Ground Facilities - Alabama

Lawrence Carey

University of Alabama in Huntsville (UAH)

Gratefully acknowledge

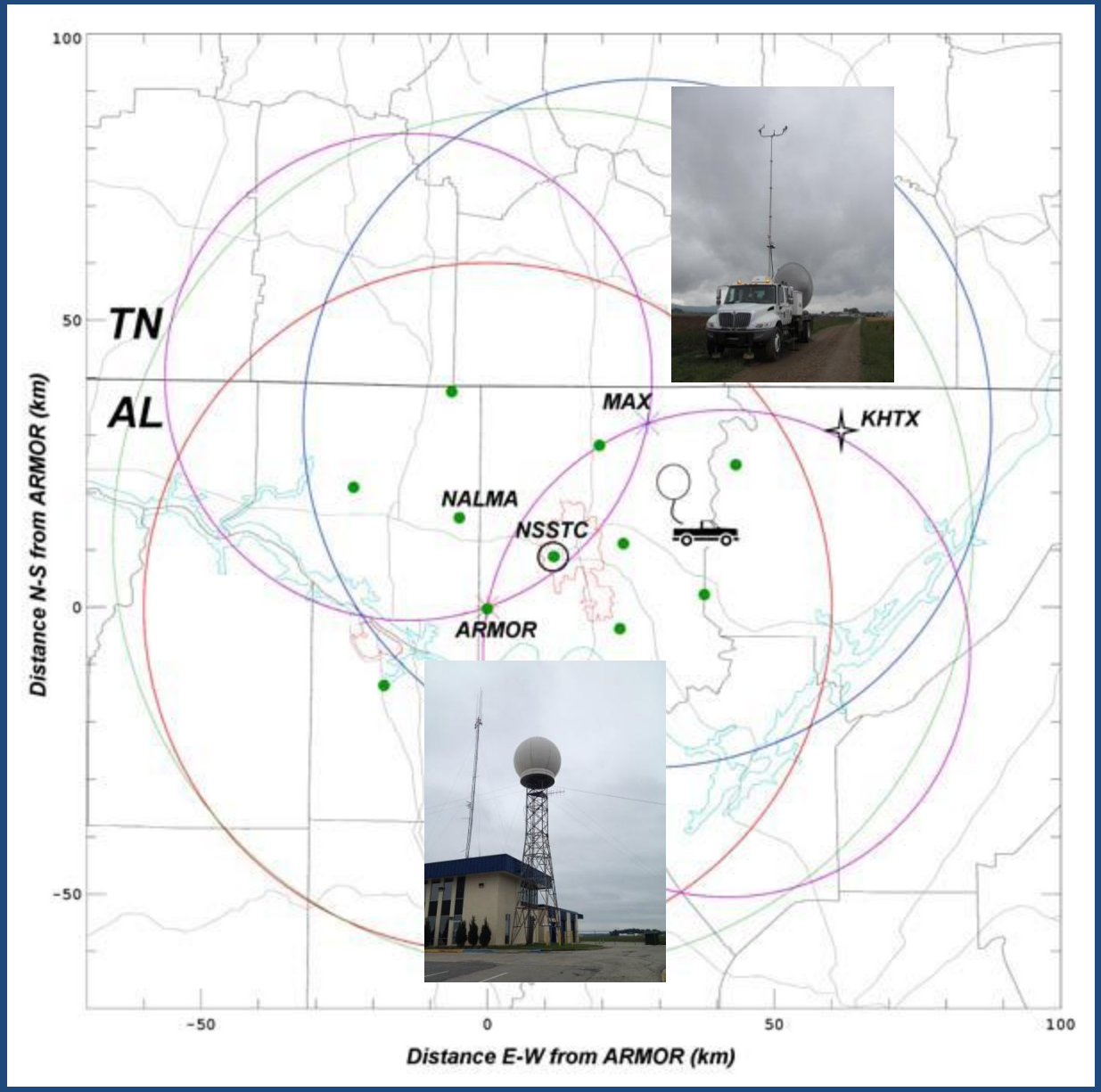
- **NASA MSFC (Rich Blakeslee, William Koshak) for operation of the NA-LMA and collaboration on lightning NO_x**
- **UAH graduate students Lamont Bain, Retha Matthee and Chris Schultz for contributions to this talk**
- **Many UAH, NASA MSFC and UND (Gretchen Mullendore) students, faculty and staff for hard work during and after DC3 field operations**
- **Support of the NSF Physical and Dynamical Meteorology program under the direction of Dr. Bradley Smull (AGS-1063573)**

DC3 Alabama Ground Facilities

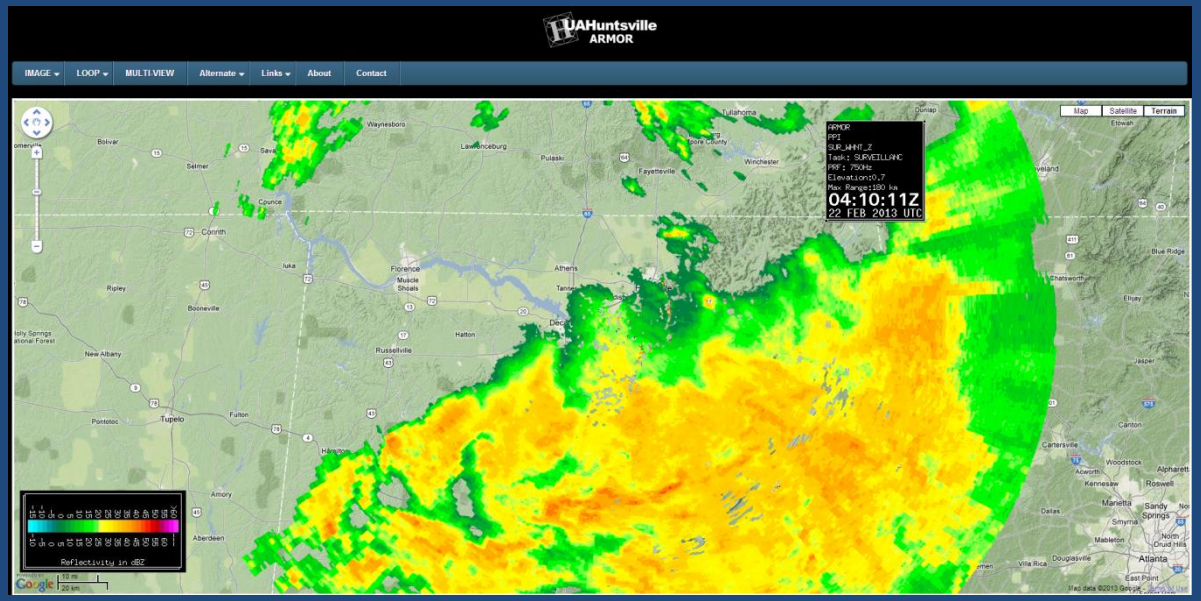
- UAH
  - **Advanced Radar for Meteorological and Operational Research (ARMOR) C-band polarimetric radar**
  - **Mobile Alabama X-band (MAX) polarimetric radar**
  - Mobile Integrated Profiling System (MIPS)
  - iMET-3150 GPS sounding system – mobile van based
- NASA MSFC
  - **Northern Alabama - Lightning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



UAH Advanced Radar for Meteorological and Operational Research (ARMOR)



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

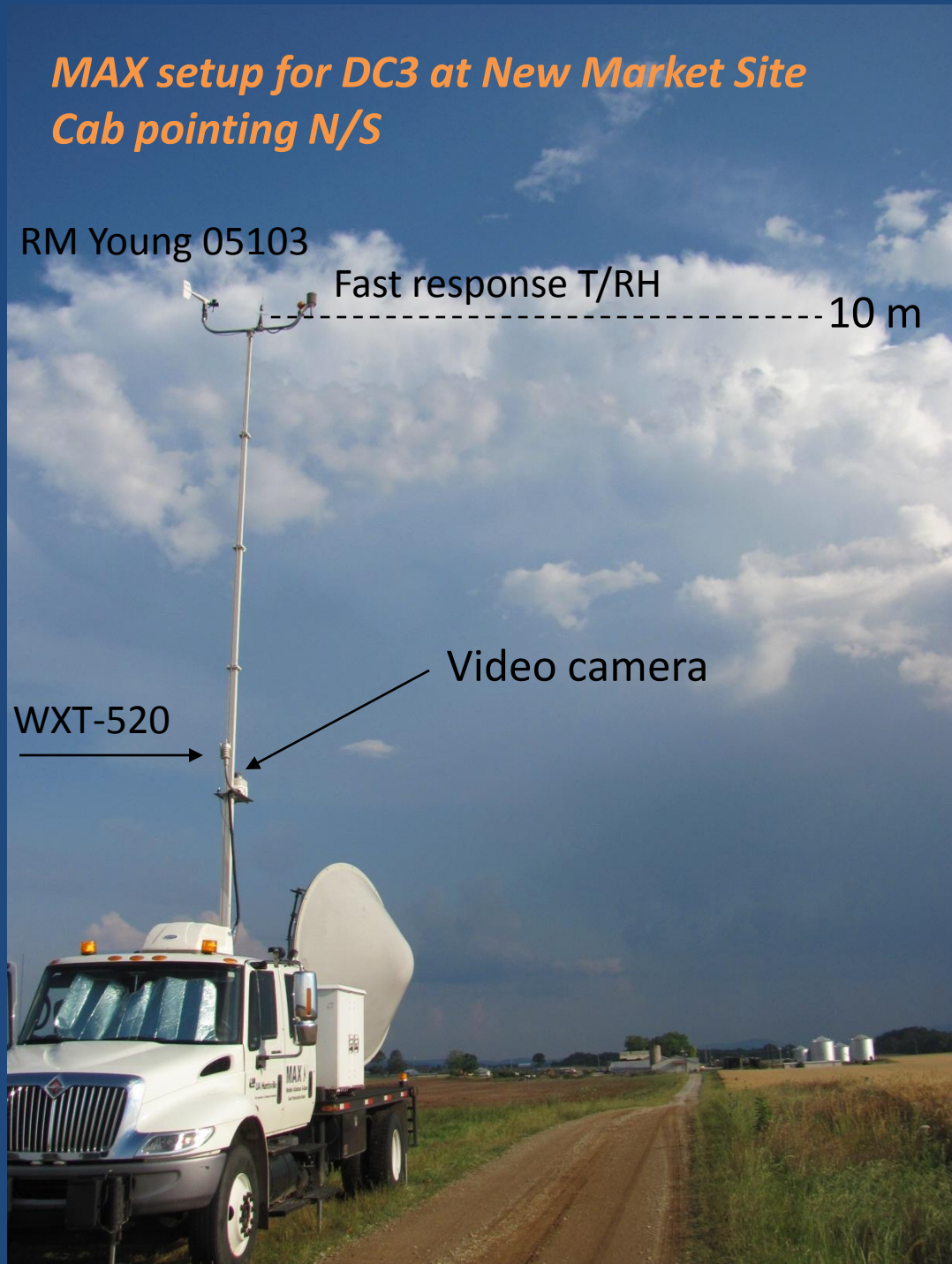
- Frequency: 5625 MHz (C-band)
- Antenna Beam width: 1.1^{o}
- Dual-polarization: transmit simultaneous H + V (dual-channel receive, H + V)
- Variables: Z_h, V_r, σ, Z_{dr}, ρ_{HV}, ϕ_{dp}, K_{dp}
- Vaisala RVP-8 IRIS control from UAHuntsville NSSTC network computer
- Continuous research operations/scanning: 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)

UAH Mobile Alabama X-band (MAX)

- Frequency: 9450 MHz
- Dual-polarization:
  - Simultaneous transmit (H+V), dual receive (H, V)
- Z_h, V_r, σ, Z_{dr}, ϕ_{dp}, K_{dp}, ρ_{hv}
- Antenna Beam width: 1^o
- 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

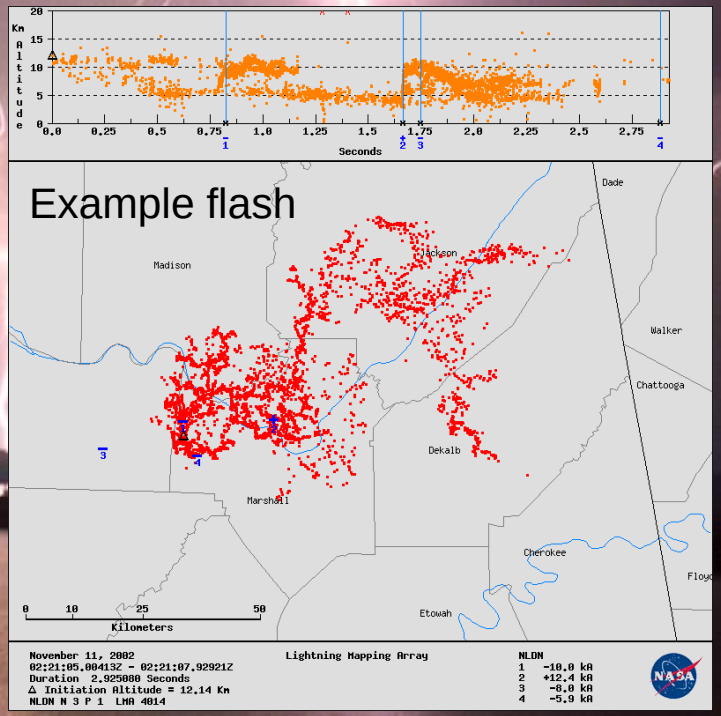
http://vortex.nsstc.uah.edu/mips/max/

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



NASA MSFC'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



SPORT

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

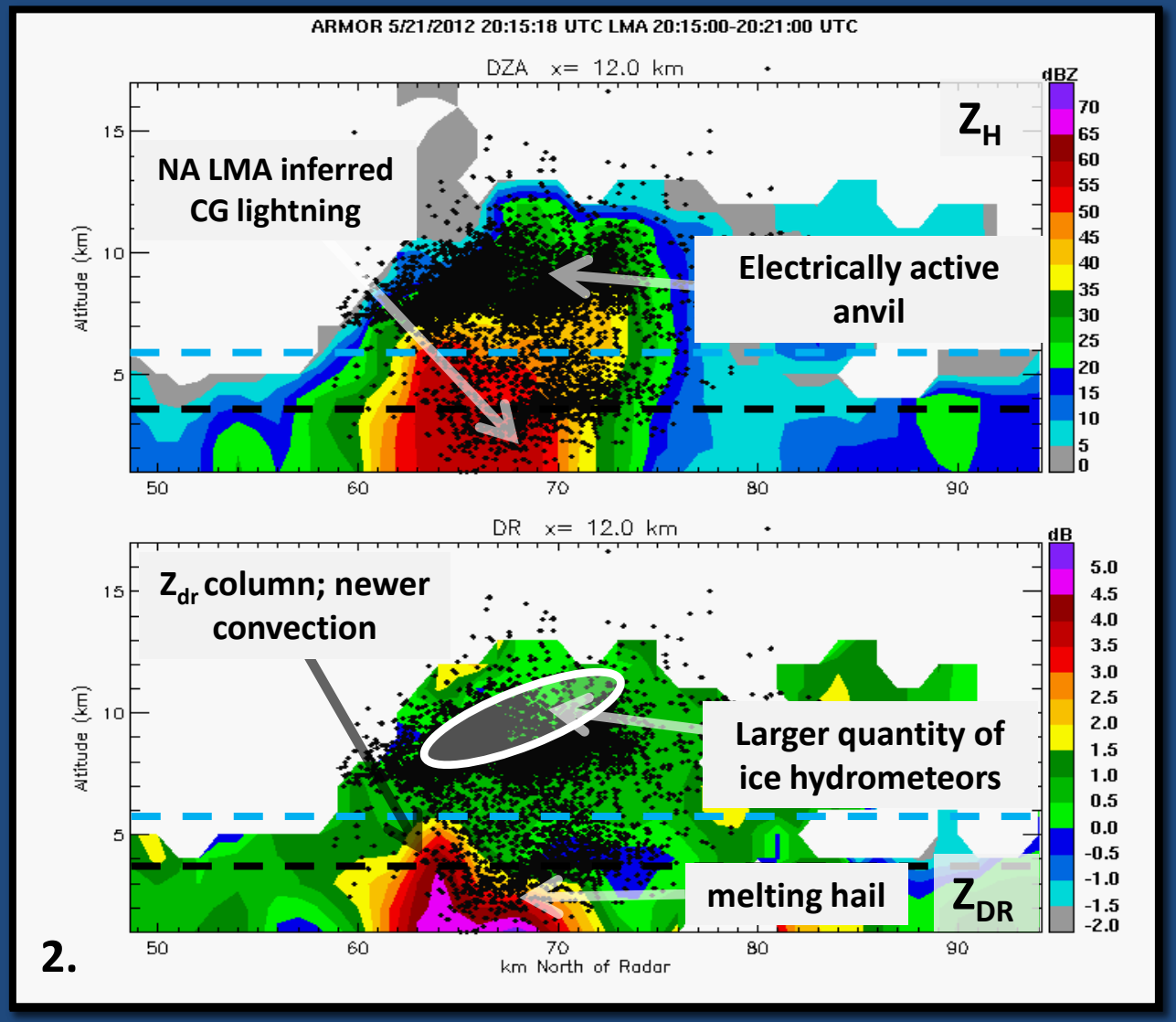
- 21 May (Aircraft #1): ARMOR-MAX-KHTX radars, NALMA, MIPS at NSSTC, 4 sondes (1 pre-convective, 3 inflow), **isolated to multicell convective line**
- 11 June (Aircraft #2): ARMOR-MAX-KHTX radars, NALMA, MIPS at NSSTC, 5 sondes (1 pre-convective, 4 inflow), **multicell thunderstorms**
- Ground-only 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**	**Aircraft #1**	**ARMOX-MAX-KHTX, NALMA, 4 sondes, MIPS**	**Isolated thunderstorms evolving to multicell line**
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**	**Aircraft #2**	**ARMOR-MAX-KHTX, NALMA, MIPS, 5 sondes**	**Multicell thunderstorms during aircraft mission.**
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**

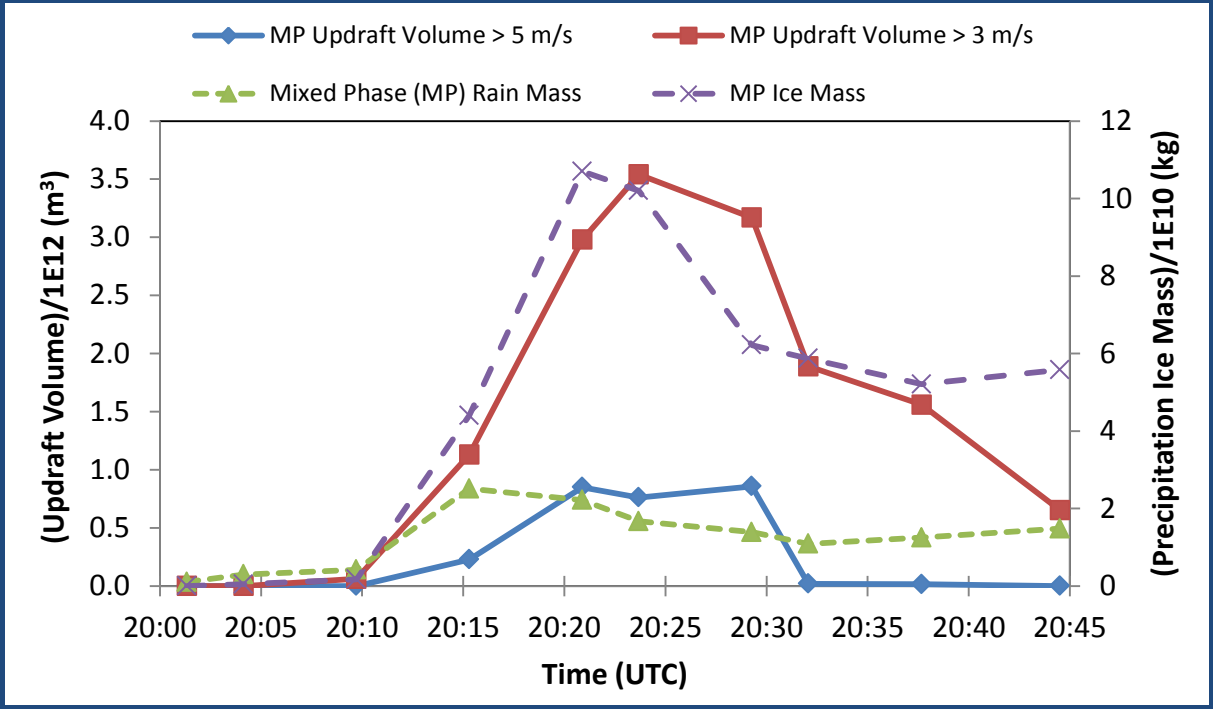
DC3 AL on May 21, 2012
Aircraft Case #1: ordinary isolated to multicell thunderstorms



ARMOR (20:15 UTC) NA LMA (20:15-20:21 UTC)

DC3 AL on May 21, 2012
Aircraft Case #1: ordinary isolated to multicell thunderstorms

Lightning – Radar Parameter Study

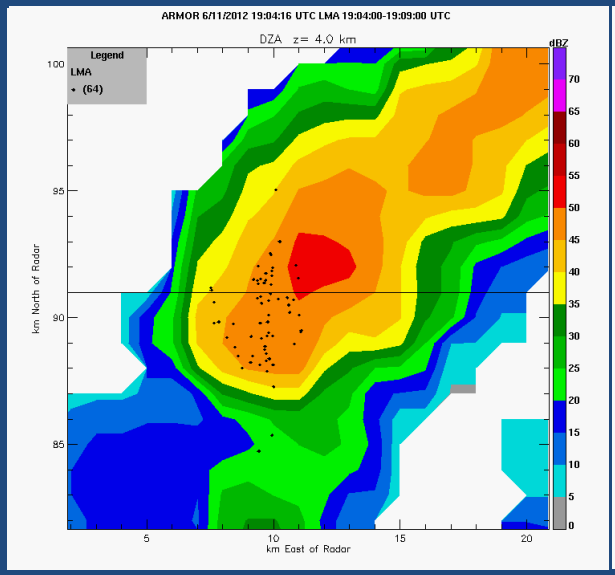


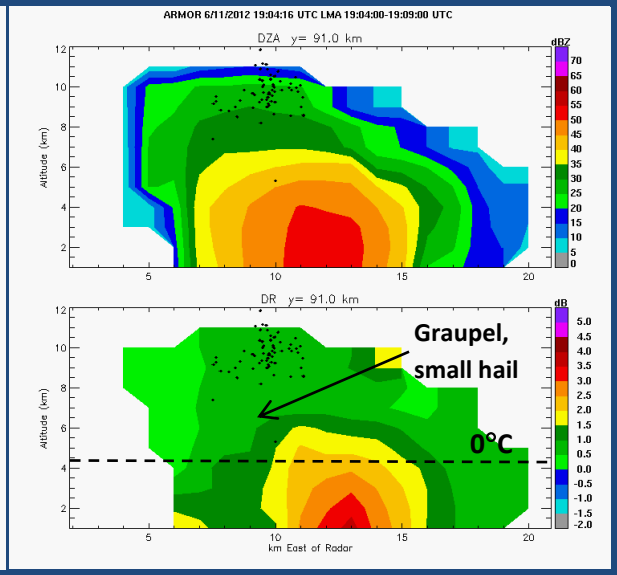
- Freezing of supercooled rain (Z_{dr} columns) continuous source of ice mass
- Lightning after maximum mixed-phase (MP) updraft > 5 m s^{-1}, ample precipitation ice mass and significant MP updraft volume (> 3 m s^{-1})
- Trends in precipitation ice mass typically just proceed total lightning (ρ=0.8)
- Normal polarity flashes; 100% negative CG; IC:CG=2.7

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

1904 UTC (NALMA sources)

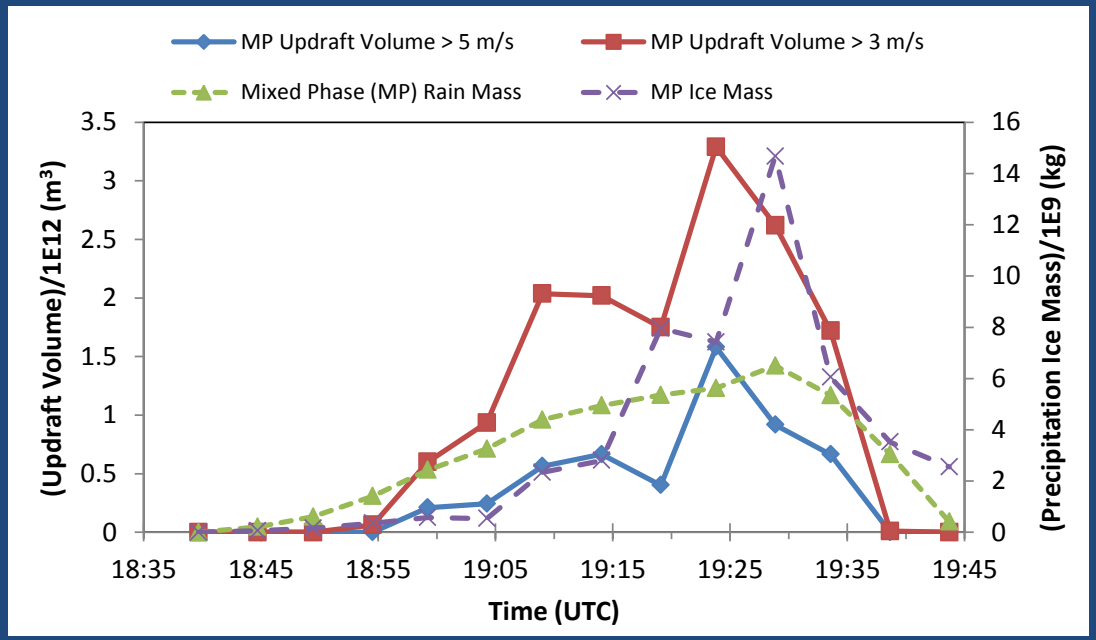
ARMOR CAPPI 4 km





Vertical cross-section of Z_h (dBZ)

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

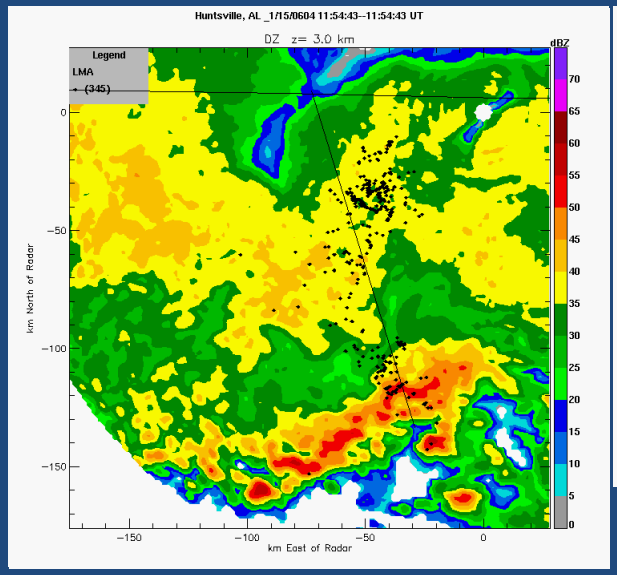


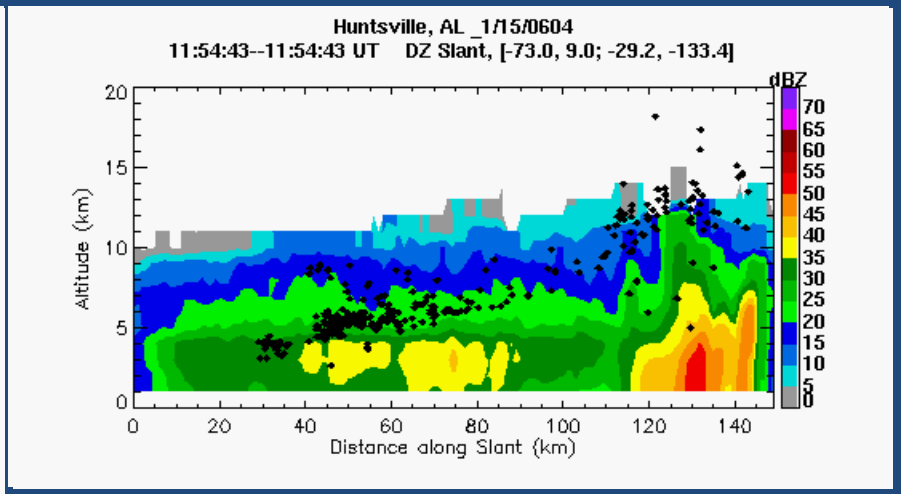
- MP supercooled rain fraction large early and production of ice and lightning delayed
- large warm cloud depth; moist; weak low-level lapse rate, CAPE, shear
- Ice and lightning highly correlated, ρ=0.9
- Normal polarity flashes; 100% -CG; IC:CG=3.9

DC3 AL on June 4, 2012, 11-12 UTC
Trailing stratiform MCS lightning

KHTX
Z_h
CAPPI
3 km

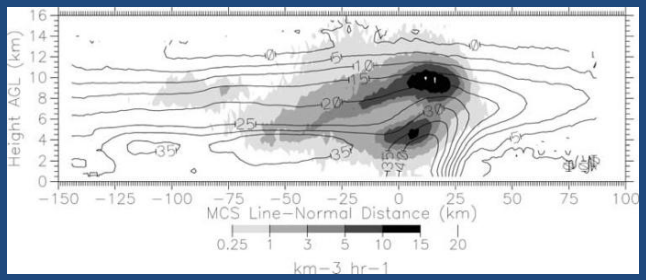
NALMA
VHF
Sources

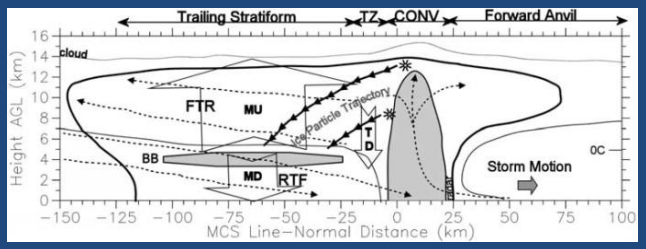




Vertical cross-section of Z_h (dBZ)

1155 UTC



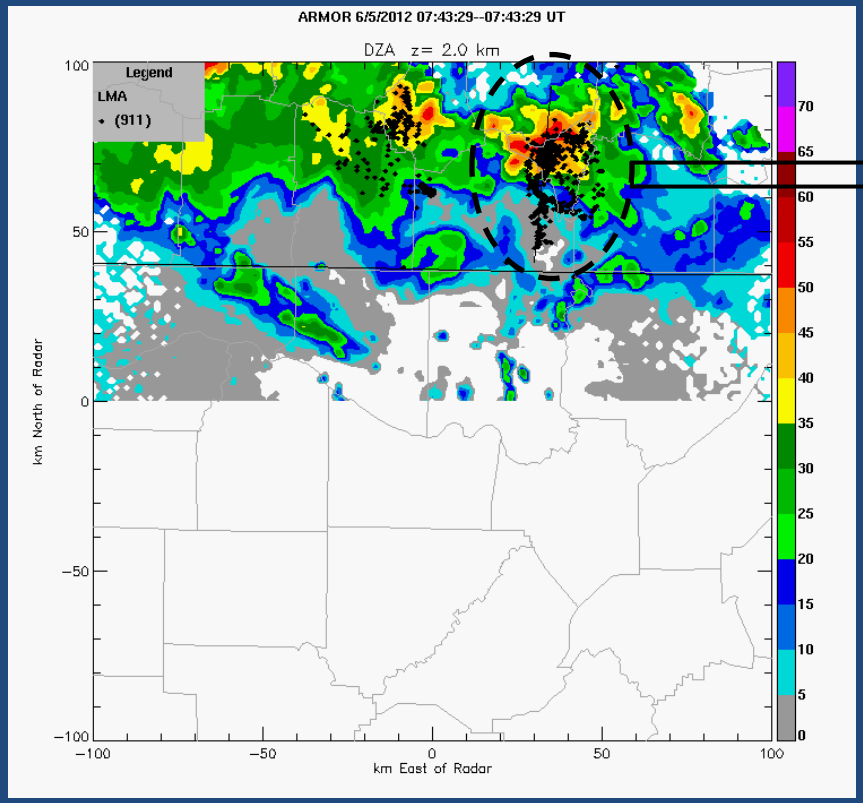


Carey et al. (2005)

- 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
- Meteorological controls

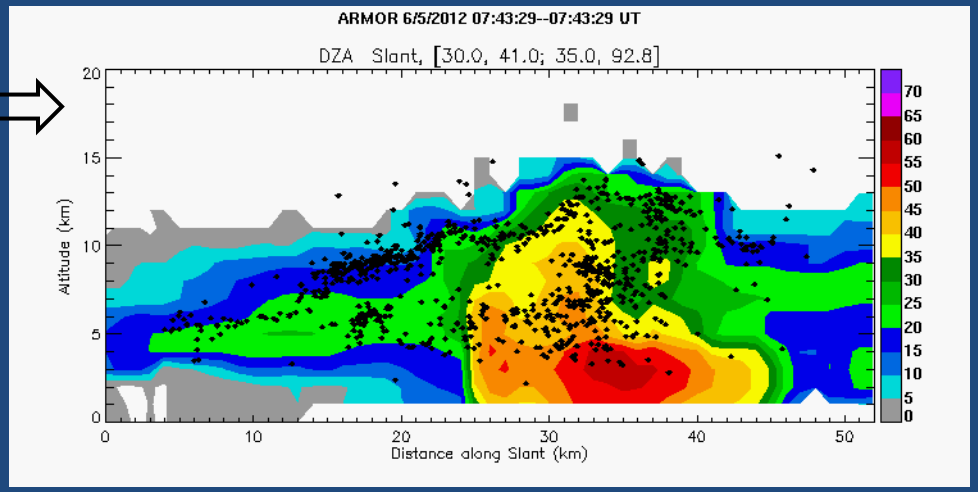
DC3 AL on June 5, 2012, 0743 UTC
Leading stratiform anvil MCS lightning

ARMOR reflectivity (dBZ) and NA-LMA VHF sources

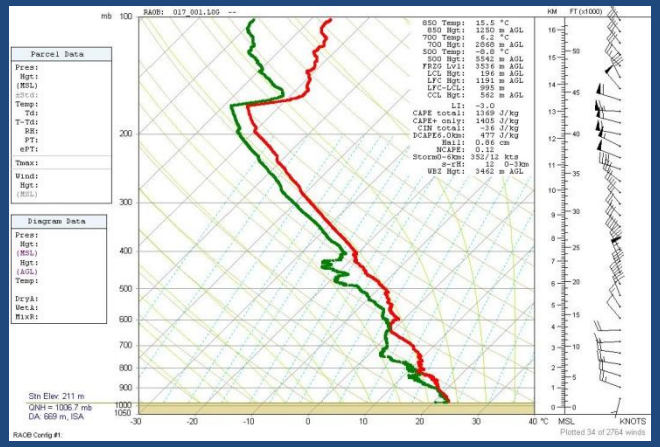


2 km CAPPI from ARMOR

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



Sonde through leading stratiform anvil at 0929 UTC



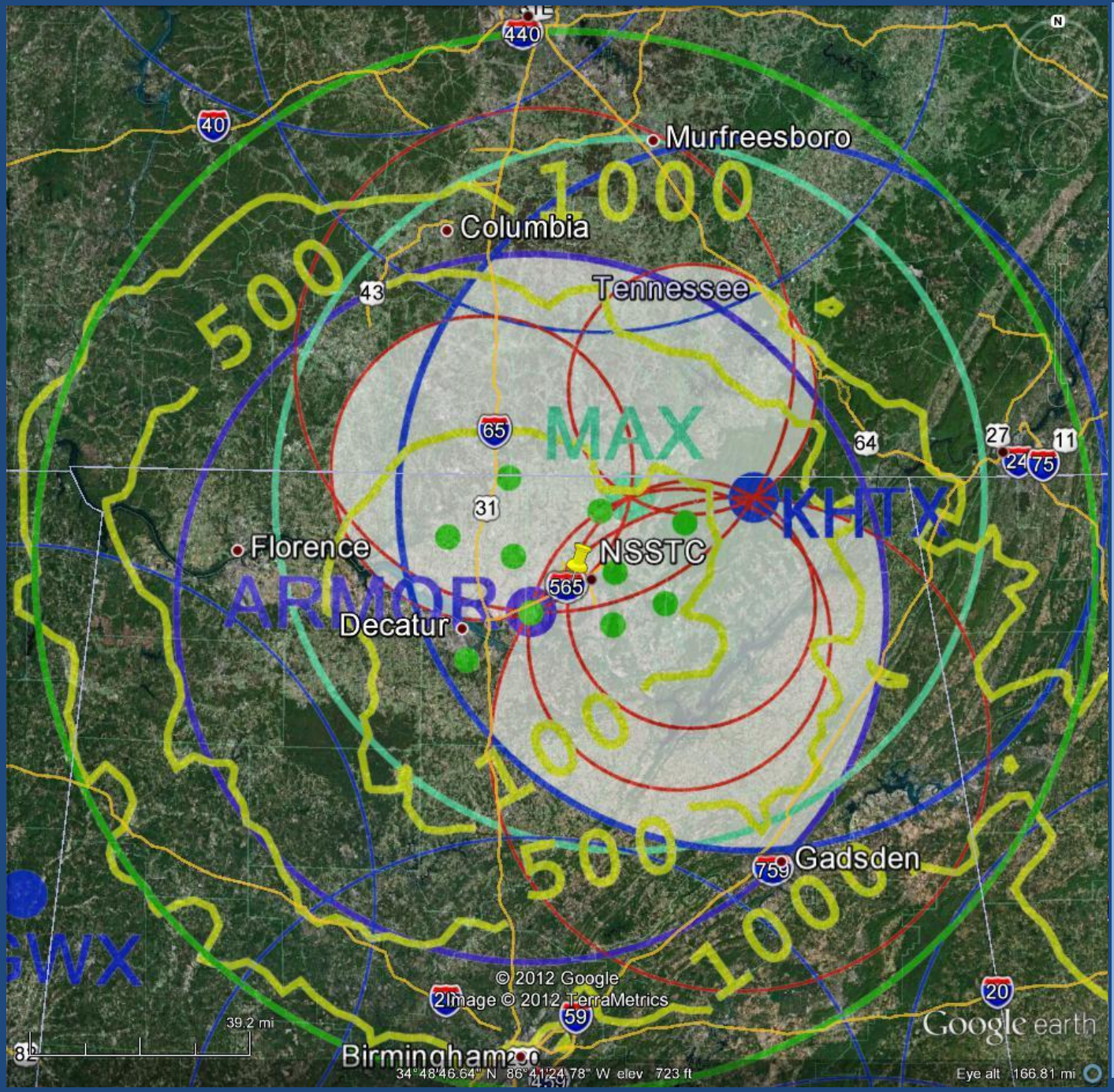
NNW flow

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

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, MIPS) delivery to NCAR Field Catalog (FC) complete
- Meteorological, kinematic and microphysical control of lightning flash rate, type, and extent
  - Initial priority on the 2 multicell aircraft cases **(Please visit poster)**
  - Collaboration with NASA MSFC to apply the Lightning Nitrogen Oxides Model (LNOM) to individual thunderstorms
  - Requirements for lightning; MCS electrification and lightning

EXTRA 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

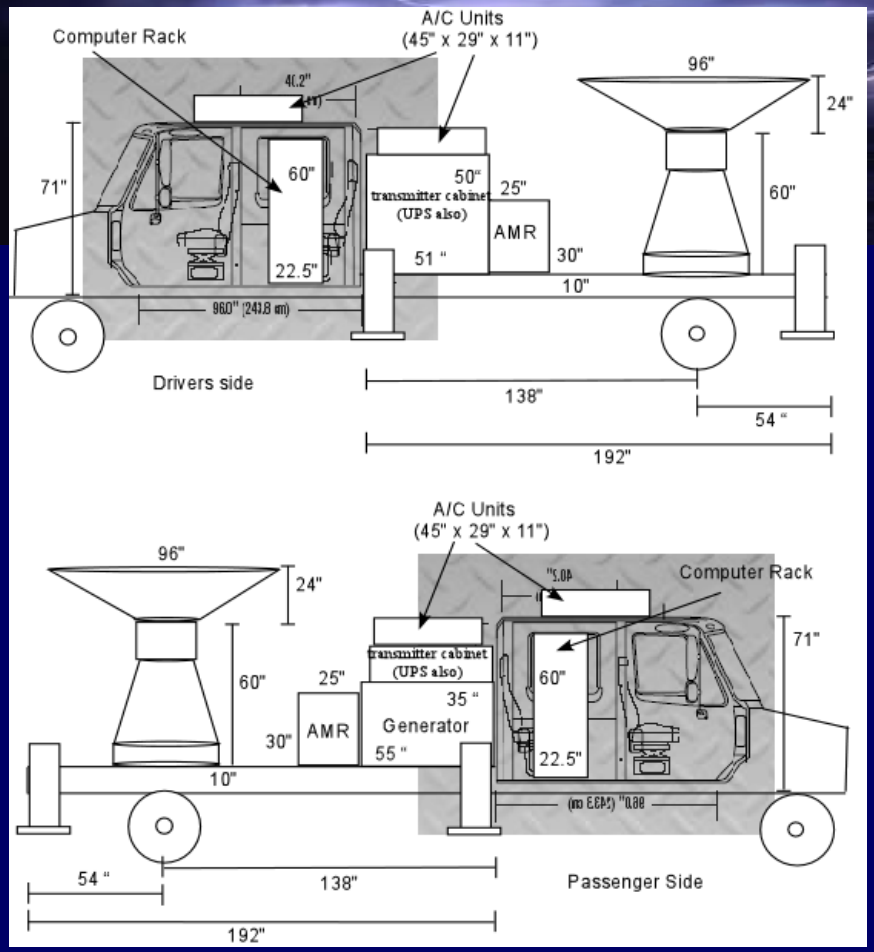
ARMOR at HSV Airport

• 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 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_{dr}, ρ_{HV}, ϕ_{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, ϕ_{DP}, KDP, ρ_{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

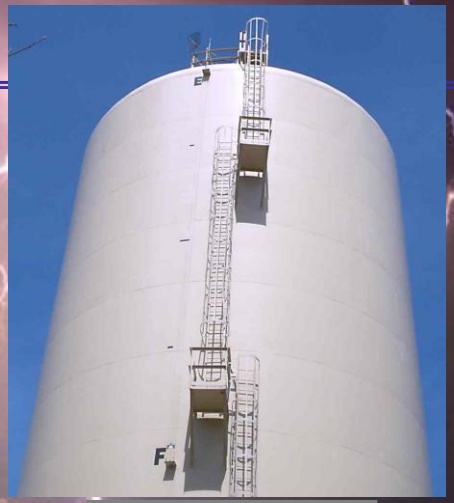
LMA Hardware

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

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)

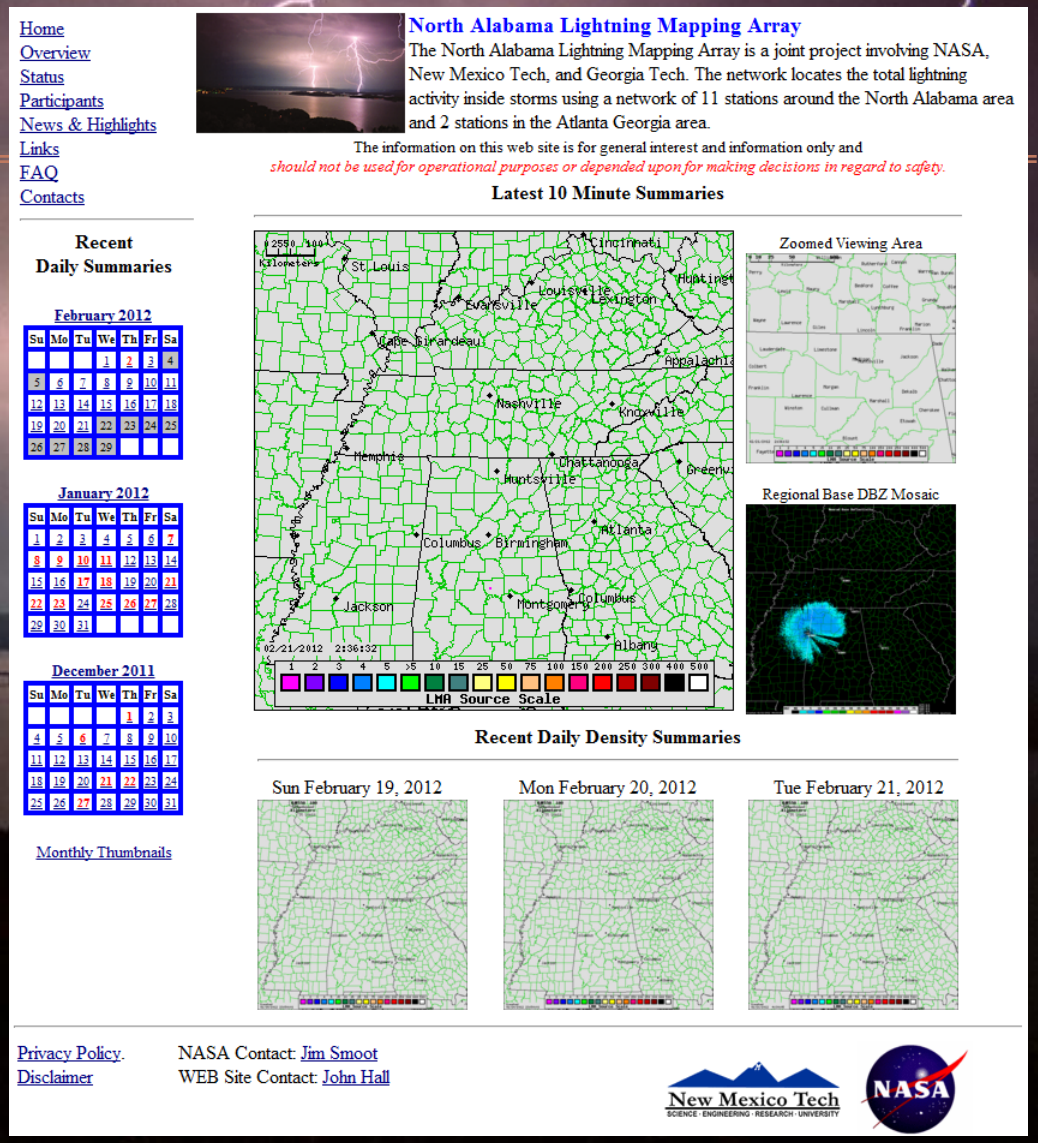
Utility pole
(AAMU)

Commercial radio tower
(Drake)

SPORT

transitioning unique NASA data and research technologies to the NWS

North Alabama LMA



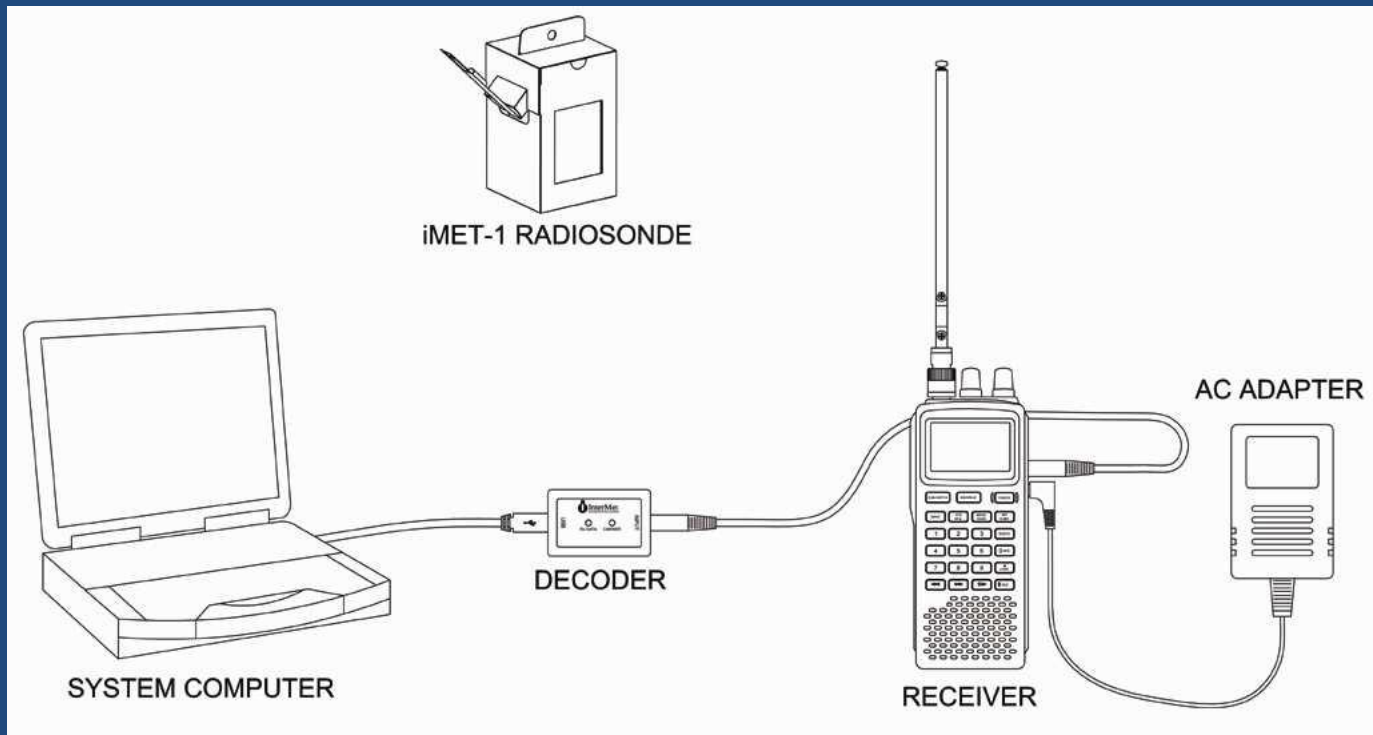
http://branch.nsstc.nasa.gov/PUBLIC/NALMA/

Mobile Integrated Profiling System (MIPS)

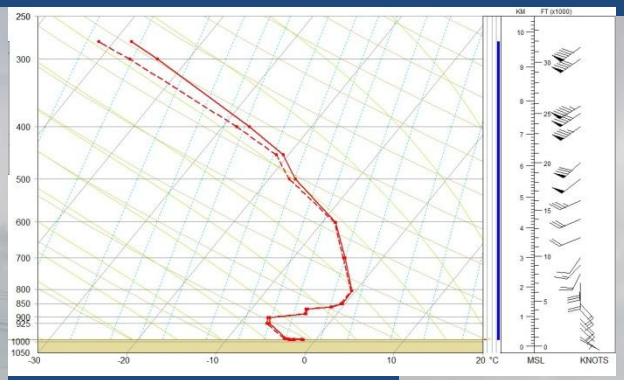
iMET-3150 (403 MHz GPS) Upper Air Sounding System

- 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.)



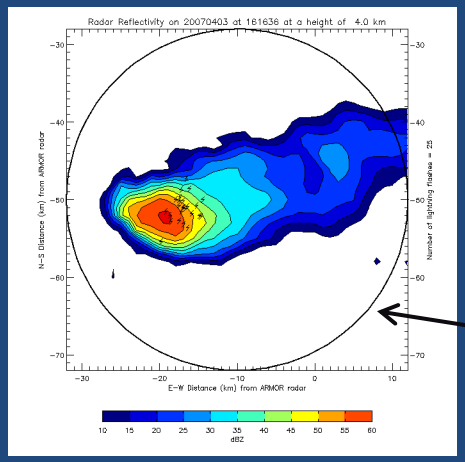
- 60 radiosondes for DC3 (40/20 reserved for flight/non-flight operations)
  - iMet-1-AB 403 MHz GPS Radiosonde C/A code GPS receiver with solid state pressure sensor
  - De-reeler, pre-wound with 30 m string
  - 300 gm Latex meteorological balloon (24.7 km burst altitude), parachute



3 person crew

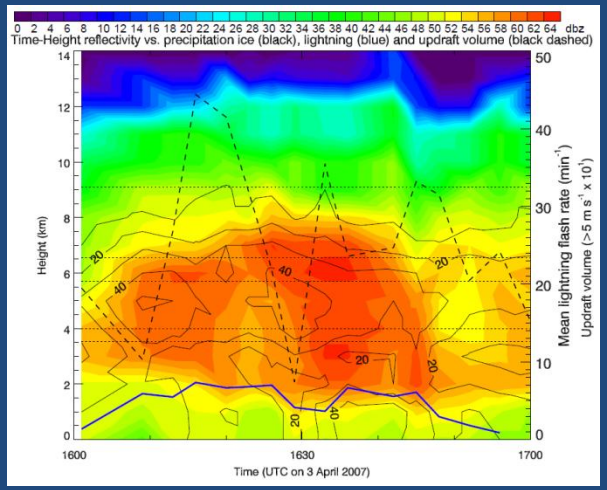
NASA Lightning Nitrogen Oxides Model (LNOM) Application toward Thunderstorm Studies

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

Time-Height Cross-Section of LNOM Segment Altitude Distribution (SAD)