Department of Civil Engineering
Faculty of Engineering
Jenderal Soedirman University

Multisite daily precipitation simulation in Singapore

by

Dr.-Ing. Suroso, ST., M.Sc

4th International Conference on Rehabilitation and Maintenance in Civil Engineering
Best Western Premier Hotel, Solo Baru
July,11-12 2018

Outline

1. Background, motivations, and research goals
2. Data and study locations
3. Methods
4. Results
5. Conclusions

Background and motivations

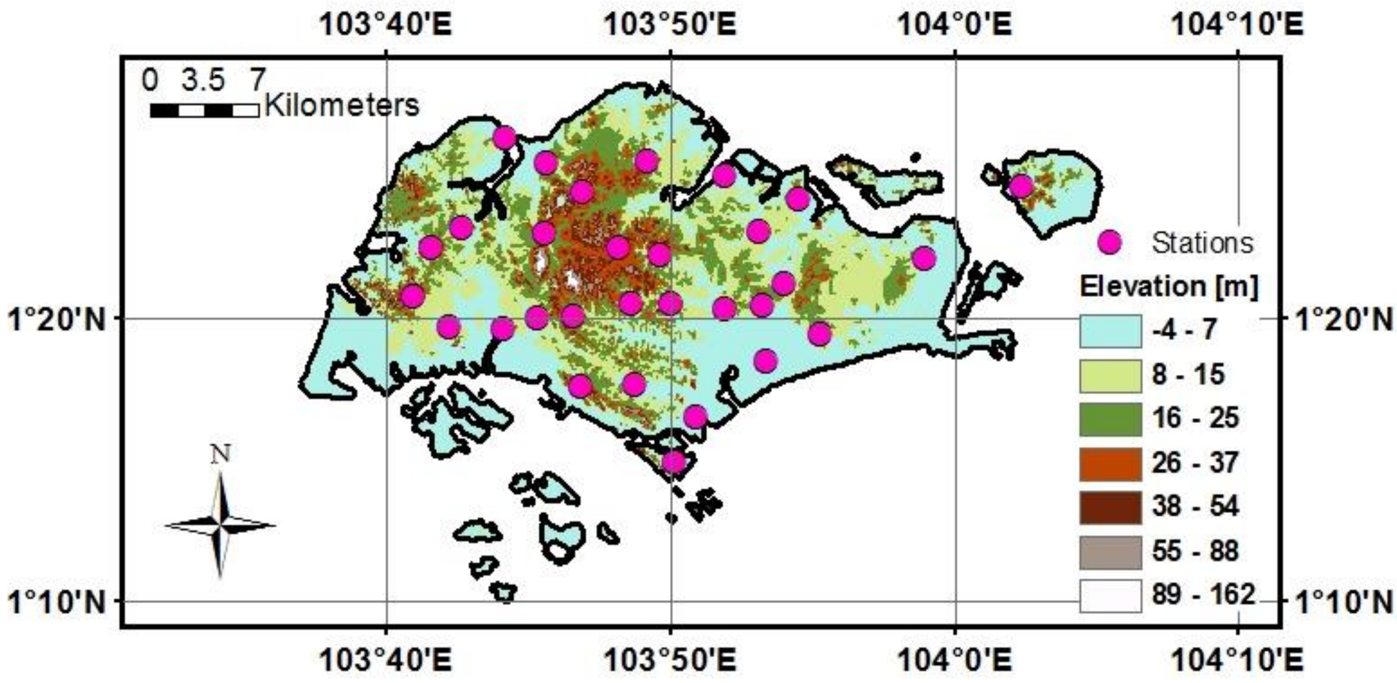
- Precipitation is the main input of hydrological analysis
- Lack of spatial and temporal observations
  - Spatial interpolations (coarse → finer resolution)
  - Infilling missing observations → extend length of series
- Exhibit unique behavior
  - zero inflated data and skewed distribution

Objectives

- To develop daily precipitation models at multiple locations incorporating both temporal and spatial dependencies
- Zero-inflated data for dry days are treated as latent variables

Data and Study Location

- Area: 718.3 km^2
- 26 rain gauge stations (1980-2010)
- Daily resolution



Methods

1. Temporal Model Development

- Single Site Model
- Power Transformed AR(1) Model

$$Y_t = \begin{cases} Z_t^{\frac{1}{\beta}}, & \text{for } Z_t > 0 \\ Yt, & \text{for } Zt = 0 \end{cases} \rightarrow Y_t = \mu + r.Y_{t-1} + \varepsilon_t$$

Z_t : precipitation amounts in real domain

- For $Z_t > 0$ → positively skewed
- For $Z_t = 0$ (dry days) → censored data approach

Y_t : beta power transformed normal domain on day t

μ & **r**: AR(1) parameters

ε_t: residual error of AR(1) process on day t (**i.i.d**)

Methods

2. Spatial Model Development

- Residual errors (ε_t) ≠ (i.i.d) → still correlated each others
- εt modelled spatially by Conditional Spatial Gaussian Model
- To fill in censored εt coming from censored daily precipitation

$$\begin{bmatrix} X_1 \\ X_2 \end{bmatrix} \sim N\left(\begin{bmatrix} \mu_1 \\ \mu_2 \end{bmatrix}, \begin{bmatrix} \Sigma_{11} & \Sigma_{12} \\ \Sigma_{21} & \Sigma_{22} \end{bmatrix}\right)$$

X_1 : censored εt
X_2 : true εt

Methods

3. Model Simulation

- Generate errors **εt** based on fitted Conditional Gaussian Model
- Simulate daily precipitation Y_t using fitted AR(1) Model for each station.
- If $Y_t \leq 0$ → transformed back to zeroes $Z_t = 0$ (dry days)
- If $Y_t > 0$ → transformed to the skewed distribution (positive rainfall) using beta (β) power transformation

Methods

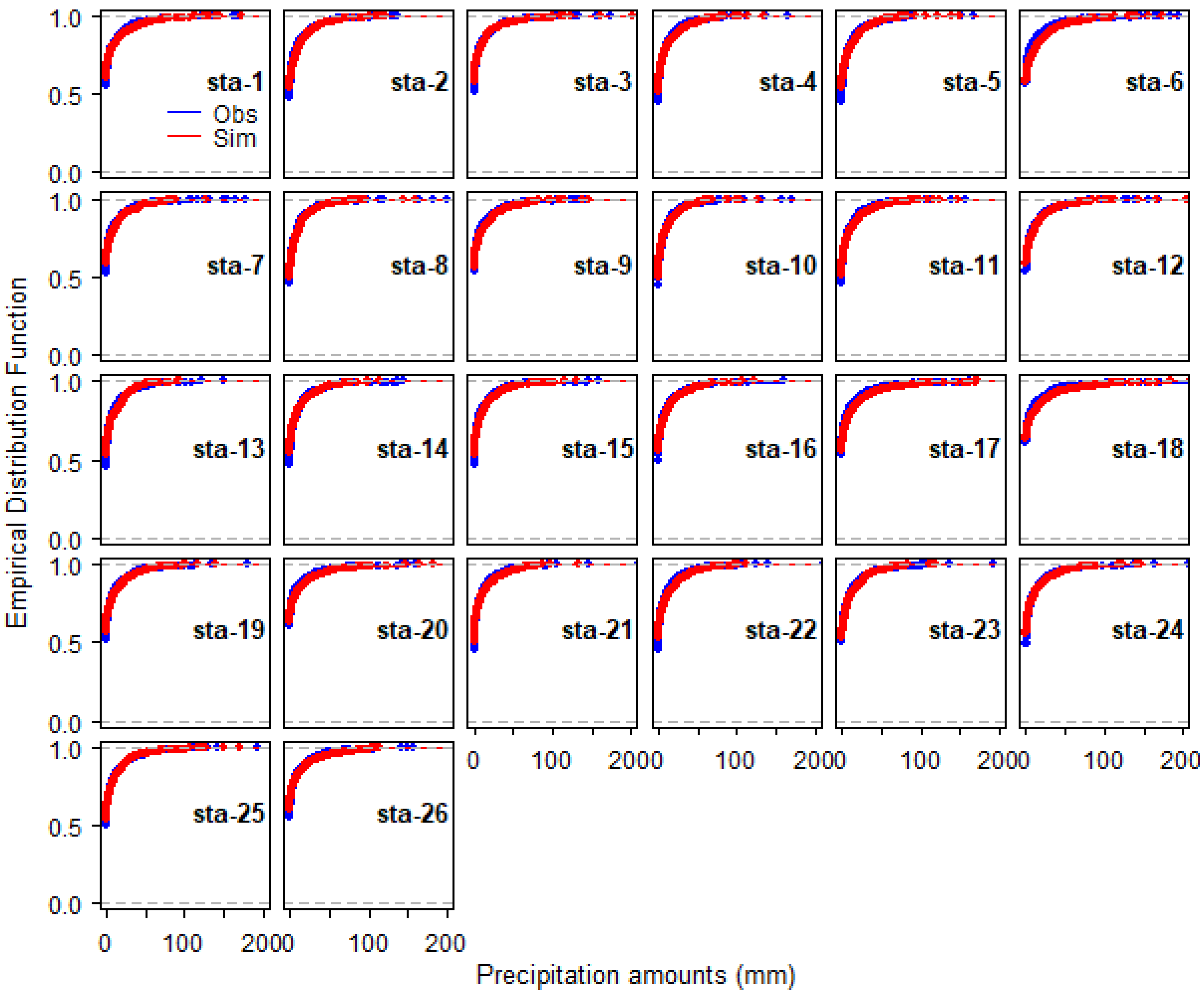
4. Model Evaluation

- Conventional measures: mean, variance, empirical cumulative distribution function, important quantiles values and cross correlation coefficient (CCC).
- Novelty measure: entropy-based approach (Bardossy and Pegram, 2009*) → to measure uncertainty information

* A. Bárdossy, GGS. Pegram. **Copula-based multisite model for daily precipitation simulation**. *Hydrology and Earth System Sciences* 13 (12), p. 2299, (2009)

Results

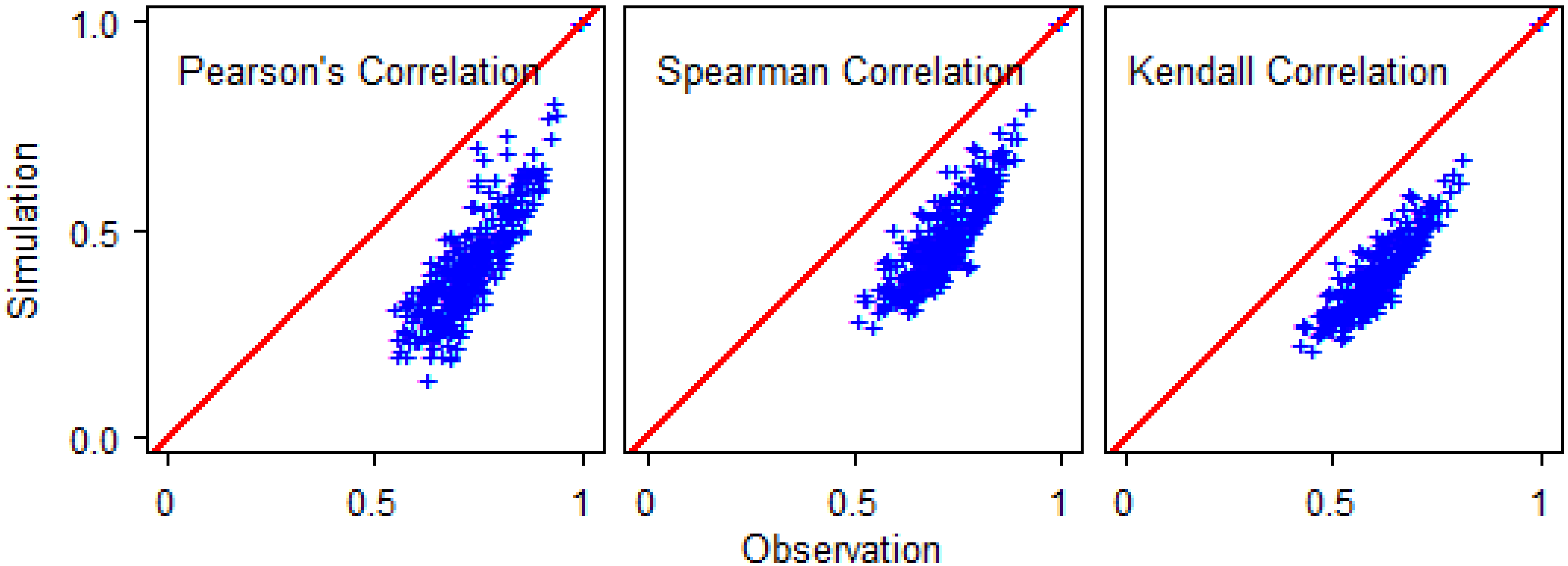
1. Single Site Evaluation



Model reproduces simulated rainfall perfectly

Results

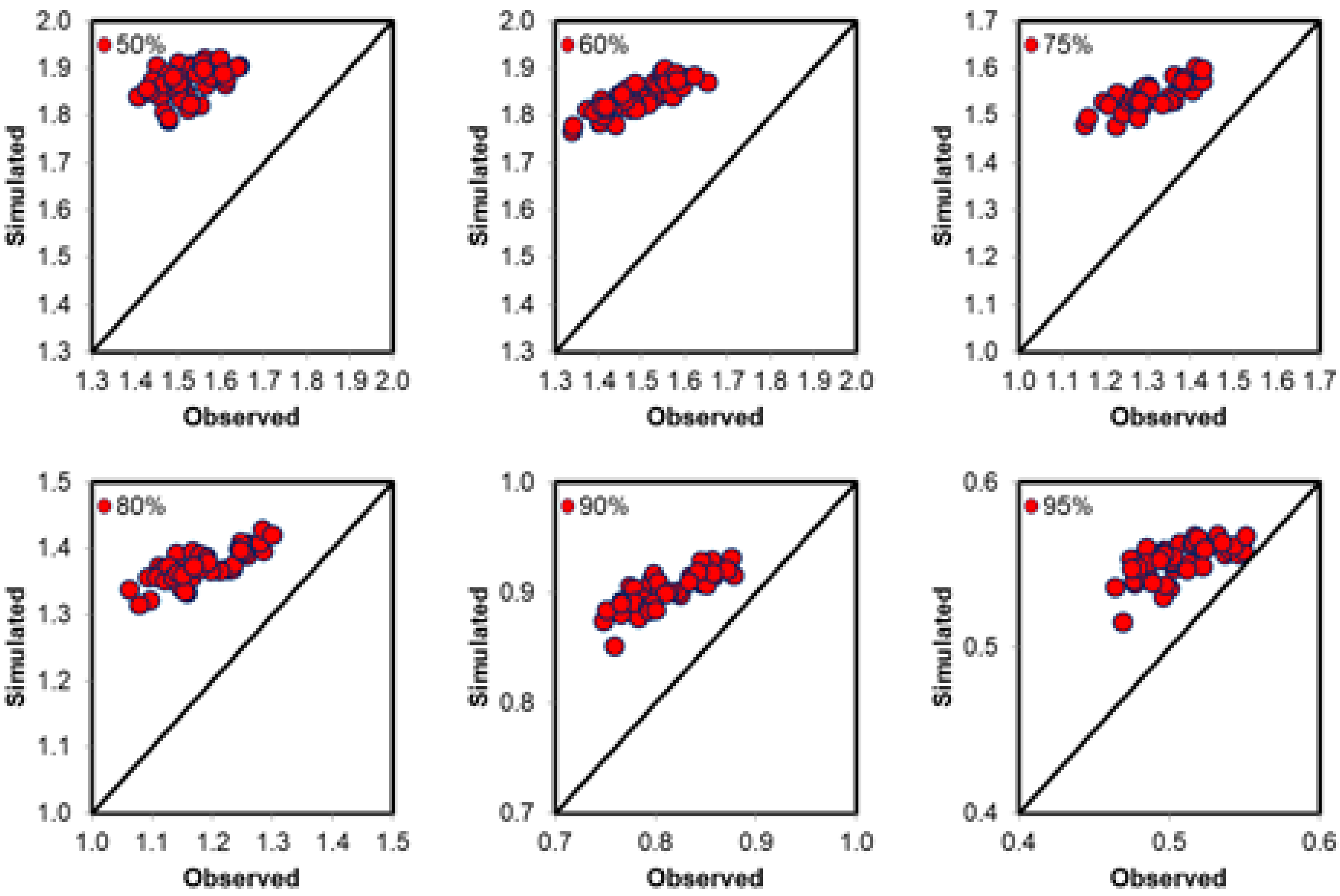
2. CCC-based Evaluation



Simulated daily precipitation exhibits slightly lower CCCs compared to observed data.

Results

3. Entropy-based measure



Simulated rainfall give larger entropy

Conclusions

1. Model performs very well for single site evaluation (mean, variance, cumulative distribution function, and important quantiles)
2. There is only slight a difference value for all CCCs between simulated and observed daily precipitation.
3. Simulated daily precipitation amounts give larger entropy than observed data → greater uncertainty

Thank You