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Real-Time WSR-88D Velocity Data Quality Control on Bird Detection

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1. Introduction

VAD winds from WSR-88D radars were first used in the Rapid Update Cycle-2 data assimilation system in June 1997. This was followed by use in the Eta model's 3-dimensional variational assimilation system in July 1997 and in the Global SSI assimilation system in February 1998. However, many problems with the VAD winds became evident, and all operational use of the VAD winds ended in January 1999. Investigations at NCEP (Collins 2001) showed that VAD winds could be most frequently contaminated by radar signal returns from migrating birds in the nighttime during the migrating seasons. The problem showed as a north-south wind component that was too strong from the north in the spring and too strong from the south in the fall within preferred limits of altitude and temperature. Doppler velocity (Vr) data quality problems caused by migrating birds were notorious. The existing operational quality control (QC) identifies bird problems purely based on observed increments (differences between VAD winds and 6-hour forecast winds interpolated to observation locations) together with the wind speed and height-time residuals. As real-time WSR-88D level-II data will soon become available for operational data assimilation at NCEP, new data QC should be developed to take advantage of high-resolution level-II data. This is the motivation of this study. In particular, a prototype single-Doppler wind retrieval system is developed for real-time applications of level-II Doppler radar data. This system has been used to produce vector wind retrievals and monitor data qualities since June 2002. The general aspects of data quality problems encountered and QC algorithms developed are reported in Liu et al. (2003). This paper is focused on data quality problems caused by biological flying targets (birds and insects), especially migrating birds.

2. QC parameters for bird detection

As described in Gauthreaux and Belser (1998), bird echoes have their signatures such as disk-like/annular shape with peak reflectivity 15-30dBZ. By using polarimetric radar observations, rawinsonde winds, and satellite images, the true existences of birds can be verified. Then, bird echoes can be subjectively separated from other echoes. When this technique of echo separation was used in Zhang et al. (2002), a simple QC parameter was identified for bird detection, which is the standard deviation (SD) of Doppler radial velocity with respect to along-beam nine-point averages. This parameter was used for bird detection.

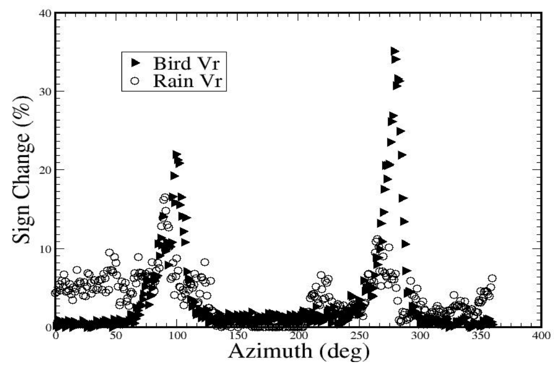

Fig. 1. Beam-to-beam variations of SC percentage on 0.5^o of KTLX scans in the presence of birds (triangles) and KPBZ scans in the presence of rain (circles).

In this study, additional QC parameters are identified, which include the averaged percentage of along-beam sign changes (SC) for Vr within the range of |Vr| < 5 m/s, the averaged SD, and the averaged reflectivity on each tilt of radar scans. The SC percentage is computed by first dividing the number of SC by the total number of gates with |Vr| < 5 m/s along each beam and then averaging the computed ratios over the entire tilt. As shown in Fig. 1, the beam-to-beam variations of the SC percentage reveal a major difference between the KTLX 0.5^o scans in the presence of birds on 4 November 2002 and the KPBZ 0.5^o scans in the presence of rain on 5 November 2002. Note that the mean wind was northerly (or southerly) over KTLX (or KPBZ), so Vr became nearly zero (not shown) around the azimuths of 90^o and 270^o where the radar beam was perpendicular to the mean wind. This explains why the SC percentage increases sharply around 90^o and 270^o in the presence of birds, but not so in the presence of rain only. Since the SC percentage is clearly higher in the presence of birds than in presence of rain, it can be used as a new QC parameter, in addition to the SD and averaged SD, to measure the granulation of Vr fields. This parameter costs almost no additional computation.

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3. Determination of QC thresholds

On 1 April 2003, typical migrating bird signatures (disk-like reflectivity patterns and favorite tailwind) were showed on radar images. The averaged reflectivity increased slowly to its nighttime maximum 3.5dBZ at 04:30UTC (Fig.2a). The averaged SC percentage increased sharply and reached 20% around 11:00UTC (06:00CDT), then decreased gradually during the daytime. The time variations of the averaged SC percentage are well correlated with the evolution of bird signatures in the radar images (not shown). The situation becomes very different in the presence of rain (or absence of bird). For example, as shown in Fig. 2a, when a scattered thunderstorm passed over Oklahoma and observed by KTLX during the period from 00UTC to 17UTC on 20 May 2003, the averaged SC percentage was recorded lower (< 7.5%) and the average reflectivity was higher (> 5dBZ). The QC threshold can be then determined from these (and other) time series of the averaged SC percentages.

The time series of the QC parameters identified above and in Liu et al. (2003) are also useful for general studies of data quality problems in the WSR-88D level-II velocities. As these time series are recorded by the real-time single-Doppler wind retrieval system, a database is being built. This database will be used for sorting information needed for systematic studies of bird echo, statistic evaluations of QC parameters and determinations of QC thresholds.

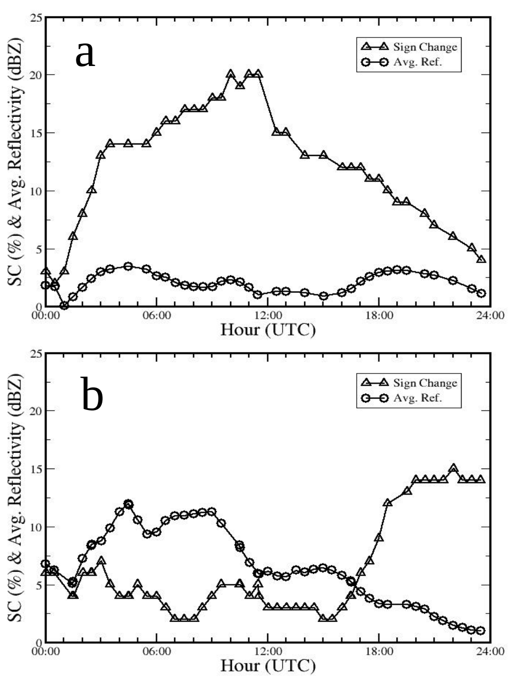

Fig. 2. Time series of SC percentage and average reflectivity of KTLX on 1 April (a) and 20 May (b) 2003.

4. Conclusions and future works

The current radar data QC algorithms are focused on two-dimensional textures of Doppler velocity and reflectivity fields on each tilt of radar scans. This two-dimensional approach is found to be particular suitable for operational applications due to its high resolution in texture identification and high efficiency in computation, although three-dimensional approach may add more information to the classification algorithms in general. Bird-echo related high-resolution textures and patterns often could be identifiable by an experienced researcher but hard to detect by an automated computer algorithm. Converting human experiences into automated computer algorithms is and will continue to be one of challenging tasks for bird-echo identifications and for level-II data QC in general. To meet this and other challenges in level-II data QC, problematic cases will be continuously detected and recorded by the above and other selected parameters (Liu et al. 2003) through the existing real-time retrieval system. KTLX level-II data will be selected from these cases and compared with additional observations from the NSSL S-band polarimetric radar, OUN rawinsondes, and GOES satellites. These additional observations are expected to provide ground validation for the existence of migrating birds. So the parameters and related QC threshold values selected empirically in this study can be greatly improved, as they will be determined statistically and systematically. The results will be reported at the conference.

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