Calibration, validation and uncertainty analysis of SWAT Model for predicting reservoir inflow in Umiam watershed, Meghalaya.

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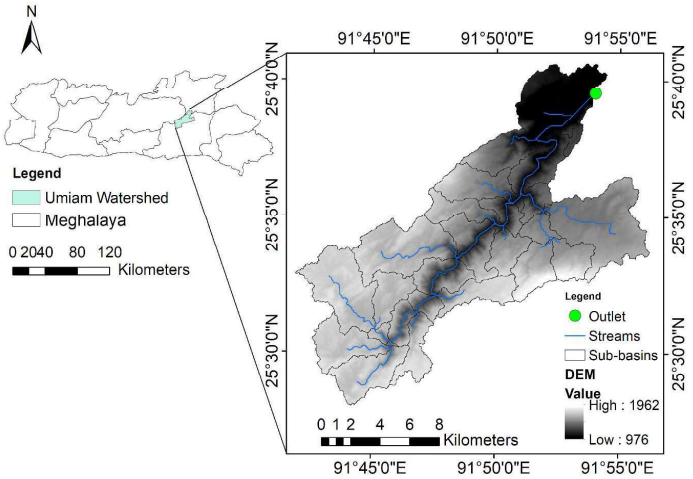
Introduction

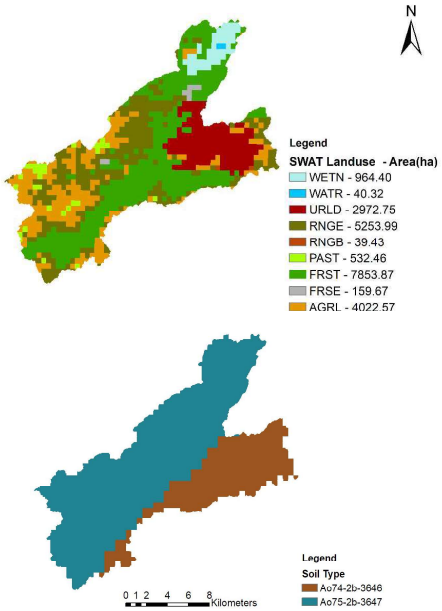
- Hydrologic models serves as an important tool for quantifying inflows to reservoirs and thus help in planning and management of water-use in a catchment.
- However, natural processes are difficult to predict using simple mathematical equations and thus, there is always some uncertainty associated with hydrological models.
- Before a hydrological model is considered satisfactory for decision-making process, its uncertainties needs to be analysed and quantified.

Significance of the study

- Umiam river provides water for 5 cascading reservoirs generating 216 MW of power.
- Hydrological model will help in assessment of water balance in the watershed.
- Hydrological model can help in getting an insight into the optimal operation of reservoirs under climate change scenario.
- Thus the objective of this study is to establish SWAT model for the study area and to perform calibration, validation and to quantify the uncertainties.

Methodology
Watershed description



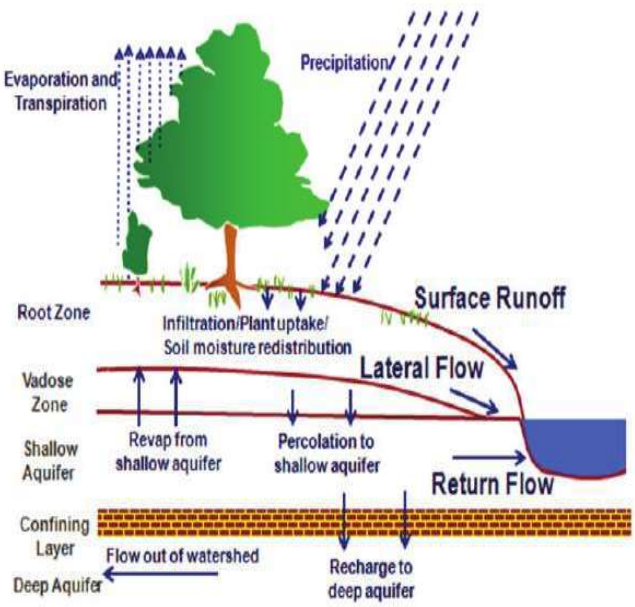


SWAT (Soil & Water Assessment Tool)

Developed by United States Department of Agriculture(USDA), Agriculture Research Service (ARS)

SWAT is a hydrological model which can simulate the quality and quantity of surface and ground water in a watershed.

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

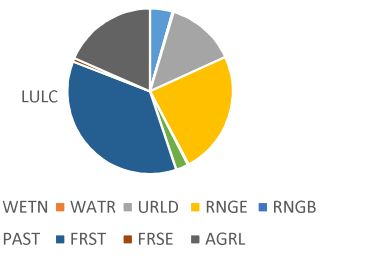


Data

Data type	Data used	Description	Source
Topographic	SRTM 30 m DEM	Shuttle Radar Topographic Mission Digital Elevation Model (DEM) of 30 m resolution.	https://earthexplorer.usgs.gov/
Soil	Harmonized World Soil Database v 1.2	Global 30 arc-second raster database	http://www.fao.org
Land Cover	MODIS Land Cover Type	Resolution 500 m	https://modis.gsfc.nasa.gov/data
Weather	IMD gridded data 1 Deg	Daily Precipitation and temperature data for 1974-2000 period	Indian Meteorological Department
Streamflow	Daily streamflow	Daily discharge data for 1979-2000 period	Meghalaya Power Generation Corporation Limited, Shillong

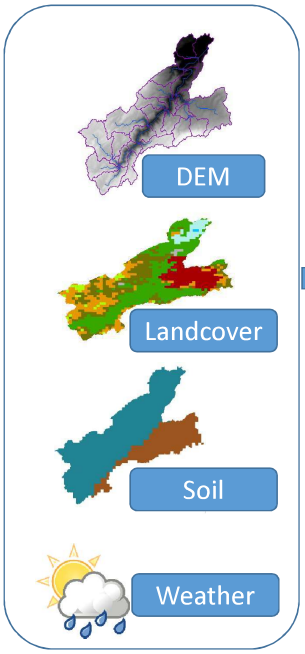
Model set up

Area: 21839.4751 Ha
No. of Sub-basins: 31
Number of HRUs: 258



Orthic Acrisols (FAO)	
Ao74-2b-3646	Ao75-2b-3647

Precipitation, Temperature



SWAT Simulation

Warm up:1974-78

Sensitivity

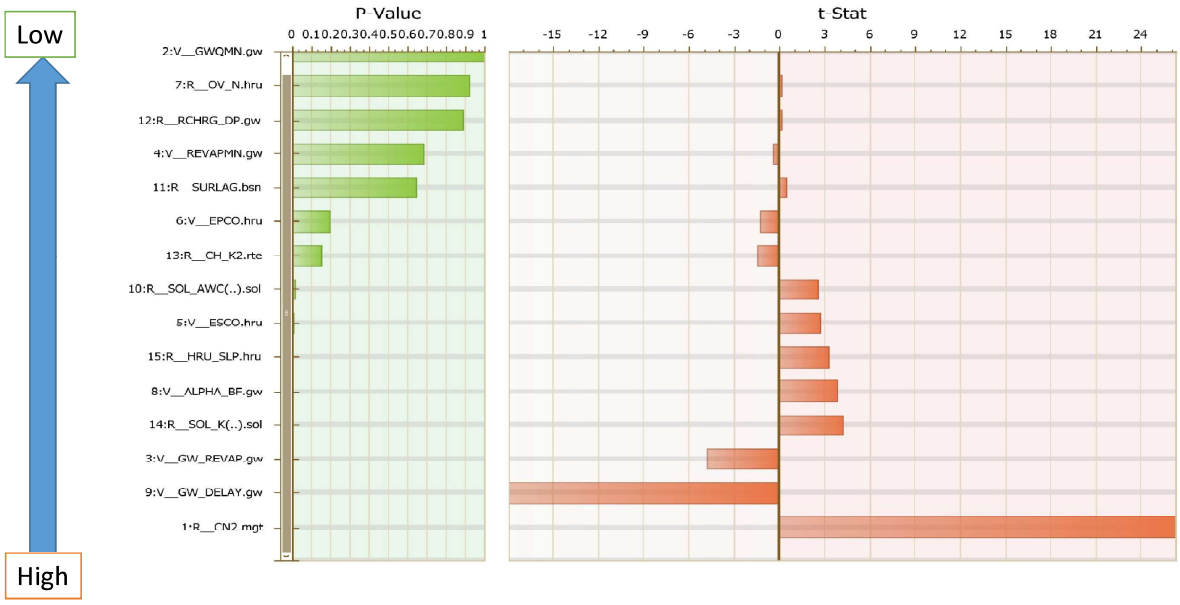
Calibration 1979-1995

15 Parameters

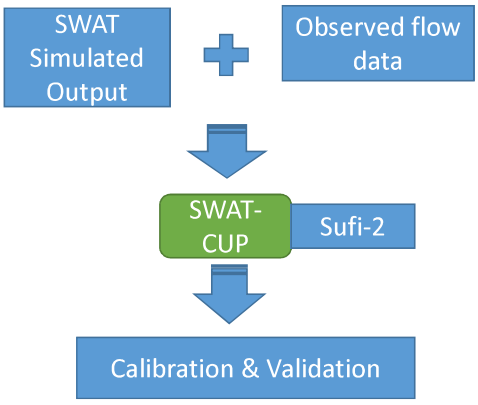
Validation 1996-2000

Final Model

Sensitivity Analysis



Calibration



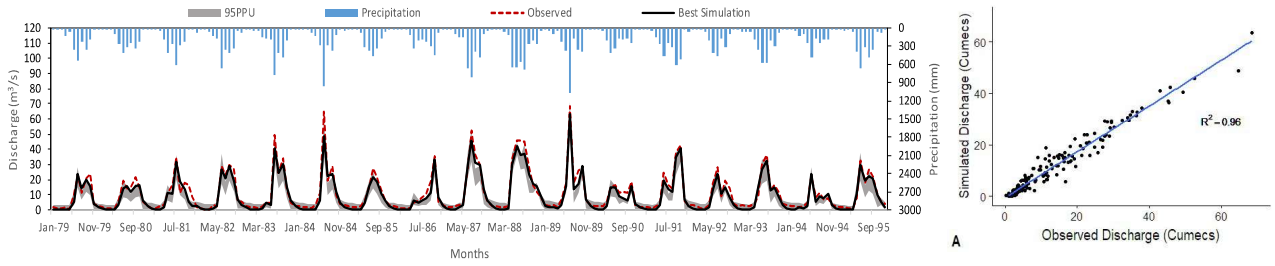
Warm-up =1974-1978
No. of Iterations = 4
Each Iteration = 500 simulations
Objective function is R^2

Parameter Calibration

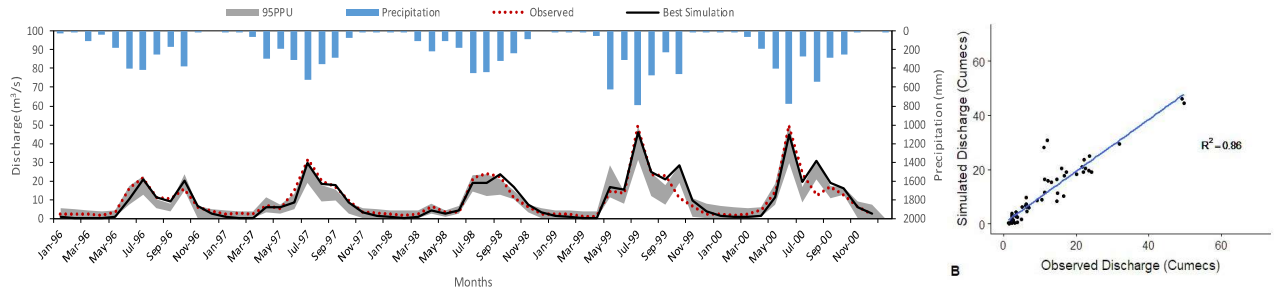
Sl. No	Parameter	Description of Parameter	Lower and Upper Bounds	Fitted Value	Sensitivity Rank
1.	R__CN2.mgt	SCS runoff curve number	-0.20 to 0.20	0.034	1
2.	V__GWQMN.gw	Threshold depth of water in the shallow aquifer required for return flow to occur (mm)	0 to 25	21.37	15
3.	V__GW_REVAP.gw	Groundwater "revap" coefficient	0.02 to 0.2	0.073	3
4.	V__REVAPMN.gw	Threshold depth of water in the shallow aquifer for "revap" to occur (mm)	0 to 10	9.79	12
5.	V__ESCO.hru	Soil evaporation compensation factor	0.8 to 1	0.85	7
6.	V__EPCO.hru	Plant uptake compensation factor	0.8 to 1	0.87	10
7.	R__OV_N.hru	Manning's "n" value for overland flow	-0.2 to 0.2	0.066	14
8.	V__ALPHA_BF.gw	Baseflow alpha factor (days)	0 to 1	0.725	5
9.	V__GW_DELAY.gw	Groundwater delay (days)	30 to 450	40	2
10.	R__SOL_AWC(..).sol	Available water capacity of the soil layer (mm H2O /mm soil)	0.2 to 0.4	0.08	8
11.	R__SURLAG.bsn	Surface runoff lag time (days)	-0.3 to 0.2	0.12	11
12.	R__RCHRG_DP.gw	Deep aquifer percolation fraction	-0.2 to 0.2	0.14	13
13.	R__CH_K2.rte	Effective hydraulic conductivity in main channel alluvium (mm/hr)	-0.2 to 0.2	0.19	9
14.	R__SOL_K(..).sol	Saturated hydraulic conductivity (mm/h)	-0.8 to 0.8	0.136	4
15.	R__HRU_SLP.hru	Average slope steepness (m/m)	0 to 0.2	0.089	6

Results and Discussion

Calibration



Validation



Results and Discussion

- The peak flows are under predicted by SWAT.
- Lower baseflow prediction.
- Surface flow and groundwater parameters like Curve Number, Groundwater delay, Groundwater revap coefficient are most sensitive parameters in the study area.
- SWAT simulated stream flows were in good agreement with the observed data.
- Uncertainty expressed by p-factor and r-factor are under acceptable limits.

Performance Index	Calibration	Validation
R^2	0.96	0.86
NSE	0.94	0.85
PBIAS	15	1.6
p-factor (1)	0.81	0.88
r-factor	0.50	0.66

Conclusions

- SWAT model was successfully established for the study area.
- Model was successfully calibrated and validated for Umiam watershed.
- Model performance is satisfactory.
- Most sensitive parameters are CN2, GW_DELAY, GW_REVAP, SOL_K, REVAPMN, ALPHA_BF, HRU_SLP.
- Some limitations are observed in simulating baseflows accurately.
- Further studies may use climate projection data(GCM/RCM) to drive the SWAT model to study climate change effects on stream flow.

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Thank You