Comparison of Two Tropical Cyclone Bogussing Schemes

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1. Introduction

Recently, the air force weather agency (AFWA) and NCAR (2001) proposed a scheme for bogussing TC into the initial condition of MM5 (Pennsylvania State University-National Center for Atmospheric Research non-hydrostatic Mesoscale Model version 5). And a litter earlier, Zou and Xiao (2000) developed a new bogussing approach by using a four dimensional variational data assimilation technique (4DVAR). Although these two schemes had improvements in different aspects of the bogussing technique, relatively few attempts have been made to systematically study their impact on numerical TC forecasts, particularly for those in the western North Pacific (WNP). The objective of this study is therefore to compare the impact of these two bogussing schemes.

2. Bogus data assimilation (BDA) and NCAR-AFWA (N-A) bogussing scheme

The BDA method includes: (1) prescribing an axisymmetric sea-level pressure (SLP) distribution from the Fujita formula; and (2) assuming temporal change of SLP is relatively small within 30 minutes so that the bogus SLP field is assimilated every two time steps.

The NCAR-AFWA bogussing scheme also includes two primary steps: (1) Once the first-guess vortex is located by searching the maximum vorticity, the vorticity, geostrophic vorticity and divergence are modified. Changes in the non-divergent stream function, geopotential and velocity potential are then computed, which are used to calculate a modified velocity field. (2) The bogus axisymmetric vortex with wind given by the Rankine vortex, nonlinear balanced mass and wind, and nearly saturated core is implanted into the background using a weight function.

3. Results and discussion

An example of the impact on the initial conditions is presented for the case of Rusa in its mature stage. The initial vortex becomes more intense and realistic, with the center of the maximum winds closer to the vortex center (Fig. 1a and 2a). A warm and wet core in the mid troposphere is adjusted by the N-A scheme (Fig. 2b and c). Meanwhile a more realistic vertical structure is obtained from BDA scheme, with a wet center near the low troposphere, and a warm core which becomes warmer and larger with increasing height until upper troposphere (Fig. 1b and c).

The results from the 41 cases occurring over the WNP in 2002 suggest that the adjustments in the initial structures cause improvements in TC track predictions (Fig. 3a). The mean 24-h position error for the BDA experiments is reduced from 175 to 121 km, and the 48-h error from 238 to 189 km, the reductions being 31% and 21%, respectively. The improvements for the N-A experiments occur however, only up to the 42-h prediction. The vortex in six cases has larger initial location and intensity errors after using N-A bogussing scheme, and with these six cases rejected, the mean track errors become smaller than the CTRL experiments at all the forecast times. The improvements in the intensity forecasts are significant using BDA scheme, but it seems the N-A bogussing scheme has a negative impact on the intensity predictions.

The results show that the BDA scheme has better performance in both track and intensity forecasts, and although the initial wind fields in N-A scheme seem more reliable, they are unable to be maintained during integration.

References

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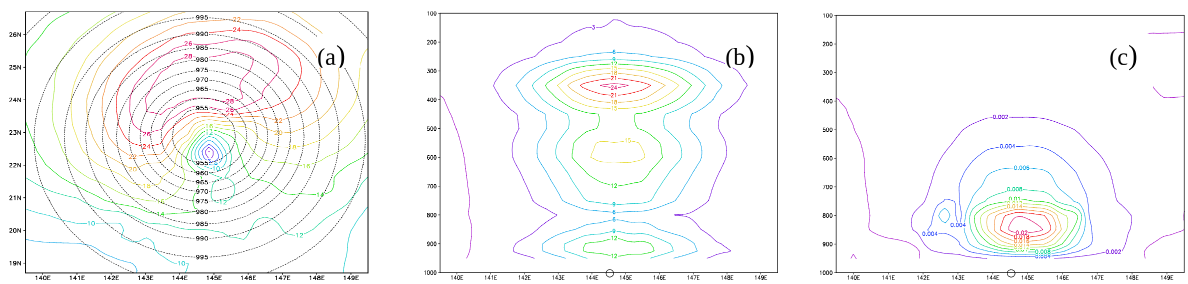

Fig. 1 (a) Distributions of SLP and wind speed fields at 850 hPa,

and east-west cross section of (b) temperature and (c) specific humidity differences between CTRL and BDA

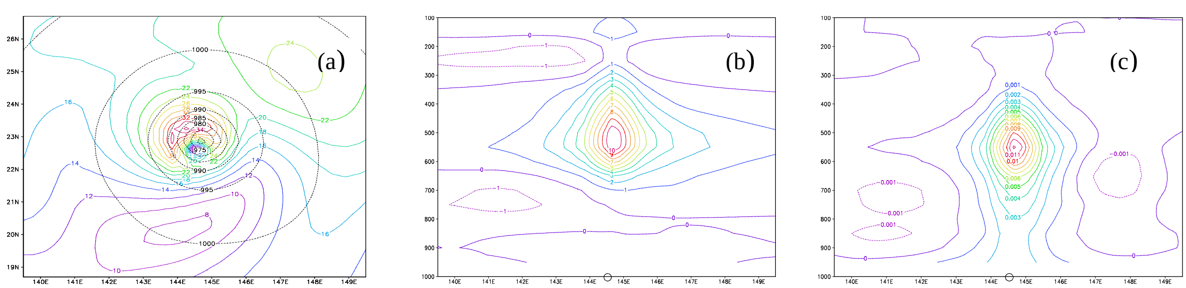

Fig. 2 Same as Fig. 1 but for N-A bogussing scheme

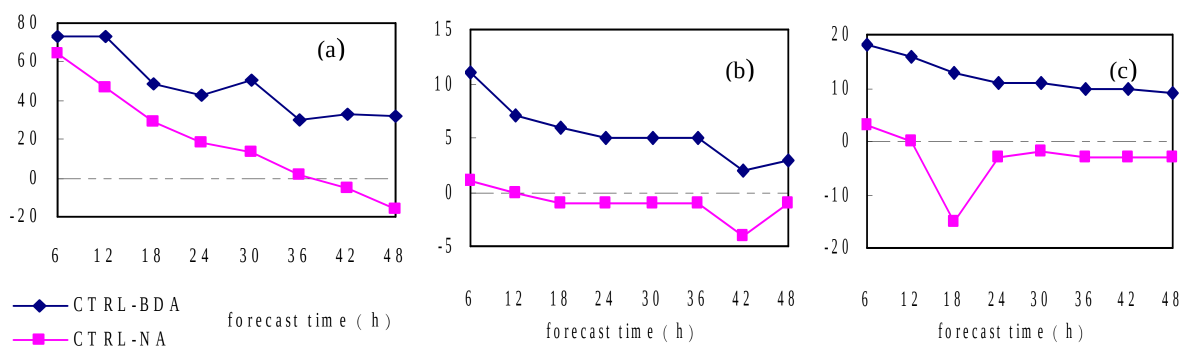

Fig. 3 Differences of forecast errors between CTRL and BDA or N-A scheme for

(a) TC track (km), (b) maximum winds (m s^{-1}) and (c) MSLP (hPa)