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Precipitation downscaling and multi-sensor fusion based on sparse representation and non-Gaussian statistics

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Precipitation fields often contain sparsely populated coherent high intense rain-cells embedded within lower intensity areas. A statistical manifestation of these isolated extremes is the remarkably non-Gaussian statistics with symmetrically extended heavy tails in the wavelet domain. A probability model is found which explains well this observed heavy tail structure via mixtures of Gaussian densities in the wavelet domain. Exploiting this probability model, a new framework is presented which permits multiscale adaptive fusion of multi-sensor precipitation data while preserving precipitation local extremes by taking into account the intrinsic non-Gaussian structure of rainfall in the estimation process.
A direct consequence of this observation is that these fields exhibit a nearly sparse representation when projected onto an appropriately chosen basis. This sparsity opens up the opportunity to explore a new paradigm for high-resolution recovery of precipitation data from low-resolution noisy observations via dictionary learning and l1-norm minimization. We demonstrate both the downscaling and fusion methodologies and demonstrate their advantages using a dataset of coincidental observations of precipitation events by the space-born precipitation radar abroad the Tropical Rainfall Measurement Mission (TRMM) satellite and ground-based weather surveillance Doppler radars.