SWAT | Soil & Water Assessment Tool

Application of a Basin Scale Hydrological Model for Characterizing flow and Drought Trend

20 July 2012

International SWAT conference, Delhi INDIA

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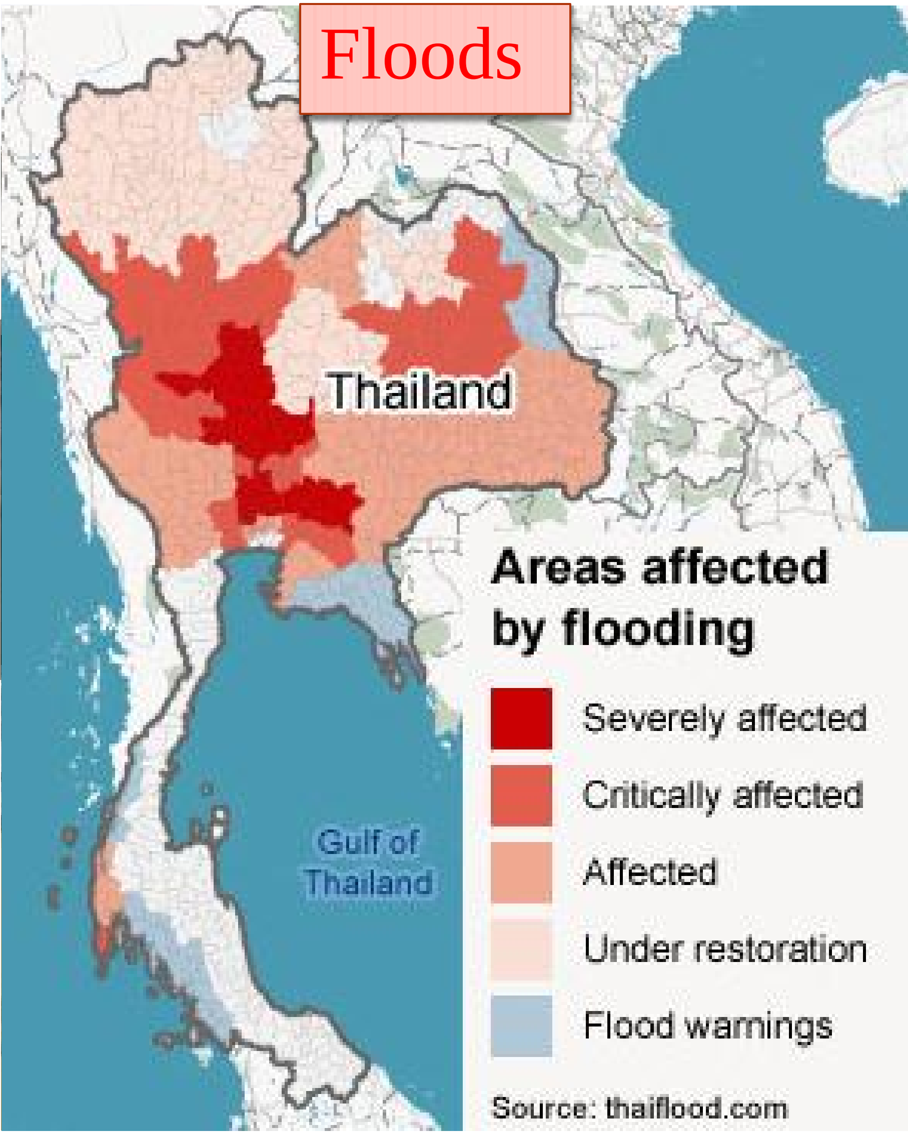
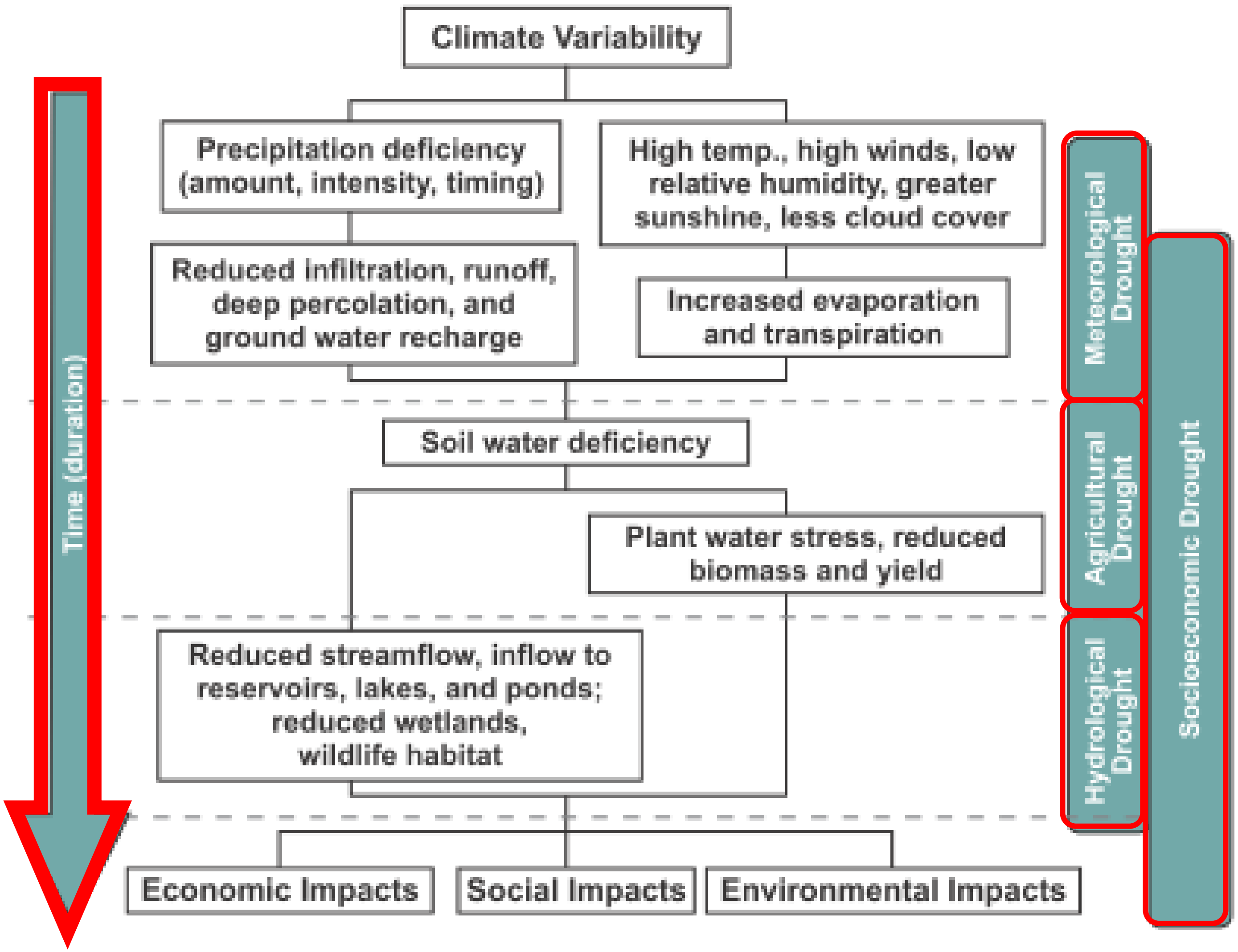
Introduction: How extreme climate hits Thailand ?



Types of drought



Relationship between meteorological, agricultural, hydrological and socio-economic drought
(Source: national Drought Mitigation Center, University of Nebraska-Lincon, USA)

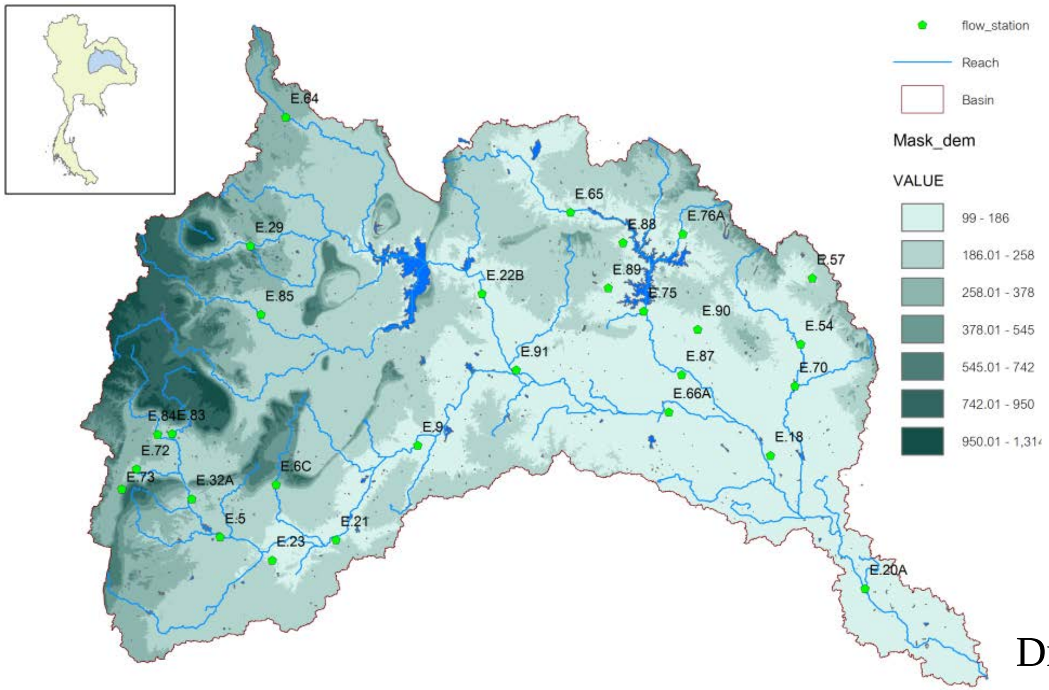
declining of soil moisture and consequent crop failure without any reference to surface water resourced

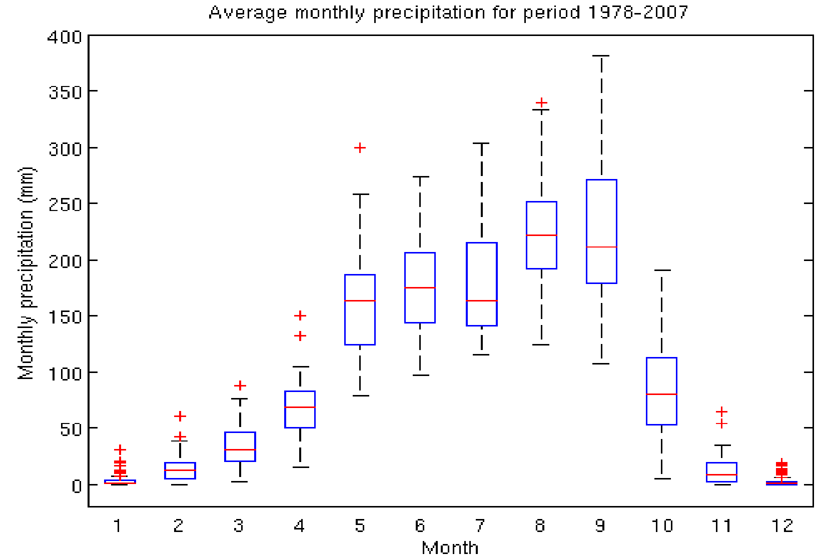
inadequate surface and subsurface water resources

failure of water resources systems to meet water demands occurring when demand exceeds supply

(http://drought.unl.edu/whatis/concept.htm)

Study area





✓Total catchment Area: 49,477 km^2 (60 % rainfed agricultural area)
✓Most area is high plateau (steep at the upstream mountain area and flat at the lower part)
✓the tropical monsoon region

Drought events :

- Dry spells always occurred in Jun –July : an important period for agriculture
- Dry up in river always occurred in dry season
- Frequency, severity and duration of drought are higher than other regions (Suwanabatr and Mekhora, 2002).

Statement of problems

- Thailand : experienced with repeated deficit of river discharges but there is still less research conducted for hydrological drought analysis in the basin.
- The suitable evaluation will be useful to predict and monitor drought events in the future leading to a disaster risk reduction through early warning.

Objectives

propose the criterion for evaluating hydrological drought using two methods; the threshold level method and the standardized streamflow drought index (SDI).

Scope of this study

Data collection → **Hydrological model** → **Drought Analysis**

Data collection

Meteorological data:
- Precipitation
- Winds speed
- Relative humidity
- Solar radiation
- Temperature

GIS data
- DEM
- Soil map
- Land use map

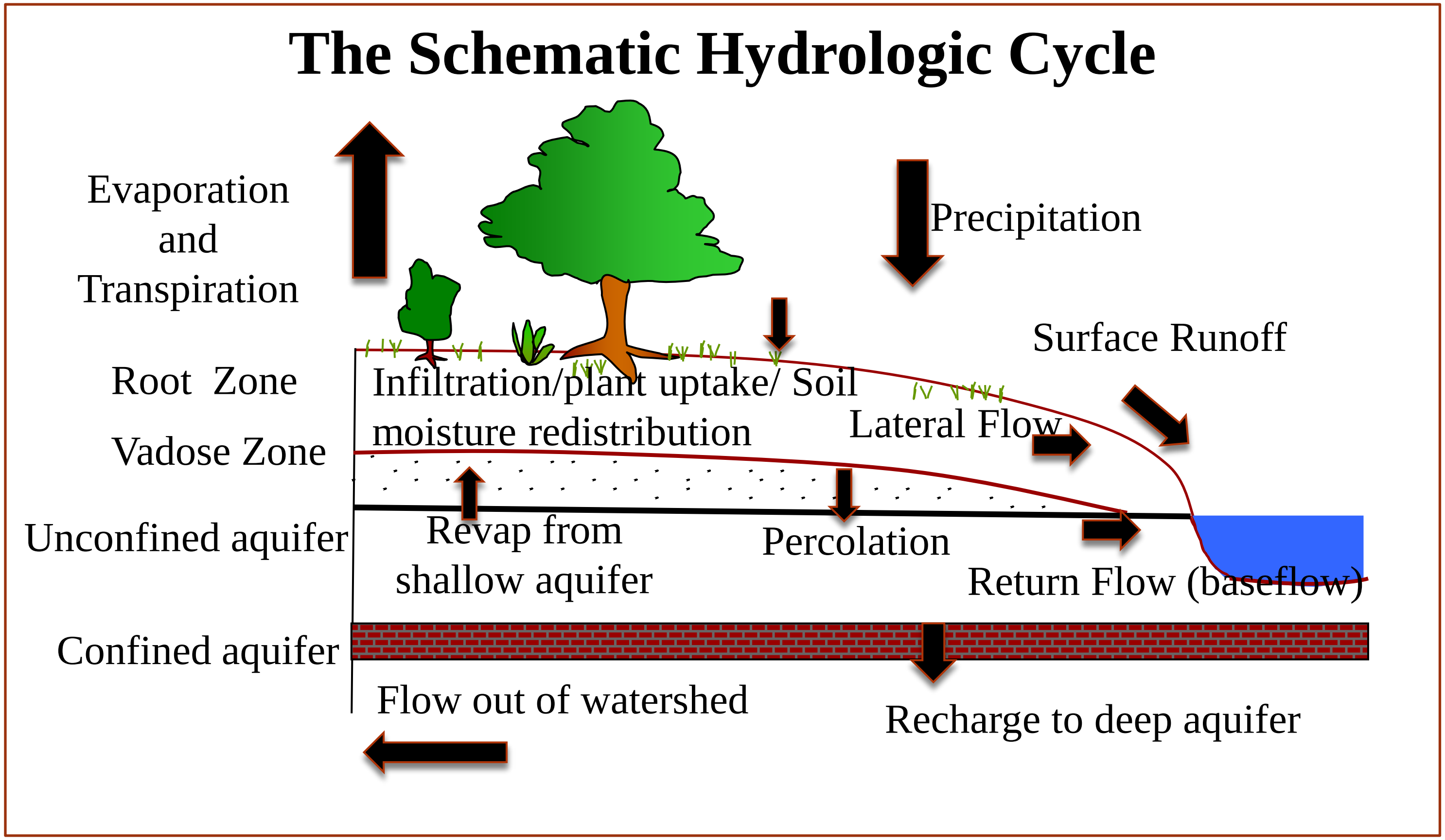
Hydrological model

- SWAT model
- Sensitivity analysis
- Calibration and validation
- Flow time series

Drought Analysis

- Threshold level method
- Standardized drought index (SDI)

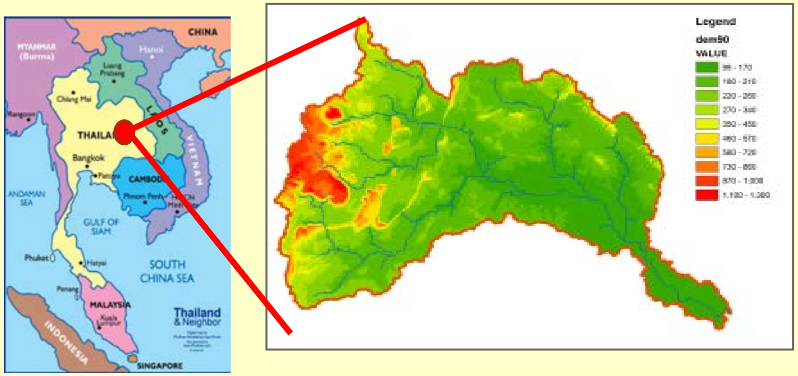
Methodology : Hydrological Simulation Model



$$SW_t = SW_0 + \sum_{i=1}^{t}(R_{day} - Q_{surf} - E_a - w_{seep} - Q_{gw})$$

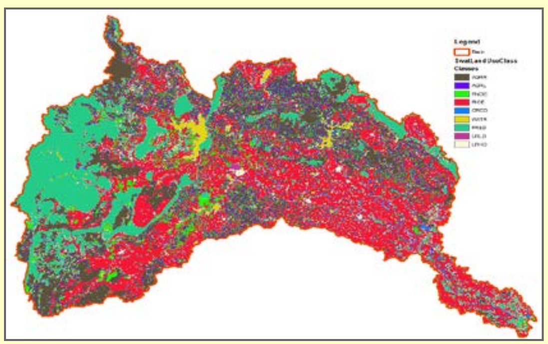
SW	=	Soil Water Content (mm H2O)
Rday	=	Amount of precipitation
Qsurf	=	Amount of surface runoff
ET	=	Amount of daily evapotranspiration
Wseep	=	Amount of water entering the vadose zone from the soil profile
Qgw	=	Amount of return flow

Methodology: SWAT Simulation model



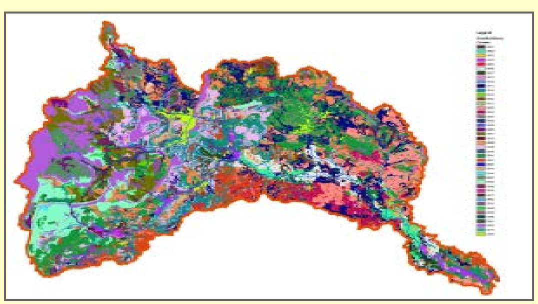
DEM

- steep slope at the upstream mountain area and flat at the lower part.



Land use

- Rice 43.5 %
- Forest deciduous 20.4 %
- Agricultural area 25.4 % (cassava, corn, sugarcane)
- Others 19.0%



Soil Types

Main Soil types

- Loam
- Sandy clay
- Clay loam

Watershed Delineation

↓

HRU Determination

↓

Flow simulation

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Sensitivity Analysis

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Base flow Separation:
Automated Base flow Separation &Recession Analysis Technique (Arnold et al.1995)

↓

Calibration and Validation

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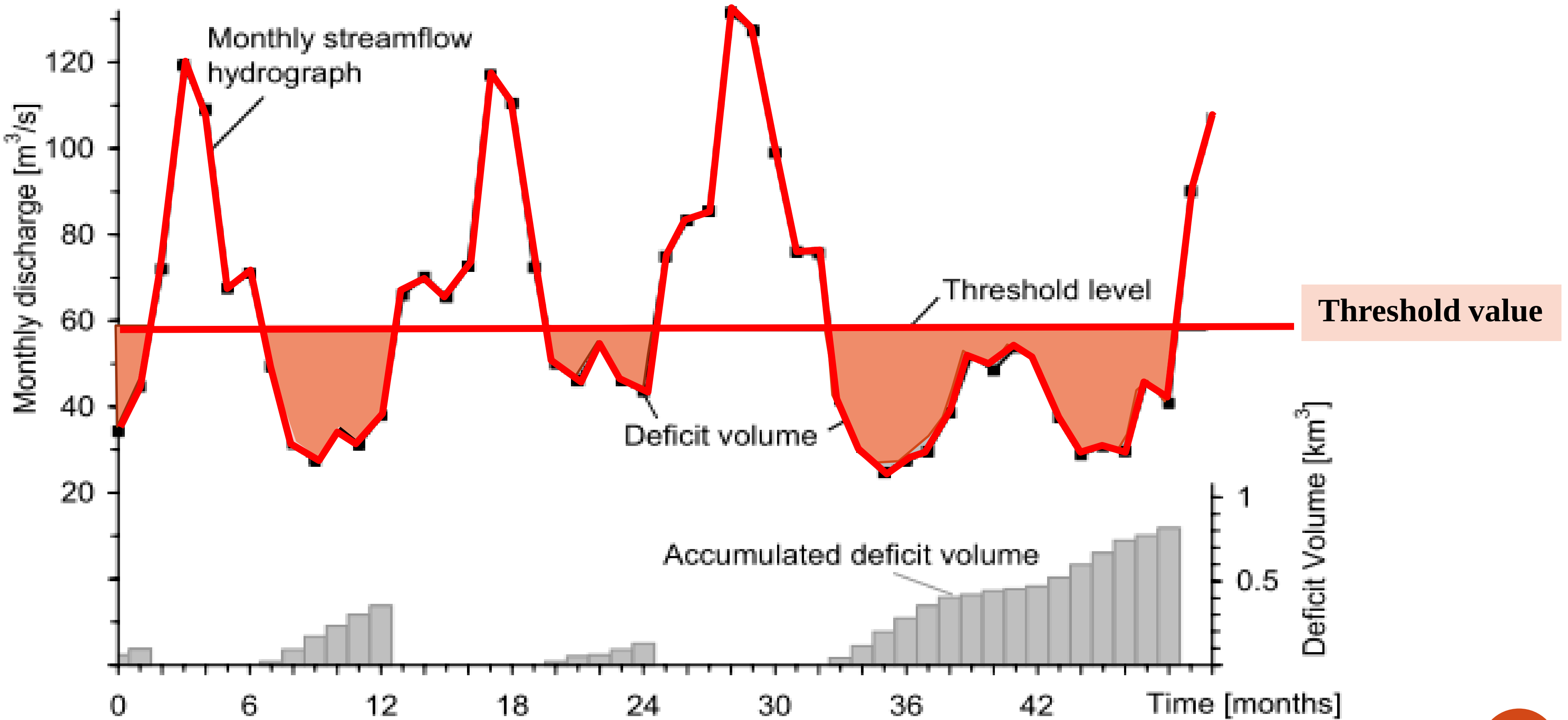
Simulated Flow Evaluation

Methodology: Drought Analysis

1) Threshold level method: a constant or a variables threshold which can be chosen in several ways: the mean or median over a long period of flows



Methodology: Drought Analysis

Standardized Streamflow drought index (SDI)

❖identical to the monthly standardized streamflow volume.

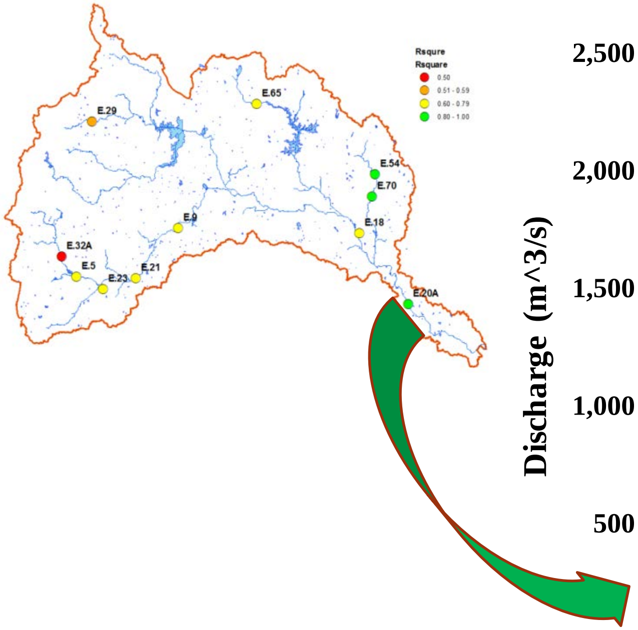
To calculate SDI index, average of monthly streamflow was estimated as following formula.

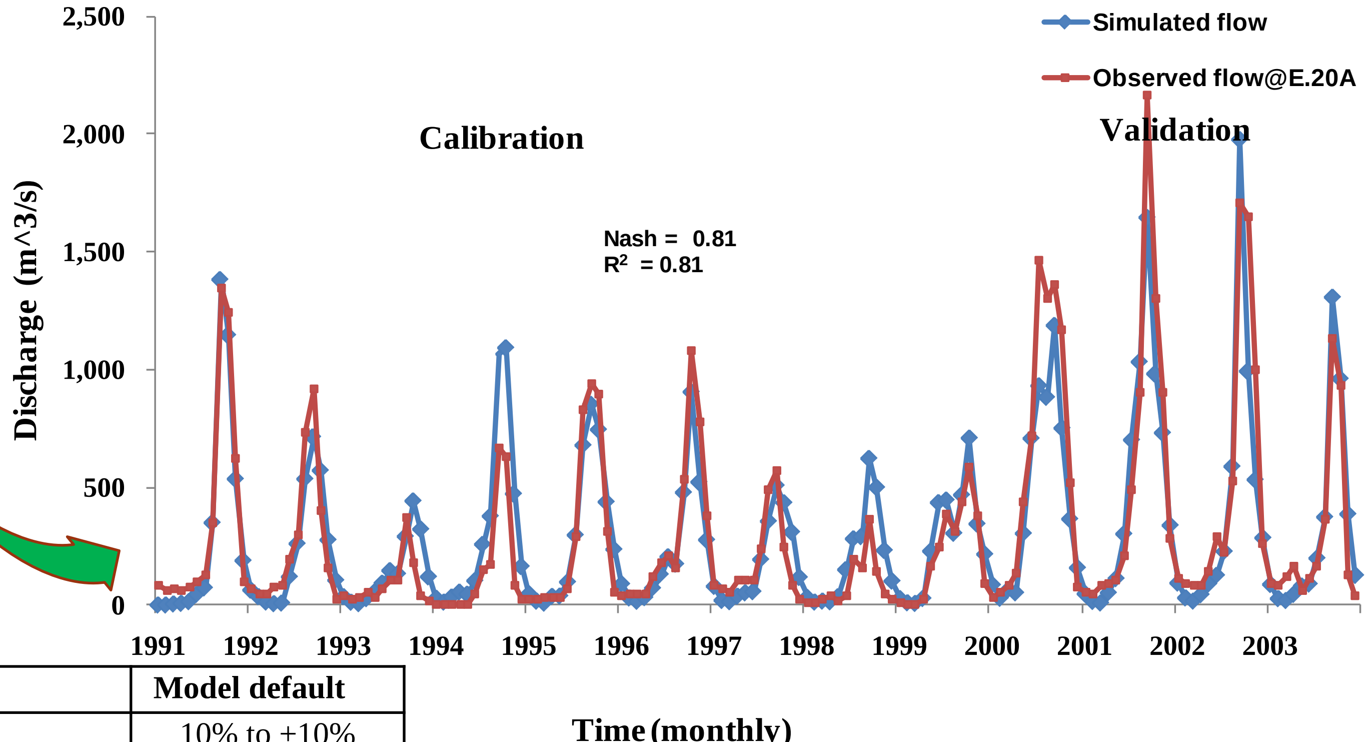
$$V_i = mean\,(\textstyle\sum_0^j V_{ij})$$

designed drought characteristic by standardized streamflow volume, which used threshold level as monthly basis as follows:

$$SD = \frac{V_i - \bar{V}_i}{S_i}$$

Results: Calibration and Validation model

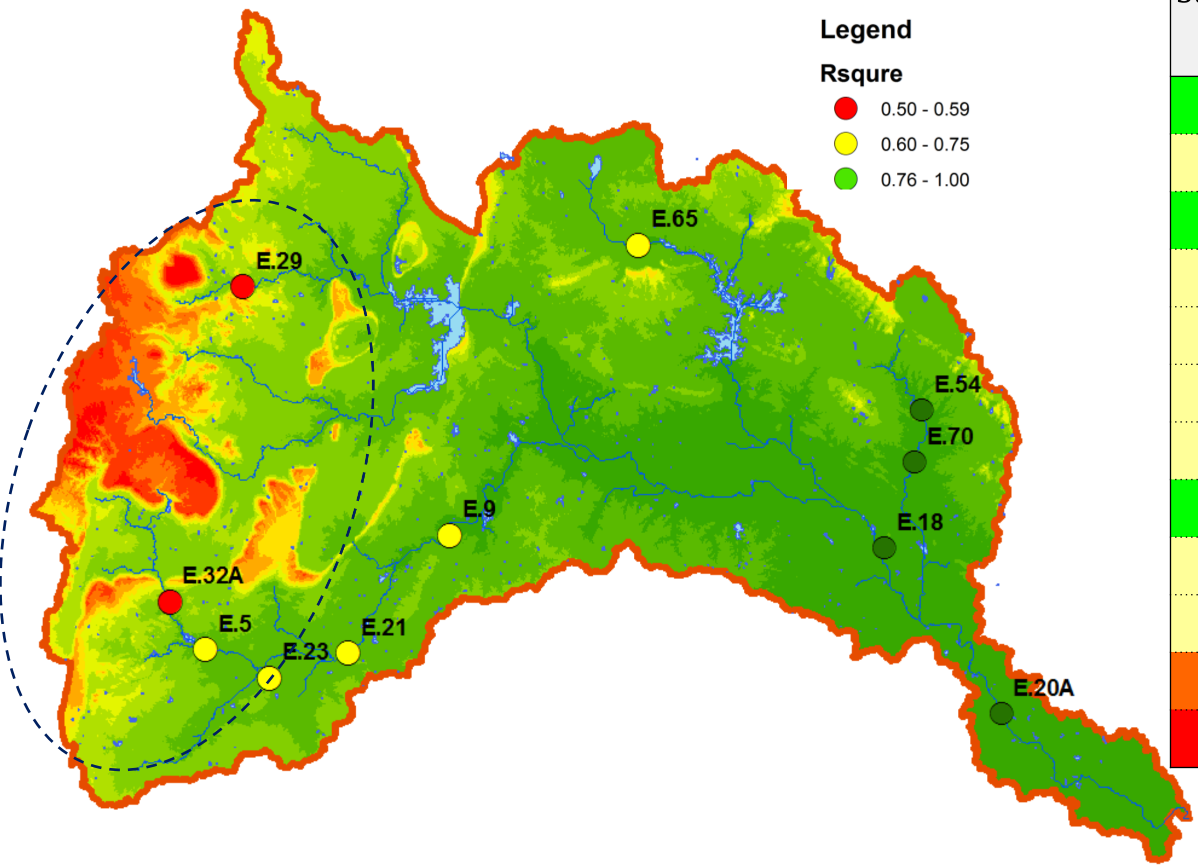




Parameters	Description	Model default
CN	Initial SCS CN II	10% to +10%
Esco	Soil evaporation compensation factor	0.01-1.0
SOL_AWC	Available water capacity	15% to +15%
Alpha_BF	Baseflow alpha factor	0.0-1.0
GW_REVEP	Groundwater ‘revap’ coefficient	0.02-0.2
Rchrg_dp	Deep aquifer percolation fraction	0.5-1
Gw_Delay	Groundwater delay	0-50 days

Ranking of the seven most sensitive parameters

Results: Calibration and Validation model



Observed streamflow	Calibration 1991-2000		Validation 2001-2003	
	R^2	Nash	R^2	Nash
E20	0.83	0.83	0.88	0.88
E5	0.68	0.55	0.89	0.38
E54	0.87	0.86	0.6	0.47
E65	0.73	0.67	0.87	0.86
E21	0.73	0.69	0.59	0.47
E18	0.77	0.76	0.72	0.75
E9	0.68	0.67	0.67	0.56
E70	0.83	0.71	0.72	0.68
E23	0.73	0.64	0.87	0.41
E8A	0.68	0.63	0.74	0.52
E29	0.51	0.48	0.91	0.71
E32A	0.5	0.35	0.89	0.3

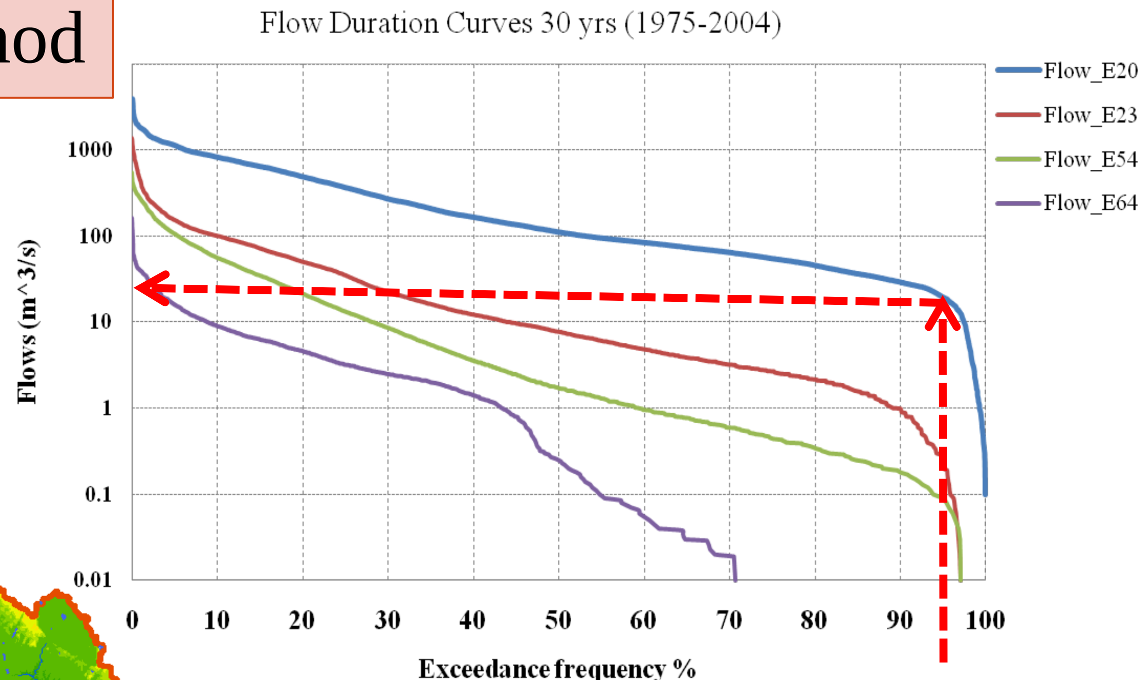
World Meteorological Organization (WMO) recommended a minimum density for precipitation gauge network of 100-250 km2 per station for mountain area.

Results: Assessment of drought duration and severity

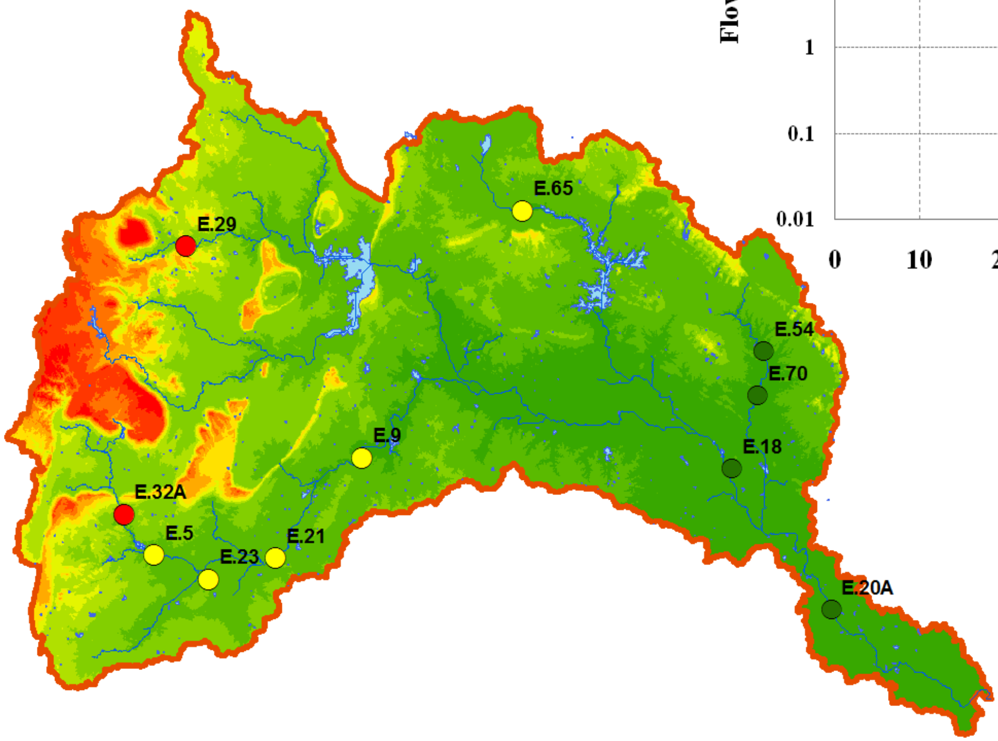
1) Threshold level method

Define Threshold value :

❖ Flow Duration Curve (FDC)



95 percentile of flows



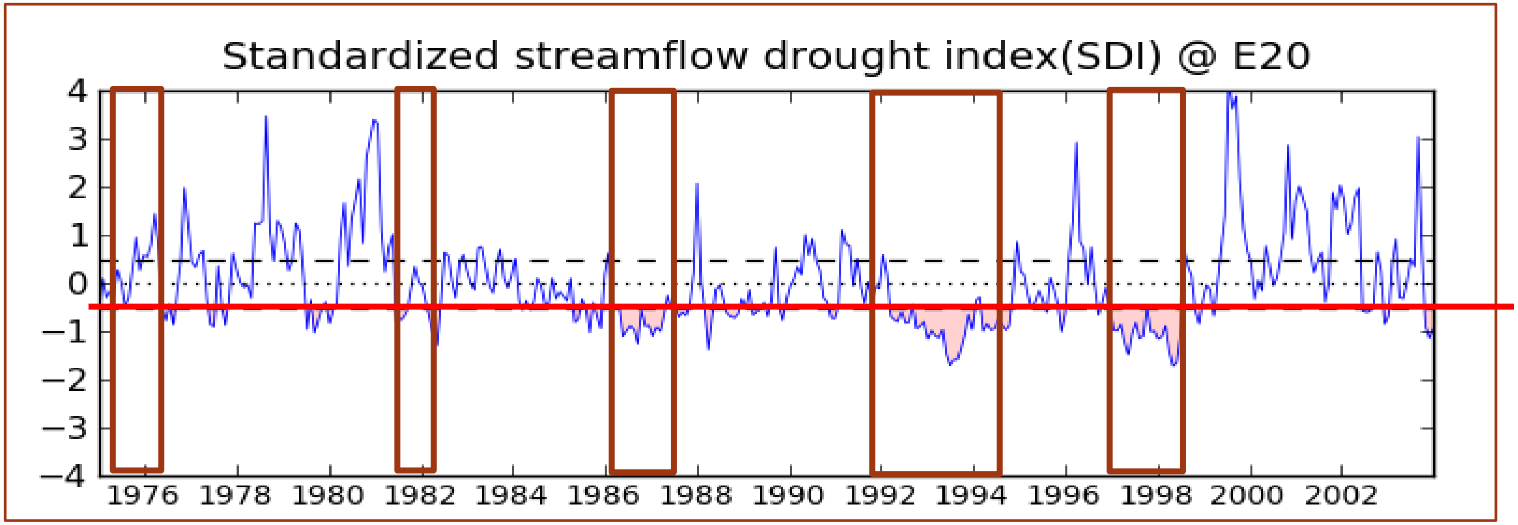
Results: Drought duration and severity

Table 1 Streamflow drought events and their severity for Chi river basin at outlet basin E20A (1975- 2004)

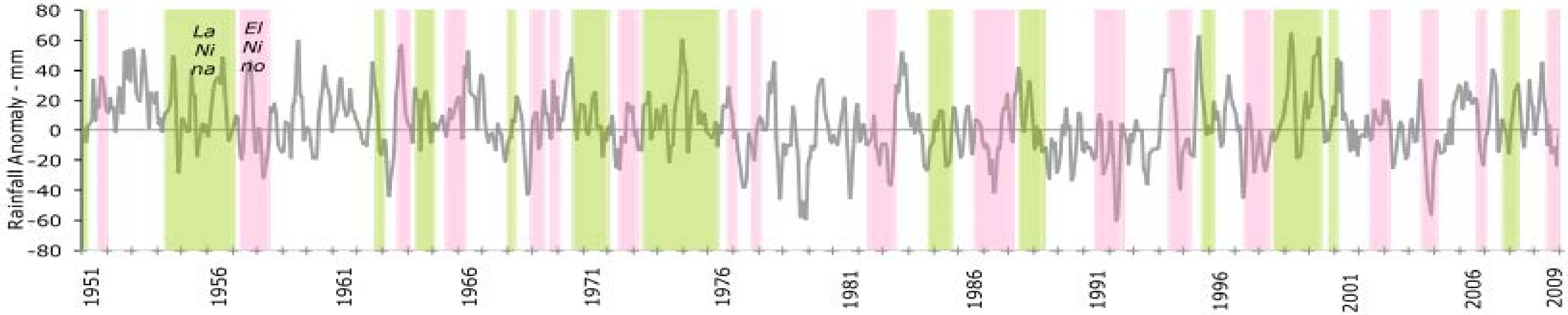
No.	Year of event	Onset date	Termination date	Durations (days)	Severity (MCM)
1	1982	1-Jul	28-Jul	28	-1053.91
2		3-Aug	20-Aug	18	-251.37
3	1987	2-Jun	18-Jun	17	-240.45
4		12-Jul	22-Jul	11	-200.92
5		20-Sep	8-Oct	20	-586.31
6	1992	12-Feb	28-Feb	22	-7.99
7		14-Sep	18-Sep	5	-252.36
8		29-Nov	10-Dec	14	-121.33
9	1993	2-Apr	27-May	56	-452.57
10		12-Jun	21-Jun	10	-102.69
11		19-Oct	30-Oct	12	-248.67
12		14-Dec	30-Dec	17	-54.18
13	1994	10-Jan	31-Jan	22	-55.97
14		8-Mar	21-Mar	14	-2.13
15		1-May	26-May	26	-166.93
16		22-Jun	16-Jun	6	-18.33
17	1997	4-Feb	26-Feb	23	-21.91
18		24-Jun	30-Jun	8	-66.06
19		26-Nov	31-Nov	6	-36.56
20	1998	24-Jan	31-Jan	8	-6.65
21		6-Apr	19-Apr	14	-59.02
22		1-Jun	6-Jun	5	-53.28
23		1-Aug	6-Aug	7	-61.36
24		7-Sep	14-Sep	8	-347.20
25		1-Nov	6-Nov	6	-77.07
26	1999	18-Jan	31-Jan	14	-19.21
27		1-Mar	31-Mar	31	-21.244

Results: Assessment of drought duration and severity

2) Standardized streamflow drought index (SDI)



Thailand Rainfall Anomaly- mm & El Nino – La Nina (ONI)



Conclusions

The SWAT model was applied to assess changes in hydrological drought occurrences.

✓the model performs sufficient well to simulate flow in the basin with relatively high values of coefficient of determination and Nash-Sutcliffe coefficient.

✓Most sensitive parameters are the parameters representing surface runoff and soil properties such as CN, Esco and SOL_AWC.

Propose criteria to characterize hydrological drought conditions (in terms of duration, frequency and severity.)

- ✓ These results showed that the drought trends computed by threshold level and SDI are broadly consistency and likely reliable coinciding with such a kind of actual drought as El Niño events.
- ✓ However, drought analysis are subjective depending on objective, perspective and region of interest, thus application is much more significant.

Thank you for your attention