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Sensitivity of SWAT modeling in the Mediterranean Joumine dam catchment

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Outline

- Introduction
- Objectives
- Study Area
- Methodology
- Results
- Conclusion

1. Introduction

- Hydrological models are useful tools to understand problems and to simulate the influence of land use, soil, agriculture management and climate conditions on flow, sediment and nutrient yields under different temporal and spatial dimensions.

- Model input data are actually the primary sources of errors in estimated hydrological variables

- Model outputs are very sensitive to input data, especially rainfall (Abbaspour , 2012; Tuo et al, 2018; Aouissi et al, 2018).

2. OBJECTIVES

- The objective of this study was to enhance understanding of the sensitivity of the SWAT model to the input variables.

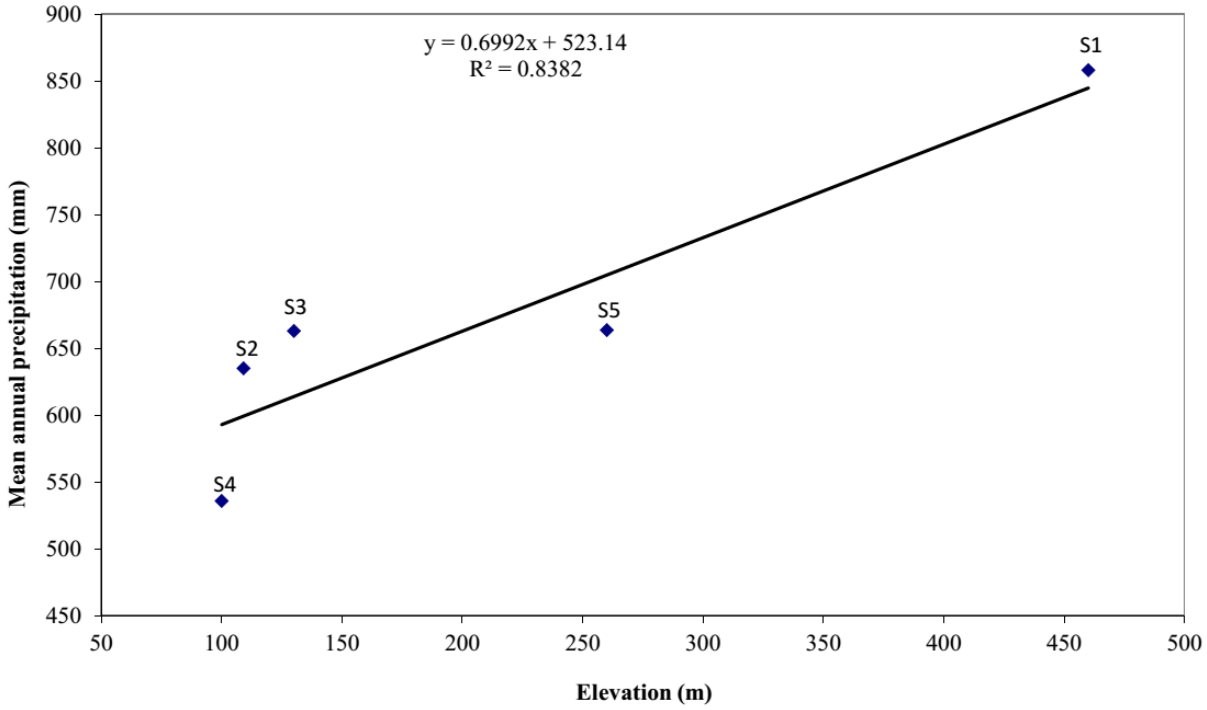
- Evaluate the impact of input variables using SWAT model

- Sensitivity analysis of SWAT model for the input variables helps modeler to choice the best combination for enhancing the simulation results before calibration

3. SUDY AREA

The Joumine catchment:

- located in Northern subhumid mountainous Tunisia
- Discharging into the lake Ichkeul in northern Tunisia, a UNESCO World Heritage site since 1980
- is dominated by intensive agricultural production.
- Paverage=750 mm/y, Annual Evaporation: 1600 mm/y



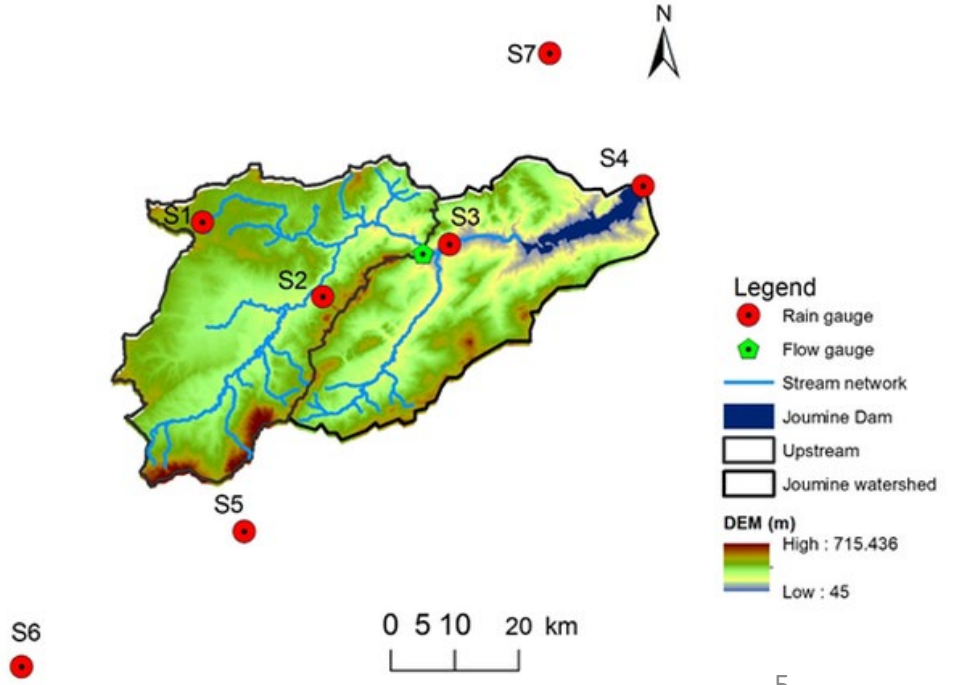
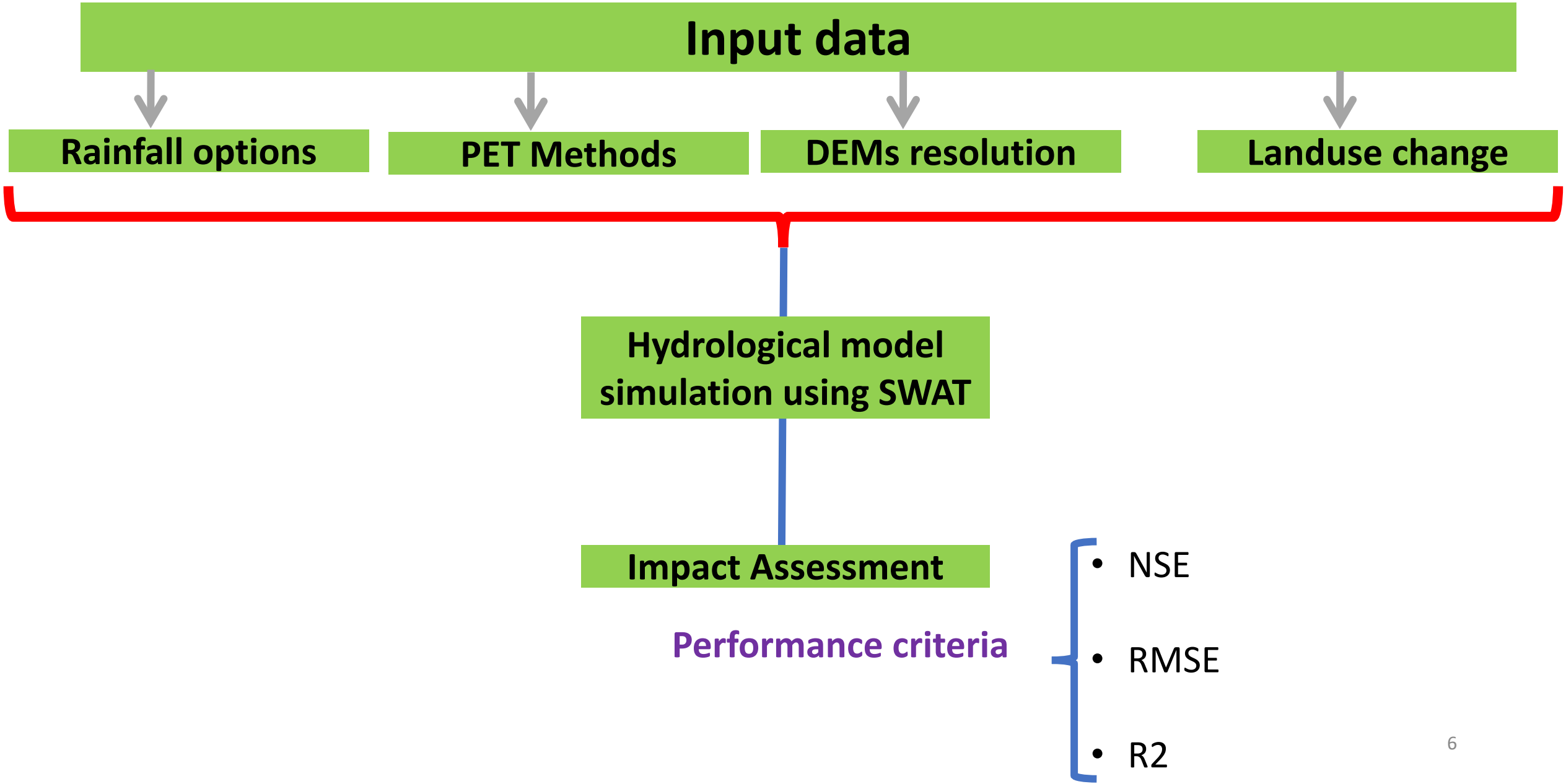
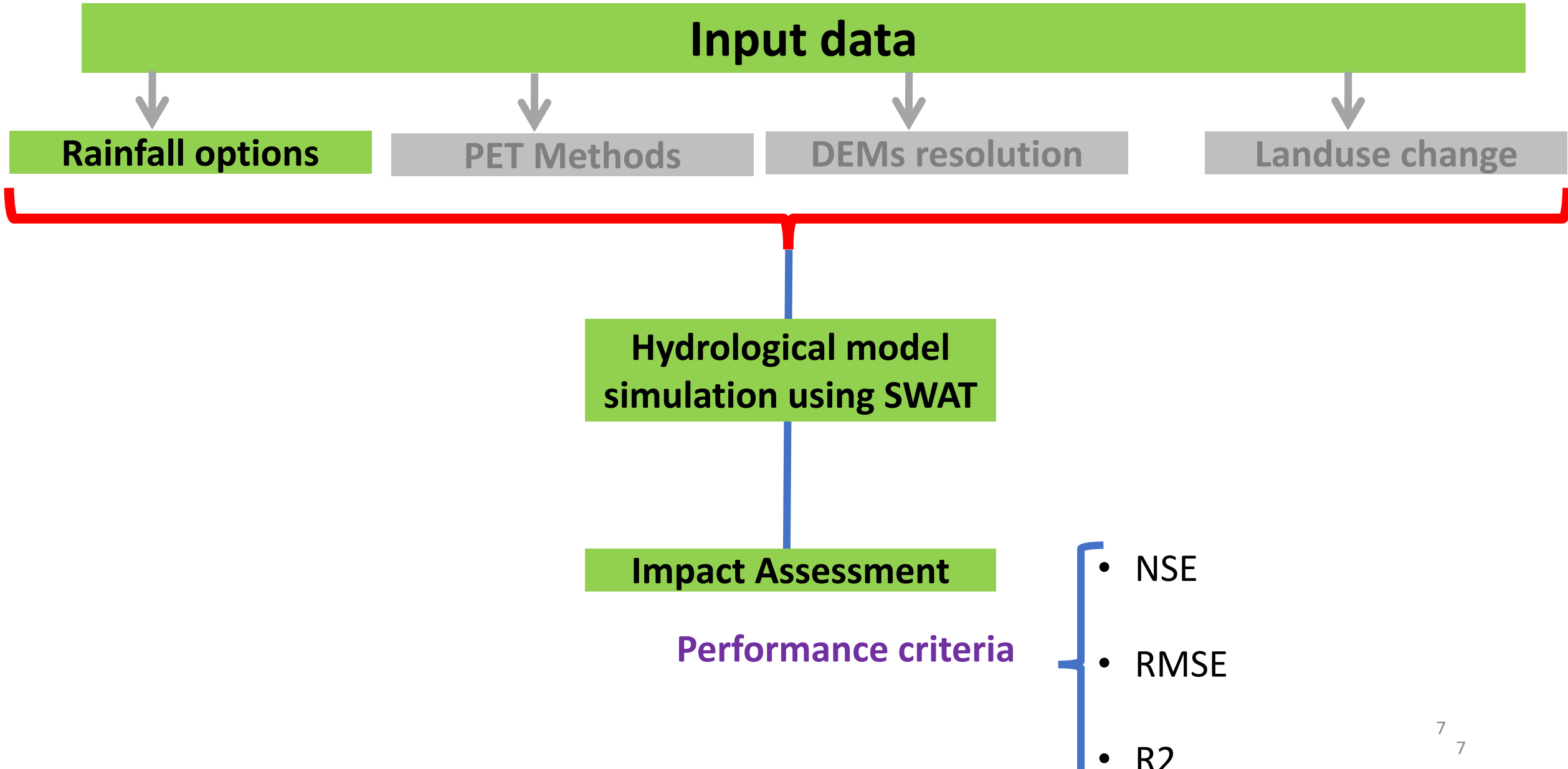


Figure shows that annual rainfall increases with elevation at the rate of 69.9 mm per 100 m of elevation

4. METHODOLOGY



5. RESULTS


Input data
Rainfall options
PET Methods
DEMs resolution
Landuse change
Hydrological model simulation using SWAT
Impact Assessment
Performance criteria
NSE
RMSE
R2

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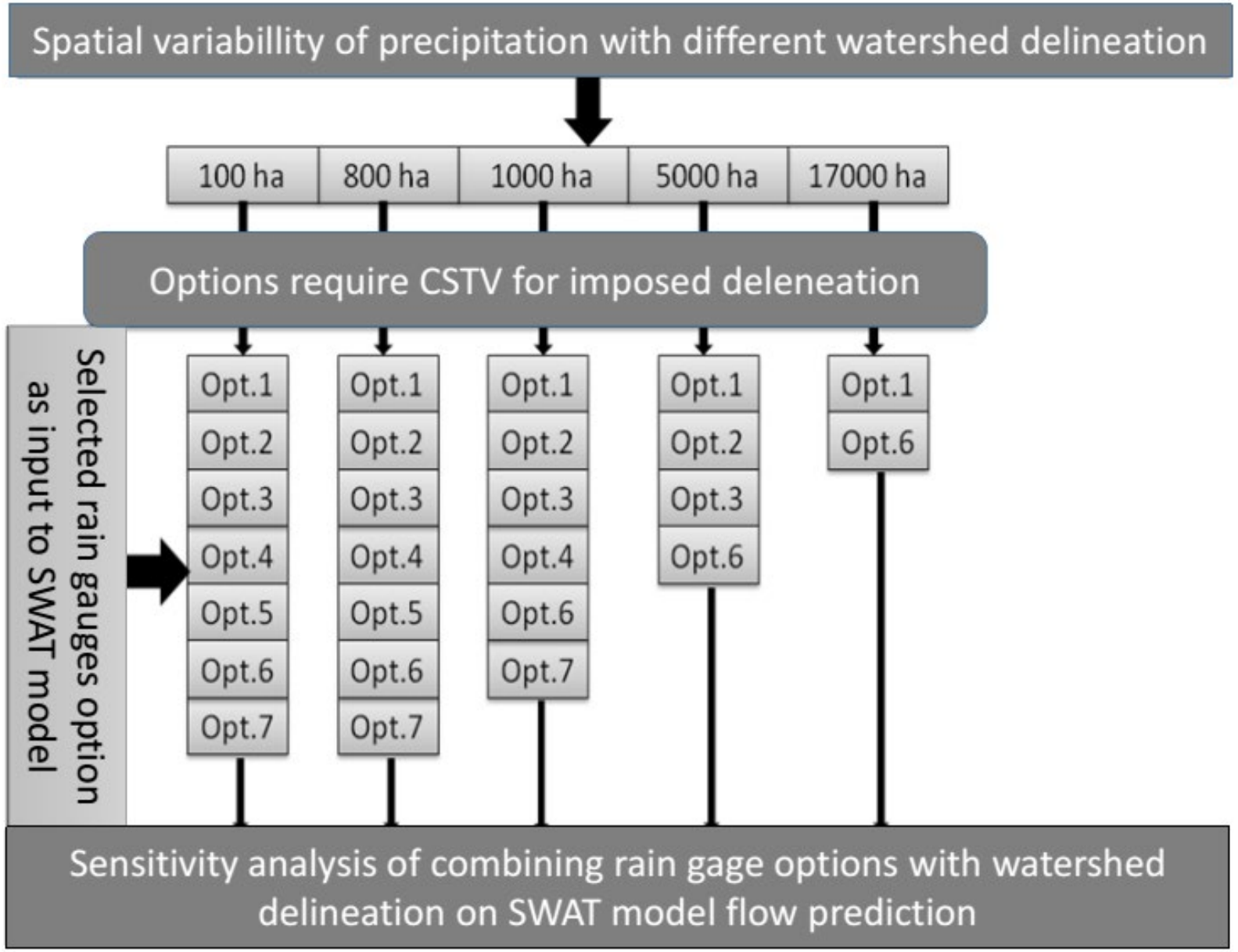
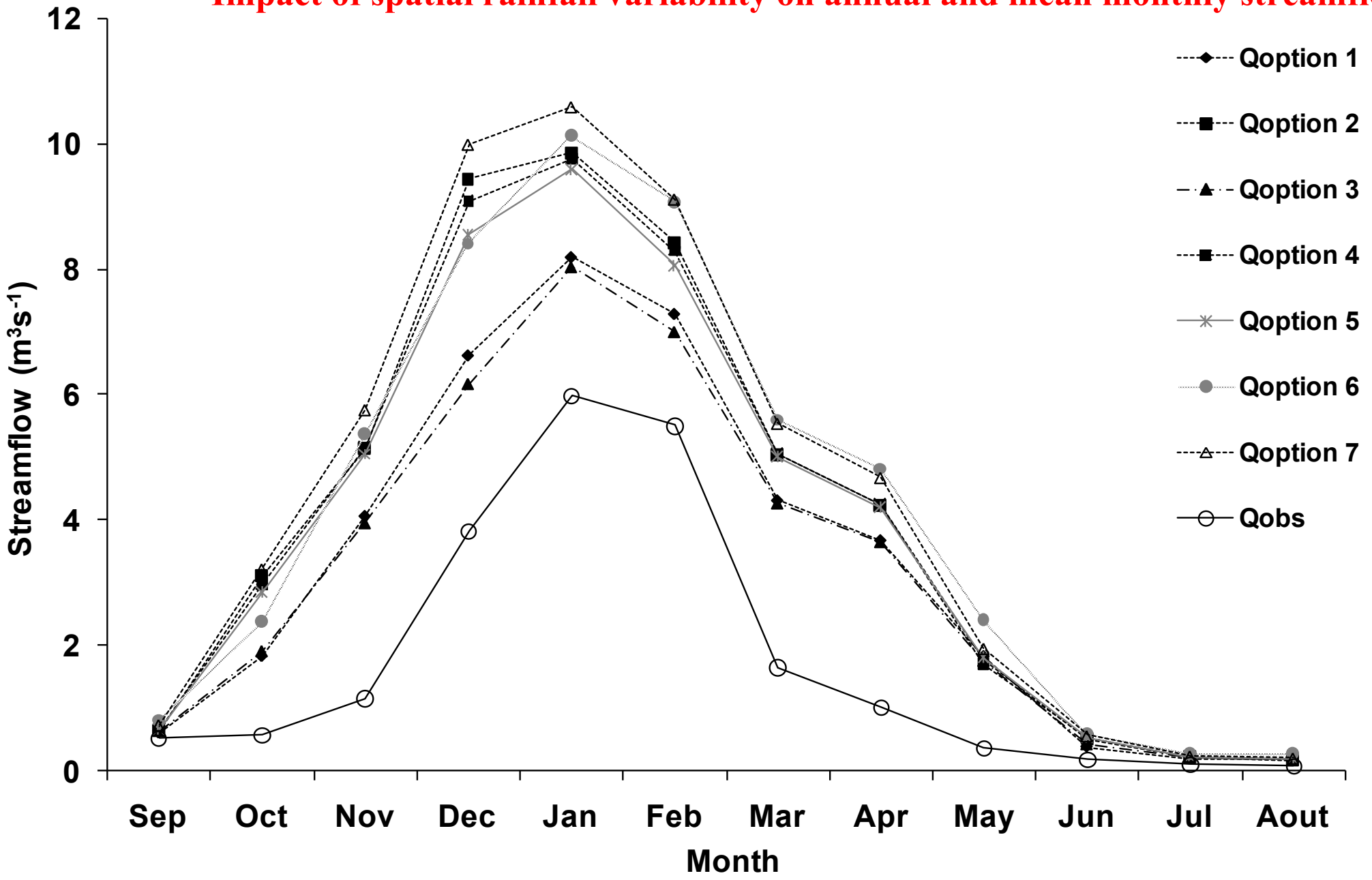
Methodology flowchart

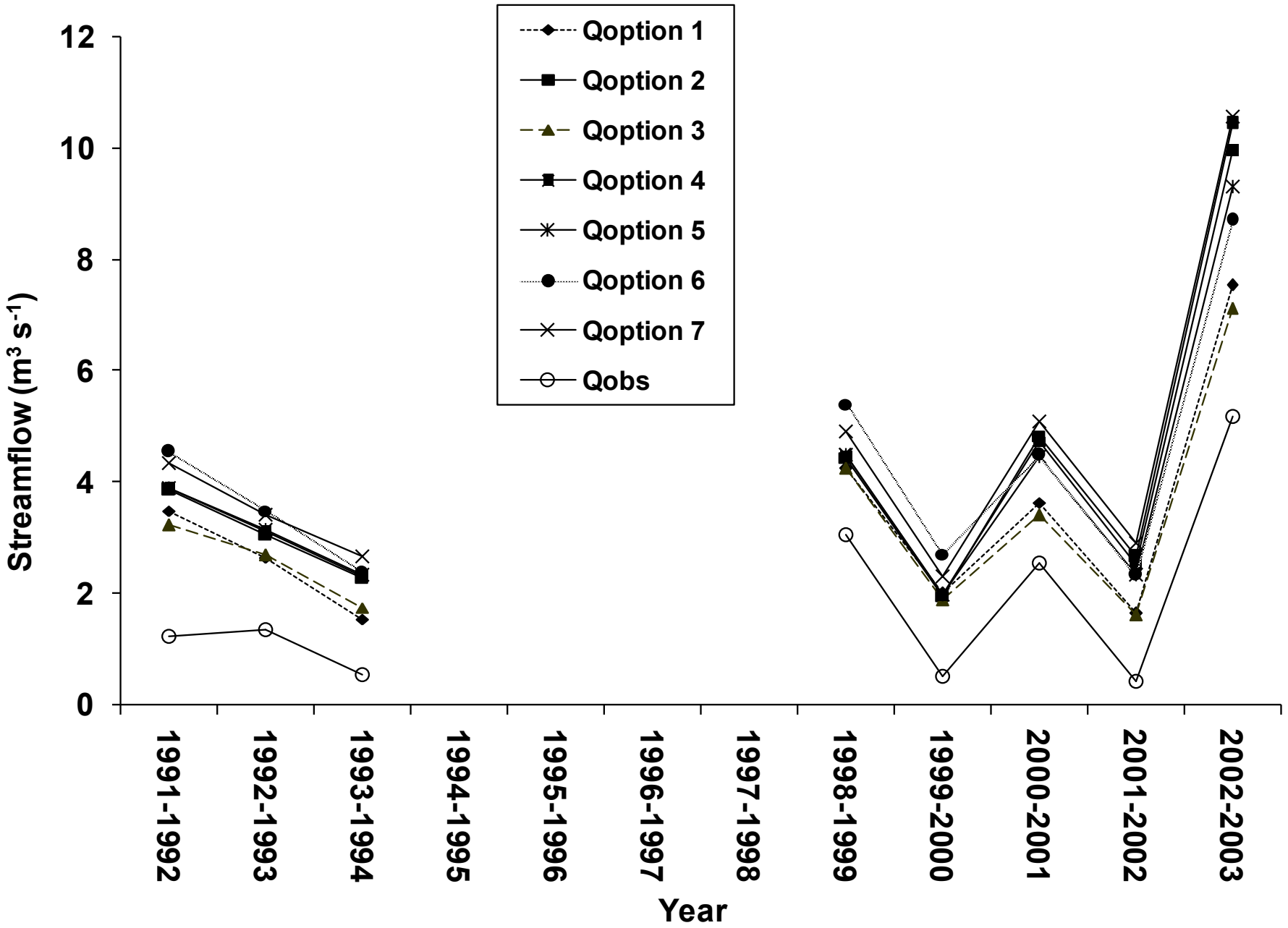


Impact of spatial rainfall variability on annual and mean monthly streamflow simulations



Predicted average monthly stream flow for each option and measured stream flow

Predicted annually for 1991- 2003 stream flow for each option and measured stream flow:

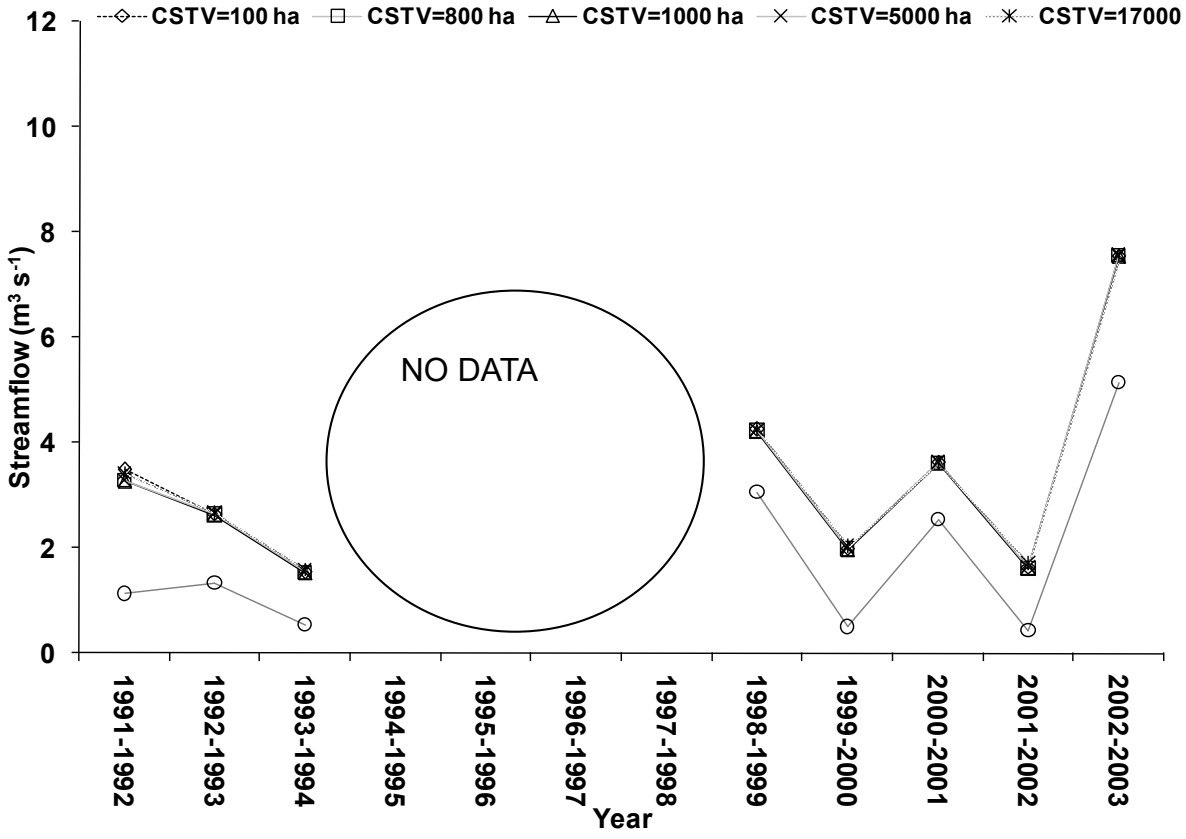


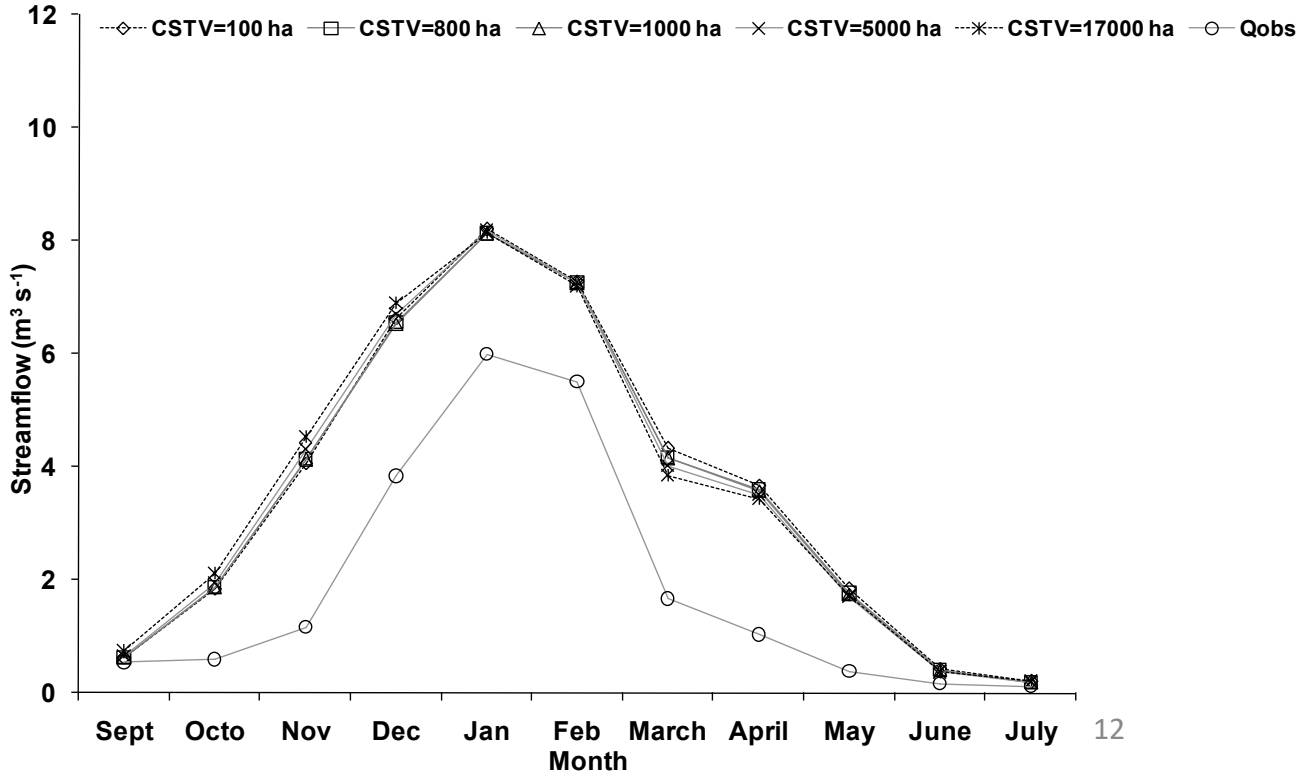
SWAT model showed a high sensitivity for the spatial rainfall distribution

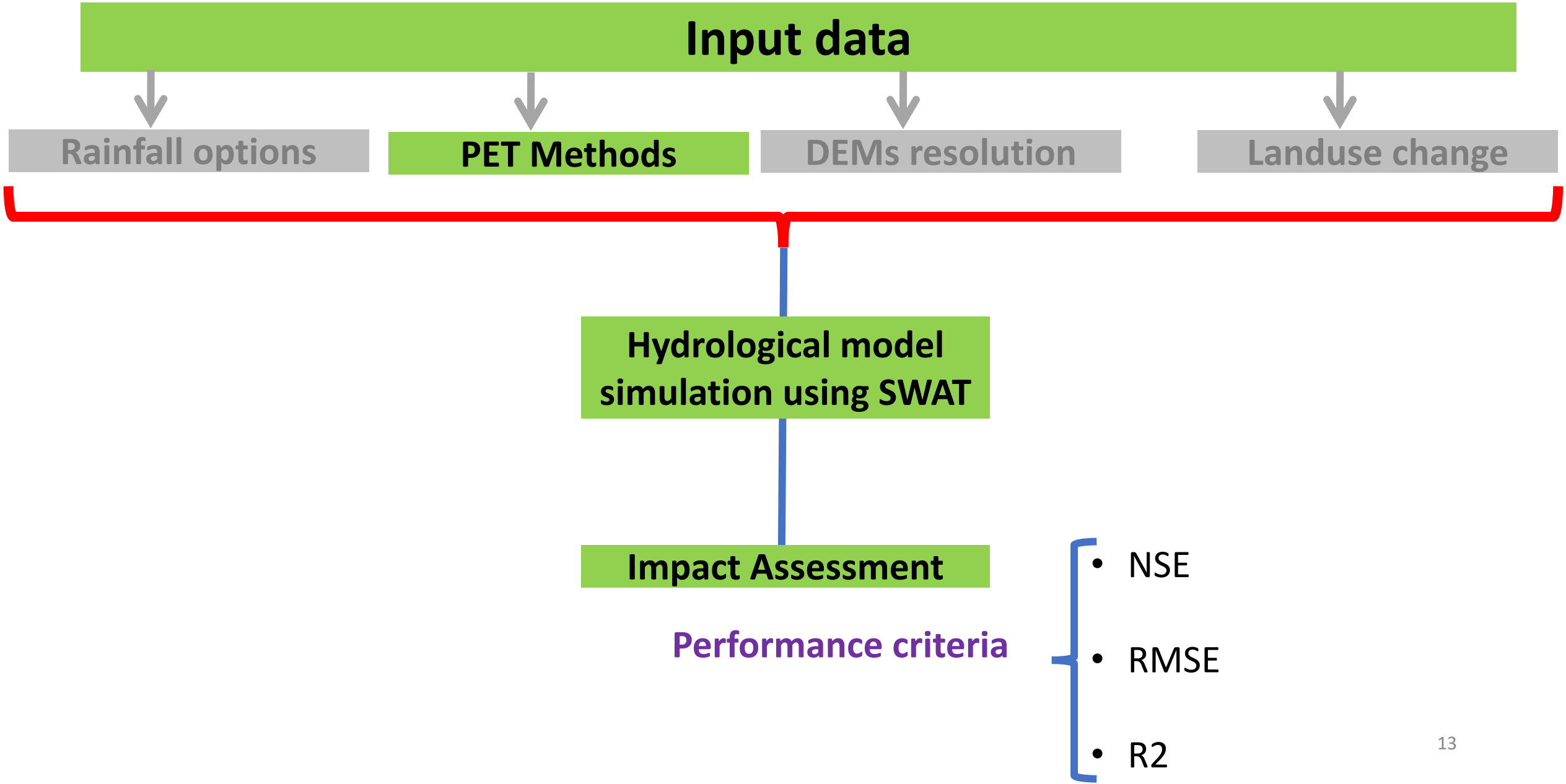
The Nash (E) value does not exceed 0.25 at the monthly level and 0.5 at the annual level

Options	E values for mean monthly simulation	E values for annual simulations
Opt1	0,15	0.4
Opt2	-1	-0.67
Opt3	0.25	0.5
Opt4	-0,91	-0.5
Opt5	-0,7	-0.3
Opt6	-1,12	-0.49
Opt7	-1,6	-1

Impact of catchment delineation (CSTVs) on annual and mean monthly runoff simulations



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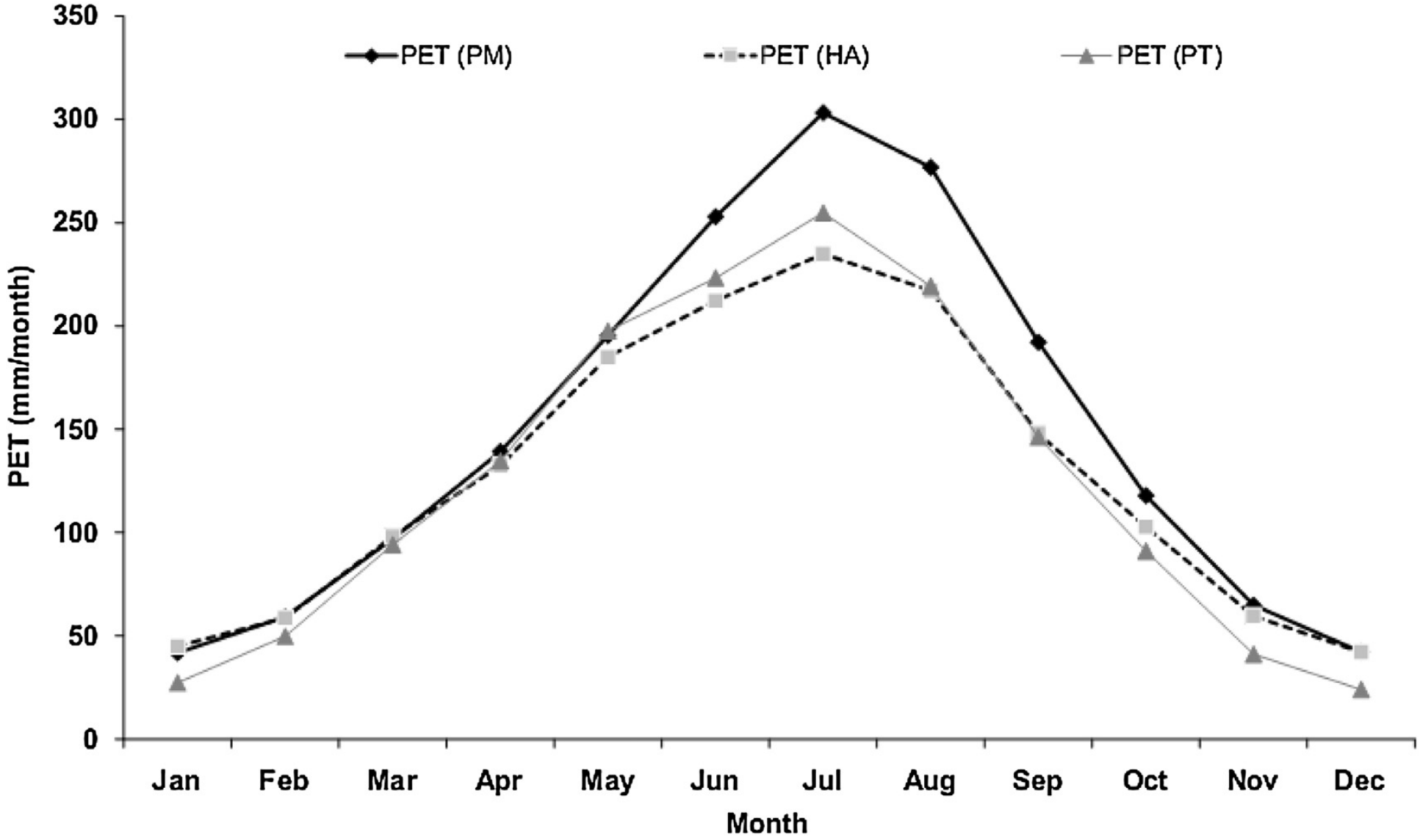
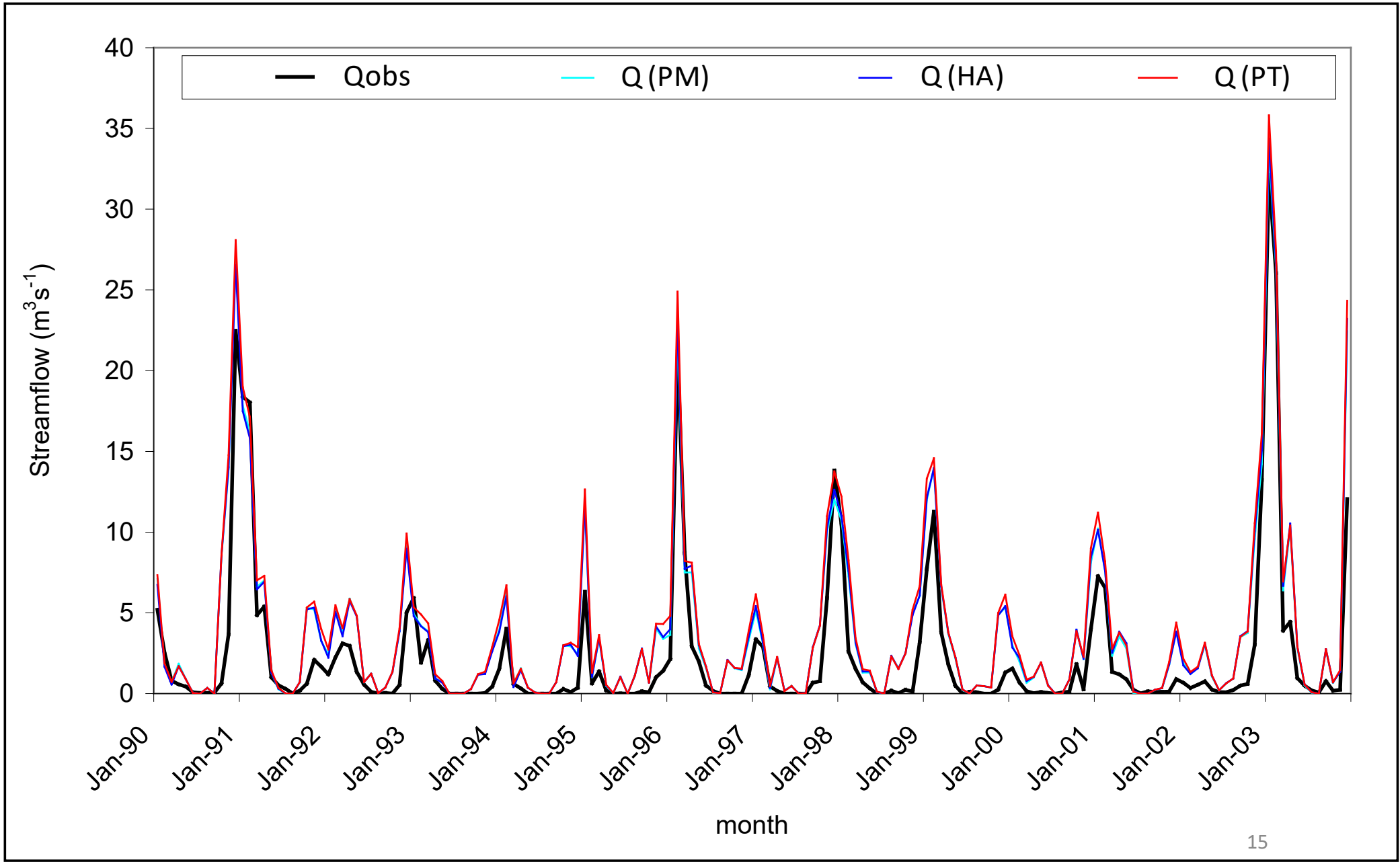
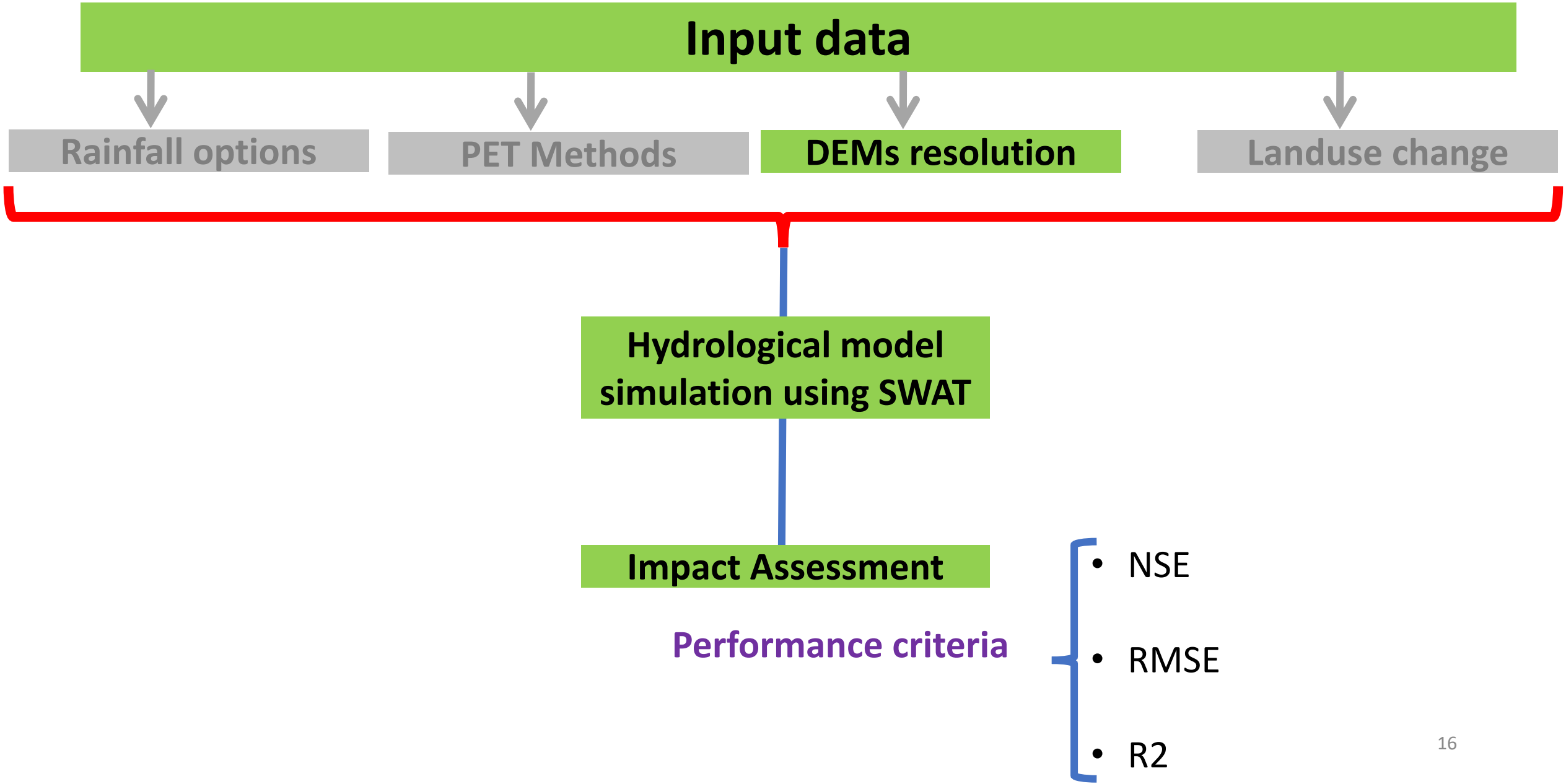
Mean monthly potential evapotranspiration (PET) predicted using Penman-Monteith (PM), Hargreaves (HA) and Priestley-Taylor (PT) methods



Comparison of monthly observed streamflow predicted using PM, HA and PT methods

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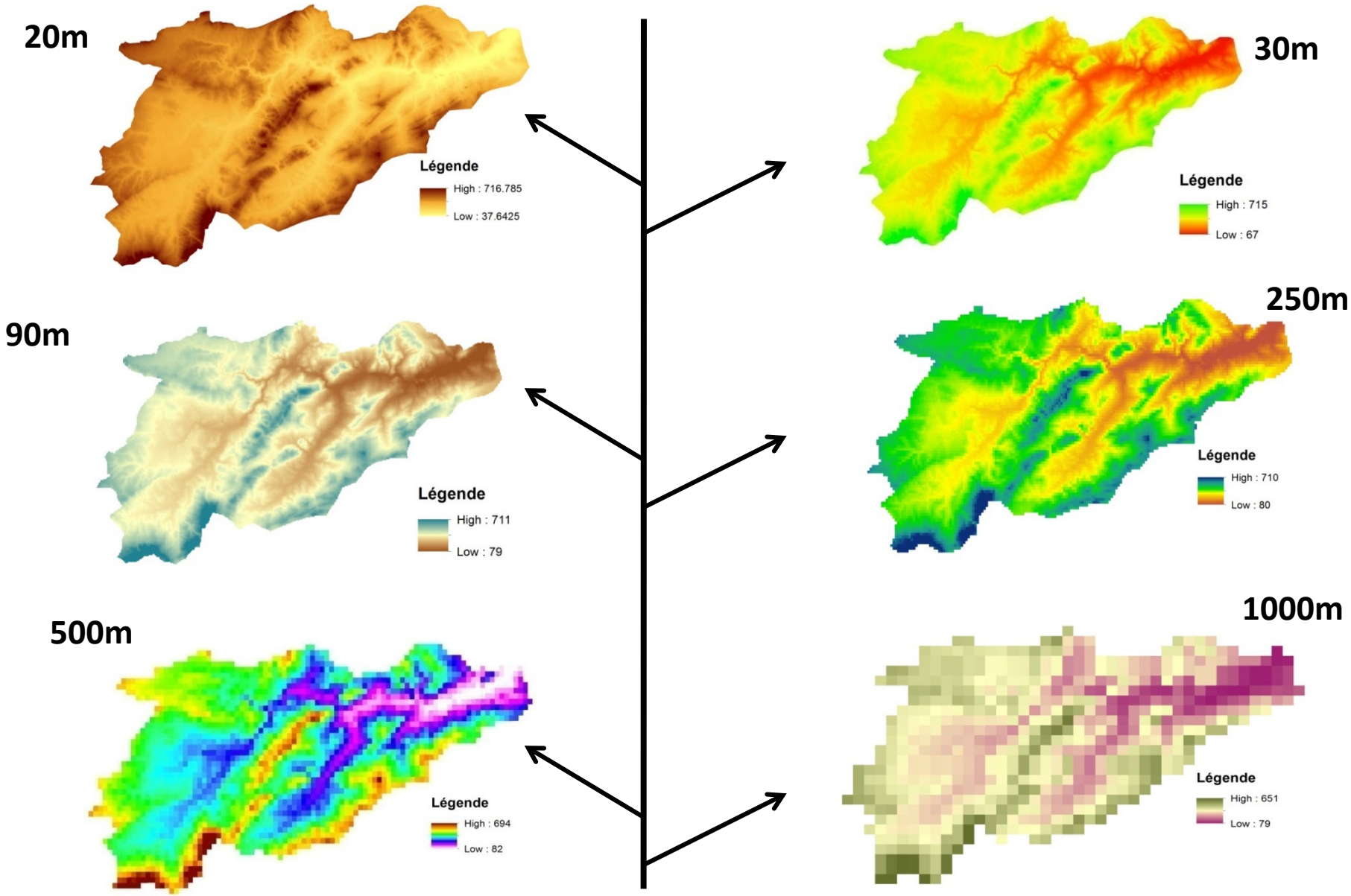
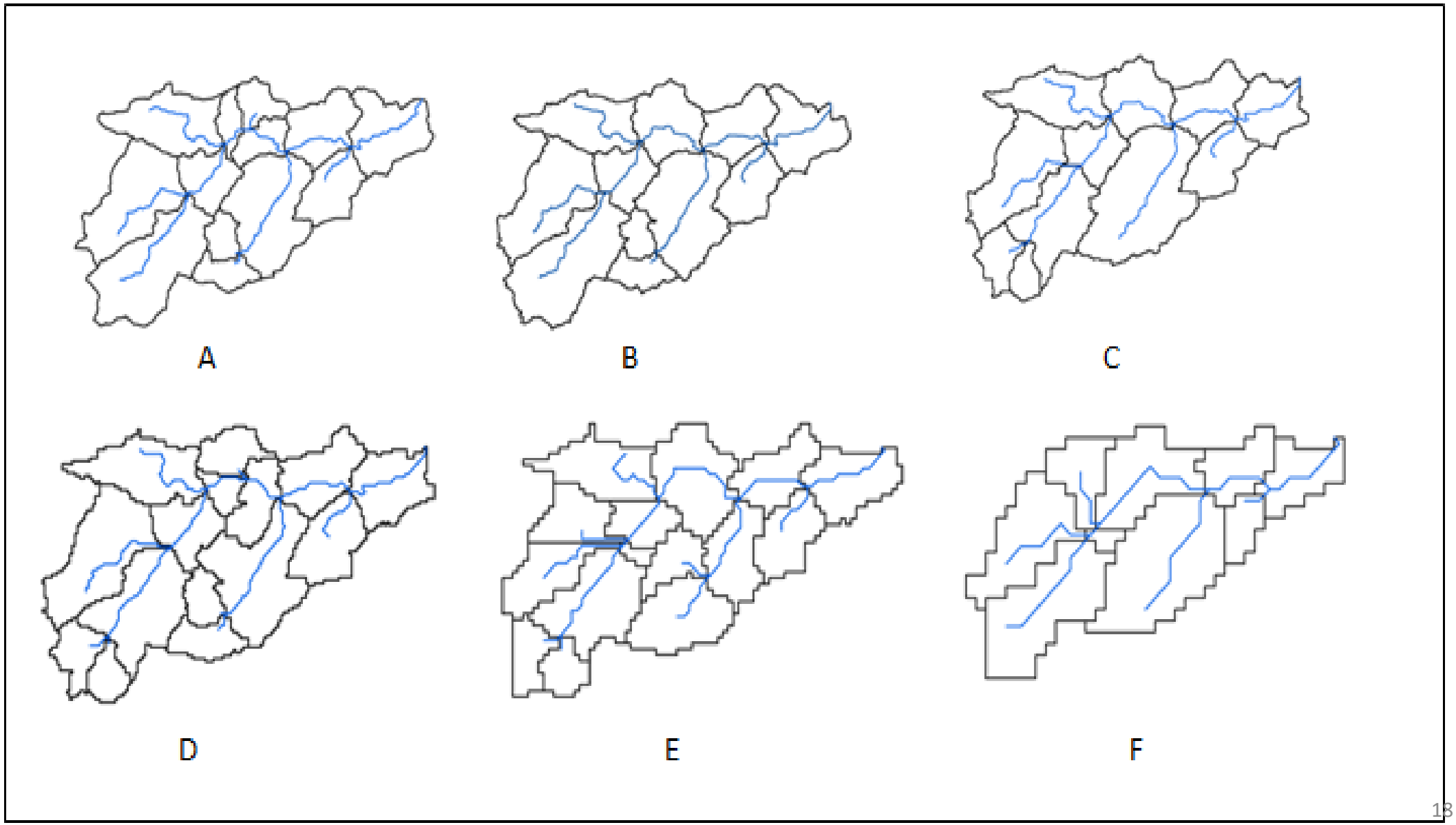
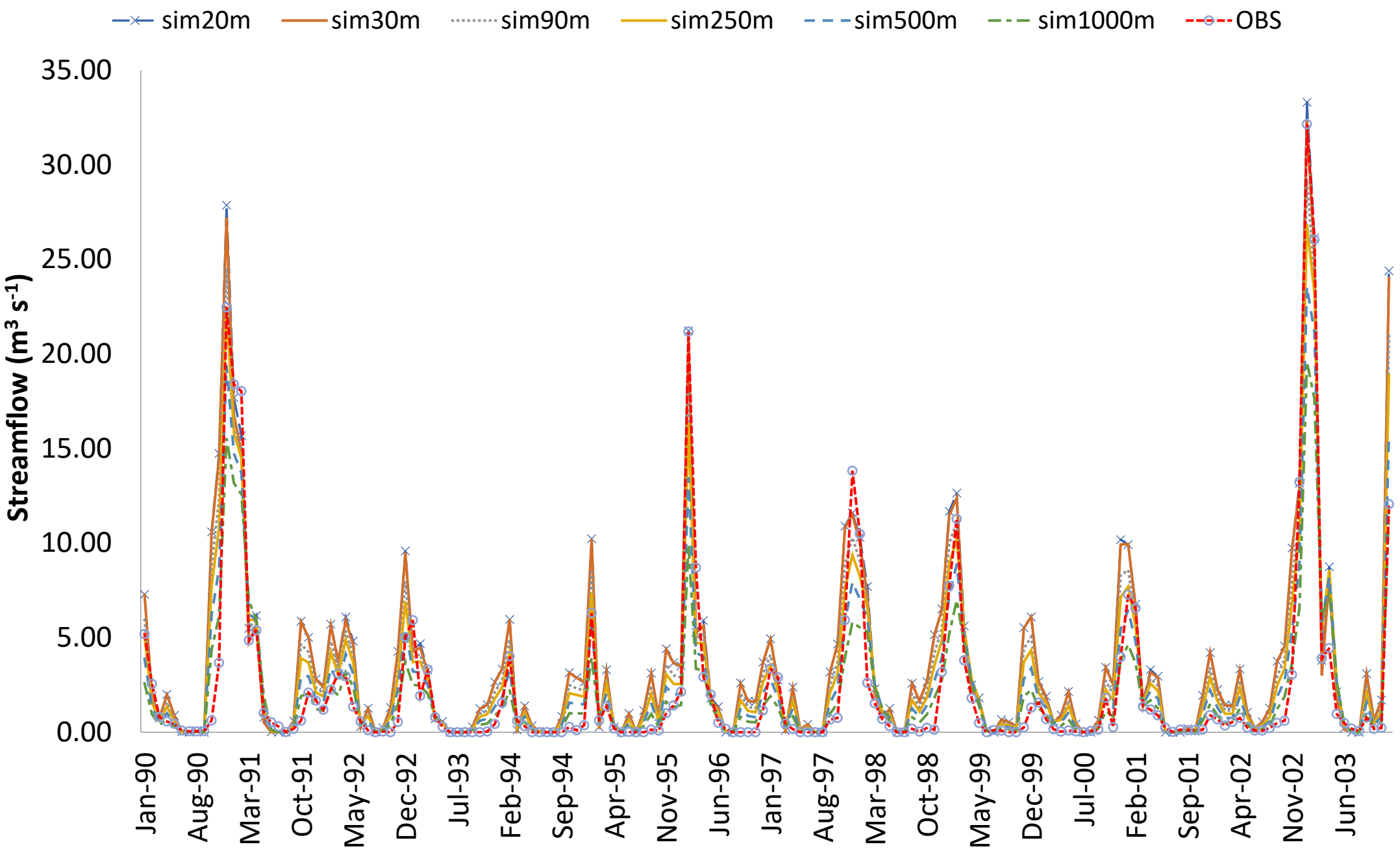
DEM resolutions



Impact of DEM resolutions on Subwatershed delineation



Impact of DEM resolutions on monthly stream flow simulation



Results of performance criteria show that the use of finer resolution spatial data does not necessarily improve the performance of hydrological model predictions

DEM	NSE	R^2	RMSE
20m	0.72	0.84	2.53
30m	0.73	0.83	2.47
90m	0.83	0.86	1.98
250m	0.86	0.88	1.76
500m	0.87	0.89	1.72
1000m	0.8	0.89	2.15

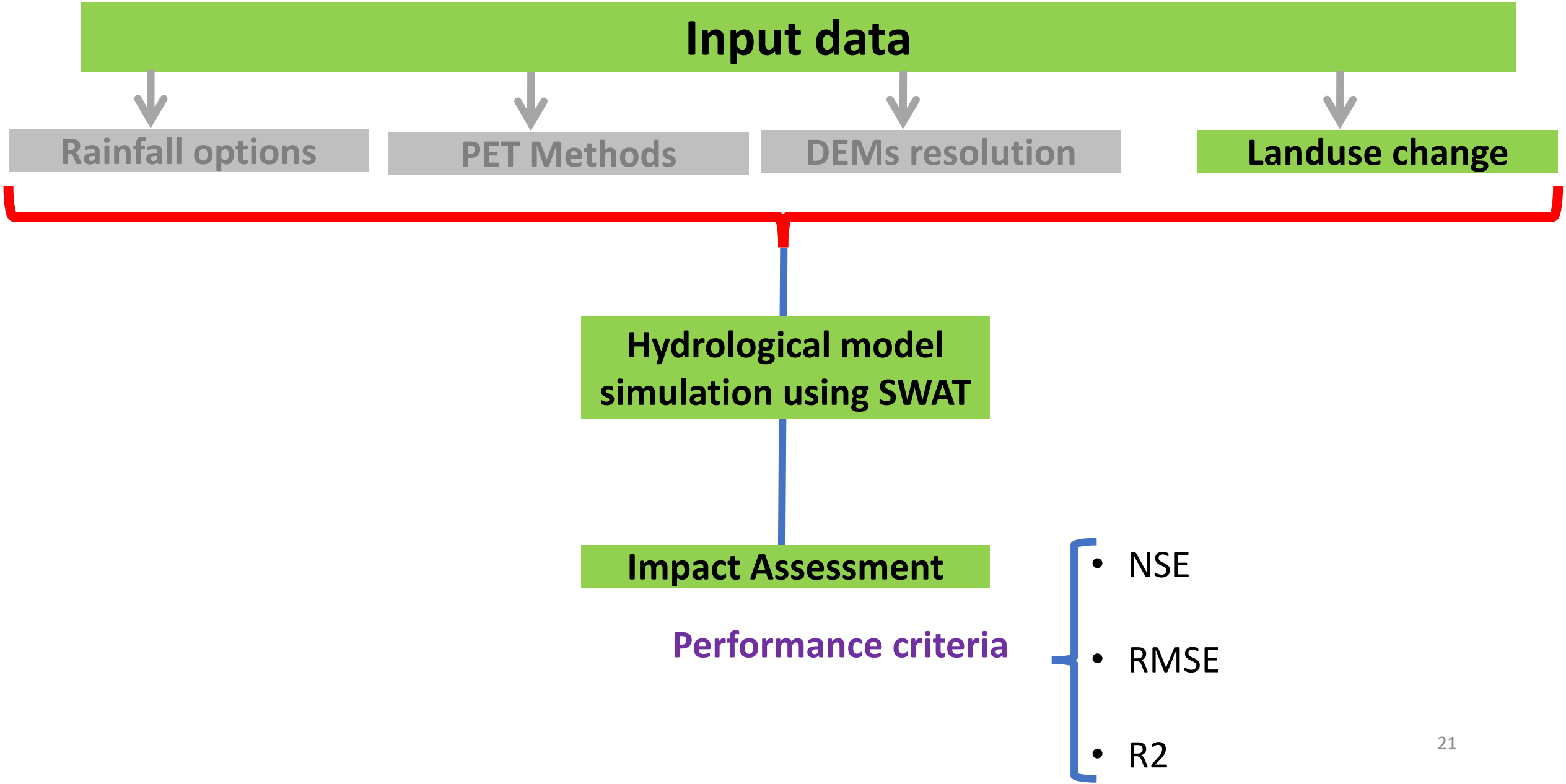

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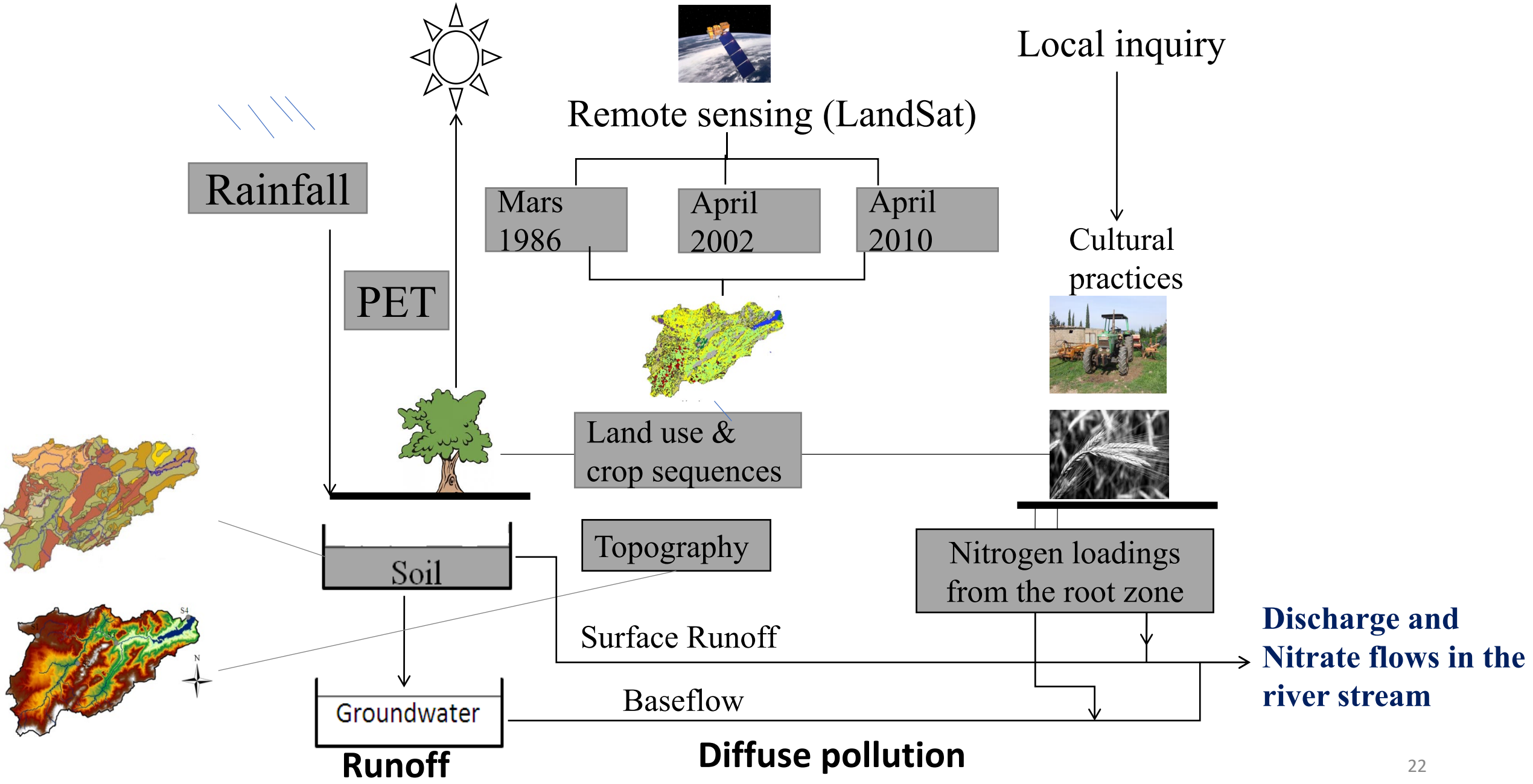
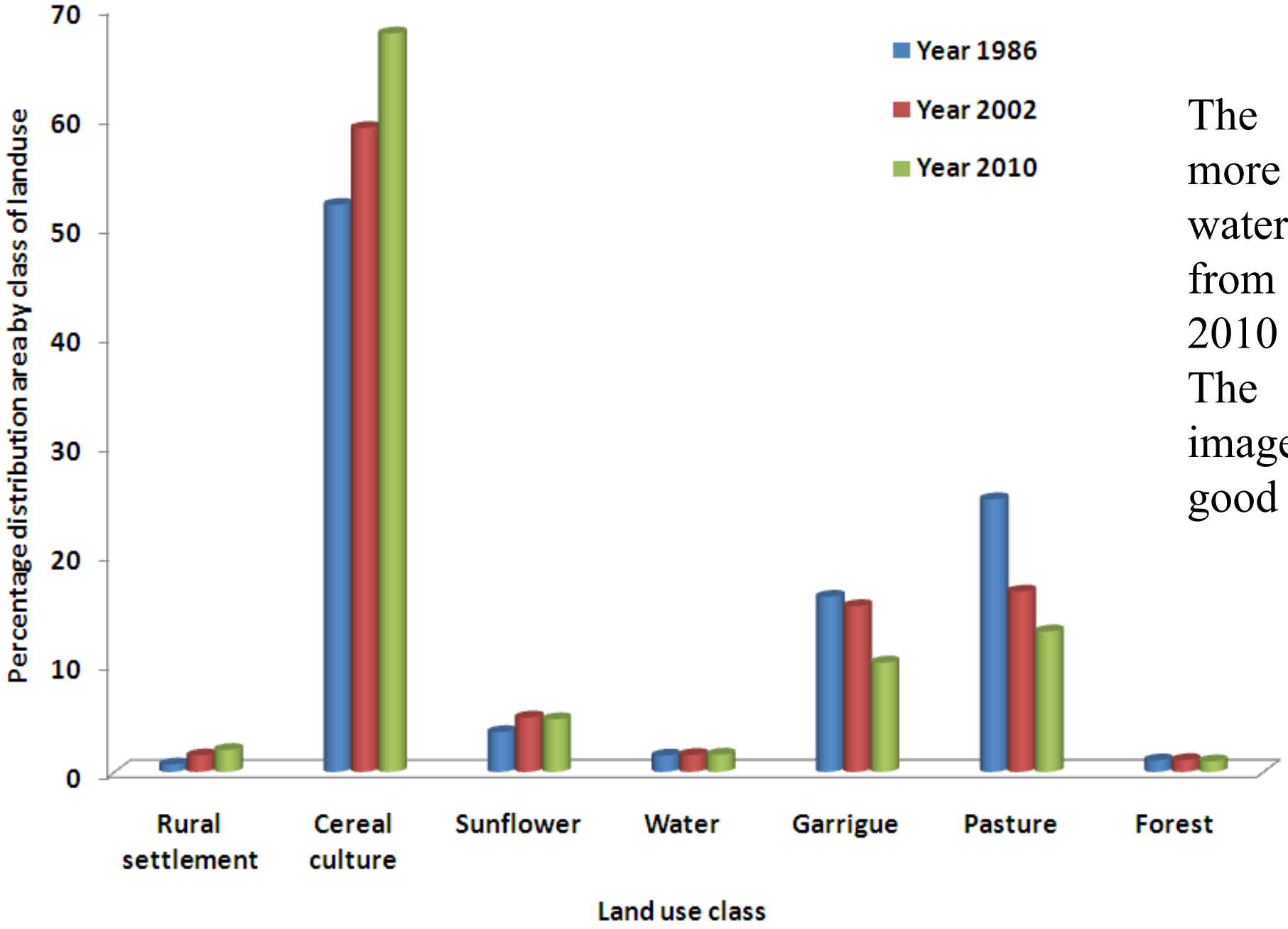
Diagram showing the method of applying the SWAT model in this study

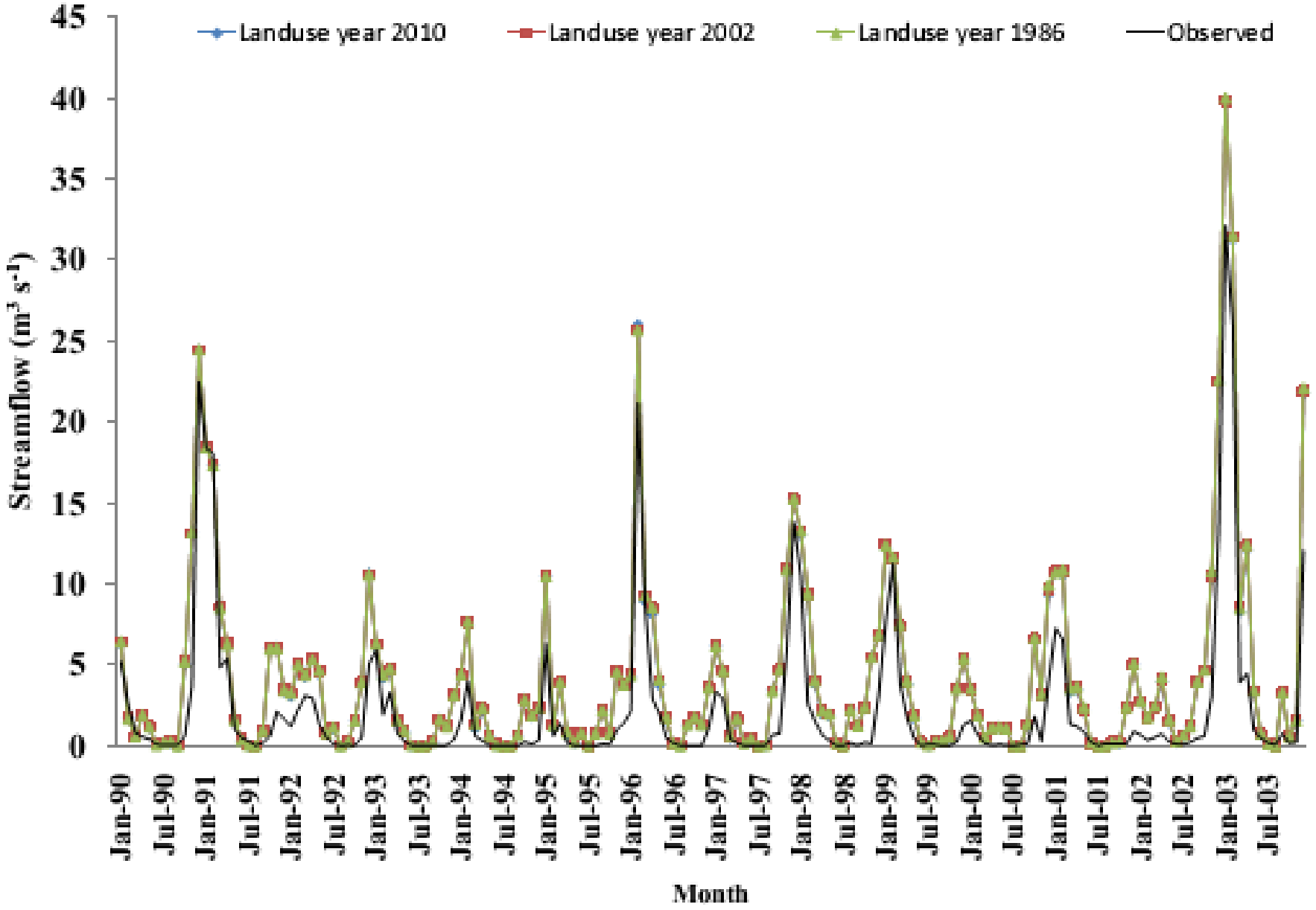




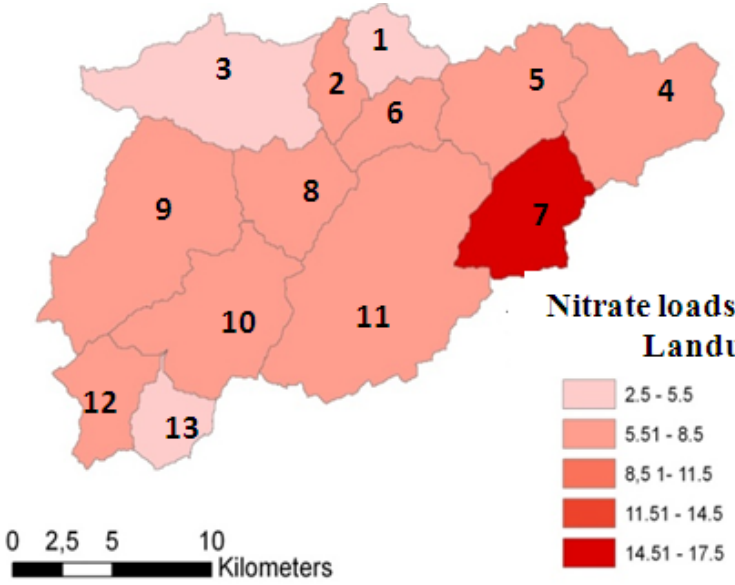
The cereal culture occupied more than 50% of the Joumine watershed area . It increased from 50 % in 1986 to 70 % in 2010 over the garrigue area.

The classification of LandSat image for April 2010 shows a good precision of 90%.

The land use change at the Joumine watershed did not affect significantly the hydrological response in terms of streamflow, the Nash values are about 0.66, 0.67, 0.68 for land use 1986, 2002 and 2010 respectively.

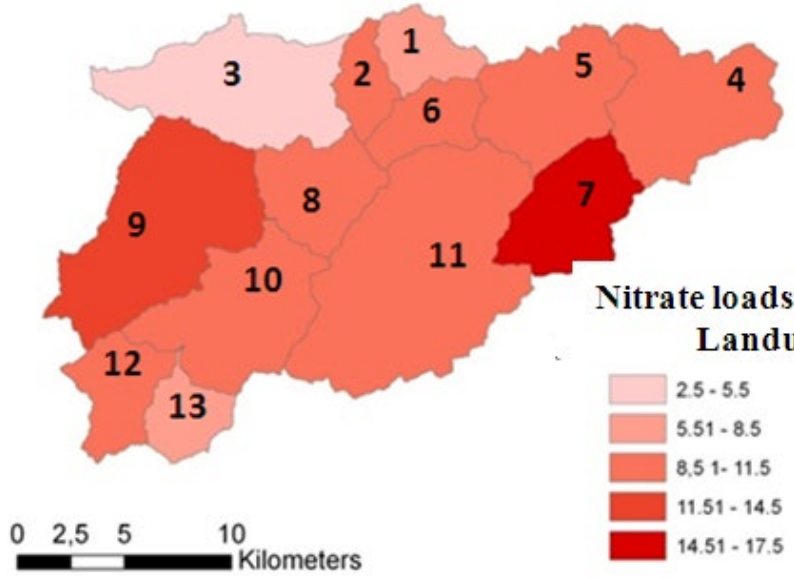


The land use change did have a large impact on nitrate fluxes.



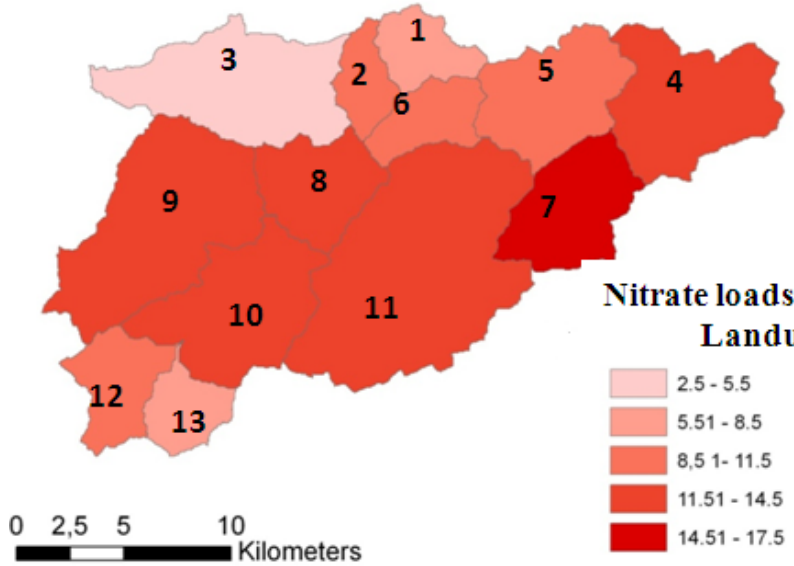
Nitrate loads (kgN-NO_3. $ha^{-1}.y^{-1}$)
Landuse year 1986

- 2.5 - 5.5
- 5.51 - 8.5
- 8,5 1- 11.5
- 11.51 - 14.5
- 14.51 - 17.5



Nitrate loads (kgN-NO_3. $ha^{-1}.y^{-1}$)
Landuse year 2002

- 2.5 - 5.5
- 5.51 - 8.5
- 8,5 1- 11.5
- 11.51 - 14.5
- 14.51 - 17.5



Nitrate loads (kgN-NO_3. $ha^{-1}.y^{-1}$)
Landuse year 2010

- 2.5 - 5.5
- 5.51 - 8.5
- 8,5 1- 11.5
- 11.51 - 14.5
- 14.51 - 17.5

The water quality problem is related to the area devoted to cereal crops that requires large amount of fertilizers.

Sensitivity analysis and autocalibration of SWAT model

Sensitivity analysis (SA)

✓Latin Hypercube (LH)-One-factor-At time (OAT)

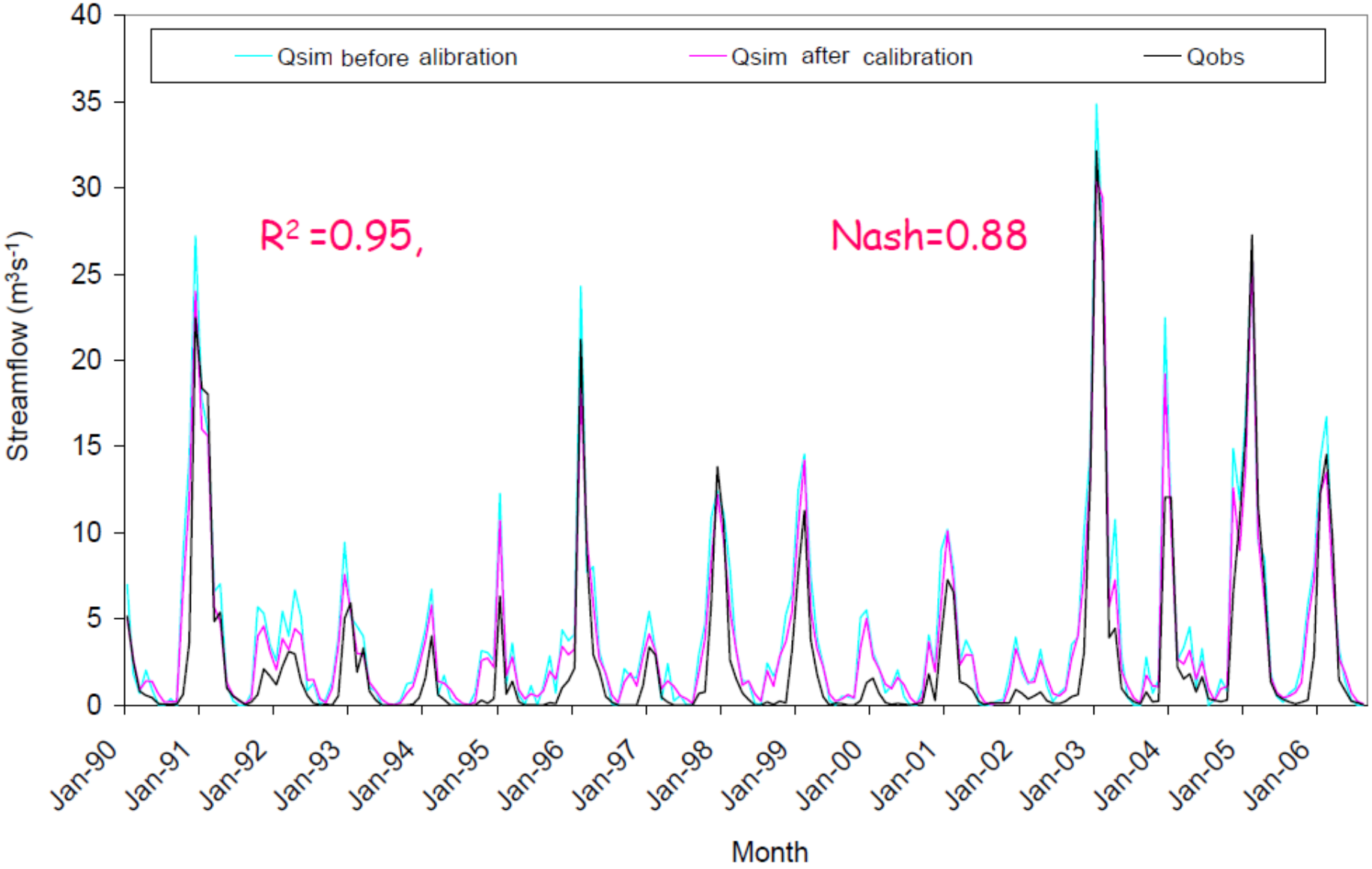
✓A parameters SA provides insights on which parameters contribute most the output variance.

✓The SA was performed for 16 parameters of hydrology that are related to streamflow (Q).

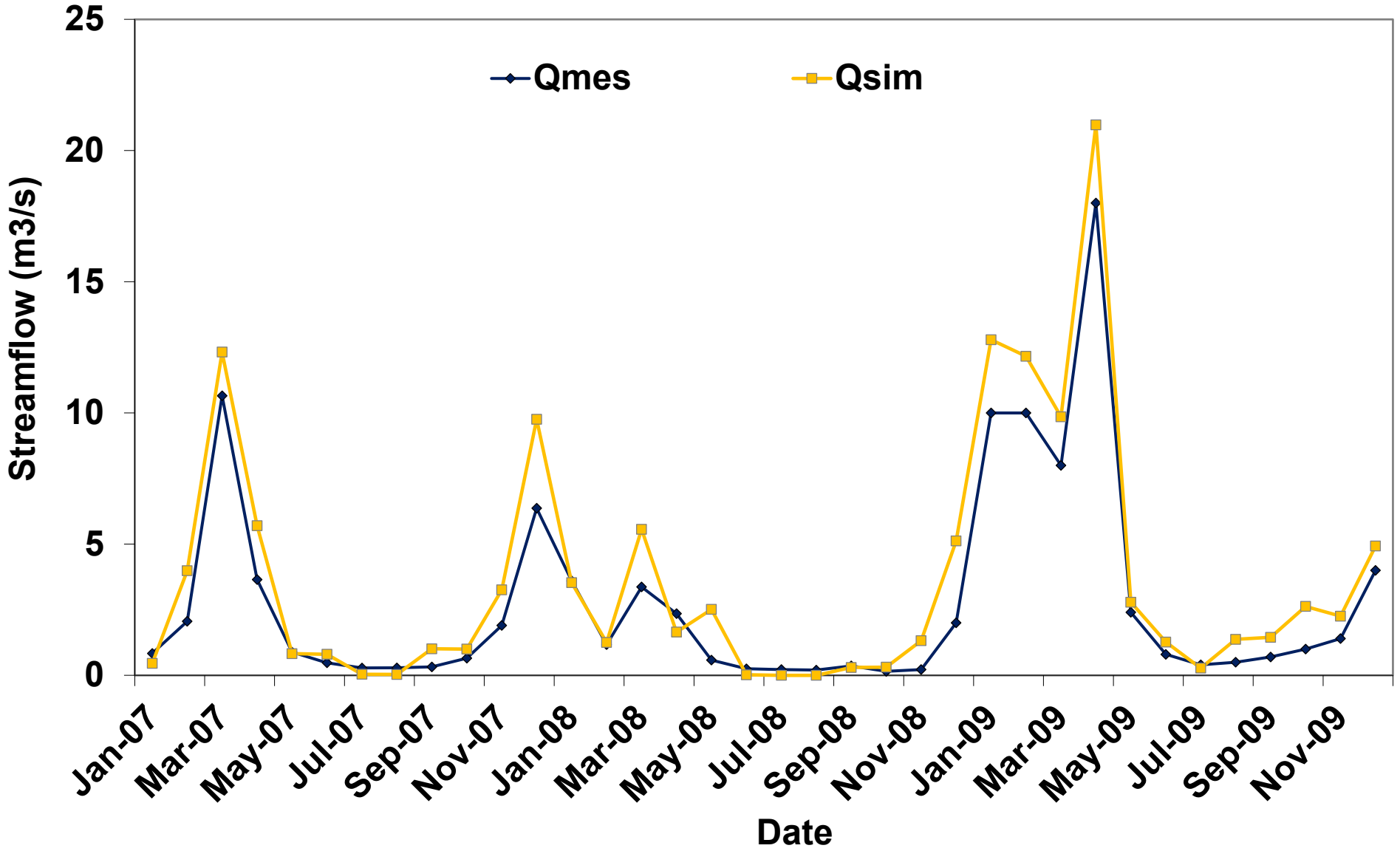
✓The parameters for calibration were selected by the SA results (the red parameters)

Paramètres	rang
Alpha_Bf	1
Cn2	2
Ch_K2	3
Ch_N2	4
Esco	5
Sol_Z	6
Sol_Awc	7
Slope	8
Sol_K	9
Rchrg_Dp	10
Surlag	11
Epco	12
Gwqmn	13
Gw_Delay	14
Gw_Revap	15
Revapmn	16

Results of autocalibration of SWAT model



Predicted and measured monthly discharge during the validation period (2007–2009).



The values of Nash, R2 and biais are 0.89, 0.9 et 19% respectively

4. CONCLUSION

- Results show that streamflow simulations were:

Most sensitive to climatic conditions and rainfall options,

Less sensitive to CSTVs,

Less sensitive to PET methods and topographical data,

In this study the land use change modelling results showed a low effect on the runoff at the Joumine catchment, but it did have a large impact on nitrate fluxes

- The most sensitive parameters for streamflow were Alpha_Bf, curve number (CN2), Ch-K2, ESCO and SOL_Z.

- Identification of the sensitive SWAT parameters in the Joumine watershed helps modelers for SWAT calibration.

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Acknowledgements

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Agence canadienne de développement international

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Thank you!

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