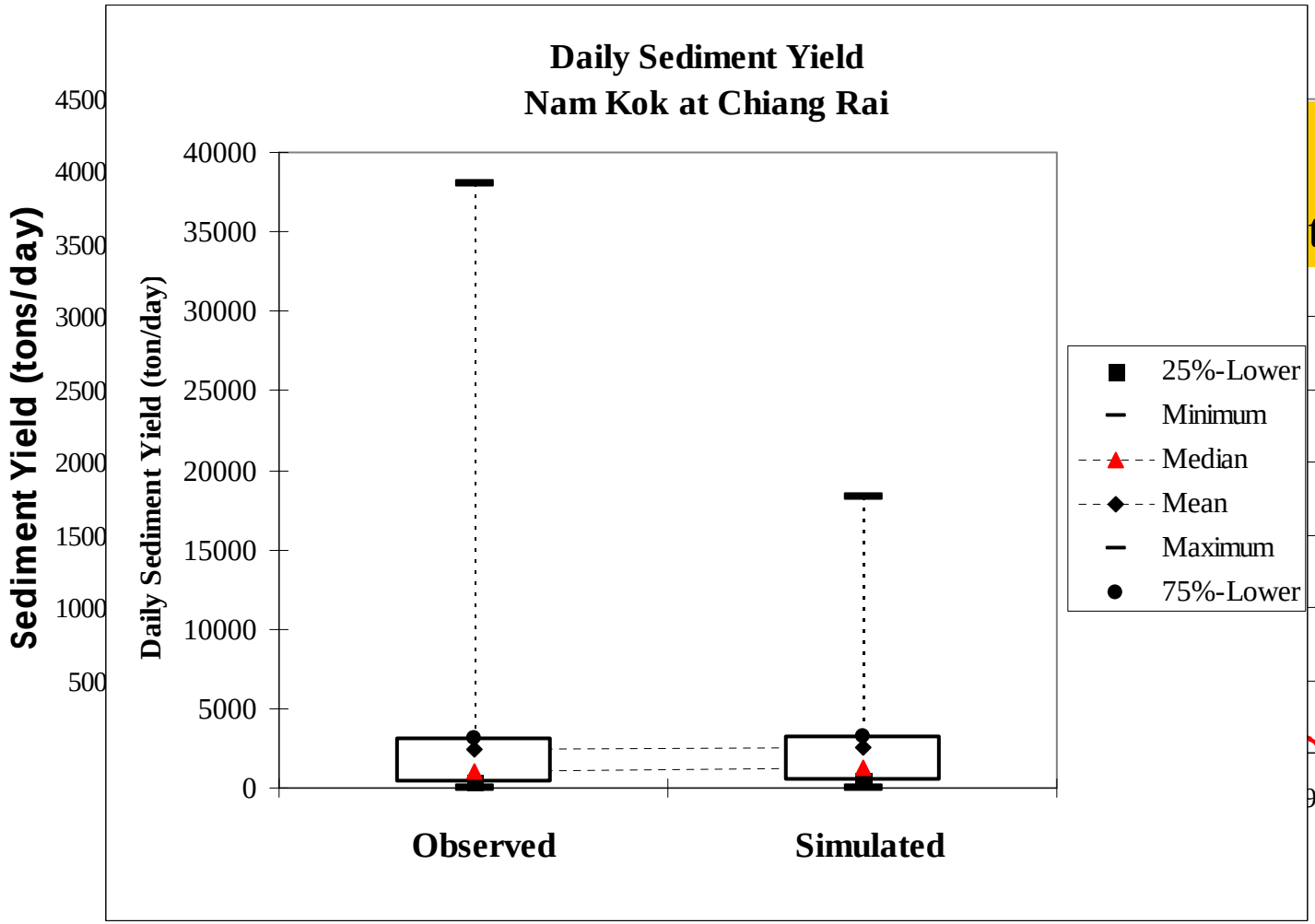
- *PRF* in “basins.bsn” controls the maximum sediment concentration that can be transported;
- *SPCON* (Linear parameter for sediment routing) in “basins.bsn” controls for sediment transport;
- *SPEXP* (Exponential parameter for sediment transport) in “basins.bsn” controls for sediment transport;
- *CH_EROD* (Channel erodibility factor) in “.rte” controls for channel erosion;
- *CH_COV* (Channel cover factor) in “.rte” controls for channel erosion;
- *USLE_P* (Support or conservation practice factor) in “.mgt” controls subbasin erosion;
- *USLE_C* (Cover or crop management factor) in “crop.dat” controls for subbasin erosion;

Parameters for model calibration (con't):

- Type of tillage operation whether it is proper on not;
- *RSCDO* (Crop residue coefficient) in "basins.bsn" ;
- *BIOMIX* (Bio-mixing efficiency) in ".mgt";
- *SLSUBBSN* (Slope length) in ".hru" controls the erosion from each hydrologic response unit;
- *HRU_SLP* (Slope) in ".hru" controls the erosion from each hydrologic response unit.

Note

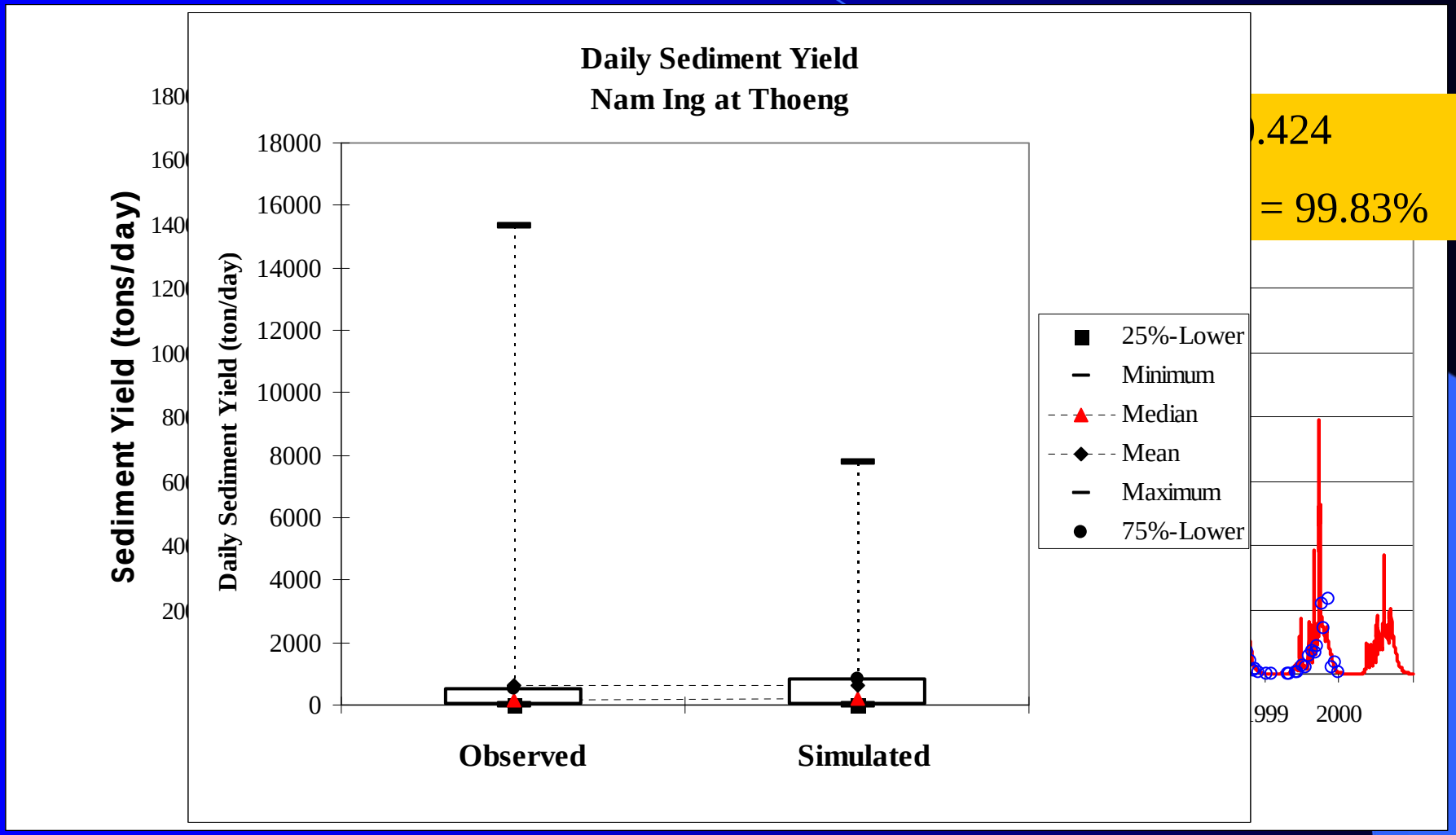
For this calibration SLSUBBSN and HRU_SLP have not been changed in order to keep pre-calibrated flow unchanged.

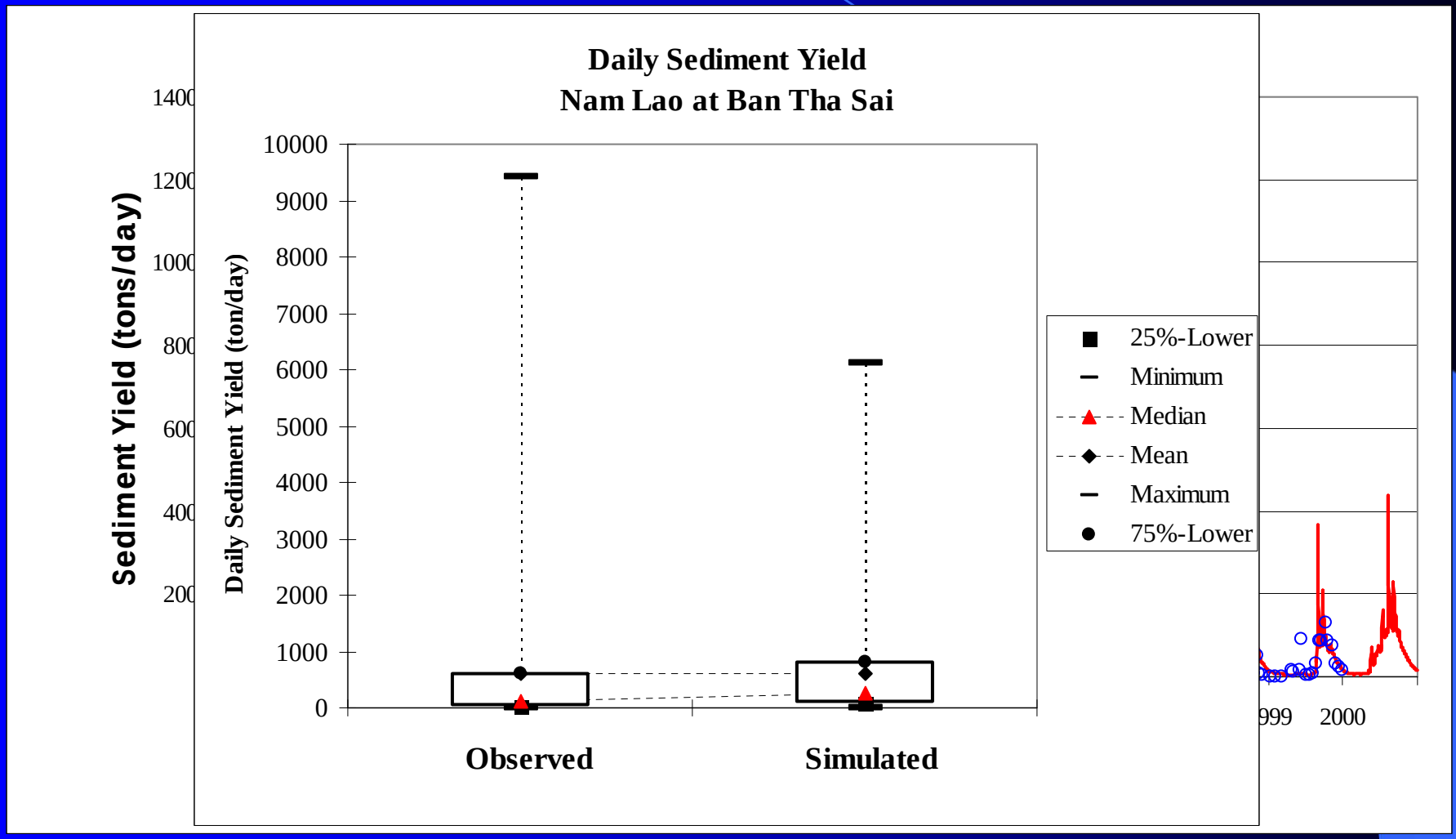


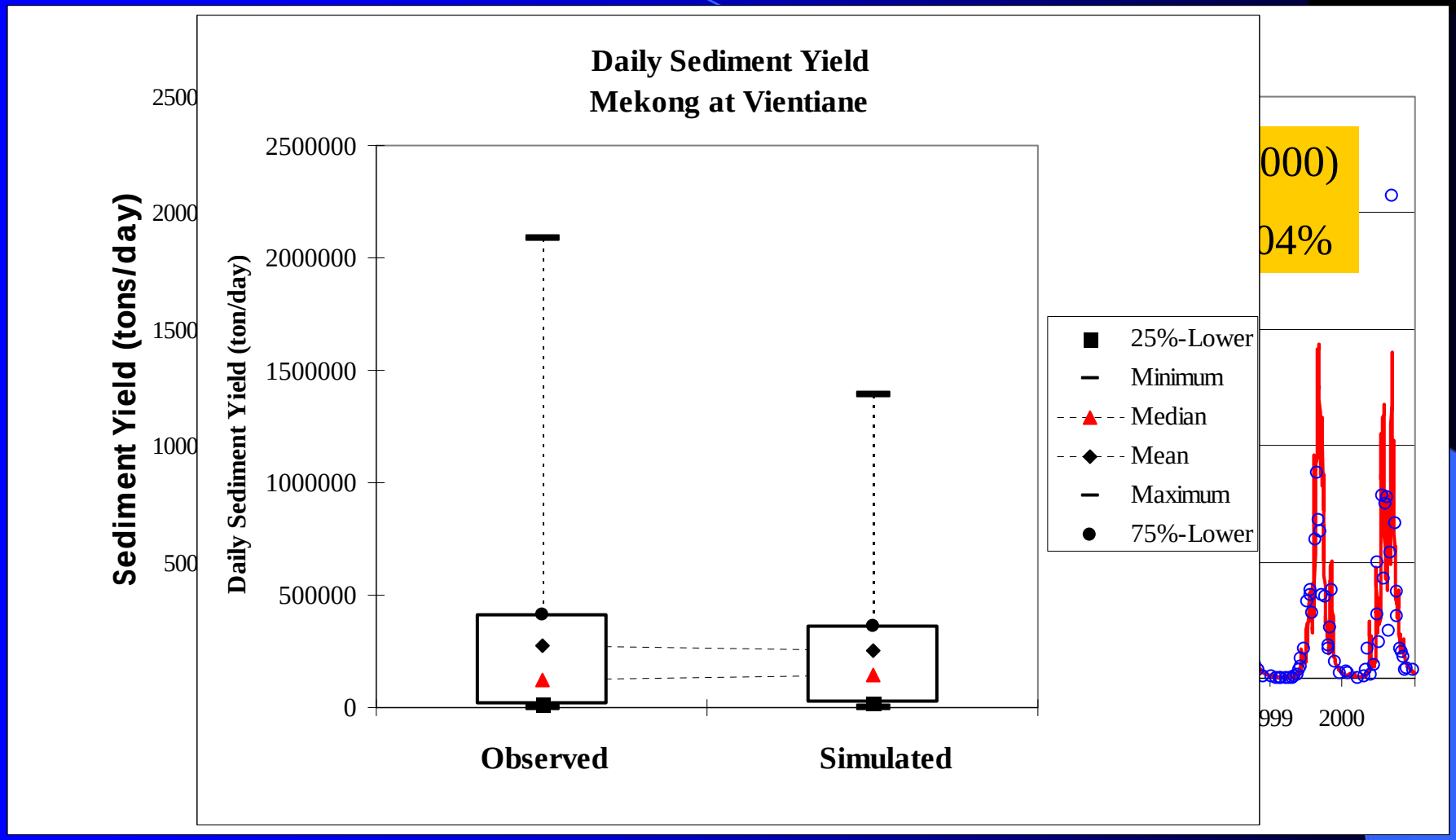
= 0.508

tio = 100.99%

999 2000


Daily Sediment Yield
Nam Ing at Thoeng
Sediment Yield (tons/day)
Daily Sediment Yield (ton/day)
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
Observed
Simulated
25%-Lower
Minimum
Median
Mean
Maximum
75%-Lower
.424
= 99.83%
999
2000


Daily Sediment Yield
Nam Lao at Ban Tha Sai
Sediment Yield (tons/day)
Daily Sediment Yield (ton/day)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Observed
Simulated
25%-Lower
Minimum
Median
Mean
Maximum
75%-Lower
999
2000


Daily Sediment Yield
Mekong at Vientiane
Sediment Yield (tons/day)
2500
2000
1500
1000
500
Daily Sediment Yield (ton/day)
2500000
2000000
1500000
1000000
500000
0
Observed
Simulated
25%-Lower
Minimum
Median
Mean
Maximum
75%-Lower
000)
04%
999
2000

Preliminary Calibration Results

NO.	STATION NAME	RIVER	COUNTRY	SWAT SUB-MODEL	SWAT SUB-BASIN	CALIBRATION PERIOD	CALIBRATION RESULT		REMARK
							COE	VOL RATIO	
1	Chiang Sean	Mekong	Thailand	1	3	- n/a -	- n/a -	- n/a -	only for inlet flow
2	Luang Prabang	Mekong	Laos	2	45	1997-2000	0.456	100.47%	
3	Thoeng	Nam Mae Ing	Thailand	2	20	1985-1999	0.424	99.83%	
4	Chiang Rai	Nam Mae Kok	Thailand	2	18	1985 - 1994	0.508	100.99%	
5	Ban Tha Sai	Nam Mae Lao	Thailand	2	21	1985-1999	0.420	98.63	
6	Muong Ngoy	Nam Ou	Laos	2	13	1990-2000	-0.452	97.73%	
7	Ban Sibounhom	Nam Suong	Laos	2	- n/a -	- n/a -	- n/a -	- n/a -	few obs. TSS points
8	Wang Saphung	Nam Loei	Thailand	3	11	1985-1999	0.482	93.06%	
9	Vientiane	Mekong	Thailand	3	4	1985-2000	0.565	100.04%	used Nong Khai data
10	Mukdahan	Mekong	Thailand	4	68	1985-2000	0.628	100.35%	
11	Na Kae	Nam Kam	Thailand	4	49	1985-1999	0.201	89.31%	
12	Ban Hin Heup	Nam Lik	Laos	4	4	1990-2000	-12.120	324.86%	big gap between 1993-96 with anomaly data
13	Ban Pak Kanhoung	Nam Ngum	Laos	4	43+56	1993-2000	-5.812	243.77%	
14	Ban Signo	Nam Theun	Laos	4	75	1996-2000	-0.433	97.65%	
15	Mahaxai	Se Bang Fai	Laos	4	73	1990-2000	-220.245	1815.26%	
16	Ban Huai Khayuong	Huai Khayuong	Thailand	5	could not calibrate for the erosion module in SWAT, the change of USLE parameter values, especially USLE_C did not affect to erosion amount				
17	Ban Fang Phe	Lam Dom Yai	Thailand	5					
18	Ubon	Nam Mun	Thailand	5					
19	Ban Keng Done	Se Bang Hieng	Laos	5					
20	Kengkok	Se Champhone	Laos	5					
21	Souvanna Khili	Se Done	Laos	5					
22	Pakse	Mekong	Laos	5	11	1997-2000	0.430	99.58%	
23	Ban Nong Kiang	Huai Rai	Thailand	7	could not calibrate for the erosion module in SWAT, the change of USLE parameter values, especially USLE_C did not affect to erosion amount				
24	Ban Chot	Nam Chi	Thailand	7					
25	Ban Na Thom	Nam Yang	Thailand	7					
26	Yasothom	Nam chi	Thailand	7	9	1985-1999	0.143	84.42%	
27	Rasi Salai	Nam Mun	Thailand	8	14	1985-1999	0.059	97.73%	

Conclusions and recommendations

- In this study, only the sediment sampling points where the flow calibration were carried out are considered for calibrating sediment model (about 27 points);
- Compared to the outputs from, the annual sediment loads estimated for 5 points (Chiang Saen, Luang Prabang, Nong Khai, Mukdahan and Pakse) are consistency with Prof Walling's study (2005) especially during the calibration period of 1985-00;
- The idea of point-calibration was adopted for SWAT sediment model. The idea is useful for calibrating against the observed data with missing values;

- At a specific location, the transported sediment calculated from SWAT depends very much on flow, high sediment resulting from high flow;
- Since 1997, the sediment load at Luang Prabang is going down while the flow and sediment load at Chiang Saen show increasing trend, this phenomenon needs further in-depth investigation or research;
- The observed sediment data especially for tributaries needs to be verified on both the sampling process and analysis methods;

- The SWAT uses only one set of model parameters for sediment transport and deposition for the whole watershed, it may not represent enough for the large watershed with high variability of channel size, slope, roughness, etc.;
- The SWAT limits only one value of USLE_C (crop management factor) for the whole watershed, it may not represent enough for the large watershed with high variability of real crop management practices. Moreover, it was found that the change of USLE_C values did not cause the change in erosion amounts of Chi, upper Mun and Mukdahan to Pakse.


THANK YOU