Deep Convective Clouds and Chemistry (DC3) MAX Radar Data Set Summary

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1.0 Data Set Overview

1.1 Introduction

The University of Alabama in Huntsville (UAH) conducted DC3 operations on twelve days between May 15 and June 15 2012. One of the radars used in support of operations for DC3, and the platform outlined in this document, was the Mobile Alabama X-band (MAX) radar.

1.2 Time period covered by the data

The data was collected from May 15th 2012 to June 15th 2012. Table 1 outlines each operation day, including other instruments used. In this table, Advanced Radar for Meteorological and Operational Research (ARMOR), KHTX is the Hytop WSR88D dual-polarimetric radar, NALMA is NASA MSFC's Northern Alabama Lightning Mapping Array, and MIPS is UAH's Mobile Integrated Profiling Systems.

Date	Ground Instruments
5/15/2012	ARMOR-KHTX, NALMA, 1 sonde
5/18/2012	ARMOR-MAX-KHTX, NALMA, 2 sondes
5/19/2012	ARMOR-KHTX, NALMA
5/20/2012	ARMOR-KHTX, NALMA
5/21/2012	**ARMOX-MAX-KHTX, NALMA, 4 sondes, MIPS**
5/29/2012	ARMOR-MAX-KHTX, NALMA, 2 sondes
5/31/2012	ARMOR-MAX-KHTX, NALMA, MIPS deployed in DD lobes, 3 sondes
6/3/2012-6/4/2012	ARMOR-MAX-KHTX, NALMA, MIPS
6/4/2012-6/5/2012	ARMOR-MAX-KHTX, NALMA, MIPS deployed in DD lobes, 4 sondes
6/11/2012	**ARMOR-MAX-KHTX, NALMA, MIPS, 5 sondes**
6/14/2012	ARMOR-KHTX, NALMA, 1 sonde
6/15/2012	ARMOR-KHTX, NALMA, 1 sonde

Table 1 - Operation days including all platforms in use. Aircraft operation days in bold.

As shown in Table 1, the MAX radar was deployed on 7 DC3 Alabama operational missions (5/18, 5/21, 5/29, 5/31, 6/3-6/4, 6/4-6/5 and 6/11). More details on these specific events can be found in the DC3 Field Catalog (FC), including MAX daily summaries and science logs - http://catalog.eol.ucar.edu/dc3/.

1.3 Physical location

During DC3, the MAX radar was deployed during operations to a fixed site near New Market, Alabama located at 34°55'56.23"N and 86°27'57.01"W.

1.4 Any web address references

Additional information about MAX can be found at http://vortex.nsstc.uah.edu/mips/max/

2.0 Instrument Description

MAX is an X-band, dual-polarimetric truck-based mobile radar. The MAX truck cab has room for a 2-3 person team who will similarly accomplish radar control via IRIS display, communications (via Internet chat on cell phone modem), and Nowcasting duties. Like most truck-based mobile radars, MAX's view of storms is obscured in the direction of the truck cab (i.e., "cab block"). MAX's cab block is about 30°-40° in azimuthal width and is up to 10° in elevation. During DC3 multi-Doppler operations, MAX was deployed from its home base at NSSTC to a fixed site near New Market, AL, which is 42.5 km north-northeast of ARMOR (Fig. 1). For a region characterized by ubiquitous trees and rolling terrain, the New Market site, which is around old farmland, has excellent line-of-sight visibility for radar operations in Alabama. Most azimuths have little-to-no partial blocking. A sector from the north-northwest to east-northeast (340° to 60° in azimuth) has sporadic partial blocking up to an elevation angle of 2.5° due to trees. The New Market site allowed for the MAX truck cab to be pointed toward the north or the south only due to access considerations, which varied based on operational considerations (see MAX daily summaries in DC3 FC).

2.1 Domain

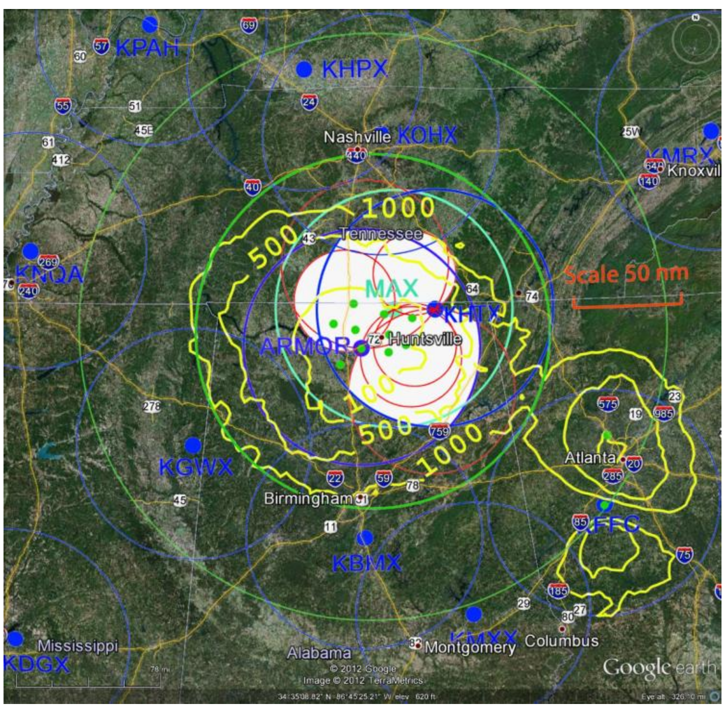

Figure 1 – DC3 Alabama radar domain with radar locations, including MAX radar, and multi-Doppler radar lobes (white). Other instrument locations such as NALMA are shown.

The MAX domain is highlighted in Figure 1. This figure also includes the multi-Doppler lobes with the ARMOR and KHTX radars and other instrument locations.

2.2 Table of specifications

Location	**Near New Market, AL : 34°55'56.23"N and 86°27'57.01"W**
Transmit frequency	9450 MHz (magnetron)
Peak Power	250 kW
Pulse width	0.4, 0.8, 1.0, 2.0 μs
Maximum PRF	250-2000 s^{-1}
Antenna Diameter	2.44 m (Center-fed parabolic)
Antenna Beam width	0.95^{o}
First side-lobe	-31 dB
Maximum rotation rate	24° s^{-1} (18-21° s^{-1})
Transmit polarization	Simultaneous H and V, or H
Receive polarization	Dual-channel; H and V
Signal Process	SIGMET RVP/8
Variables	Z, V, σ, Z_{DR}, ϕ_{DP}, KDP, ρ_{hv}, LDR

Table 2 - Table of specifications for MAX.

3.0 Data Collection and Processing

3.1 Description of data collection

When MAX deployed during a weather event, a combination of full Plan Position Indicator (PPI) volume scans, PPI sector volume scans, and vertical scans over a single azimuth (or Range Height Indicators, RHIs) were implemented. The main goal of the radar operator during MAX scanning was to cover the entire horizontal and vertical extent of the precipitation, including the anvil, as quickly and thoroughly as possible. More details regarding the scan strategy can be found in the DC3 Operations Plan.

3.2 Description of quality assurance and control procedures

A receiver calibration was conducted at the start of MAX operations to help maintain absolute calibration. Vertically pointing Z_{DR} calibrations scans were performed as often as operations permitted and precipitation echo was present overhead (Gorgucci et al. 1999).

Since it is a truck-based mobile system, the MAX radar azimuth data have been corrected for any deviations to true north. A GPS system was used in the field to identify the MAX azimuth relative to true north and adjust MAX heading accordingly. These preliminary field corrections to MAX azimuth angles were verified and fine-tuned in post-processing during and after the intensive observational period using well characterized nearby stationary ground targets and comparison to other radars such as KHTX or ARMOR. A sector shift problem was also identified in the MAX IRIS data in some PPI sector volumes. These shifts were corrected in MAX data in the same fashion as described for ARMOR. Essentially, the azimuthal angles (locations) of MAX radar data for every other PPI in a PPI sector volume were shifted from their true heading during raw data recording in the RCP8. These shifted PPI's were identified and corrected with a combination of automated scripts and careful manual analysis. Well characterized ground targets and comparison to adjacent MAX 360° surveillance scans or other radar displays were used to identify and verify the MAX azimuth angle corrections.

The data were also converted to Universal Format (UF) and to Dorade Sweep (sweep) formats with the use of NCAR's Radx software (Dixon, 2010).

4.0 Data Format

4.1 Data file structure and file naming conventions

The MAX data set delivered to the DC3 Data Archive is in the Dorade Sweep format. An example of the MAX file naming convention is as follows:

swp.1120605143038.MAX.0.0.7_PPI_v001

where swp indicates the file format, 120605 indicates the date (YYMMDD), 143038 indicates the time in UTC (HHMMSS), MAX is the radar name, 0.0.7 indicates the elevation angle (00.7 degrees), PPI indicates the scan type (in this case PPI, RHIs were also performed).

4.2 List of parameters with units

Identifier	Units	Definition
DR	dB	Differential reflectivity (Z_{DR}) (Uncorrected for propagation effects)
DZ	dBZ	Horizontal reflectivity (Z_H) (Uncorrected for propagation effects)
KD	$° \, km^{-1}$	Specific differential phase (K_{DP})
PH	°	Differential propagation phase (ϕ_{DP}) (filtered)
RH	Unitless	Co-polar correlation coefficient (between H- and V- polarization)
SW	$m \, s^{-1}$	Spectral width (σ)
SQ	Unitless	Correlation Coefficient (ρ_{HV})
VR	$m \, s^{-1}$	Radial (or Doppler) velocity (V_R)
ZT	dBZ	Horizontal reflectivity (Z_H) (Raw)

Table 3 - Table of MAX parameters.

4.3 Data version number and date

This document describes the final DC3 MAX data delivery (July 2013).

5.0 Data Remarks

5.1 PI's assessment of the data (i.e., disclaimers, instrument problems, quality issues, etc.)

Propagation effects have not been corrected in MAX reflectivity and differential reflectivity data. The Bringi et al. (2001) methodology for attenuation and differential attenuation correction, which was developed at C-band, could be adapted to X-band using local disdrometer drop size distribution data and a radar scattering model. Significant progress has been made in the development of the X-band algorithm however, since this is an experimental procedure, researchers may contact the PI to have this methodology applied to the MAX radar data as needed.

Radial (Doppler) velocity data is still folded at the Nyquist interval (9.5 m s^{-1}). Researchers may need to unfold the radial velocity data prior to using the data set, especially when conducting multi-Doppler synthesis.

The post-processing corrections of the azimuth angle associated with heading errors and some PPI sector shift problems are expected to be accurate to better than a couple tenths of a degree (< 0.2°). We continue to assess the accuracy of the azimuth angle post-processing corrections.

Spatial smearing of the MAX radar data, which appears as azimuthally or elevationally elongated range gate samples, sometimes occurred on the outer azimuthal edges of PPI tilts in some sector volumes or in the middle of RHI scans, respectively. The occasional spatial smearing in MAX data appears to be associated with occasional inappropriate scan speeds and accelerations due to intermittent MAX antenna motor control problems during DC3, as noted during daily briefings and in the MAX daily summaries and science logs. The spatial smearing is infrequent and is fairly easy to identify and remove manually. The smearing on the edge of several PPI sector volumes were removed. However, some spatial smearing may remain in a few PPI's and RHI's.

A preliminary check on absolute and relative calibration has been accomplished and found to be stable based on available calibration scans and procedures. However, two vertically pointing Z_{DR}-calibration scans (Gorgucci et al. 1999) were carefully analyzed for relative calibration bias. The average computed Z_{DR} bias values are shown in

Date	Z_{DR} Calibration Results
May 13, 2012	0.0692 dB
June 4, 2012	-0.654 dB

Table 4 - Z_{DR} calibration scan dates and results for MAX radar during DC3.

Table 4. Since these calibrations scans were only performed twice, it was decided that the data user should make the final decision about Z_{DR} bias corrections. The user may choose to subtract the Z_{DR} bias value from the Z_{DR} values on the dates on the table, apply an average of the Z_{DR} bias for the dates when the calibration scan was not performed, or the data user may choose not to correct for the Z_{DR} bias.

Finally, absolute calibration was not conducted in the MAX dataset. It was decided that, although the methodology highlighted in Ryzhkov et al. (2005) which calibrates reflectivity based on polarimetric self-consistency could be applied to this dataset, the outcome would be experimental because of differences in wavelength compared to ARMOR. Therefore, if a data user wishes to assess the reflectivity bias for a specific case, they are welcomed to contact the PI for assistance. Preliminary comparisons between ARMOR, HYTOP and MAX radar reflectivity suggest that the MAX reflectivity had little or no bias during DC3. Calibration analysis continues and users are encouraged to contact the PI.

5.2 Missing data periods

When deployed for DC3 (Table 1), the MAX radar was operated continuously. A few known exceptions when the MAX radar went down during DC3 operations are discussed in the MAX daily summaries and science logs on the DC3 Field Catalog.

5.3 Software compatibility (i.e., list of existing software to view/manipulate the data)

MAX data in NCAR Dorade sweep (swp) format can be viewed and manipulated with the NCAR soloii radar software package found at http://www.eol.ucar.edu/Members/dennisf/soloii-and-xltrsii/getting-soloii-and-xltrsii and described at http://www.eol.ucar.edu/rdp/solo/solo_home.html .

6.0 References

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