APPLICATION OF SWAT MODEL TO COMPARE SIMPLE AND COMPLEX BIAS CORRECTION TECHNIQUES FOR CLIMATE CHANGE ANALYSIS

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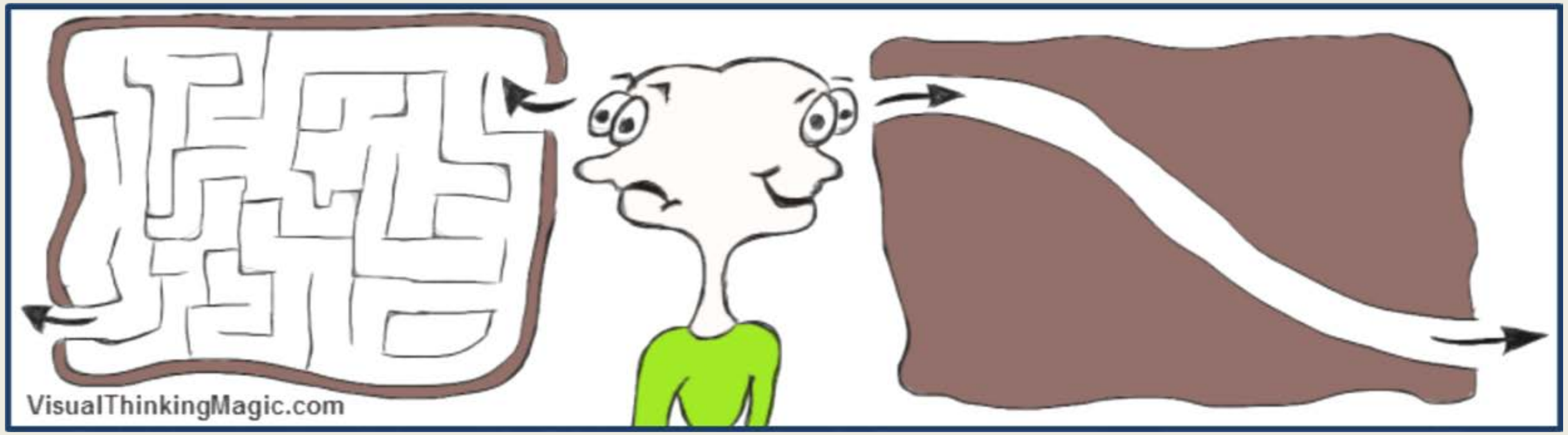
Background

- RCM/ GCMs are widely use for climate change analysis.
- However, these models are not perfect and needs to be corrected before applying at basin level scale.
- Many techniques has been developed for correcting these biases (errors): from simple like Delta change, Linear Scaling, to complex like Power Transfer, Quantile Mapping etc.
- Quantile mapping technique had been concluded to be the best at daily time scale by various authors (Themeßl et al., 2011; Berg et al., 2012; Gudmundsson et al., 2012; Teutschbein and Seibert, 2012; Chen et al., 2013; Gutjahr and Heinemann, 2013; Teutschbein and Seibert, 2013; Teng et al., 2015).

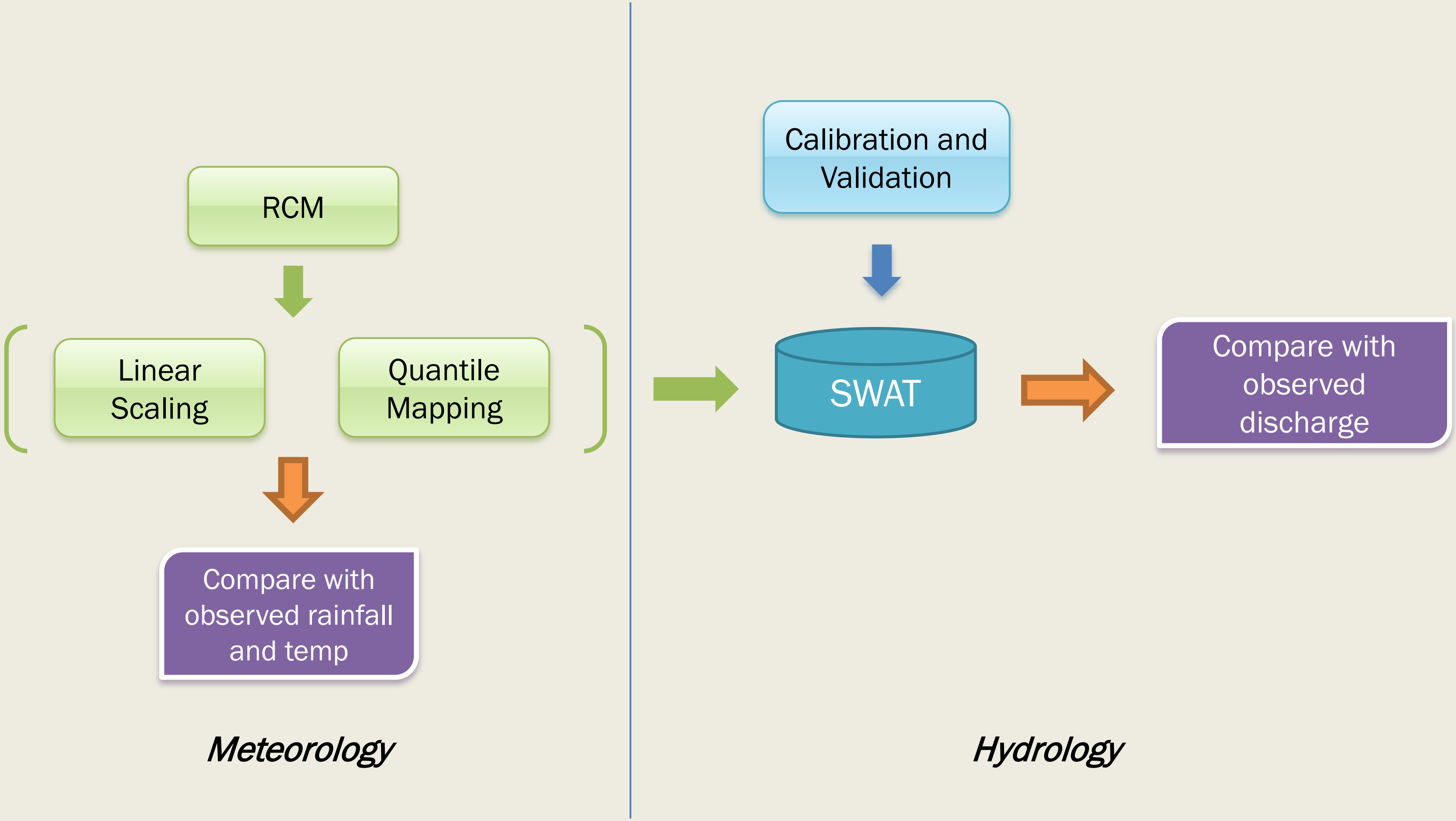
But the question is, are the simple techniques equally good at monthly resolution ???

Objective

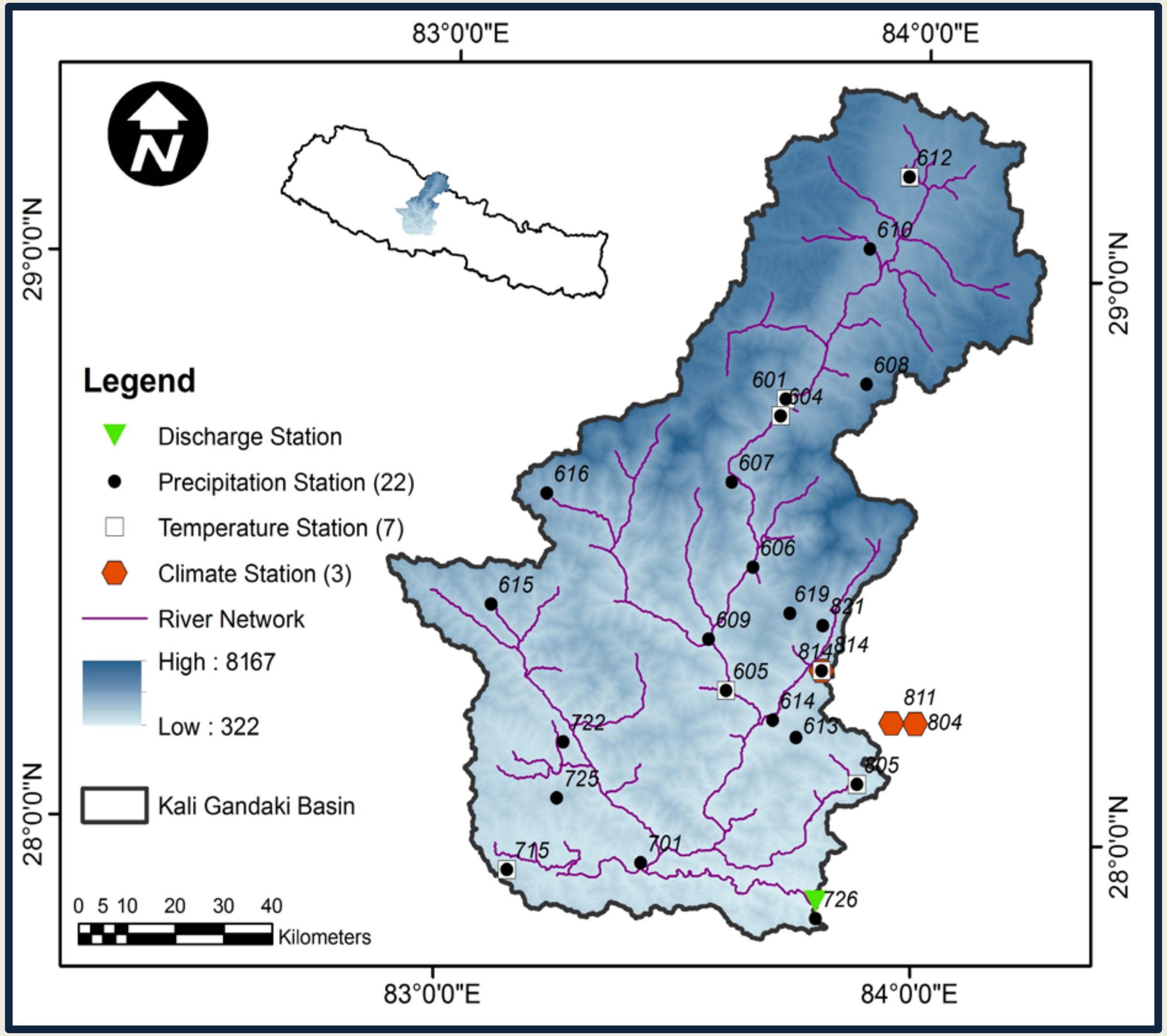
Simple or a complex bias correction technique at monthly time scale



Methodology



Study Area



- Kali Gandaki River Basin– 10,666 km^2
- Accommodates Dhaulagiri (7th) and Annapurna (10th) mountain peaks.
- The river flows through the world's deepest gorge.
- Average annual rainfall – 114 mm (N) to 5527 mm (S).
- 90% of rainfall occurs – May to Oct
- Temperature – -26^{0}C (Winter) to 36^{0}C (summer)
- Drains to Ganges River
- Discharge – 422m^3/s (5000m^3/s during monsoon season)
- Huge variation of elevation and climate

Bias Correction technique

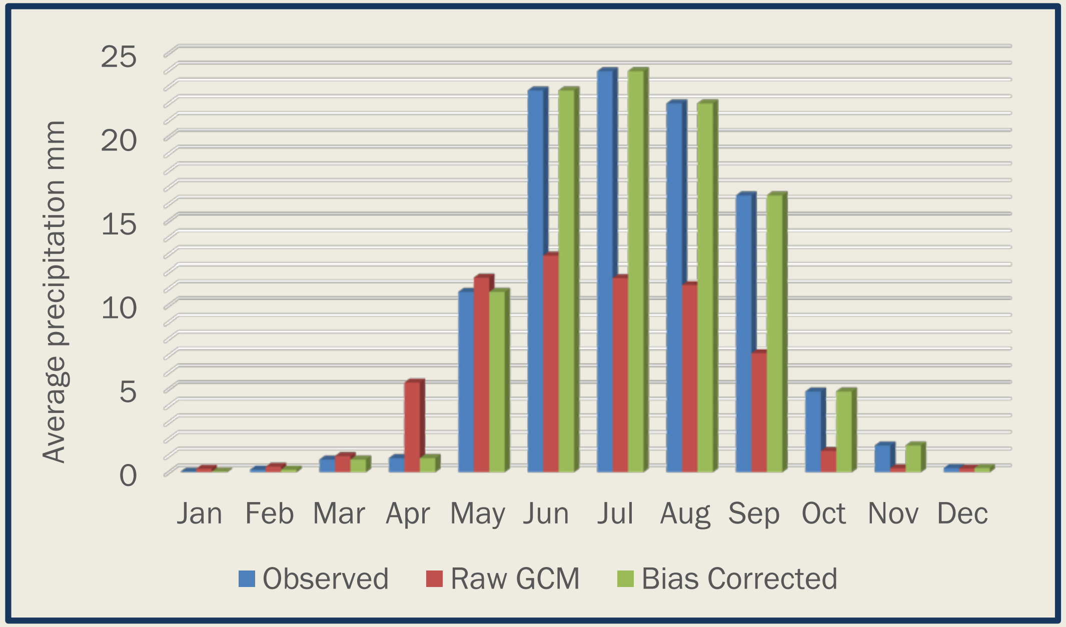
Linear Scaling (LS)

- Simple technique
- Use to adjust mean value of climate model data.
- The difference between the monthly mean observed and model data is applied to the model data to obtain bias corrected climate data.

$$P_{his}(d)^* = P_{his}(d).\,[\mu_m(P_{obs}(d)) / \mu_m(P_{his}(d))]$$

$$T_{his}(d)^* = T_{his}(d) + [\mu_m(T_{obs}(d)) - \mu_m(T_{his}(d))]$$

Where, P = precipitation, T = temperature, d = daily, μ_m = long term monthly mean, * = bias corrected, his = Raw RCM data, obs = observed data



Bias Correction technique

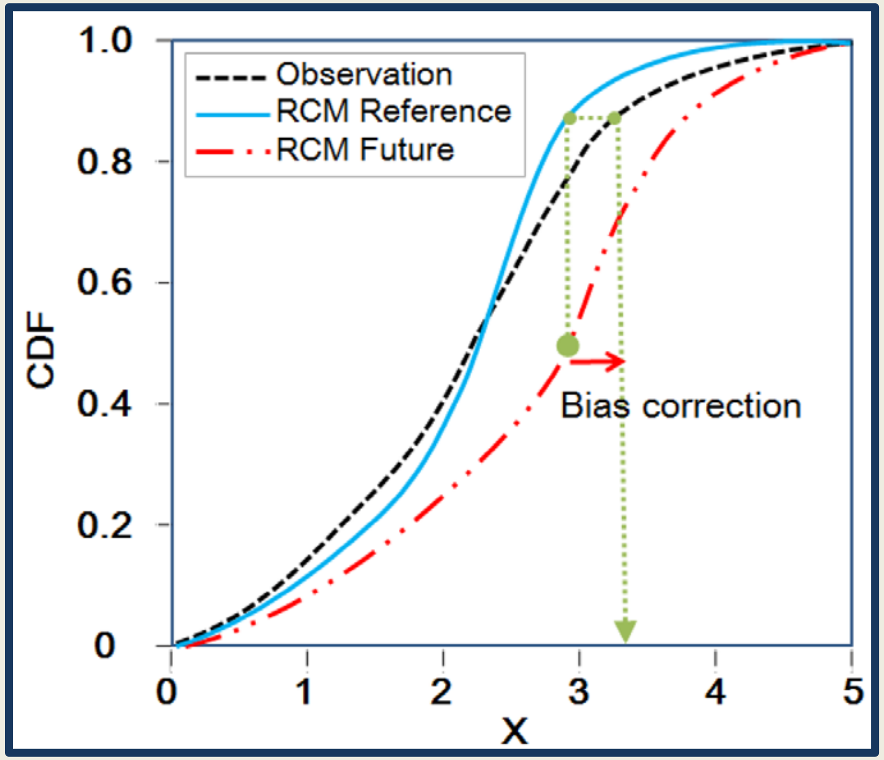
Quantile Mapping (QM)

- Complex technique
- Use to adjust quantiles of climate model data.
- Correct the quantiles of RCM data to match with the quantile of observed data by creating a transfer function to shift the quantile of precipitation and temperature.

$$P_{his}(d)^* = F^{-1}_{obs,m}[F_{his,m}(P_{his,m})]$$

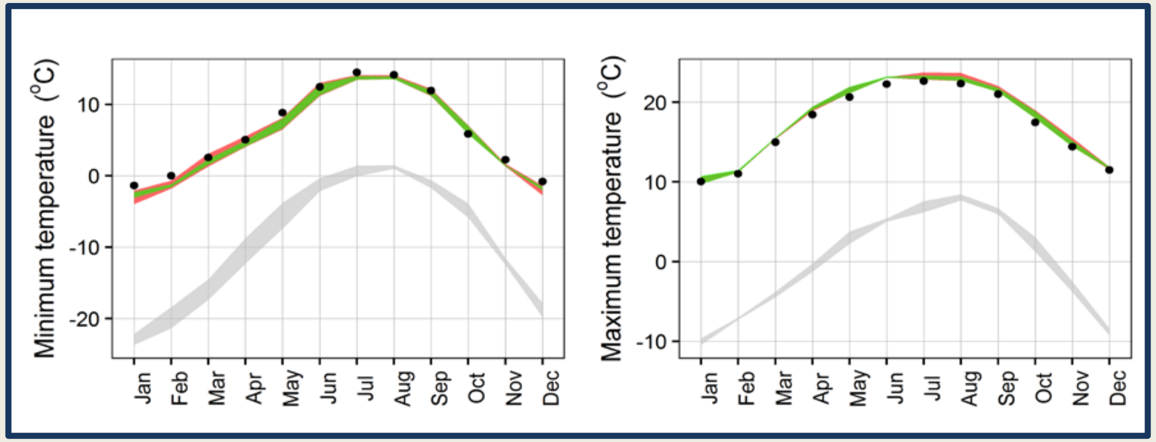
$$T_{his}(d)^* = F^{-1}_{obs,m}[F_{his,m}(T_{his,m})]$$

Where, F = Cumulative Distribution Function (CDF),
F^{-1} = inverse of CDF

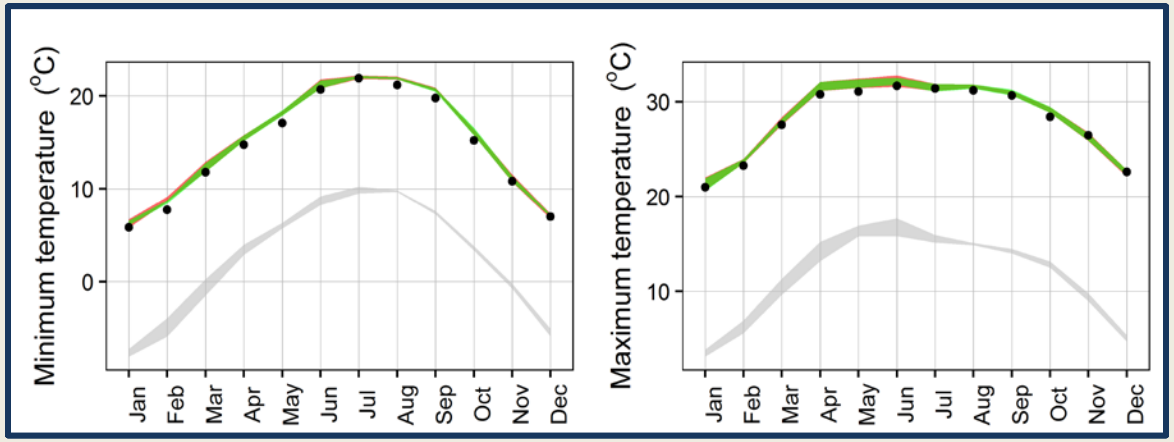


RESULTS

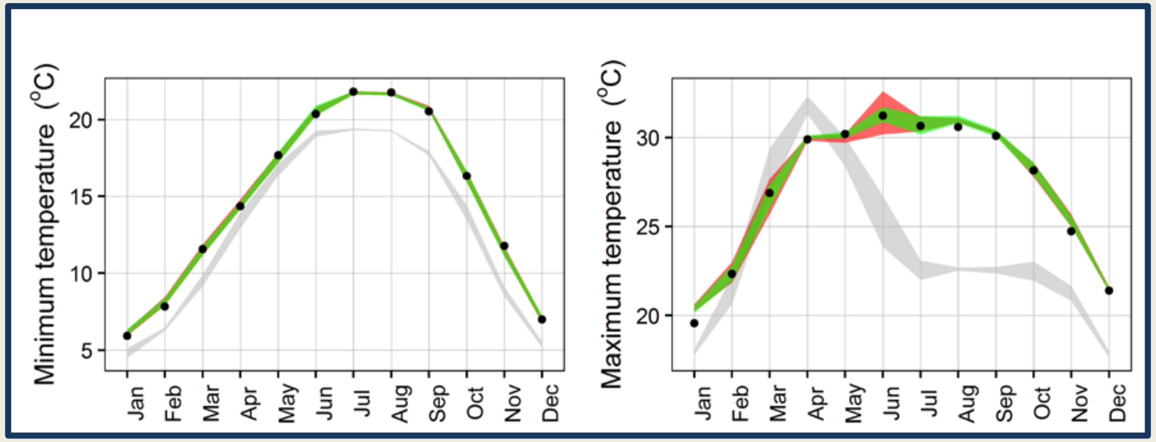
Temperature



High altitude station at Jomsom

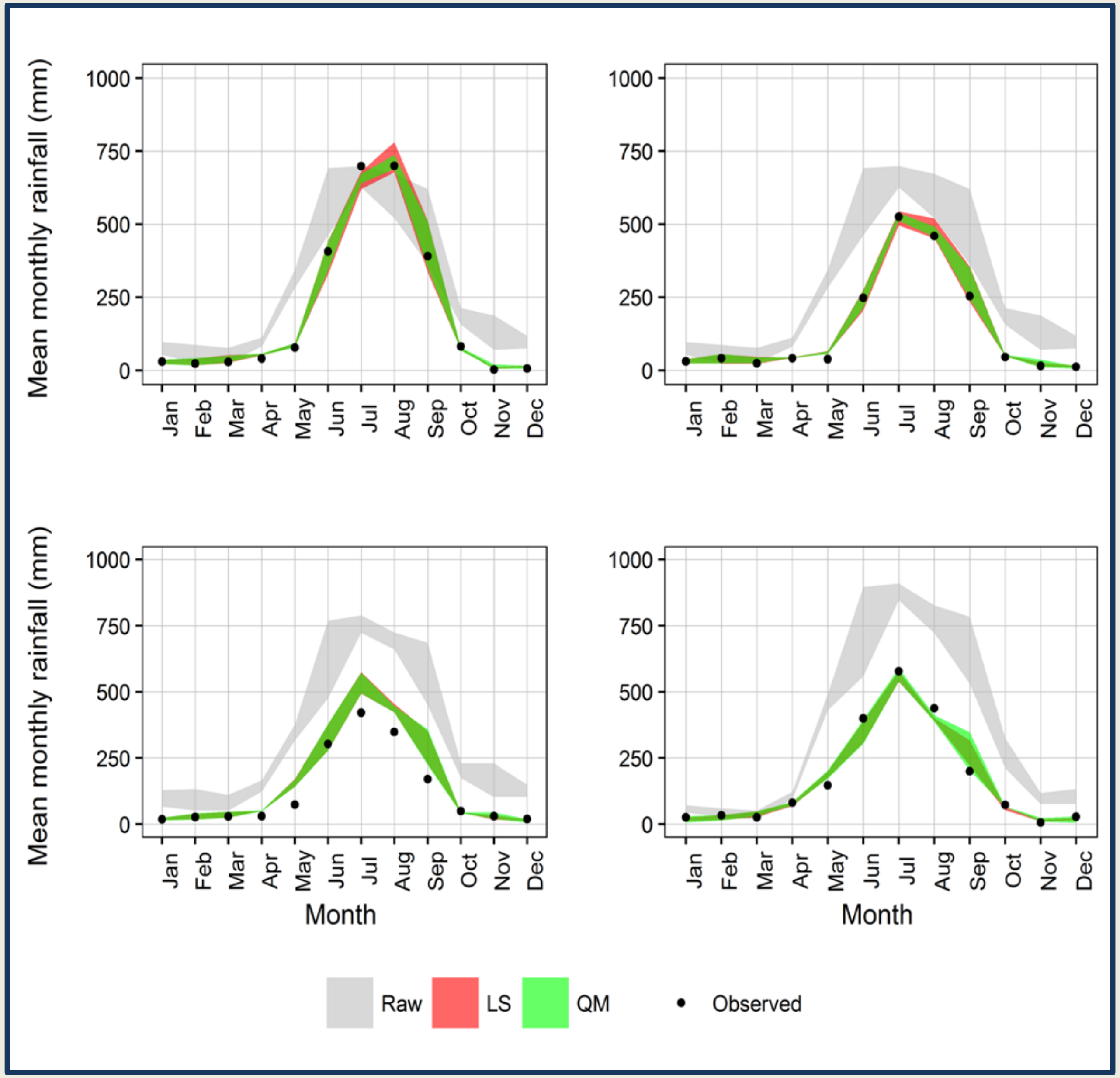


low altitude stations at Baglung



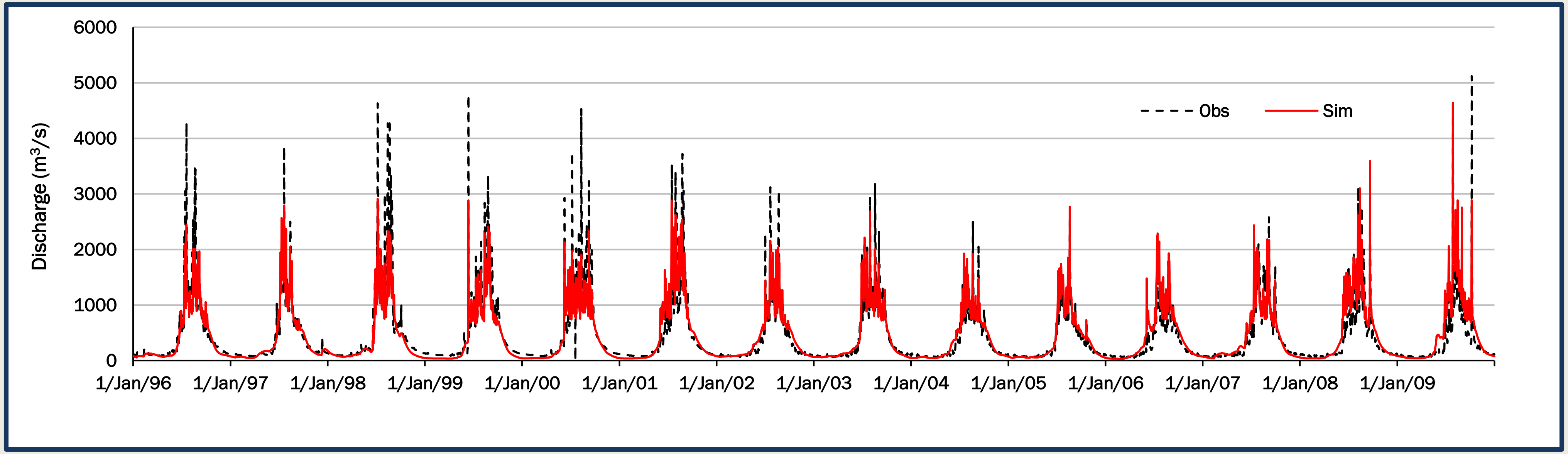
Mid altitude station at Syangja

Rainfall



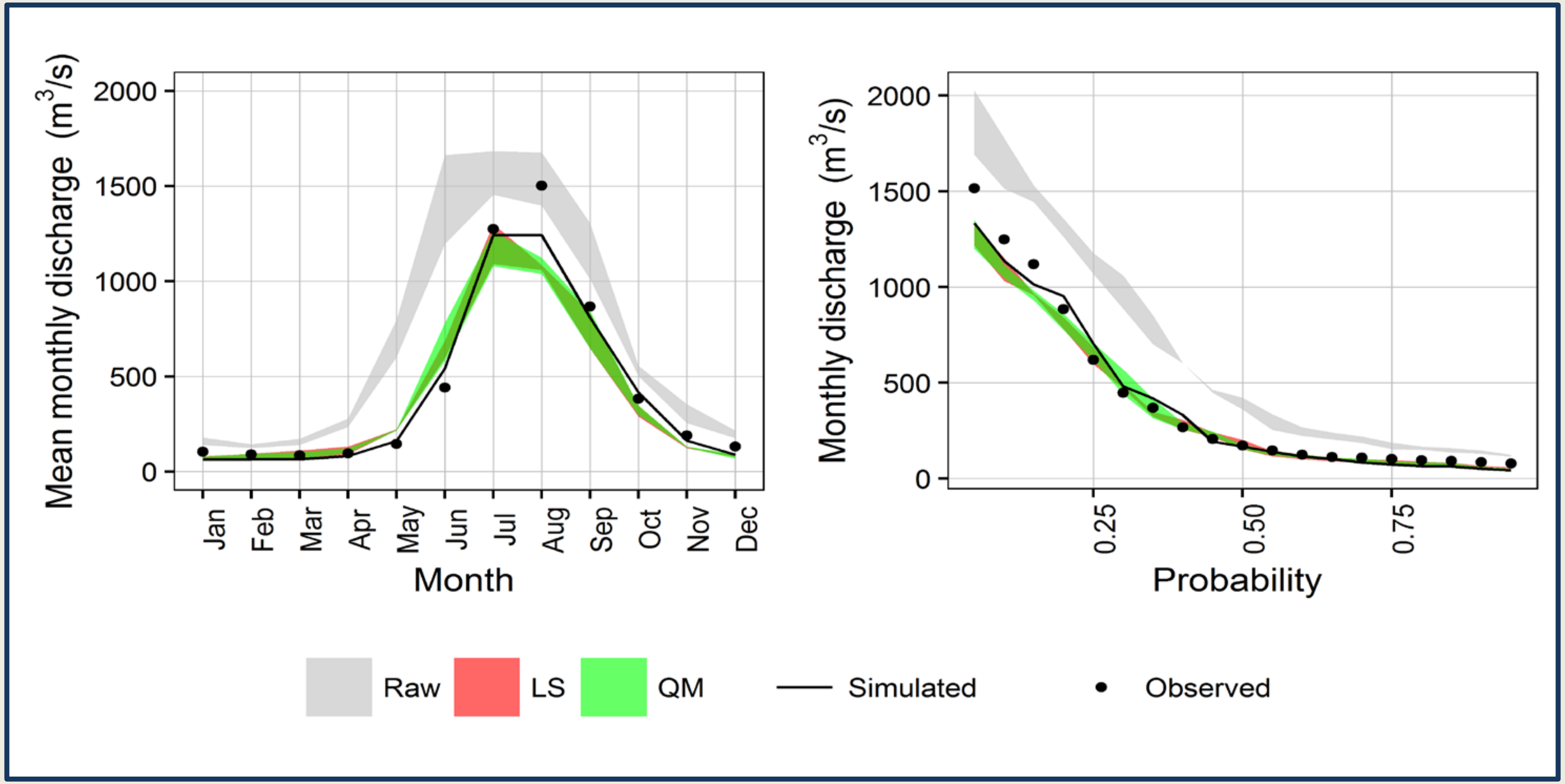
High altitude stations at Bobang, and Gurja Khani, (upper row), and low altitude stations at Baglung and Garakot, (bottom row).

Hydrological modeling



Model period	R^2	NSE	NSE_{rel}	PBIAS (%)	RSR
Calibration (1996 – 2005)	0.84	0.83	0.91	-6.9	0.41
Validation (2006 – 2009)	0.78	0.70	0.73	+19.7	0.55

Hydrographs



Statistics (monthly) for model hydrology for various precipitation and temperature model input

Statistic	Performance for different weather Input			
	Simulated	Raw RCM	RCM - LS	RCM - QM
R^2	0.92	0.68	0.78	0.84
NSE	0.91	0.35	0.77	0.82
NSE_{rel}	0.93	-1.30	0.81	0.85
PBIAS	-6.9	+54.1	-10.8	-10.0
RSR	0.31	0.80	0.48	0.42

RCM - LS: Linear scaling corrected RCM

RCM - QM: Quantile mapping corrected RCM

Conclusions

- The SWAT model is found to be suitable for modeling hydrology in Mountainous region of Nepal.
- The study shows RCM simulation have large discrepancies to observe data and needs to be corrected prior application.
- At coarser temporal resolution (monthly scale), simple technique such as linear scaling is equally effective as complex technique.
- Every research may not posses high level of statistical and programing skill for computing complex bias correction techniques whereas simple techniques are easy and can be performed in simple spreadsheet.
- Simple techniques have dual benefit – easy to learn (can involve larger radius user) and saves resources (time and effort).

Publication

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Bias correction of climate models for hydrological modelling – are simple methods still useful?

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ABSTRACT: The spatial climatic characteristics of the Himalayas are complex and a challenge for regional climate models (RCMs). There is no doubt that some form of correction before any application of RCM simulations is a must. In recent years, simple bias correction techniques have been overshadowed by more popular and complex bias correction techniques. In this study an attempt is made to compare the performance of a simple and of a comparatively complex correction technique for hydrological analysis at a monthly resolution in the Kaligandaki River Basin of Nepal. The research workflow consists of bias correction of temperature and precipitation using a simple technique (linear scaling) and a comparatively complex one (quantile mapping). The performance at monthly resolution is evaluated against observed meteorological data while a combined evaluation is made *via* hydrological model response analysis. The wetter and colder RCM estimates were significantly improved after bias correction. The hydrological modelling response also shows the importance of the bias correction of the RCMs. However, no significant difference was observed between the outputs of linear scaling and quantile mapping which exhibited almost identical performances. Hence, this study has a novel conclusion that a simple method, such as linear scaling, is sufficient for hydrological analysis at monthly resolution.

KEY WORDS bias correction; Himalayan basin; hydrological modelling; Kali Gandaki; linear scaling; quantile mapping; SWAT

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THANK YOU

Dziękuję

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