Case Study on the Impact of Radar-derived TREC Winds on Model Forecast of Heavy Rain Associated with Landfalling Tropical Cyclone

C.C. Lam
Hong Kong Observatory, Hong Kong, China
cclam@hko.gov.hk

The initialization of numerical simulations using radar-derived winds has been studied for around a decade (Crook and Tuttle, 1994). In recent years, applications of radar data in operational mesoscale models become increasingly popular. Many techniques exist for retrieving horizontal winds from radar data, including dual-Doppler, TREC (Tracking Radar Echoes by Correlation), reflectivity conservation methods (Qiu and Xu, 1992; Laroche and Zawadsky, 1993; Shapiro, 1993) and the adjoint method applied to the radial momentum equation (Xu *et al*., 1993).

This study assessed the potential of the application of TREC winds in initializing tropical cyclones, using the case of tropical cyclone Kammuri (0212) in 2002. Numerical experiments on the assimilation of TREC winds were performed at the Hong Kong Observatory (HKO) using the hydrostatic Operational Regional Spectral Model (ORSM) and the non-hydrostatic Advanced Regional Prediction System (ARPS). The TREC method was based on the assumption that reflectivity features are transported by the local flow. It was originally adapted for use in the HKO for nowcasting purpose (Li *et al.*, 2000).

The ORSM was configured to run at a 20-km inner domain one-way nested inside a 60-km domain with 36 vertical levels. The ARPS was run at a 6-km inner domain one-way nested inside a 30-km outer domain with 40 levels. The boundary conditions of both outer models were provided by the Global Spectral Model (GSM) of Japan Meteorological Agency (JMA). The ORSM employs 3-dimensinal multivariate optimal interpolation. The ARPS Data Assimilation System (ADAS) adopts the Bratseth successive correction scheme. In the ADAS, radar velocity and reflectivity data were assimilated. The Doppler radar velocity data were utilized to calculate increments to the horizontal winds by estimating the Cartesian component increment from the radial winds.

The impact of TREC winds on model rainfall forecasts was evaluated with and without the presence of tropical cyclone bogus data. TREC winds at 1 km and 3 km levels were assimilated in the models. Figure 1(a) and (b) shows the radar reflectivity data and the radar-derived TREC winds at 3-km level valid at 18 UTC 4 August 2002 respectively. The circulation of Kammuri was well depicted by the TREC winds.

With the assimilation of TREC winds, the ARPS predicted generally higher rainfall intensities in the first few hours (Fig.2(a) vs. Fig.2(b)). The impact was still observable in later forecast hours (figures not shown). For the ORSM, the impact of TREC winds was less prominent that that of ARPS (Fig.3(a) vs. Fig3(b)). The ORSM was not very sensitive to the use of TREC wind data. Instead, the effect of TC bogus data was significant (figures not shown).

Indications are that additional radar derived wind data like TREC winds with finer vertical resolution may produce a more substantial impact on the rainfall forecasts of tropical cyclone upon landfall. Further experimentation with TREC winds with finer vertical resolution in addition to Doppler velocity data will be carried out. Effort will continue in the development of better methods to utilize radar in mesoscale models, particularly for the forecasting of winds and rain associated with landfalling tropical cyclones.

References

Crook, A., and J.D. Tuttle, 1994: Numerical simulations initialized with radar-derived winds. Part II: Forecasts of three gust-front cases. *Mon. Wea. Rev*., **122**, 1204-1217.

Laroche, S., and I. Zawadzki, 1993: Echo tracking by three variational analysis methods. *Proc. 26th Int. Conf. on Radar Meteorology*, Norman, OK, Amer. Meteor. Soc., 438-440.

Li, P.W., W.K. Wong, K.Y. Chan, and E.S.T. Lai, 2000: SWIRLS – An Evolving Nowcasting System. Technical Note, No. 100, Hong Kong Observatory.

Qiu, C.-J., and Q. Xu, 1992: A simple adjoint method of wind analysis for single-Doppler data. *J. Atmos. Oceanic Technol.*, **9**, 588-598.

Shapiro, A., 1993: A single-Doppler velocity retrieval in the convective boundary layer. *Proc. 26th Int. Conf. on Radar Meteorology*, Norman, OK, Amer. Meteor. Soc., 441-443.

Xu, Q., C.-J. Qiu, J.-X. Yu, H.-D. Gu, and M. Wolfson, 1993: Adjoint-method retrievals of microburst winds from TDWR data. *Proc. 26th Int. Conf. on Radar Meteorology*, Norman, OK, Amer. Meteor. Soc., 433-434.

Acknowledgments

The ORSM was developed based on the RSM of Japan Meteorological Agency. The ARPS was originally developed by CAPS of the Univeristy of Oklahoma.

(a) (b)

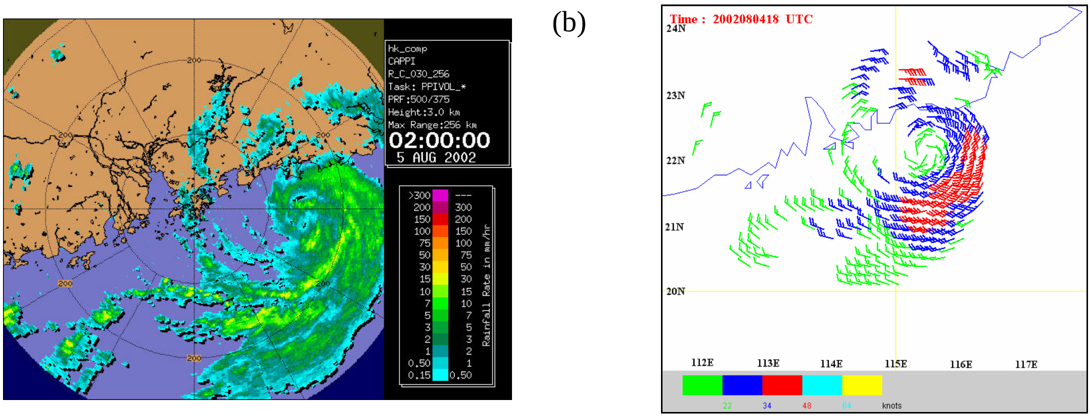

Fig.1 (a) Rainfall reflectivity and (b) radar-derived TREC winds at 3-km level valid at 18 UTC 4 August 2002.

(a) (b)

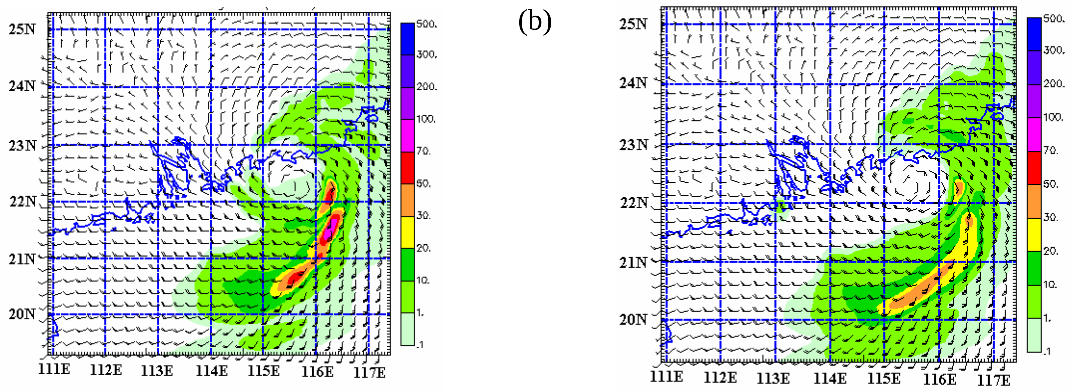

Fig.2 6-km ARPS T+3 h forecast for 3-hourly accumulated rainfall (mm) and surface winds (a) with TREC wind data and (b) without TREC wind data. The model valid time is 21 UTC 4 August 2002.

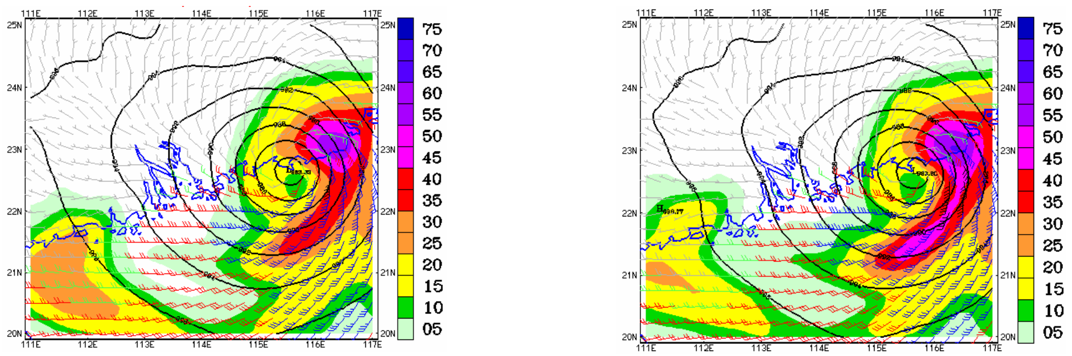

Fig.3 Same as Fig.2 except for 20-km ORSM.