6A.7 LONG-TERM CLOUD AND PRECIPITATION OBSERVATIONS WITH THE ARM W-BAND CLOUD RADARS

Karen L. Johnson[1*], Michael Jensen[1], Pavlos Kollias, Edward Luke[1], Kevin Widener[2], Mark Miller[1], Eugene Clothiaux[3]

[1]Brookhaven National Laboratory, Upton, New York
[2]Pacific Northwest National Laboratory, Richland, Washington
[3]The Pennsylvania State University, State College, Pennsylvania

1. INTRODUCTION

The Atmospheric Radiation Measurement (ARM) program continuously operates W-Band (95 GHz) ARM Cloud Radars (WACRs) at the ARM Climate Research Facility fixed site located in Oklahoma, United States, and at the ARM Mobile Facility site in Niamey, Niger (2006) and Black Forest, Germany (2007) for the purpose of collecting climatically relevant datasets on the vertical distribution of clouds. At each radar site, an extensive suite of additional instruments is available, including lidars, ceilometers and radiometers. At the fixed site, there is also a collocated Ka-band (35-GHz) cloud radar.

2. WACR SYSTEM DESCRIPTION

The WACRs are zenith-pointing dual polarization Doppler systems, operating at 95.04 GHz. (Mead and Widener, 2005). The radars run semi-autonomously, requiring operator intervention only to power up and down the systems. The WACRs continuously collect both Doppler moments and Doppler spectra, alternating between co-polarization and cross-polarization modes approximately every 2 sceonds. Table 1 summarizes WACR operating characteristics at each of the sites at which a WACR is, or has been, installed.

3. WACR DEPLOYMENTS

WACRs have been deployed at three sites so far: the Southern Great Plains (SGP) fixed site in north-central Oklahoma, and at two deployments of the ARM Mobile Facility (AMF), in Niamey, Niger and the Black Forest, Germany.

*Corresponding Author address: Karen L. Johnson, Brookhaven National Laboratory, Environmental Sciences Department, Building 490D. Upton, NY, 11973. email: kjohnson@bnl.gov

Table 1. WACR System Parameters

Radar Parameter	SGP	AMF Niamey	AMF Black Forest
Frequency(GHz)	95.04	95.04	95.04
Pulse Repetition Frequency (Hz)	10000	8333	10000
Pulse Width (ns)	300	300	300
Gate Spacing (m)	42.86	42.86	42.86
Number of Gates	341	411	341
Spectral Averages	160	160	160
FFT Length	256	256	256
Observe/Processing Time (s)	2.14	2.55	2,14
Nyquist Velocity (m/s)	7.885	6.571	7.885

The longest ongoing deployment is at the Oklahoma SGP site, where Doppler moments and spectra have been collected since December 2005. These data are being collected in concert with the full suite of ACRF instrumentation designed for the long-term monitoring of clouds, radiation, atmospheric state and aerosols. Included in the site instrumentation are a collocated vertically-pointing Ka-band (35-GHz) millimeter cloud radar (MMCR), micropulse lidar, ceilometer, radiometers, rain gauges and other instruments.

A second WACR operated in Niamey, Niger during the AMF deployment from March through December 2006, coincident with portions of the African Monsoon Multidisciplinary Analysis project. This deployment captured both dry season dust storms and the summer monsoon season.

Currently the WACR is operating as part of the AMF site in the Black Forest region of Germany. This deployment, which began in March 2007 and will continue through December 2007, supports the long-term Convective and

Orographically Induced Precipitation Study (COPS).

The WACR is scheduled to be deployed with the AMF to Shanghai, China in 2008.

4. DATA PRODUCTS

The ARM program has developed "value-added" data products to make WACR measurements more readily usable and enhance the radar measurements with those from other collocated instruments.

These WACR-based products are similar in many ways to existing multi-year ARM data sets at the five fixed ARM sites (SGP, plus three Tropical Western Pacific sites and a North Slope of Alaska site), These products provide cloud boundaries and "best estimates" of cloud reflectivities, Doppler velocities and Doppler spectral widths by combining measurements from the MMCR, micropulse lidar, ceilometer and surface instruments (Clothiaux, et al., 2000).

A similar data product will soon be available which combines WACR data with micropulse lidar and ceilometer data to provide cloud boundaries at the AMF sites as well. The product uses WACR dual-polarization measurements and linear deploraization ratios (LDR) to separate hydrometeor from non-hydrometeor (e.g. insect) returns.

Figure 1 is an example of images produced by the product for the Niamey deployment, during the summer monsoon. The top left image is the measured WACR reflectivity in a time vs. height plot for a single day, followed on the right by a "best estimate" version of the reflectivity, after non-hydrometeor clutter has been eliminated. Here the black dots indicate cloud base as determined by the lidar and ceilometer. On the bottom left are data flags associated with the best-estimate image, showing regions identified as clutter and which instruments contributed to each portion of the cloud mask. Finally, on the bottom right, is an LDR image. Here, yellow represents an LDR of near zero dB, indicating non-spherical, or ice, scatterers while the blues indicate LDR's from –10 to –35 dB, indicative of spherical, or liquid, scatterers. The melting layer is clearly visible near 4 km.

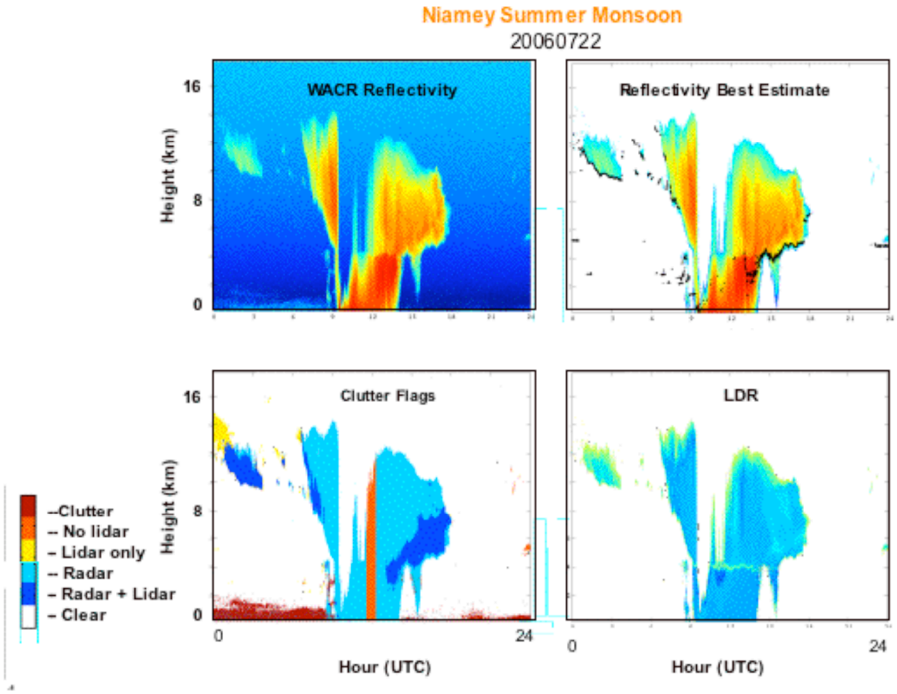

Figure 1. Example of images from "value-added" WACR-based data product.

5. SUMMARY

The ARM program continuously operates two W-band cloud radars at the ARM Climate Research Facility SGP site and the ARM Mobile Facility. New value-added data products are available and under development to combine data from the radars with additional instruments to provide a reliable picture of the vertical distribution of clouds and precipitation in the column above the instrumented sites.

6. REFERENCES

Clothiaux, E. E., and Coauthors, 2000: Objective determination of cloud heights and radar reflectivities using a combination of active remote sensors at the ARM CART sites. *J. Applied Meteor.* **39**, 645-665.

Mead, J. B. and K. B. Widener, 2005: W-Band ARM cloud radar, Proc. 32nd Conf. on Radar Meteorology, Albuquerque, Am. Meteor. Soc.