HYDROLOGICAL MODELING OF UPPER GANGA CATCHMENT USING SWAT 2009

A Presentation
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- I am grateful to my collegues and friends and professors for making the data easily accessible through the IIT Delhi server.
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- Above all, I would acknowledge Prof. CSP Ojha without whose support and advice I would be unable to present this work.

INTRODUCTION

- The Ganges basin covers about one third of the Indian sub continent.
- It has high slope in the upper stretch and causes a high velocity in flow.
- Also, apart from the rainfall contribution, the glacial melt has a considerable impact in the addition to the flow to the river.
- The SWAT model is applied to the upper Ganga catchment upto Haridwar and covers about 22580km^2
- The application of SWAT to a Himalayan sub basin to study the discharge characteristics including snow melt contribution is discussed here.

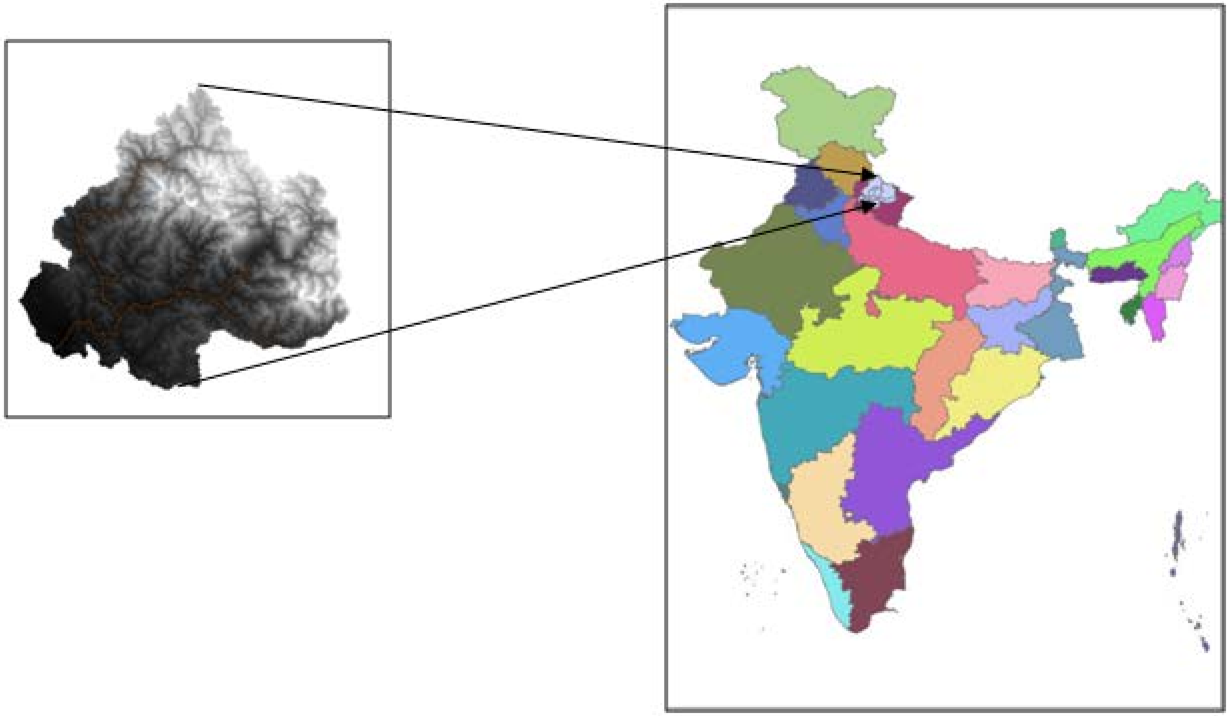
ORGANIZATION OF THE PRESENTATION

- The presentation is organized in the following sequence
  - Study area
  - Data and data processing
  - SWAT run
  - Results and discussion
  - Snow modelling
  - Conclusion

STUDY AREA

- The area here is the initial stretch of the Ganga catchment.
- The project is a part of the Ganga River Basin Management Plan carried out By the Govt. Of INDIA in collaboration with 7 IIT's
- The Ganges is a glacier fed Himalayan river. This initial stretch is highly slopy and mountainous terrain.
- The basin has a wide variety of soil types .The areal extent is around 22580km^2

STUDY AREA



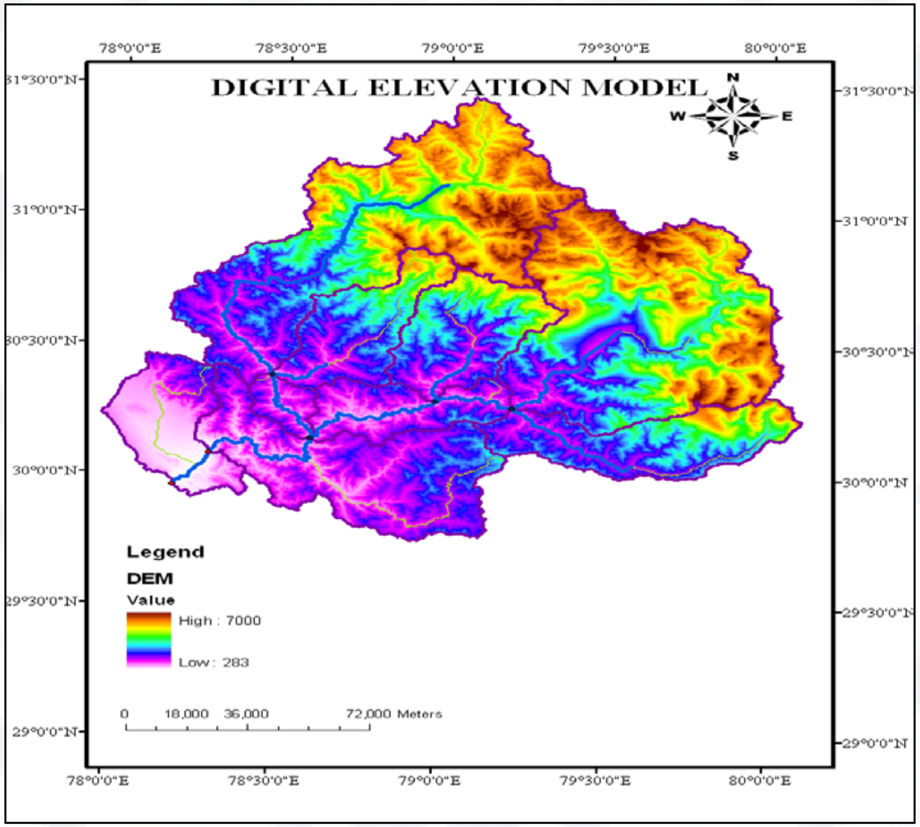
The study area

The sub basin area where discharge is measured and verified is located upstream of Rishikesh.

DATA&DATA PROCESSING

❖Digital Elevation Model (DEM):

➤The data here is the Digital elevation model. It is of 90 m resolution and is SRTM data.

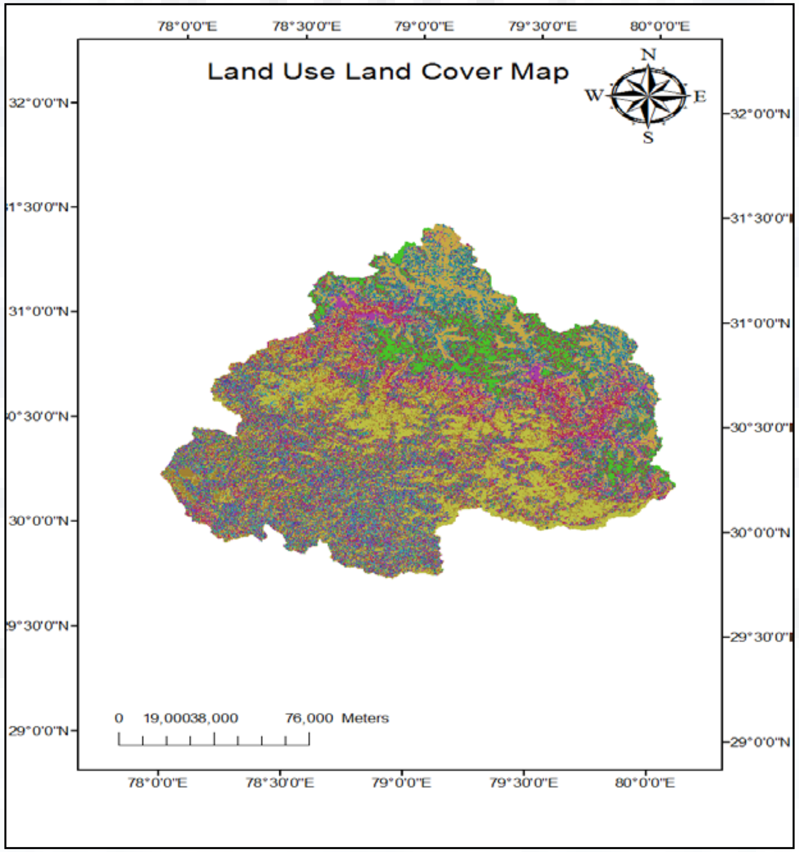


Digital Elevation Model

DATA&DATA PROCESSING

❖Land Cover/Land Use:

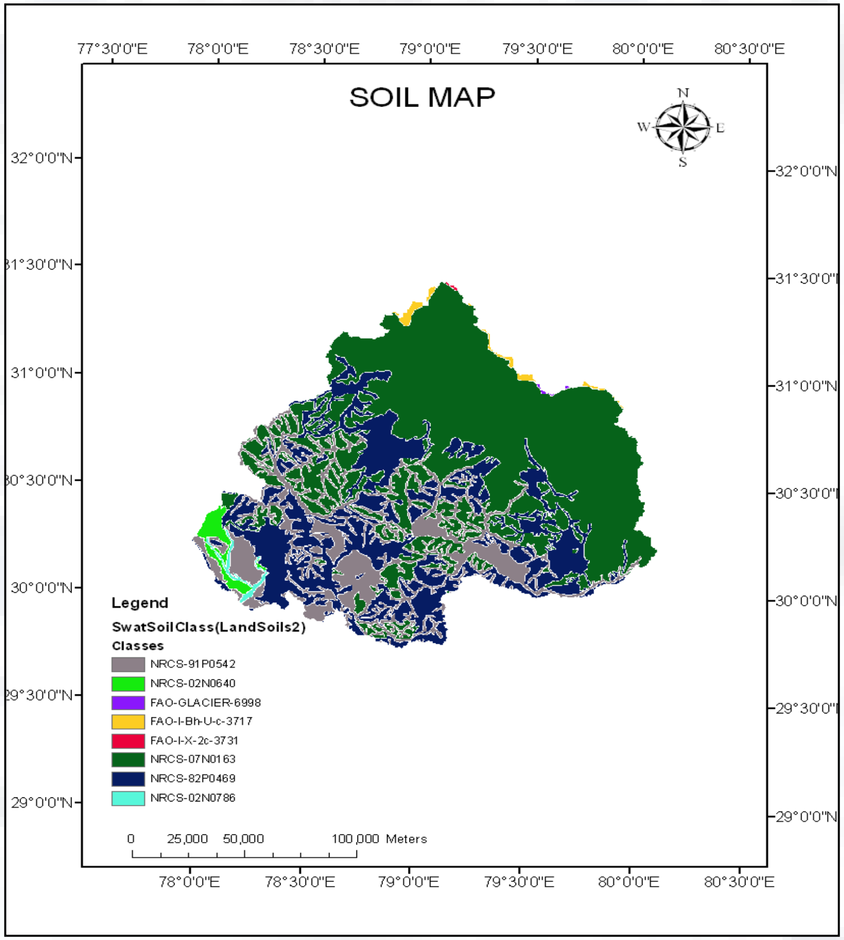
➢A large number of LULC classes defined here is by result of the district wise agricultural and land use class classification.



Land Use Land Cover map(Courtesy:Dr N Balaji through IITD server).

DATA&DATA PROCESSING

❖ Soil MAP: The soil here is classified using FAO, NBLSS AND NRSC soil classifications..



Soil Map

DATA&DATA PROCESSING

- **Weather data:** The weather data defined here is daily data and is of the following specifications.
  - The APHRODITE rain data in (mm/day), Temperature (deg. C), Wind speed (m/sec), Solar radiation (mJ/m2) of 0.5 deg resolution in ASCII format from 1961 to 2007
  - Princeton university weather data daily including max and min temp.of 1 deg resolution in ASCII format from 1948-2006.

SWAT RUN

- The SWAT model was run initially for a known period (1970-1986) to check the validity of SWAT model for the basin.
- The run was monthly and the outlet was selected based on the location where the monthly data was recorded.
- The flow was analysed for virgin condition assuming no obstructions

RESULTS AND DISCUSSIONS

HRU analysis:

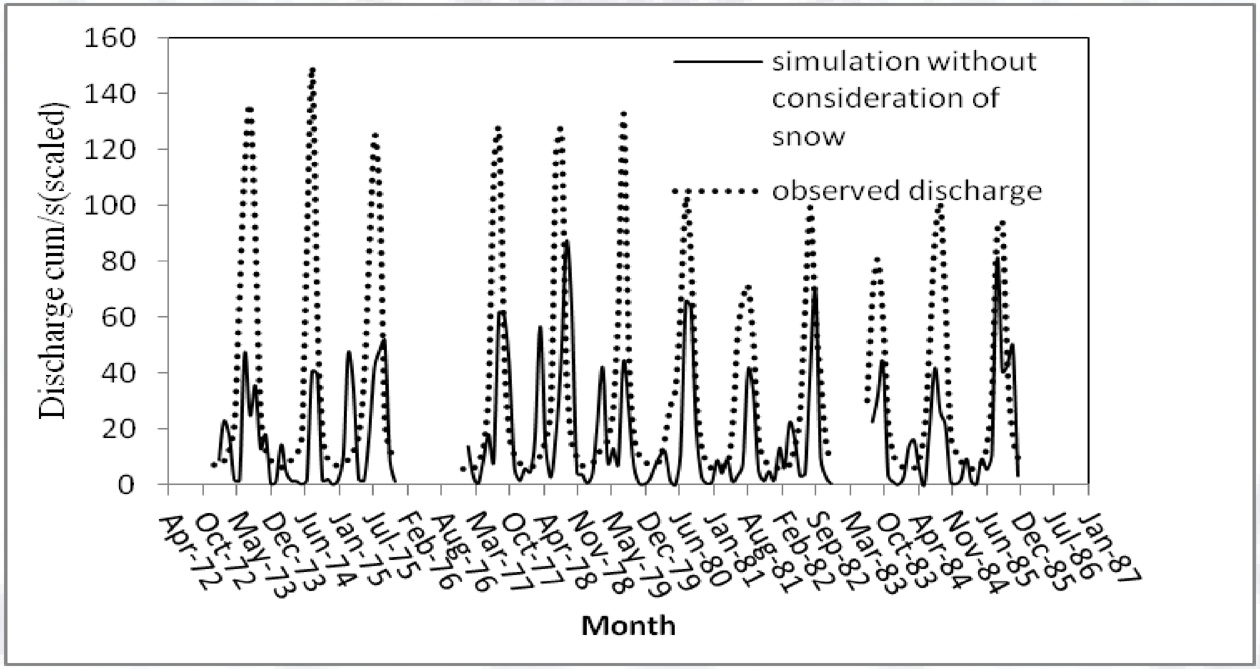
		Area [ha]	
Watershed		2257965	
		Area [ha]	%Wat.Area
LANDUSE:	forest-Evergreen --> FRSE	781216.7	34.6
	Pasture --> PAST	527773.5	23.37
	Range-Grasses --> RNGE	382910	16.96
	SNOW --> SNOW	283187.7	12.54
	Forest-Mixed --> FRST	215646.7	9.55
	Rainfed --> A277	6478.722	0.29
	Forest-Deciduous --> FRSD	60751.55	2.69
SOILS:	NRCS-07N0163	1275603	56.49
	NRCS-82P0469	590810	26.17
	NRCS-91P0542	363506.1	16.1
	NRCS-02N0640	28046.2	1.24
SLOPE:	50-80	757717.7	33.56
	30-50	710308.3	31.46
	0-30	578344.8	25.61
	80-9999	211594.2	9.37

RESULTS AND DISCUSSIONS

- The discharge here is corrected using a scaling factor 'r'.
- The non snow analysis done here showed stimulations where there is considerable deficit between the observed and computed discharges. This can be seen in the plot shown.
- The preliminary analysis results are discussed here.the finetuning and further SWAT-CUP analysis is to be done as a future work.

RESULTS AND DISCUSSIONS

- ✓The sensitivity analysis gave a sensitivity ranking as shown in Table.
- ✓Accordingly, the parameters were varied.
- ✓Of the number of simulations, the best results are shown here.



RESULTS AND DISCUSSIONS

Parameter	Ranking	Parameter	Ranking
CN2	1	EPCO	14
ESCO	2	CH_N2	15
CANMX	3	SOL_ALB	16
SOL_AWC	4	GW_DELAY	17
REVAPMN	5	BIOMIX	18
SOL_Z	6	SURLAG	19
GWQMN	7	SLSUBBSN	20
BLAI	8	SFTMP	27
GW_REVAP	9	SMFMN	27
SOL_K	10	SMFMX	27
CH_K2	11	SMTMP	27
ALPHA_BF	12	TIMP	27
SLOPE	13	TLAPS	27

Model parameters sensitivity ranking by SWAT

RESULTS AND DISCUSSIONS

Name	Description	Max	Min	Process
CN2	SCS runoff CN for moisture condition II	35	98	Runoff
SURLAG	Surface runoff lag coefficient	0	10	Runoff
SOL_AWC	Available water capacity of the soil layer (mm/mm soil)	0	1	Soil
SOL_K	Soil conductivity (mm/hrs)	0	100	Soil
SOL_Z	Soil depth	0	3000	Soil
EPCO	Plant evaporation compensation factor	0	1	Evaporation
ESCO	Soil evaporation compensation factor	0	1	Evaporation
SOL_ALB	Soil albedo	0	0.1	Evaporation
ALPHA_BF	Baseflow alpha factor (days)	0	1	Groundwater
GW_DELAY	Groundwater delay (days)	0	50	Groundwater
GW_REVAP	Groundwater 'revap' coefficient.	0.02	0.2	Groundwater
GWQMN	Threshold depth of water in the shallow aquifer required for return flow to occur (mm)	0	5000	Groundwater
RCHR_DP	Groundwater recharge to deep aquifer (fraction)	0	1	Groundwater
REVAPMN	Threshold depth of water in the shallow aquifer for 'revap' to occur (mm).	0	500	Groundwater
SLOPE	Average slope steepness (m/m)	0.0001	0.6	Geomorphology
SLSUBBSN	Average slope length (m).	10	150	Geomorphology
CH_N1	Manning coefficient for tributary channel	0.008	30	Channel
CH_K1	hydraulic conductivity in tributary channel (mm/hrs)	0	150	Channel
CH_S1	Average slope of tributary channel (m/m)	0	10	Channel
CH_N2	Manning coefficient for main channel	0.008	0.3	Channel
CH_S2	Average slope of main channel (m/m)	0	10	Channel
CH_K2	hydraulic conductivity in main channel (mm/hrs)	0.01	150	Channel

Parameters and parameter ranges used in sensitivity analysis using SWAT model.

SNOW MODELLING AND ANALYSIS

- The basin here has a major input from glaciers.
- The basic snow model built in SWAT was redefined to model the elevations and the corresponding snow depths available.
- The snow melt contribution was analyzed by dividing the total elevation into five elevation bands as in Table.
- The snow depth initially considered to be zero was varied to about 3000mm from 300mm.
- The model gave a very high discharge for snow depth of 3000 mm indicating the dependency of the basin discharge to snowmelt contribution.

SNOW MODELLING AND ANALYSIS

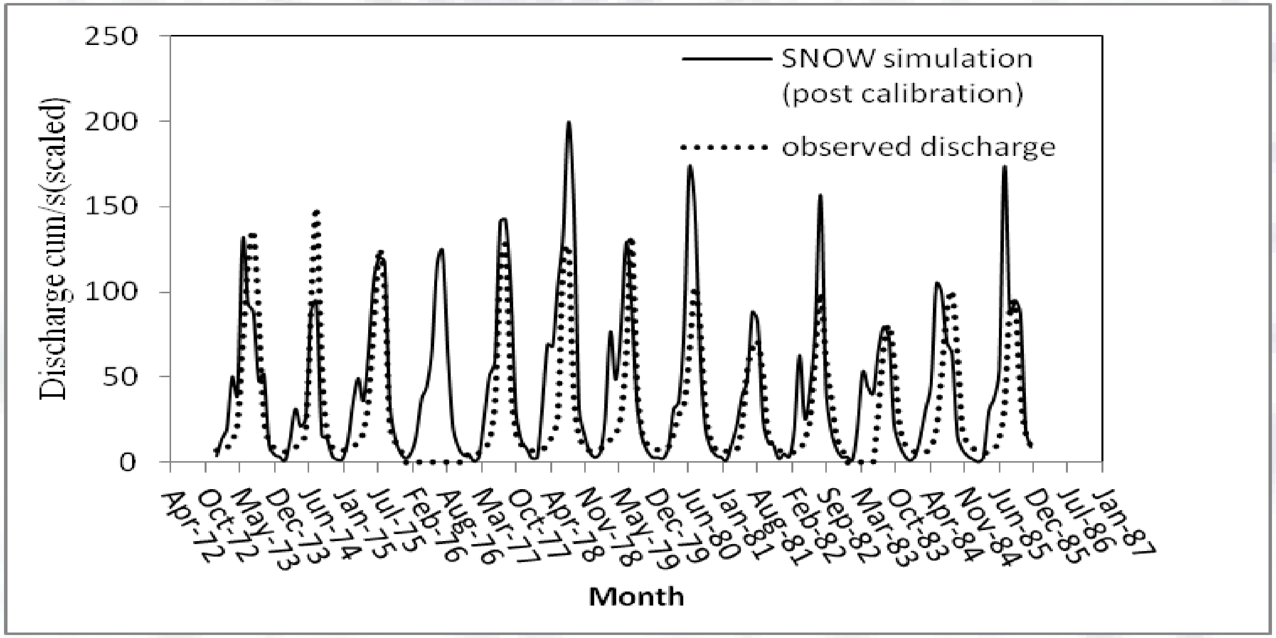
S.No.	Elev Bands	S.No.	Elev Bands
SIB BASIN 1	1505.39	SIB BASIN 6	762.10
	2433.18		1114.57
	3702.45		1460.67
	4744.84		1833.80
	5532.35		2289.02
SIB BASIN 2	1361.80	SIB BASIN 7	687.33
	2116.68		1109.46
	2930.92		1476.15
	3972.59		1844.19
	5126.57		2353.51
SIB BASIN 3	1366.73	SIB BASIN 8	1521.34
	2183.83		2230.04
	3018.40		3029.45
	4040.62		4047.39
	5038.44		5214.73
SIB BASIN 4	1635.87	SIB BASIN 9	422.744
	2663.19		657.318
	3717.83		1050.67
	4713.22		1540.39
	5570.37		1994.68
SIB BASIN 5	713.92		
	1021.09		
	1284.40		
	1568.54		
	1900.66		

Elevation band distribution

SNOW MODELLING AND ANALYSIS

➢SWAT over predicts the peaks in case of snow modelling and under-predicts the base flows (Fontaine et.al.,(2002)).

➢Similarly, in this case, the peaks at four annual cycles are over predicted and the lows are under predicted.



CONCLUSIONS

- SWAT applied to the upper Ganga catchment gives an idea of the vulnerability of the model to the terrain conditions and the discharge input variations.
- The variation of a number of vital parameters like the curve number or the base flow factor or even the ground water delay factor showed very less or no improvement in the model output.
- The sensitivity of the model to the snow melt contribution is ascertained here for this basin and the variation required in maintaining the authenticity of the model as applied to this basin is done here and is calibrated successfully.
- The error reduced to about 15% in the post calibration stage after snowmelt contribution was considered as compared to the 50% pre snowmelt calibration.

THANK YOU