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## HRGEN: A stochastic generator of hourly rainfall

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Rainfall data are needed as input to drive hydrological and soil erosion models. Daily rainfall data are commonly used and widely accessible, whether sourced from meteorological observations or simulated by Global Climate Models (GCMs). However, daily data cannot capture intensity variations during a storm event, and may not be sufficient to capture the changes during extreme weather events under climate change scenarios. Weather generators (WGs) are statistical models that can generate random sequences of meteorological variables that exhibit statistical characteristics that are similar to observations. However, the low accuracy of generated sub-daily rainfall intensities motivated this study to stochastically disaggregate daily precipitation total at hourly intervals so that observed or GCM generated daily rainfall can be downscaled into hourly scale stochastically. To achieve this, we developed a model, HRGEN, based on long-term hourly precipitation data from 1971 to 2020 from 2405 meteorological stations across mainland China. The major improvement of this model over CLIGEN includes: (1) HRGEN significantly enhances the simulation accuracy of maximum peak intensities on an hourly basis ( $H_{\max}$ ). The average  $H_{\max}$  over 2405 stations of hourly observations and HRGEN-generated are  $4.0 \text{ mm h}^{-1}$  and  $4.2 \text{ mm h}^{-1}$ , respectively, while that generated by CLimate GENERator (CLIGEN) is  $6.5 \text{ mm h}^{-1}$ . The mean absolute relative error (MARE) over 2405 stations is 8.2%. This improvement is critical for accurately estimating daily  $EI_{30}$  values, a key index in soil erosion models and soil loss prediction; (2) HRGEN preserves the relationship between total daily precipitation and storm duration and peak intensity; (3) The model has only six parameters, markedly simplifying the calibration and simulation processes. The HRGEN-simulated hourly rainfall data can be used to estimate rainfall erosivity for erosion prediction. The R-factor estimated using HRGEN-generated hourly data agrees well with the observed R-factor values, with a high Nash-Sutcliffe efficiency coefficient (NSE) of 0.92. The average R-factor estimated from hourly observations and HRGEN-generated hourly observations over 2405 stations are  $3699.2$  and  $3720.7 \text{ MJ mm ha}^{-1} \text{ h}^{-1} \text{ a}^{-1}$ , respectively. In comparison, R-factor estimated by CLIGEN-generated rainfall is  $9100.7 \text{ MJ mm ha}^{-1} \text{ h}^{-1} \text{ a}^{-1}$ . This study highlights HRGEN's potential as a robust tool for stochastic generation of sub-daily rainfall as input to hydrologic and soil erosion models.