Alabama Ground Operations during the Deep Convective Clouds and Chemistry Experiment

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Paper J7.4, AMS Sixth Conference on the Meteorological Applications of Lightning Data, 7-10 January 2013
DC3 Alabama Ground Facilities

• UAHuntsville
  – Advanced Radar for Meteorological and Operational Research (ARMOR) C-band polarimetric radar
  – Mobile Alabama X-band (MAX) polarimetric radar
  – Mobile Integrated Profiling System (MIPS)
  – iMET-3150 GPS sounding system – mobile van based

• NASA MSFC
  – Northern Alabama - Lightning Mapping Array (NA-LMA)
  – Other lightning data (Regional/Global LF/VLF networks such as Vaisala NLDN, Vaisala GLD360, Earth Networks ENTLN)

• Other
  – Army Redstone Arsenal 12z sounding
  – KHTX Hytop (also KBMX, KOHX, KFFC) WSR-88D S-band upgraded dual-polarimetric radars)
  – KGWX WSR-888D (not upgraded)
N. Alabama Network

- MAX deployed to New Market, AL site
  - 42.5 km ARMOR-MAX DD baseline
  - Multi-Doppler opportunities with KHTX
- ARMOR, MAX in coordinated DD sector volumes with surveillance
- 11 NA-LMA sensors (green dots)
- Mobile sounding positioned to be in approximate inflow
- MIPS (at NSSTC or in dual-Doppler lobes)
UAHuntsville Advanced Radar for Meteorological and Operational Research (ARMOR)

- Frequency: 5625 MHz (C-band)
- Antenna Beam width: 1.1°
- Dual-polarization: transmit simultaneous H + V (dual-channel receive, H + V)
- Variables: $Z_h$, $V_r$, $\sigma$, $Z_{dr}$, $\rho_{HV}$, $\phi_{dp}$, $K_{dp}$
- Vaisala RVP-8 IRIS control from UAHuntsville NSSTC network computer
- Continuous research operations/scanning: surveillance, PPI sector volume, RHI’s
- 2 person team: 1 Radar Operator, 1 Nowcaster & Comms
- Real-time quality control, propagation correction, preliminary product generation (HID, QPE)
Mobile Alabama X-band (MAX)

- Frequency: 9450 MHz
- Dual-polarization:
  - Simultaneous transmit (H+V), dual receive (H, V)
- $Z_h, V_r, \sigma, Z_{dp}, \phi_{dp}, K_{dp}, \rho_{hv}$
- Antenna Beam width: 1°
- 2 person MAX team
  - 1 Operator
  - 1 Nowcaster/Comms
- Vaisala RVP-8 IRIS controlled
  - PPI sector volumes, RHI’s
- 10-m meteorological tower
- Mobile cell phone internet, data and voice comms

http://vortex.nsstc.uah.edu/mips/max/
NASA’s North Alabama Lightning Mapping Array (NALMA)

- Network of 11 detectors centered about Huntsville, AL (NMT heritage)
- Operational since ~ November 2001
- Detects VHF (76-82 MHz, “Ch. 5”) radiation along the lightning channel - up to 100s-1000s of sources per flash
- Computes 4-D location of all electrical discharges (“flashes”) within LMA (CG...and IC, CC, CA)
- LMA Sensors: New Mexico Tech (NMT)
  - VHF ground plane antenna
  - Sensor electronics / site computer (first generation)
- Communications
  - mostly 2.4 GHz wireless Ethernet network link
  - Cell phone modems used at some sites

transitions unique NASA data and research technologies to the NWS
DC3 Alabama Mission Summary

• 12 intensive ground operations on 13 days during May-June 2012
  – 2 combined aircraft (GV and DC8) and ground operations: 21 May, 11 June
  – 10 ground only: 15, 18, 19, 20, 29, 31 May; 3-5, 14, 15 June
  – UAH ARMOR, NOAA KHTX and NASA NALMA, in combination with UAH MAX (7 deployments), mobile sonde (9 deployments) and MIPS (2 deployments)

• Continuous NA-LMA, MIPS and low-level ARMOR record for all of DC3
DC3 Alabama Highlights

• 21 May (Aircraft #1): ARMOR-MAX-KHTX radars, NALMA, MIPS at NSSTC, 4 sondes (1 pre-convective, 3 inflow), isolated to multicell convective line

• 11 June (Aircraft #2): ARMOR-MAX-KHTX radars, NALMA, MIPS at NSSTC, 5 sondes (1 pre-convective, 4 inflow), multicell thunderstorms

• Ground-only operations included isolated weak convection, weak to vigorous multicell thunderstorms, linear convection, severe storms, and 2 nocturnal Mesoscale Convective Systems (MCSs)
  – (next page for table details)
<table>
<thead>
<tr>
<th>Date</th>
<th>Type</th>
<th>Ground Instruments*</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5/15</td>
<td>ARMOR-KHTX, NALMA, 1 sonde</td>
<td>Few low flash rate shallow convection</td>
</tr>
<tr>
<td>2</td>
<td>5/18</td>
<td>ARMOR-MAX-KHTX, NALMA, 2 sondes</td>
<td>Several hours multicell thunderstorms</td>
</tr>
<tr>
<td>3</td>
<td>5/19</td>
<td>ARMOR-KHTX, NALMA</td>
<td>Several hours isolated to multicell storms</td>
</tr>
<tr>
<td>4</td>
<td>5/20</td>
<td>ARMOR-KHTX, NALMA</td>
<td>Few isolated thunderstorms</td>
</tr>
<tr>
<td>5</td>
<td>5/21</td>
<td>ARMOX-MAX-KHTX, NALMA, 4 sondes, MIPS</td>
<td>Isolated thunderstorms evolving to multicell line</td>
</tr>
<tr>
<td>6</td>
<td>5/29</td>
<td>ARMOR-MAX-KHTX, NALMA, 2 sondes</td>
<td>Isolated to widely scattered weak convection</td>
</tr>
<tr>
<td>7</td>
<td>5/31</td>
<td>ARMOR-MAX-KHTX, NALMA, MIPS deployed in DD lobes, 3 sondes</td>
<td>Few isolated thunderstorms. Some low flash.</td>
</tr>
<tr>
<td>9</td>
<td>6/4 – 6/5</td>
<td>ARMOR-MAX-KHTX, NALMA, MIPS deployed in DD lobes, 4 sondes</td>
<td>Overnight operations. Leading stratiform nocturnal MCS.</td>
</tr>
<tr>
<td>10</td>
<td>6/11</td>
<td>ARMOX-MAX-KHTX, NALMA, MIPS, 5 sondes</td>
<td>Multicell thunderstorms during aircraft mission.</td>
</tr>
<tr>
<td>11</td>
<td>6/14</td>
<td>ARMOR-KHTX, NALMA, 1 sonde</td>
<td>Few isolated airmass convection. 1 vigorous.</td>
</tr>
<tr>
<td>12</td>
<td>6/15</td>
<td>ARMOR-KHTX, NALMA, 1 sonde</td>
<td>Limited operations with isolated storms</td>
</tr>
</tbody>
</table>

DC3 AL on June 11, 2012, 0743 UTC
Aircraft Case #2: ordinary multicell thunderstorms

1404 CDT
1904 UTC
(NALMA sources)

1344–1844 UTC

Vertical cross-section of $Z_h$ (dBZ)

Graupel, small hail

Vertical cross-section of $Z_{dr}$ (dB)

ARMOR CAPPI 4 km

Max Updraft Velocity in Mixed Phase Region vs. NA LMA Lightning Flash vs. Time

For more details on Aircraft Cases #1 and #2, please see Poster #267

Microphysical, Kinematic and Lightning Properties of Deep Moist Convection across Northern Alabama during the Deep Convective Clouds and Chemistry Experiment

A. L. Bain and L. D. Carey
DC3 AL on June 4, 2012, 11-12 UTC
Trailing stratiform MCS lightning

- Document radar and lightning morphology associated with trailing stratiform MCS
  - Lightning rate, type, extent
- Infer microphysical and kinematic conditions from polarimetric and multi-Doppler radar analyses
- Infer charge structure from NA-LMA
- Investigate meteorological, microphysical and kinematic control of lightning rate, type, and extent and charge structure in MCS
DC3 AL on June 5, 2012, 0743 UTC
Leading stratiform anvil MCS lightning

ARMOR reflectivity (dBZ) and NA-LMA VHF sources

2 km CAPPI from ARMOR
Few multi-Doppler, polarimetric studies of electrification and lightning in leading stratiform MCS

Vertical-cross section through Lincoln Co. TN flash (NE)

Sonde through leading stratiform anvil at 0929 UTC
NNW flow
NASA Lightning Nitrogen Oxides Model (LNOM) Application toward Thunderstorm Studies
April 3, 2007: Ordinary Convection over N. Alabama

Reflectivity at 4 km altitude with NA-LMA flash origins

Lagrangian LNOM analysis cylinder follows thunderstorm cell for 1 hour lifecycle

Time-Height Cross-Section of ARMOR Radar Reflectivity, Precipitation Ice Volume, and Updraft Volume

For more details see Poster #271

The Kinematic and Microphysical Control of Storm Integrated Lightning Flash Extent

Lawrence D. Carey; William J. Koshak; Harold S. Peterson; Elise V. Schultz; Retha Matthee; Christopher J. Schultz; Walter A. Petersen; A. Lamont Bain
Summary

• Successful ground operations for DC3 Alabama, including
  – 2 aircraft missions in and around multicell ordinary convection
  – 2 nocturnal MCS’s – 1 trailing and 1 leading stratiform event
  – Multiple ordinary thunderstorms – isolated (airmass), multicell, squall line, severe storms
  – Shallow, warm-cloud base convection - well sampled spectrum of no flash convection to marginal flashing thunderstorms

• Preliminary data (mobile sonde, NALMA, ARMOR, MAX) delivery to NCAR Field Catalog (FC) finishing up now

• Meteorological, kinematic and microphysical control of lightning flash rate, type, and extent
  – Initial priority on the 2 multicell aircraft cases (Poster #267)
  – Collaboration with NASA MSFC to apply the Lightning Nitrogen Oxides Model (LNOM) to individual thunderstorms (Poster #271)
  – Minimal requirements for lightning; MCS electrification and lightning
EXTRA/BACK-UP SLIDES
Radars:

**Triple-Doppler (30°)**
- **ARMOR**: 100 km
- **MAX**: 100 km
- **KHTX/Hytop**: 100 km

Other WSR-88D’s
- **KBMX/Birmingham**
- **KOHX/Nashville**
- **KFFC/Atlanta**
- **KNQA/Memphis**
- **KMRX/Knoxville**
- **KGWX/Columbus AFB**
- **KHPX/Ft Campbell**
- **KPAH/Paducah**
- **KMXX/Maxwell AFB**
- **KDGX/Jackson**
  *dual-pol upgraded*

NA-LMA:

**NA-LMA sensors,**
150, 250 km range rings

**Altitude errors (m)**
UAHuntsville ARMOR: Advanced Radar for Meteorological and Operational Research.

C-band Polarimetric

- Location: Huntsville Intl. Airport
- Altitude (antenna MSL): 206 m
- Transmit frequency: 5625 MHz (C-band)
- Peak Power: 350 kW (Magnetron)
- 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
- Cross-pol isolation: < -41 dB
- Maximum rotation rate: 36° s⁻¹
- Transmit polarization: Simultaneous H and V, [or H]
- Receive polarization: Vaisala Sigmet dual-channel; H + V, or H
- Signal Process: Vaisala Sigmet RVP/8
- Variables: Z, V_r, W, Z_dir, \( \rho_{HV} \), \( \phi_{dp} \), \( K_{dp} \), [LDR]

- 2002: NWS Doppler WSR-74C donated to UAHuntsville
- 2004: Upgraded to dual-polarimetric using the SIGMET Antenna Mounted Receiver
- 2005: Upgrade to solid state transmitter by Baron Services
- 2006: Upgrade to high performance Seavey antenna and Orbit pedestal with integration by Baron Services
- More information regarding the ARMOR can be found at http://nsstc.uah.edu/armor/
**MAX:** Mobile Alabama X-band polarimetric Doppler Radar

http://vortex.nsstc.uah.edu/mips/max/

**Oct. 2006:** Initial procurement of hardware

**Nov. 2006 - Fall 2007:** Construction

**Fall 2007 - Winter 2008:** Shakedown/field ready

- Transmit frequency: 9450 MHz (H+V, H)
- Peak Power: 250 kW
- Pulse width: 0.4 – 2.0 μs
- Min/Max PRF: 250 / 2000 s⁻¹
- Antenna Diameter: 2.4 m (8 ft, CF Parabolic)
- Antenna Gain: 44.5 dB
- Antenna Beam width: 1°
- First side-lobe: -31 dB
- Cross-pol isolation: <-36 dB
- Receiver polarization: RVP/8
- Variables: Z, V, W, ZDR, φDP, KDP, ρHV, LDR

**Radar Development**

- Tx/Rx/Ant. Design/Integration: Baron Services, Huntsville
- MP-61 Pedestal (Radio Research): UAH with prep. work and checkout by Mr. Bob Bowie, CSU-CHILL
- Truck/generator/data system: UAH
LMA Hardware

New Mexico Tech System

- LMA Sensor Sites
  - VHF ground plane antenna
  - Sensor electronics / site computer (first generation)
  - Communications (mostly 2.4 GHz wireless Ethernet network link)
- Relay Sites and Central Station
  - PC router (up to 4 network links)
  - Communications (multiple antennas require great care in channel selection)
  - Cell phone modems used at some sites
LMA Site Installations

- Sites selected on basis of noise level, ability to establish wireless com link, and low / no cost access
- Installations include: water towers, public/private radio towers, user supplied towers/masts, utility poles, even a firetower and a building
North Alabama LMA

http://branch.nsstc.nasa.gov/PUBLIC/NALMA/
	ransitioning unique NASA data and research technologies to the NWS
Mobile Integrated Profiling System (MIPS)

http://vortex.nsstc.uah.edu/mips/

10 kW generator
915 MHz Doppler wind profiler
Microwave Profiling Radiometer
X-band Profiling Radar
Lidar Ceilometer
iMET-3150 (403 MHz GPS) Upper Air Sounding System

- **iMetOS (Windows PC based) provides**
  - Flight status display
  - Radiosonde data display
  - Real-time processing, quality control and reporting of met data
  - Graphical output (e.g., Skew-T Log-P) of T, Td, RH, wind speed & direction
  - Playback of previously recorded flights
  - Data editing and archiving
  - WMO, STANAG and custom reports

- **iMet-1 radiosonde**
  - Factory calibrated, 1 year accuracy
  - meets the current NWS radiosonde specification (NWS-J070-RS-SP005C.)

![Diagram of the iMET-3150 system setup]
• 60 radiosondes for DC3 (40/20 reserved for flight/non-flight operations)
  – iMet-1-AB 403 MHz GPS Radiosonde C/A code GPS receiver with solid state pressure sensor
  – De-reeler, pre-wound with 30 m string
  – 300 gm Latex meteorological balloon (24.7 km burst altitude), parachute