Evaluation of a scale decomposition-based stochastic ensemble quantitative precipitation estimation scheme

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Despite the increasing sophistication of the data processing chains, the radar-based quantitative precipitation estimation (QPE) will always be characterized by significant uncertainty. This uncertainty also affects the quality of very-short term forecasts up to one hour lead time.

In this study, we develop and evaluate a stochastic ensemble QPE scheme to be used in combination with the Short-Term Ensemble Prediction System (STEPS). To simulate rainfall fields with correct scaling properties, the radar image is first decomposed into an 8-levels lognormal multiplicative cascade. The QPE ensemble is generated by adding stochastic perturbations to this radar cascade. The stochastic perturbations are provided by a separate cascade of spatially and temporally correlated stochastic noise. A spatially correlated noise cascade is generated by filtering a white noise field using a power-law spectrum similar to the radar. The temporal correlation is simulated using a hierarchy of auto-regressive processes of order 1. The radar cascade is blended with the noise cascade using a weighting scheme that preserves the large scales and only perturbs the small scale structures. To obtain error perturbations that are consistent with the typical variability of the Z-R relationship, space and time correlations of the order of 30-40 kilometers and 2 hours respectively were imposed.

The consistency of ensemble members is evaluated by comparing their statistical distributions and power spectra with the ones of the original unperturbed radar field using data from the weather radar composite of Belgium. The spread of the QPE ensemble is optimized using rain gauge accumulations, which would account for the total QPE error, not only the one arising from the space-time variability of the Z-R relationship. The simplicity of this ensemble QPE scheme is sought for easy portability within STEPS, the treatment of other error sources being too specific to the characteristics of the radar and surrounding terrain.