Quantifying SWAT runoff using gridded observations and Reanalysis data for Dakbla river basin, Vietnam

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Outline

1. Introduction
2. Methodology
3. Calibration and Validation
4. Application of gridded observations and Reanalysis data
5. Conclusion

1. Introduction

- Precipitation is crucial in hydrology modeling

- Shortage of data collection in remote area leads to inaccurate runoff simulation

- To over come this problem:
  + borrow rainfall data from similar catchments
  + lengthen the data time series based on statistic methods
  + use gridded observation data

1. Introduction

- SWAT model is applied for Dakbla river basin (small tributary of Mekong river) in Vietnam.

+ Sensitivity analysis

+ Auto-Calibration (PARASOL) 2000-2005

+ Validation 1995-2000

+ Various gridded observation datasets are applied for verification to assess their accuracy and ensemble study

+ Uncertainty in using gridded observation datasets

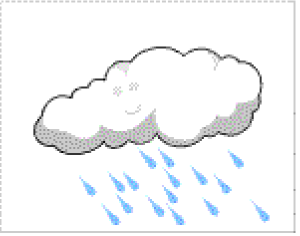
+ Application of dynamical downscaling method for climate change applications to hydrology

1. Introduction

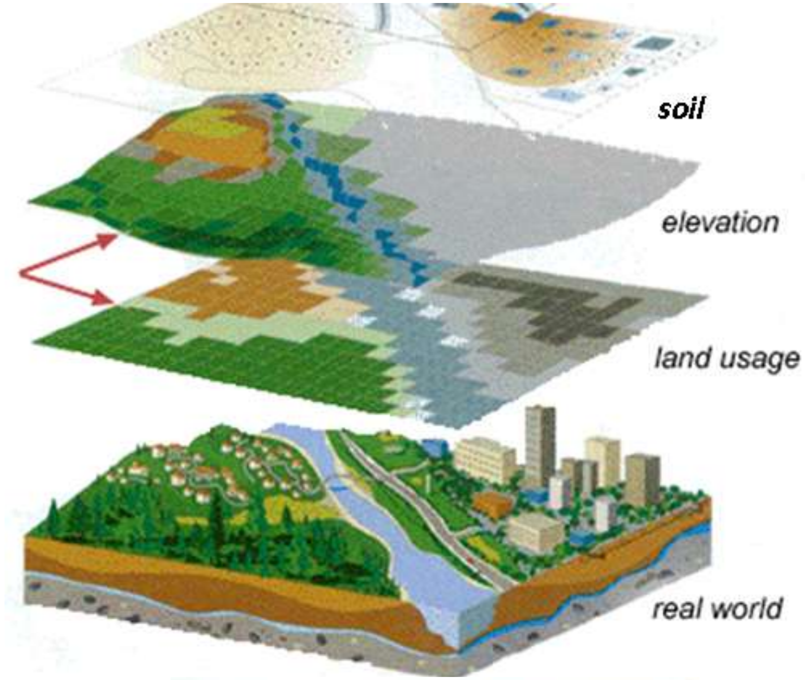
Application to runoff over Dakbla river basin

Input: Rainfall station data

- APHRODITE;
TRMM; PERSIANN;
GPCP; NCEP



Optimal parameters



SWAT

Output: runoff simulated from station data

- APHRODITE;
TRMM; PERSIANN;
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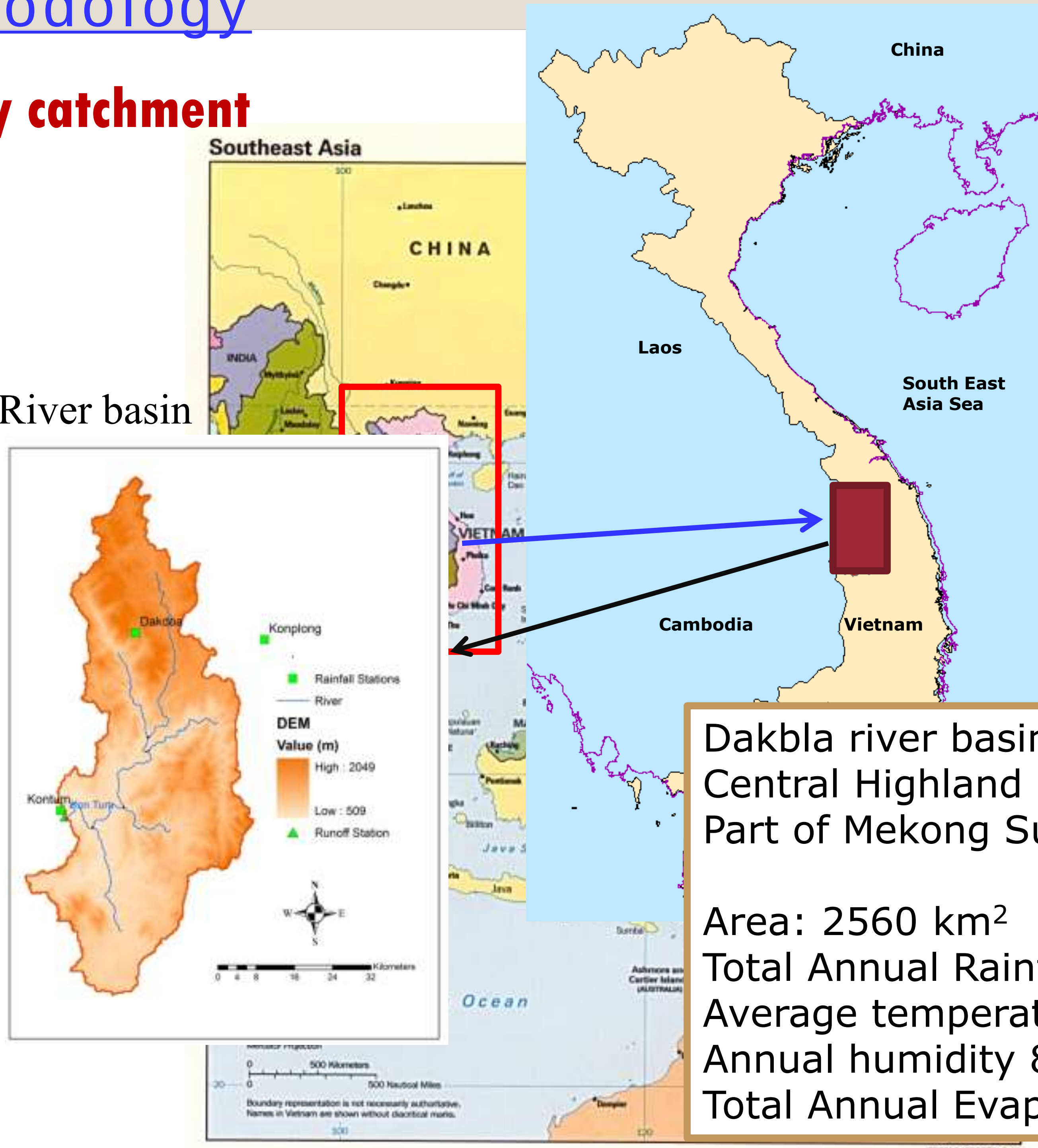
Study catchment

SESAN River basin



Dakbla river basin
Central Highland of Vietnam
Part of Mekong Sub-Region

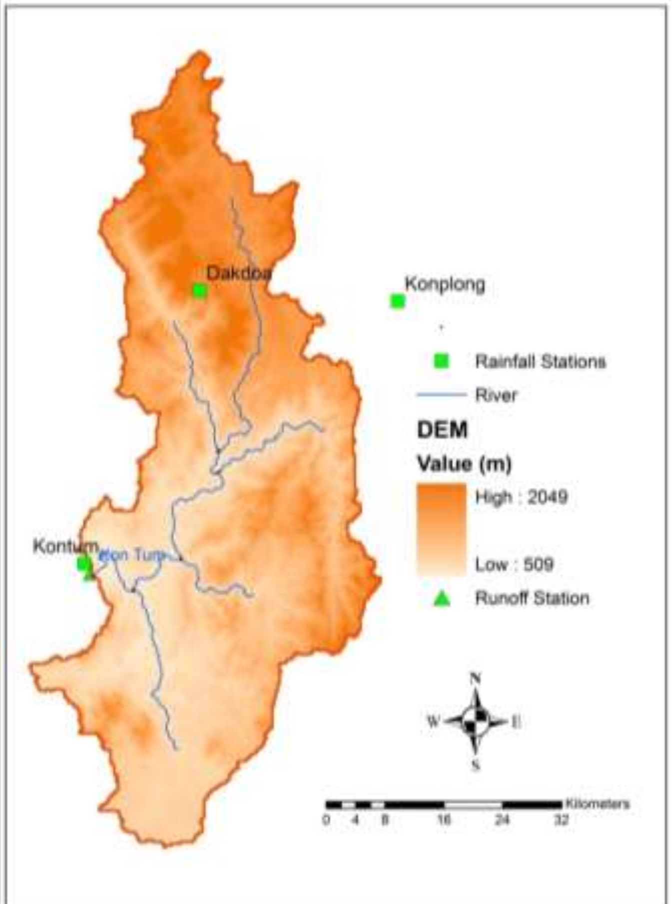
Area: 2560 km^2
Total Annual Rainfall: 1800mm
Average temperature 21-25^{o}C
Annual humidity 80%
Total Annual Evaporation 1500mm

2. Methodology

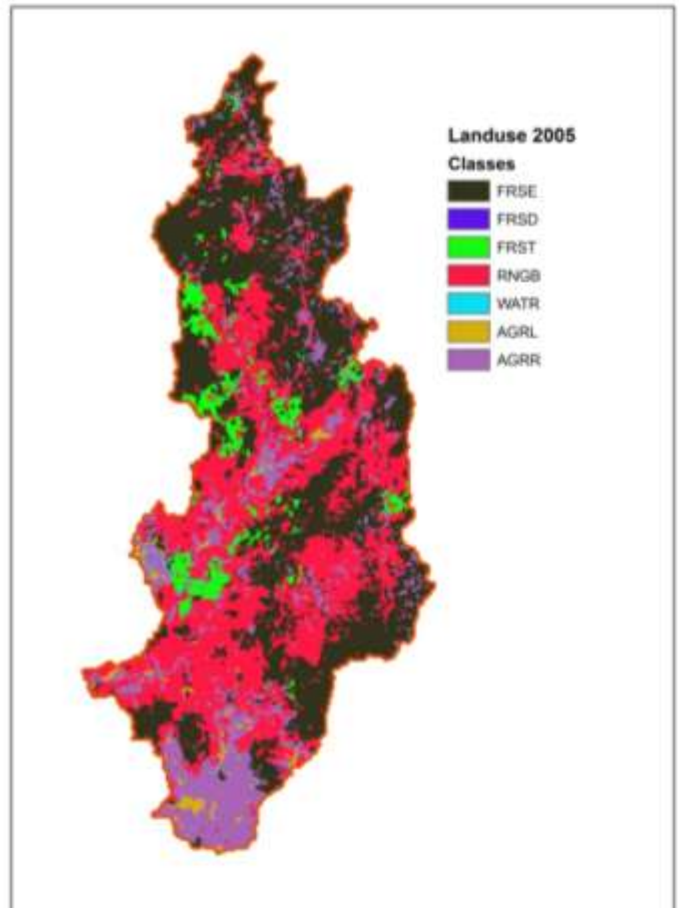
SWAT Model

Inputs

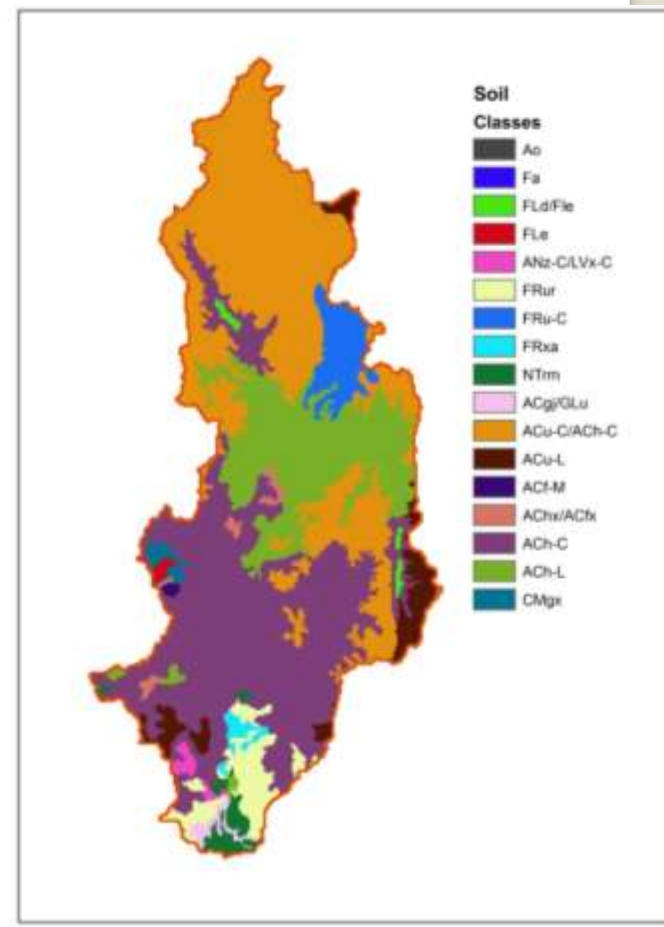
Rainfall data from 3 stations
Runoff data from 1 stations



DEM (resolution 250m x 250m)



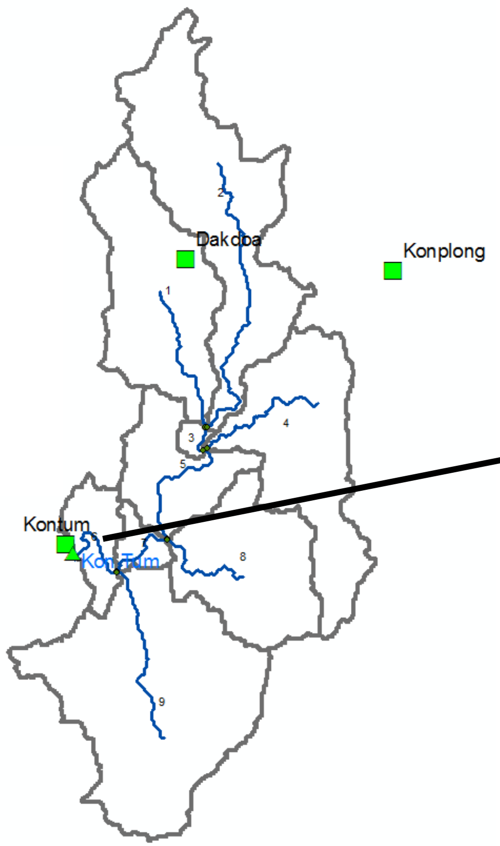
Land use map

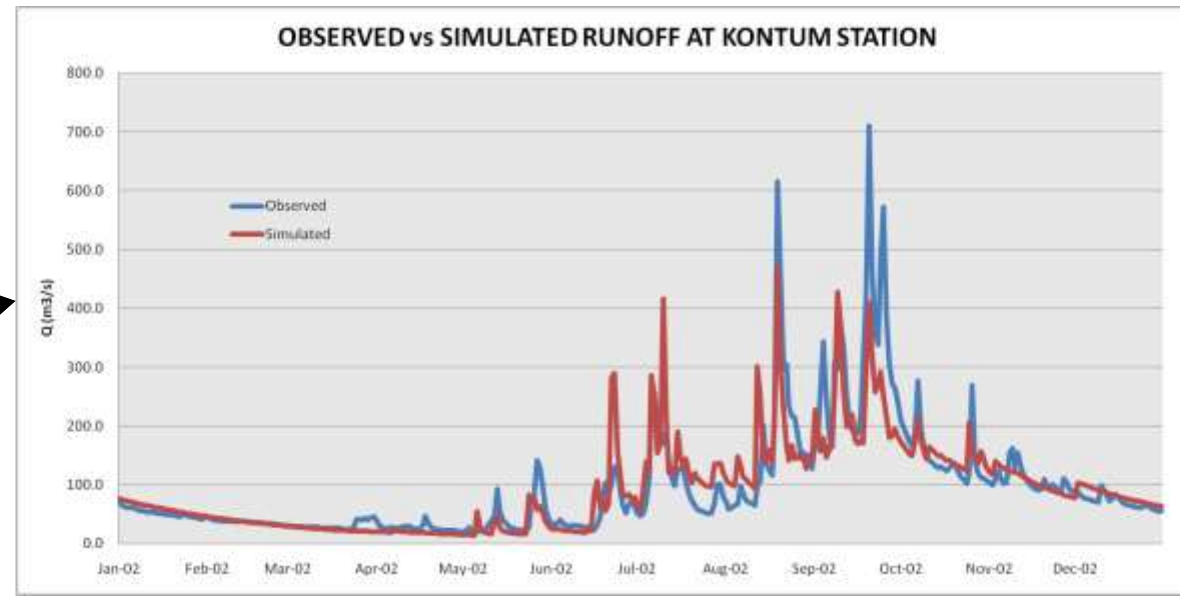


Soil map

SWAT Model

Outputs





HRUs

Digitized stream network

Simulated runoff at selected location
Using observed rainfall from 3 stations

2. Methodology

SWAT Model ***Comparing indexes***

Coefficient of determination: R^2

$$R^2 = \left\{ \frac{N\sum_{i=1}^{N} S_i O_i - \sum_{i=1}^{N} S_i \sum_{i=1}^{N} O_i}{\sqrt{N\sum_{i=1}^{N} S_i^2 - \left(\sum_{i=1}^{N} S_i\right)^2} \sqrt{N\sum_{i=1}^{N} O_i^2 - \left(\sum_{i=1}^{N} O_i\right)^2}} \right\}^2$$

Nash-Sutcliffe Efficiency: NSE

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

Where: O is Observed and S is Simulated Flow

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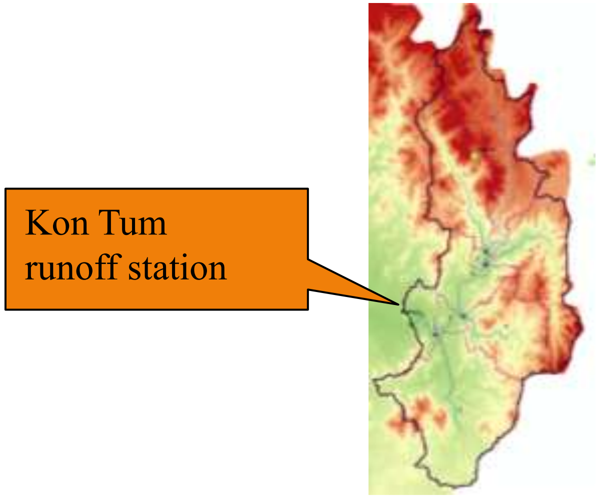
3. Calibration and Validation

Model Simulation

Model setup

- Model runs in daily scale for Dakbla



Dakbla river basin

- **Calibration:** 6 years from 2000 to 2005 with 2000 as the warmed up year.

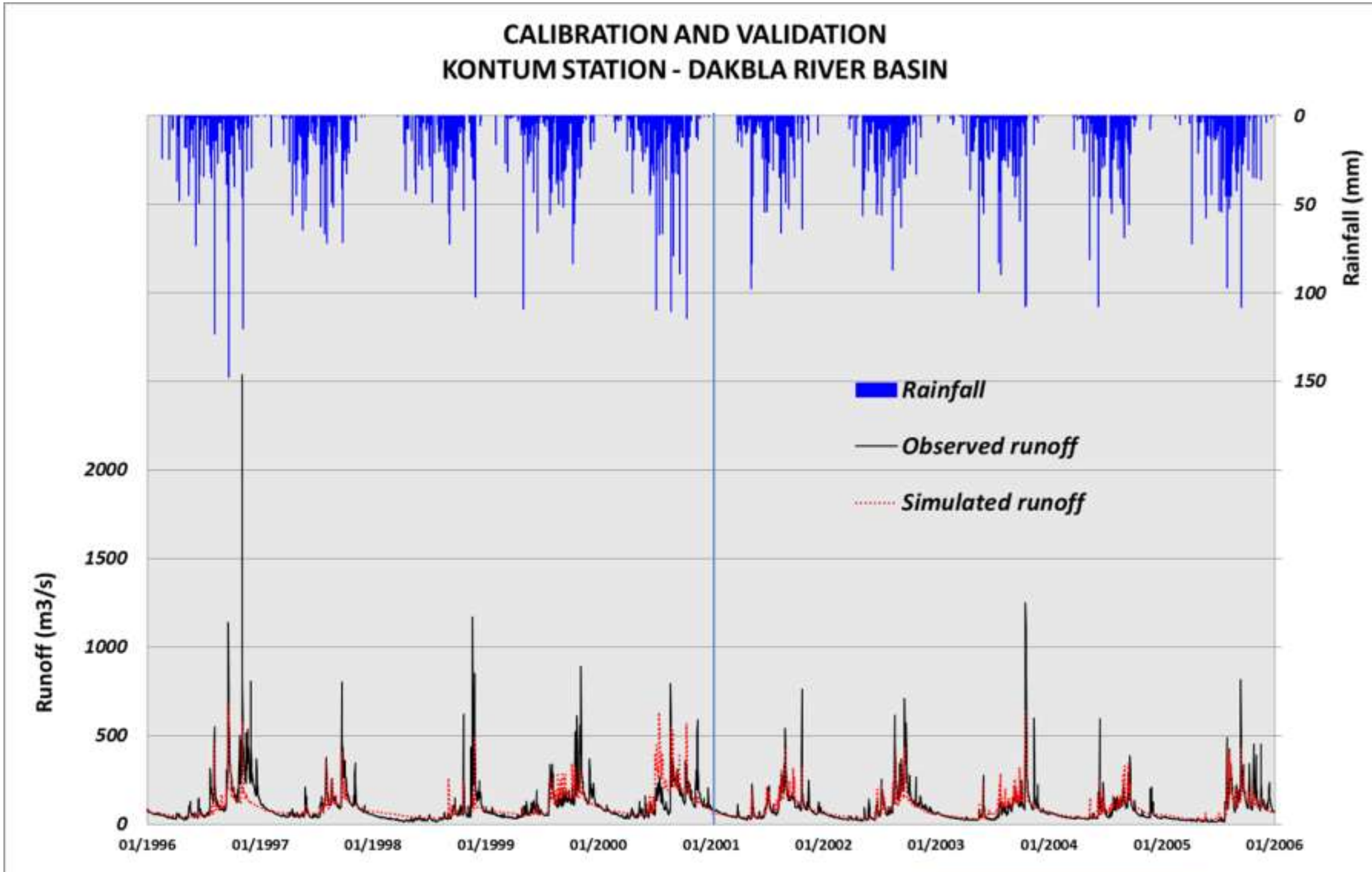
- **Validation:** 6 years from 1995 to 2000 with 1995 as the warmed up year.

3. Calibration and Validation

Sensitivity Analysis and Calibrated parameters using PARASOL

Sensitivity Analysis Order	*Parameter*	*Description*	*Parameter range*	*Optimal value*
1	Alpha_Bf	*Baseflow recession constant*	*0 ~ 1*	*0.02*
2	Cn2	*Moisture condition II curve no*	*35 ~ 98*	*40.33*
3	Ch_N2	*Manning n value for the main channel*	*-0.01 ~ 0.3*	*0.04*
4	Ch_K2	*Effective hydraulic conductivity in main channel*	*-0.01 ~ 500*	*129*
5	Sol_K	*Saturated hydraulic conductivity*	*0 ~ 2000*	*150.7*
6	Sol_Awc	*Available water capacity*	*0 ~ 1*	*0.32*
7	Surlag	*Surface runoff lag coefficient*	*1 ~ 24*	*1.58*
8	Esco	*Soil evaporation compensation factor*	*0 ~ 1*	*1*
9	Gwqmn	*Threshold water level in shallow aquifer for base flow*	*0 ~ 5000*	*0.36*
10	Gw_Revap	*Revap coefficient*	*0.02 ~ 0.2*	*0.09*
11	Gw_Delay	*Delay time for aquifer recharge*	*0 ~ 500*	*466.2*

3. Calibration and Validation



Validation
NSE: 0.43
R^2: 0.47

Calibration
NSE: 0.68
R^2: 0.71

3. Calibration and Validation

- Performance of SWAT model very promising with average NSE and R^2 ~0.7 for calibration.
- Validation shows good match between observed station data as well.
- Such calibrated parameters will be applied for verification purpose with gridded observation data in daily time step.

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4. Application of gridded data

APHRODITE (Asian Precipitation Highly Resolved Observational Data Integration Towards the Evaluation of Water Resources) - Japan

TRMM: Tropical Rainfall Measuring Mission - USA

PERSIANN: Precipitation Estimation from Remotely Sensed Information using Artificial Neural Network) - USA

GPCP Global Precipitation Climatology Project - USA

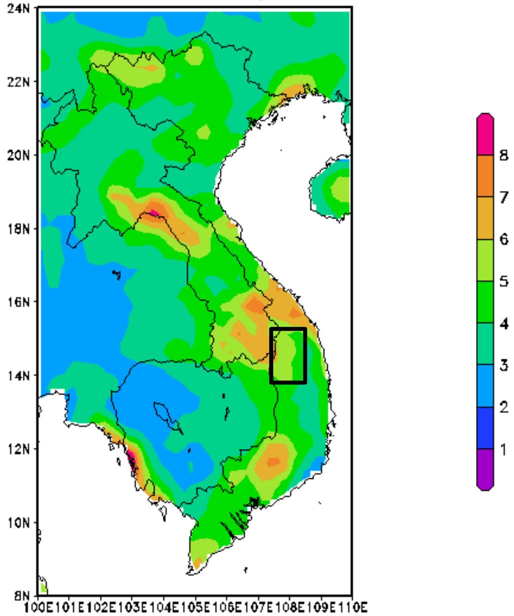
NCEP: National Centers for Environmental Prediction - USA

DATASET	Period available	Spatial Resolution (⁰)	Temporal Resolution	Region
APHRODITE	1951-2007	0.25	daily	Monsoon Asia
TRMM	1998-present	0.25	3 hourly	Global
PERSIANN	2000-present	0.25	3 hourly	Near Global
GPCP	1997-present	1	daily	Global
NCEP	1948-2011	2.5	daily	Global

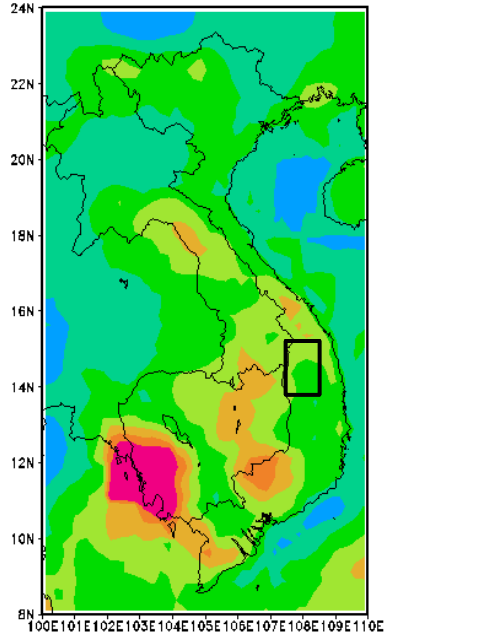
The period between 2000-2005 used in this study

4. Application of gridded data

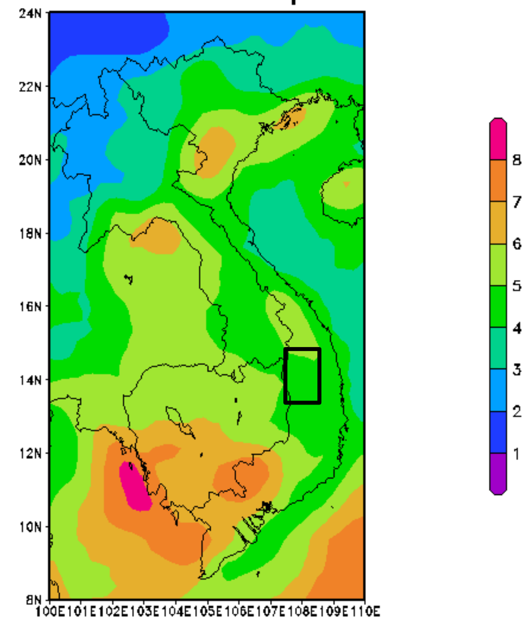
APHRO Ann Clim Precip 2000–2005



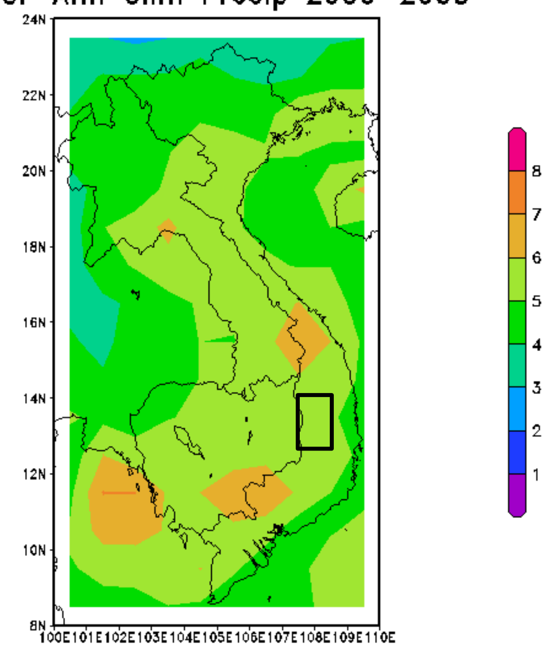
TRMM Ann Clim Precip 2000–2005



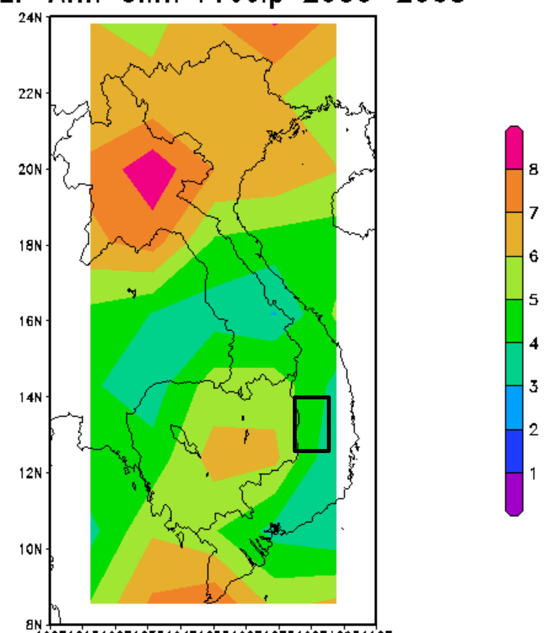
PERSIANN Ann Clim Precip 2000–2005



GPCP Ann Clim Precip 2000–2005

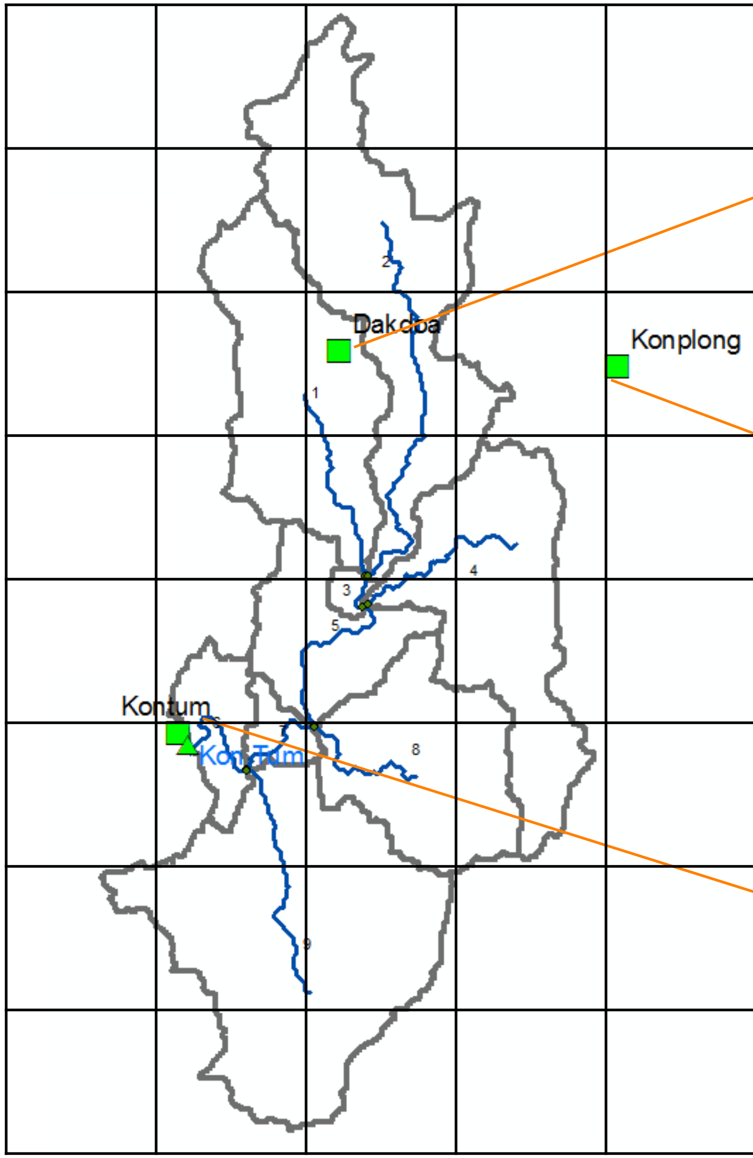


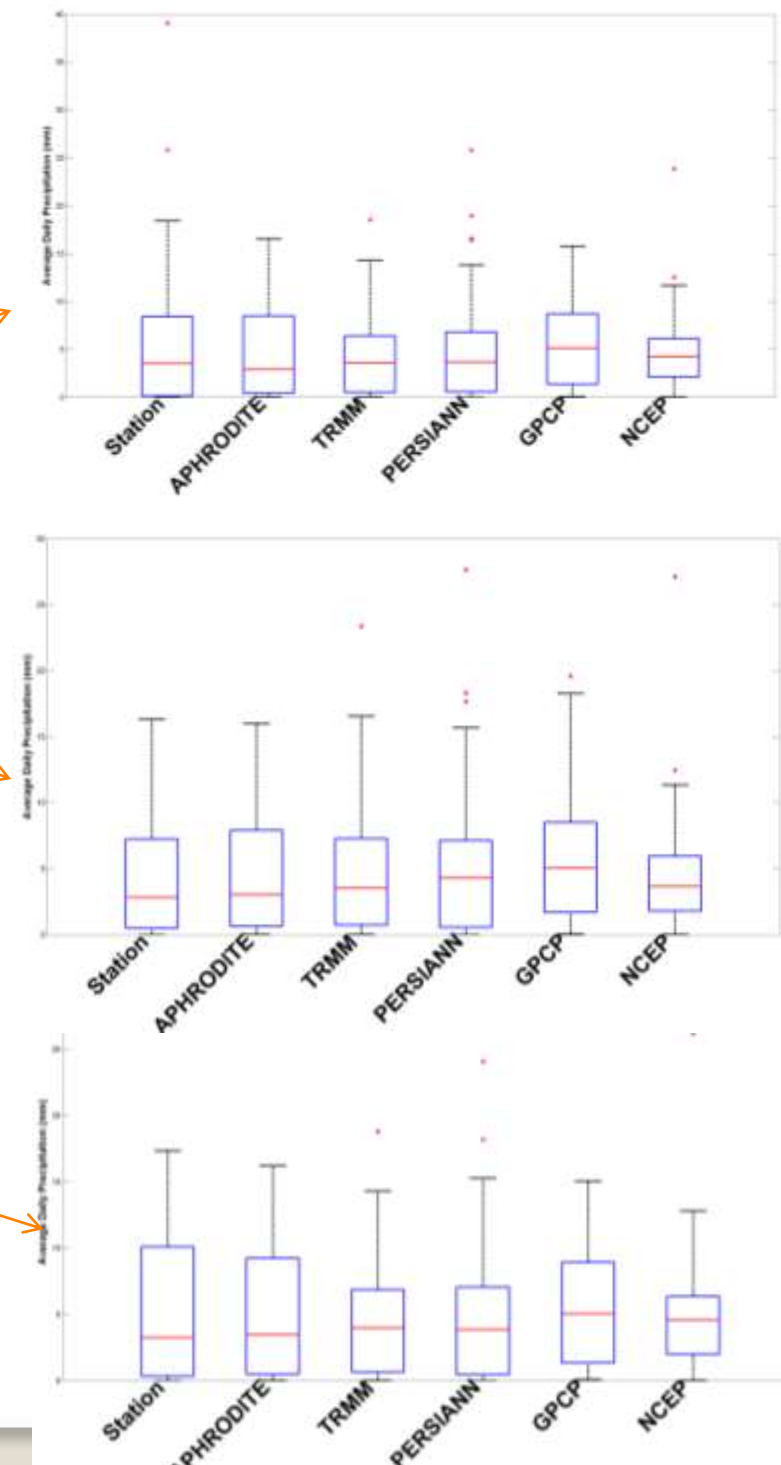
NCEP Ann Clim Precip 2000–2005



4. Application of gridded data

Gridded data are downscaled to station location using bilinear interpolation method

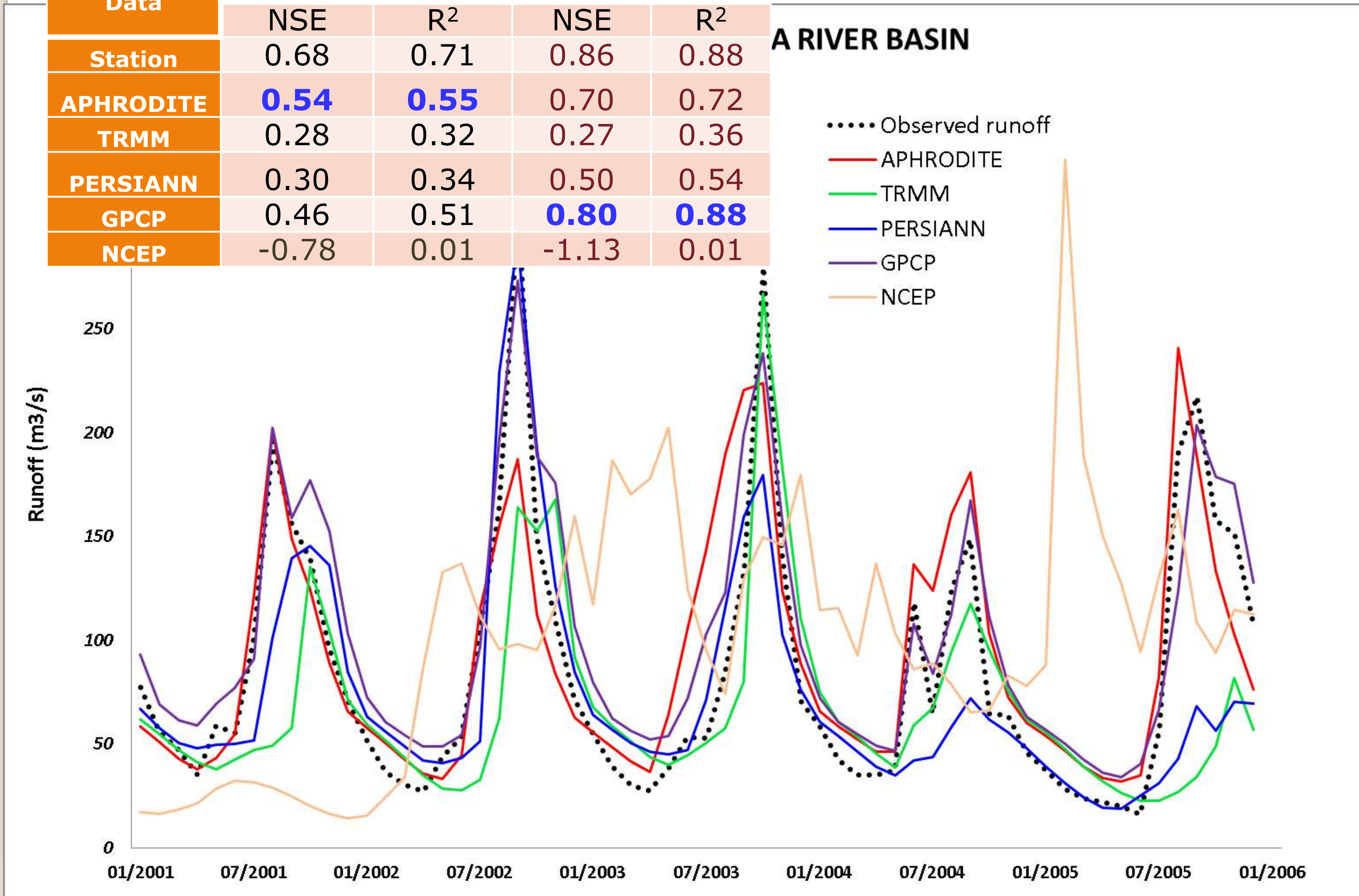




4. Application of gridded data

Application to runoff over Dakbla river basin

Data	Daily		Monthly	
	NSE	R^2	NSE	R^2
Station	0.68	0.71	0.86	0.88
APHRODITE	**0.54**	**0.55**	0.70	0.72
TRMM	0.28	0.32	0.27	0.36
PERSIANN	0.30	0.34	0.50	0.54
GPCP	0.46	0.51	**0.80**	**0.88**
NCEP	-0.78	0.01	-1.13	0.01

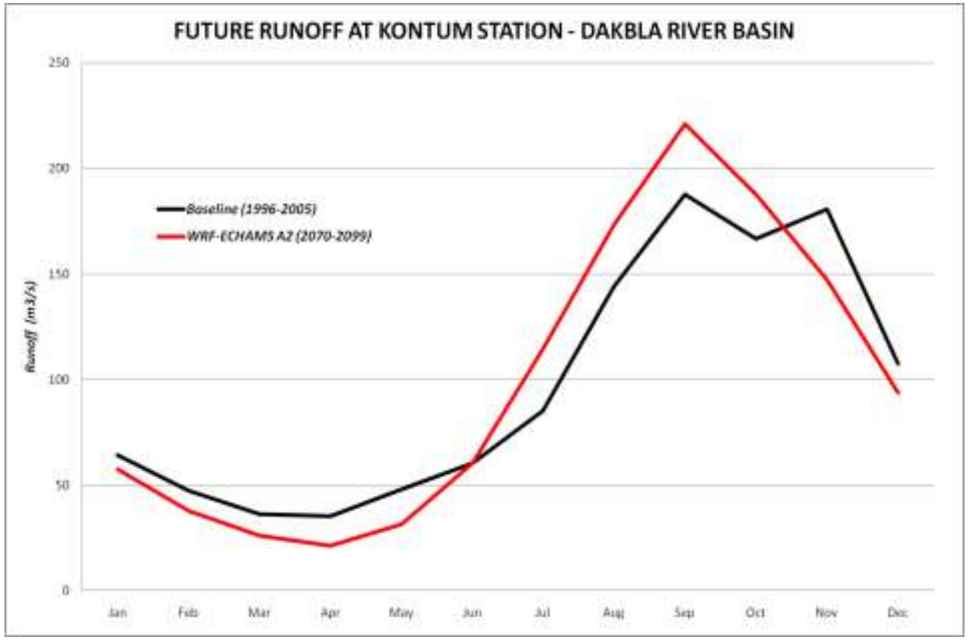


Climate Change Application

Annual cycle RUNOFF for period 2070-2099 using DELTA factor derived using RCM WRF driven by GCM ECHAM5

$$\Delta_{month} = \left(\overline{P^{RCM.ECHAM5}_{2070-2100}} - \overline{P^{RCM.ECHAM5}_{1961-1990}} \right)_{month}$$

$$New\_P_{day} = P^{Station.Observed}_{day} + \Delta_{month}$$



Black Line – Current condition

Red Line – Future change

5. Conclusion

- **SWAT model proves to be a good tool for assessment of hydrological responses.**
- **SWAT model has been applied for Dakbla river in Vietnam.**
- **6 year daily data has been used for Sensitivity analysis and Auto calibration.**
- **NSE and R^2 are used to benchmark model, it shows very good performance of the model to study catchment**

5. Conclusion (contd.)

- **Gridded observation data and Reanalysis data are applied in verification process.**
- **APHRODITE data shows very good agreement with daily simulation whilst GPCP is perfect in monthly simulation.**
- **Applications to climate change studies also promising.**

THANKS FOR YOUR ATTENTION!

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