Impact of GMS-5 Cloud-drift Winds on the Track Prediction of Tropical Cyclones

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1. Introduction

The assimilation of cloud-drift winds into numerical-weather-prediction models for tropical cyclones has been done in the past using some simple schemes such as the three-dimensional optimum interpolation method (e.g. Goerss et al. 1995; Brian et al. 2001). Such assimilations generally resulted in some reductions in the mean track errors. Recently, Xiao et al. (2002) examined the impact of satellite-derived winds on the prediction of a mid-Pacific cyclone using a more sophisticated tool – the four-dimensional variational (4DVAR) data assimilation method. They demonstrated that the data only had a slight positive impact on the prediction, although their study was limited to only five time-lag experiments. The objective of this study is to carry out a set of 4DVAR experiments to assess further the impact of cloud-drift winds from the Geosynchronous Meteorological Satellite 5 (GMS-5) on the initial conditions and track predictions of tropical cyclones (TCs) in the western North Pacific (WNP).

2. Cloud-drift wind dataset and assimilation methodology

The data assimilated in this paper are derived from GMS-5 infrared and water vapor imageries and provided by the China National Satellite Meteorological Center. About 70% of the multispectral winds are observed above 400 hPa, and 50% of the data are between 200 and 300 hPa.

Experiments are carried out using the nonhydrostatic National Center for Atmospheric Research Mesoscale Model Version 3.3 (MM5) and its 4DVAR system. A 6-h assimilation window is used to incorporate the cloud-drift winds at the initial time and 6 h later. Previous statistics suggest that the error in the upper-troposphere cloud-drift winds is ~ 6 m s^{-1}. Therefore, a simple quality control similar to the first-guess check in the ECMWF system is used here: any cloud-drift wind with a difference from the MM5 original analysis > 3 times the error, i.e. 18 m s^{-1}, is rejected.

Twenty-two cases are examined for 8 different WNP TCs in 2002. Forecasts up to 48 h are performed with the original and 4DVAR-assimilated initial conditions.

3. Results

An example of the impact on the initial conditions is presented for the case of Phanfone (Fig. 2). The largest adjustment through assimilation occurs south of the typhoon center (30^{O}N，138^{O}E). The original MM5 analysis produces inaccurate south to southwesterly winds (Fig. 2b). Assimilation of the cloud-drift winds apparently brings back the observed anticyclonic circulation (Fig. 2c) so that the flow in this area is very close to that observed (Fig. 2a).

The effectiveness of the assimilation of the cloud-drift wind data apparently varies with TC intensity. For a strong TC (e.g. Sinaku, central pressure 960 hPa, Fig. 2a), the track errors are reduced at all the forecast times. However, for a weak TC (e.g. Fungwong, central pressure 975 hPa, Fig. 2b), the track errors are increased at two forecast times.

If a central pressure of 960hPa is selected as the demarcation between strong and weak TCs, the mean track error changes for the strong TCs show that assimilation of cloud-drift winds gives significant improvements, with track error reductions of 25% and 21% at 24 and 48 h respectively (Fig. 3). However, for weak TCs, slight increases in track errors are observed.

4. Discussion

The results from these 22 cases suggest that track prediction of strong TCs is more sensitive to the upper tropospheric data, which is reasonable since these have a deeper vertical structure than the weak TCs. More case studies are required to ascertain this conclusion. It would also be of interest to examine cases of weak TCs in which lower tropospheric cloud-drift winds are available.

References

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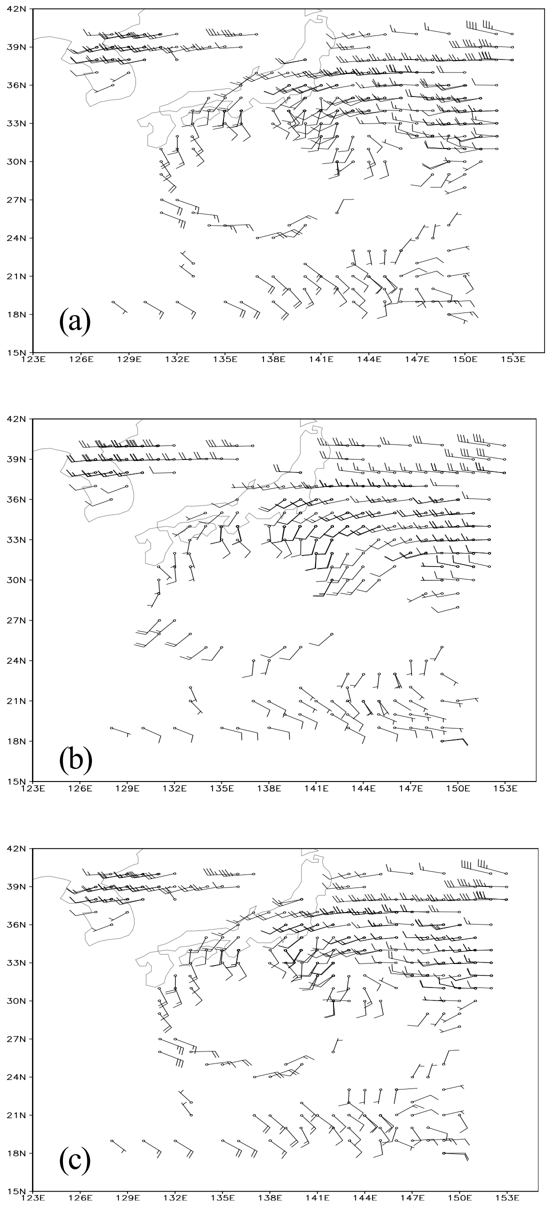

Fig. 1. (a) The cloud drift winds at 1200 UTC 17 August 2002 at 250-300hPa, (b) original analysis and (c) analysis with 4DVAR-assimilated cloud-drift winds.

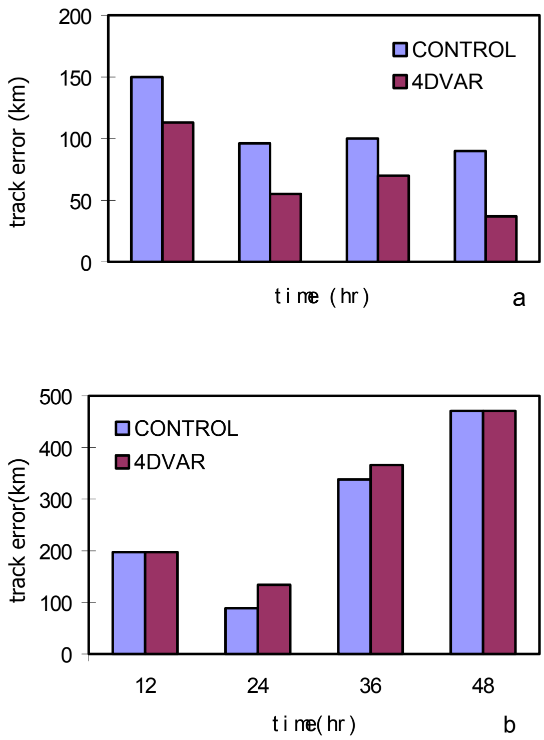

Fig. 2. Track errors from (a) Typhoon Sinlaku at 1200 UTC on 3 Sep 2002, and (b) Tropical Storm Fungwong at 0000 UTC on 25 Jul 2002.

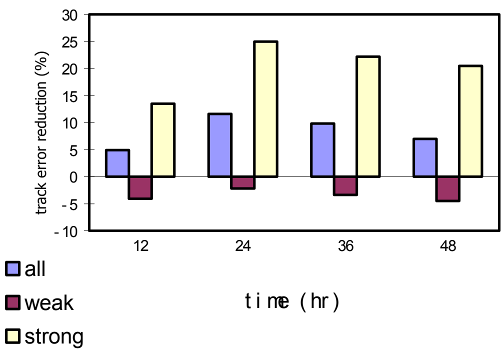

Fig. 3. The mean percentage reduction in track errors due to the assimilation of cloud drift winds for different types of TCs.