Meso-ensemble experiments on potential parameter of tornado formation using JMANHM

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1. Introduction Tornados with Fujita scale of 2 and 3 occurred in Japan in 2006, and caused severe disasters. Numerical simulations have been performed with cloud-resolving model to investigate the structure and formation mechanisms of tornados (e.g. Tsuboki, 2007; Mashiko, 2007; Kato 2007). Besides the simulation of the tornados, the forecast and warning system of tornados is developed by the JMA. In this system, potential of tornado formation is predicted by the deterministic forecast. However, the forecast does not always express the real state of atmosphere because the initial field of numerical forecast includes the analysis error. In ensemble forecast, many perturbations that have the property of atmosphere (e.g. large perturbation near the disturbance) are added to the initial fields, and then numerical forecasts are performed from these initial fields. It is statistically known that ensemble means becomes closer to the actual atmosphere. Moreover, probability that the parameter, such as CAPE, exceeds some threshold can be obtained from the many forecasts of ensemble members. The oversights of the severe weather become fewer when the forecasts of ensemble member are used. Therefore, ensemble forecast is expected to be useful to reduce the impact of the disaster. With collaborating with Japan Meteorological Agency (JMA), Meteorological Research Institute participates WWRP Beijing 2008 project (hereinafter, Beijing project), and develops the mesoscale ensemble forecast system. In this study, the techniques, which have been developed in the Beijing project, is applied to the parameters of tornado formation to show the usefulness of ensemble forecast.

2. Specification of ensemble experiment The numerical model and the initial perturbation producing method are the same as those of Beijing project. The domain of the model is set to be 3300 km x 3000 km. The horizontal grid interval is 15 km. The initial perturbation was produced by adding the normalized perturbation of one-week ensemble of JMA to the initial fields of the JMA regional spectrum model (RSM) (Saito et al, 2006). In this report, potential parameters of two tornado case events were investigated. First case is F2 tornado occurred in Kyushu (southernmost main island of Japan) on 17 September. Another is F3 tornado occurred in Hokkaido (northernmost main island of Japan) on 6 November 2008. Initial times of the ensemble forecasts are 12UTC of previous days. Figure 1 shows the surface pressure and rainfall region of the control run, which was the prediction from the initial condition without adding any disturbances. Typhoon and low-pressure system, in which the tornados occurred, were reproduced in both forecasts. Because the positions of the simulated typhoon and low-pressure system are similar to the observed ones, the environment (e.g. vertical shear) around the tornadoes is expected to be well reproduced in the control run forecast.

3. Results of ensemble experiment Figures 2 and 3 show the probability distributions of storm relative helicity (SReH), CAPE and product of CAPE and SReH that exceeds 25, 1000 and 30000, respectively. CAPE is the parameter that indicates how intense convection can be generated. SReH indicates how intense vorticity is produced by the low-level airflows. The product of CAPE and SReH, which corresponds to the parameter of EHI, indicates both effects.

In the first case, there were high probability areas, in which SReH exceeds 25, in the central part of Japan on northeast of the center of Typhoon (fig. 2). On the other hand, high probability that CAPE exceeds 1000 existed on the south of western part of Japan. In both distributions, there are excess regions of high probability on central part of Japan and on the southern side of Japan, respectively. As for the products of CAPE and SReH, the region that probability of this product exceeding 30000 is more than 50% remained at only the eastern part of Kyushu. This result indicates that the ensemble forecast is useful, when the product of CAPE and SReH is used as potential parameter of the tornado formation.

Can products of CAPE and SReH be well forecasted in the second case? Figure 3 shows the same as the fig. 2 except but the date of the forecast. High probability region in which the product of CAPE and SReH exceeds 30000 remained at the eastern Hokkaido. This result supports the usefulness of the ensemble forecasts.

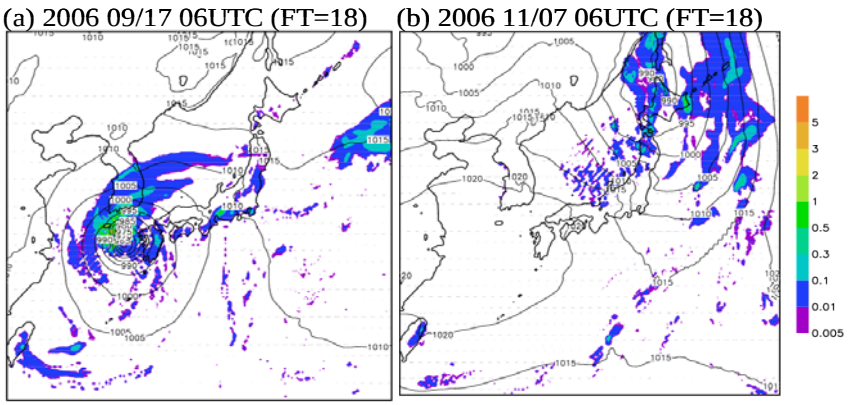

Fig. 1 Horizontal distribution of mixing ratio of rain water at the lowest level of JMANHM at 06UTC 17 Sep 2006 and 06UTC 7 November 2006. Counter lines indicate the sea surface pressure.

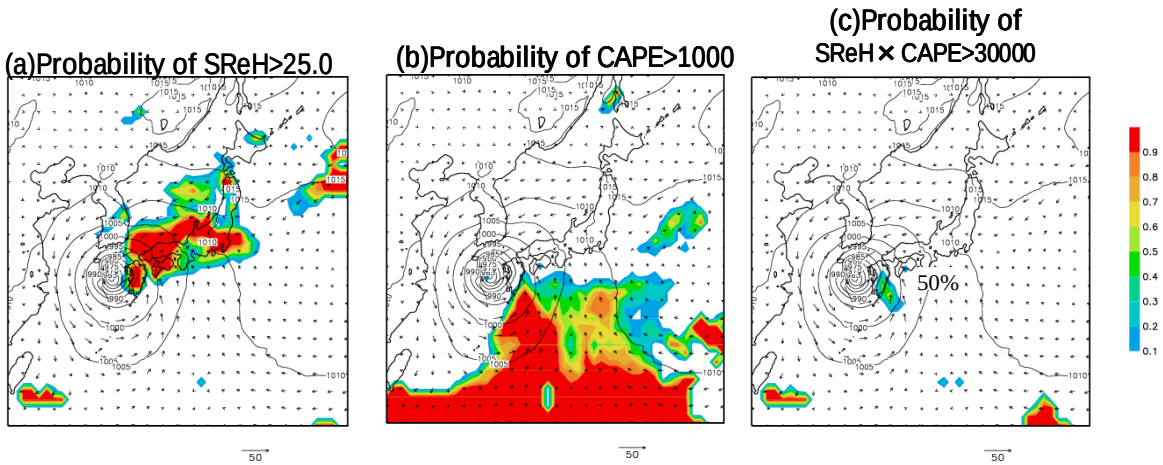

Fig. 2 Probability of (a) SReH, (b) CAPE and (c) SReH*CAPE exceeding to 25.0, 1000, and 300000, respectively. These probabilities were produced from output of ensemble forecast at 06UTC 17 September 2006.

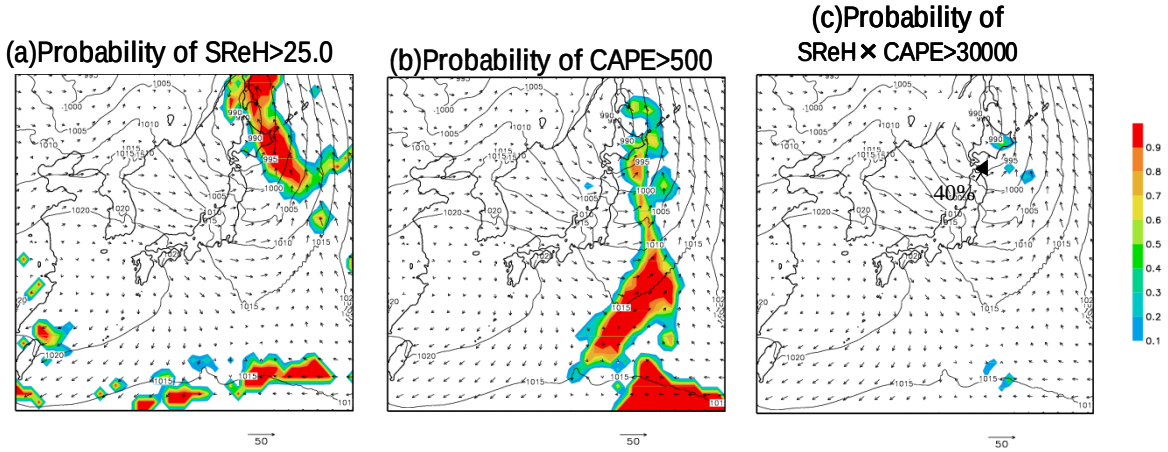

Fig.3 Same as fig.2 except for at 06UTC 7 November 2006.