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Modelling rainfall with a Bartlett–Lewis process: pyBL (v1.0.0), a Python software package and an application with short records

Chi-Ling Wei et al.

Correspondence to: Li-Pen Wang (lpwang@ntu.edu.tw)

S1 Sensitivity analysis of Bartlett-Lewis model parameters

This supplement presents a sensitivity analysis of model parameters within the Bartlett-Lewis (BL) stochastic rainfall model, as implemented in the pyBL package. To our understanding, three main factors affect the sensitivity of model parameters, ranging from local to global sensitivities: (1) the capacity of the numerical solver to determine optimal model parameters, (2) the estimation of observed rainfall properties, and (3) the sample size.

We first address local sensitivity introduced by the numerical solver. The proposed numerical strategy based upon a basin-hopping algorithm is utilised here. To demonstrate the impact of the numerical solver, we conducted an experiment using 69 years of rainfall records from Bochum. As shown in Fig. S1, when a fixed random seed (related to the initial guess) is used, the solver consistently results in the same parameters. When varying random seeds are used, the solver produces nearly identical parameters in most months, except for July and September, where greater variability in some parameters is observed. However, when these parameters are used to compute rainfall properties such as skewness at 5-min and 1-day time scales (shown in Fig. S2), the variability in skewness estimates is minimal.

Comparing these results with those derived from the bootstrapping method (see Sect. 2.4 of the manuscript) shows that the variability in rainfall properties from bootstrapping is consistently larger than that caused by the numerical solver (see Fig. S2). Even in July, where parameter variation from varying random seeds exceeds that from bootstrapping, the resulting variability in rainfall properties remains smaller. This sensitivity analysis demonstrates that while the consistency of the numerical solver is important, the uncertainty in model calibration is largely driven by the estimation of observed rainfall properties rather than the solver's consistency.

Finally, we conducted another experiment to examine the impact of sample size, using the bootstrapping method to derive model parameters from 5- and 69-year rainfall records. As shown in Fig. S3, sample size has a significant impact on parameter variability (or sensitivity). When the sample size is small, the variability in model parameters is much greater than when using the full records. Furthermore, this sensitivity propagates into rainfall properties, as can be seen when comparing Figures S2 and S4. We conclude that sample size has the largest impact on the sensitivity of model parameters compared to the other two factors discussed.

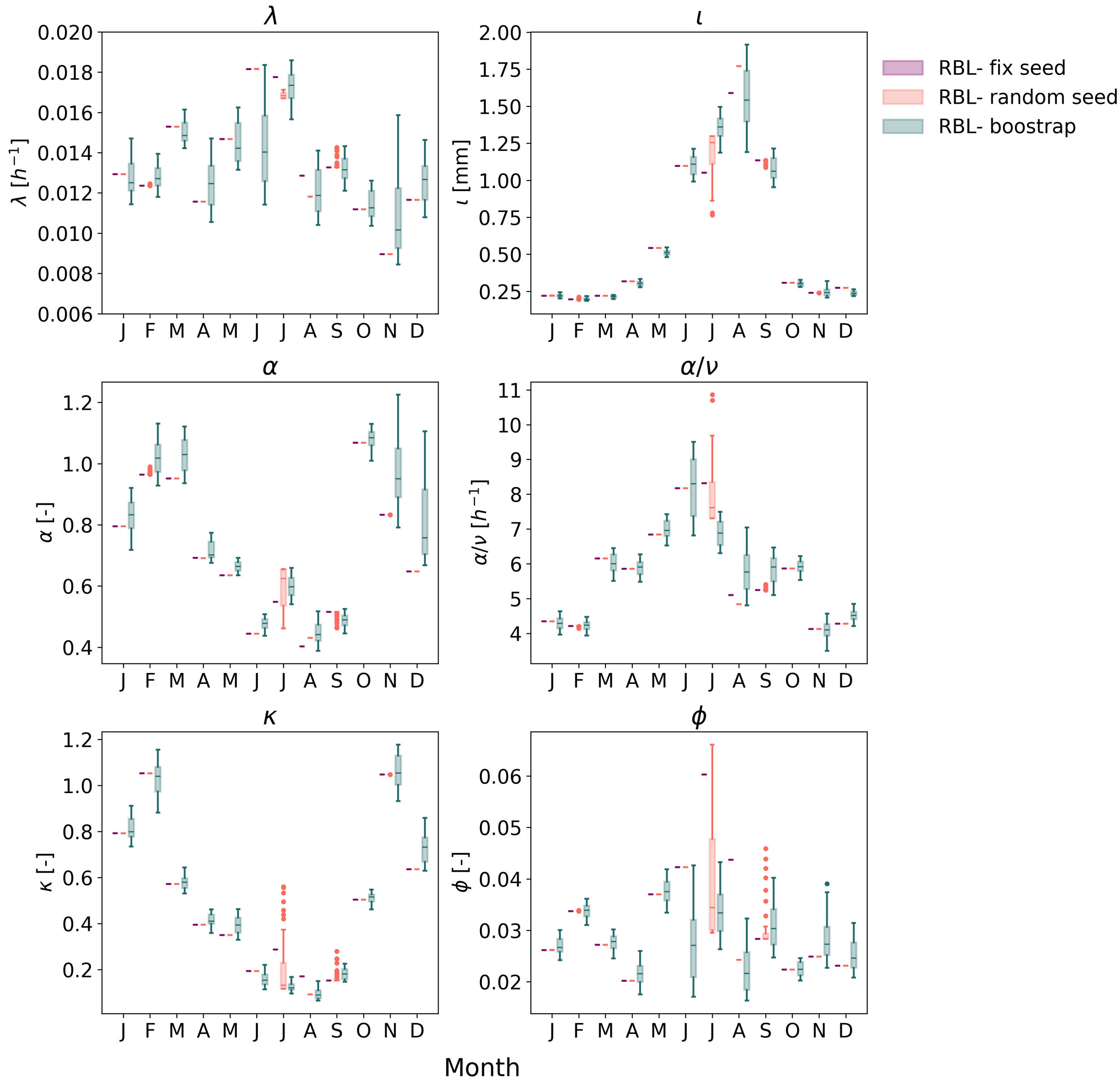

Figure S1. Variability of model parameters calibrated under three different scenarios: (1) fixed random seeds, (2) varying random seeds for initial guesses, and (3) the bootstrapping method.

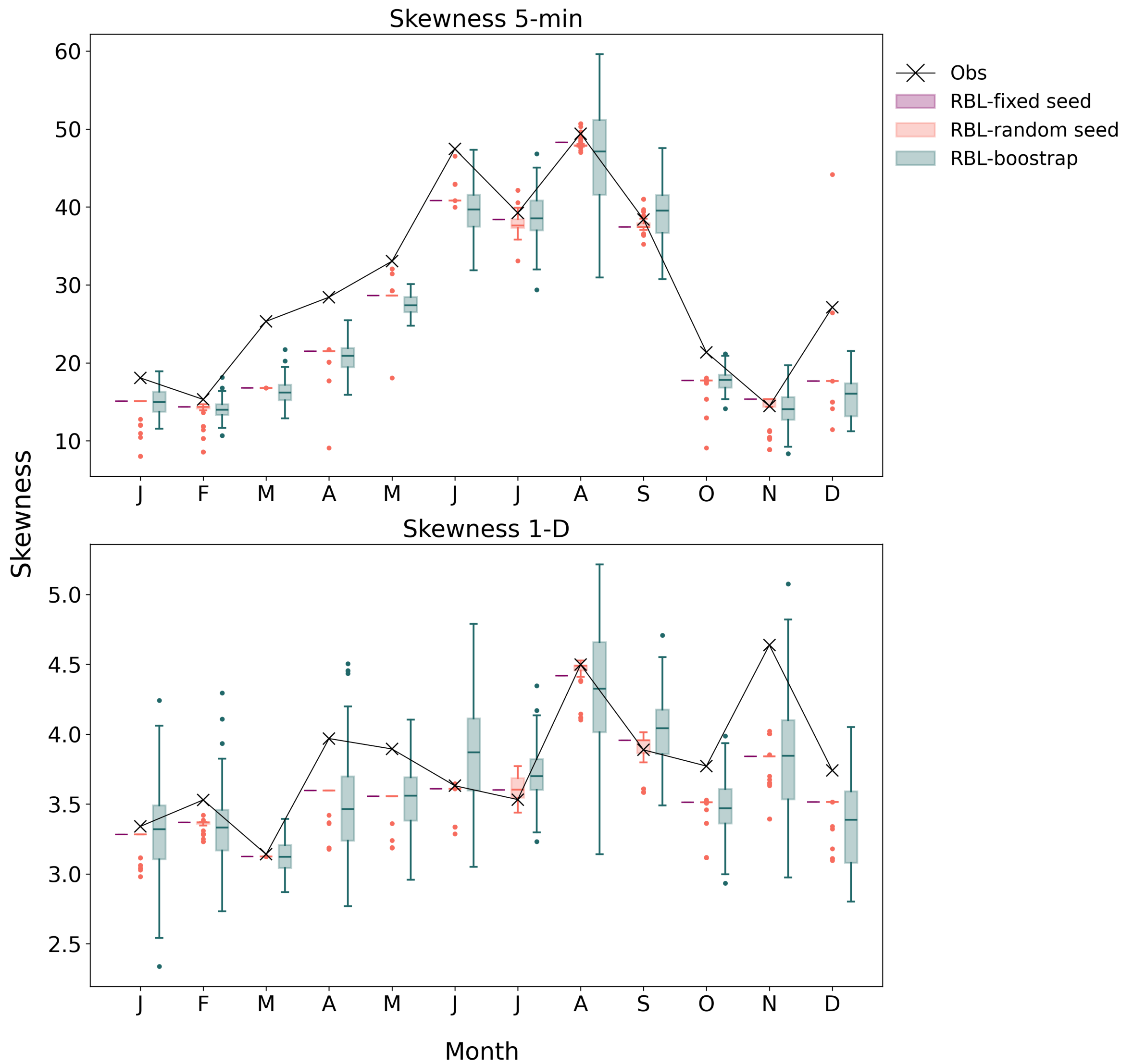

Figure S2. The corresponding 5-min and 1-day skewness estimates were computed using the model parameters shown in Fig. 1.

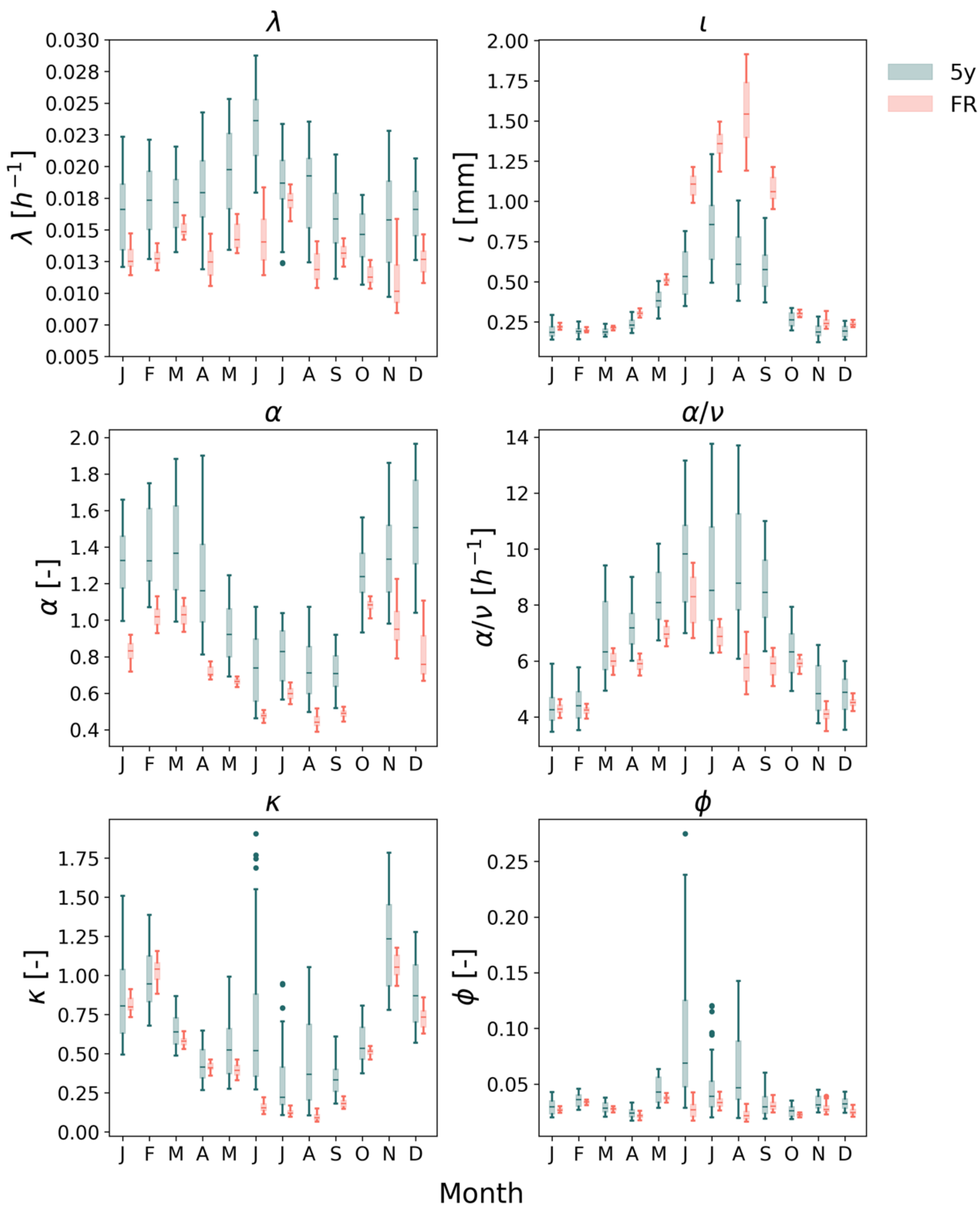

Figure S3. Boxplots of monthly model parameters (storm arrival rate (λ), cell intensity ratio (ι), cell duration shape (α), cell duration scale (ν), cell arrival rate (κ), and storm duration rate (φ)) calibrated using different record lengths (light blue boxes: 5 years, green boxes: full records). Each member of 100 bootstrapping iterations is calculated, and their interquartile ranges (IQR) are presented.

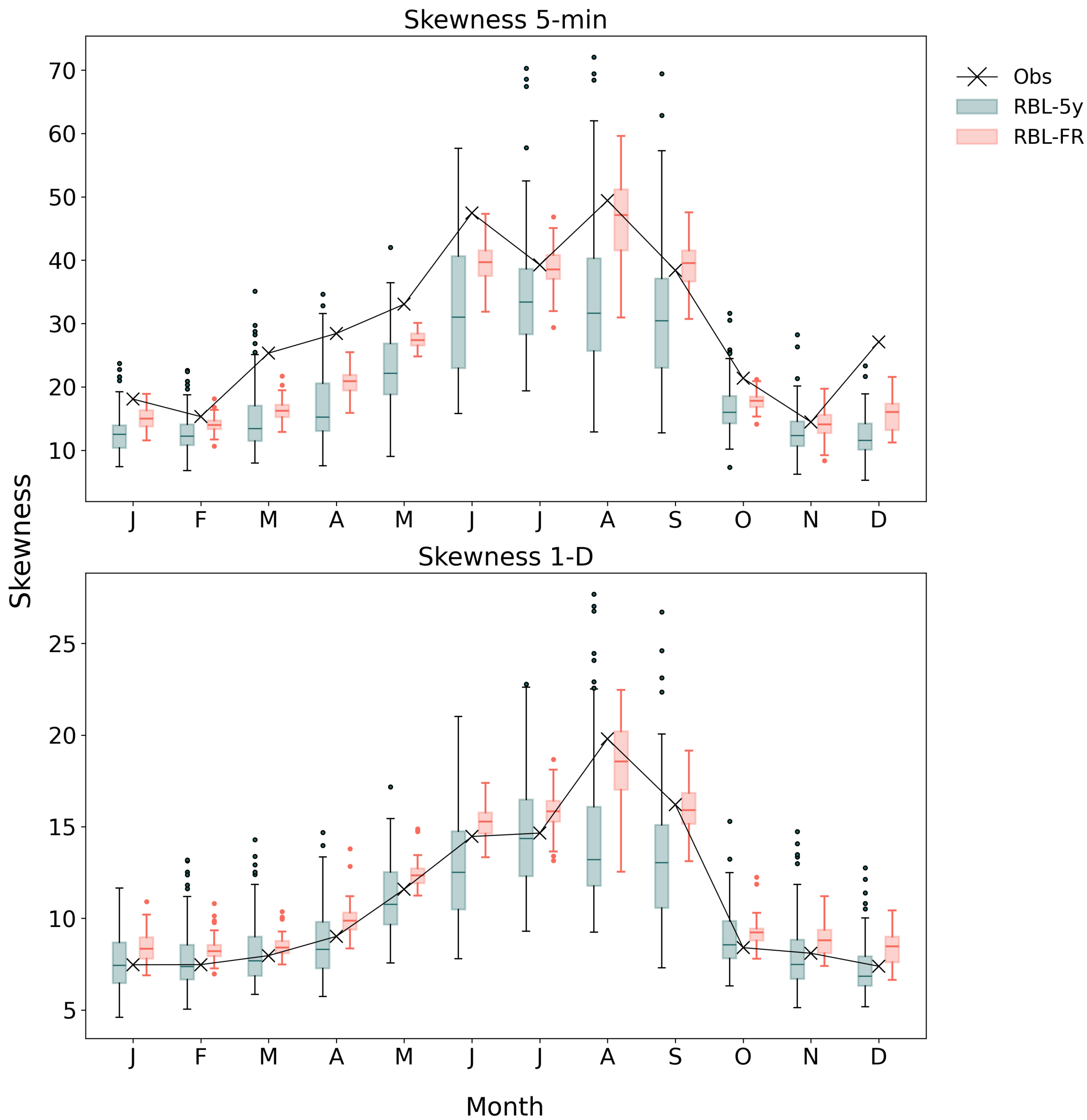

Figure S4. The corresponding 5-min and 1-day skewness estimates were computed using the model parameters shown in Fig. 3.

References

Onof, C. and Wang, L.-P.: Modelling rainfall with a Bartlett–Lewis process: new developments, Hydrology and Earth System Sciences, 24, 2791–2815, https://doi.org/10.5194/hess-24-2791-2020, 2020.