2011 SWAT

Konkuk University, Seoul, South Korea

Evaluation of snowmelt contribution to streamflow in a heavy snowfall watershed of South Korea using SWAT model

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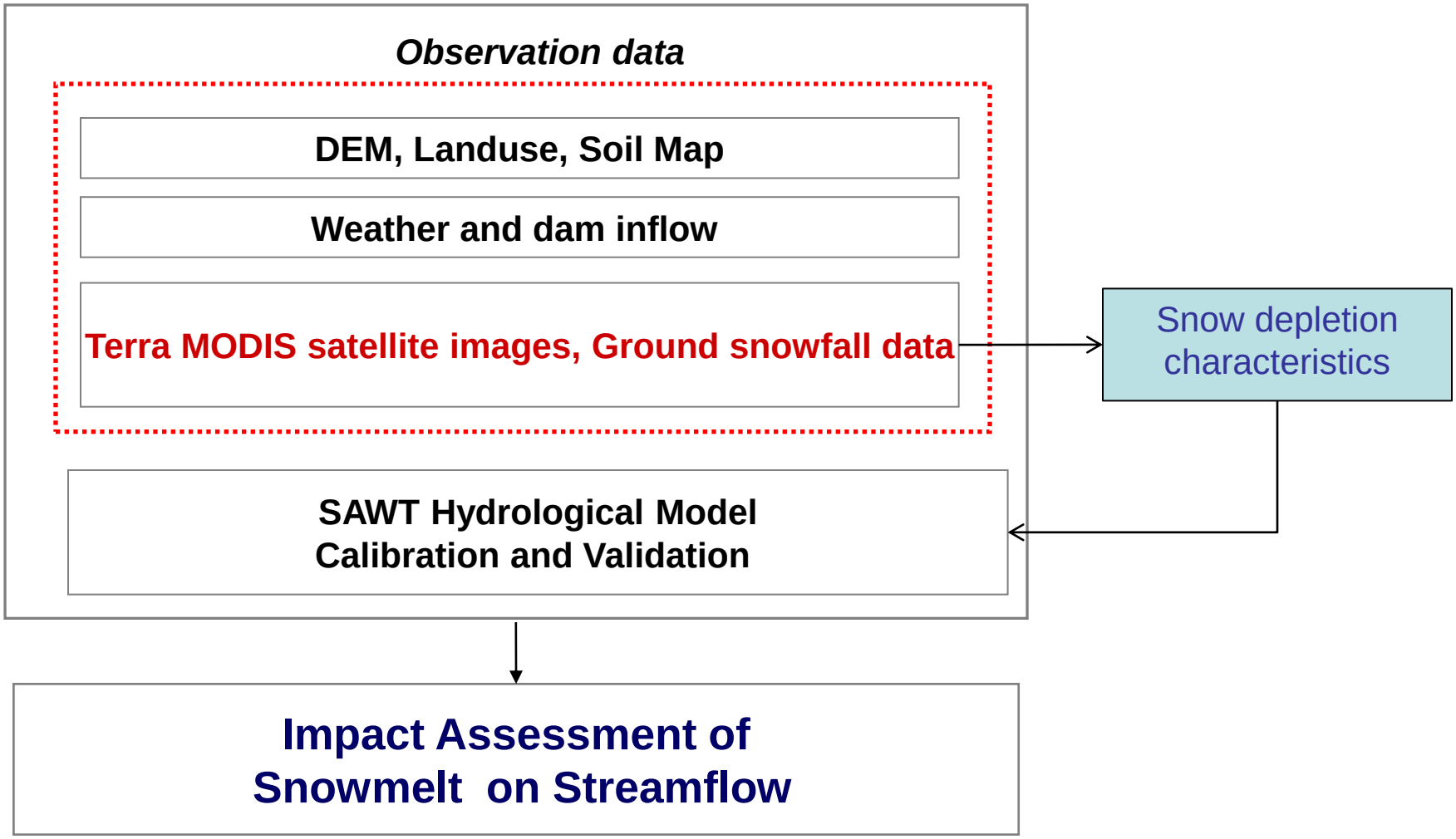
Contents

Introduction

- **We have snowfall from the beginning of November to the first period of April.**
- **Three areas (Southwest-plain area, Northeast-mountainous area, and far East island) of South Korea usually have big snowfall up to 50 cm, 100 cm, 200 cm respectively. Recently since 2000, we suffer some unexpected heavy snowfall events in other areas except the above three areas.**
- **In our case, the heavy snowfall is treated as a natural disaster not for use as water resources. Thus, we have few studies for the snowmelt impact on streamflow (contribute about less than 5 %) as a part of hydrology.**
- **SWAT has algorithms and parameters related with the snowmelt.**
- **We need our own snowmelt parameters. So, here by using the ground measured snowfall data and satellite snow cover area information, we can determine our parameters to simulate the snowmelt driven streamflow.**

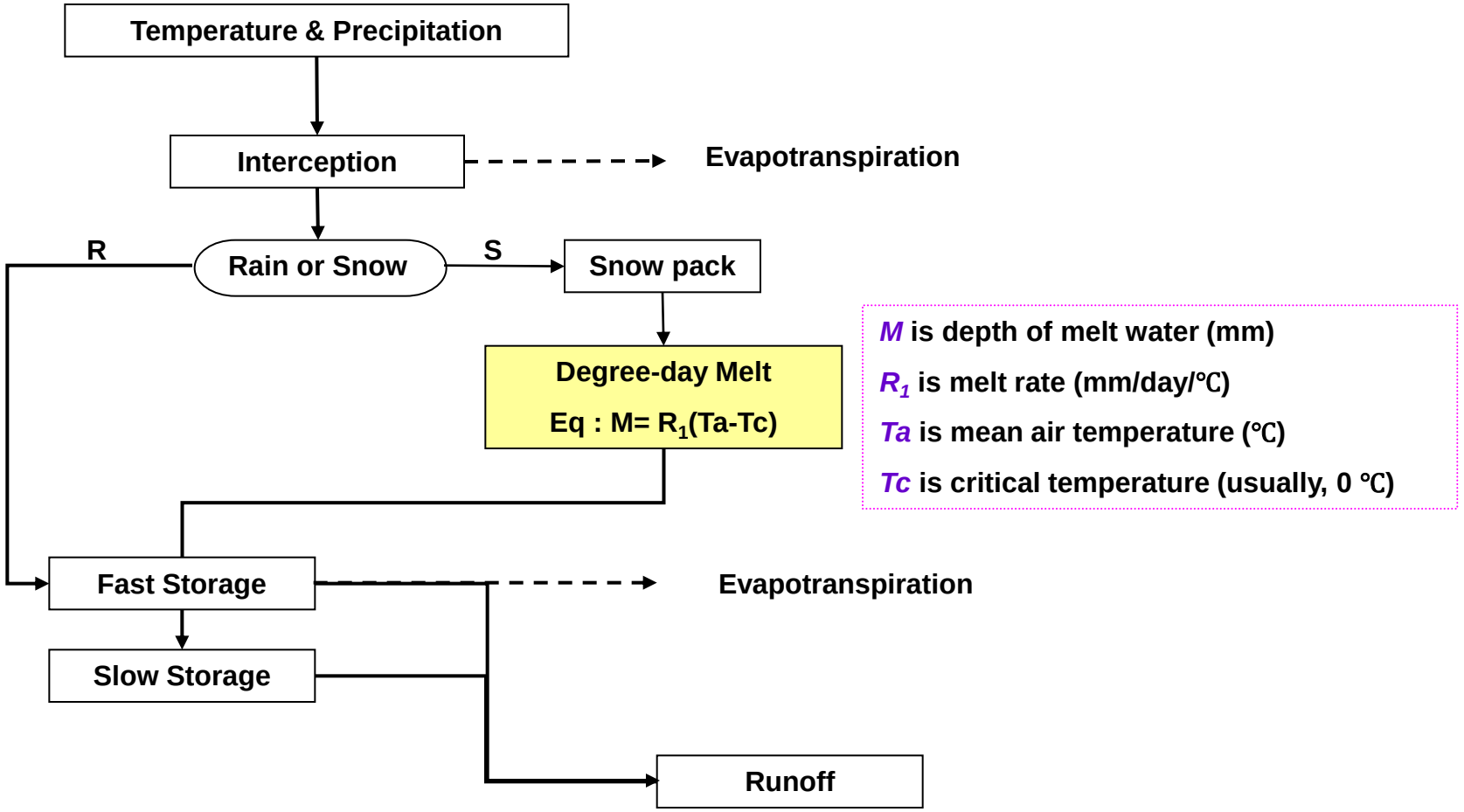
- ***The objective of this study***
  - ✓ **Is to determine the SWAT snowmelt related parameters using 9 years snowfall and Terra MODIS data and calibrate the streamflow during the snowmelt periods (March to April) for a mountainous watershed located in the northeastern part of South Korea.**

Flowchart of Study

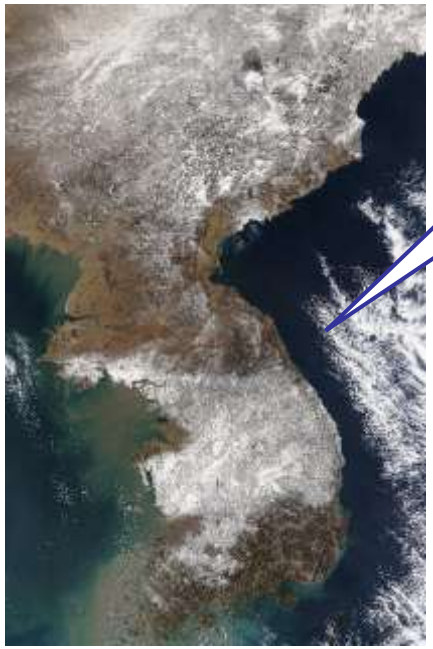


Model Description

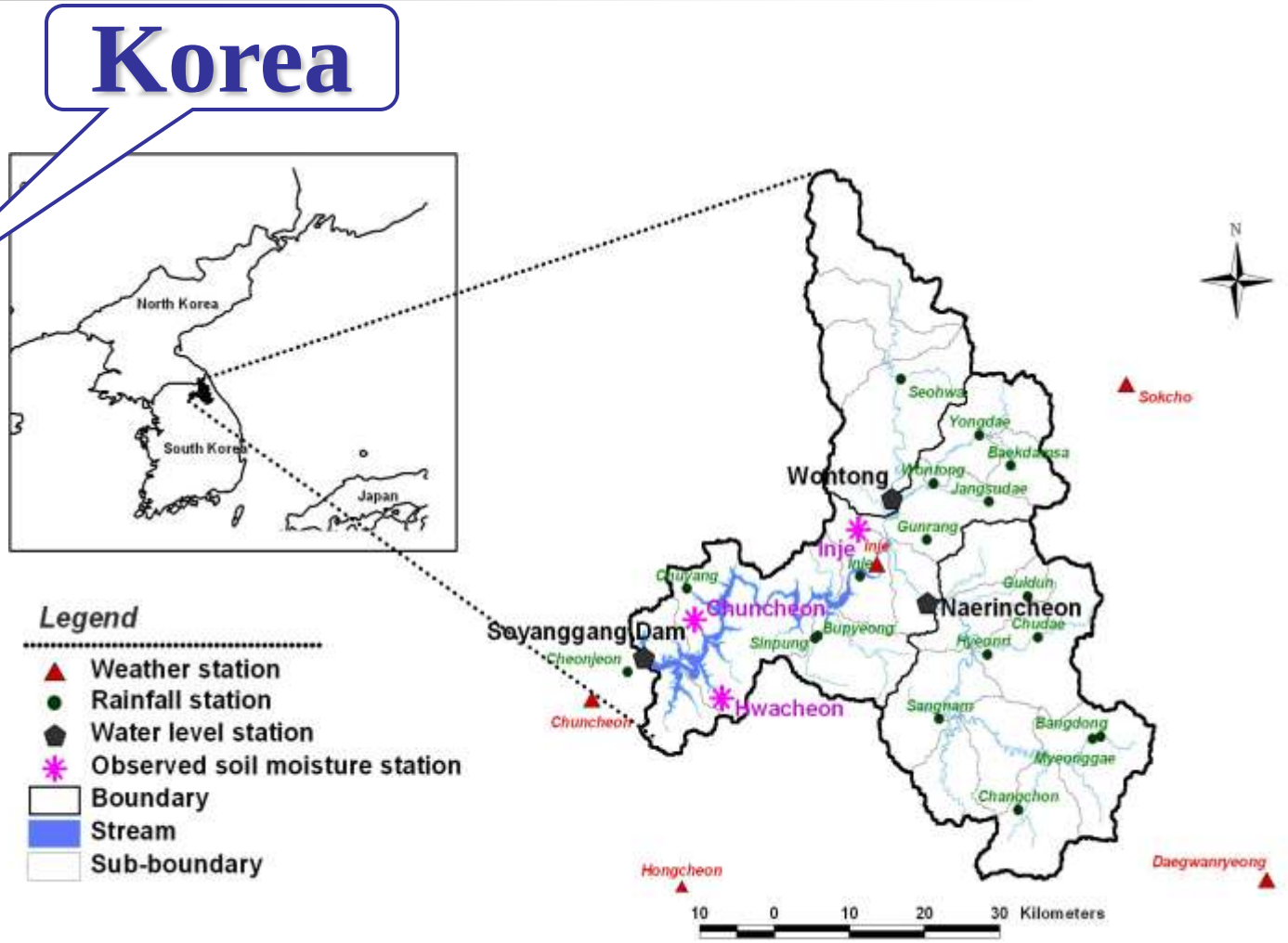
❖ ***Algorithm of snowmelt simulation in SWAT model (Degree-day Method)***



Study Watershed

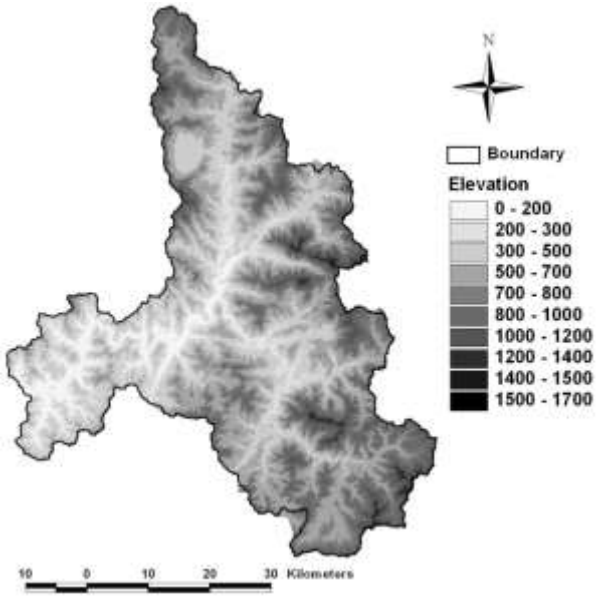


2004. 3. 7
MODIS image



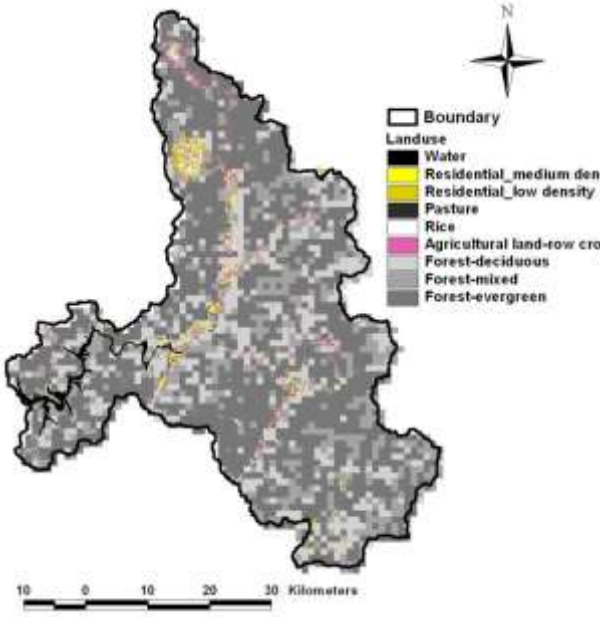
- Study area: 2,694.4 km^2 forest-dominant (93 %) watershed
- The annual average precipitation is 1,359.5 mm, and the mean temperature is 9.4 ℃ over the last 30 years (1977 - 2006).

Elevation, Soil, Land Cover Data



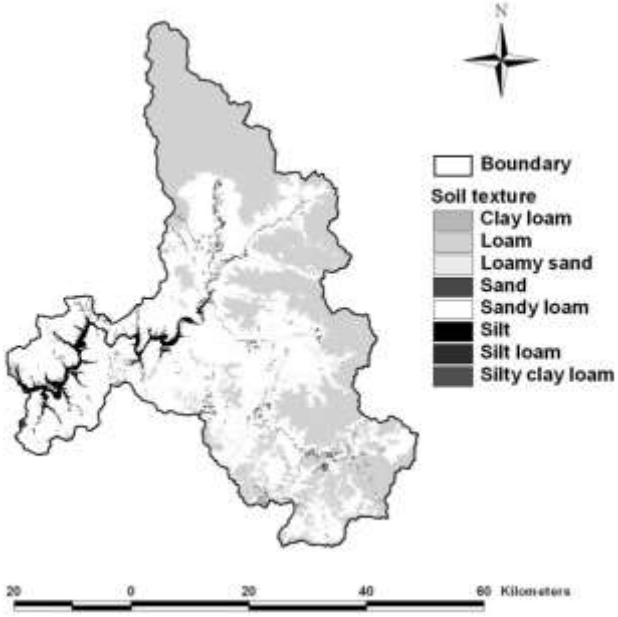
Elevation

- range : 155 - 1,639 m
- average : 643.9 m



Land use

- The 9 categories
- prepared by 2000 Landsat TM (Thematic Mapper) supervised classification with NOAA NDVI

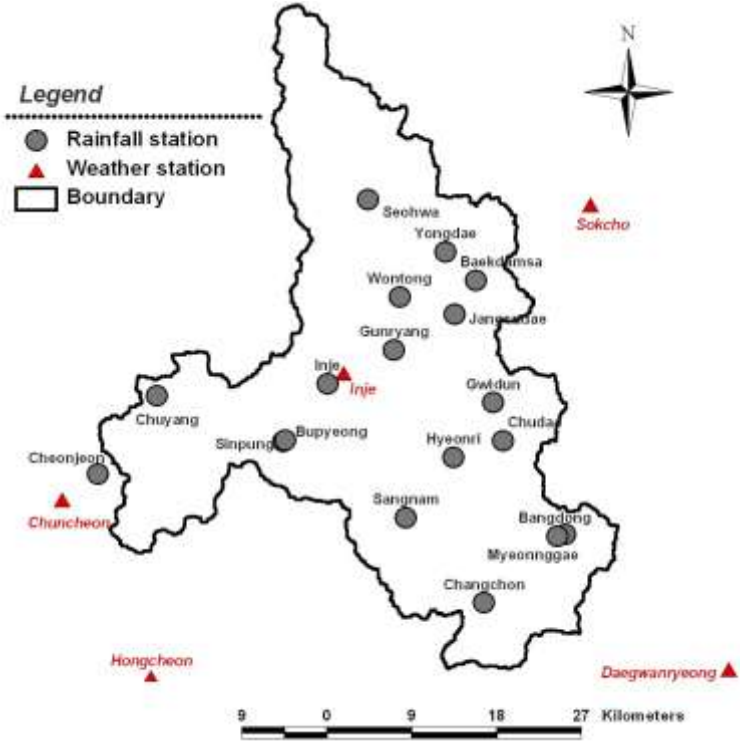


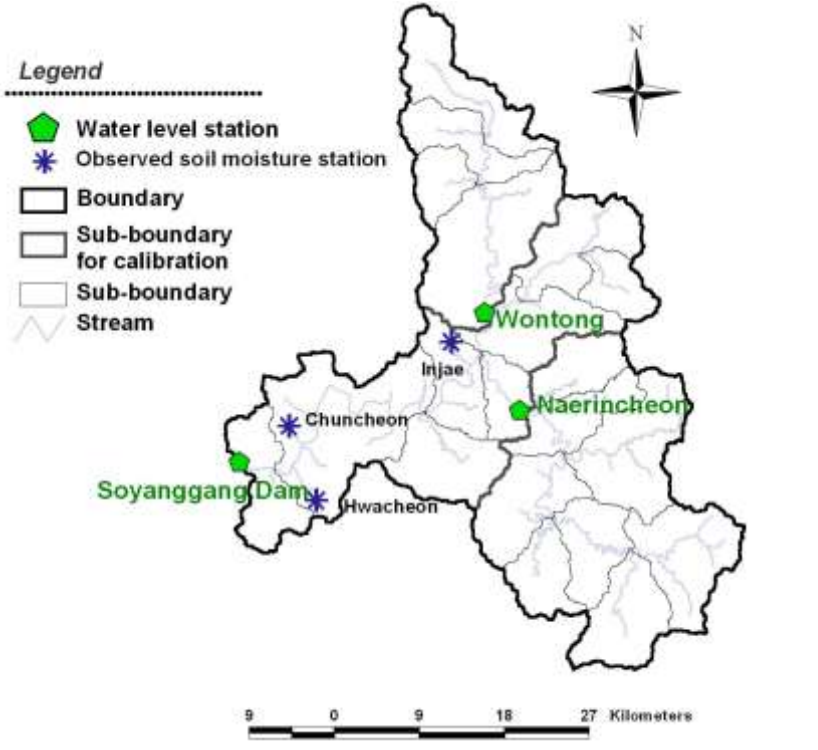
Soil

- loam (52.4 %), and loamy sand (42.4 %)

Material and Method

❖ *Input Datasets for Calibration and Validation of the SWAT Model*





Meteorological data

- Daily weather data (temperature, relative humidity, wind speed, sunshine hour) were collected from five stations (1998-2008)
- Daily precipitation data were collected from eighteen stations (1998-2008)

Streamflow data

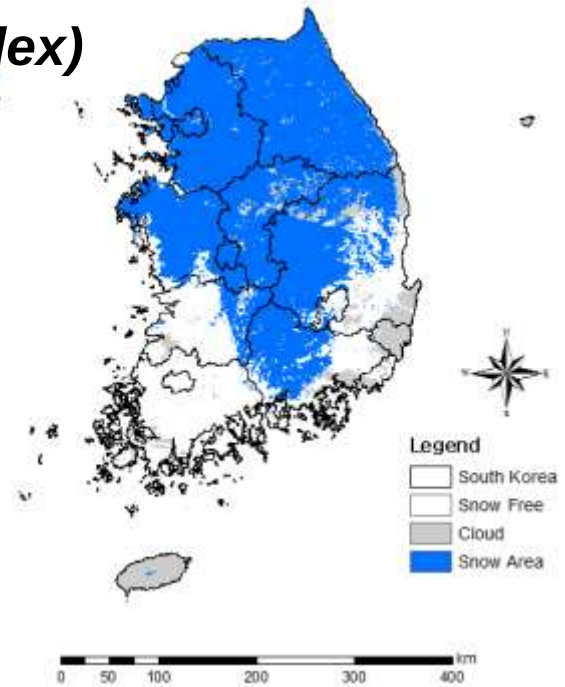
- Daily streamflow data at the three water level stations were obtained (1998-2008) from the Ministry of Construction and Transportation.

Terra MODIS Snow Cover Area

- ***MODIS (Moderate Resolution Imaging Spectroradiometer)***
  - ✓ *MODIS is one of four sensors carried on-board NASA's first Earth Observing System (EOS) satellite 'Terra'.*
  - ✓ *The automated MODIS snow-mapping algorithm uses at-satellite reflectances in MODIS bands 4 (0.545-0.565 ㎛) and band 6 (1.628-1.652 ㎛) to calculate the normalized difference snow index (Hall, Riggs, & Salamonson, 1995)*

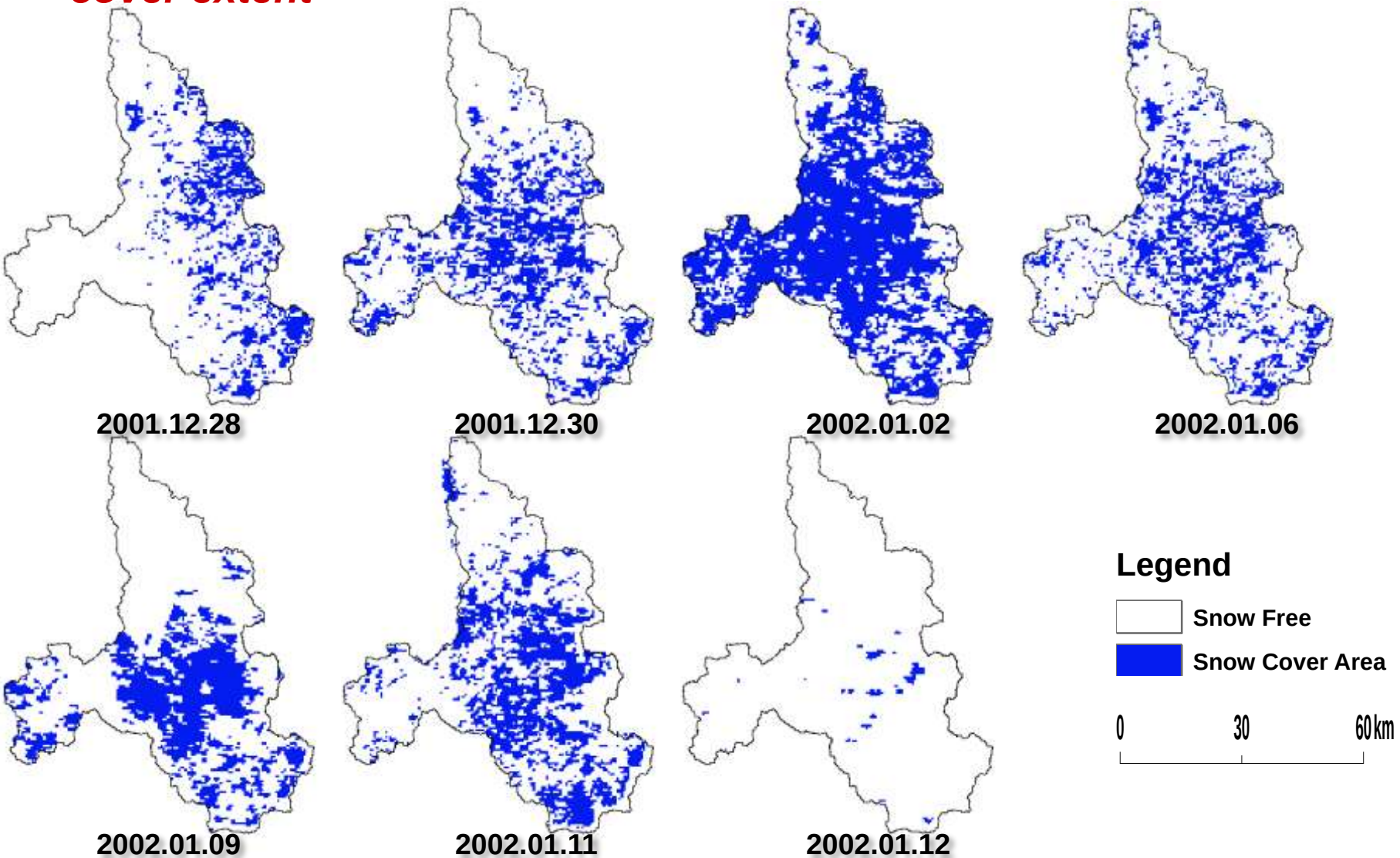
- ***SNOW COVER (Normalized Difference Snow Index)***
  - *1 day interval & 500 m resolution*

$$NDSI = \frac{MODIS4 - MODIS6}{MODIS4 + MODIS6}$$



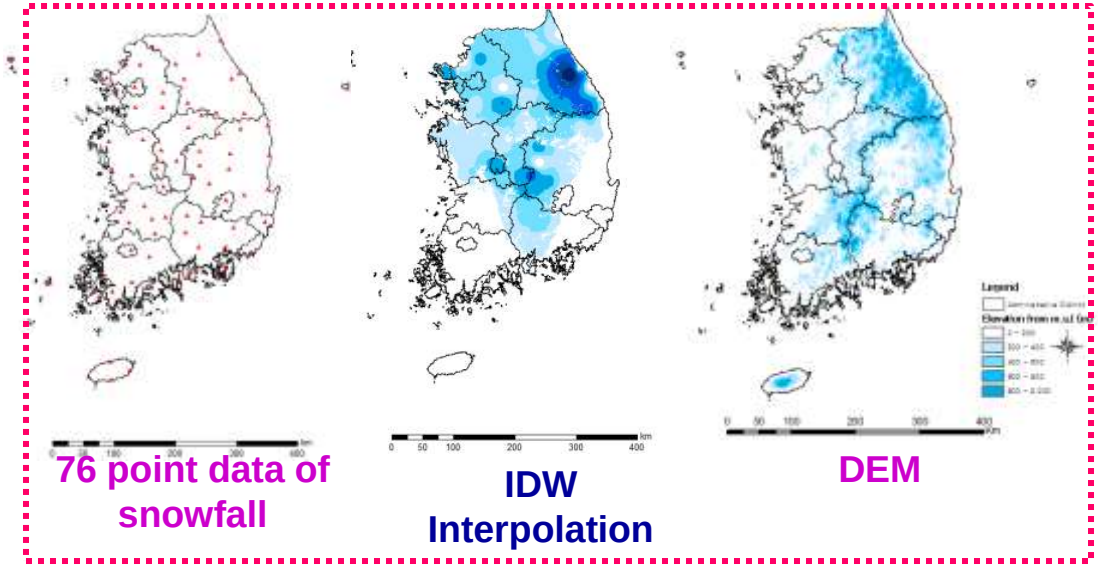
Sample of Terra MODIS Snow Cover Area

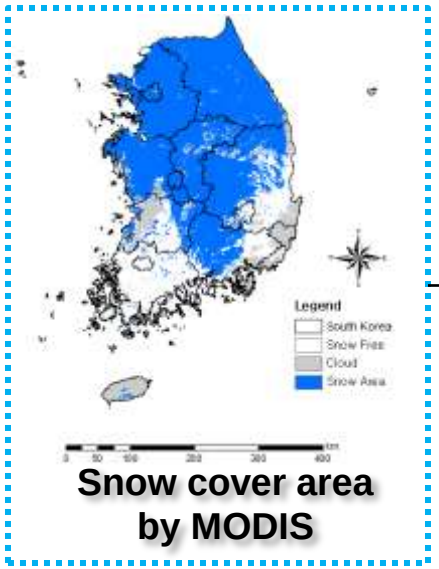
- **The generated snow depth distribution within the MODIS snow cover extent**

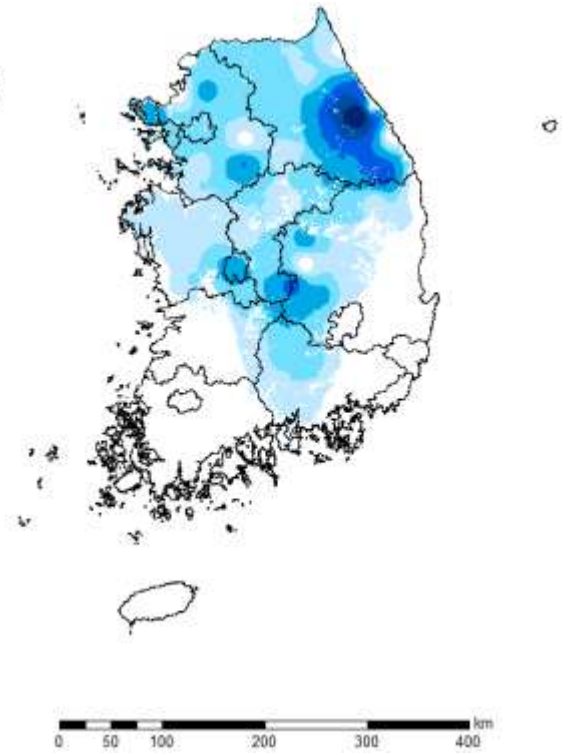


Spatial distribution map of snow depth using GIS interpolation and MODIS SCA

❖ IDW (Inverse Distance Weighting)

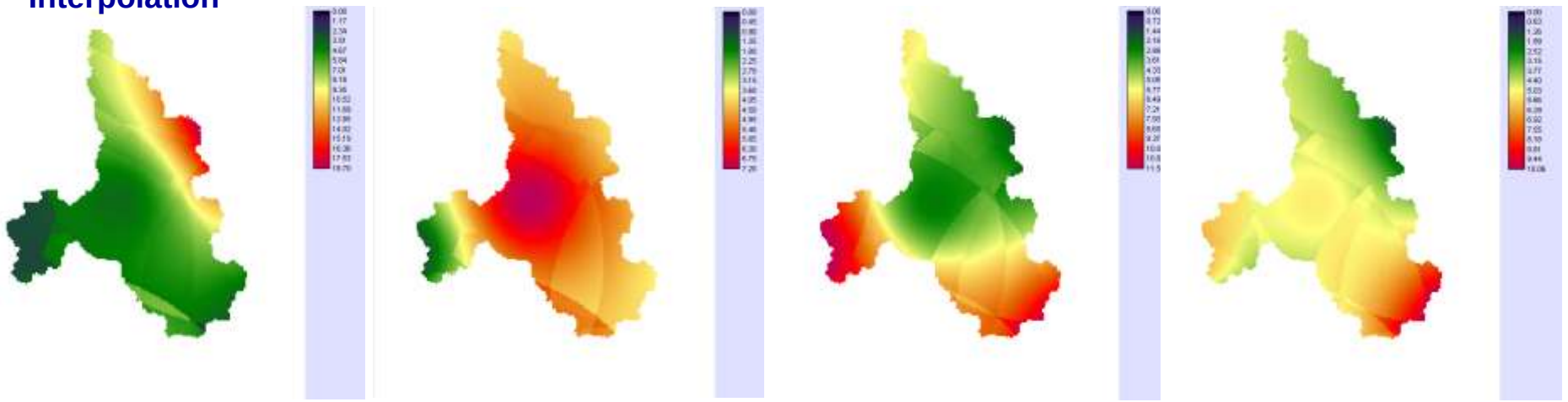






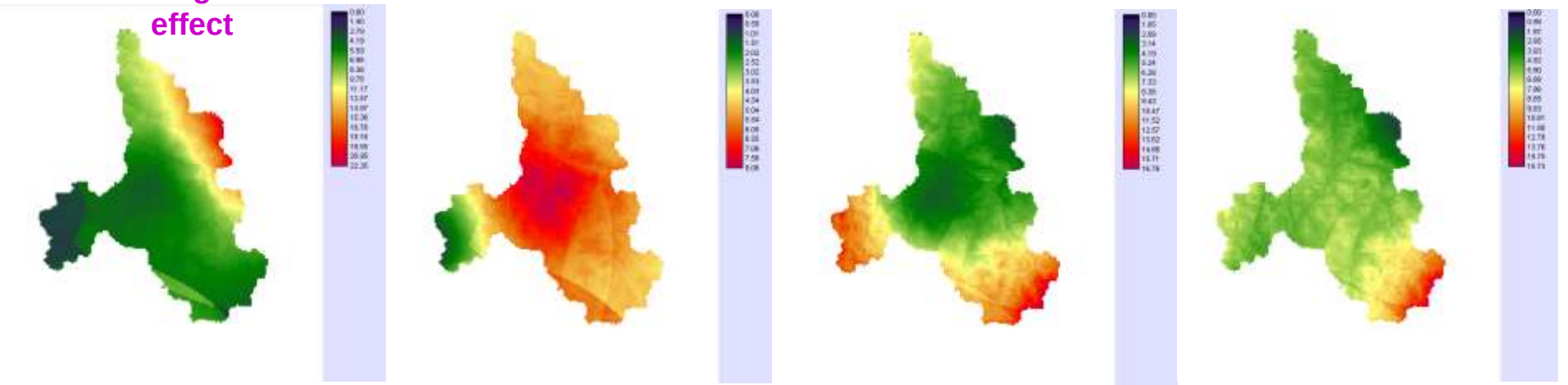
Spatial distribution of snow depth considering elevation effect

IDW Interpolation



2001.12.25 2001.12.29 2001.01.02 2002.01.10

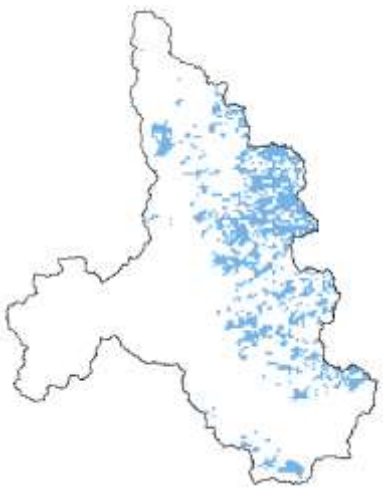
Considering elevation effect



2001.12.25 2001.12.29 2001.01.02 2002.01.10

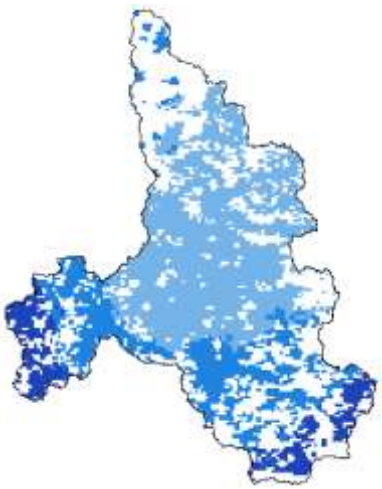
2001-2002 Spatial distribution of snow depth

- **The generated snow depth distribution within the MODIS snow cover extent using the ground-measured snowfall data**

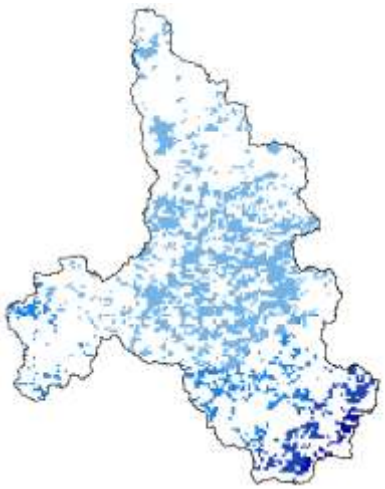


2001.12.28

2001.12.30



2002.01.02



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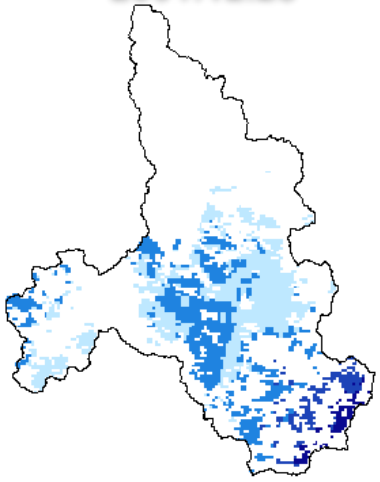

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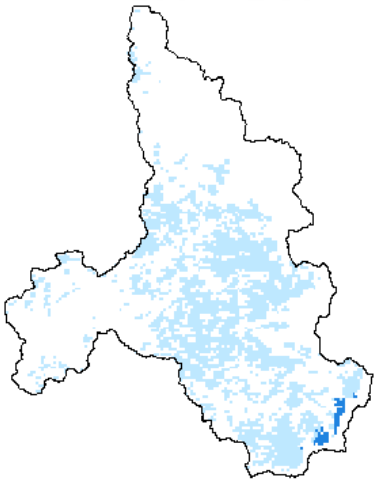
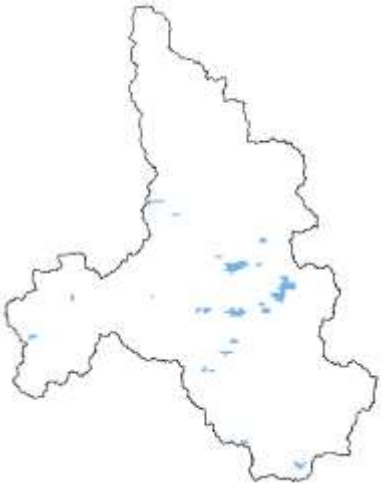


2002.01.11



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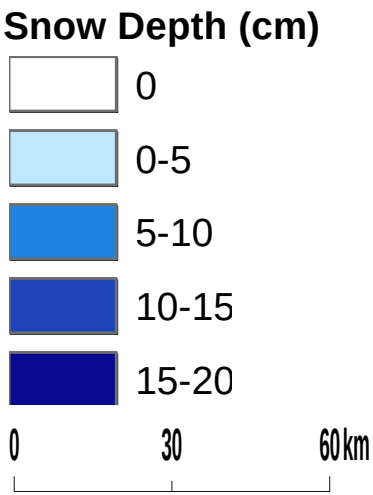
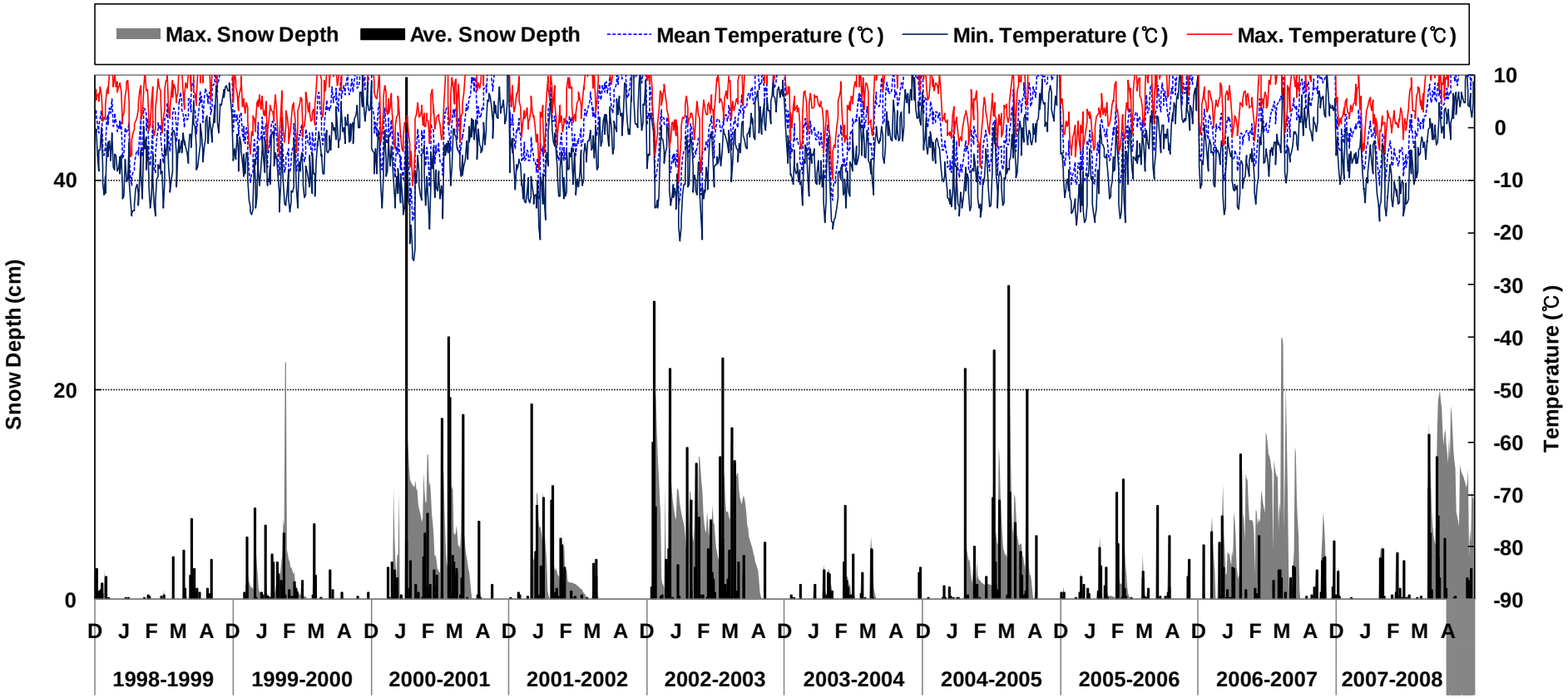


The watershed snow depth summary (1998-2008)

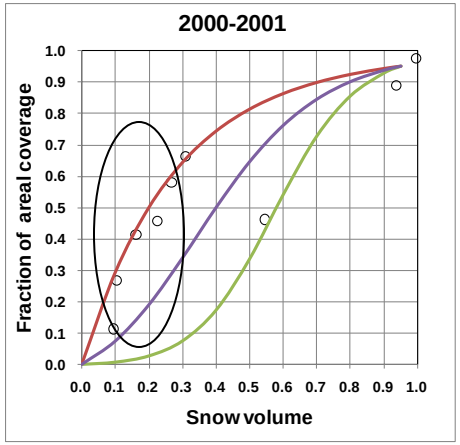
❖ Average snow depth and temperature

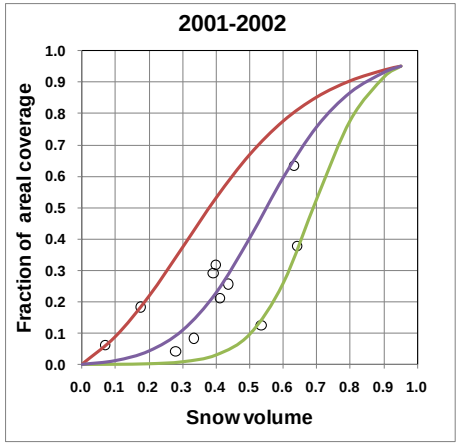
Maximum (old-gray) and average (new-black) snow depth

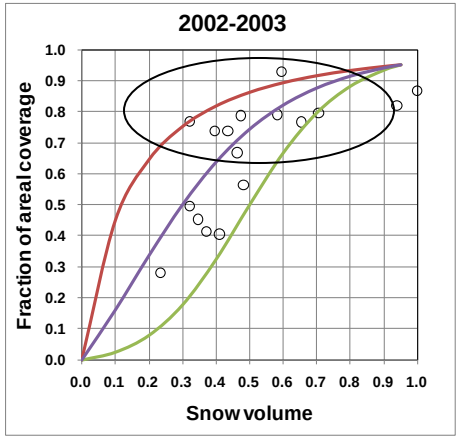


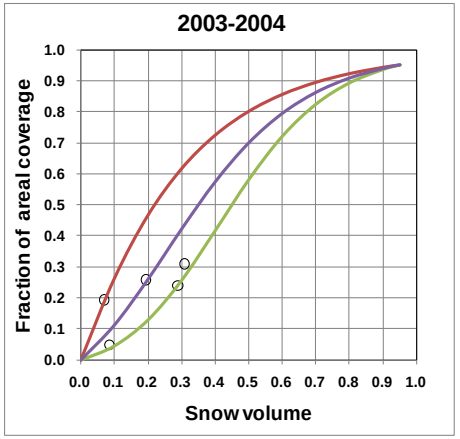
Derivation of snow depletion curve

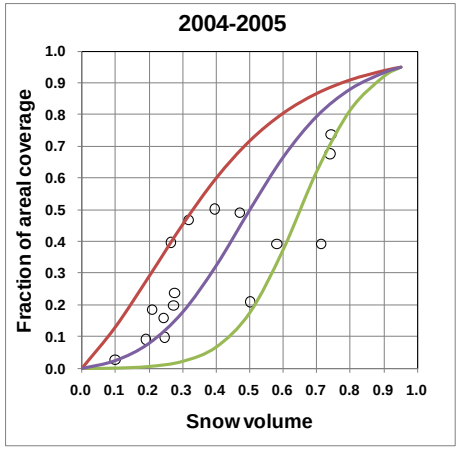
- **The snow depletion curves from the fraction of snow cover area and snow volume of each data set (heavy snowfall year: 2000-2001, 2002-2003, 2007-2008)**

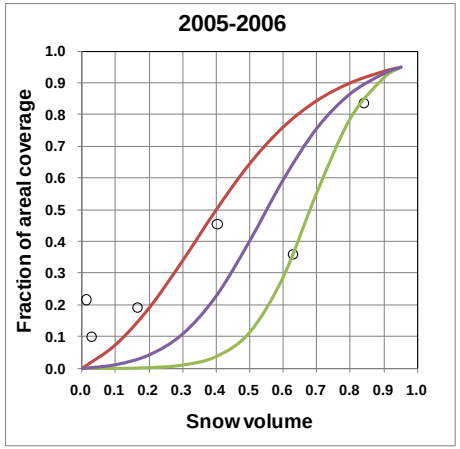


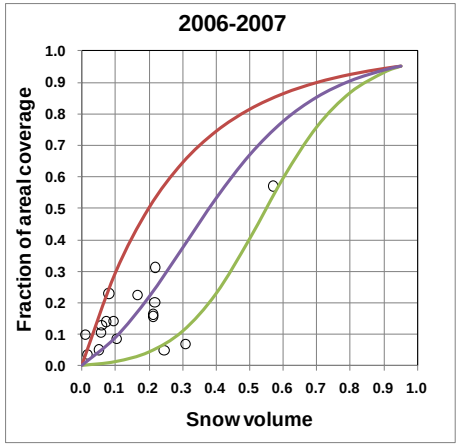


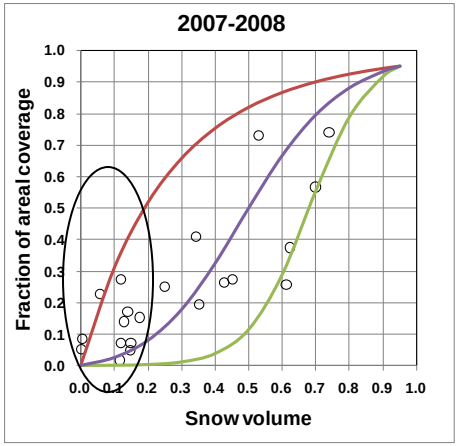






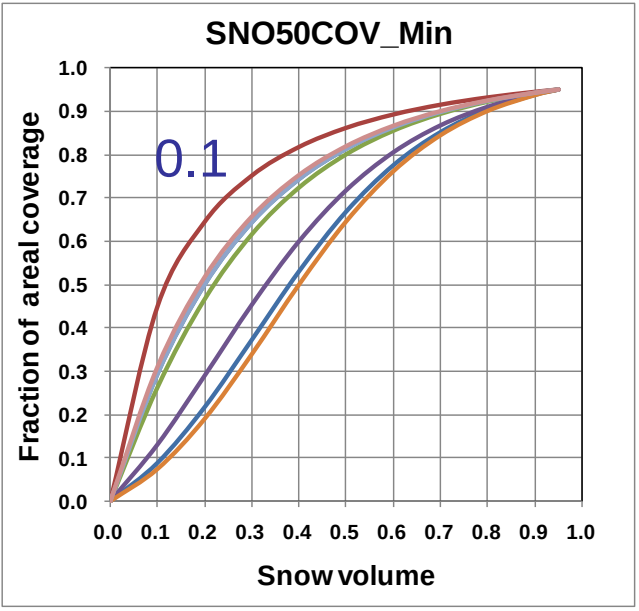


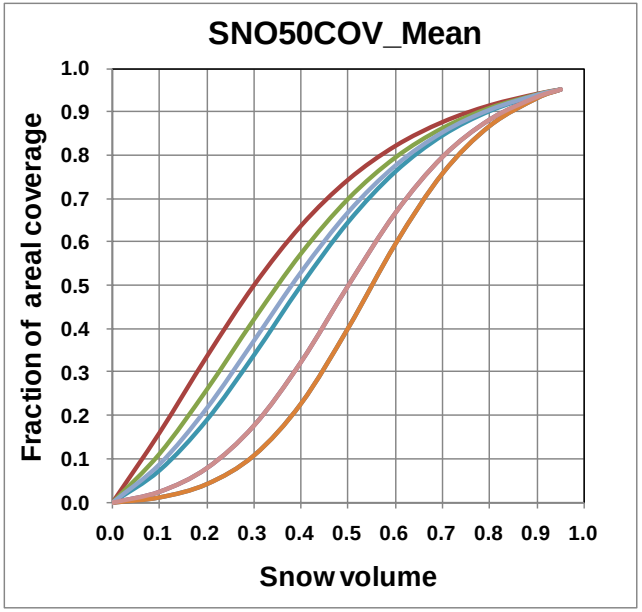


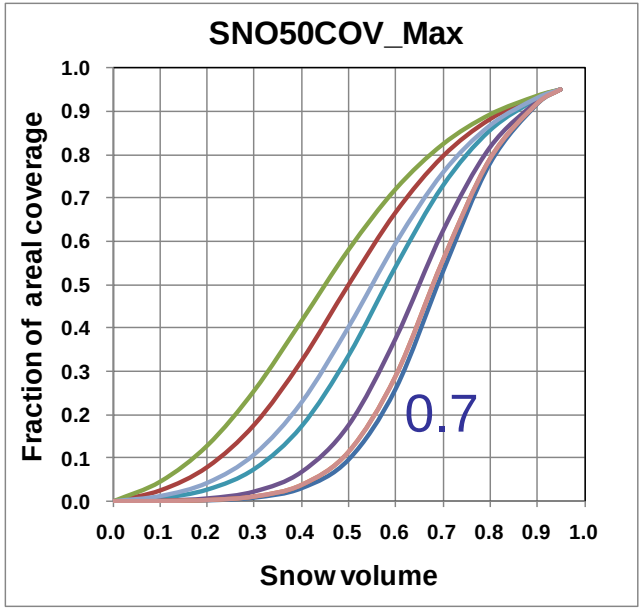


Derivation of snow depletion curve

- ***Maximum, minimum and mean snow depletion curve*** **(I chose the most left curve after calibration)**
  - **As the curve goes to the left, the snow is melt slowly.**







Model Calibration and Validation for the Study Watershed

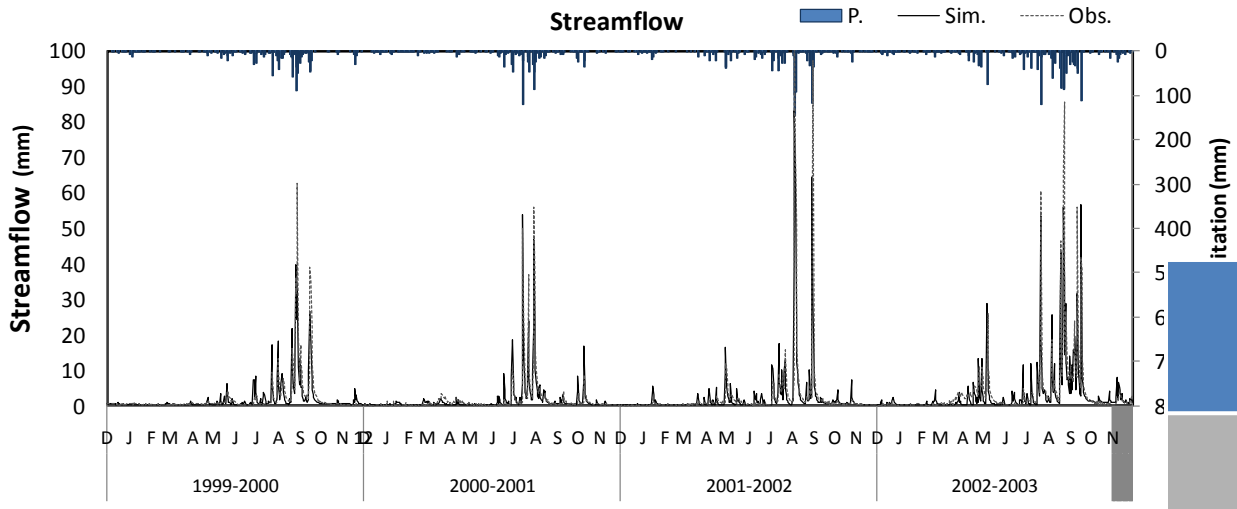
❖ Model Calibration and Validation for the Streamflow

- SWAT model setup process
  - ✓ No. of Subbasin : 20
  - ✓ No. of HRU : 348
- The calibrated model parameters

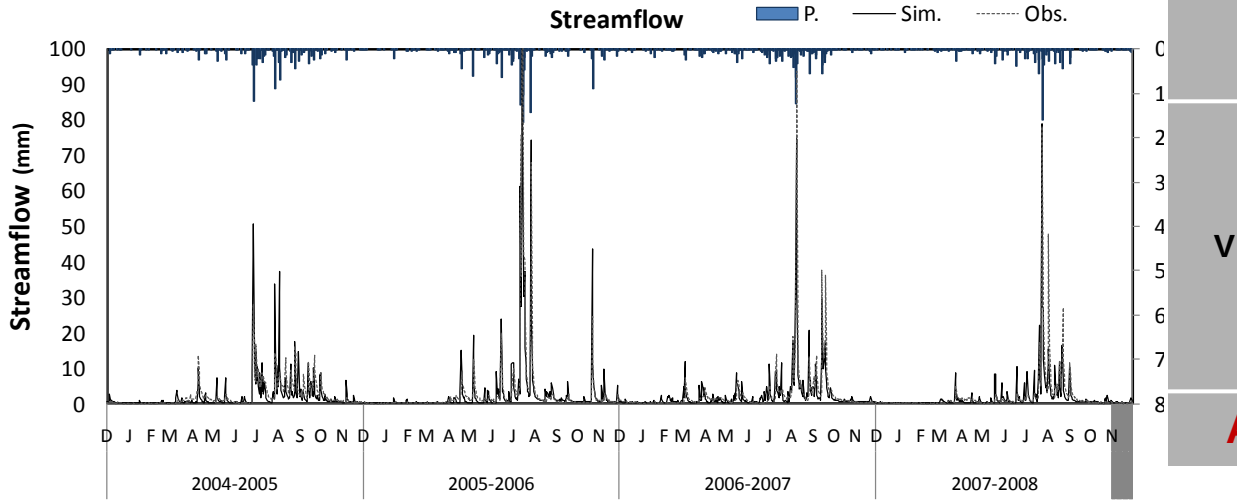
Parameter	Description	Calibration Range	Soyanggang Dam Default	Soyanggang Dam Optimal value
SFTMP	Snowfall temperature (℃)	- 5 ~ +5	1	1
SMTMP	Snow melt base temperature (℃)	- 5 ~ +5	0.5	0
SMFMX	Maximum snow melt factor (mm H2O/ºC-day)	0 - 10	4.5	2
SMFMN	Minimum snow melt factor (mm H2O/ºC-day)	0 - 10	4.5	1
TIMP	Snow pack temperature lag factor	0 - 1	1	0.05
SNOCOVM	Threshold depth of snow, above which there is 100% cover [mm]	**0 ~ 500**	50	500
SNO50COV	Fraction of SNOCOVMX that provides 50% cover	0-1	0.5	0.1
PLAPS	Precipitation lapse rate (mm H2O/km)		0	5.33
TLAPS	Temperature lapse rate (°C/km)		0	-5.10

Model Calibration and Validation for the Study Watershed

Calibration period (1999-2003: Full period)



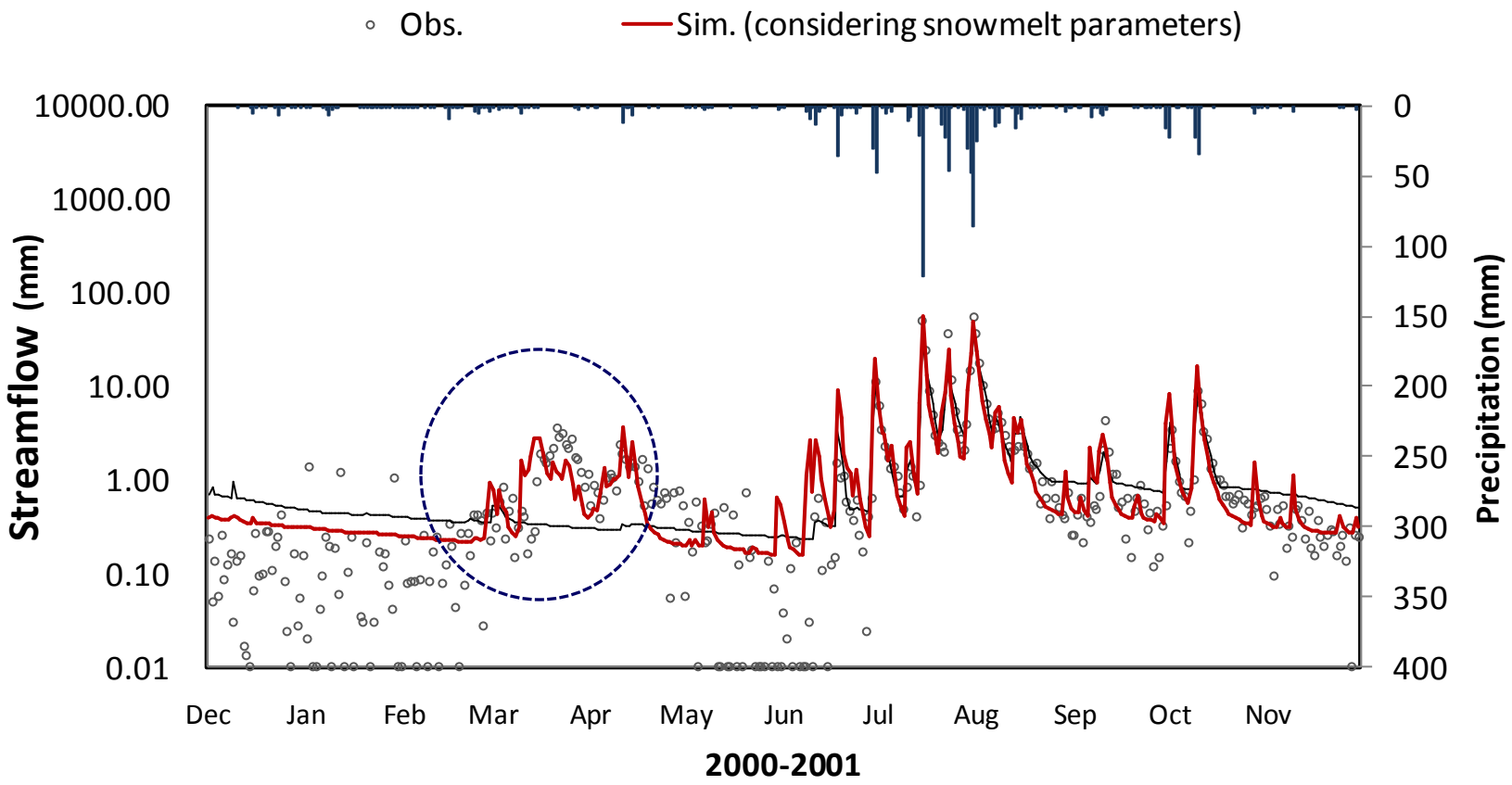
Validation period (2004-2008: Full period)



Year		R^2	RMSE (mm/day)	NSE
C	2000-01	0.75	2.9	0.74
	2001-02	0.86	1.9	0.97
	2002-03	0.66	5.5	0.66
	2003-04	0.64	5.3	0.64
V	2005-06	0.55	3.0	0.21
	2006-07	0.82	5.6	0.80
	2007-08	0.69	4.3	0.67
	2008-09	0.69	3.9	0.68
Average		0.71	4.1	0.67

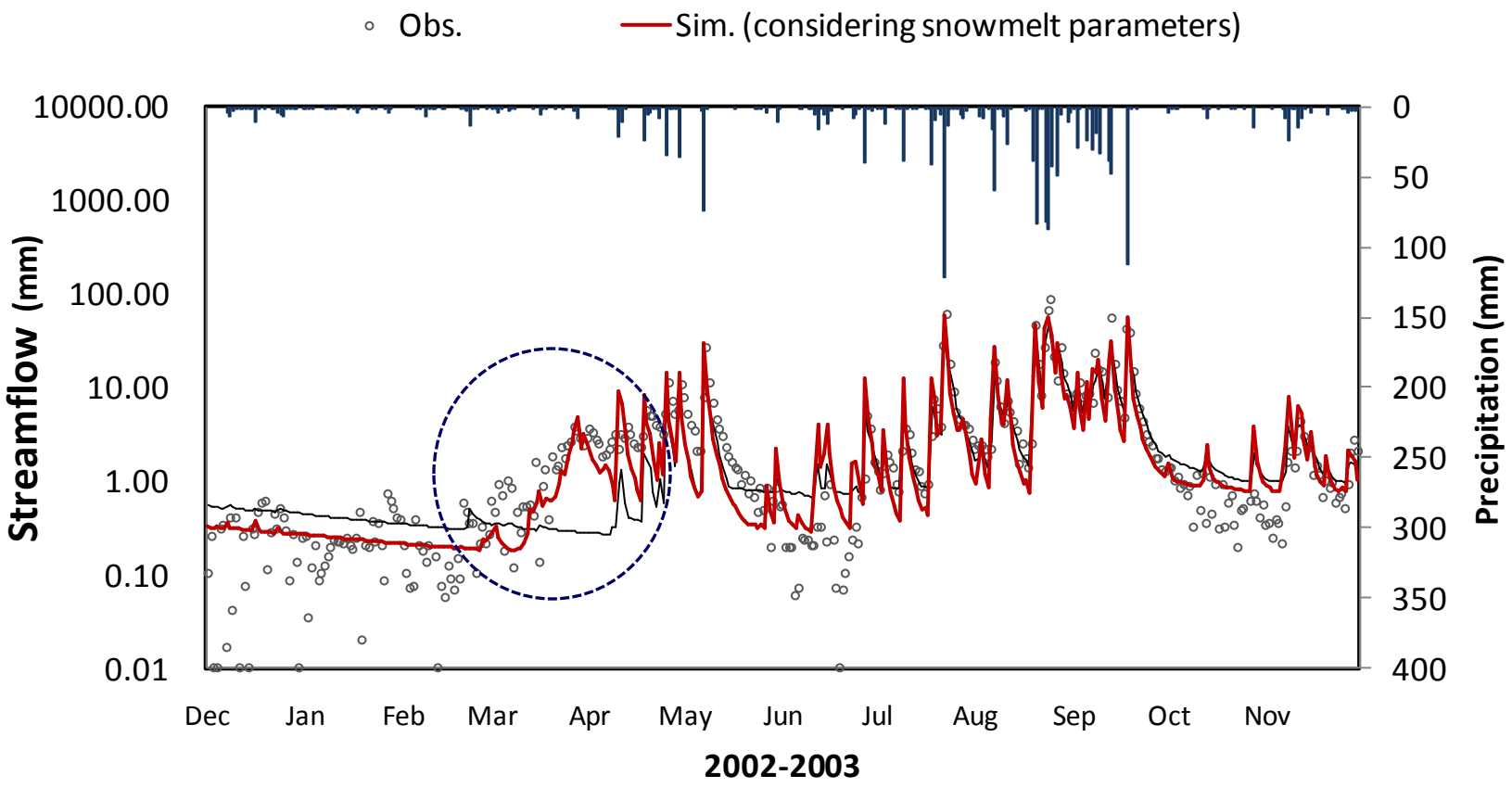
Model Calibration and Validation for the Study Watershed

- **The 2001 calibrated streamflow considering the snowmelt parameters**



Model Calibration and Validation for the Study Watershed

❖ **The 2001 calibrated streamflow considering the snowmelt parameters**



Summary and Conclusions

- **This study tried to identify the SWAT snow depletion characteristics for a mountainous watershed (2,694.4 km^2) located in the northeastern part of South Korea using the 8 years (2000-2008) sets of snow depth distribution information.**

- **Through understanding the characteristics of our snow depletion using Terra MODIS data, we could simulate the snowmelt driven streamflow better than before.**

Thank you

For your attention