Evaluating the Change of Hydrological Processes and Sediment Yield Considering the Impact of Climate Change

Dao Nguyen Khoi

Ph.D candidate, Interdisciplinary Graduate School of Medicine and Engineering, University of Yamanashi, Japan

Email: dnkhoi86@gmail.com

Tadashi Suetsugi

Professor, Interdisciplinary Graduate School of Medicine and Engineering, University of Yamanashi, Japan

International Research Center for River Basin Environment
UNIVERSITY OF YAMANASHI

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Background

- IPCC report reaffirmed that "*global warming*" is occurring (IPCC, 2007).
  - Global warming leads to changes in precipitation and temperature, which affects the hydrological cycle, and thus changes the streamflow and modifies the transformation and transport characteristics of sediment as well as water pollutants.
- Understanding the responses of hydrological processes and sediment yield to climate change is important for planning and managing water resources (Kienzle *et al.* 2012).
- There are numerous studies in the literature on impacts of climate change on hydrology and sediment yield.
  - The hydrological model is first calibrated against observed data, and then run with future climate scenarios using calibrated parameters.
- Kingston *et al.* (2011) emphasized the importance of multi-GCMs evaluations in the climate change impacts.

Background

❖ In hydrological modeling, physically-based models are preferable (Oeurng *et al.* 2011).

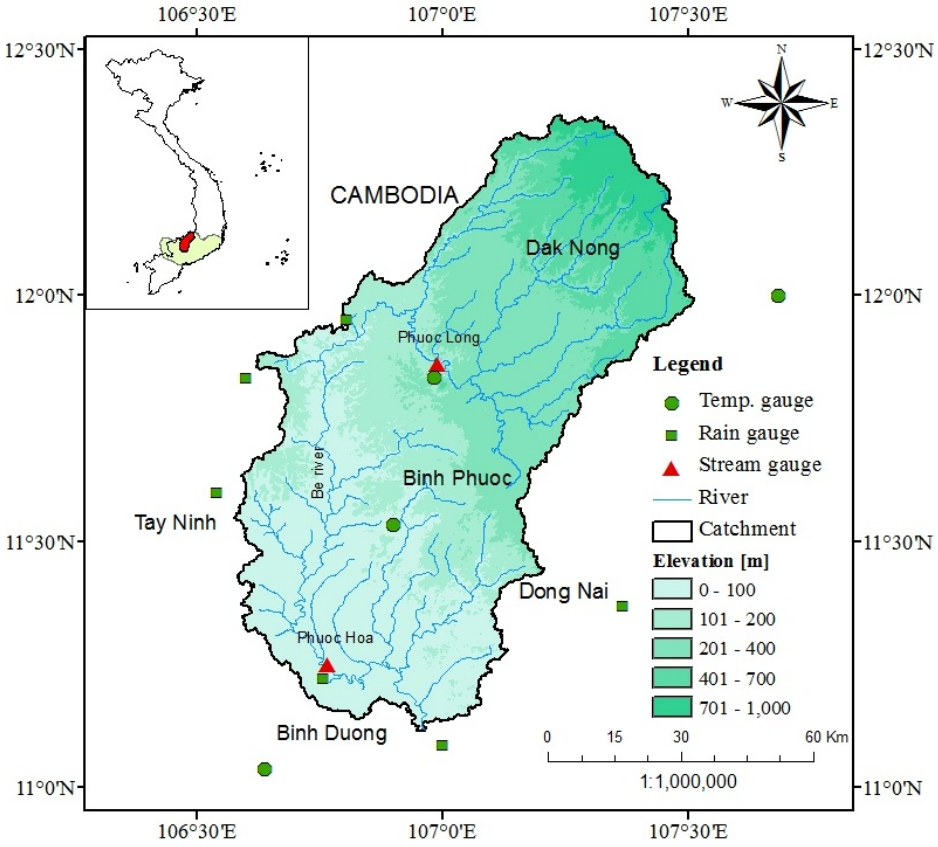
- Many hydrological models such as HSPF, WaTEM/SEDEM, SWAT,…
- Soil and Water Assessment Tool (SWAT) is frequently used to assess hydrology and water quality in agricultural catchments.

➢ Objective

To assess the impact of climate change on hydrological processes and sediment yield in Be River Catchment, Vietnam

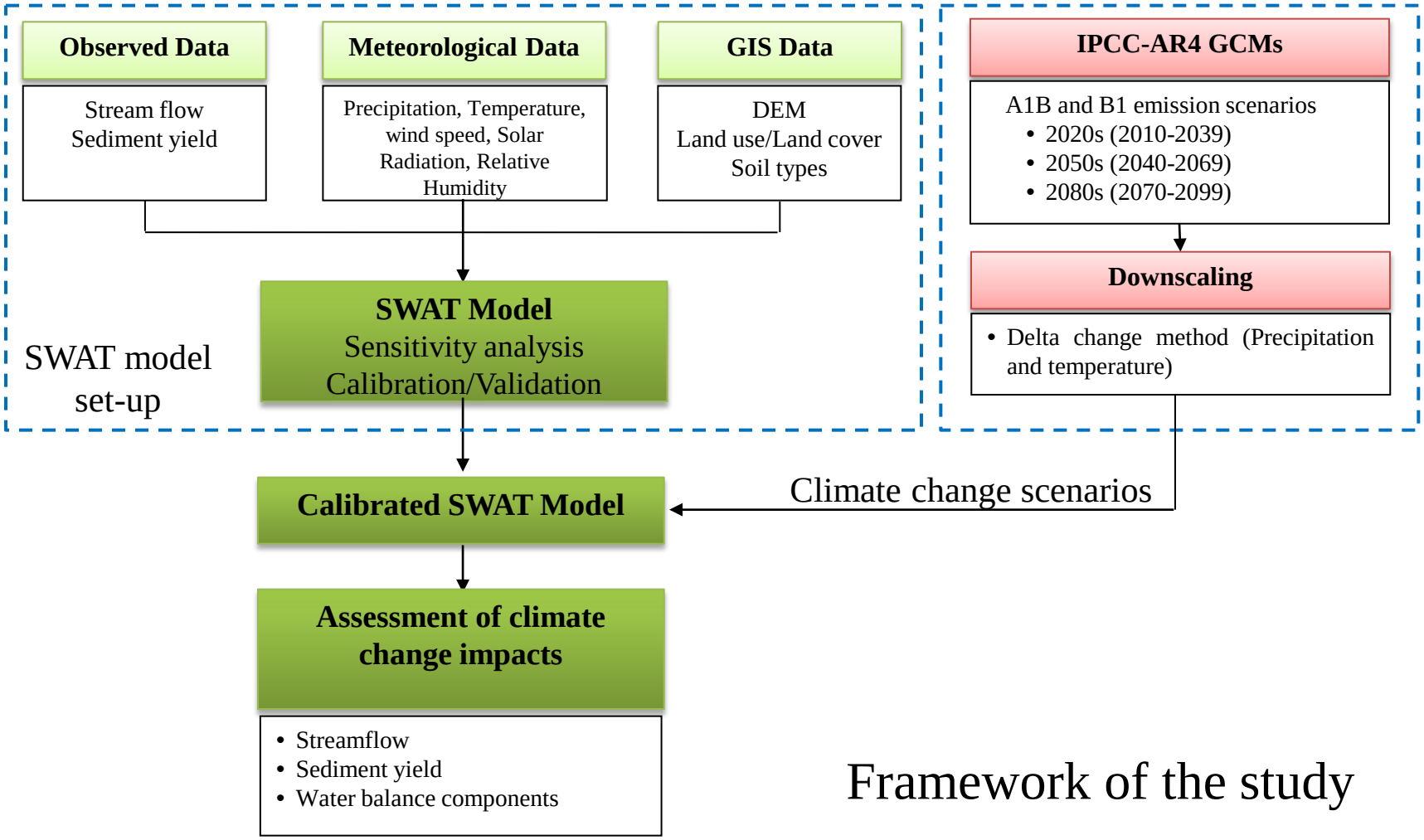
Study area

- Catchment area: 7,650 km^2;
- Main river: Be river, 350 km;
- Climate: tropical climate monsoon, with 2 seasons: rainy season (May-Oct) and dry season (Nov – Apr), annual averaged rainfall: 2,400 mm;
- Soil: relatively fertilized land (75% basalt soil) consistent with agricultural development (perennial cropland)
- Steep slope + high precipitation → the catchment become susceptible to soil erosion.
- Population total in 2010: about 1 million inhabitants.



Be River Catchment

Methodology



Framework of the study

Methodology

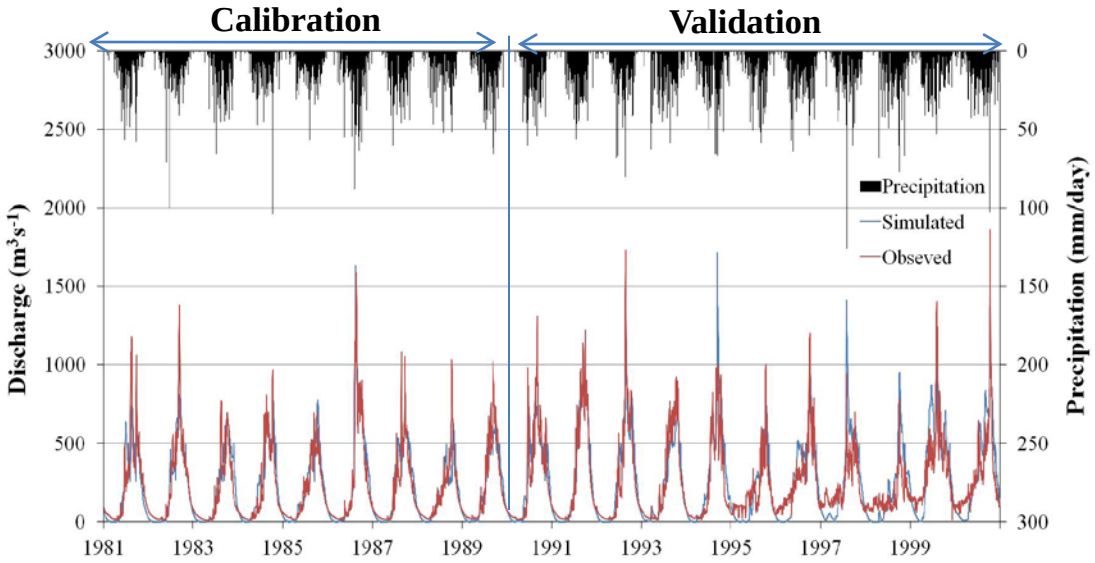
- **Input data preparation**

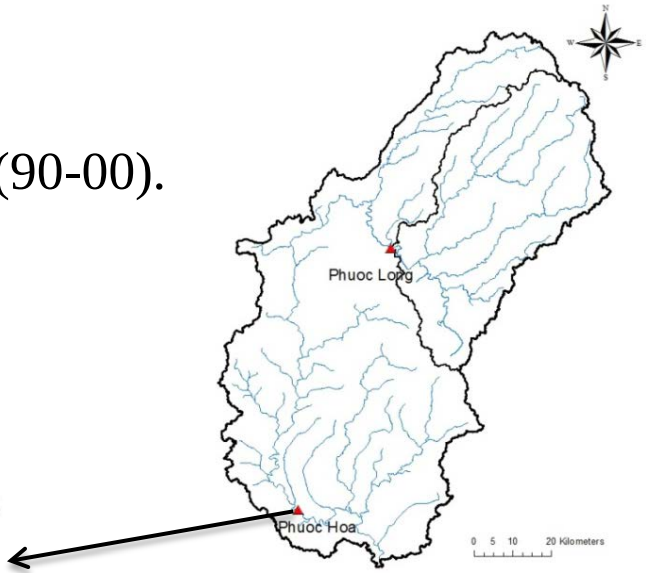
Data set	Source	Resolution	Data Description/Properties
Terrain	HydroSHEDS	90m	SRTM 90m DEM
Soil types	FAO	10 km	Soil classifications and physical properties.
Land use	Sub-NIAPP	1 km	Land use classifications, 2005.
Weather	HMDC	Daily	Precipitation, min and max temperature data (1978-2007); 6 rain stations and 3 meteorological stations.
Stream flow	HMDC	Daily	Phuoc Long (78-93), Phuoc Hoa (78-00).
Sediment load		Monthly	Phuoc Hoa (99-04)

Results and discussion

Calibration and validation

- **For flow simulation**
  - Calibration period (81-89), validation period (90-00).
  - Use daily streamflow record (78-00).





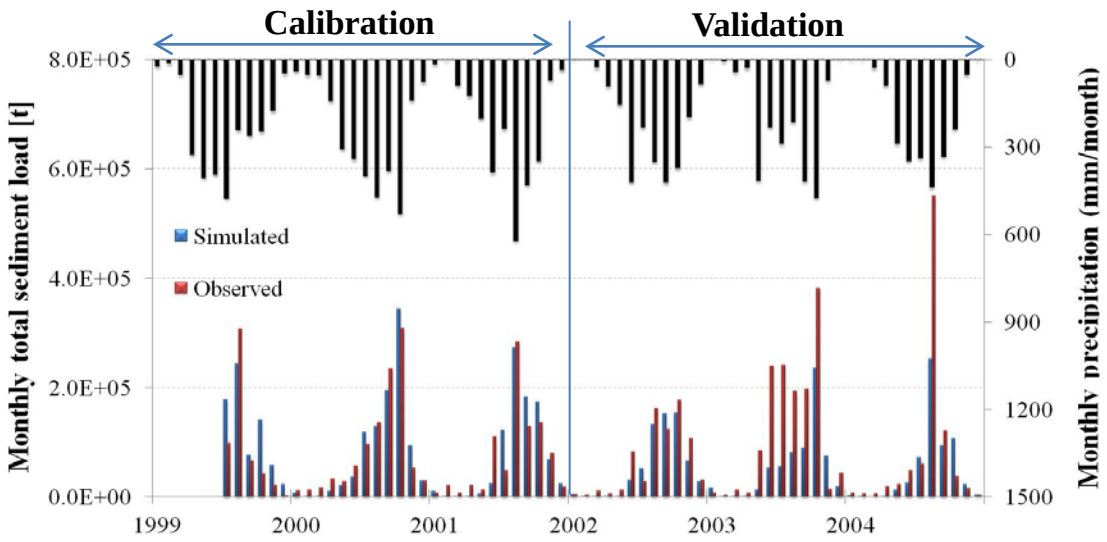
	Daily		Monthly	
	Cali	***Vali***	***Cali***	***Vali***
NSE	0.80	0.70	0.92	0.79
PBIAS	-1.20	-6.00	-1.20	-6.00
RSR	0.44	0.55	0.28	0.46

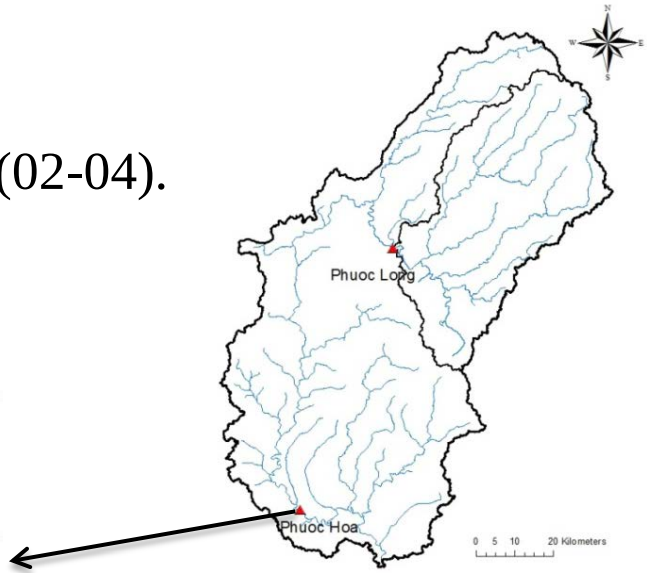
Calibration and validation

❖ **For sediment simulation**

— Calibration period (99-01), validation period (02-04).

— Use monthly sediment load record (99-04).

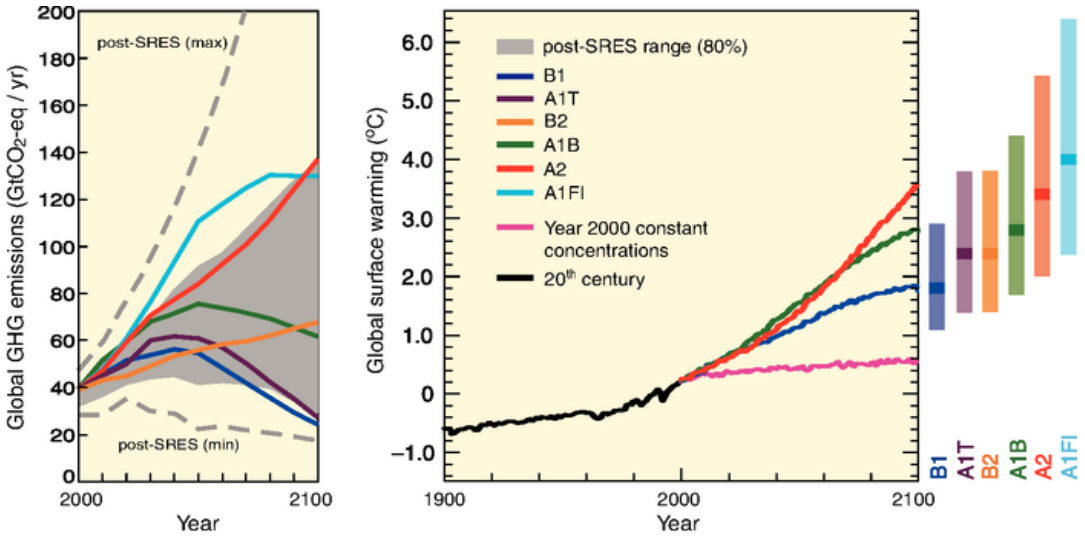




	NSE	PBIAS	RSR
Cali	0.80	-6.72	0.44
Vali	0.54	-39.72	0.67

→SWAT model can simulate well the streamflow and sediment yield for Be River Catchment using the calibrated parameters

Climate change scenarios



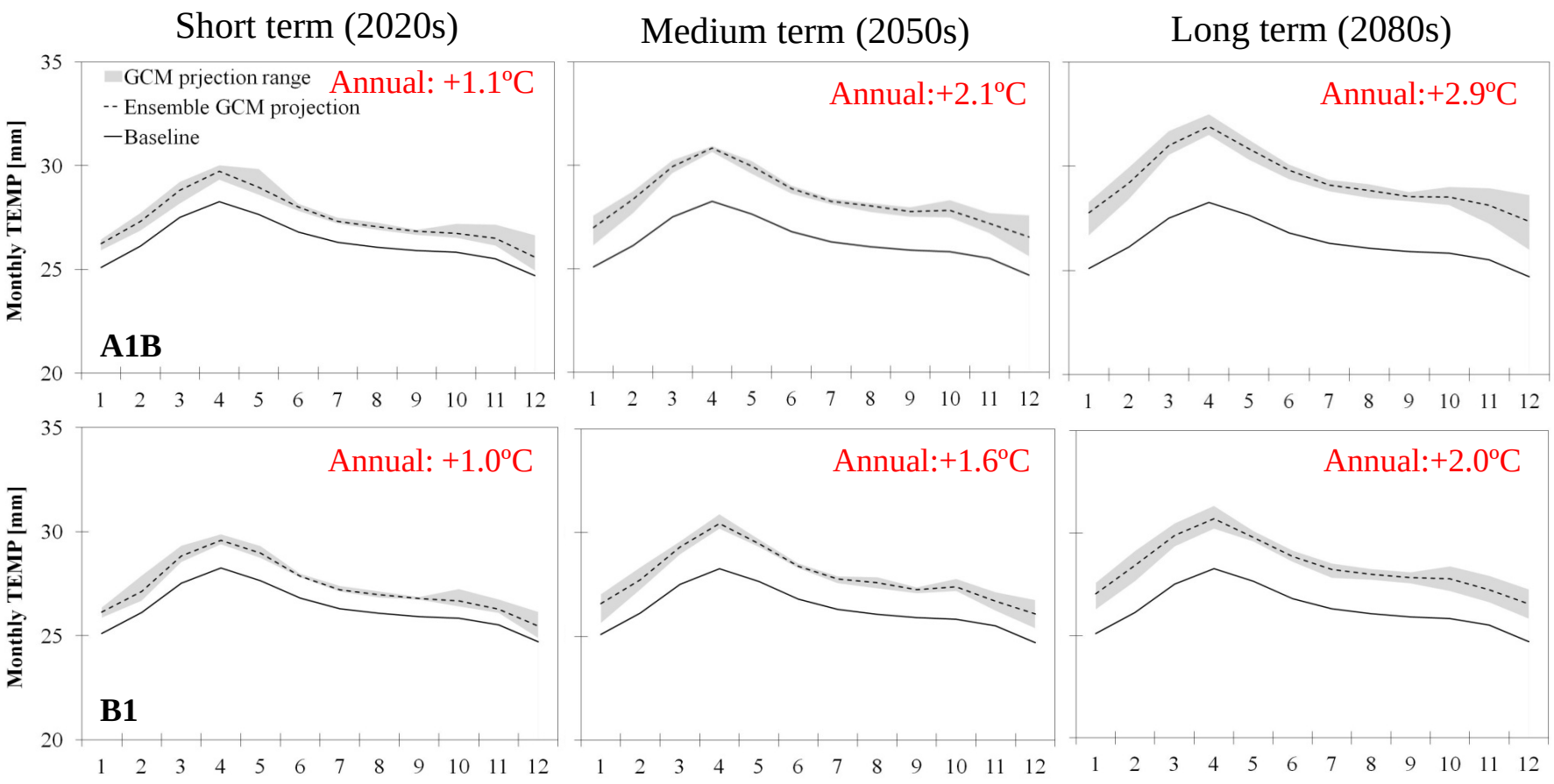
— In this study, GHG emission scenarios adopted SRES A1B (warming middle) and B1 (warming low) scenario were used.

Center, country	Center abbreviation	Model identify	Model resolution	
			Longtitude	*Latitude*
Canadian Centre for Climate Modelling and Analysis, Canada	CCCMA	CGCM3.1(T63)	3.750000	3.711136
Geophysical Fluid Dynamics Laborary, USA	GFDL	CM2.0	2.500000	2.022471
		CM2.1	2.500000	2.022471
UK Met. Office, UK	UKMO	HadCM3	3.750000	2.500000

Khoi and Suetsugi (2012)

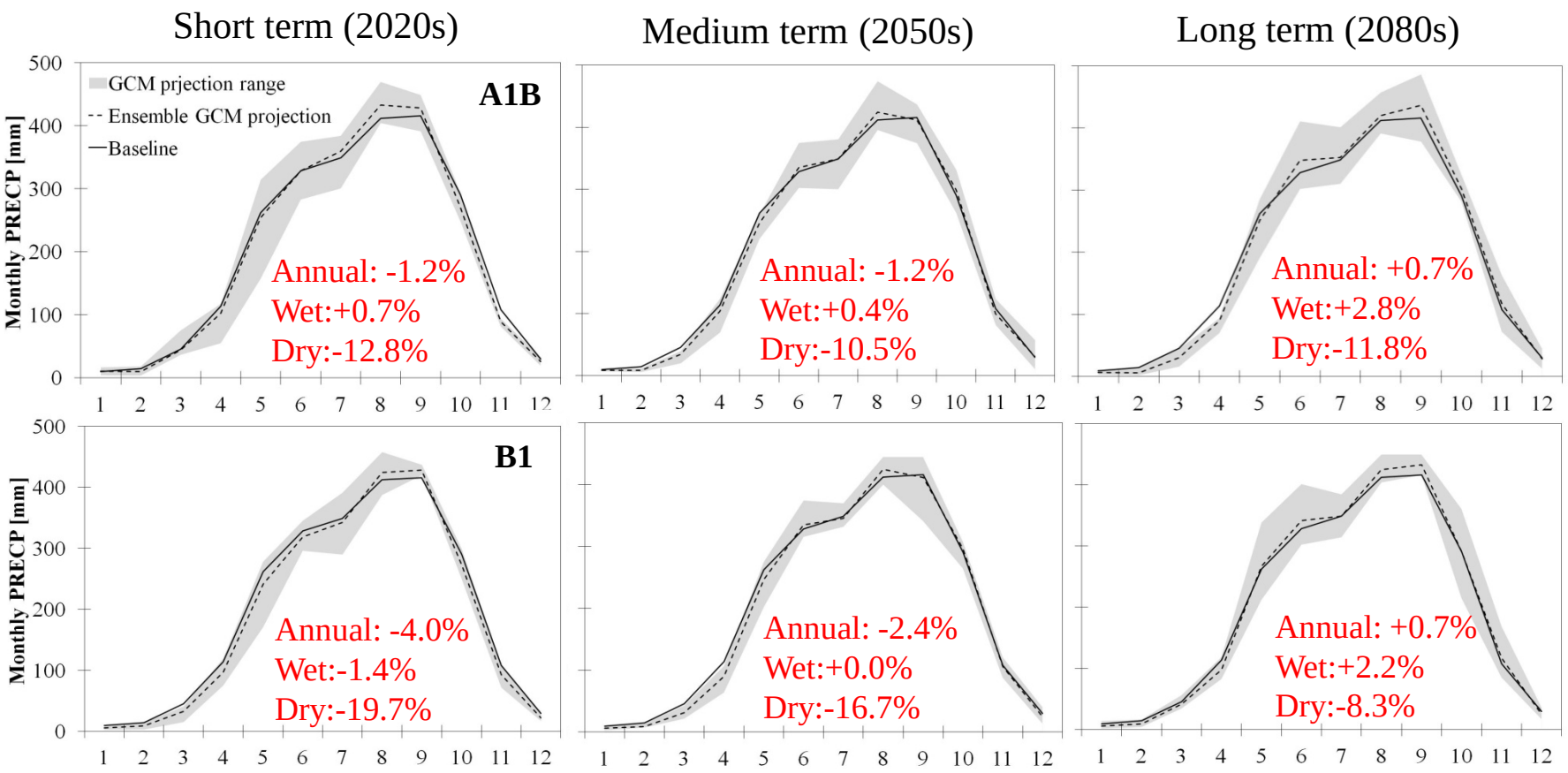
Climate change scenarios

➢ Climate scenarios for temperature



Climate change scenarios

➢ Climate scenarios for precipitation



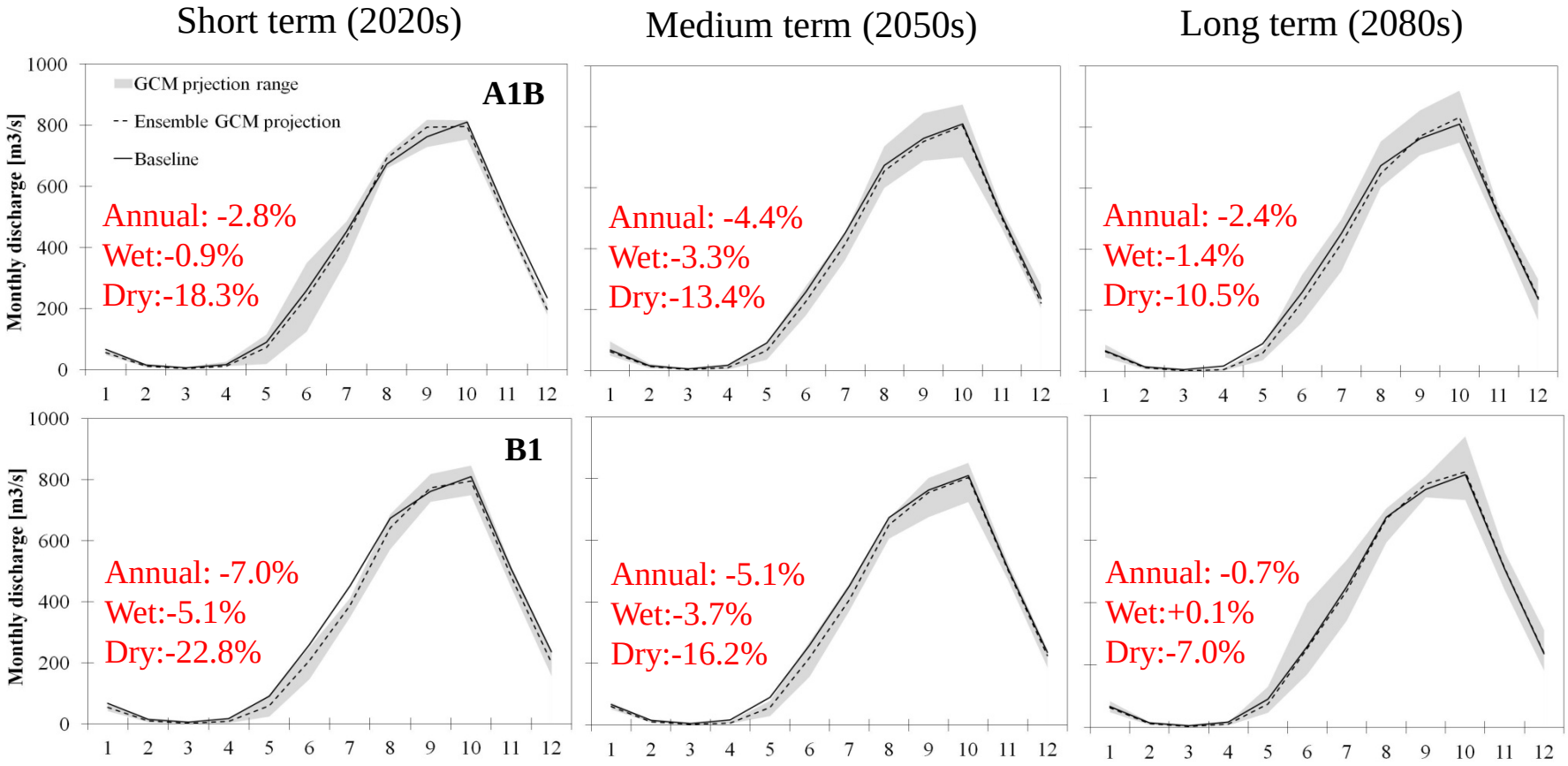
Impacts on water balance components

Period		A1B scenario						
		ET	*PET*	*SURQ*	*GW_Q*	*LAT_Q*	*PERC*	*SW*
2020s	Min	-1.7	2.8	-2.0	-10.7	-5.9	-6.2	-4.7
	Max	1.5	3.8	5.8	-1.5	0.3	0.1	-1.1
	Ensemble	0.8	2.9	-0.8	-4.4	-1.5	-2.1	-2.0
2050s	Min	-0.6	4.9	-8.2	-9.6	-4.2	-4.6	-6.1
	Max	2.6	6.2	5.0	-3.2	0.0	-0.4	-2.9
	Ensemble	2.1	5.5	-2.2	-6.1	-2.1	-2.4	-3.4
2080s	Min	0.7	6.4	-6.0	-12.7	-6.2	-5.8	-7.6
	Max	3.6	9.0	11.8	-1.1	1.5	1.4	-3.4
	Ensemble	2.8	7.8	1.8	-5.7	-2.1	-1.5	-4.8

Period		B1 scenario						
		ET	*PET*	*SURQ*	*GW_Q*	*LAT_Q*	*PERC*	*SW*
2020s	Min	-2.7	2.4	-11.1	-11.9	-6.2	-6.9	-6.2
	Max	0.3	3.4	0.3	-7.0	-4.5	-3.8	-3.4
	Ensemble	-0.6	2.6	-5.3	-8.4	-4.5	-4.8	-3.8
2050s	Min	-0.9	3.5	-11.4	-12.8	-6.8	-7.3	-5.2
	Max	1.9	4.9	0.5	-4.7	-1.5	-1.7	-2.3
	Ensemble	0.5	4.2	-2.8	-6.9	-3.3	-3.4	-4.0
2080s	Min	1.1	4.2	-3.3	-6.8	-3.3	-3.0	-4.2
	Max	3.3	6.4	7.6	-1.3	1.5	-1.0	-1.8
	Ensemble	2.3	5.3	2.3	-3.0	-0.6	-0.4	-2.7

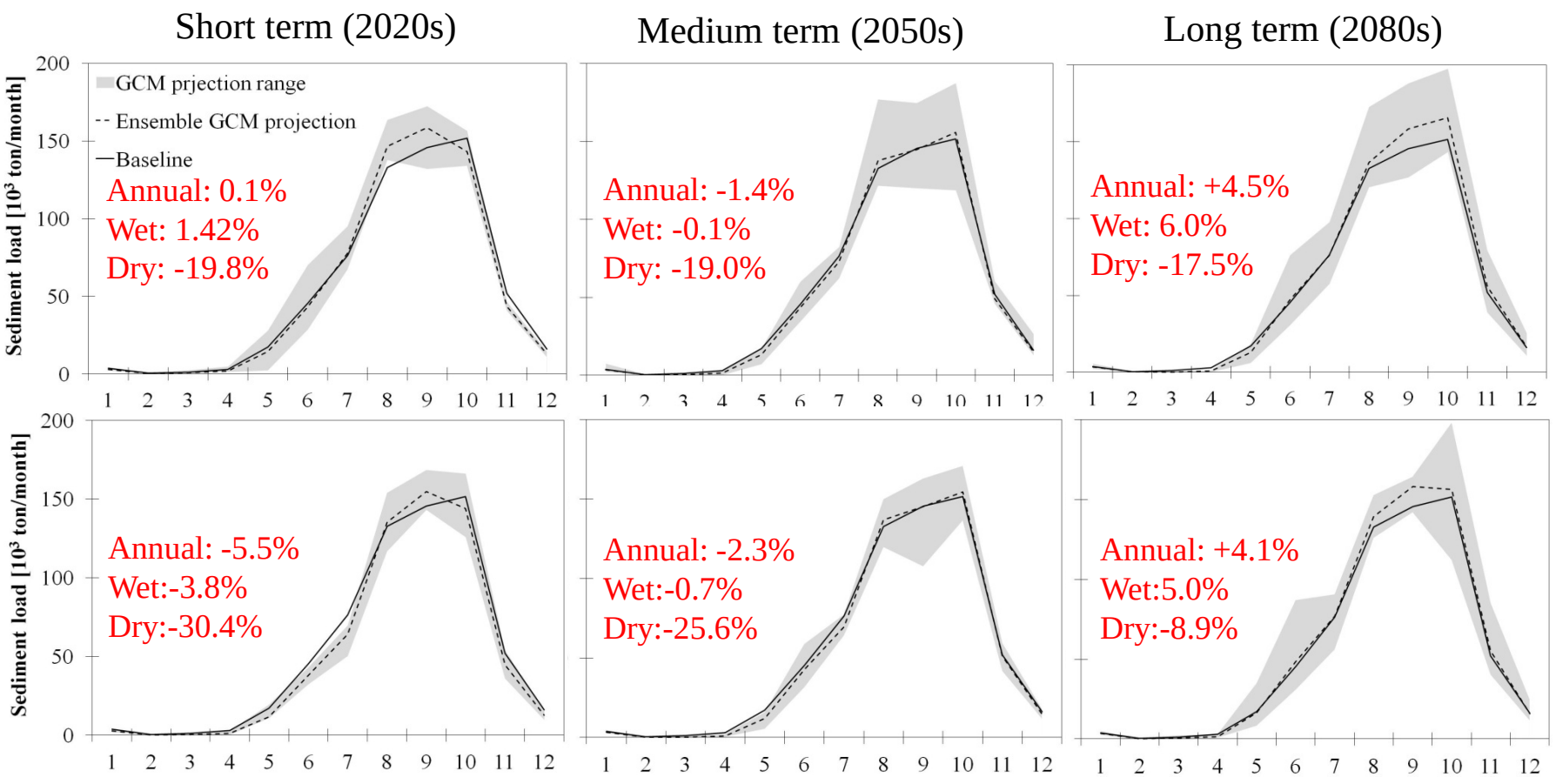
Impacts on streamflow and sediment

➢ Streamflow



Impacts on streamflow and sediment

➢ Sediment yield



Conclusion

- The SWAT model could simulate streamflow and sediment yield well for the catchment.
- The climate in the study area would generally become warmer under most scenarios and drier in the 2020s and 2050s, but wetter the 2080s.
- An increase in temperature combined with variable rainfall causes variations of hydrological processes and sediment yield over the year.
- The impact of climate change on sediment yield is more variation than on streamflow and the responses of streamflow and sediment yield do not always occur in the same way.
- The impacts of climate change also would exacerbate serious problems related to water shortage in the dry season.

Conclusion

➢Limitations

- Lack of sediment load data.
- The impact of land-use change is not considered in this study and land-use in the basin is assumed to keep the same in the future.
- Although it is possible to generate realistic future climate scenarios quickly for four selected GCMs, the delta change method still has the limitation. It does not modify the temporal and spatial pattern of the observed data.

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Thank you!