climate

MDPI

Supplementary Material

Application of Satellite-Based Precipitation Estimates to Rainfall-Runoff Modelling in a Data-Scarce Semi-Arid Catchment

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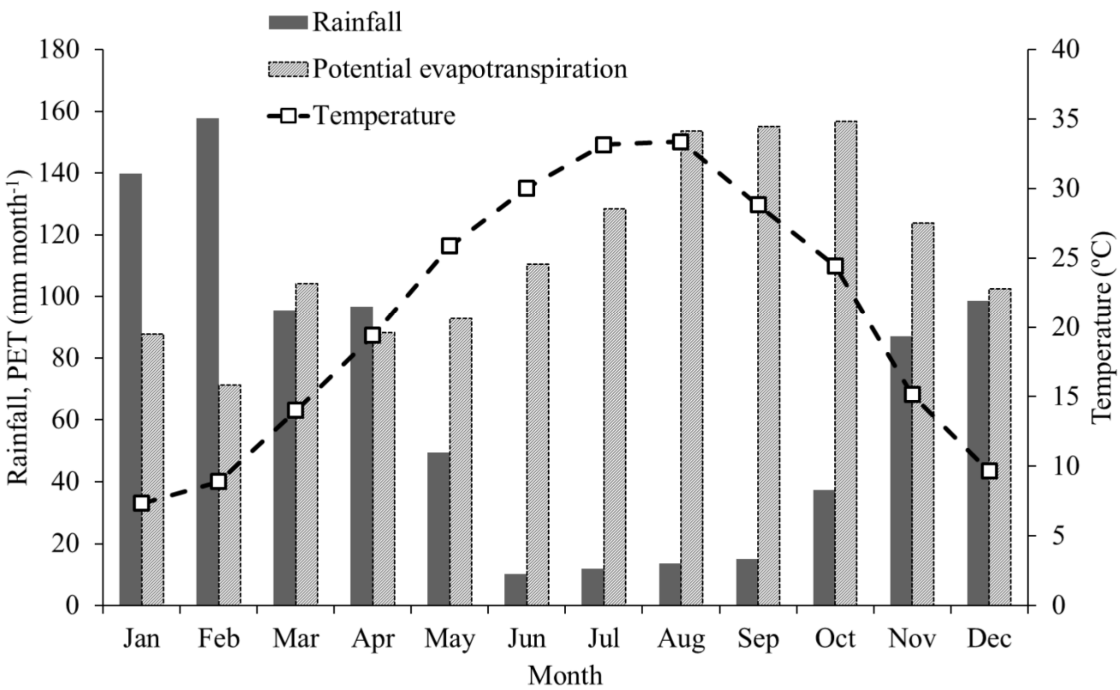


Figure S1. Mean monthly spatially-averaged rainfall (Theisen polygons), temperature and reference evapotranspiration (calculated using the Wasim-ET model: Hess et al., 2000) in the Lesser Zab catchment (2003–2014).

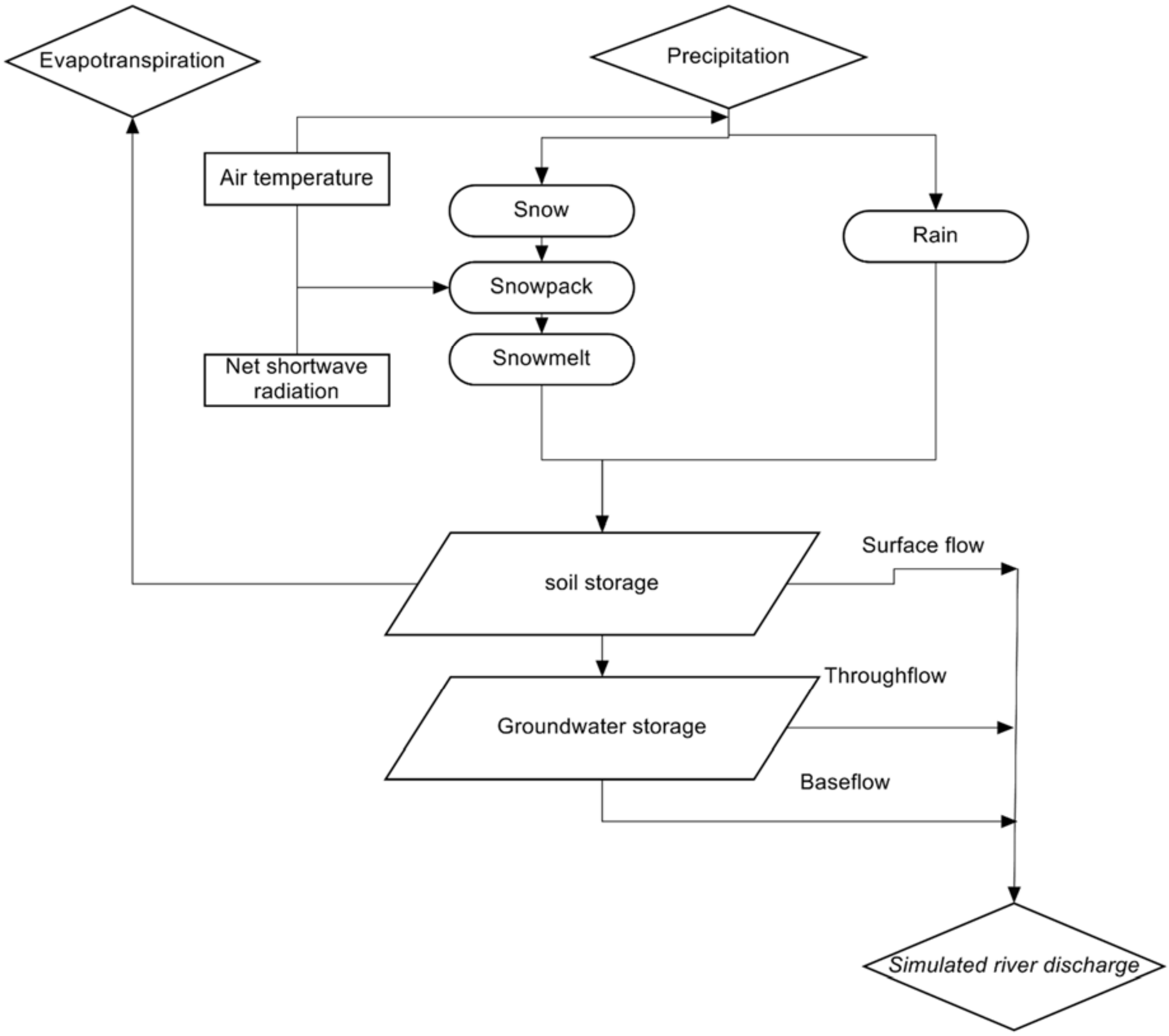


Figure S2. Structure of the LEMSAR model

Table S1. Contingency table comparing gauge area average and TMPA rainfall estimates.

TMPA-event forecast	Gauge-event observed		
	Yes	**No**	**Marginal total**
Yes	a	b	a + b
No	c	d	c + d
Marginal total	a + c	b + d	a + b + c +d

$$FAR = \frac{b}{a+b} \quad (S1)$$

$$POD = \frac{a}{a+c} \quad (S2)$$

$$HSS = \frac{2(ad-bc)}{(a+c)(c+d)+(a+b)(b+d)} \quad (S3)$$

where: a, b, c, d represent, respectively, hits, false alarms, missed and correct negatives

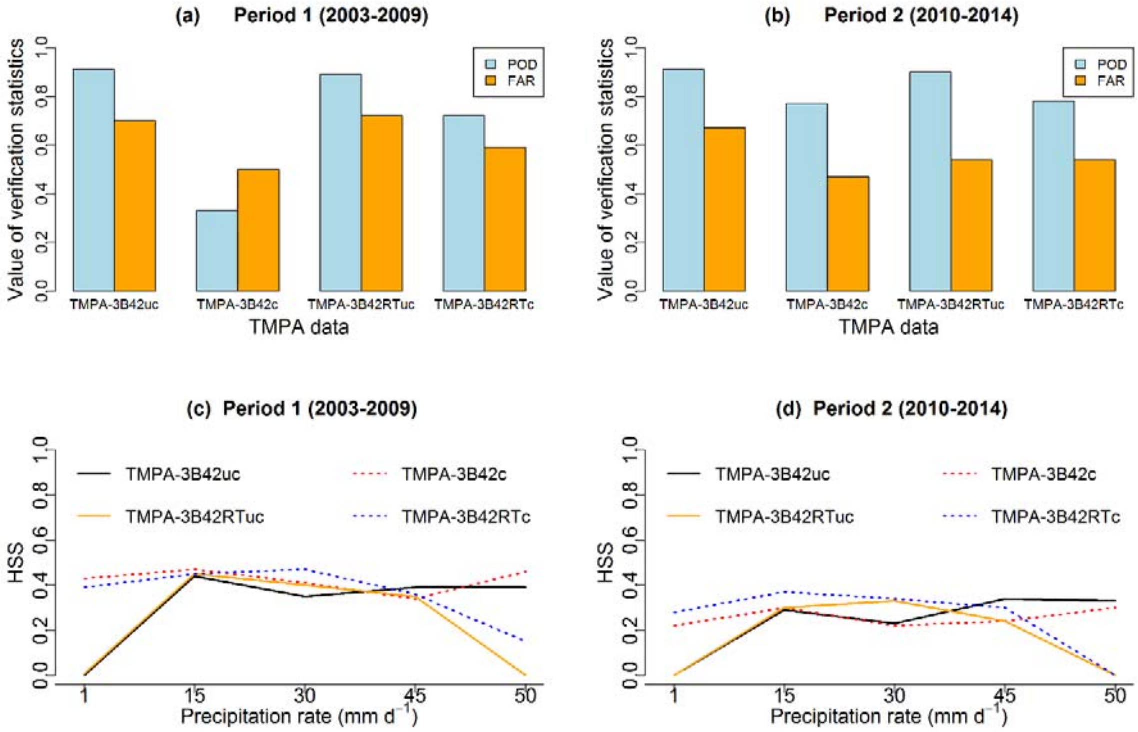
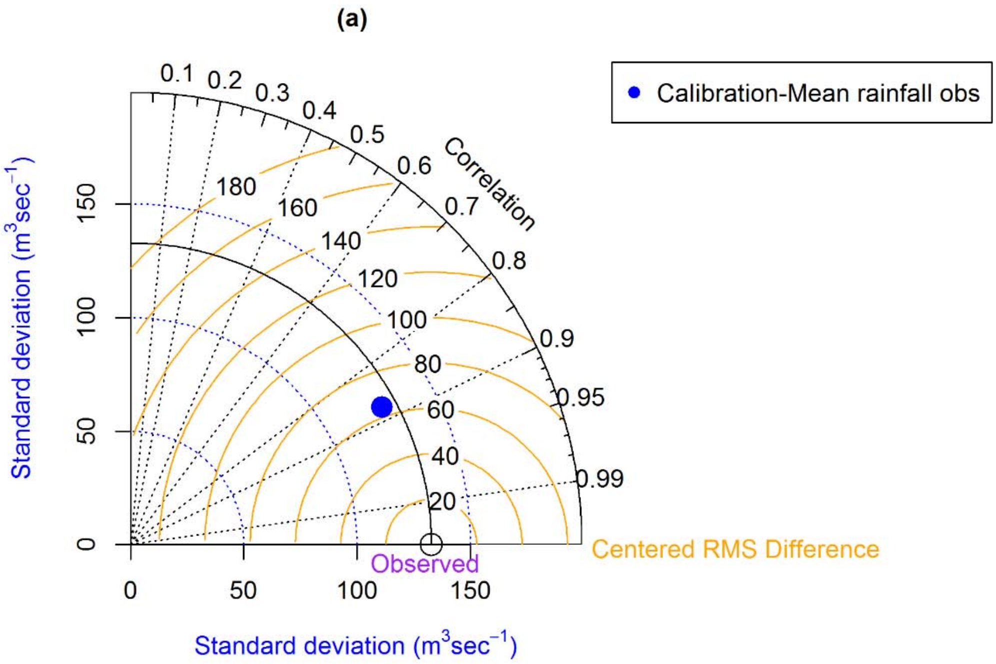


Figure S3. Verification statistics between TMPA-3B42 / 3B42RT and observed (gauge) rainfall. Panels (a) and (b) show FAR and POD for Periods 1 and 2, respectively. Panels (c) and (d) show the HSS between TMPA-3B42 and TMPA-3B42RT and observed (gauge) rainfall for different rainfall intensities during Periods 1 and 2, respectively.

Taylor Diagrams

Taylor diagrams summarising the performance of the model when driven by different precipitation data are shown in Figure S4. The position of each point appearing on the plot quantifies how closely simulated river discharge matches observations. In the case of the calibration period, when the model is driven by the area-weighted rain gauge data, the blue point lies closer to the dashed arc (line of standard deviation). Its correlation coefficient is about 0.89, the RMS error is about 65 $m^3 s^{-1}$ and the standard deviation is about 148 $m^3 s^{-1}$. The relative merits of various validations of the model can be inferred from Figure S4b. The black point represents validation when the model was driven by the area-weighted rain gauge data. This lies on the black arc line which means that the standard deviation of the simulated discharge is similar to that of the observed data (i.e., the mean amplitude of discharge variations is similar). The green point represents simulated river discharge in the validation period when the model was driven by the corrected TMPA-3B42. This model run generally produced the best agreement with the observations and has the highest correlation (r = 0.89) and lowest RMSE (79 $m^3 s^{-1}$).



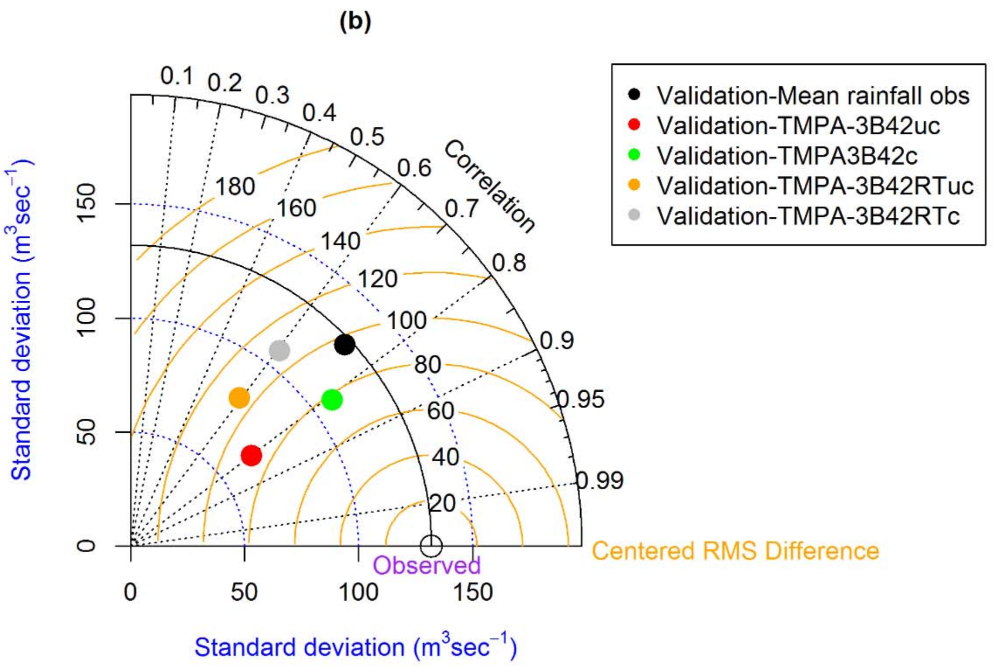


Figure S4. Taylor diagram summarising the statistical performance of simulated versus observed river discharge for (a) the calibration period (2010–2011) and (b) the validation period (2012-2014) when the model was driven by the weighted-average gauge-derived rainfall, uncorrected and corrected TMPA-3B42/3B42RT rainfall data. The orange contours indicate the centred Root Mean Square (RMS) values which is proportional to the distance from the point on the X-axis identified as "observed". The blue dashed line shows standard deviations which are proportional to the radial distance from the origin.

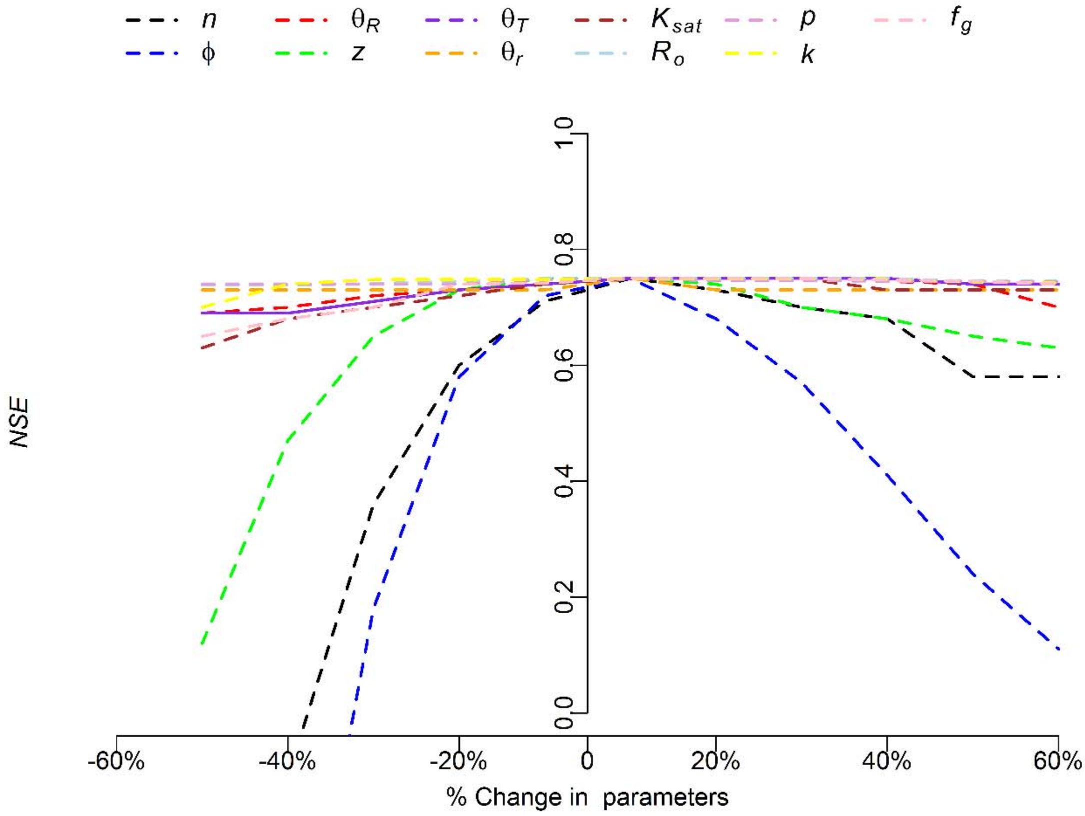


Figure S5. Sensitivity analysis of the LEMSAR model for all parameters using a local sensitivity method.

Goodness of fit statistics

$$NSE = 1 - \left[\frac{\sum_{i=1}^{m}(Q_i^{sim} - Q_i^{obs})^2}{\sum_{i=1}^{m}(Q_i^{obs} - \bar{Q}^{obs})^2}\right] \quad (S4)$$

$$r = \frac{\sum_{i=1}^{n}(Q_i^{obs} - \bar{Q}^{obs})(Q_i^{sim} - \bar{Q}^{sim})}{\sqrt{\sum_{i=1}^{n}(Q_i^{obs} - \bar{Q}^{obs})^2}\sqrt{\sum_{i=1}^{n}(Q_i^{sim} - \bar{Q}^{sim})^2}} \quad (S5)$$

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n} Q_i^{sim} - Q_i^{obs}}{N}} \quad (S6)$$

$$Percent\ bias = \frac{\sum_{i=1}^{N}(Q_i^{sim} - Q_i^{obs})}{\sum_{i=1}^{N} Q_i^{obs}} * 100 \quad (S7)$$

where Q_i^{obs} and Q_i^{sim} are the observed and simulated discharges, respectively, $\bar{Q}^{obs}$ is the average observed discharge, $\bar{Q}^{sim}$ is the average simulated discharge and N is the number of records.