Automated W-Bands/S-Band Radar Profilers for the ARM SGP 2001

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Abstract

The University of Massachusetts (UMass) and National Oceanic and Atmospheric Administration (NOAA) Aeronomy Laboratory deployed automated vertically profiling radar systems at the U.S. Department of Energy (DOE) Atmospheric Radiation Measurement (ARM) Program Southern Great Plains (SGP) Cloud and Radiation Testbed (CART) facility in Oklahoma for an extended intensive operational period (IOP) in 2001. Both radars were deployed within a few meters of the existing ARM 35-GHz millimeter wave cloud radar (MMCR) profiling radar, so that the IOP yielded a unique dataset of triple-wavelength data, which was collected over a nine-month period. This paper describes the radar and radar hardware performance. Two other papers by Williams and Khandwalla (also published in this proceedings) describe measurements.

Introduction

This paper provides an overview of hardware and software automation and describes the operation and reliability of UMass 95-GHz (W-band) cloud radar (Sekelsky and McIntosh 1996) at the ARM Program SGP CART site in Oklahoma during the ARM multi-filter radiometer (MFR) IOP. Here simultaneous measurements from the W-band radar, the NOAA Aeronomy Laboratory S-band radar (Ecklund et al. 1999; Carter et al. 1995), and the ARM 35-GHz MMCR were collected over a nine-month period. The MFR IOP has two goals. One is to collect vertically pointing radar reflectivity, Doppler and depolarization data during the spring and summer when insects contaminate measurements of low-level clouds collected by the CART site 35-GHz cloud radar. Research results obtained using the UMass 33-GHz/95-GHz cloud profiling radar system (CPRS) radar indicate that insect contamination is reduced by several orders of magnitude at W-band. However, a long dataset is needed to quantify insect clutter suppression at W-band over a variety of conditions. Second, Doppler spectrum observations of precipitation have shown how MFR can serve as a very accurate profiling rain gauge (Sekelsky et al. 1999). W-band and S-band are an ideal pair of radar bands for this purpose. W-band can accurately measure vertical winds in precipitation, while S-band is non-attenuating. Parameters for the three radars are summarized in Table 1 and a photograph of the systems at SGP CART is shown in Figure 1.

Table 1. Parameters for the S-band, W-band, and Ka-band radars.

	NOAA S-band	MMCR Ka-band	CPRS W-band
Frequency (GHz)	2.835	34.86	94.92
Transmit polarization	V	V	V or H
Receiver polarization	V	V	V and H
Peak power (kW)	0.38	0.1	1.5
Average power (W)	7.6	25	15
Antenna	3m dish with shroud	3m dish	1m lens
Two-way HPBW (deg)	3.2	0.19	0.2
Range resolution (m)	105 or 495	45 or 90	30 or 75
Noise figure (dB)	2.6	--	13
Min detectable reflectivity (dBZe) 1km, 30s averaging	-40	-60	-59

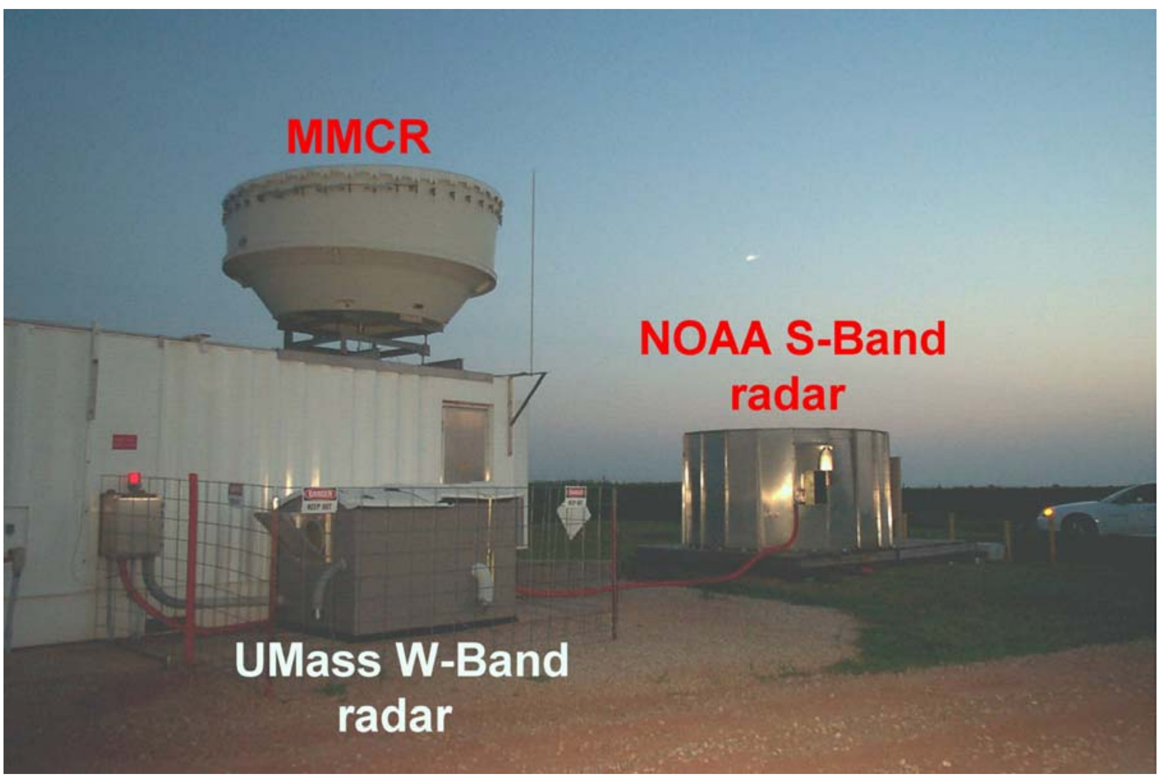

Figure 1. MMCR, S-band, and W-band radars at SGP CART site, Oklahoma.

95-GHz Radar Modifications for Autonomous Operation

Hardware and software modifications to the UMass CPRS W-band radar were required for continuous unattended operation. This work includes implementation of a network-based system remote control that allows the operator to change radar parameters through an internet connection, adding an embedded PC to record system "health" data, such as temperatures and voltages and developing a small computer network for monitoring system "health" variables, automatically processing raw data into NetCdf and GIF format images, providing a real-time display of data via a local Web site, and automatically uploading processed data to the ARM archive.

The automated UMass W-band radar system consists of several subsystems. Their interconnections are shown below in Figure 2, and details are provided below.

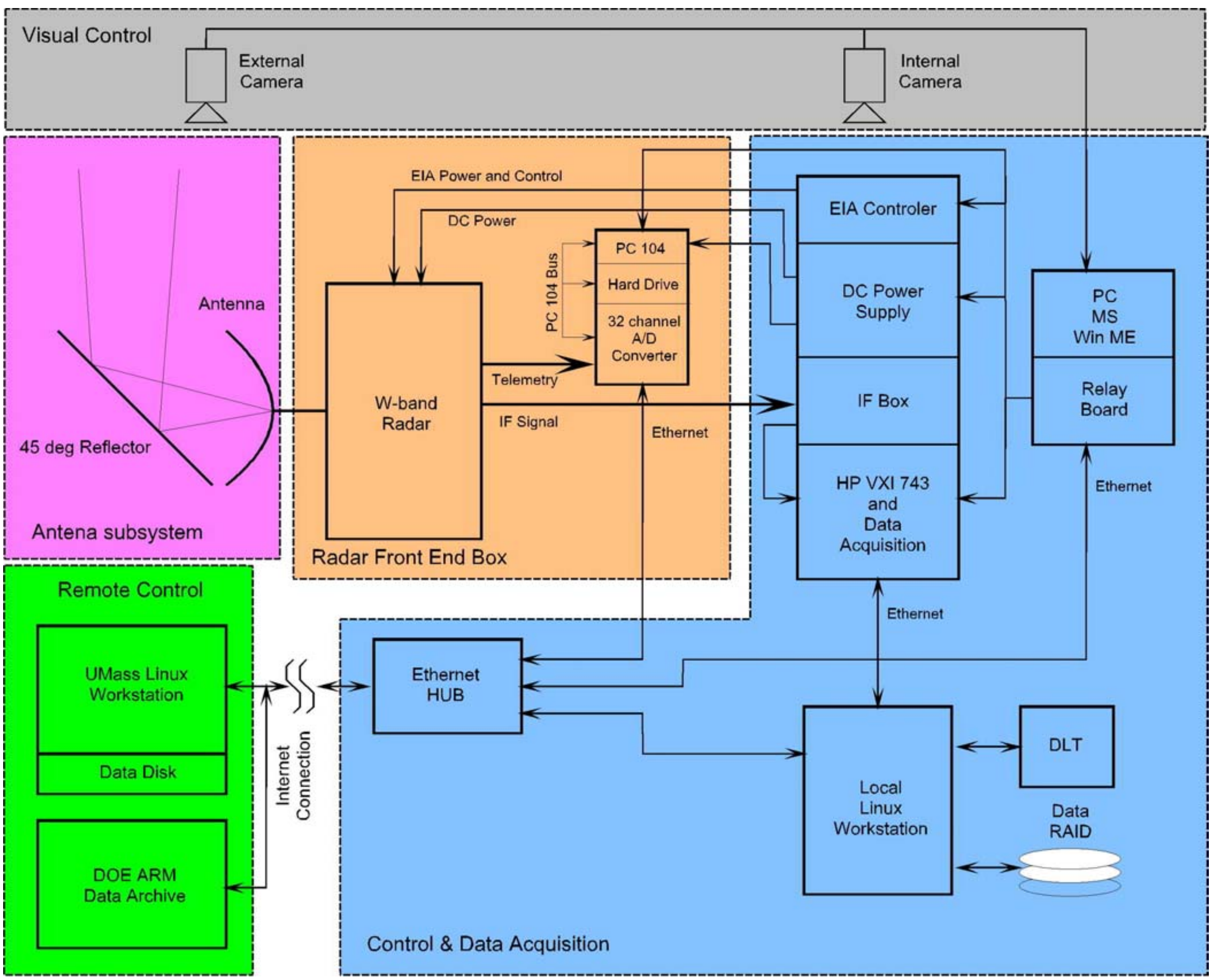

Figure 2. Block schematic of the W-band radar system.

Antenna Subsystem: The UMass W-band radar uses a 12-inch-diameter sealed dielectric lens antenna (Alpha Industries) designed to operate at 94.92 GHz.

Radar Front End Enclosure: The radar front end contains all microwave radar components and a PC 104 computer that records system "health" information such as DC voltages and component temperatures.

Hardware Management Computer: This PC allows remote control of all physical switches needed to control the radar hardware. It also has installed a video capture card used for periodic collection of pictures from outside the video camera. These pictures are used to monitor the status of the antenna and the reflector plate.

HP VXI 743 Computer: The HP VXI 743 computer receives analog baseband signals prepared within the analog signal processing IF Box. It performs Analog-to-Digital conversion and stores the digital data as a raw data file on the local hard drive. Raw files are stored here temporarily and then automatically FTP'd to a Linux Workstation for processing into NetCdf files hourly.

Linux Automated Data Processing Workstation: This Linux workstation performs multiple tasks including: (1) gathering data from HP VXI 743 computer, (2) performing data processing, and (3) storing processed data to a Mass Storage Disk Array (RAID). This PC also serves as a Web Server for the current experiment. Processed data and "health" status of the radar are available for the previous hour via the Internet. A DLT Drive attached to this PC is used to automatically back up raw and processed data to DLT tapes.

Visual Control Subsystem: The Visual Control Subsystem consists of two video cameras and a video capture card installed inside the Hardware Management Computer. One weatherproof camera is placed outside to allow easy monitoring of the antenna lens and reflector plate. The second camera is located inside the sea-container.

Remote Control: The Linux workstation, Hardware Management Computer, Embedded PC104, and HP VXI 743 computer are accessible via the Internet, which allows the radar operator to run the radar remotely using any ordinary PC with a network connection. Data is periodically sent to the ARM archive via FTP. Approximately 50 M bytes of processed data is transferred to the archive daily.

95-GHz Radar Reliability and Performance

95-GHz radars have not been widely used on an operational basis. Therefore, the automation and long deployment for the MFR IOP are significant as they give confidence in the reliability of 95-GHz transmitters and receiver components. During the nine-month MFR IOP there were no hardware failures. Here the radar experienced environment temperature extremes between 0° and 37°C, extreme humidity, and shocks due to prime power outages.

Figures 3 and 4 show the near 100% reliability of the 95-GHz radar outside the summer thunderstorm season, and the strong inverse correlation between thunderstorm activity and radar up-time. The

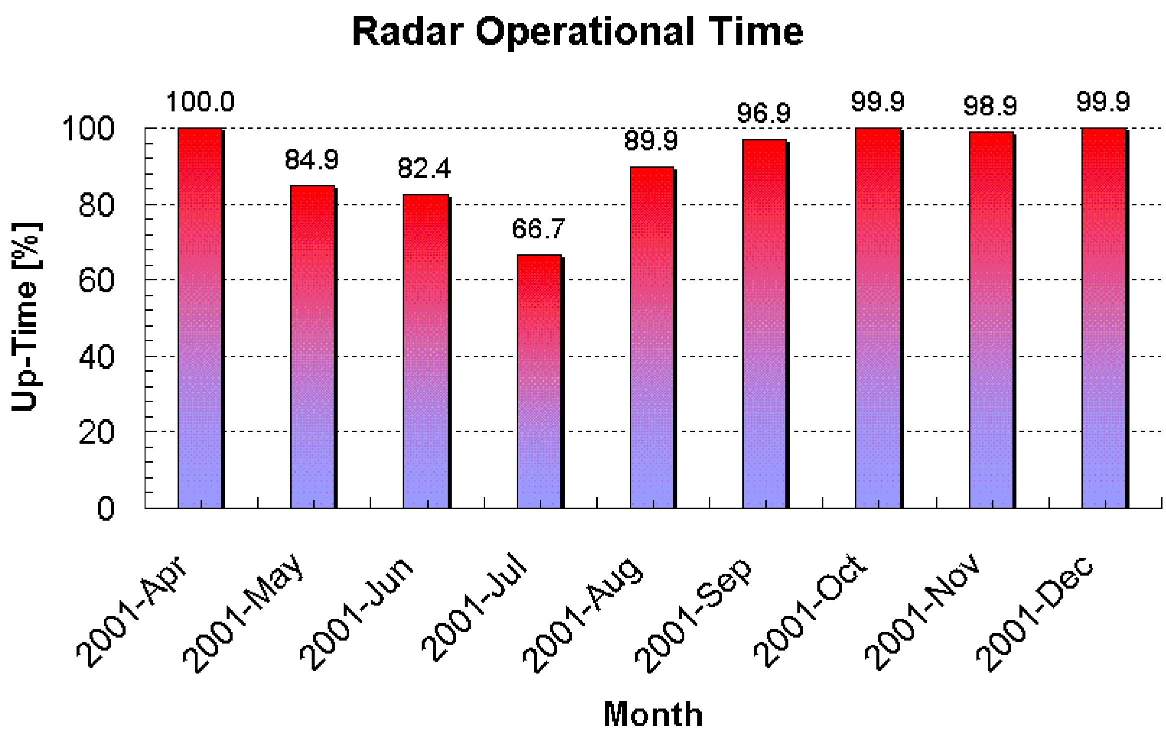

Figure 3. Radar up-time (entire system connected to UPS on August 24, 2001).

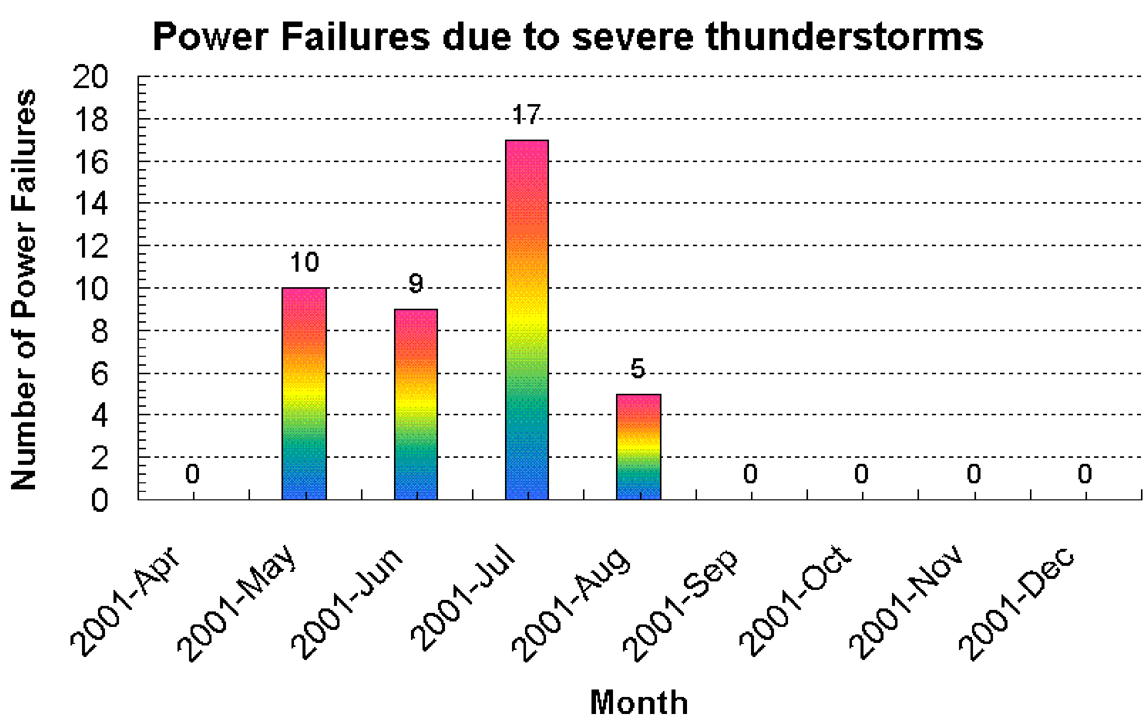

Figure 4. Number of detected power failures.

95-GHz radar was installed without uninterruptible power supply (UPS). Unfortunately, a considerable number of thunderstorm-related power failures occurred. These account for nearly all of the radar down-time. Most of the power failures were relatively short (only a few seconds), but that was enough to interrupt the operation of the equipment. In coordination with the ARM SGP staff, the entire radar system was connected to 1.6 kW UPS in August 2001. The up-time was nearly 100% from this point onward.

MFR IOP 2001-2002, SGP CART Site, Oklahoma

The UMass 95-GHz radar was deployed for nearly nine months at the SGP CART site in Oklahoma as a part of MFR IOP 2001. Data and GIF images, such as those shown in Figures 5 and 6, were uploaded to the ARM archive and are available to the ARM Science Team. Processed NetCDF format data files can also be accessed via the UMass Cloud radar measurement archive at: http://abyss.ecs.umass.edu/Wband2001.

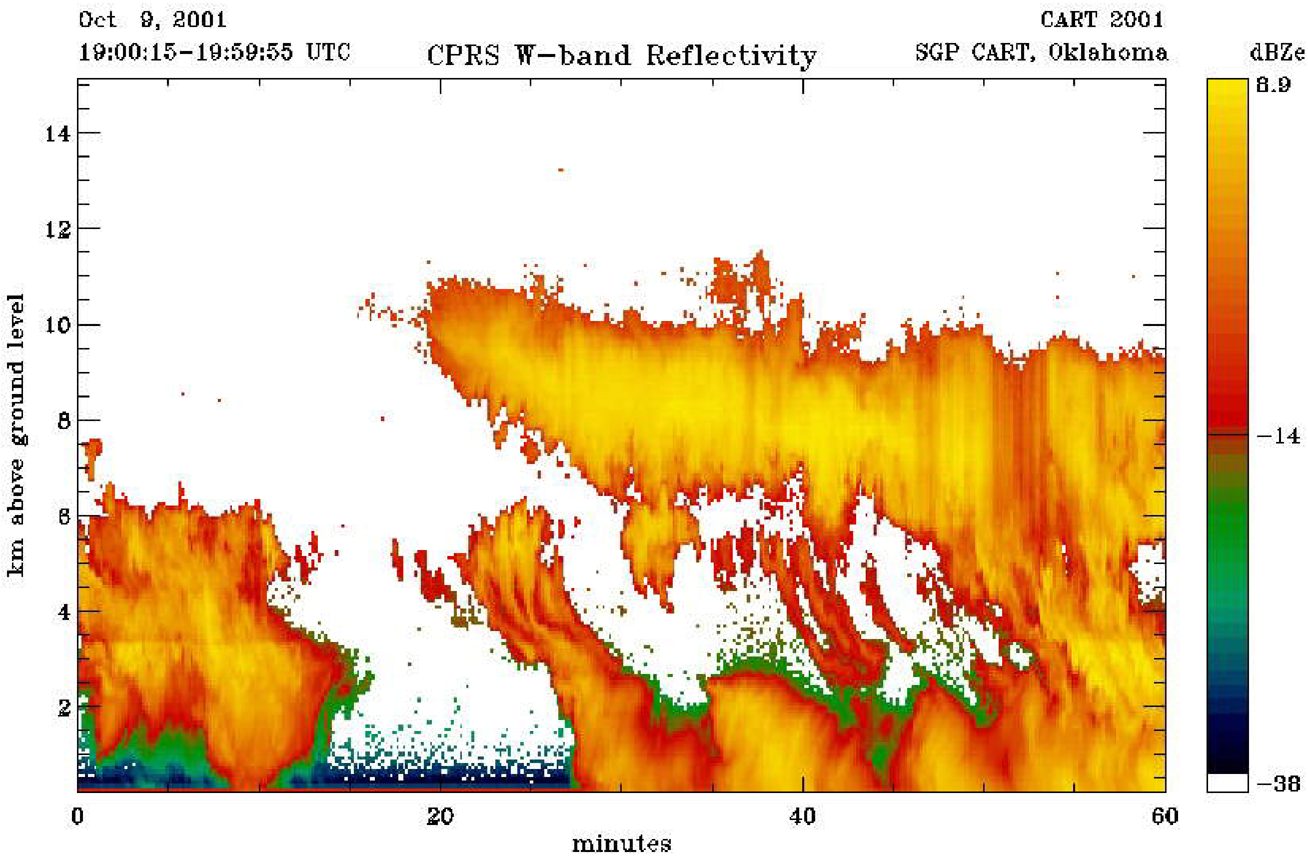

Figure 5. 95-GHz radar reflectivity, October 9, 2001, 19:00 to 20:00 Universal Time Coordinates (UTC).

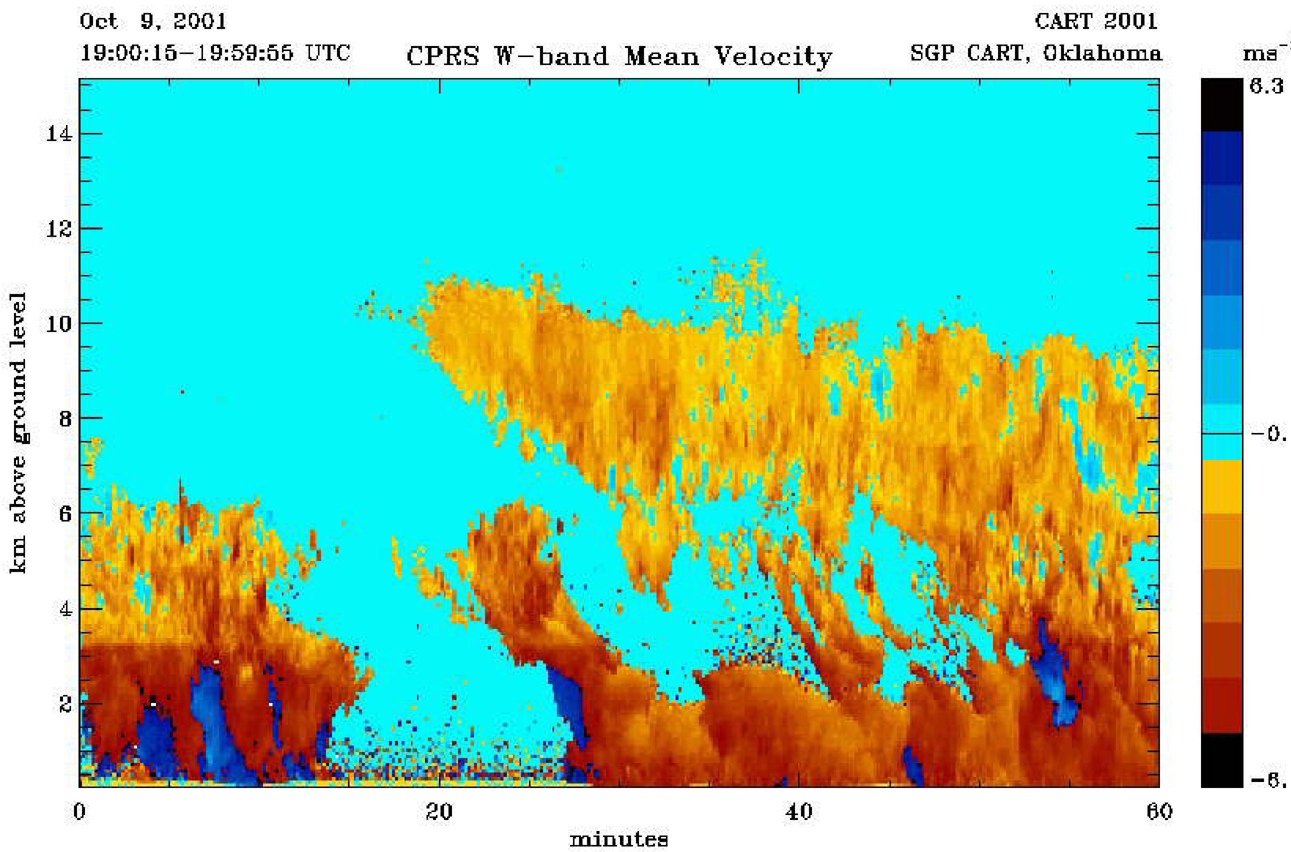

Figure 6. 95-GHz radar mean velocity, October 9, 2001, 19:00 to 20:00 UTC.

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