Application of SWAT in a Mountainous Region in Turkey using Remote Sensing Data

Bilal Peker, Dr. Arda Sorman

Eskisehir Technical University, Turkey

Department of Civil Engineering

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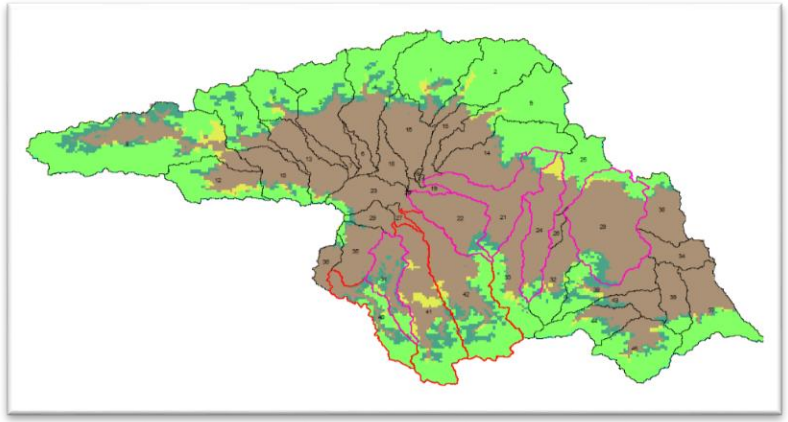
Universität für Bodenkultur Wien
University of Natural Resources and Applied Life Sciences, Vienna

SWAT Soil & Water Assessment Tool

Contact: ismailbilalpeker@eskisehir.edu.tr

OUTLINE



1. Motivation of the Study
2. Study Area
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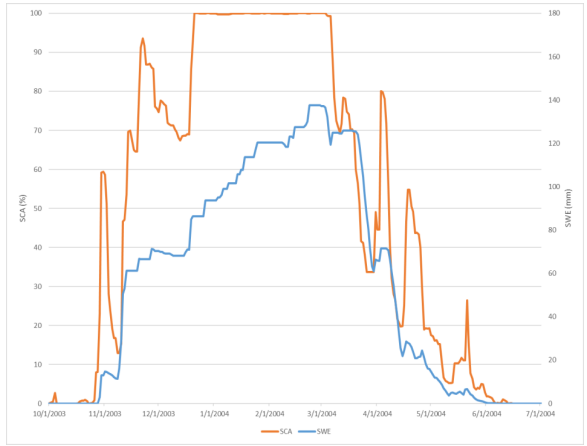
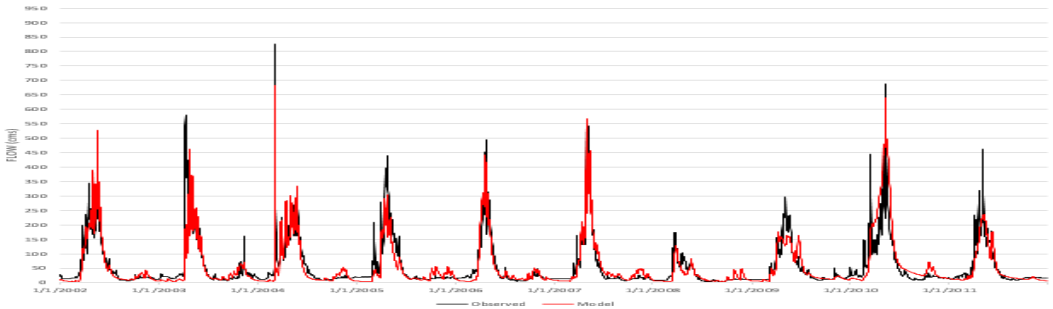
7. Conclusions & Recommendations



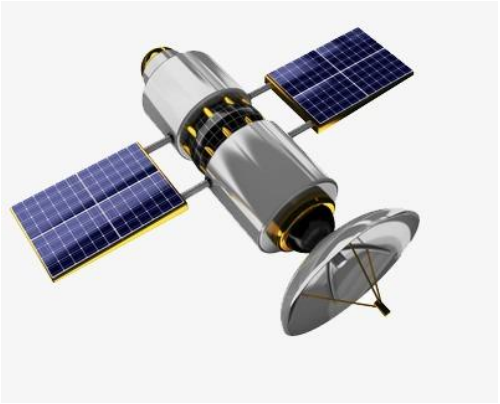


Motivation of the Study

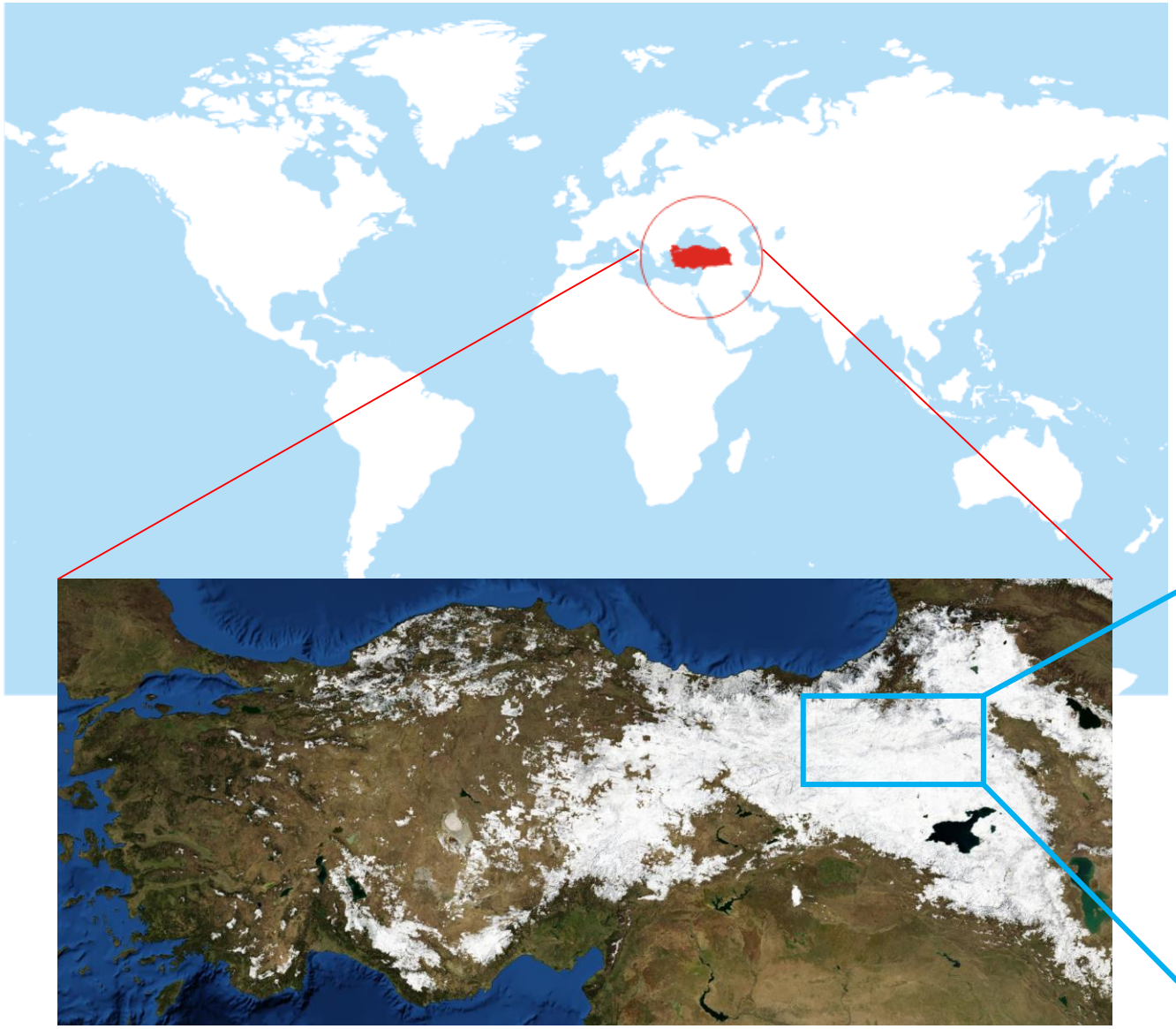
There are several successful SWAT model applications in Turkey, however, all is about water quality, agricultural management and non-point source pollution control at low elevated snowless areas.

The mountainous and snow-dominated watersheds are selected for this work, therefore snow-melt process is very important for the study area.

Remote sensing data is used for the more preferable model setup in the study.

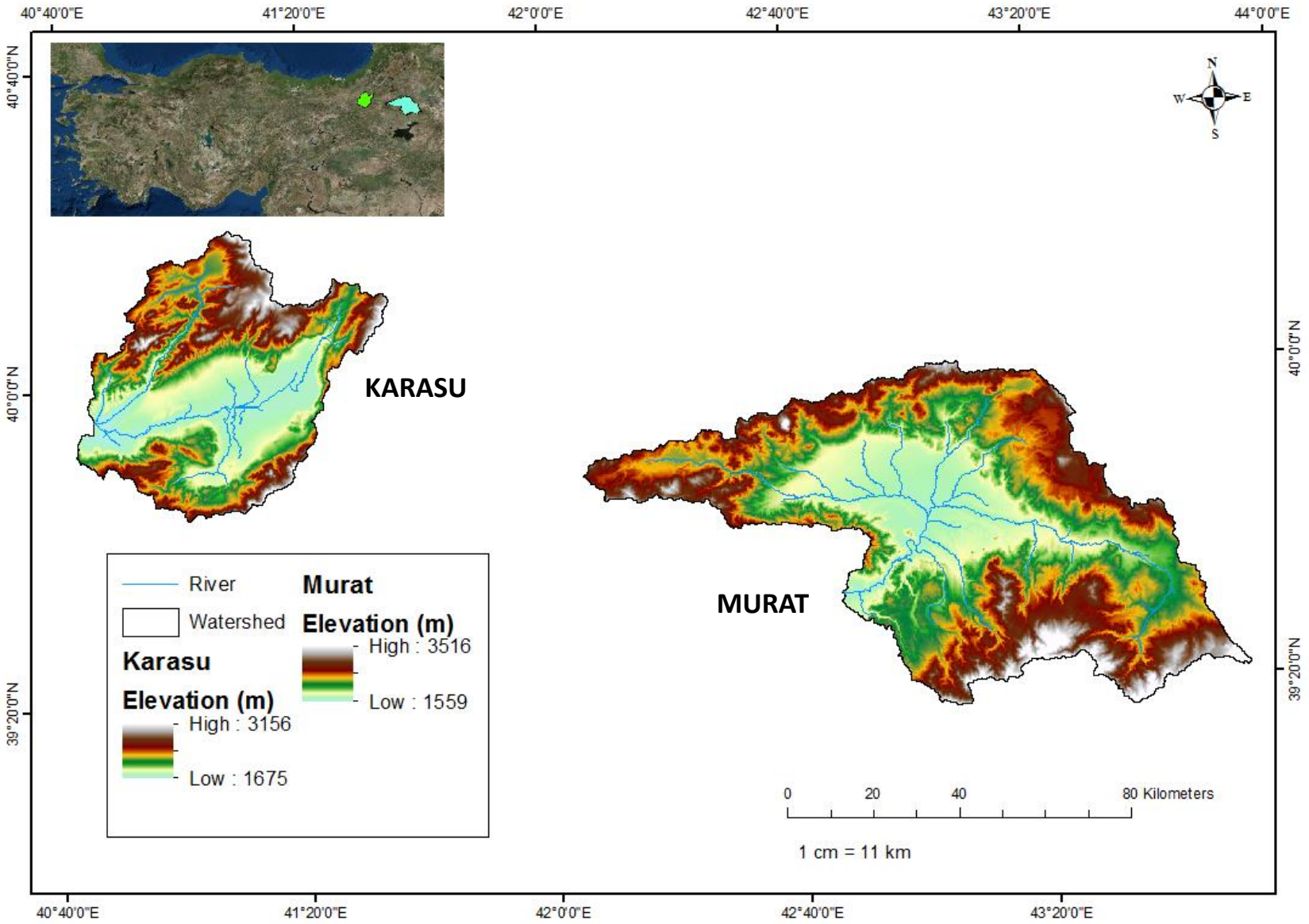


Study Area



- Turkey is a peninsula surrounded on 3 sides by the sea.
- Average elevation of Turkey > 1100 m, snow is frequent.
- Most transboundary rivers are fed by snowmelt.

Two headwater basins of the Euphrates River, named as Karasu and Murat.



Basin Name	Karasu	Murat
Drainage Area	2800 km^2	5900 km^2
Hypsometric Elevation	2100 m	2100 m
Min. Elevation	1675 m	1559 m
Max. Elevation	3156 m	3516 m

Data Sources

- **HRU Definition Data**

DEM (SRTM, 90x90 m) (3 Slope Classes for each basin)

Land Use (Corine, 1:100 000)

Soil (FAO, 1:5 000 000)

- **Climate Data**

Turkish Met. Office (Precipitation & Max./Min. Temperature)

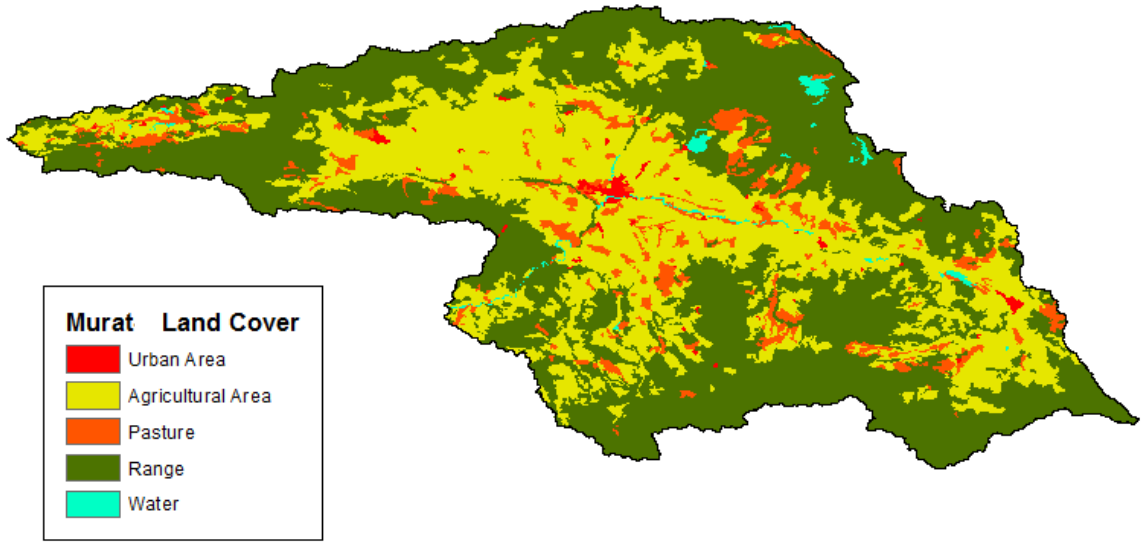
CFSR (Relative Humidity, Solar Radiation & Wind Speed)

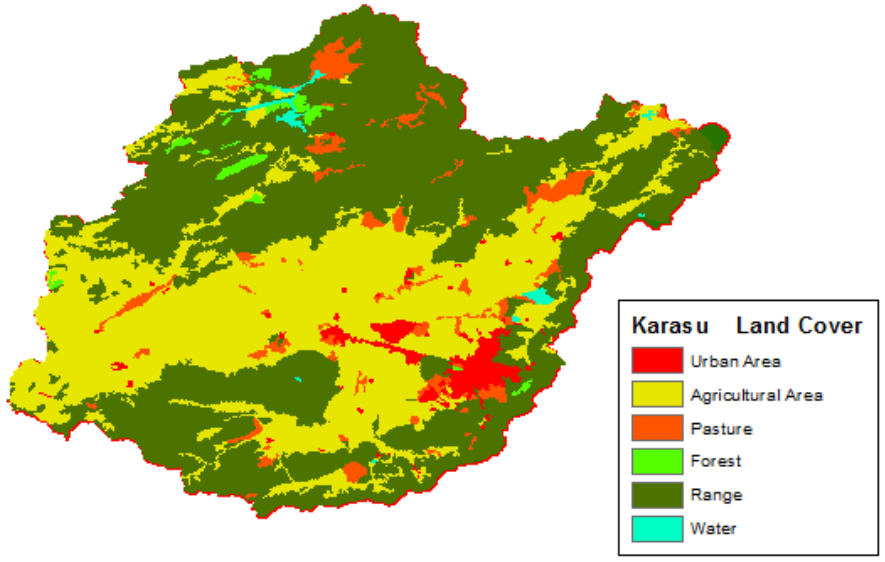
- **Calibration & Validation Data**

Turkish Hydro. Office (Discharge & Snow Ground Stations)

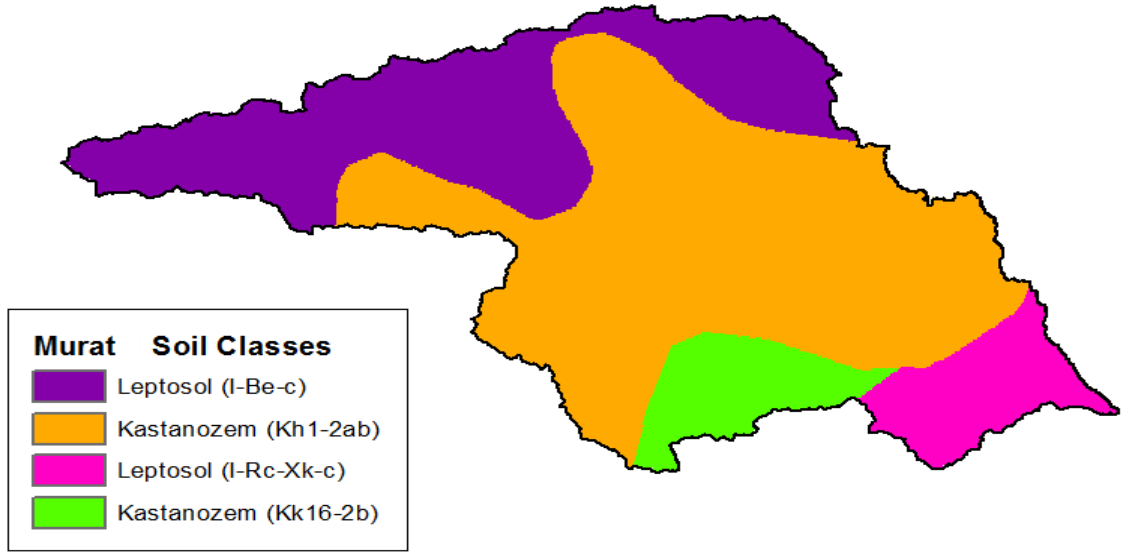
MODIS (Cloud-Filtered Snow-covered Images)

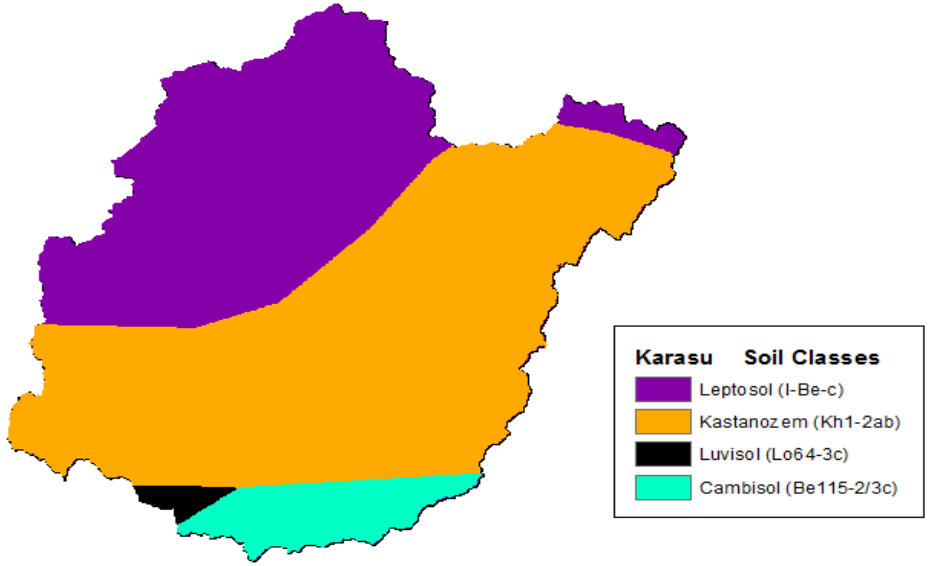
LAND COVER MAPS



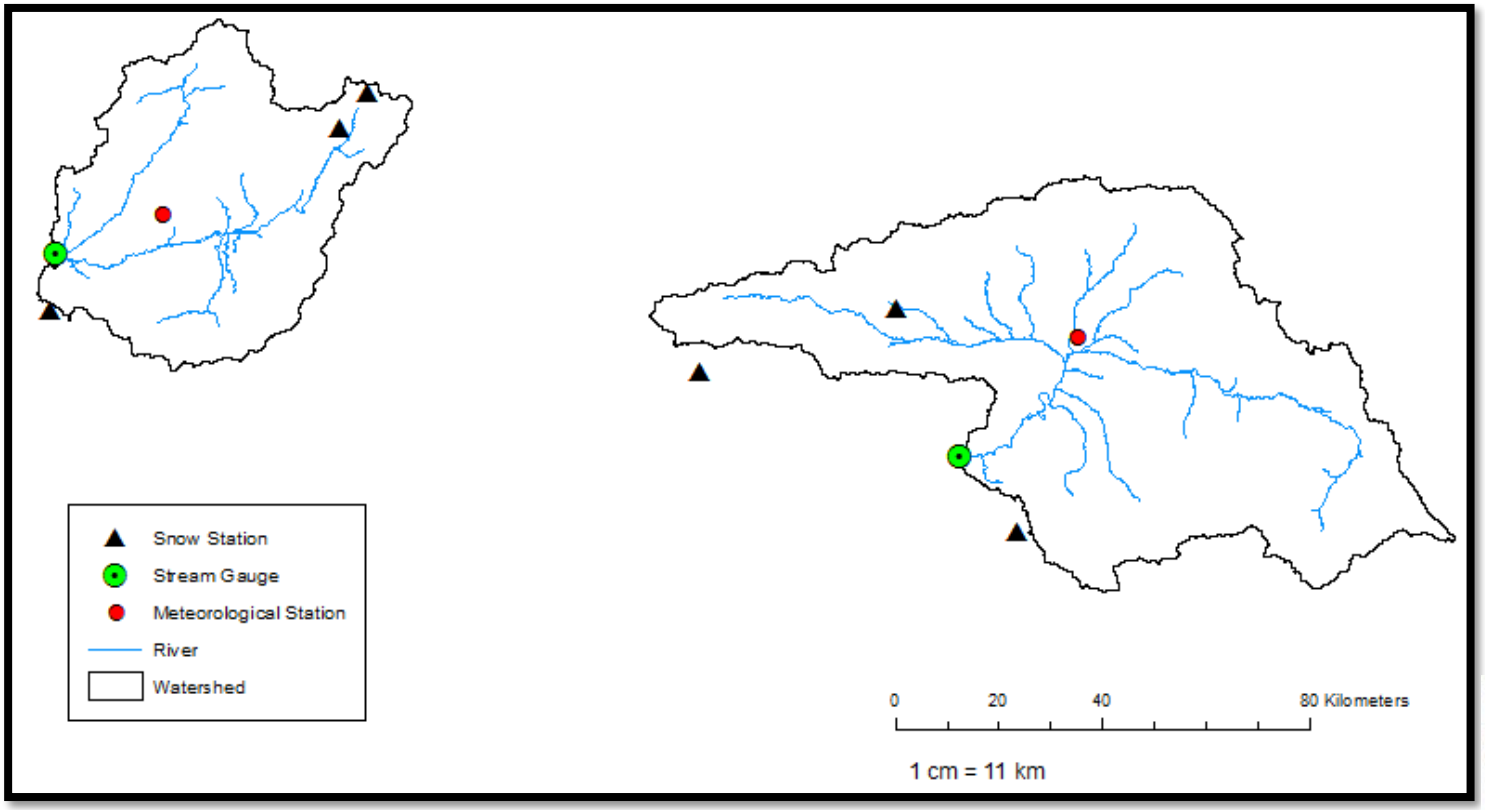


SOIL TYPE MAPS

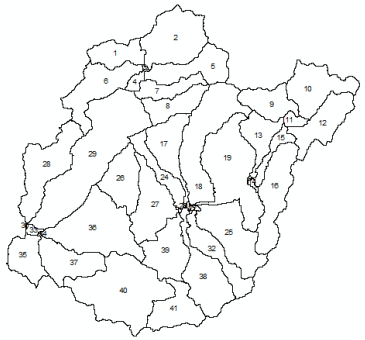


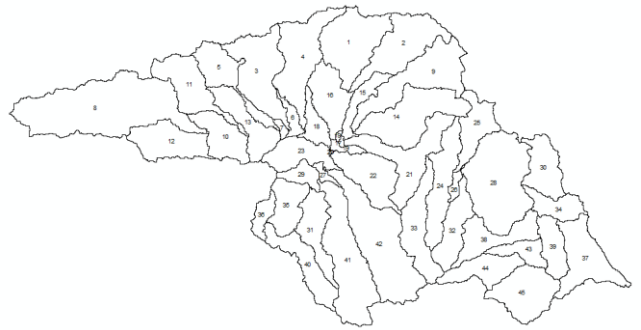


GAGE STATIONS *(Rainfall, Temperature, Stream, Snow)*



Base Model Setup





	Karasu	Murat
Interface	ArcSWAT 2012.10_4.19	
Subbasin Threshold Area	5 000 Ha	10 000 Ha
HRU Threshold (Soil/LU/Slope)	0/0/0 (%)	0/0/0 (%)
Subbasin Number	41	45
HRU Number	462	663
Elevation Band Number	10	10
Warm up	1999-2001 (3 yrs)	2000-2001 (2 yrs)
Calibration Period	2002-2007 (6 yrs)	2002-2007 (6 yrs)
Validation Period	2008-2011 (4 yrs)	2008-2011 (4 yrs)

PROCEDURE

Snow parameters should not be calibrated simultaneously with other parameters.

(Abbaspour et al., 2017)

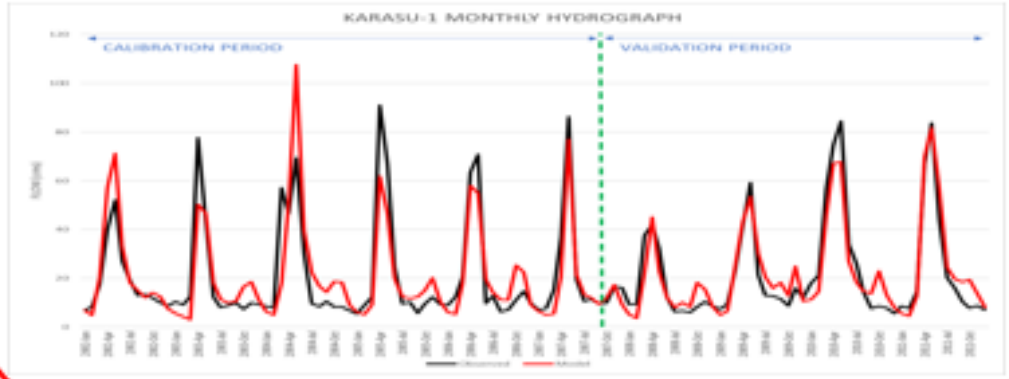
1) ADJUSTMENT OF SNOW PARAMETERS (WITH MODIS)

(SNOW CALIBRATION)

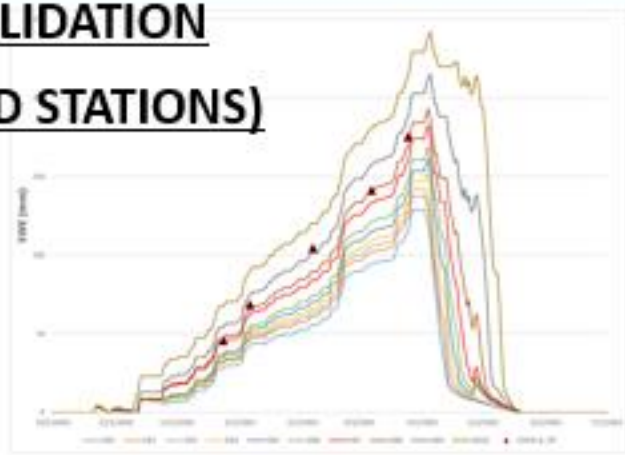
CONVERSION SWAT SWE OUTPUTS TO BASIN-SCALE FROM HRU-SCALE & COMPARISON WITH SNOW COVER AREA AS A CHART

VISUALIZING SWAT SWE OUTPUTS & COMPARISON WITH MODIS IMAGES AS A MAP

2) FLOW CALIBRATION & VALIDATION



3) SNOW VALIDATION (WITH GROUND STATIONS)



.hru output file

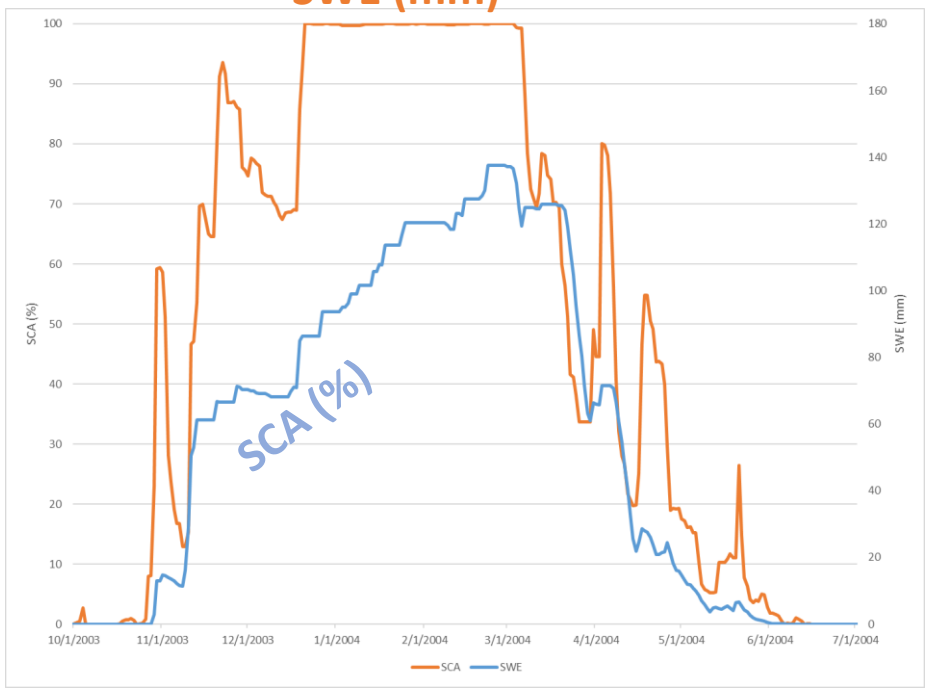
SWE (mm) – SCA (%) COMPARISON

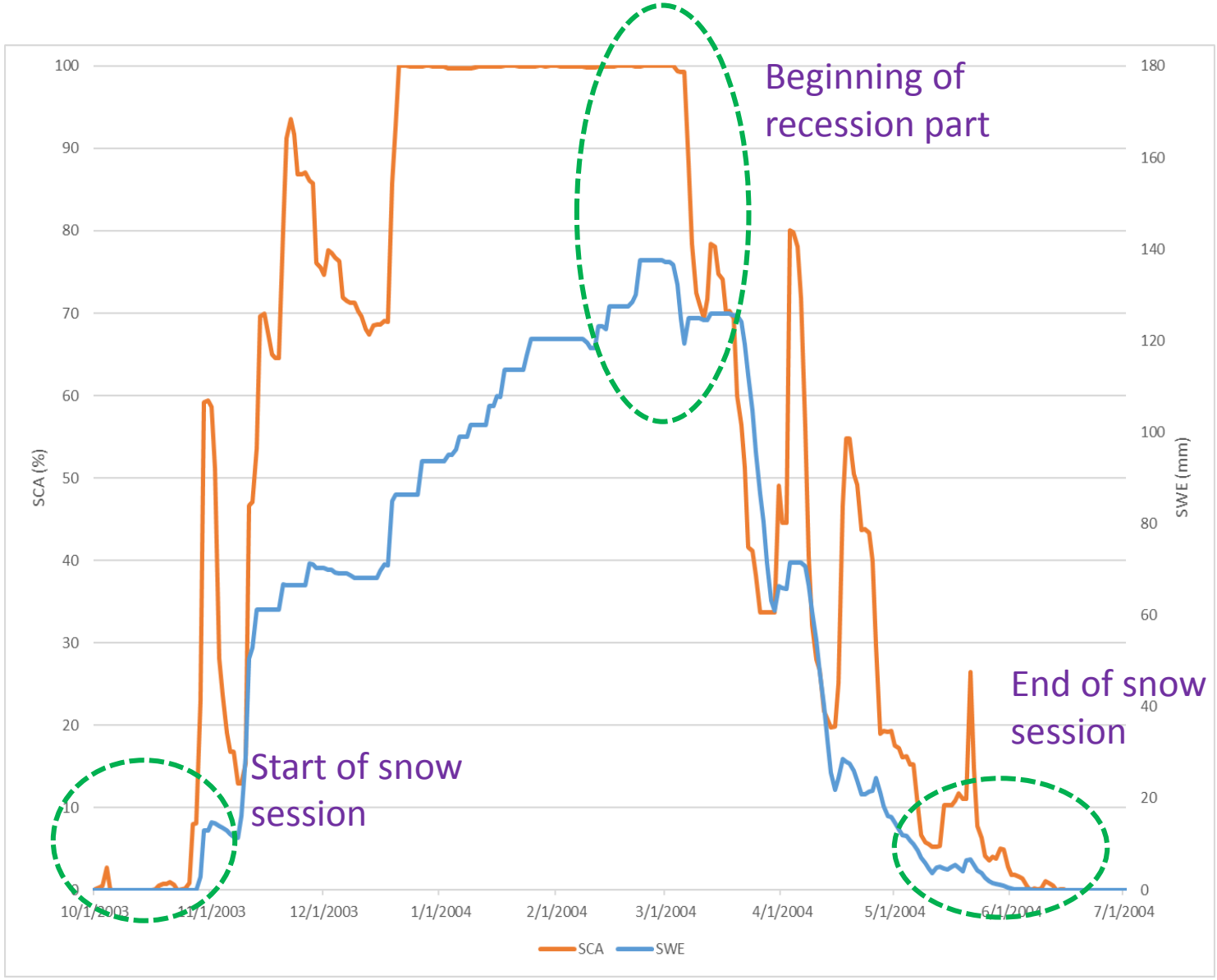
- HRU-BASED SWE
- SUBBASIN-BASED SWE
- **BASIN-BASED SWE**

Areal Percentage Weights

- **MODIS Snow Cover Area (SCA) (%)**

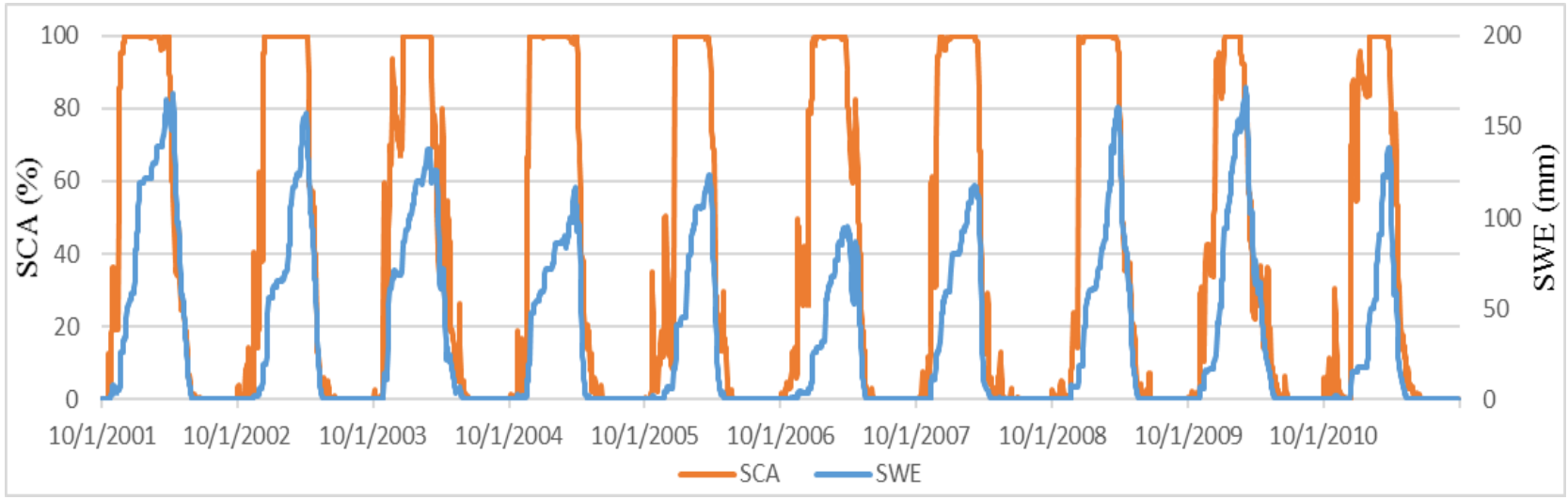
SWAT BASIN-SCALE SWE (mm) values are obtained daily.



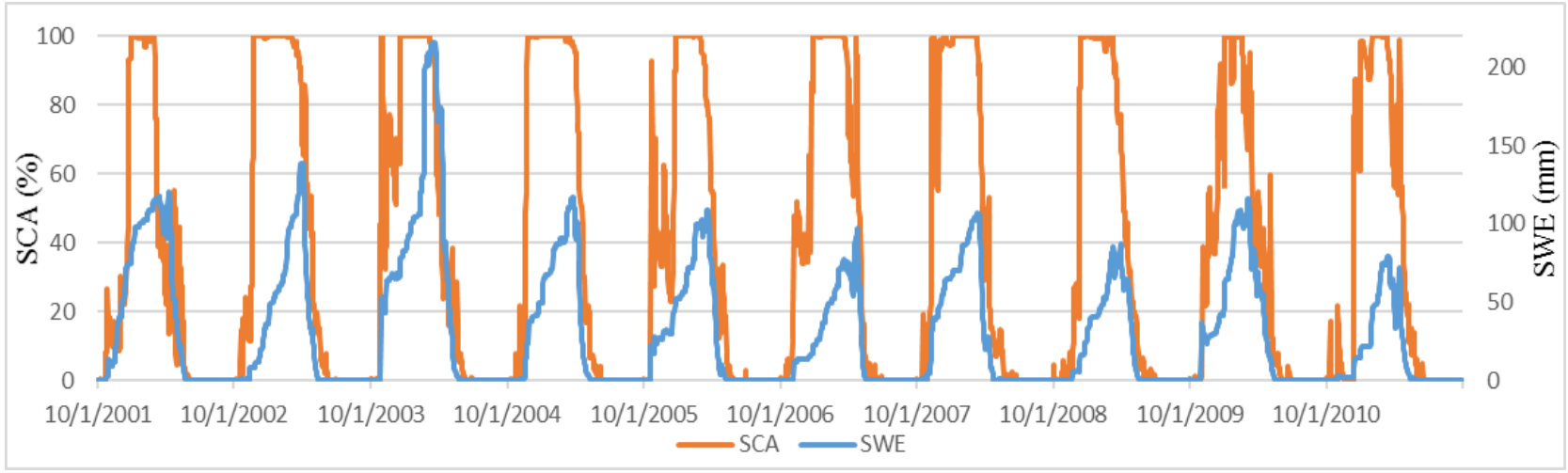


EXAMPLE: MURAT BASIN 2004 HYDROLOGICAL YEAR

MURAT BASIN



KARASU BASIN



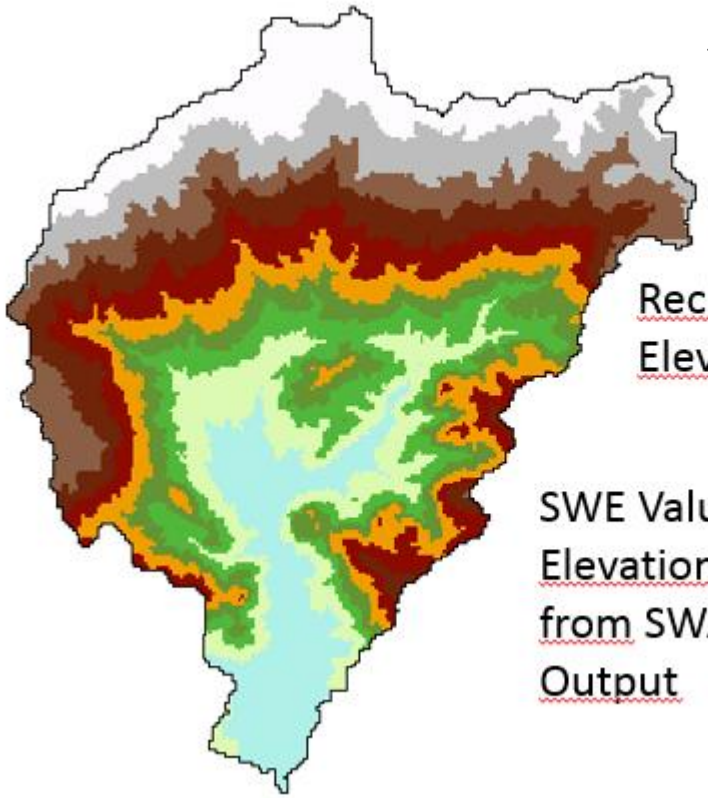
VISUALIZATION PROCESS

.snw output file

SWAT SWE OUTPUTS ARE HRU-BASED AT EACH ELEVATION BAND.

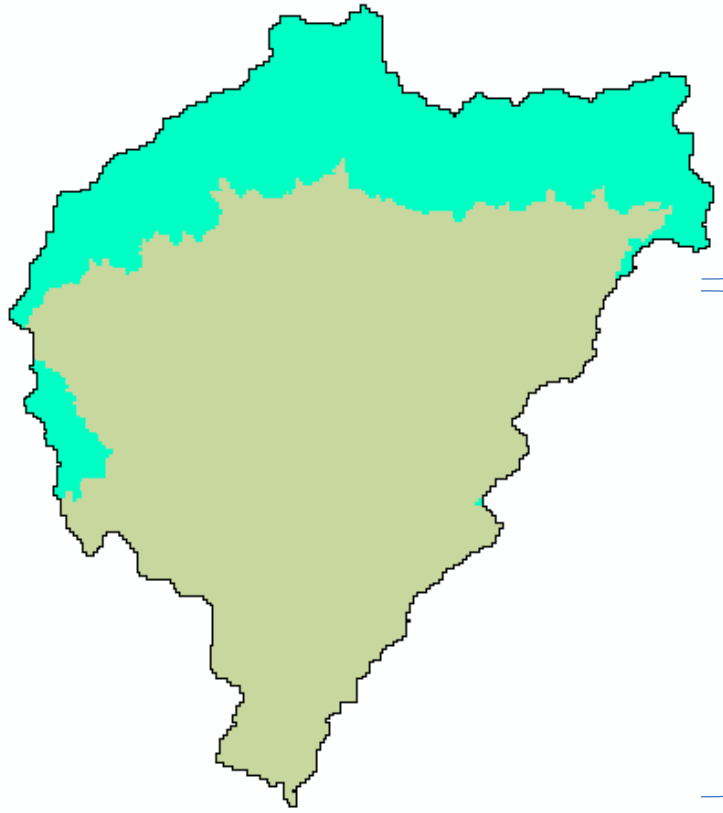
DERIVATION OF SUB-SWE FOR EACH SUBBASINS AT EACH ELEVATION BAND

MURAT SUB-1



Reclassified 10 Elevation Classes

SWE Value for Each Elevation Band from SWAT .snw Output



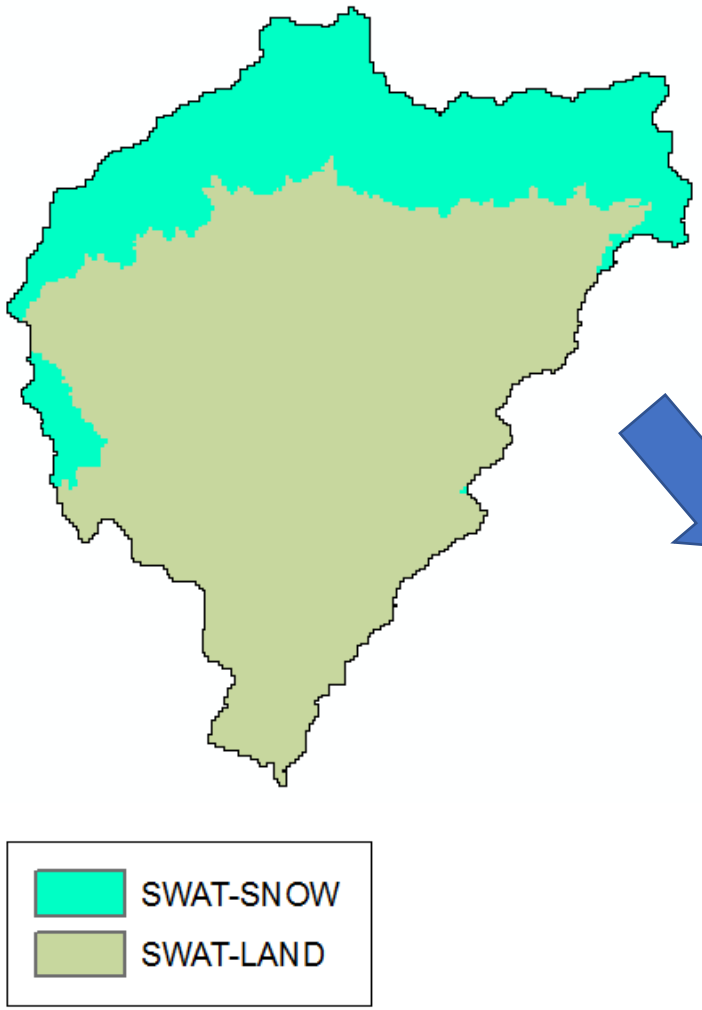
SNOW

THRESHOLD SWE

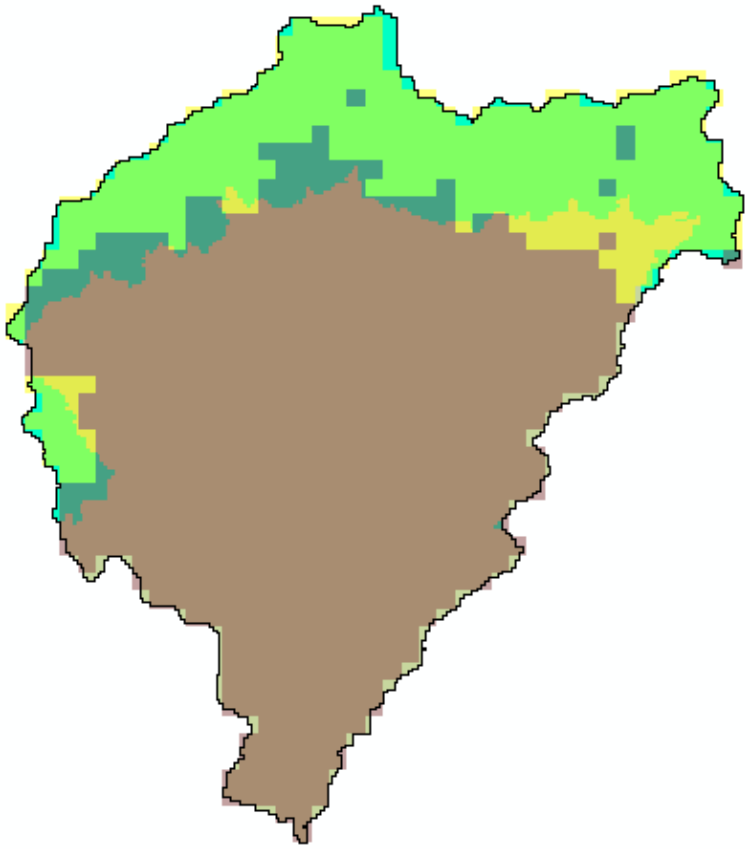
LAND

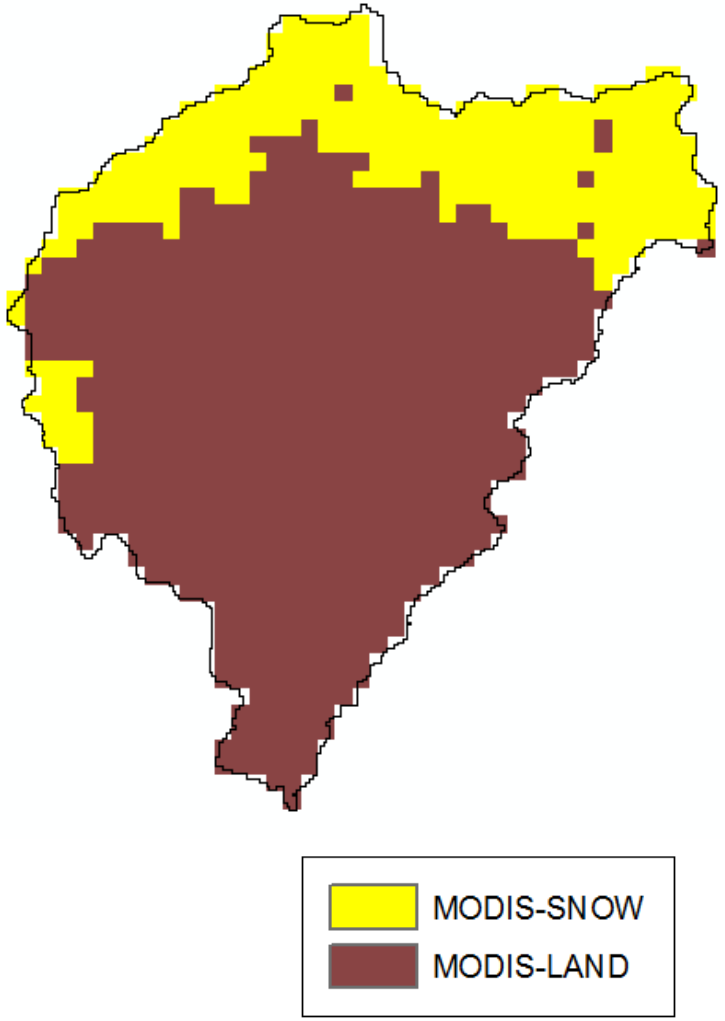
SWAT SUB-SWE VISUALIZATION

MODIS IMAGE



OVERLAYING





	SWAT	MODIS	STATE
	Snow	*Snow*	MATCH
	Snow	*Land*	MISMATCH
	Land	*Snow*	MISMATCH
	Land	*Land*	MATCH

- VISUALIZATION PROCESS IS IMPLEMENTED FOR EACH SUBBASIN AND BASIN-SCALE SWE MAPS ARE OBTAINED.
- 7 DATES ARE SELECTED:

04 DECEMBER 2005 (ACCUMULATION PERIOD)

30 DECEMBER 2005 (~100% SNOW COVER)

30 MARCH 2006 (RANDOMLY)

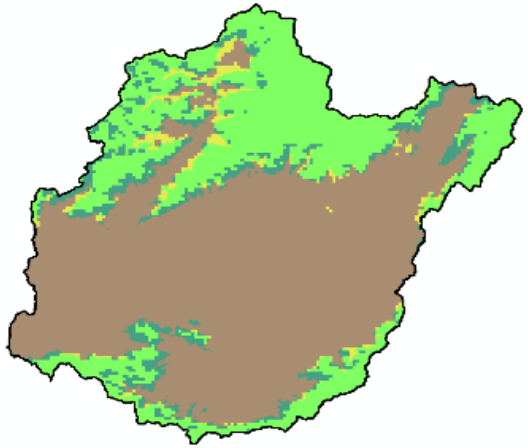
08 APRIL 2006 (RECESSION PERIOD)

13 APRIL 2006 (RANDOMLY)

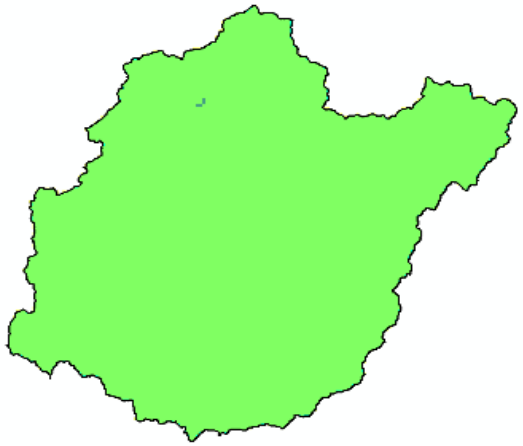
18 APRIL 2006 (RANDOMLY)

12 MAY 2006 (~0% SNOW COVER)

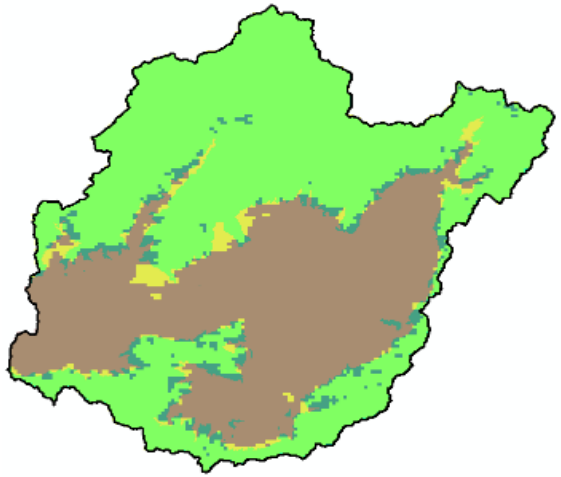
04 DEC 05



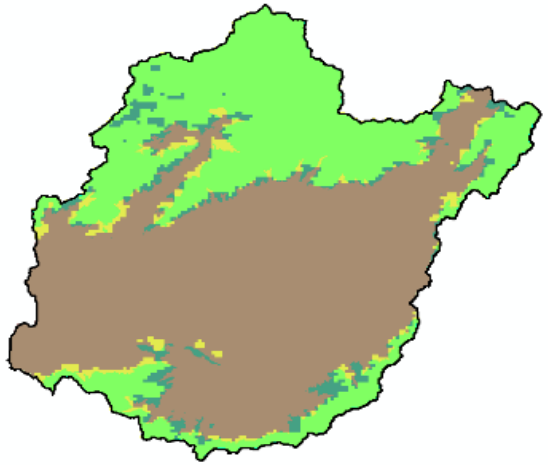
30 DEC 05



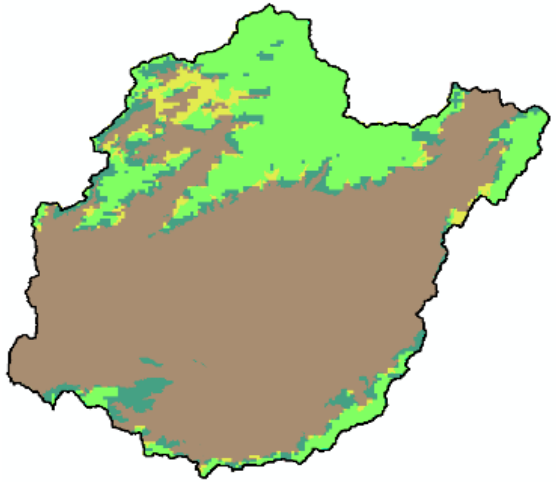
30 MAR 06



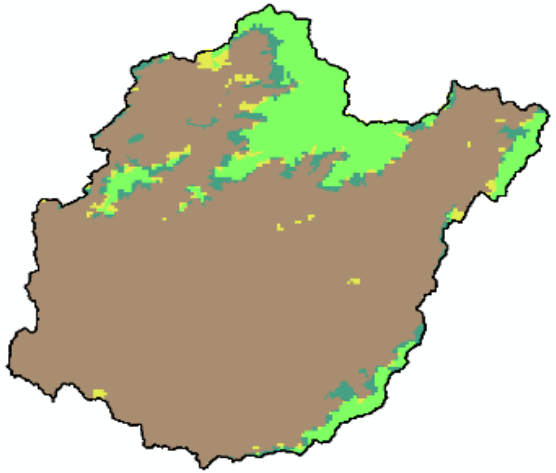
08 APR 06



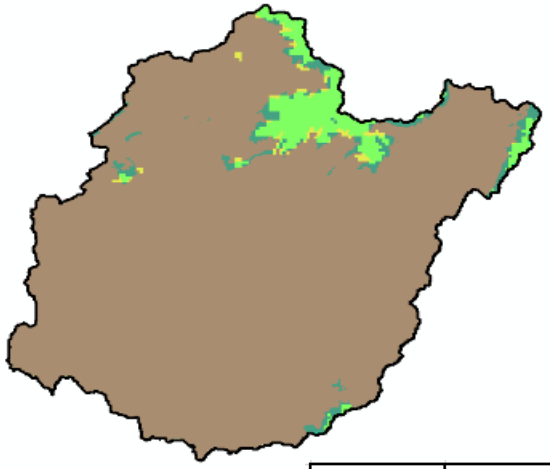
13 APR 06



18 APR 06



12 MAY 06



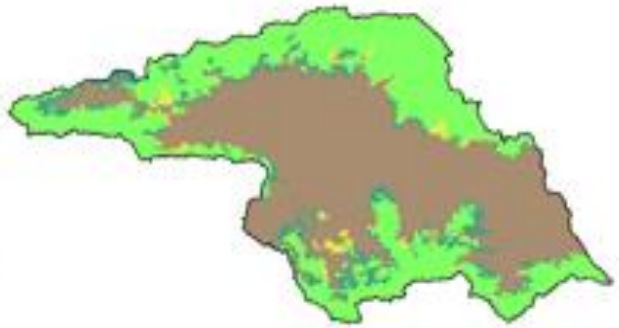
	SWAT	MODIS	STATE
	Snow	*Snow*	MATCH
	Snow	*Land*	MISMATCH
	Land	*Snow*	MISMATCH
	Land	*Land*	MATCH

04 DEC 05

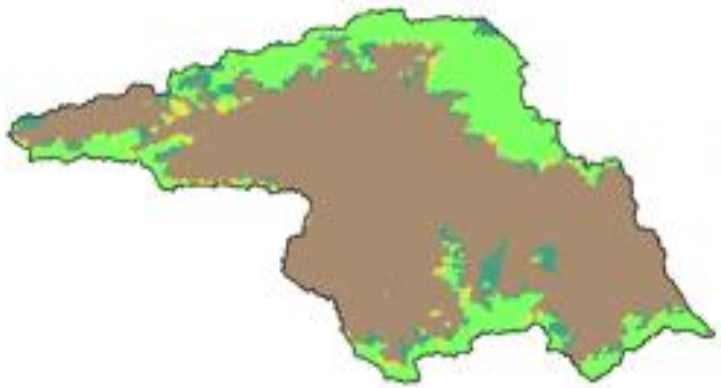
30 DEC 05

30 MAR 06

08 APR 06



13 APR 06

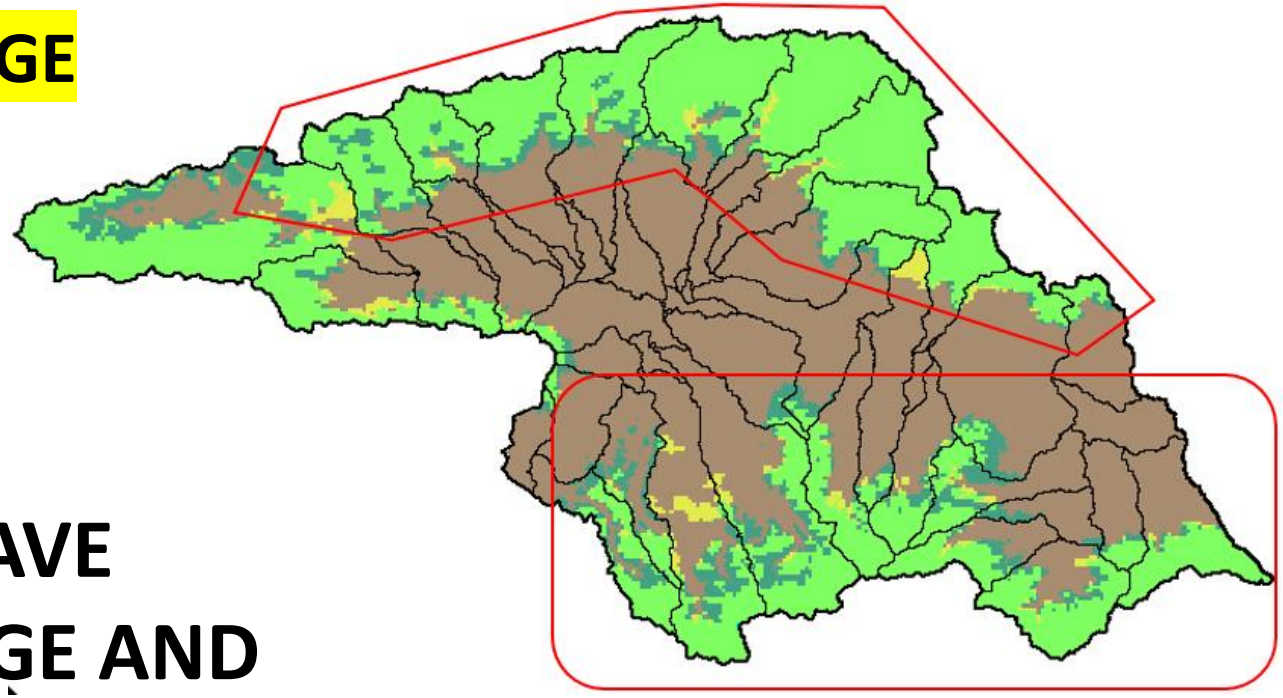


18 APR 06

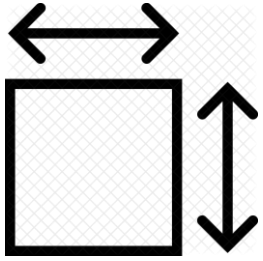
12 MAY 06

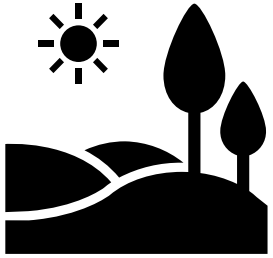
	SWAT	MODIS	STATE
	Snow	*Snow*	MATCH
	Snow	*Land*	MISMATCH
	Land	*Snow*	MISMATCH
	Land	*Land*	MATCH

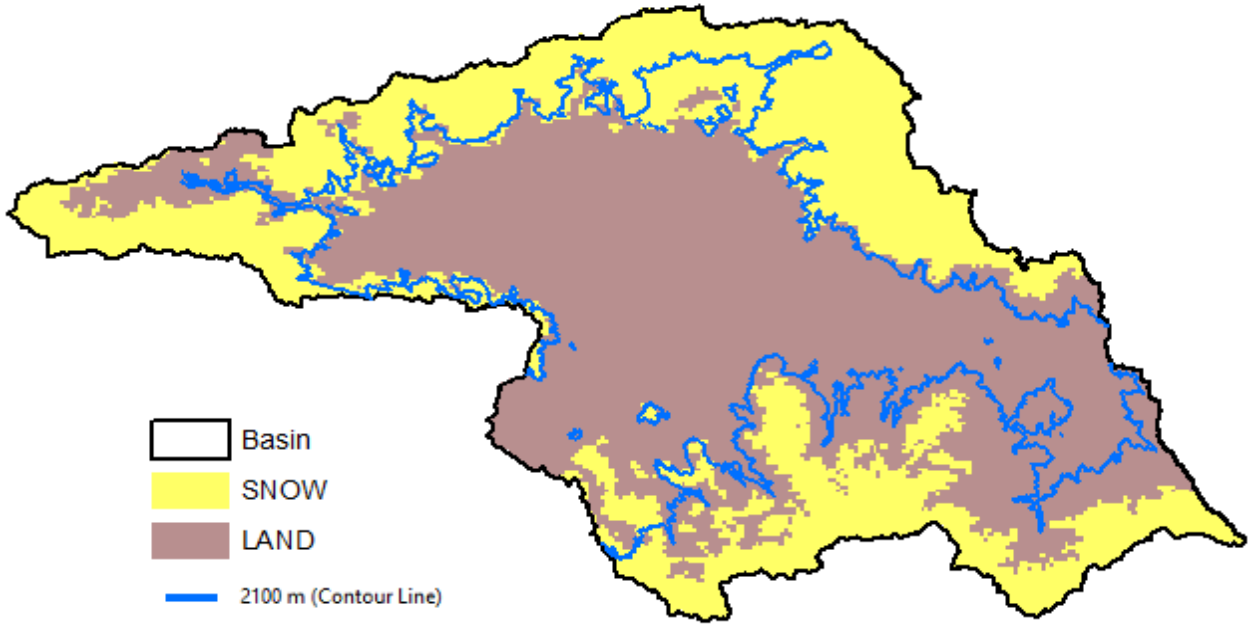
SWE THRESHOLD CAN CHANGE



BECAUSE SUBBASINS HAVE DIFFERENT ELEVATION RANGE AND ASPECT







Adjustment of Snow Parameters & Lapse Rates

PARAMETER NAME	UNIT	FITTING VALUE
SFTMP	˚C	1
SMTMP	˚C	0.5
SMFMX	mm H_2O/˚C-day	2.5
SMFMN	mm H_2O/˚C-day	0.5
TIMP	unitless	1
SNOCOVMX	mm H_2O	55
SNO50COV	unitless	0.55
PLAPS	mm H_2O/km	175
TLAPS	˚C/km	-5.5

These values are fixed as a result of the many trials according to the physical meaning and experiences from the previous studies at the study area.

AUTO-CALIBRATION PROCEDURE

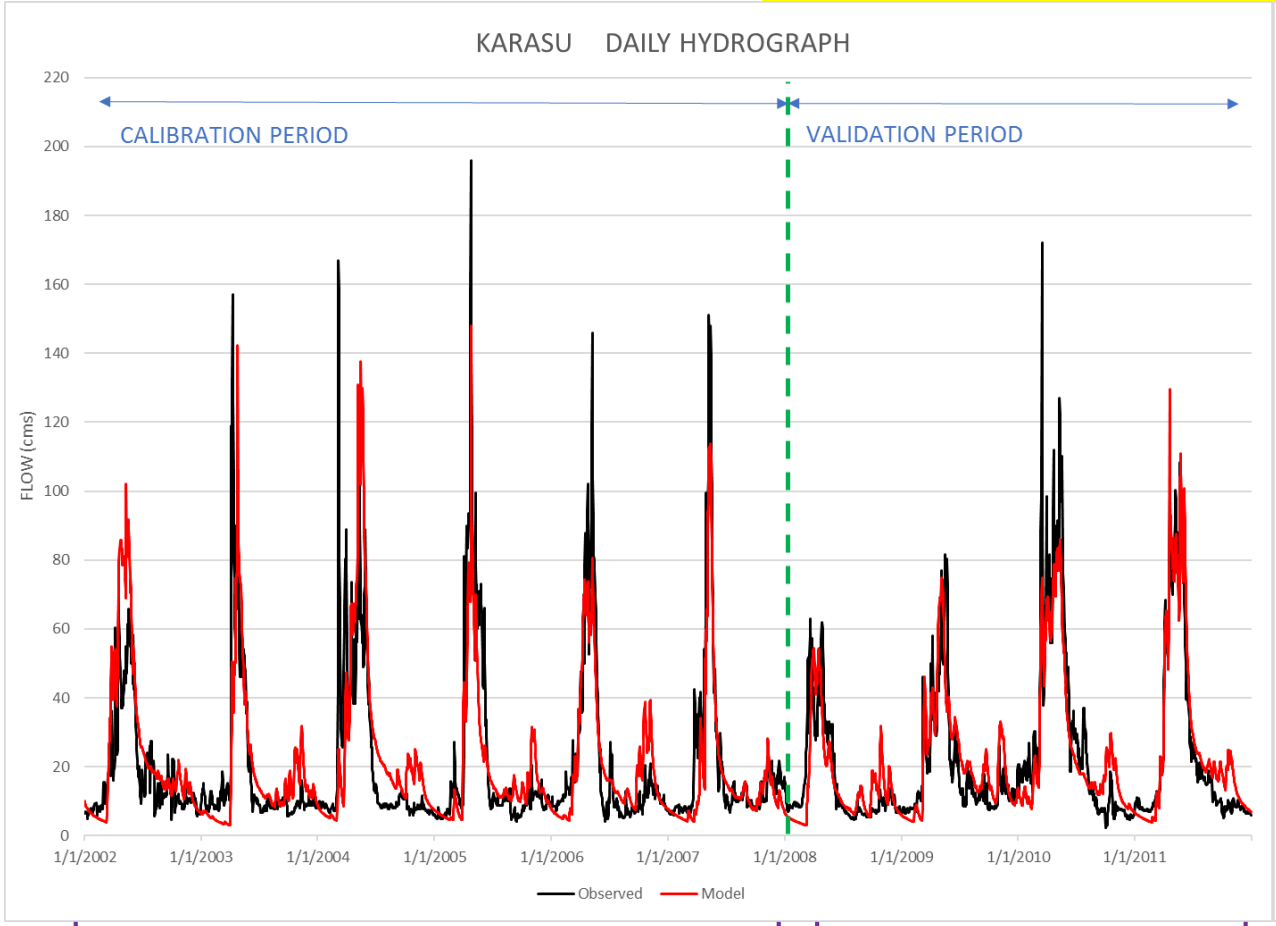
SWAT-CUP is used for model calibration.

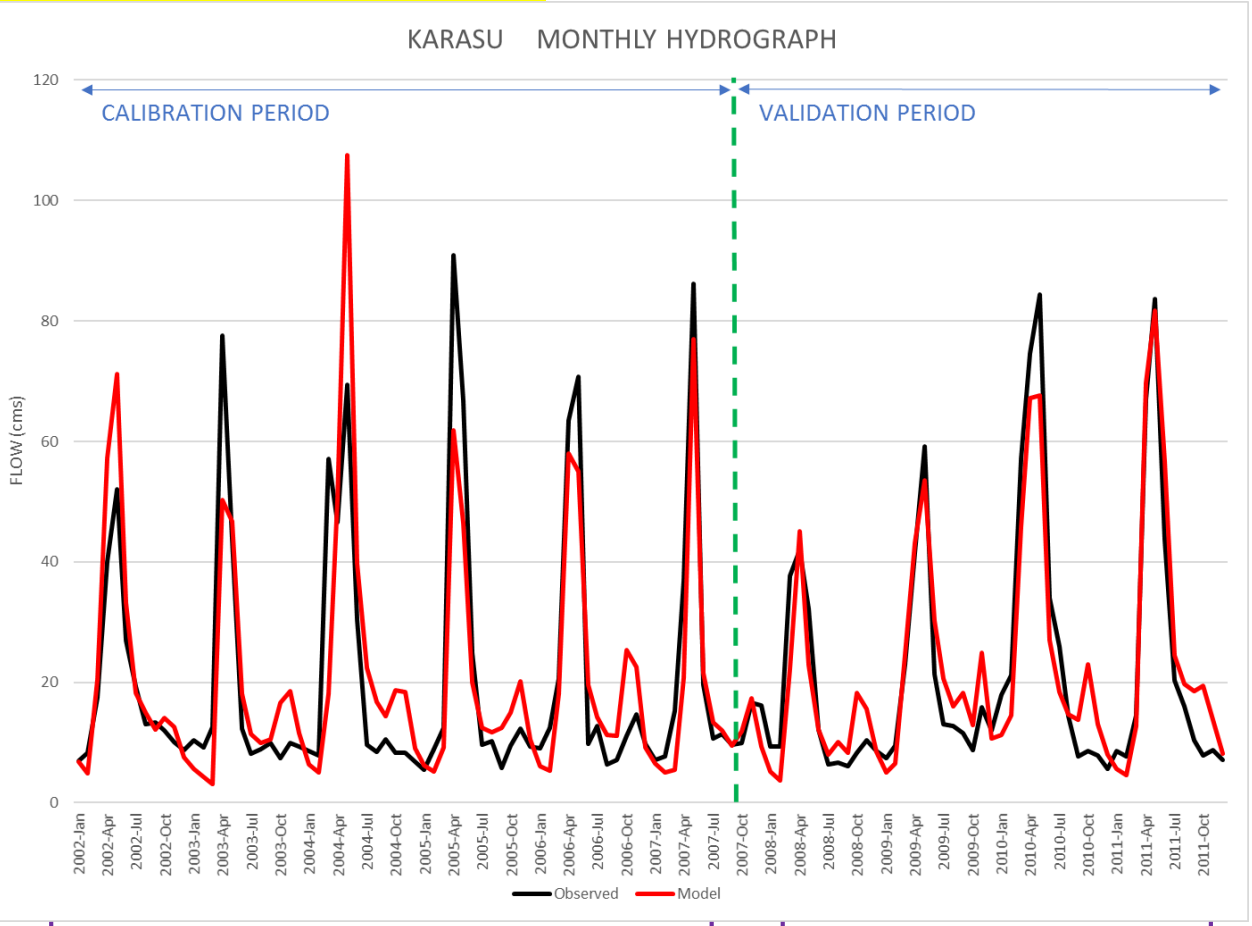
Determined sensitive parameters. *(One-at-a-time procedure, Abbaspour,2013)*

				Fitted Value	
	Parameter Name	Initial Range		**MURAT**	**KARASU**
r_	CN2.mgt	-0.3	0.3	**-0.28**	**-0.16**
v_	ESCO.hru	0.7	1	**0.73**	**0.75**
r_	SOL_Z.sol	-0.3	0.3	**-0.21**	**0.3**
r_	SOL_K.sol	-0.3	0.3	**-0.19**	**0.3**
r_	SOL_AWC.sol	-0.3	0.3	**0.29**	**0.19**
v_	ALPHA_BF.gw	0.01	0.99	**0.79**	**0.92**
v_	GW_DELAY.gw	1	50	**10.69**	**7.53**
v_	GWQMN.gw	1	250	**172.85**	**15.04**
v_	RCHRG_DP.gw	0.2	0.5	**0.36**	**0.4**

Same for each basin model.
1000 simulations for 2 iterations.

HYDROGRAPHS FOR KARASU BASIN



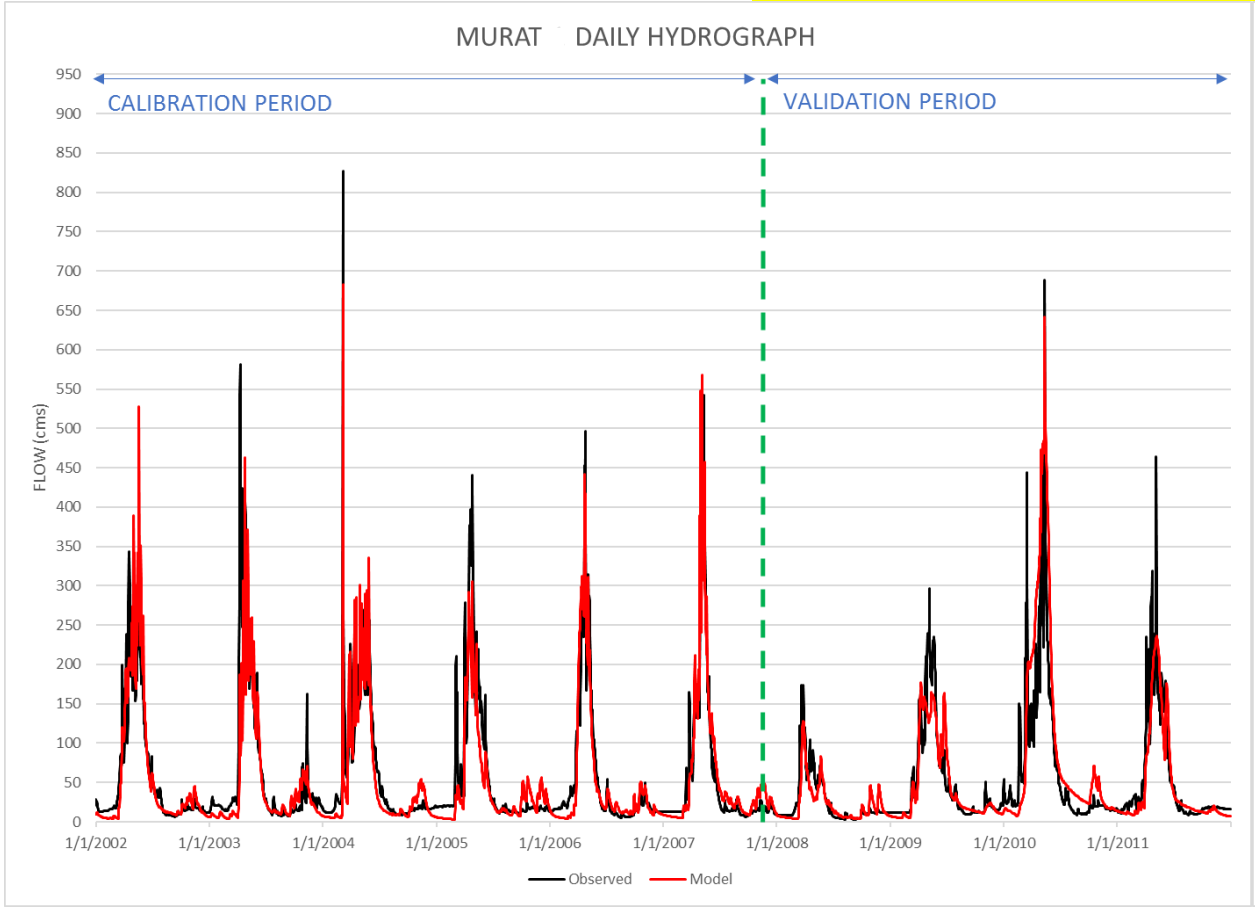


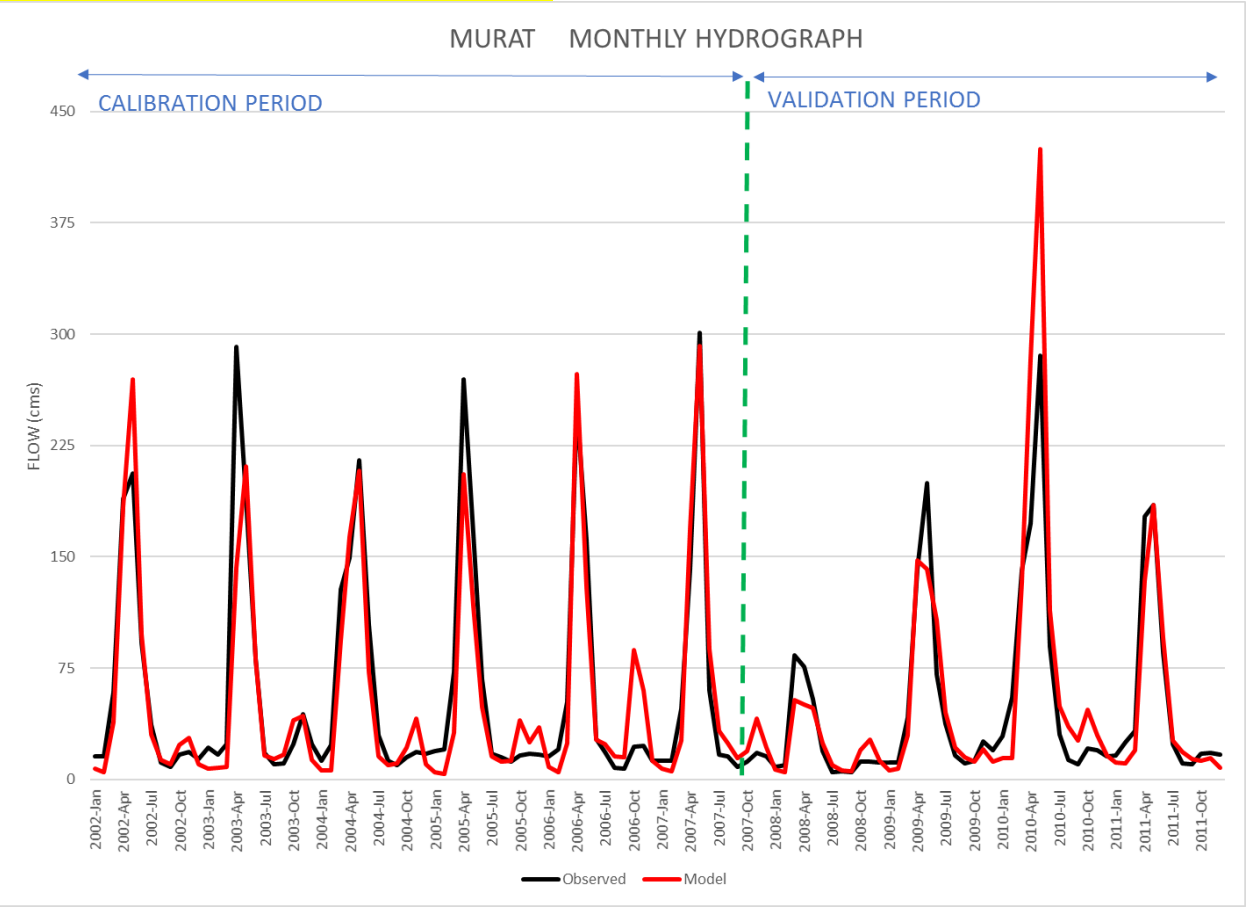
CAL-DAILY		VAL-DAILY		CAL-MONTHLY		VAL-MONTHLY	
Q-NSE	R^2	Q-NSE	R^2	Q-NSE	R^2	Q-NSE	R^2
0.64	0.63	0.82	0.82	0.74	0.75	0.89	0.90

NSE: NASH-SUTCLIFFE EFFICIENCY

R^2: COEFF. OF DETERMINATION

HYDROGRAPHS FOR MURAT BASIN



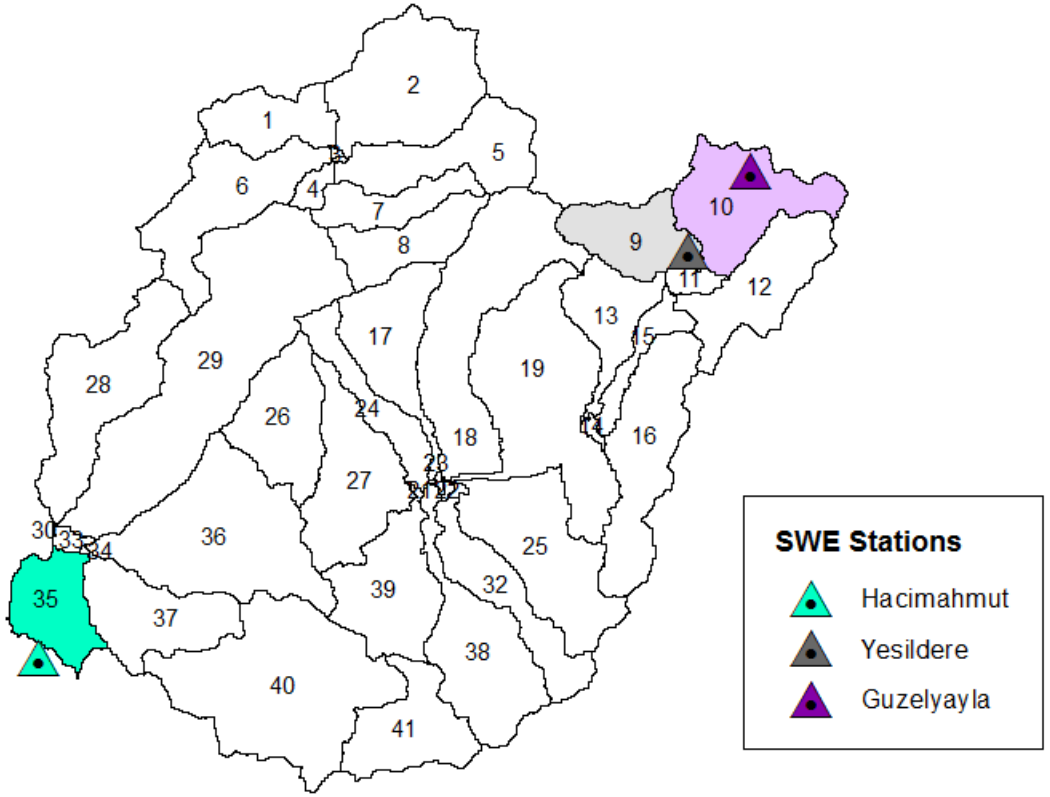


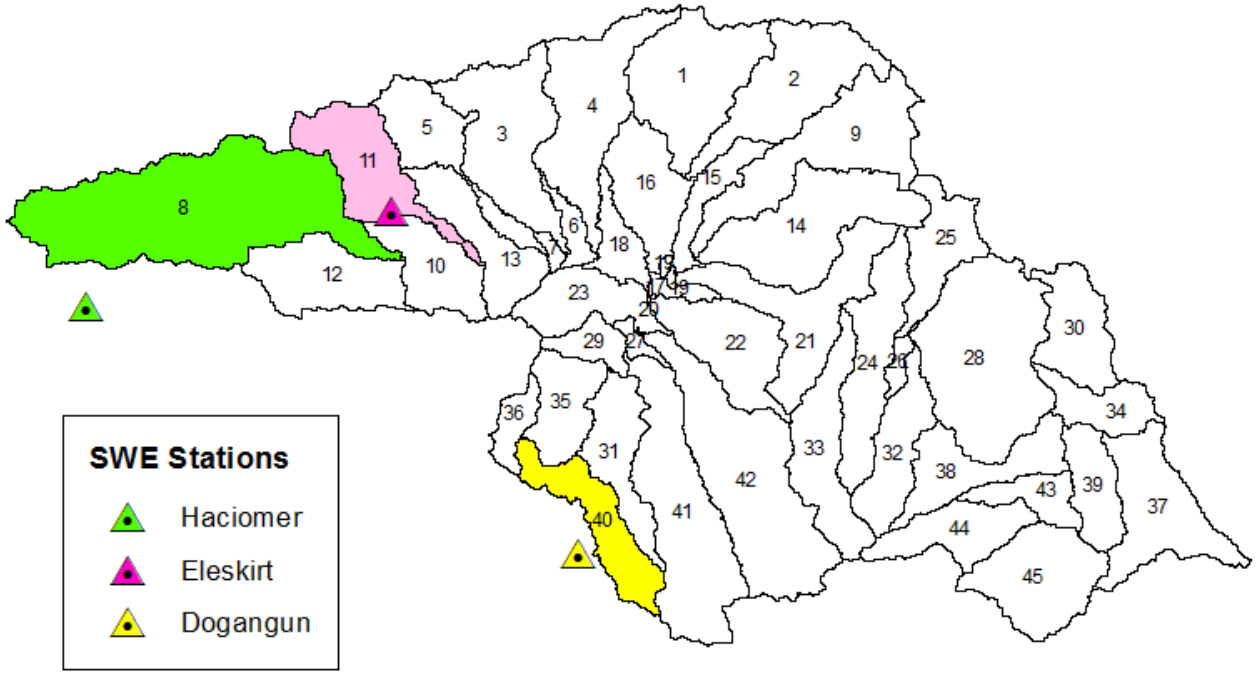
CAL-DAILY		VAL-DAILY		CAL-MONTHLY		VAL-MONTHLY	
Q-NSE	R^2	Q-NSE	R^2	Q-NSE	R^2	Q-NSE	R^2
0.73	0.74	0.67	0.76	0.83	0.87	0.76	0.86

NSE: NASH-SUTCLIFFE EFFICIENCY

R^2: COEFF. OF DETERMINATION

Snow Stations

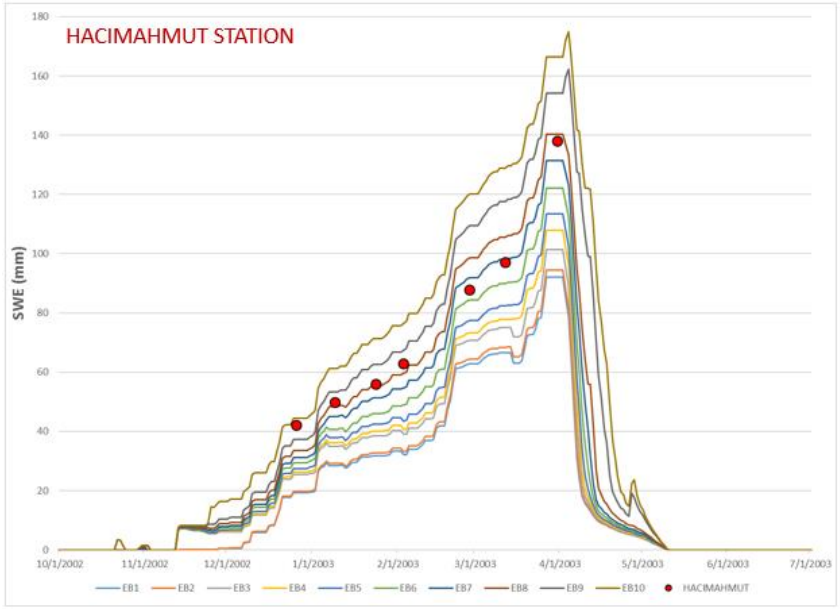


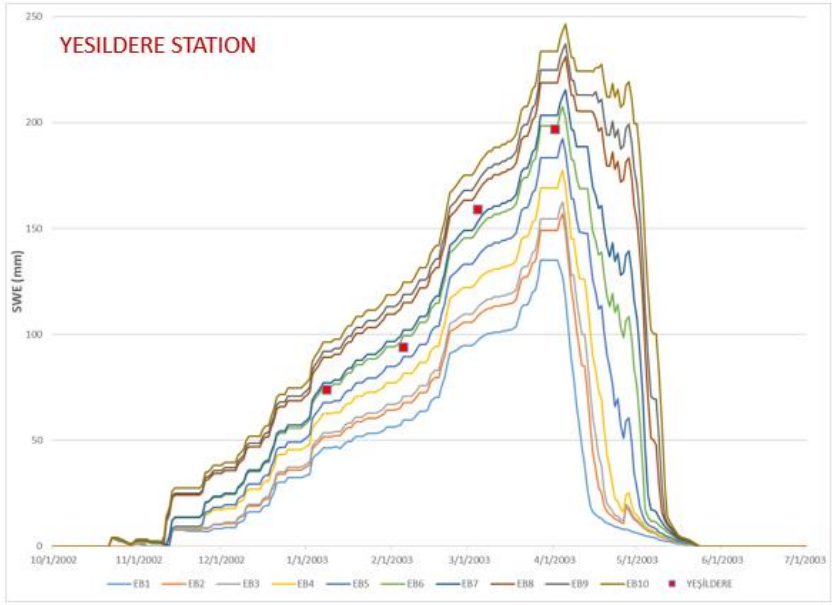


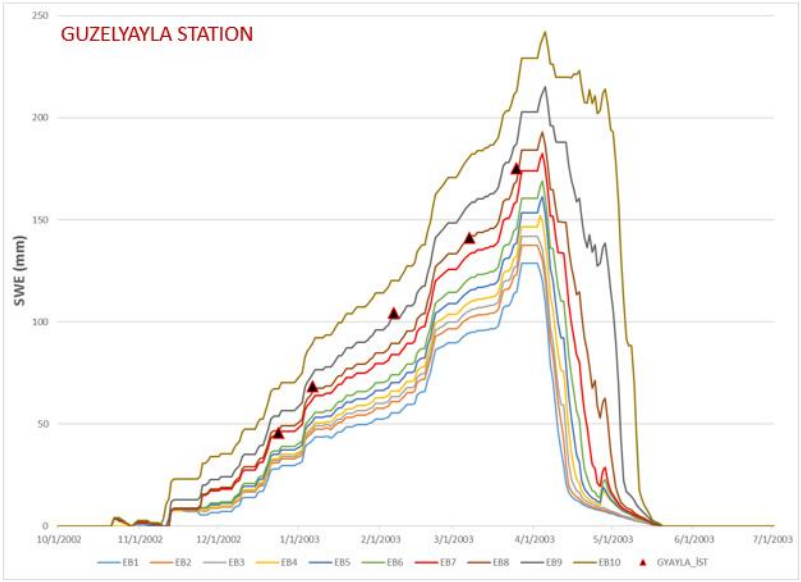
Station Name	Elevation (m)	Location	
Hacimahmut	1945	SUB 35	BAND 6
Yesildere	1935	SUB 9	BAND 1
Guzelyayla	2070	SUB 10	BAND 7

Station Name	Elevation (m)	Location	
Haciomer	1865	SUB 8	BAND 1
Eleskirt	1780	SUB 11	BAND 4
Dogangun	1660	SUB 40	BAND 1

Snow Validation







TREND IS MATCHING

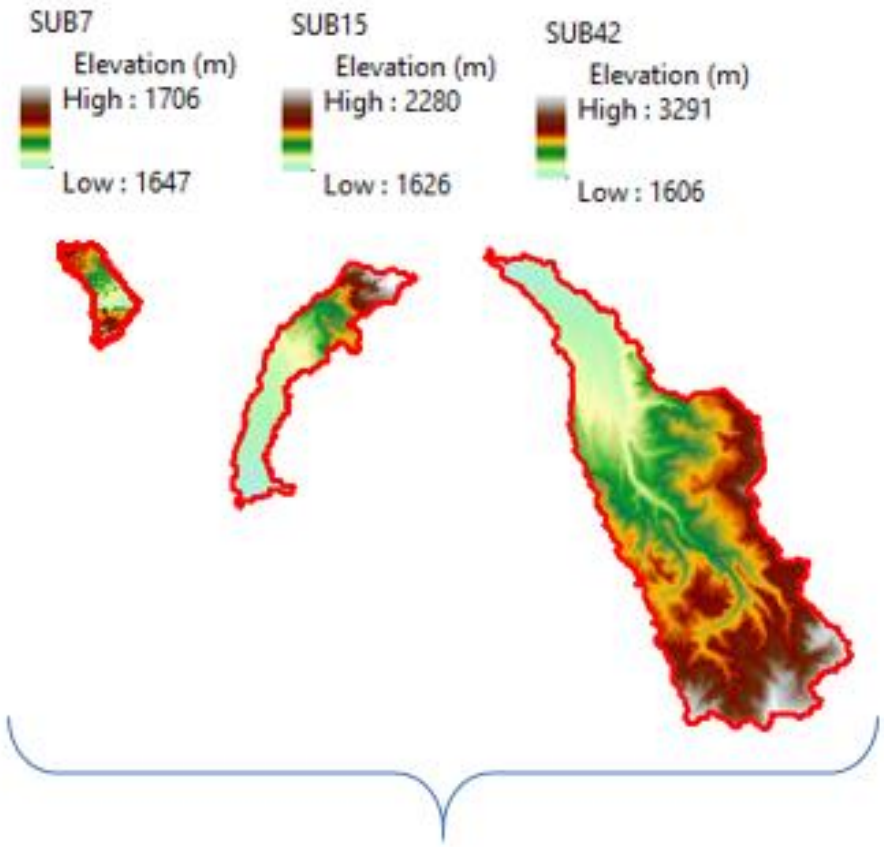
CONCLUSIONS

- SWAT was used for mountanious and snow-fed basins in Turkey.
- Before the model calibration, snow parameters were fitted with two methods that utilized with MODIS.
- Auto-calibration procedure was applied according to flow data and successful results were obtained.
- Calibrated model was validated for flow data and snow validation was done using the ground snow station data.

Models are ready for future studies!

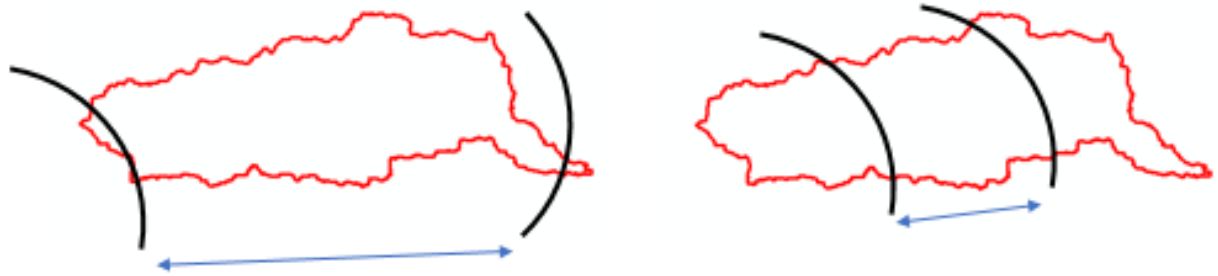
RECOMMENDATIONS

DIFFERENT ELEVATION BAND NUMBERS
FOR EACH SUBBASIN

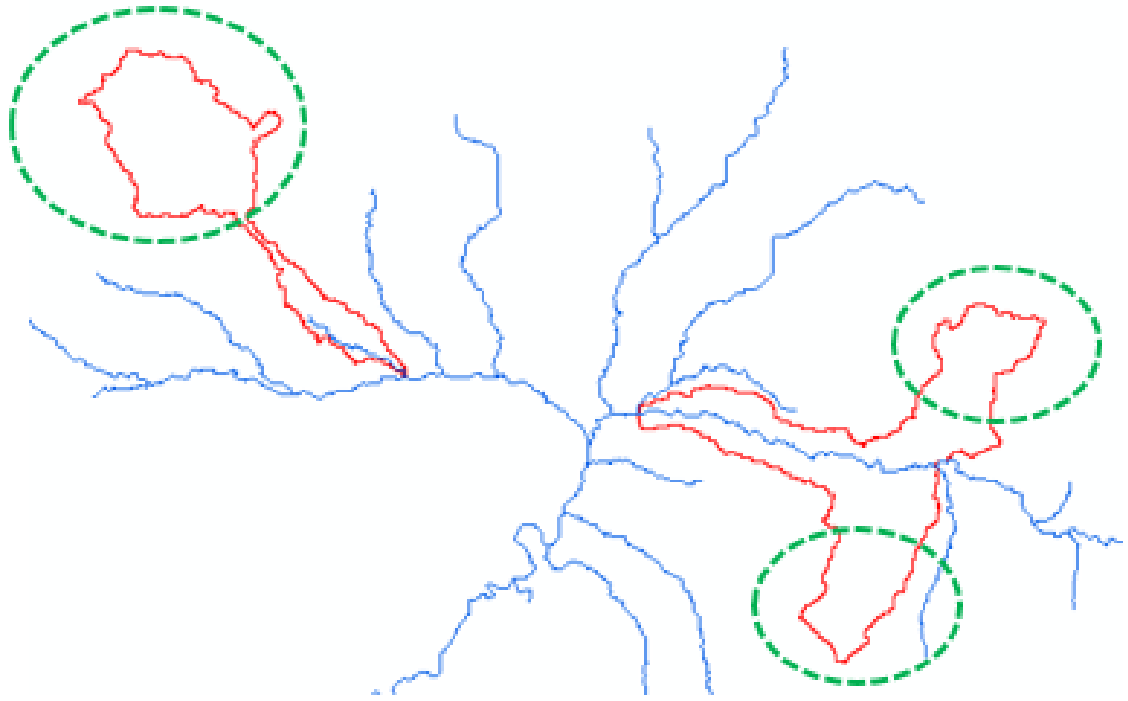


BECAUSE SUBBASINS HAVE **DIFFERENT ELE. RELIEF, AREA AND SHAPE**

ADJUSTMENT OF ELEVATION BAND RANGES
INSTEAD OF AUTOMATIC VALUES



MORE DETAILED DISTRIBUTION OF SUBBASINS



Thank you for your attention.

Contact: ismailbilalpeker@eskisehir.edu.tr

Eskisehir Technical University, Turkey

Department of Civil Engineering – Hydraulics Division