



# Alabama Ground Operations during the Deep Convective Clouds and Chemistry Experiment

Lawrence Carey<sup>1</sup>, Lamont Bain<sup>1</sup>, Ryan Rogers<sup>1</sup>, Danielle Kozlowski<sup>1</sup>, Adam Sherrer<sup>1</sup>, Matt Saari<sup>1</sup>, Brandon Bigelbach<sup>2</sup>, Mariana Scott<sup>1</sup>, Elise Schultz<sup>1</sup>, Chris Schultz<sup>1,3</sup>, Patrick Gatlin<sup>1,3</sup>, Matt Wingo<sup>1</sup>, Dustin Phillips<sup>1</sup>, Chris Phillips<sup>1</sup>, Harold Peterson<sup>4</sup>, Jeff Bailey<sup>1</sup>, Terryn Frederickson<sup>1</sup>, John Hall<sup>1</sup>, Richard Blakeslee<sup>3</sup>, William Koshak<sup>3</sup>, Nicole Bart<sup>2</sup>, Melissa Becker<sup>2</sup>, Kurtis Pinkney<sup>2</sup>, Scott Rowe<sup>2</sup>, Mariusz Starzec<sup>2</sup>, Justin Weber<sup>2</sup>, and Gretchen Mullendore<sup>2</sup>



<sup>1</sup> *University of Alabama in Huntsville*

<sup>2</sup> *University of North Dakota*

<sup>3</sup> *NASA MSFC*

<sup>4</sup> *USRA/STI*



# 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

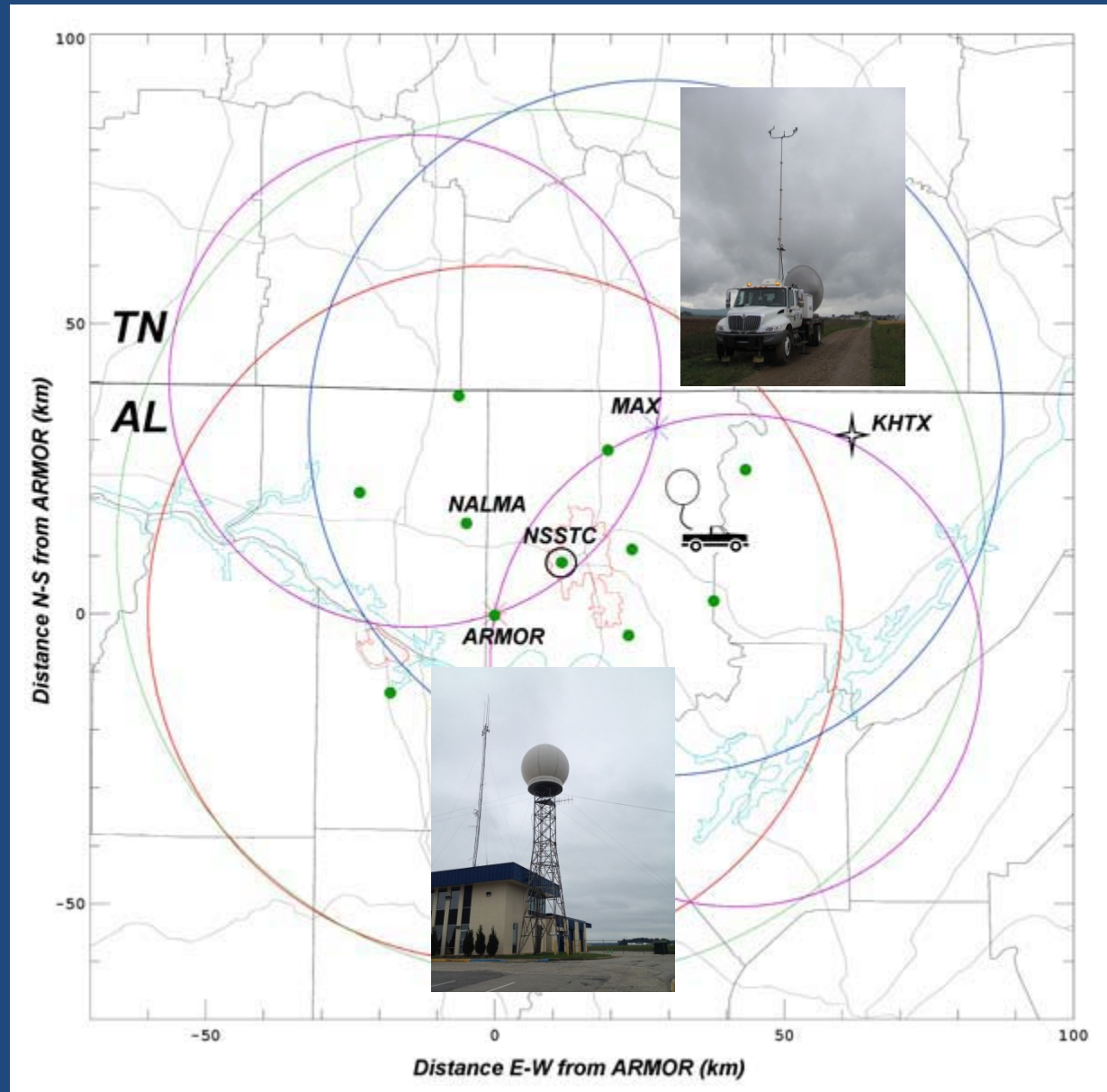
- **Northern Alabama - Lightning Mapping Array (NA-LMA)**
- Other lightning data (Regional/Global LF/VLF networks such as Vaisala NLDN, Vaisala GLD360, Earth Networks ENTLN)

- Other

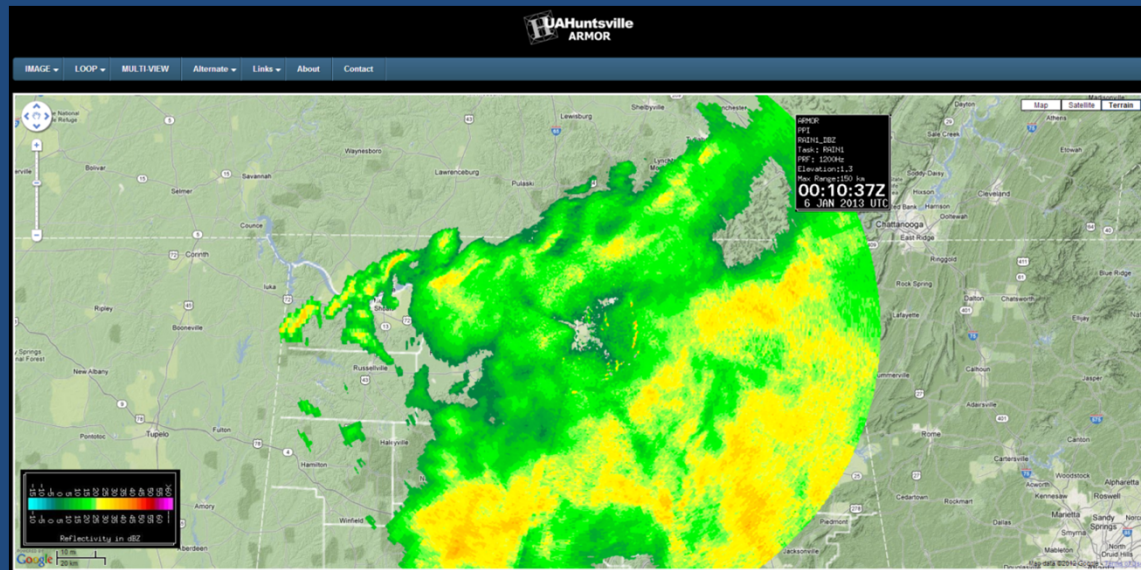
- Army Redstone Arsenal 12z sounding
- KHTX Hytop (also KBMX, KOHX, KFFC) WSR-88D S-band upgraded dual-polarimetric radars)
- KGWX WSR-888D (not upgraded)

# 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:  $1.1^\circ$
- 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)

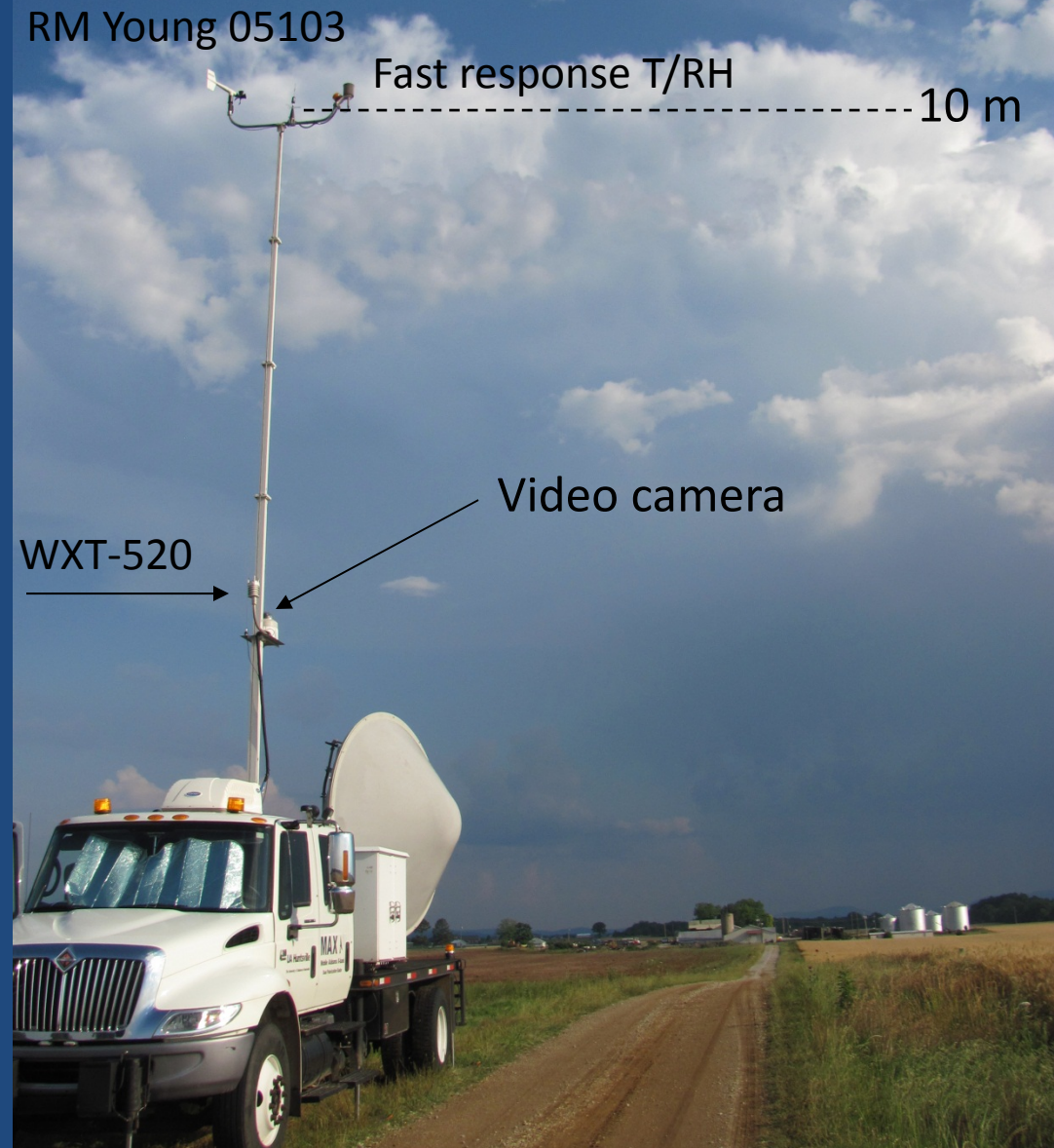
<http://nsstc.uah.edu/ARMOR/>

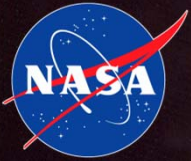
# Mobile Alabama X-band (MAX)

- Frequency: 9450 MHz
- Dual-polarization:
  - Simultaneous transmit (H+V), dual receive (H, V)
- $Z_h$ ,  $V_r$ ,  $\sigma$ ,  $Z_{dr}$ ,  $\phi_{dp}$ ,  $K_{dp}$ ,  $\rho_{hv}$
- Antenna Beam width:  $1^\circ$
- 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/>

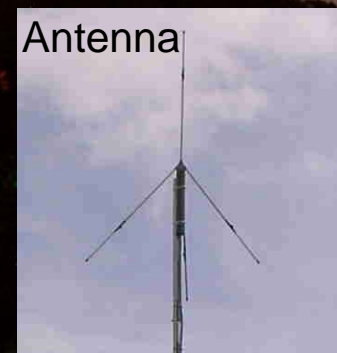
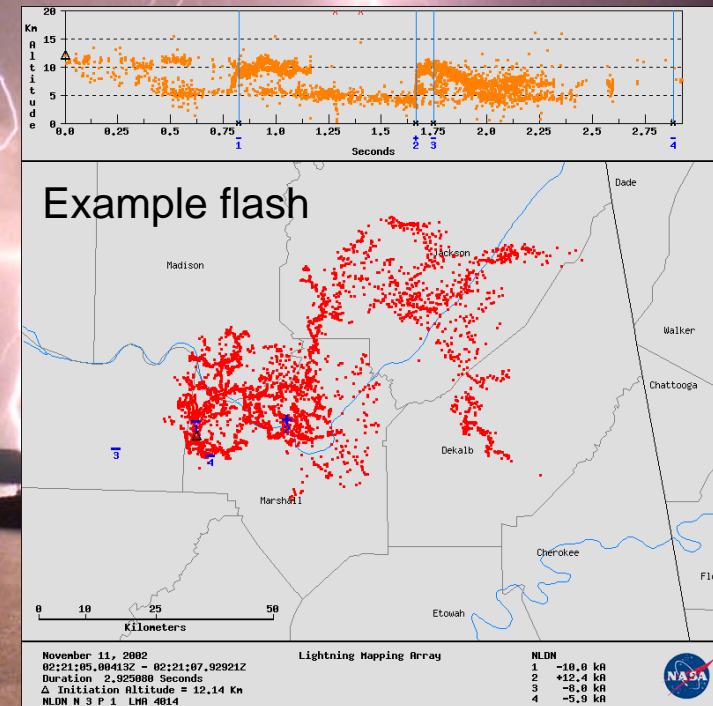
## MAX setup for DC3 at New Market Site Cab pointing N/S





# 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



transitioning 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)



## DC3 Alabama Mission Summary: 5/14/2012 – 6/30/2012

	Date	Type	Ground Instruments*	Summary
1	5/15	Ground only	ARMOR-KHTX, NALMA, 1 sonde	Few low flash rate shallow convection
2	5/18	Ground only	ARMOR-MAX-KHTX, NALMA, 2 sondes	Several hours multicell thunderstorms
3	5/19	Ground only	ARMOR-KHTX, NALMA	Several hours isolated to multicell storms
4	5/20	Ground only	ARMOR-KHTX, NALMA	Few isolated thunderstorms
5	5/21	<b>Aircraft #1</b>	<b>ARMOX-MAX-KHTX, NALMA, 4 sondes, MIPS</b>	<b>Isolated thunderstorms evolving to multicell line</b>
6	5/29	Ground only	ARMOR-MAX-KHTX, NALMA, 2 sondes	Isolated to widely scattered weak convection
7	5/31	Ground only	ARMOR-MAX-KHTX, NALMA, MIPS deployed in DD lobes, 3 sondes	Few isolated thunderstorms. Some low flash.
8	6/3 – 6/4	Ground only	ARMOR-MAX-KHTX, NALMA, MIPS	Extended operations. Many hours multicell. Severe in evening. Nocturnal MCS passage.
9	6/4 – 6/5	Ground only	ARMOR-MAX-KHTX, NALMA, MIPS deployed in DD lobes, 4 sondes	Overnight operations. Leading stratiform nocturnal MCS.
10	6/11	<b>Aircraft #2</b>	<b>ARMOR-MAX-KHTX, NALMA, MIPS, 5 sondes</b>	<b>Multicell thunderstorms during aircraft mission.</b>
11	6/14	Ground only	ARMOR-KHTX, NALMA, 1 sonde	Few isolated airmass convection. 1 vigorous.
12	6/15	Ground only	ARMOR-KHTX, NALMA, 1 sonde	Limited operations with isolated storms

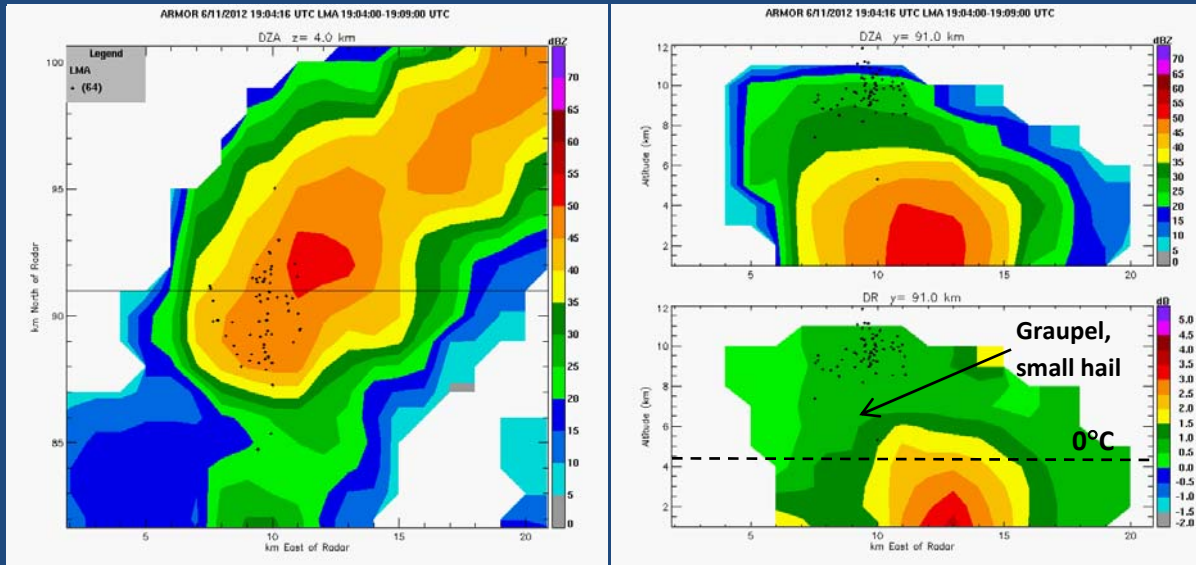
\* ARMOR = Advanced Radar for Meteorological and Operational Research, UAH; MAX = Mobile Alabama X-band Radar, UAH; KHTX=Hytop WSR88D, NALMA=Northern Alabama Lightning Mapping Array, NASA MSFC; MIPS=Mobile Integrated Profiling Systems, UAH

# DC3 AL on June 11, 2012, 0743 UTC

## Aircraft Case #2: ordinary multicell thunderstorms

1404 CDT  
1904 UTC  
(NALMA sources)

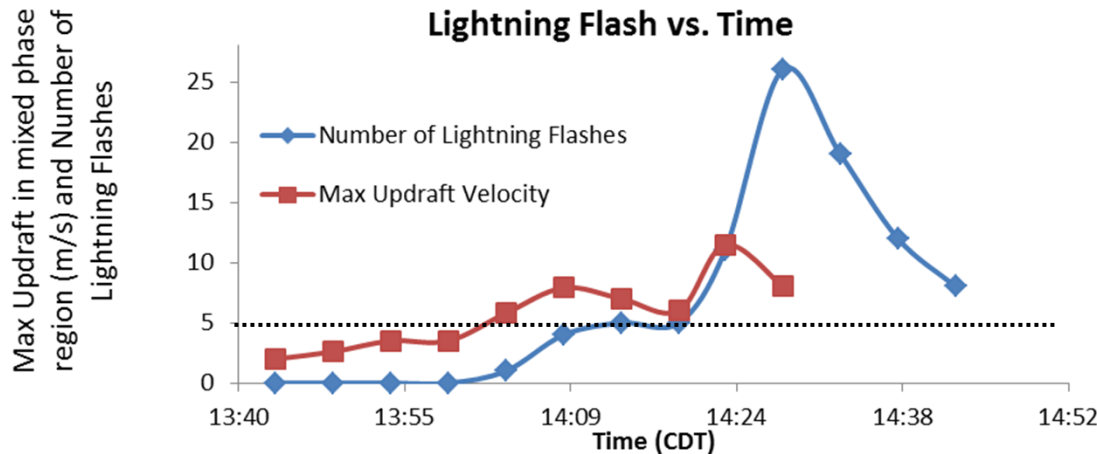
ARMOR  
CAPPI 4 km



Vertical cross-section of  $Z_h$  (dBZ)

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

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

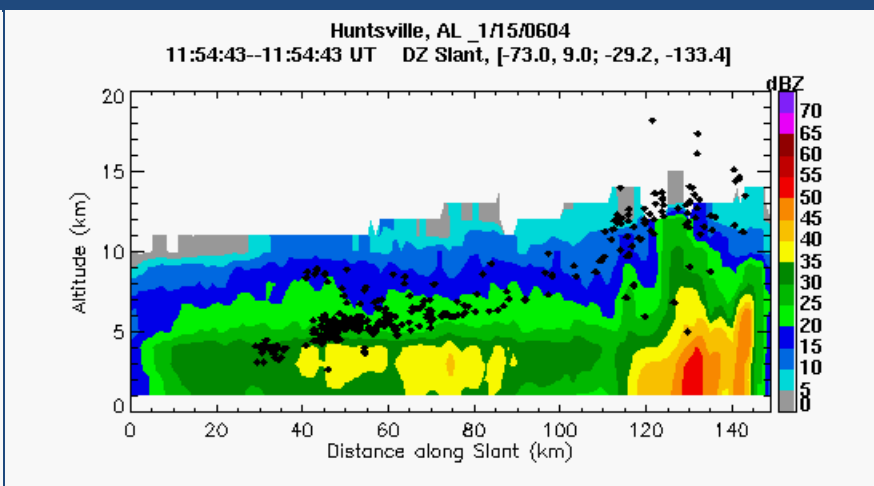
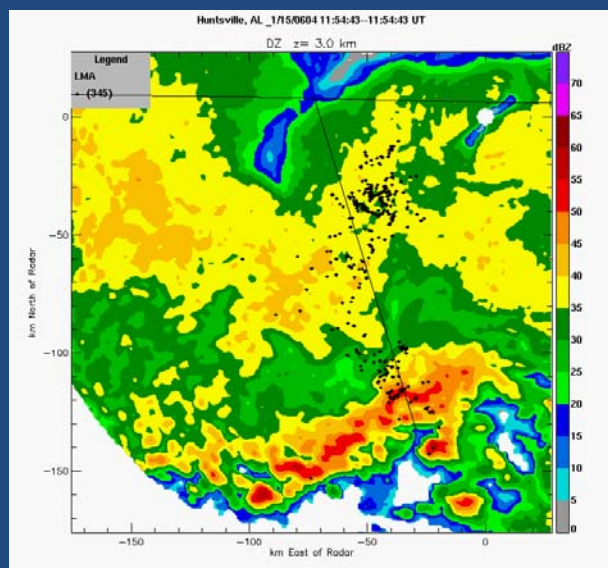
A. L. Bain and L. D. Carey

# DC3 AL on June 4, 2012, 11-12 UTC

## Trailing stratiform MCS lightning

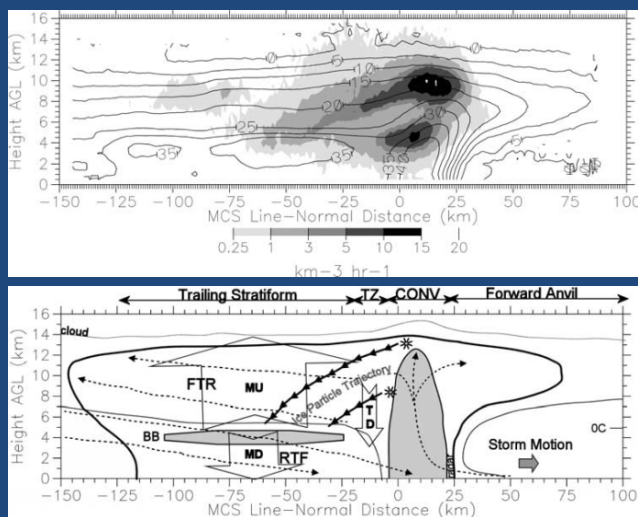
KHTX  
 $Z_h$   
 CAPPI  
 3 km

NALMA  
 VHF  
 Sources



Vertical  
 cross-  
 section  
 of  $Z_h$   
 (dBZ)

1155 UTC



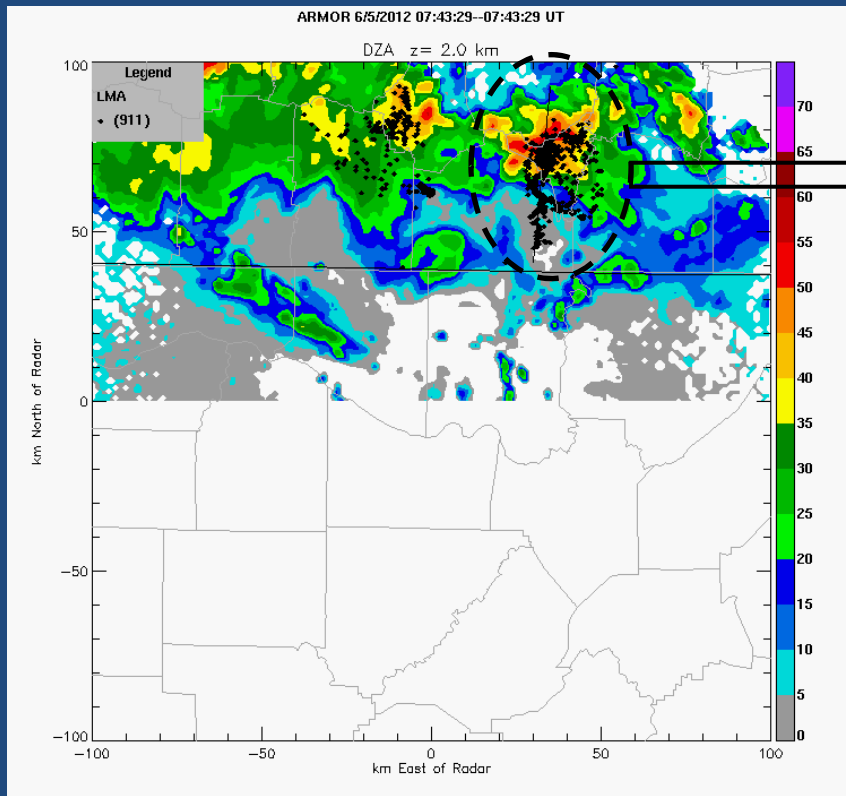
Carey et al. (2005)

- 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

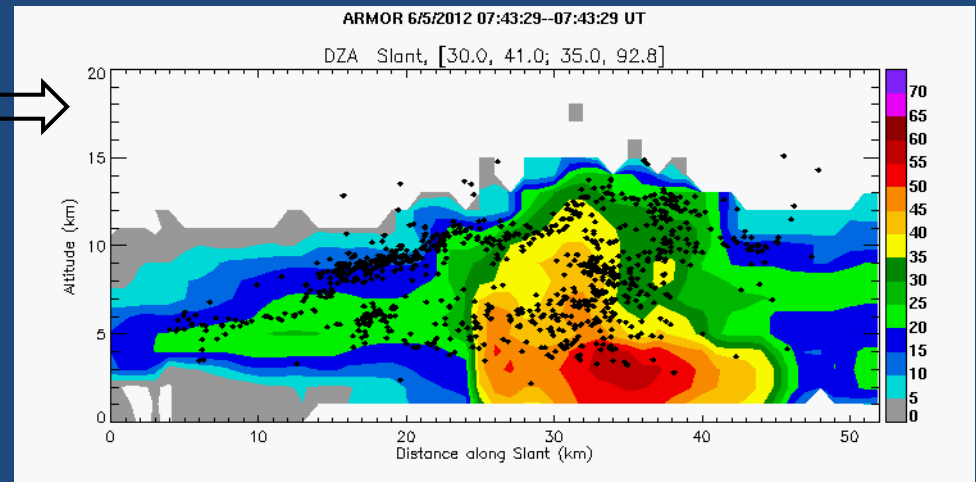
# DC3 AL on June 5, 2012, 0743 UTC

## Leading stratiform anvil MCS lightning

ARMOR reflectivity (dBZ) and NA-LMA VHF sources



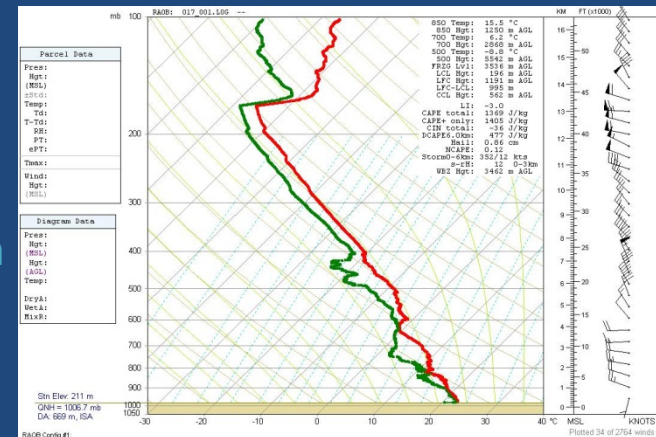
Vertical-cross section through Lincoln Co. TN flash (NE)



2 km CAPPI from ARMOR

Few multi-Doppler, polarimetric studies of electrification and lightning in leading stratiform MCS

Sonde through leading stratiform anvil at 0929 UTC

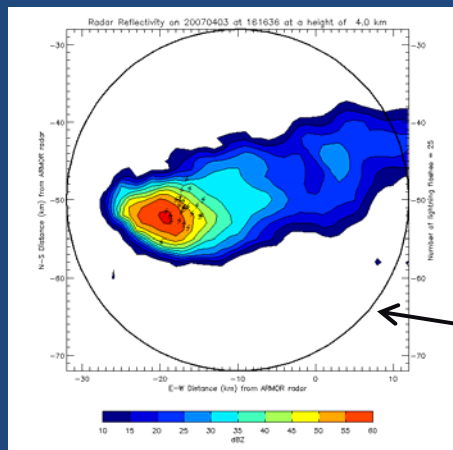


NNW flow

# NASA Lightning Nitrogen Oxides Model (LNOM)

## Application toward Thunderstorm Studies

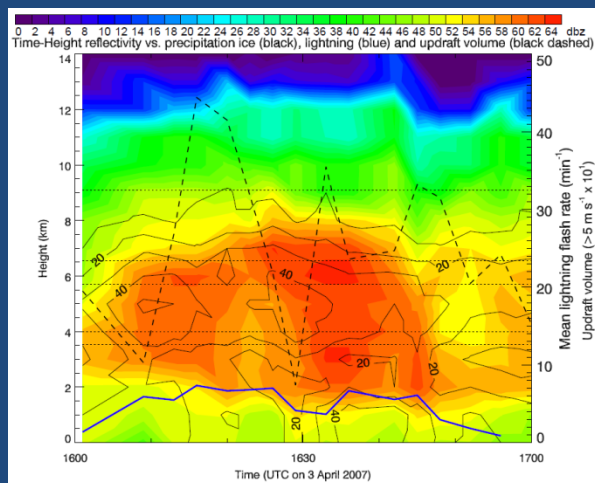
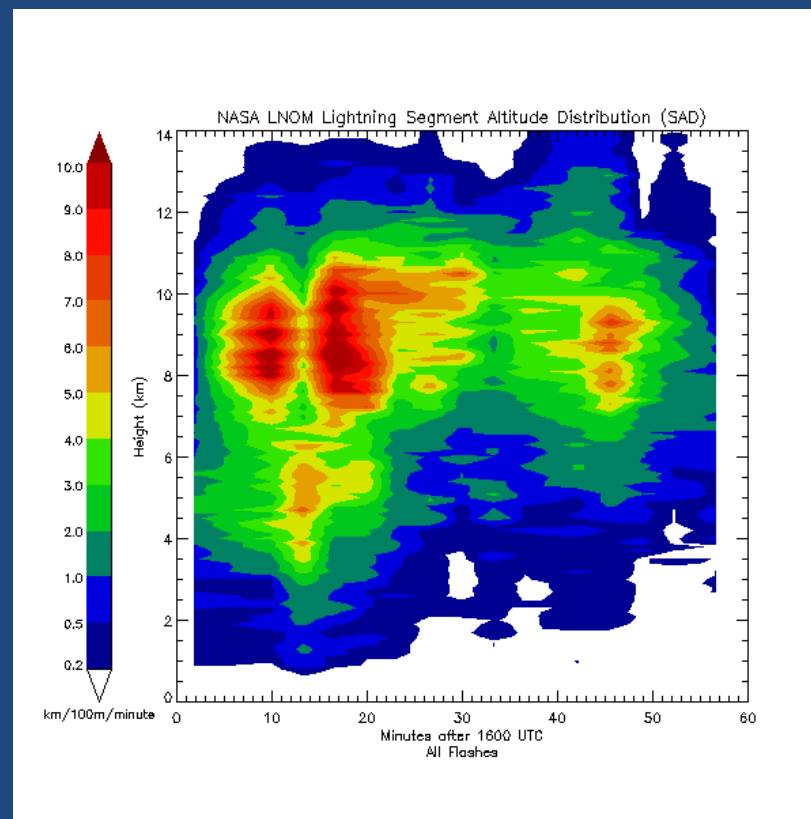
April 3, 2007: Ordinary Convection over N. Alabama



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 LNOM Segment Altitude Distribution (SAD)



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

For more details see Poster #271

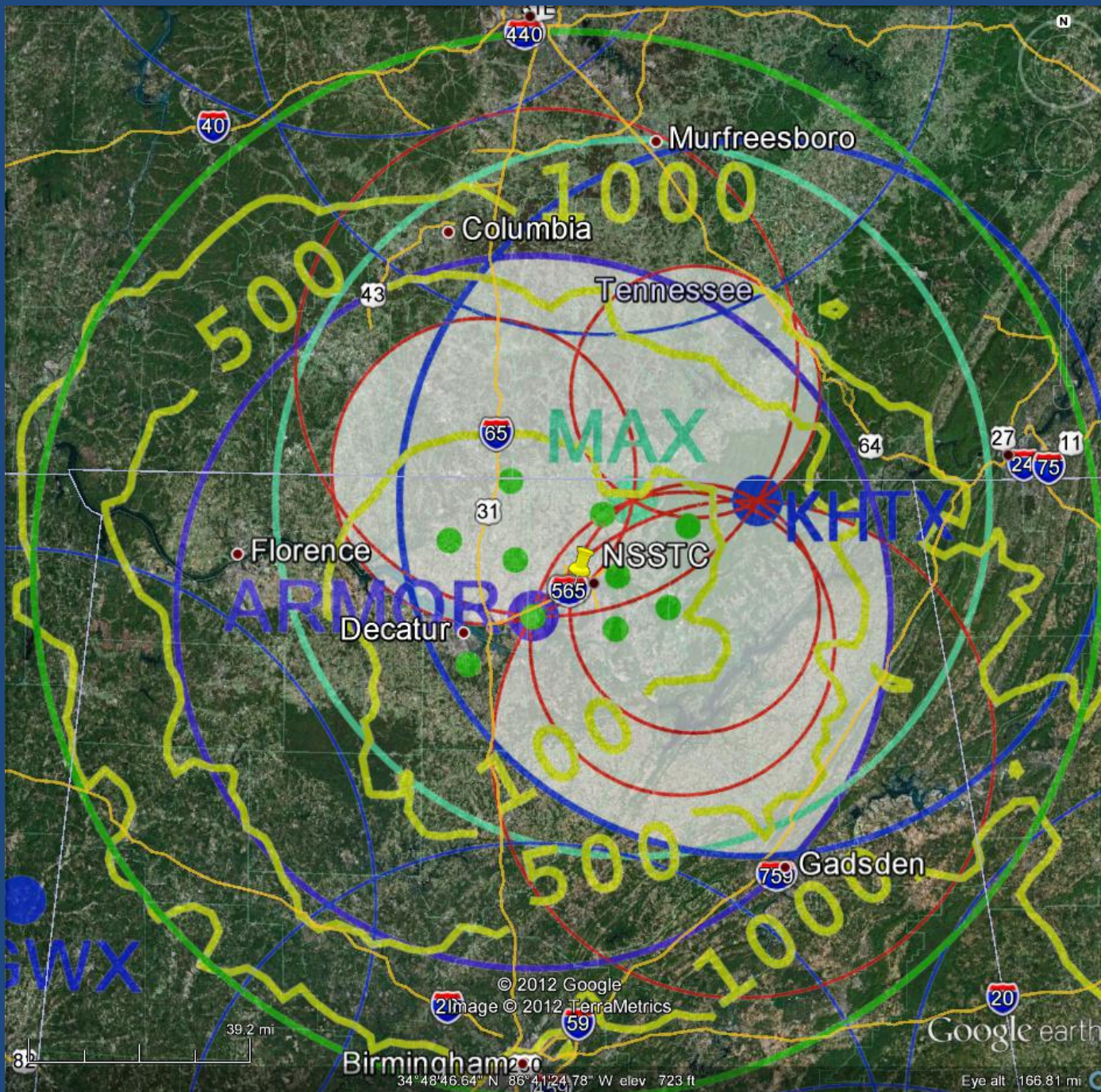
The Kinematic and Microphysical Control of Storm Integrated Lightning Flash Extent

*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



**ARMOR at HSV Airport**

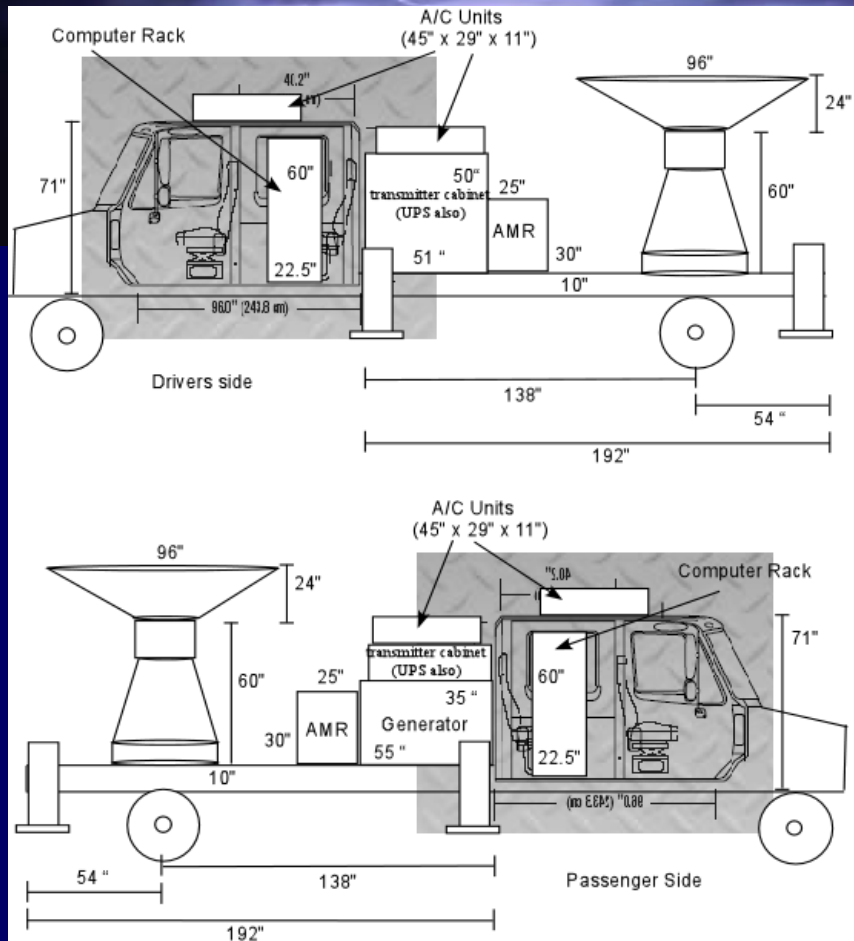
- Location : Huntsville Intl. Airport
- Altitude (antenna MSL): 206 m
- Transmit frequency: 5625 MHz (C-band)
- Peak Power: 350 kW (Magnetron)
- Pulse width: 0.4 – 2.0  $\mu$ s
- Maximum PRF: 250-2000  $s^{-1}$
- Antenna Diameter 3.7 m (12 ft CF Parabolic)
- Antenna Beam width: 1.1 $^{\circ}$
- First side-lobe: -30 dB
- Cross-pol isolation: < -41 dB
- Maximum rotation rate: 36 $^{\circ}$   $s^{-1}$
- 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,  $Z_{dr}$ ,  $\rho_{HV}$ ,  $\phi_{dp}$ ,  $K_{dp}$ , [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

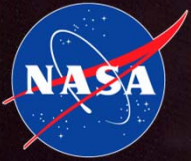


- Transmit frequency: 9450 MHz (H+V, H)
- Peak Power: 250 kW
- Pulse width: 0.4 – 2.0  $\mu$ s
- Min/Max PRF: 250 / 2000  $s^{-1}$
- Antenna Diameter: 2.4 m (8 ft, CF Parabolic)
- Antenna Gain: 44.5 dB
- Antenna Beam width: 1°
- First side-lobe: -31 dB
- Cross-pol isolation: <-36 dB
- Receiver polarization: RVP/8
- Variables: Z, V, W, ZDR,  $\phi_{DP}$ , KDP,  $\rho_{HV}$ , 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

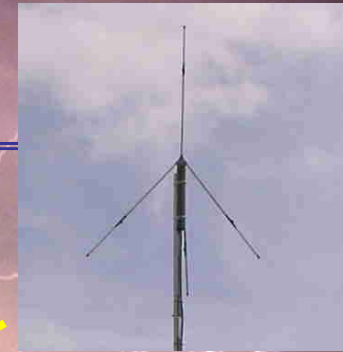




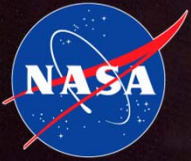
# LMA Hardware

## *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



*transitioning unique NASA data and research technologies to the NWS*



# 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



**Water tower  
(Keel)**



**User supplied tower  
(Owen)**



**Utility pole  
(AAMU)**



**Commercial radio tower  
(Drake)**



*transitioning unique NASA data and research technologies to the NWS*

# North Alabama LMA



- [Home](#)
- [Overview](#)
- [Status](#)
- [Participants](#)
- [News & Highlights](#)
- [Links](#)
- [FAQ](#)
- [Contacts](#)



## North Alabama Lightning Mapping Array

The North Alabama Lightning Mapping Array is a joint project involving NASA, New Mexico Tech, and Georgia Tech. The network locates the total lightning activity inside storms using a network of 11 stations around the North Alabama area and 2 stations in the Atlanta Georgia area.

The information on this web site is for general interest and information only and *should not be used for operational purposes or depended upon for making decisions in regard to safety.*

### Latest 10 Minute Summaries

### Recent Daily Summaries

#### February 2012

Su	Mo	Tu	We	Th	Fr	Sa
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29			

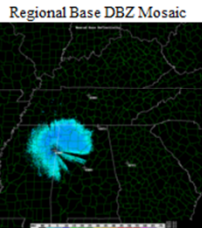
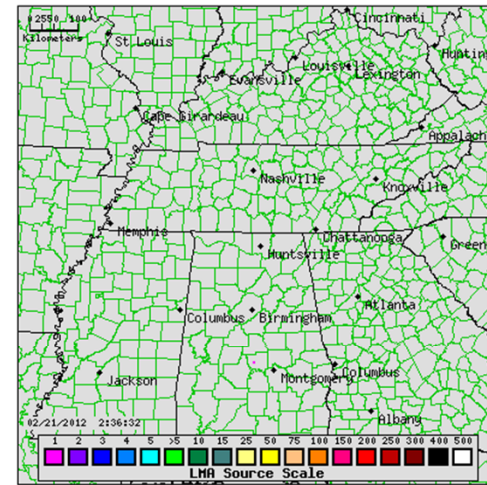
#### January 2012

Su	Mo	Tu	We	Th	Fr	Sa
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

#### December 2011

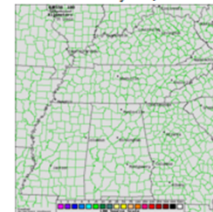
Su	Mo	Tu	We	Th	Fr	Sa
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

### Monthly Thumbnails

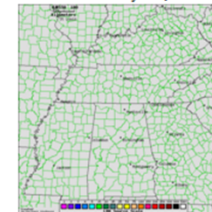


### Recent Daily Density Summaries

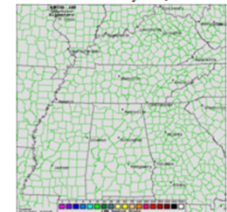
Sun February 19, 2012



Mon February 20, 2012



Tue February 21, 2012



[Privacy Policy](#)  
[Disclaimer](#)

NASA Contact: [Jim Smoot](#)  
WEB Site Contact: [John Hall](#)



<http://branch.nsstc.nasa.gov/PUBLIC/NALMA/>



# 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

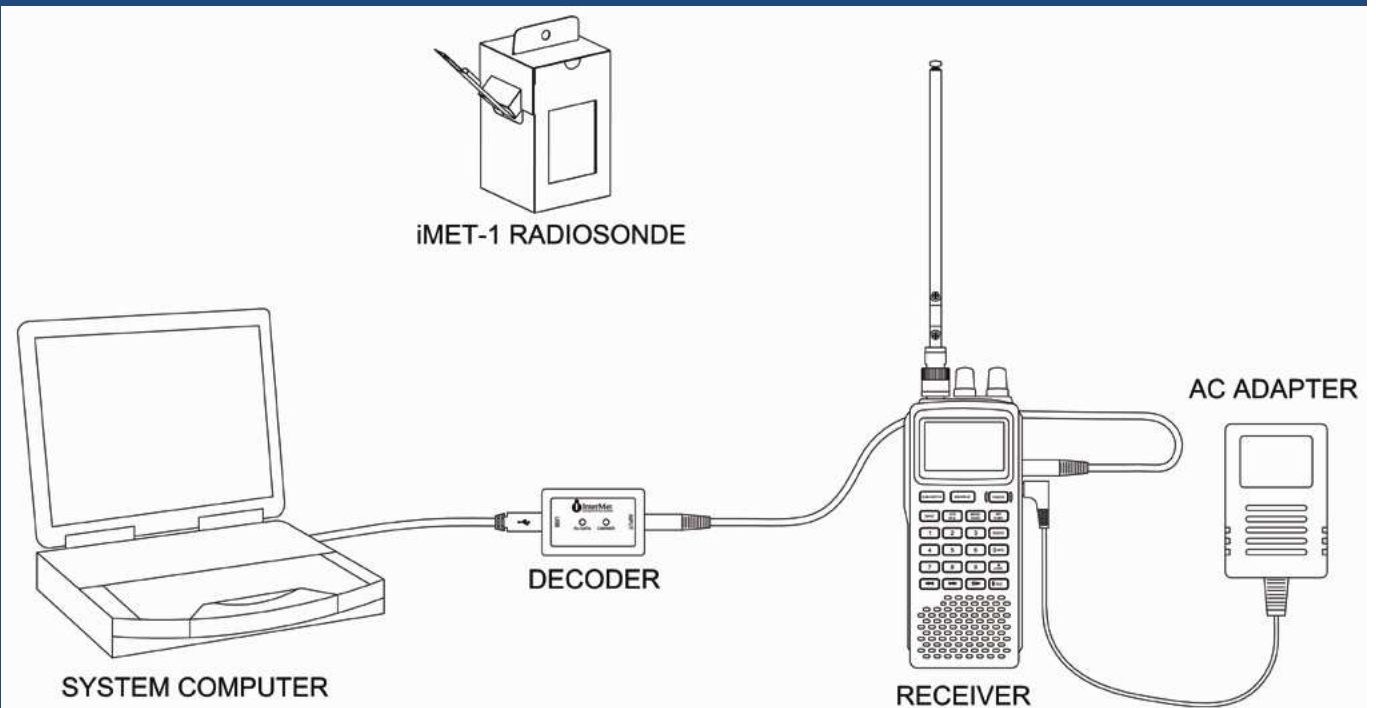
Lidar  
Ceilometer

# 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.)



- 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

