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Problems and Solutions in Real-time Doppler Wind Retrievals

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1.Introduction

A prototype single-Doppler wind retrieval system is developed for real-time applications of level-II Doppler radar data. This system has been running since June 2002 on a small but dedicated workstation to retrieve high-resolution vector wind fields from nine radars and produce real-time displays with data files on-line (http://gaussian.gcn. ou.edu: 8080/rtime.shtm). The products of the system are expected to provide verifications for model predictions and input super-observations for mesoscale data assimilation. The reliability of this real-time system and the qualities of input data and the retrieval products have been monitored since then. The data quality problems encountered and quality control (QC) algorithm developed are reported in this paper.

2. System components

The system contains four components to perform the following four steps of operations: (1) level II data fetching and decoding, (2) input data quality controlling, (3) 2dVar vector wind retrieving, and (4) product quality checking and graphic displaying. The WDSSII package (developed by NSSL) was used in the early version of QC for velocity dealiasing and range unfolding in step 2. This package alone was found insufficient (see the next section) and additional QC procedures were subsequently incorporated in step 2. In step 3, the vector wind field is retrieved on 0.5^{o} tilt of radar scans by a 2dVar package with the retrieved wind field expressed by a truncated expansion of B-spline basis functions (Xu, et al., 2001), constrained by weak divergence and vorticity penalty functions, and processed by the recursive filter. The retrievals were found to be reasonably good (or contain unrealistic features) when the input data had no (or had) quality problem. A post QC procedure was subsequently added in step 4 before the graphic displaying. This post QC has been also used for automated monitoring and detecting quality problems in the original level II data.

3. Classifications of data quality problems

Various data quality problems have been encountered in the real-time level II radial velocities from nine radars since June 2002. The problems can be classified into the following four types: (1) extremely noisy field, (2) unsuccessful dealiasing, (3) irregular variations associated with a switch of radar scanning mode, and (4) contamination due to biological flying objects (especially migrating birds). An example of type-1 problem is shown in Fig. 1 for the raw level II radial velocities from KPBZ at 22:16 UTC on 08 October 2002. This type of noisy field is often seen when very weak meteorology echoes are observed with a clear air radar scan mode. The retrieved wind field from this scan was unrealist1ic (not shown).

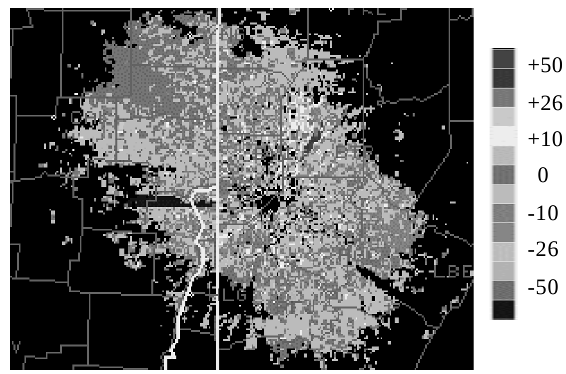

Fig. 1. Noisy radial-velocity field from KPBZ.

An example of type-2 problem is shown in Fig. 2a for the raw data from KBUF at 10:04 UTC on 19 December 2002. Figs. 2b and 2c are for the raw and dealiased data, respectively, along the circle of 220 km radius. Aliased data are seen between 240 and 280^{o} and between 330 and 360^{o} (Fig. 2b), but dealiased successfully only between 330 and 360^{o} (Fig. 2c).

The operational radars use four different scan modes for different types of weather. The type-3 problem occurs during the process of switching mode. The type-4 problem is examined in Zhang et al. (2003).

4. Raw data QC and post QC

To automatically detect the above listed data quality problems, QC algorithms need to be developed to extract and quantify the main features and/or key signatures exhibited in each type of problems. The algorithms should be relatively simple so they can be reliable and computationally efficient for automated on-line applications. The algorithms so far developed compute and check the following

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statistics and signatures in the radial-velocity field on each tilt of radar scans: (1) the percentage of along-beam sign changes with respect to beam-averages, (2) the standard deviation with respect to along-beam nine-point averages, (3) coupled large jumps of radial velocity in the azimuthal direction, (4) any switch of radar scan mode, and (5) any signature of migrating birds (Zhang et al. 2003). Threshold values are determined semi-empirically and semi-statistically for the above (1) and (2) to detect type-1 problem and to provide reference indices for type-4 (migrating birds) problem. The threshold value for the above (3) is related to the Nyquist velocity to detect type-2 problem (unsuccessful dealiasing). Information for a mode switch is contained in the raw level-II data. The checking steps and thresholds used by this raw data QC are summarized by the flow chart in Fig. 4.

Owing to the complexity of data quality problems, it is very difficult to automatically detect and eliminate all the problems in the raw data from radar observation. Bad data not detected by the above raw-data quality control can cause unrealistic retrievals. A post-quality control is developed to check the quality of the retrievals and thus to further detect quality problems not detected by the raw data quality control. The current post-quality control monitors the maximum value of the retrieved wind field on each tilt and the correlation between two successive retrieved wind fields. With this post-quality control, some raw-data quality problems undetected by the raw data quality control can be further detected.

5. Conclusions and future work

The raw data QC and post QC algorithms developed for the real-time single-Doppler wind retrieval system are proven to be efficient but not perfect. Raw level-II velocity data quality problems are being continuously monitored (although for a limited number of radars). A data base is being built to accumulate information needed to improve the existing quality control algorithms, so the related threshold values can be determined statistically and systematically (rather than empirically). The raw data QC algorithm package is expected to be delivered to NCEP for operational tests in the near future.

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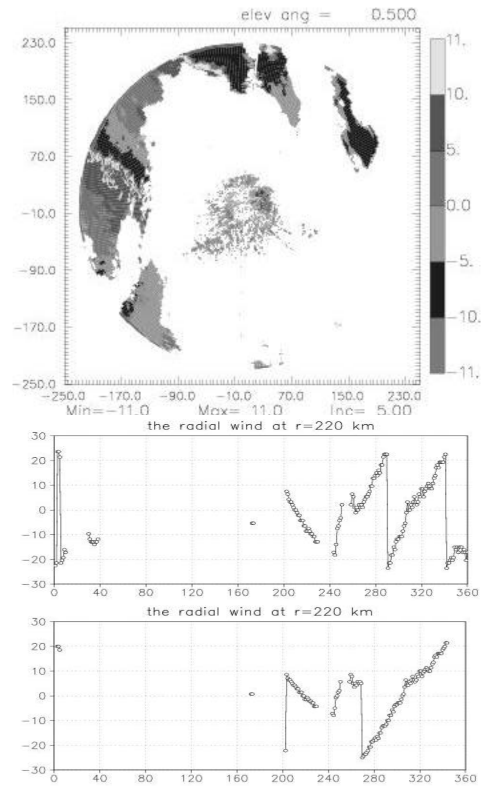

(a) (b) (c)

Fig. 2. Radial-velocity display at 0.5^o tilt (a), raw (b) and dealiasrd (c) radar velocity data along the circle of 220 km radius from KBUF

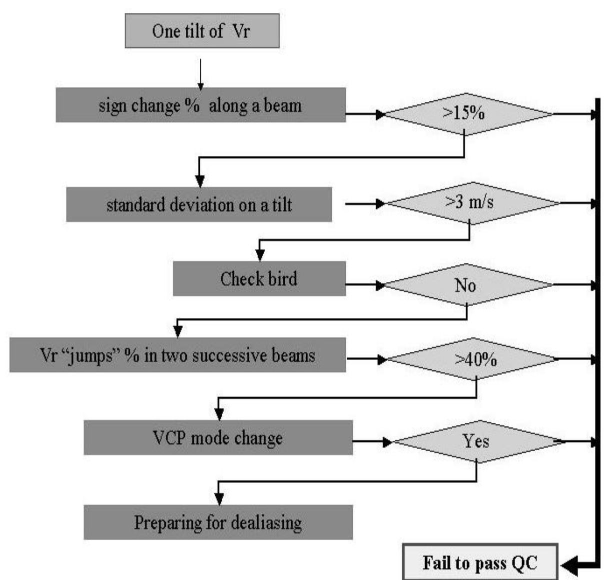

Fig. 3. Flow chart of the raw data QC system.

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