CFL-16 Wind profiler Radar

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ABSTRACT

Vertical motion information is very useful in the application, such as short range forecasting, but vertical velocity measured by single wind profiler radar (WPR) fluctuate intensively with time and altitude, due to irregular motion of atmospheric turbulence. Data from one time measure of WPR only represent motion of air in small scale. So it is usually hard to be directly used into the application like predicting and forecasting. Vertical velocity data collected from a troposphere CFL-16 WPR have been studied, The results show that although the existence of fluctuation of vertical wind, after data quality control (QC), such as confidence estimate based on signal to noise ratio (SNR) and appropriate filter processing, the estimate of vertical velocity and its evolution with time and altitude have reasonably described the atmospheric motion, that is effective for short range forecasting or now casting. This paper describes the CFL-16 WPR and its performance especially in aspect of vertical observation and some examples are provided.

Key words: wind profiler radar, vertical velocity， data quality control

1. INTRODUCTION

Early in 1980s, First wind profiler radar (WPR) was produced by China Aerospace Science & Industry Corp. (CASIC) and China academy of meteorology science (CAMS). It had played an important role in meso-scale meteorological research and in social service. Recent years, the technology of WPR has been improved perfectly in China. Several types of entire solid-state phased array WPR have been produced by several institutes and radar manufacturers.

CFL is one of WPR series made by CASIC. It includes CFL-03, CFL-08 and CFL-16 three types WPR. They represent boundary layer, mid-troposphere and troposphere WPR respectively. And CFL-03 has mobile and fixed two sub-types. Mobile CFL-03 use micro-strip antenna, fixed CFL-03 use paraboloid antenna. Now CFL series has been used in meteorology and aviation service in China.

First CFL-16 WPR was produced in 2005 and passed field experiment successfully. In this paper, the data from the experiment was gathered to estimate its performance. In section 2, the main feathers of CFL-16 WPR are introduced. And in section 3, some examples of vertical velocity observation are provided to show its performances. About CFL-08 and CFL-03 see appendix please.

2. The CFL-16 Wind profiler Radar

CFL-16 is troposphere type wind profiler radar, figure 1. Its specification is show in table1. CFL-16 works in UHF frequency band, typical working frequency is 450MHz. The working frequency can be adjusted according to the need of user. One of unique feature of CFL-16 is its antenna system. CFL-16 utilizes half-wave dipole as its element of phased array. That is convenient to obtain excellent beam characteristic. The size of the antenna is typically about 100 m^2, but it can be adjusted slightly to meet user's demands. The antenna gain is 33dB, near side lobes are samller than -21dB, fart side lobes are samller than -33dB.

In unit of transmitter and receiver solid-state transmitter-receiver (TR) have been widely used in CFL system. That makes CFL-16 with very high quality. CFL-16 use digital MF receiver to obtain a large dynamic rage, no mater it rains or not, CFL-16 works same well.

The measurement range of CFL-16 is from 150m to 16km. It has low, middle and high 3 working modes. In low mode, a part of antenna elements work, thus a relative low observing height can be reach. The minimum height is 150m. Although it has the ability to reach much lower observing height, the quality of data will be getting poor due to the interference of ground clutter. In different working model, it utilizes different pulse width, in low mode with narrow pulse width to get high vertical resolution, in high mode with wide pulse width to obtain enough energy.

Period of one entire observation is about 5-6 min. it also can be changed to adjust operating parameters such as integration times and spectral averaging times.

Fig. 1: CFL-16 wind profiler

Working frequency	445MHz	Antenna	Dipole Phased array
Peak power	23 kW	Aperture	$100\,m^2$
Average power	1.04 kW	Gain	33dBi
Number of beams	3-5	Direction	15^0
Minimum height	150m	Bandwidth	5^0
Maximum height	16km		
Vertical resolution	120m,240m, 480m	PRF	5040.32 Hz

Table1. TFL-16 specifications

3. Performance of CFL-16

a. available data rate

Available-data-rate means the rate of available data to total data observed by WPR. It can be an index to estimate the capability of a WPR system. Figure 2 is the available-data-rate of CFL-16 wind profiler radar. From Figure 2, below 12km available-data-rate is bigger than 90%.

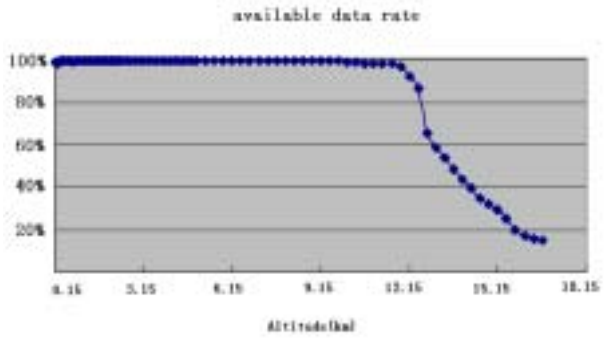

Fig. 2: Available-data-rate of CFL-16

b. vertical velocity measurements

CFL-16 provides many products, such as vertical profile of horizontal wind, vertical wind, and refractive structure parameter (C_n^2) and so on.

Because the turbulent motion, vertical wind fluctuate with time and altitude. And because of ground clutter and random interference, vertical wind data usually have relative lower quality. So, before vertical wind been applied, QC and averaging processing are necessary.

Figure 3 a, b and c are example of vertical speed and echo power observed by CFL-16 during summer season in Beijing, top is vertical speed and bottom is echo power in each picture. Y drectory is altitude in meter unit, X axis is time in hour unit. Valud of vertical speed are displayed with color scale. Cool color such as blue represent downward, warm color like red represent upward. Fique 3 is the result of after quality contoral and average processing. The temporal resolution of raw data is about 5-6 min. Some extreme error data have been identified and omited in advance, and then the raw data passed through a meadin average processing.

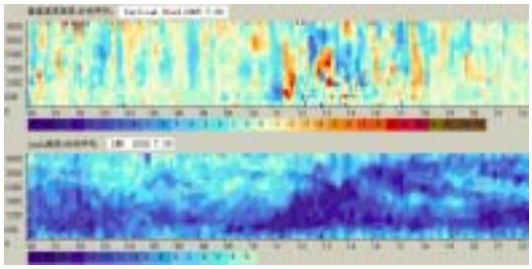

Fig.3a: top of boundary layer observed by CFL-16

In figure3a, the development of top of boundary layer with time is clearly. Due to heating by solar convection was getting intensity and altitude of top of boundary layer was getting high with time. That is very clear in the “height-time” display of echo power.

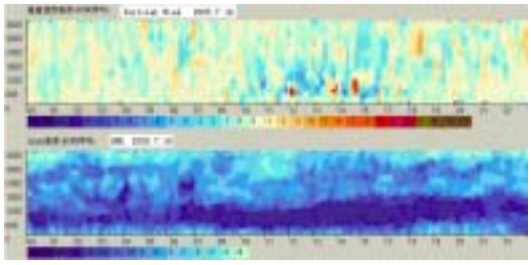

Fig.3b: heat convection observed by CFL-16

In figure3b, heat convection has been expressed clearly. It is getting stronger after noon time. Convective scale is about half an hour. Whether convective motion can go on developing, depend on the stability of atmosphere at that time. We can value the stability of atmosphere form the SNR data. SNR affected by water vapor, in top of boundary layer usually have maximum of SNR. So by using SNR, we can roughly estimate the top of boundary layer. In figure3b, the top of boundary layer was lower than 1800m, and heat convection was limited in boundary layer.

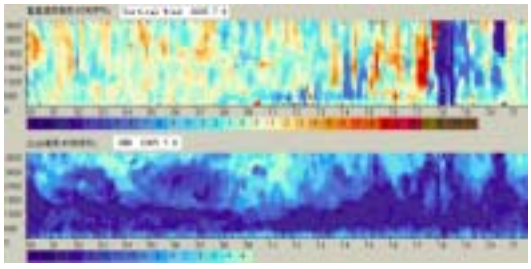

Fig. 3c: convection and precipitation

In figure3c, it was raining at 18' clock in Beijing time. Before it rained, convection had kept developing with time, convective height was higher than the top of boundary layer. From the echo power information, convective scale is about 3-4 hour. 4-5 hours before the rain, updraft was getting strong.

4. Conclusion

From the field experiment and preliminary estimate, CFL-16 has a high quality. Altitude cover form 150m to 16km, with very high data available data ratio. It provides much more information with high accuracy and high resolution. The information provided by CFL-16 is effective and helpful for prediction and short range forecasting application.

Fig. 4: CFL-08 Wind Profiler Radar with RASS

5. Appendix

Fig. 5: CFL-03 Wind Profiler Radar

		Frequency	1275～1375MHz
		Power	Peak power, 2kW
			Average power, 0.2W
		Minimum height	100m
		Altitude resolution	60～120m
		Maximum height	wind 3.6km
			temperature 1.5km
		Paraboloid	Aperture, Φ3m
		（fixed）	Gain,29dBi, 1320MHz
Resolution	Wind speed ＜1m/s	Temporal resolution	Wind, 6min
	Wind direction ＜10°		Temperature, 3min
	Temperature ＜1□		

Table2. TFL-03 specifications

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