Verification of the Origins of Rotation in Tornadoes EXperiment-Southeast (VORTEX-SE) ARMOR Radar Data Set Summary

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1.0 Data Set Overview:

1.1 Introduction

The University of Alabama in Huntsville (UAH) conducted VORTEX-SE operations on seven days between March 13th and May 01st 2016. Additional data collected prior to the start of the VORTEX-SE project have also been added. One of the radars used in support of operations for VORTEX-SE, and the platform outlined in this document, was the Advanced Radar for Meteorological and Operational Research (ARMOR).

1.2 Time period covered by the data

The data was collected from February 24th 2016 to May 1st 2016. Table 1 outlines each operation day, including other instruments used. The first two dates consist of data collected from a pre-VORTEX-SE and a shakedown operation. In this table, MAX is the Mobile Alabama X-band Radar, KHTX is the Hytop WSR88D dual-polarimetric radar, and NALMA is NASA MSFC's Northern Alabama Lightning Mapping Array.

Date	IOP #	Ground Instruments
2/24/2016	IOP_0_0	ARMOR-KHTX, NALMA
3/1/2016	IOP_0_1	ARMOR-MAX-KHTX, NALMA
3/13/2016-3/14/2016	IOP_1	ARMOR-MAX-KHTX, NALMA
3/24/2016	IOP_2	ARMOR-MAX-KHTX, NALMA
3/31/2016-4/1/2016	IOP_3	ARMOX-MAX-KHTX, NALMA
4/27/2016-4/28/2016	IOP_4	ARMOR-MAX-KHTX, NALMA
4/29/2016-4/30/2016	IOP_5	ARMOR-MAX-KHTX, NALMA
4/30/2016	IOP_6	ARMOR-MAX-KHTX, NALMA
5/1/2016	IOP_7	ARMOR-MAX-KHTX, NALMA

Table 1 - Operation days including all platforms in use.

1.3 Physical location

ARMOR is located at the Huntsville International Airport. Its physical location is 34° 38' 45.5 N 86° 46' 16.7 W, 200m MSL.

1.4 Any web address references

Additional information about ARMOR can be found at http://armor.nsstc.uah.edu/about.php

2.0 Instrument Description:

ARMOR is a decommissioned National Weather Service local warning radar (WSR-74C) that was donated to UAHuntsville in 2002. This radar is located at the Huntsville International Airport and transmits at a frequency of 5625 MHz (C-band) with a 1^0 beam width. The full specifications for the radar can be found on Table 2. The radar was converted from single to dual-polarization in 2004 through a collaborative effort between UAH, NASA, and Huntsville's local news broadcaster WHNT channel 19.

The contributions from these partners also led to a series of hardware and software upgrades to the ARMOR radar from 2005-2006 that yielded a research-quality radar facility. The details of the upgraded radar components can be found in Petersen et al. (2009). ARMOR user control and data transmission are accomplished though a T1 line from the airport to UAH and its partners. The radar is operated by a combination of researchers and graduate students in both classroom and research environments and real-time data are provided to the Huntsville Alabama office of the National Weather Service and a local television news partner (Petersen et al. 2009).

2.1 Domain

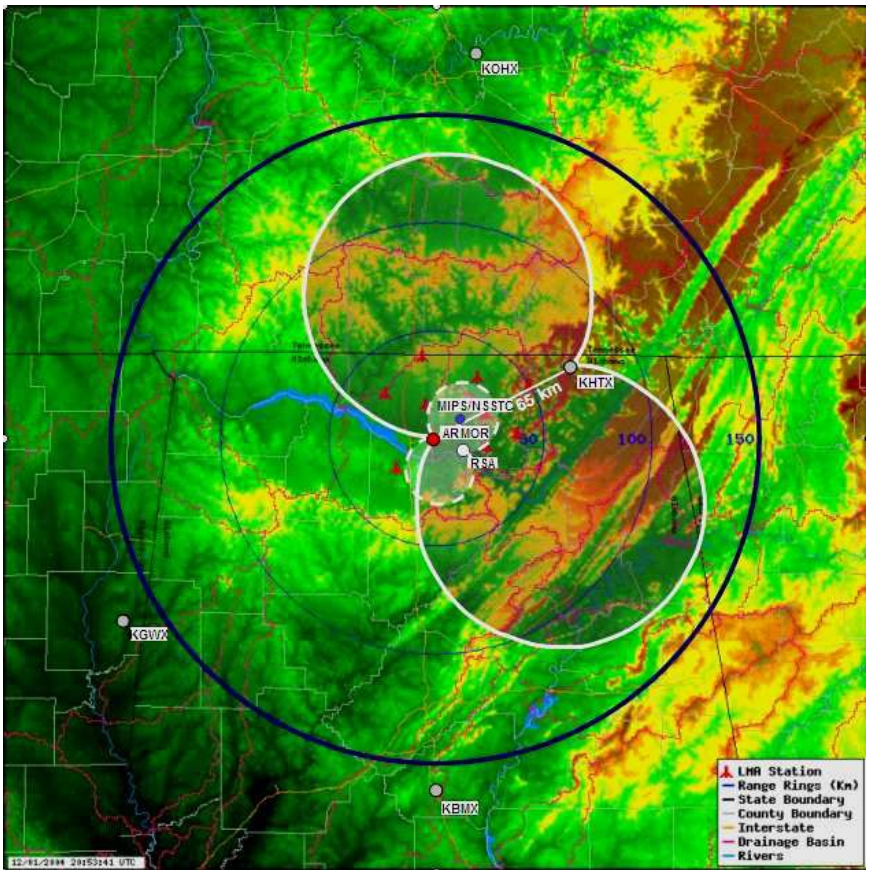

Figure 1 - ARMOR domain with dual-doppler lobes for KTHX.

The ARMOR domain is highlighted in Figure 1. This figure includes the dual Doppler lobes with the National Weather Service's Hytop radar. The baseline between ARMOR and the Hytop radar is 70 km.

2.2 Table of specifications

Location	Huntsville International Airport : 34° 38' 45.5 N 86° 46' 16.7 W
Altitude (antenna MSL)	200 m
Transmit frequency	5625 MHz
Peak Power	350 kW
Pulse width	0.4 – 2.0 μs
Maximum PRF	250-2000 s^{-1}
Antenna Diameter	3.7 m (12 ft CF Parabolic)
Antenna Beam width	1.1°
First side-lobe	-30 dB
Maximum/typical 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, W, ZDR, Φ_{DP}, KDP, ρ_{hv}, LDR

Table 2 - Table of specifications for ARMOR.

3.0 Data Collection and Processing:

3.1 Description of data collection

Data was collected 24 hours a day for the entirety of the field campaign. When not manned by radar operators, ARMOR continuously ran a combination of a three angle scan strategy (0.7, 1.3, and 2.0 degrees to 125 km) and a one angle surveillance strategy (0.7 degrees to 180 km). When ARMOR was manned by operator during a weather event, a combination of full volume scans, sector scans, vertical scans over a single azimuth (RHIs), as well as the two scan strategies highlighted above were implemented. The main goal of the radar operator during this operation was to cover the entire horizontal and vertical extent of the precipitation, including the anvil, as quickly and thoroughly as possible.

3.2 Description of derived parameters and processing techniques used

The ARMOR C-band horizontal reflectivity (Z_H) and differential reflectivity (Z_{DR}) radar data were corrected for attenuation and differential attenuation effects using the differential phase-based, self-consistent method with constraints (Bringi et al. 2001). The differential propagation phase (ϕ_{DP}) was estimated and the specific differential phase (K_{DP}) was computed using the iterative filtering approach of Hubbert and Bringi (1995).

3.3 Description of quality assurance and control procedures

As one of ARMOR's quality assurance procedures, a receiver calibration is conducted for weather permitting conditions. This calibration was performed 2/19/2016 in preparation for VORTEX-SE, as well as 4/5/2016 during the field program.

Vertically pointing Z_{DR} calibration scans (Gorgucci et al. 1999) were also conducted before the VORTEX-SE field campaign. More specifically, Z_{DR} calibration is performed as often as weather permits and this calibration was performed in anticipation of VORTEX-SE operations. The existing GDR was changed on 2/23/2016 after a series of calibrations scans to an offset of -0.19 dB.

Once the data was gathered and stored, quality control procedures were followed to ensure the data delivered was of the highest quality possible. An azimuthal sector shift problem for some ARMOR PPI sector volumes was identified during the field campaign and will be corrected in post-processing for an additional data delivery. Essentially, the azimuthal angles (locations) of ARMOR 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 will be identified and corrected with a combination of automated scripts and careful manual analysis. Well characterized ground targets and comparison to adjacent ARMOR 360° surveillance scans will be used to identify and verify the ARMOR azimuth angle corrections.

The raw data have been provided, as well as processed data converted to Universal Format (UF) with propagation correction.

4.0 Data Format:

4.1 Data file structure and file naming conventions

The ARMOR data set delivered to the VORTEX-SE Data Archive is in the Raw and Universal Format. An example of the RAW ARMOR file naming convention is as follows:

RAW_NA_000_125_20160314081927.gz

where RAW indicates the file format, 125 indicates the scan type (in this case full volume PPI, RHIs and sector volumes were also performed), 20160314 indicates the date (YYYYMMDD), and 081927 indicates the time in UTC (HHMMSS).

An example of the quality controlled UF ARMOR file naming convention is as follows:

ARMOR_20160314081927_qc1.uf.gz

where ARMOR indicates the radar, 20160314 indicates the date (YYYYMMDD), 081927 indicates the time in UTC (HHMMSS), qc1 indicates ARMOR processed data, and uf indicates the file format.

4.2 List of parameters with units

Identifier	Units	Definition
CD	dB	Corrected differential reflectivity (Z_{DR}); corrected for differential attenuation
CZ	dBZ	Corrected horizontal reflectivity (Z_H); corrected for attenuation
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})
MZ	°	Differential Phase (ψ_{DP}) (measured)
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)
VR	m s^{-1}	Radial (or Doppler) velocity (V_R)

Table 3 - Table of ARMOR parameters.

4.3 Data version number and date

This document describes the preliminary VORTEX-SE ARMOR data delivery (October 2016).

5.0 Data Remarks:

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

Propagation effects have been corrected in ARMOR reflectivity and differential reflectivity using well-tested procedures described in Bringi et al. (2001). However, some artifacts associated with propagation effects can remain or even be inadvertently generated during the correction process. We continue to assess the quality of the propagation correction during VORTEX-SE but have high confidence in the general results as we have been using the algorithms regularly during research for over 9 years. Radial (Doppler) velocity data is still folded at the Nyquist interval (15.9 m s^{-1}). Unfolding of the radial velocity data is ongoing for multi-Doppler synthesis. Unfolded data for specific case studies will be provided for specific case study periods at the final data delivery. The post-processing correction of the azimuth angle associated with some PPI sector volumes (i.e., correction of the sector shift problem) is expected to be accurate within a couple tenths of a degree (< 0.2°) and will be provided for specific case

study periods at the final data delivery. We continue to assess the accuracy of the azimuth angle post-processing corrections. A preliminary check on absolute and relative calibration has been accomplished and found to be stable based on available calibration scans and procedures.

5.2 Missing data periods

The ARMOR radar ran continuously during the VORTEX-SE field campaign, including intensive observation periods listed in Table 1. Known exceptions are discussed in the ARMOR daily summaries and science logs on the VORTEX-SE Field Catalog.

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

ARMOR data can be converted in NCAR Dorade sweep (swp) format (Dixon, 2010) to be viewed and manipulated with the NCAR soloiii 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:

Advanced Radar for Meteorological and Operational Research. http://armor.nsstc.uah.edu/about.php

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