A Study on Non-Gaussian Probability Densities on Convection Initiation and Development using a Particle Filter with a Storm-Scale Numerical Weather Prediction Model

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Abstract

Non-Gaussian probability densities in convection initiation (CI) and development are investigated using a sampling importance resampling particle filter with a nonhydrostatic numerical weather prediction model (NHM-PF). An observation system simulation experiment (OSSE) is conducted with a short assimilation period (90 min), a small domain (48×48×50 grids) with a storm scale of 2 km grid spacing and relatively small number of observations (54) and large number of particles (1,000), to avoid the 'curse of dimensionality' in particle filters. The observations are created from a nature run, which simulates a well-developed cumulonimbus, and factors of the observations are pseudo surface observations of potential temperature (PT), winds (U, V), water vapor (QV) at the lowest height level, and pseudo radar observations of rainwater (QR) at four height levels of the low troposphere. The results of the OSSE are verified with root mean square errors against the nature run in comparison with ensemble simulations without any observations (NoDA). The verifications show that PF significantly improves NoDA (Fig. 1) and the spreads of PF are smaller than that of NoDA. PDFs on grids over the CI area are examined in detail. For evaluation of non-Gaussianity of the ensembles, we proposed to apply the Bayesian Information Criterion to compare the goodness of fit of Gaussian, two-Gaussian mixture and histogram models. The PDFs become strongly non-Gaussian, when NHM-PF produces diverse particles over the CI period. This is led by non-Gaussian PDF of updraft at the beginning, and then the upper-bounded PDF of relative humidity, which creates non-Gaussian PDFs of QV and PT (Fig. 2). These are strongly connected with each other

through saturation and condensation processes. The PDFs of cloud water and QR are quite far from Gaussian distributions throughout the experimental period. Part of PDFs of QC and QR still remain in no-water region, thus, we see bimodal distributions with distant peaks in the development stage. From these examination, it is concluded that the source of non-Gaussian in the CI is updraft.

References:

Kawabata, T., and G. Ueno: A Study on Non-Gaussian Probability Densities on Convection Initiation and Development using a Particle Filter with a Storm-Scale Numerical Weather Prediction Model. (*submitted*)

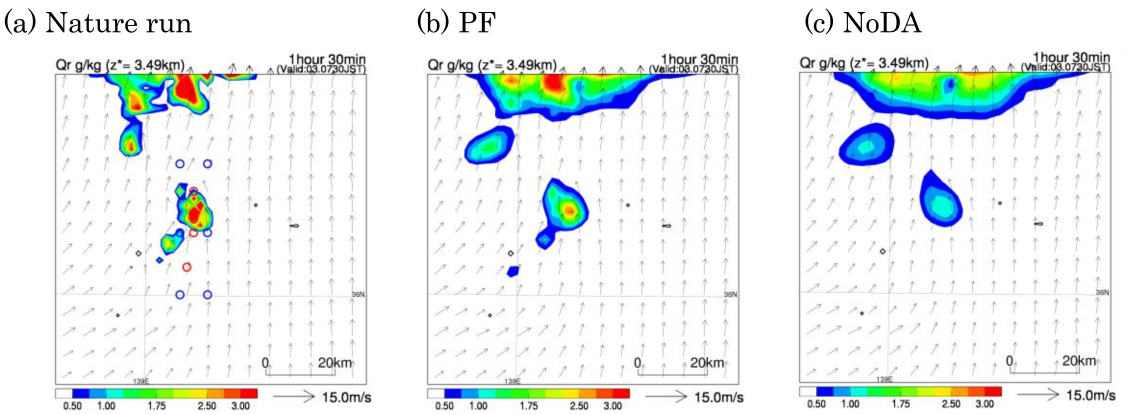

Fig. 1 Horizontal distributions of mixing ratio of rainwater (color shade) and horizontal winds (arrows) at 3.49 km height.

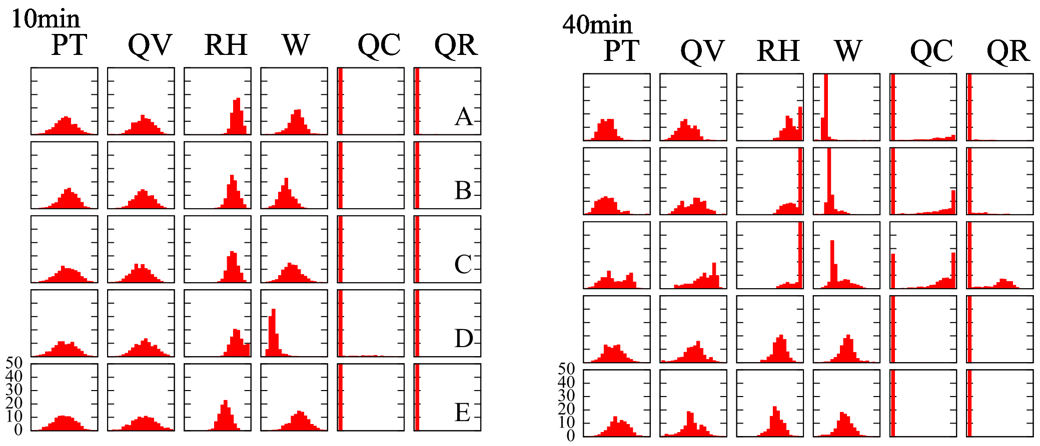

Fig. 2 Probability densities of PT, QV, RH, W, QC and QR on grids from south (lower) to north (upper) in the convection initiation region.