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A high-resolution hierarchical space–time framework for single storm events and its application for short-term rainfall forecasting

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Abstract A new phenomenological hierarchical stochastic model is developed to robustly simulate rainfall fields consistent with 10-minute 1-km^2 pixel radar images. The hierarchical framework has three levels. The first level simulates a latent Gaussian random field conditioned on the previous time step. In the second level, first-order autoregressive (AR(1)) models are used to describe the within-storm variations of the level-one parameters that control the evolution of rain fields. The third level is designed for simulation of storm sequences. Calibration and validation of the first two levels using an observed storm event (typical in Sydney, Australia) demonstrate that this two-level model produces realistic sequences of rain images which capture the physical hierarchical structure of clusters, patchiness of rain fields and the persistence exhibited during storm development. A variety of important statistics are adequately reproduced at both 10-minute and 1-hour time scales over various space scales. Application of this model to short-term rainfall forecasting is also presented.

Key words stochastic space-time rainfall; hierarchical framework; high-resolution; block Toeplitz, circulant decomposition; generalized moments; parametric bootstrap; short-term forecasting