Upgrade of initial perturbations made using the Local Ensemble Transform Kalman Filter in JMA's Global EPS

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1. Introduction

The Japan Meteorological Agency (JMA) upgraded its Global Ensemble Prediction System (Global EPS) starting from 00 UTC of March 5, 2019. Modifications from the previous operational version include (1) usage of perturbations from the six-hour forecast ensemble based on the Local Ensemble Transform Kalman Filter (LETKF) of the previous analysis instead of analysis perturbations, and (2) tuning of the horizontal and vertical localization functions in the LETKF. Retrospective experiments covering periods exceeding three months in each of summer 2016 and winter 2016/17 showed an almost-neutral impact as compared to the previous operational version. Exceptions were an increase in spread, especially in the Northern Hemisphere extra-tropics, and a slight improvement in skill for the probability of Tropical Cyclone (TC) strikes in the Northwestern Pacific.

Section 2 briefly outlines the changes included in this upgrade, and Section 3 provides a summary of verification results from retrospective experiments.

2. Changes

(1) Usage of six-hour forecast perturbations from the previous LETKF analysis ensemble

In the previous operational Global EPS, production of atmospheric initial perturbations involved a combination of leading singular vectors (SVs) and analysis perturbations of the LETKF valid at the initial time. The new Global EPS incorporates six-hour forecast perturbations from the previous LETKF analysis ensemble valid at the initial time instead of analysis perturbation. The main objectives of this change are to improve dynamical balance in initial perturbations and enable greater flexibility in operational time schedules.

(2) Tuning of horizontal and vertical localization functions in the LETKF

The horizontal localization length scale (in which the localization function is the inverse square root of *e*) of humidity-sensitive observations was shortened from 400 to 300 km based on the diagnostics of Ménétrier et al. (2015). The vertical localization function of satellite radiance observations was also changed from a normalized weighting function to the maximum of the normalized weighting function and Gaussian function with a length scale of 0.8 for scale heights centered at the peak of the weighting function.

3. Retrospective experiment results

A set of retrospective experiments was performed before approval of the upgrade for implementation in the operational system. The experimental periods covered 00 and 12 UTC initials from June 20 2016 to October 11 2016 (summer) and from November 20 2016 to March 11, 2017 (winter). In addition, all four initials (00, 06, 12 and 18 UTC) from 2016 to 2018 for periods when any TCs were present in the Northwestern Pacific were covered for verification of TC track forecasts. Two experiments were performed with the previous (CNTL) and new (TEST) versions of the Global EPS.

Figure 1 compares the spread of 500-hPa geopotential heights [m] in the Northern Hemisphere extra-tropics (20 – 90°N) in the summer experiment. The spread increased in forecasts with lead times up to nine days, thereby improving the spread-skill relationship of medium-range forecasts (i.e., those with lead times of five days or more; not shown). Figure 2 shows an example involving ensemble track forecasts for Typhoon Mangkhut (2018). It can be seen that the new system exhibits a larger spread for central positions of the TC for short-range forecasts in particular. This mitigates the underdispersiveness of TC positions and improves the skill of strike probabilities for TCs in the Northwestern Pacific in forecasts with lead times of up to three days (not shown).

References

Ménétrier B., T. Montmerle, Y. Michel and L. Berre, 2015: Linear filtering of sample covariances for ensemble-based data assimilation. Part I: Optimality criteria and application to variance filtering and covariance localization. *Mon. Wea. Rev.*, **143**, 1,622 – 1,643.

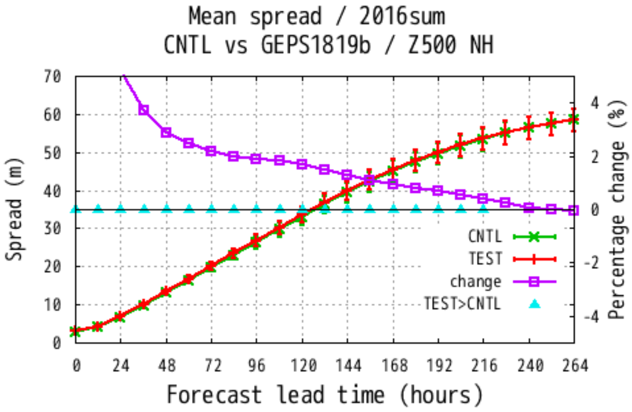

Figure 1 Spread of 500-hPa geopotential height [m] in the Northern Hemisphere extra-tropics (20 – 90°N) in the summer experiment. The horizontal axis shows the forecast lead time in hours, and the green and red lines show the spread (left axis) of CNTL and TEST, respectively. The purple line shows the normalized change of the spread [%] (right axis). The light-blue triangles indicate that increases of the spread in TEST are statistically significant with 95% confidence based on the bootstrap method.

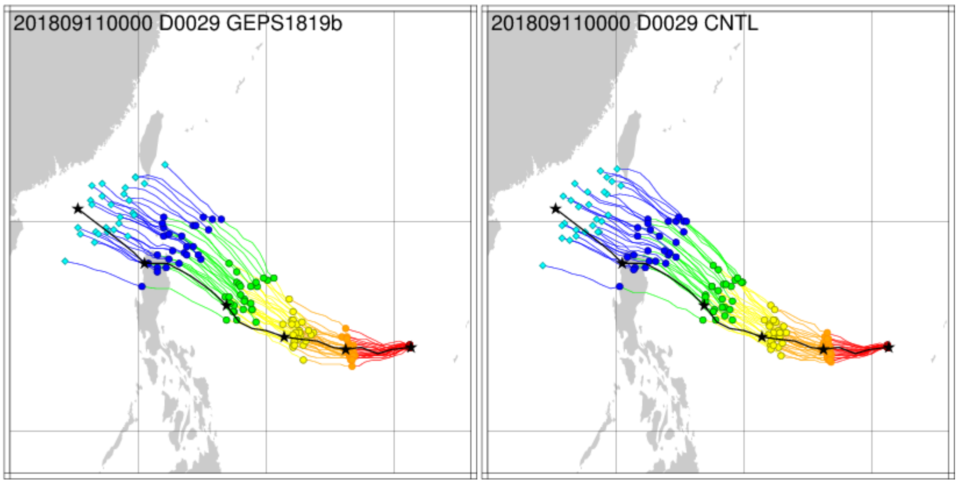

Figure 2 Central position forecasts for Typhoon Mangkhut (2018) at 00 UTC on September 11 2018 (initial) for TEST (left) and CNTL (right). The black line follows best-track analysis positions produced by RSMC/Tokyo. Red, orange, yellow, green, dark-blue and light-blue markers show TC central positions in forecasts with lead times of 0, 1, 2, 3, 4 and 5 days, respectively.