

**TH029:**

# Science and Deployment Plan for the DOE 3rd Atmospheric Radiation Measurement Mobile Facility in the Southeastern United States

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**AGU** FALL  
MEETING

SHAPING  
THE FUTURE  
OF SCIENCE

# Virtual Town Hall Logistics



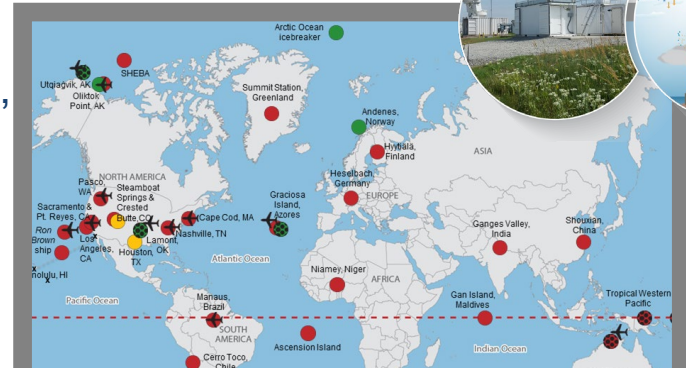
- Please rename yourself with your full names.
- Questions/discussions will be moderated by Co-organizers via the Q/A window.
- AGU is recording this Town Hall.

- **Project Introduction**
  - Question & Answer Break
- **Science-Driven Siting, Configuration, and Instrumentation**
  - Question & Answer Break

# Atmospheric Radiation Measurement (ARM): DOE User Facility

ARM

- **Strategically located atmospheric observatories** to improve scientific understanding of clouds, aerosols, precipitation, and radiation and their interactions with the Earth's surface to improve Earth System Models.
- **Comprehensive measurements:** atmospheric state, surface mass and energy exchanges, albedo/net radiation, aerosol, cloud / precipitation - **PUBLICLY AVAILABLE**
- Fixed-location and **ARM Mobile Facilities (AMF)** in diverse climate regimes.
- **AMF3: SE US, 2023**



# ARM: Comprehensive Sets of Surface and Atmospheric Measurements



Background  
Atmospheric State



Surface Energy  
Balance



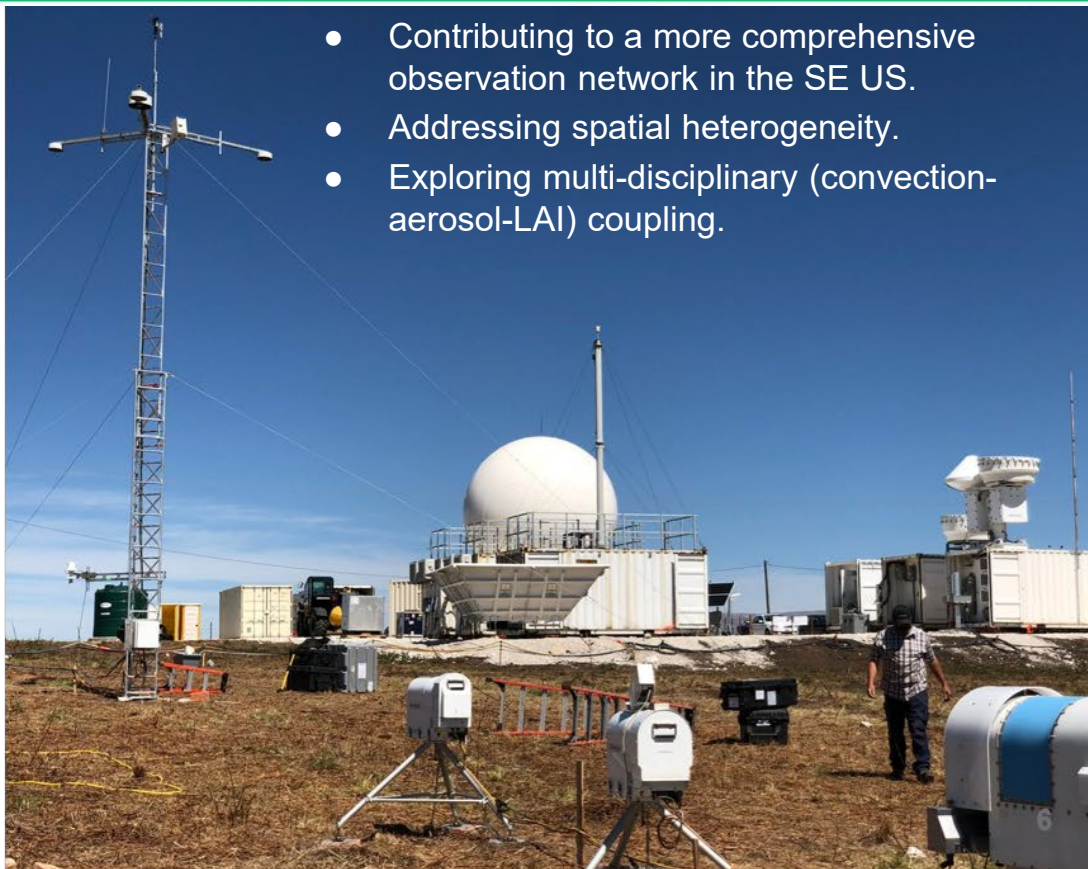
Aerosol and  
Hydrometeor Profiles



Near-Surface Aerosol  
Properties



Aerial Measurements

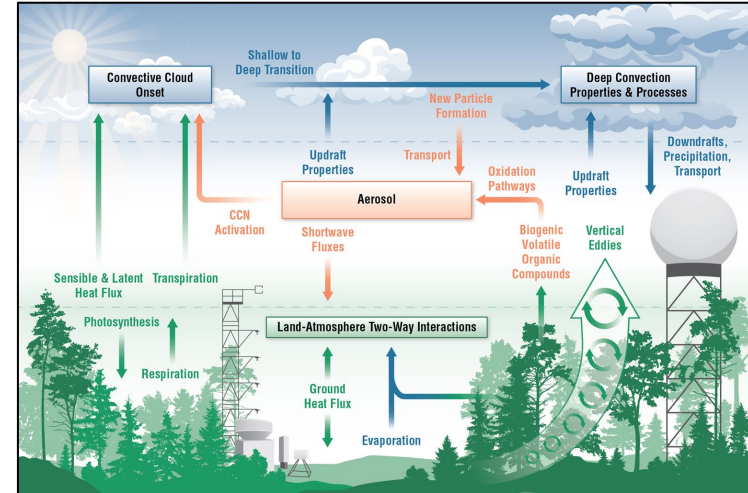
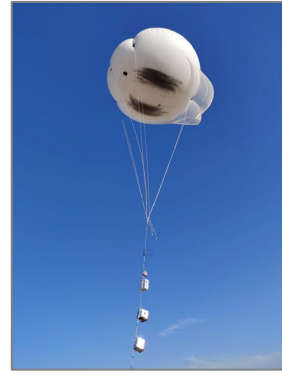


- Contributing to a more comprehensive observation network in the SE US.
- Addressing spatial heterogeneity.
- Exploring multi-disciplinary (convection-aerosol-LAI) coupling.

# AMF3 SE US: New Opportunities



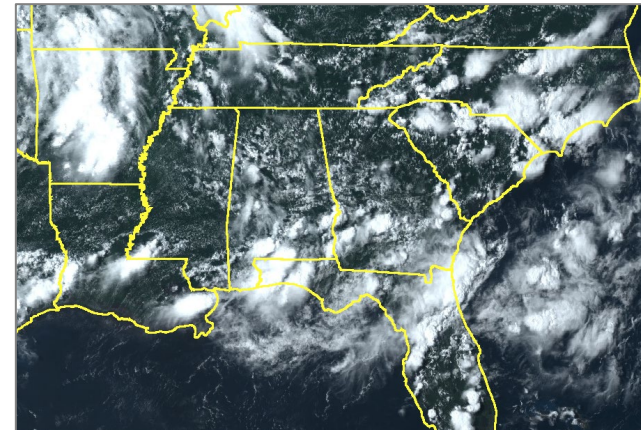
- Collaborative, interdisciplinary, transformational science.
- As a Site Science Team, we are Gravitational Attractors / Advocates / Ambassadors, not Gatekeepers.
- Emerging measurement opportunities:
  - Advanced / heavily-instrumented / spatially distributed sensing
  - High potential for collaboration with external agencies, universities and measurement networks
- A focus on Land-Atmosphere Interactions (including terrestrial focus area).
- Potential test-bed for application of AI / ML capabilities to advance earth system predictability



# Relocation of the 3rd ARM Mobile Facility to the Southeastern U.S. - AMF3 SE US



- Motivators for going to the SE US:
  - Abundant locally-forced shallow to deep convection
  - Large amount of vegetative-driven biogenic emissions
  - Strong local coupling of land surface with atmospheric processes
- Expected **5 year** deployment, operations beginning 2023.
- Joint ARM, ASR-funded project.
- Specifics on site location, configuration, and instrumentation to be determined in part through coordination between a DOE supported **Site Science Team** and the **Site Operations Team**.



# Project Membership: Core Team



- Chongai Kuang: BNL, PI (**aerosol**)
- Scott Giangrande: BNL, co-PI (**convection**)
- Shawn Serbin: BNL, co-PI (**land-atmosphere interactions**)
- James Smith: University of California, Irvine
- Allison Steiner: University of Michigan
- Gregory Elsaesser: GISS, Columbia University/NASA
- John Peters: Naval Postgraduate School
- Mariko Oue: Stony Brook University, NY
- Thijs Heus: Cleveland State University
- Pierre Gentine: Columbia University





# Critical Advisory and Logistical Partnerships



- Advisory Committee:

- BNL Leadership: Allison McComiskey, Michael Jensen, Art Sedlacek, Andy Vogelmann
- Pavlos Kollias: SBU
- Dave Turner: NOAA
- Hugh Morrison: NCAR
- Markus Petters: NCSU

- ARM

- Site Operations Contacts:



Nicki Hickmon



Mike Ritsche



Patty Campbell



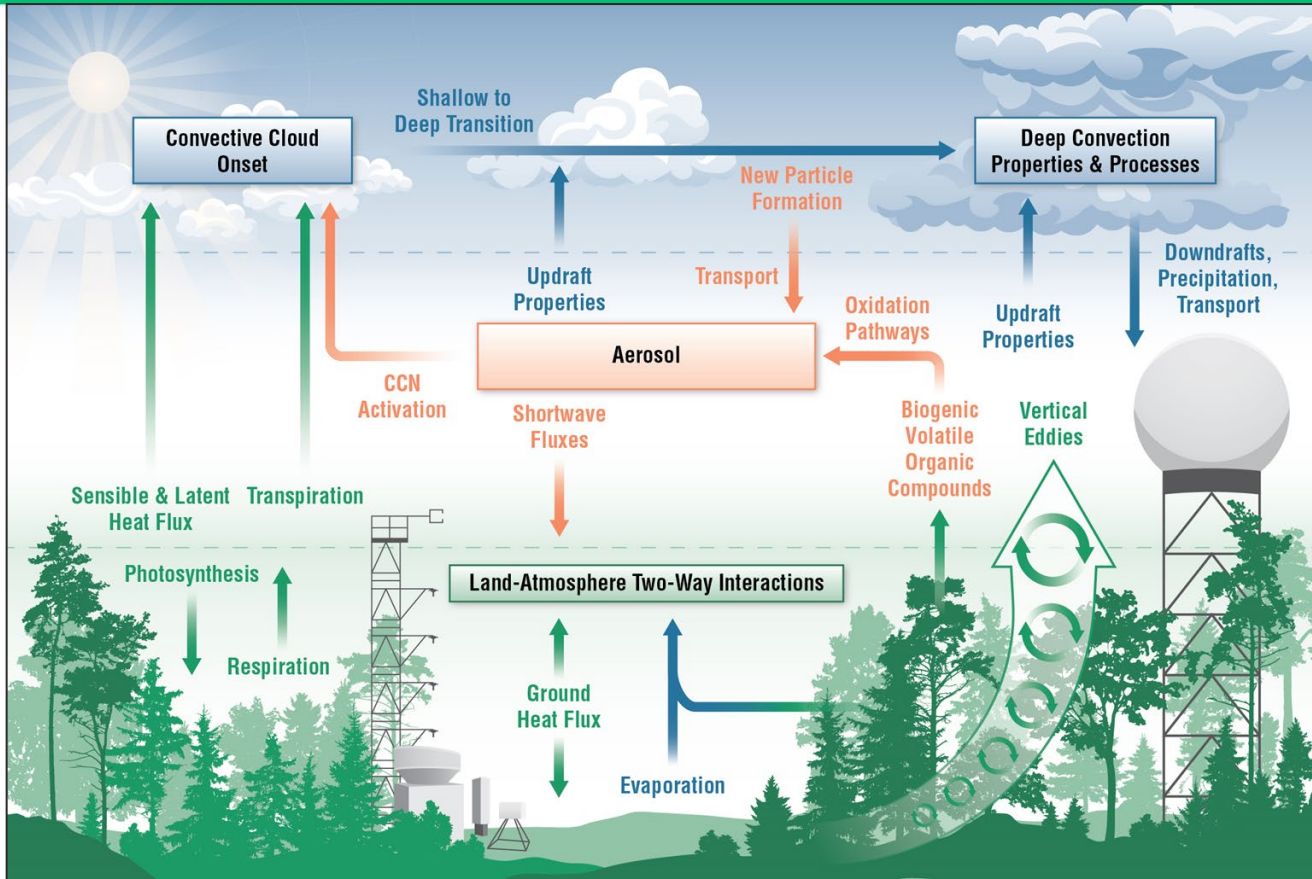
# Opportunities for Growing External Collaborations



- **United States Forest Service**
- **SE US universities**
  - Alabama A&M University, University of Alabama in Huntsville, University of Alabama in Tuscaloosa, Auburn University
- **SE US measurement networks**
  - AmeriFlux, NEON, IMPROVE, AL Mesonet
- **SE US agencies**
  - NASA (e.g., GPM, EMIT, TEMPO), NOAA
- **SE US collaborative measurement campaigns**
  - VORTEX-SE / PERiLS



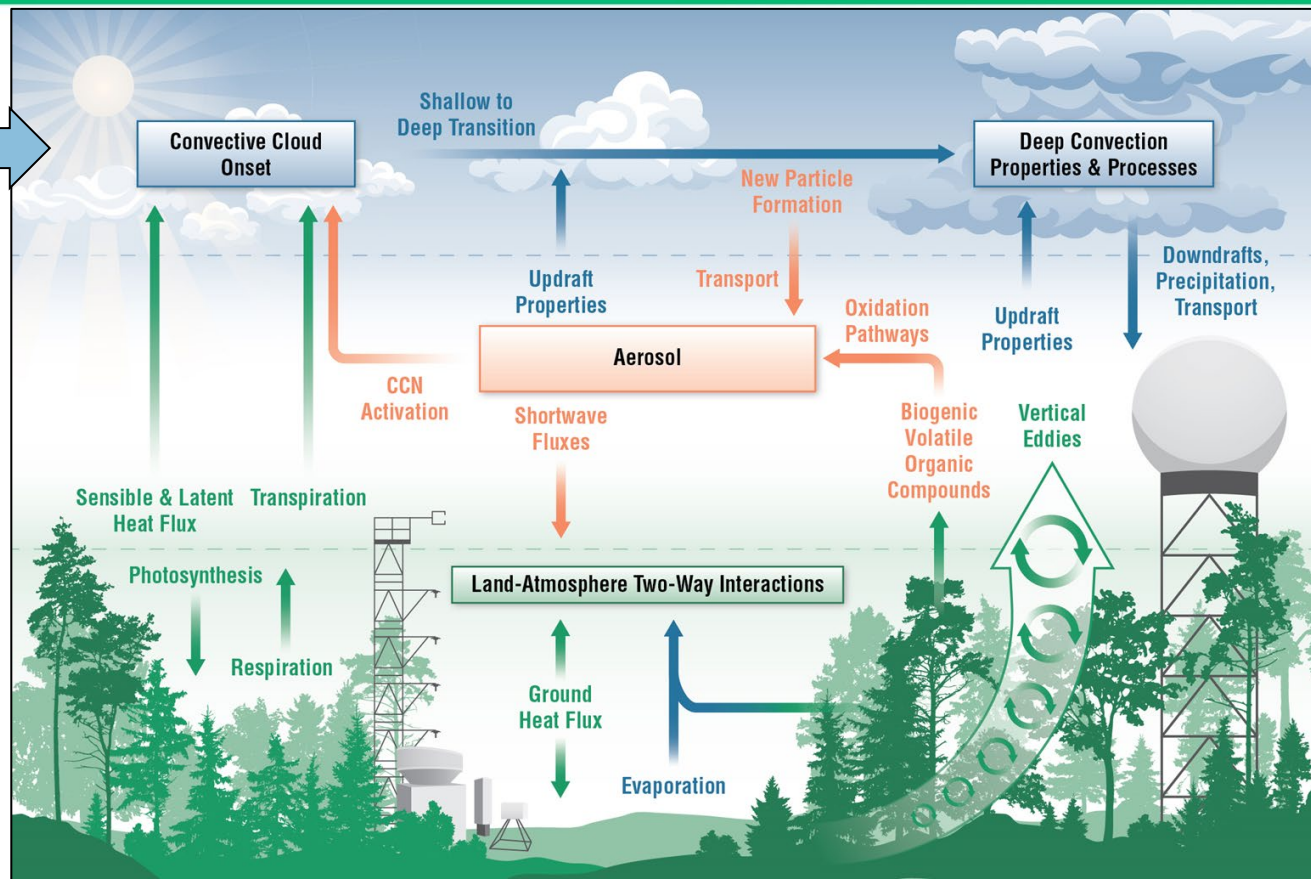
# AMF3 SE US: Cross-Cutting Science Drivers



# AMF3 SE US: Convective Cloud Science Drivers



- **Onset of Convective Clouds:**
  - Large-scale vs. meso-scale thermodynamic perturbations
  - Processes that regulate shallow-to-deep convective transitions
  - Role of moist thermals
- **Convective Cloud Processes:**
  - Relationship between boundary layer and coverage of convection
  - Nature of convective updrafts, including intensity/size
  - Convective organization and stratiform precipitation

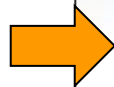


# AMF3 SE US: Aerosol Science Drivers



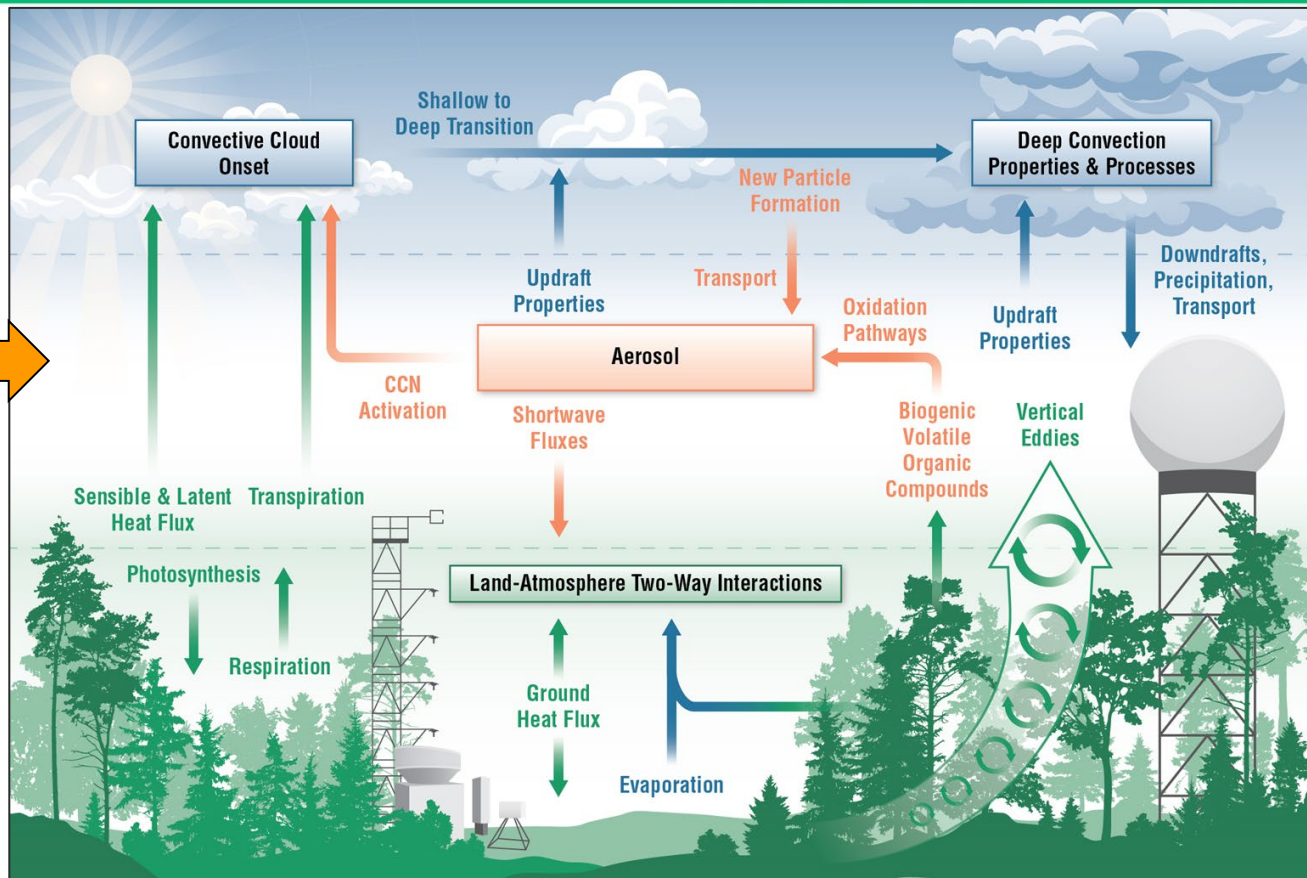
- **Properties/processes that control the cloud condensation nuclei budget:**

- New particle formation and transport
- Secondary organic aerosol
- Spatio-temporal variability in aerosol hygroscopicity



- **Aerosol optical properties:**

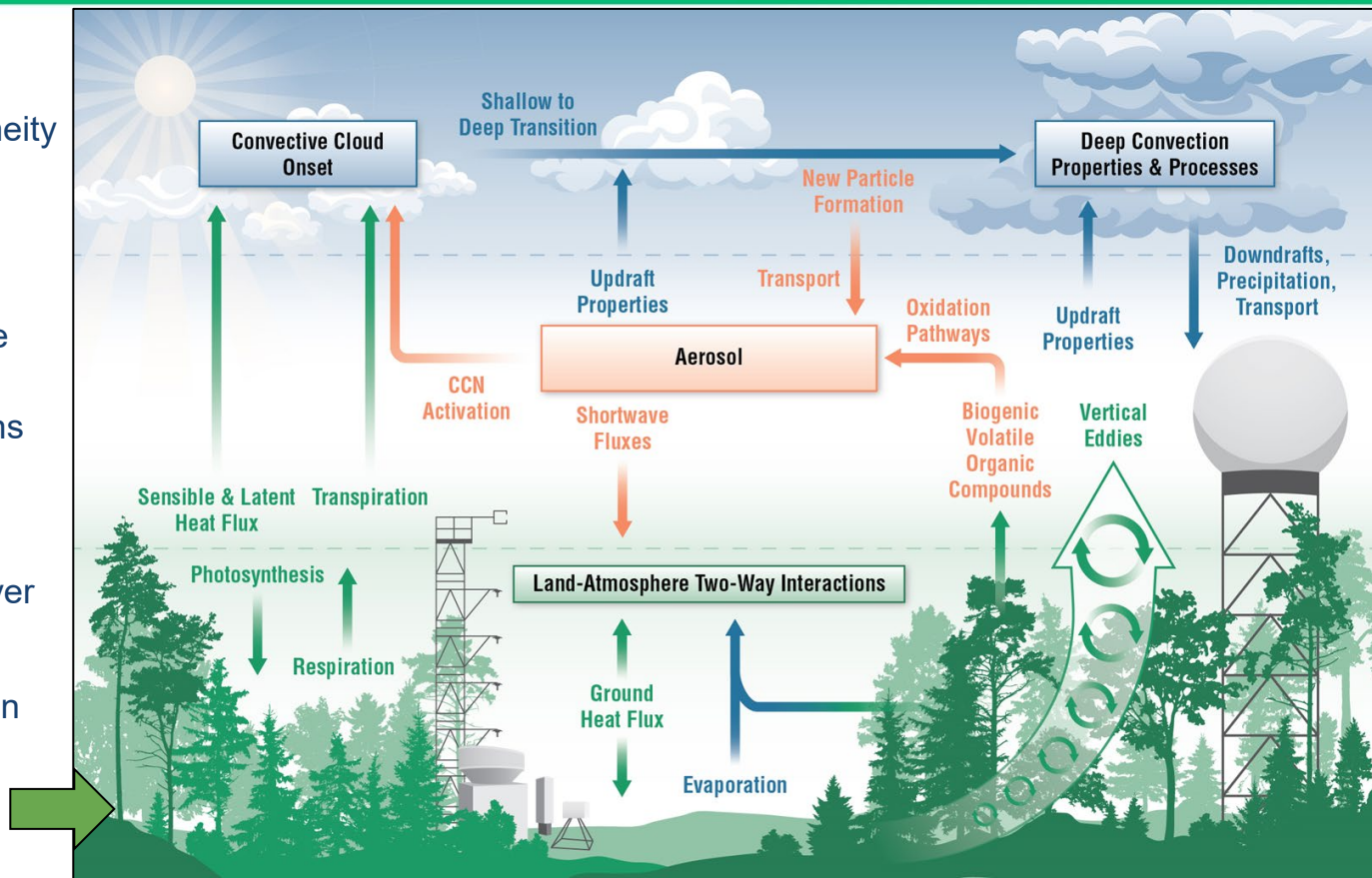
- Particle water uptake
- Biomass burning
- Brown carbon



# AMF3 SE US: Land-Atmosphere Interactions Science Drivers



- Land-atmosphere coupling
- Impacts of surface heterogeneity on coupling
- Land-surface biotic / abiotic controls on:
  - Fluxes, energy balance
  - Cloud processes and spatio-temporal patterns
  - Aerosol formation and regional variability
- Turbulence and boundary layer measurement & modeling
- Two-way interactions between plants and cloud / aerosol radiative impacts





# Question and Answer Break

For further campaign information:

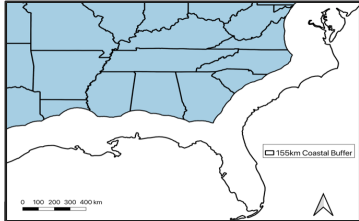
<https://www.arm.gov/capabilities/observatories/amf/locations/seus>

- Developed science-driven criteria for preferred:
  - Site locations
  - Site configurations
  - Measurement prioritization
- Initial SE US Site Visits: Summary
- Planned Instrumentation for the SE US
- Example Instrument & Site Configurations





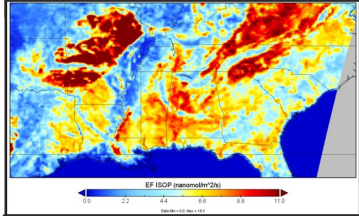
# Preferred Siting Criteria for Effective AMF3 SE US Deployment from Siting Deliverable



Avoid coastal regions and similar complexities



Representative terrain and forested locations

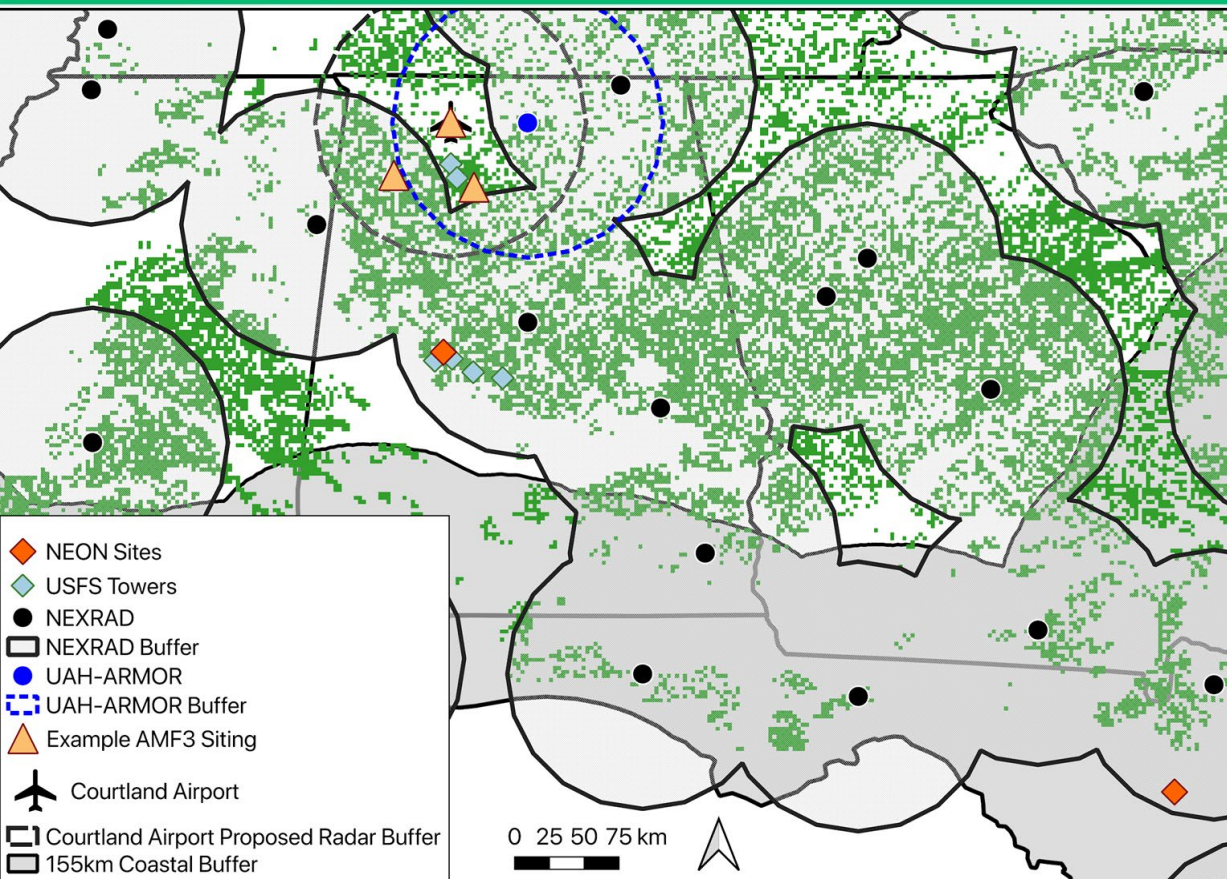


Representative air mass sampling



Frequent clouds, shallow to deep convection

# Overview SE US Map: Example Siting and Site Configuration

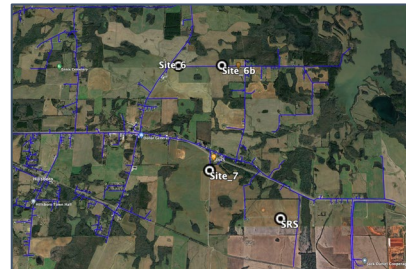


- Green regions are potentially suitable for cross-cutting drivers
- Request for 3+ non-collinear supplemental sites
- **Our preferred region: Northern Alabama**
  - High frequency of deep convective storms
  - Proximity to many potential partner facilities
  - Suitable, representative terrain & forested regions
  - Range in anthropogenic / biogenic emissions

# Siting Visits: Exploring Scientific Partnerships, Logistics, and Site Suitability



- Timeline: 3 visits to AL in June, July, and November 2021
- Activities:
  - Exploring several local partnerships (e.g., US Forest Service, universities, agencies, measurement networks)
  - Evaluating logistics (e.g., power, communications, sampling requirements)
  - Siting (e.g., main site, radar, tower)

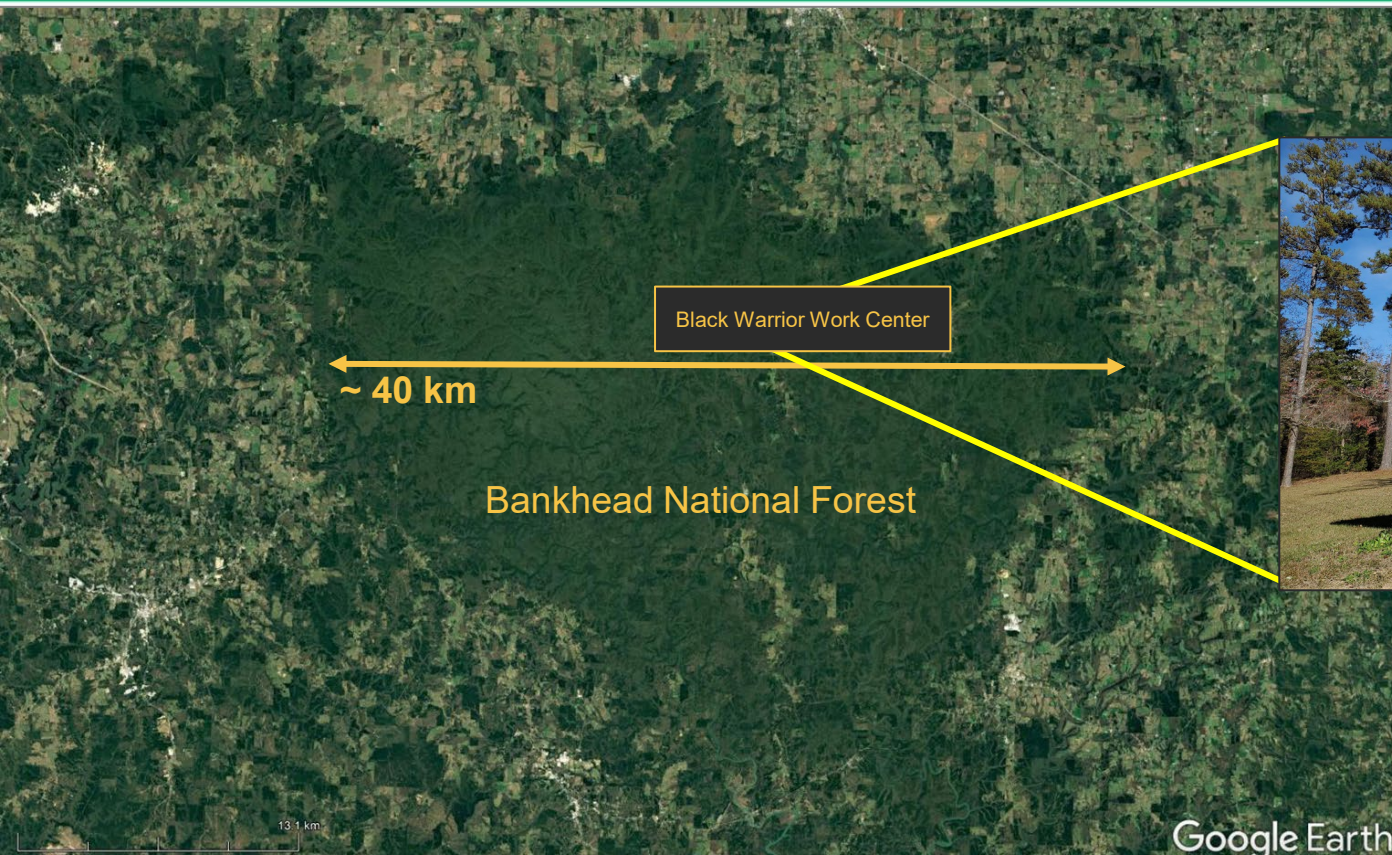


# Preferred Region: Northern Alabama

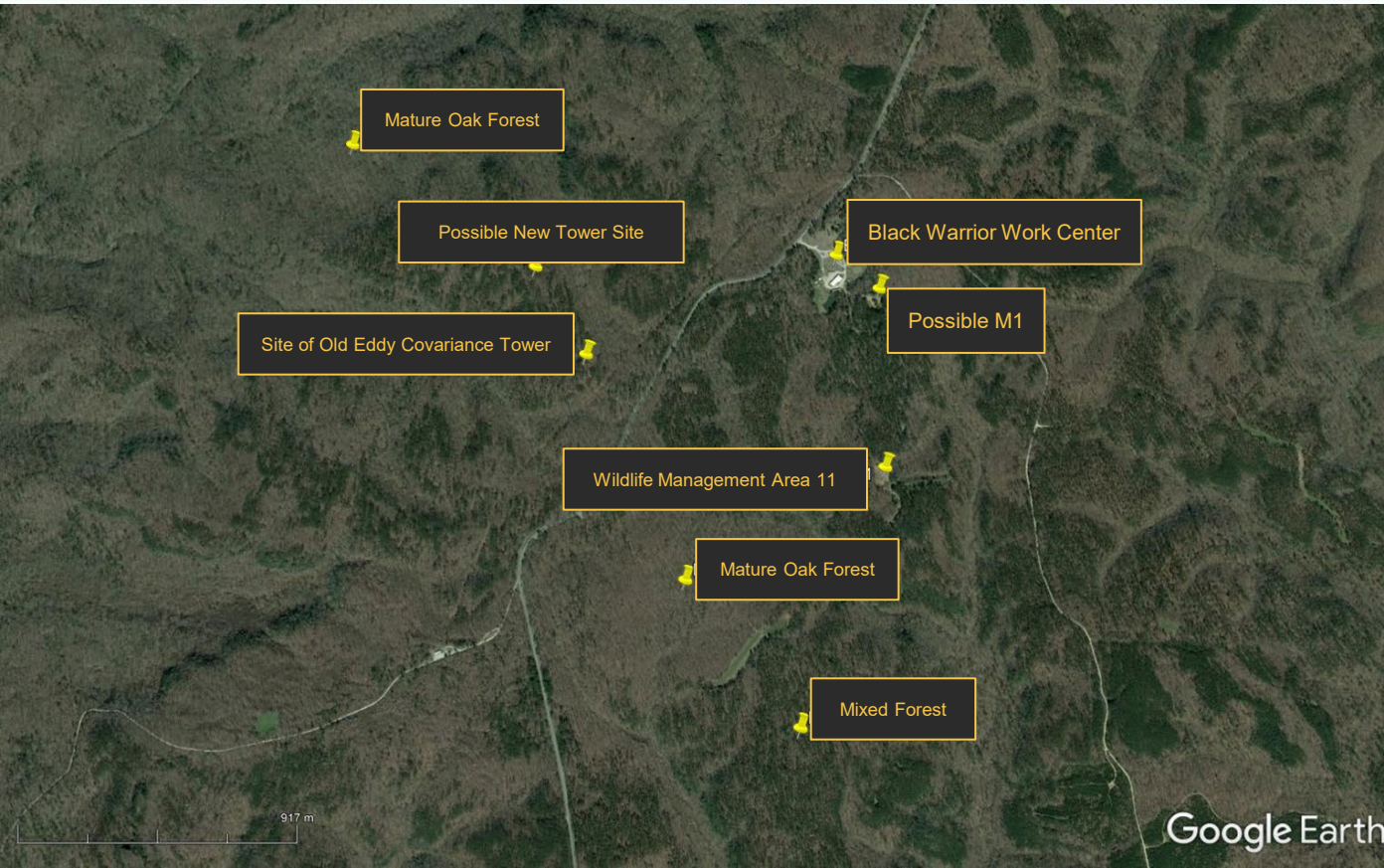


- multiple high-profile and nearby partner agencies (e.g., NASA, NOAA) and universities (e.g., UAH, AAMU)
- existing surveillance radar, lightning mapping array, and additional atmospheric profiling infrastructure
- removed from coastal influence
- frequent clouds, and a regional maxima for severe convective storms
- relatively open landscapes for placement of surveillance ARM precipitation radar

# Drilling in Further: Bankhead National Forest and Surrounding Region



# And Further Still: Black Warrior Work Center and Surrounding Region

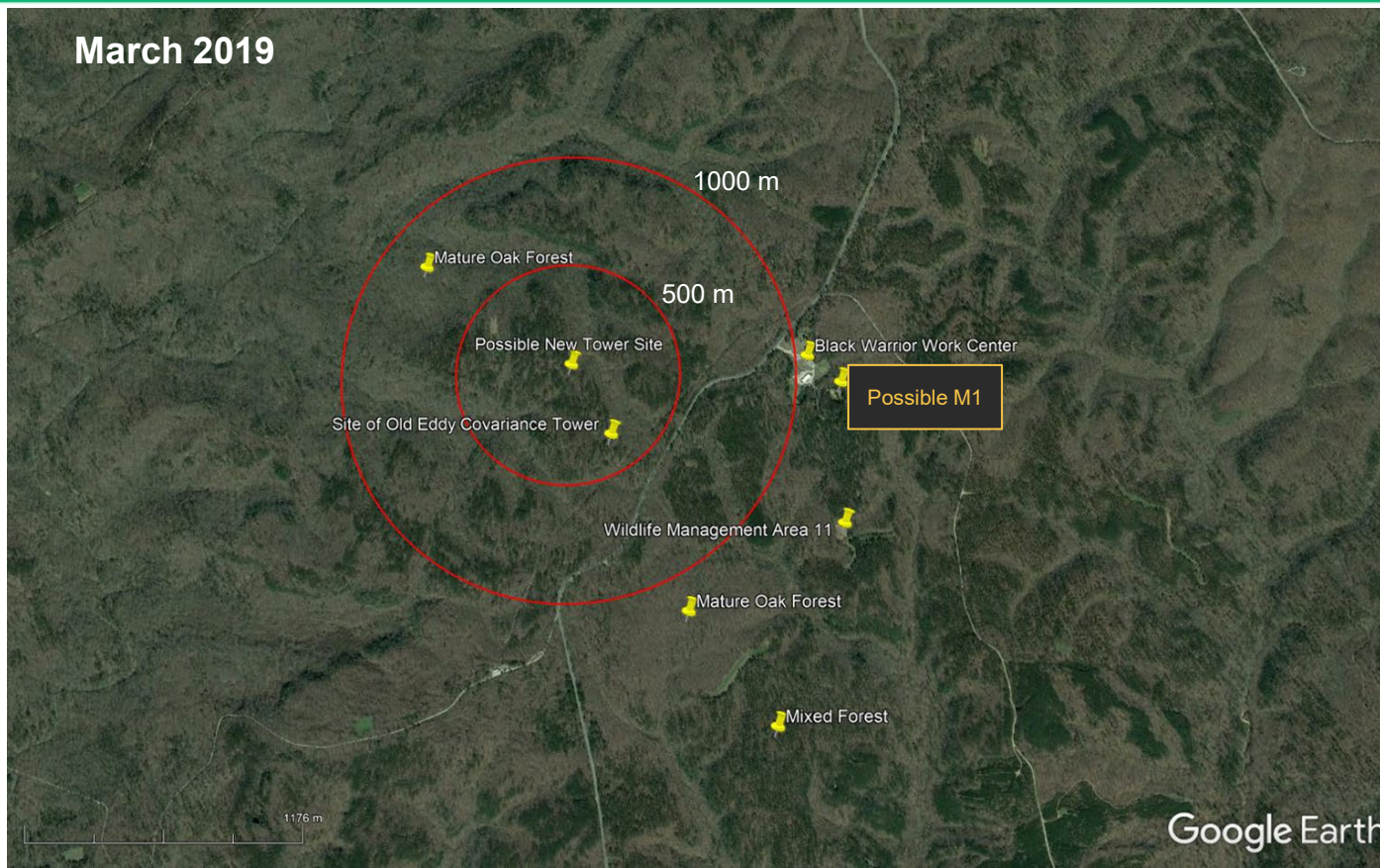


- **Black Warrior Work Center (BWWC)**
  - IMPROVE site
  - open areas
- **Possible M1 Instrument Field**
  - “closer” to power
  - “closer” to impacts
- **Wildlife Management Area 11**
  - “farther” from power
  - “farther” from impacts
- **Old Eddy Covariance Tower Site**
- **Possible New Tower Site**
- **Mix of Forest Types**

# Black Warrior Work Center and Surrounding Region



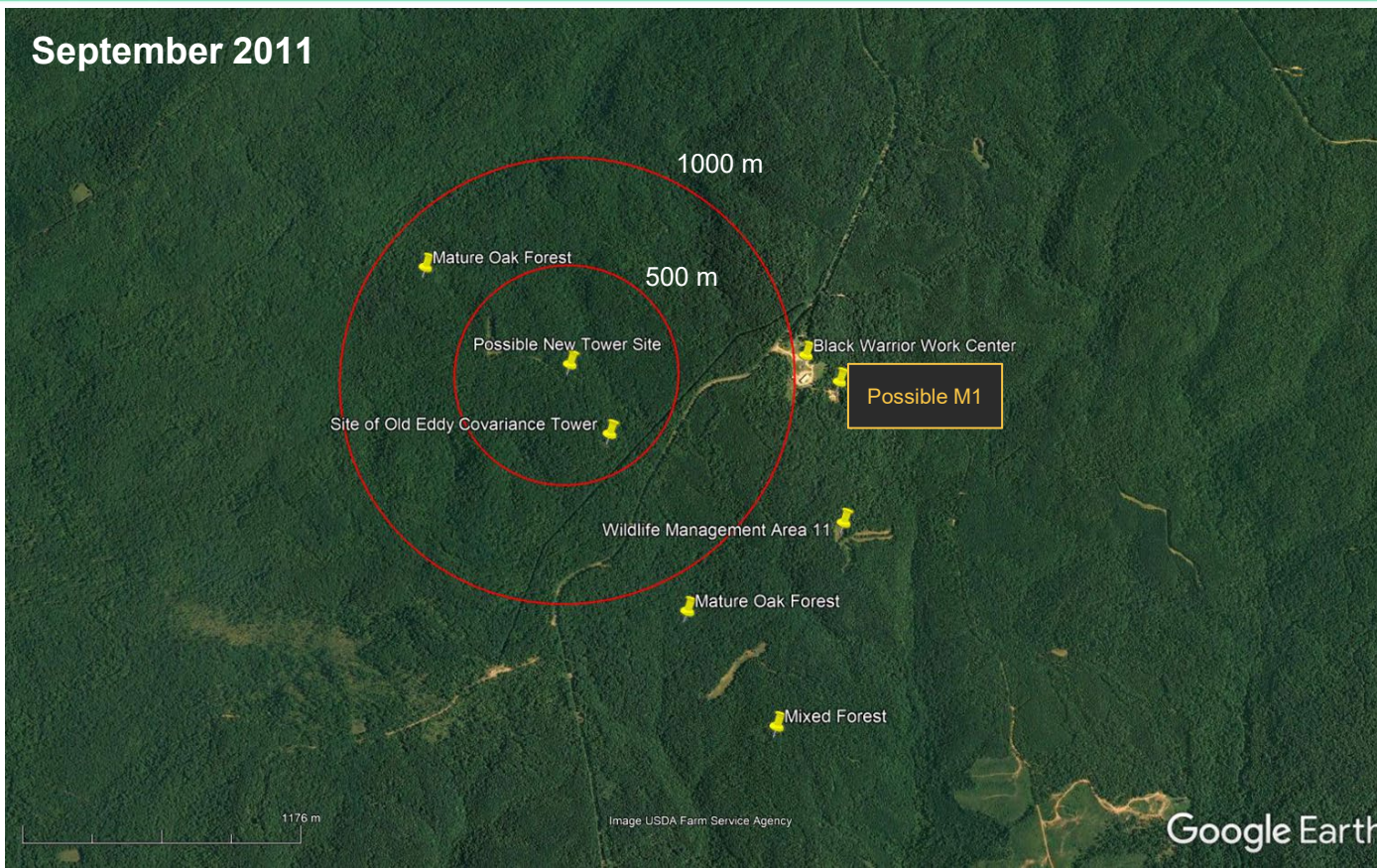
March 2019



# Black Warrior Work Center and Surrounding Region



September 2011



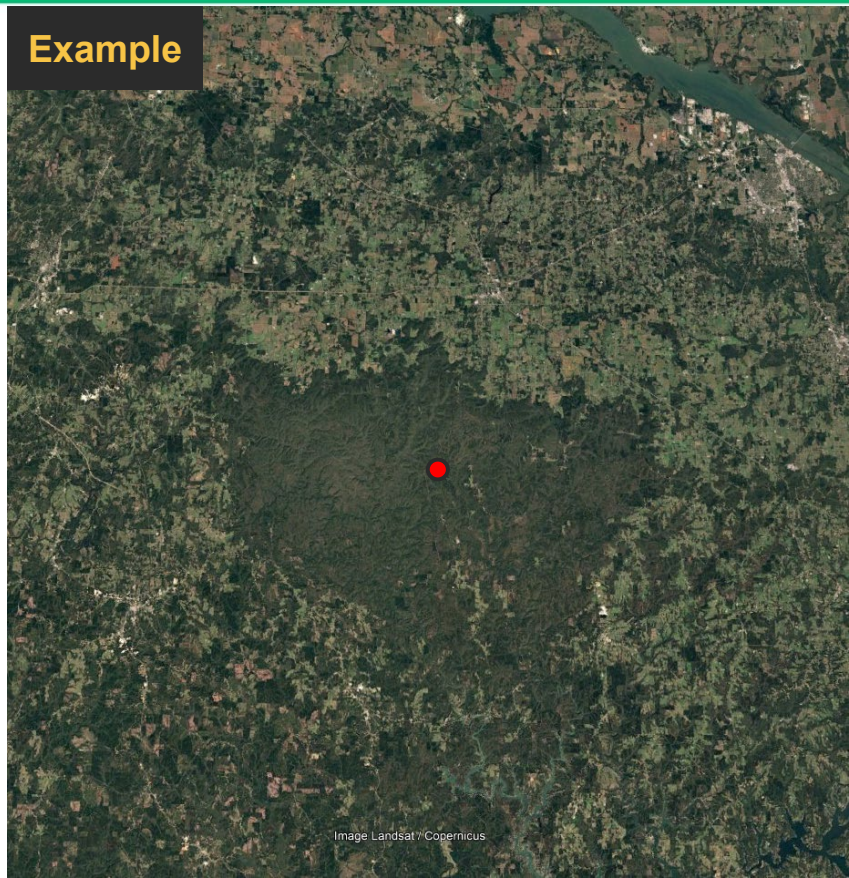


# Initial Core Deployment: Planned Instrumentation at Main Site



- Deployment of core instruments for initial operations
- Aerosol Observing System (AOS)
  - Water-uptake, chemical composition
  - Absorption, extinction, scattering
  - Concentration, size distribution
  - Trace gases
- Radiometry (upwelling/downwelling short/long-wave radiation)
- Aerosol Profile Retrievals
- Cloud Properties and Microphysics (Profiling Radar)
- Radiosondes
- Surface Carbon, Water, Energy Fluxes
- Soil Moisture and Temperature
- Surface Meteorology
- Thermodynamic Profiles

## Example

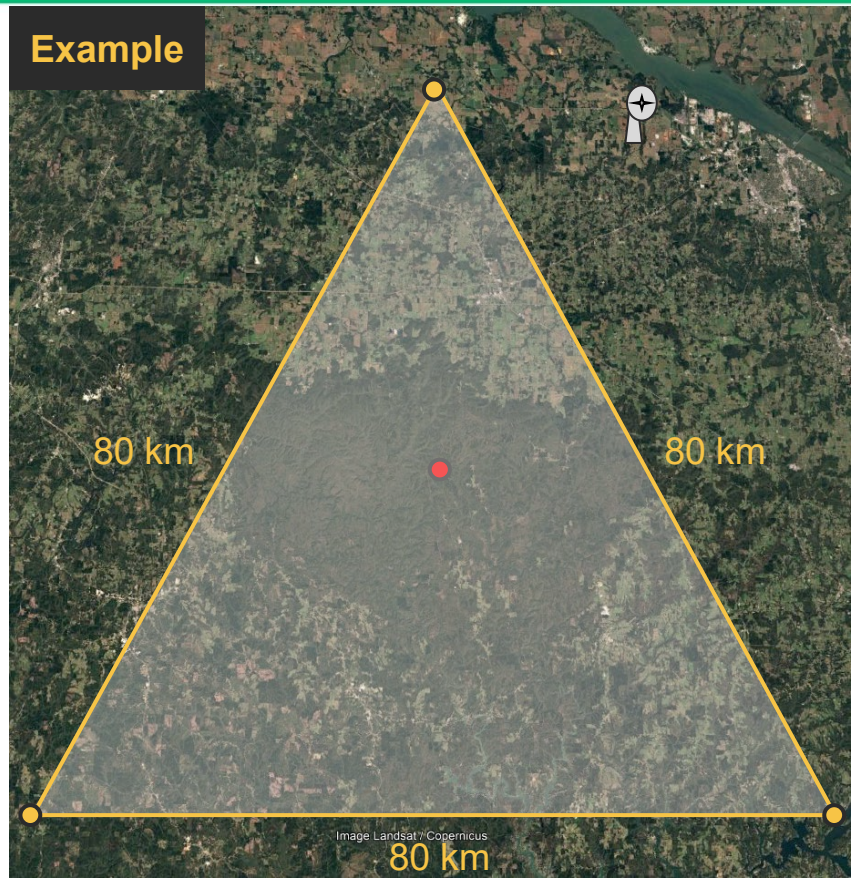


# Advanced and Spatially Distributed Deployment: Planned Instrumentation



- Informed by logistics, budgetary constraints, and site science team analyses (e.g., modeling studies, observing system simulation experiments)
- Boundary layer profiles (T, wind, water vapor, LWP)
- Precipitation amount and drop-size distributions
- Surface fluxes (atmospheric and soil)
- Surface meteorology and radiometry
- Cloud cover / fraction
- Aerosol microphysics (under discussion)
- Trace gases (under discussion)
- Aerial measurement platforms (e.g., TBS, UAS)
- Supplemental towers (multi-level flux, profiles, radiation) across forested, agricultural, and urban areas
- Surveillance Cloud/Precipitation Radar(s)

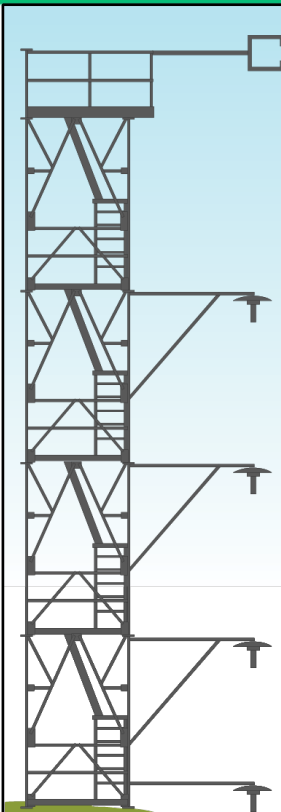
## Example



# Deployment of Instrumented Tower in the Forested Main Site: Planned Instrumentation



- 120 - 140 feet walk-up tower
- Core instrumentation under discussion, but will include:
  - Multiple levels of flux measurements (CO<sub>2</sub>, H<sub>2</sub>O, sensible heat, momentum)
  - Radiation measurements (spectral, photosynthetically active radiation, net, broadband, etc.)
  - Temperature/relative humidity at multiple levels
- Vertical and horizontal DTS (distributed temperature sensing)
- Tree-scale transpiration via automated sap flux

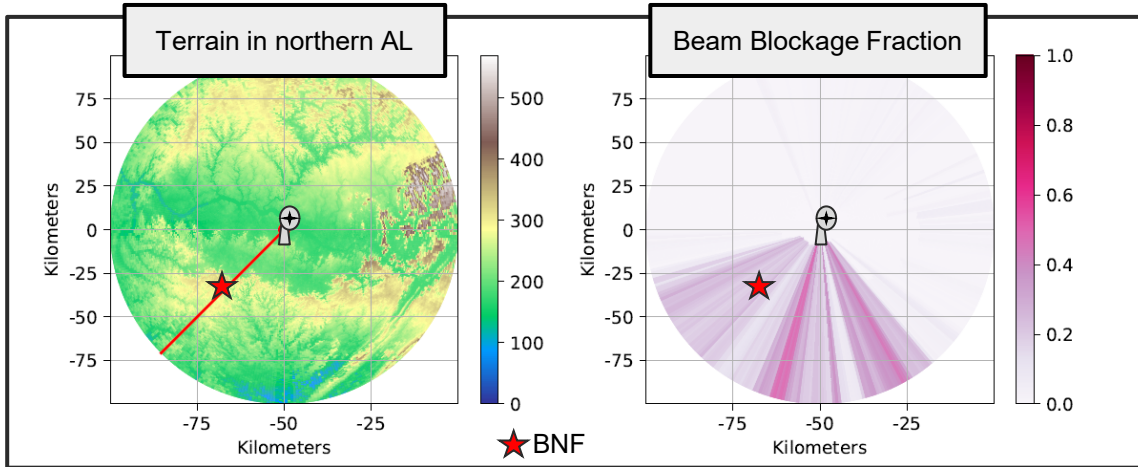


Measurements	Frequency	Tower top	Mid-levels	Near ground surface
CO <sub>2</sub> /H <sub>2</sub> O concentration & flux	20 Hz	✓		
3D wind speed & direction	20 Hz	✓		
Dust (particulate mass)	2 wks	✓		
Dust (particulate size)	1 Hz	✓		
Aerosol optical depth	30 min	✓		
Secondary precipitation (absence/presence)	when event occurs	✓		
Direct & diffused radiation	1 Hz	✓		
Incident short-wave radiation	1 Hz	✓		
Net short-wave & net long-wave radiation	1 Hz	✓		
Wet deposition chemistry & precipitation isotope	2 wks	✓		
Phenological image & snow depth	15 min	At the tower top & 3 m above ground		
Isotopes in CO <sub>2</sub> , <sup>13</sup> C concentrations	.5 Hz	✓	✓	✓
Isotopes in H <sub>2</sub> O ( <sup>18</sup> O, <sup>2</sup> H concentrations)	.5 Hz	✓	✓	✓
CO <sub>2</sub> concentration	1 Hz	✓	✓	✓
H <sub>2</sub> O concentration	1 Hz	✓	✓	✓
PAR (Photosynthetically Active Radiation)	1 Hz	✓	✓	✓
Air temperature	1 Hz	✓	✓	✓
Biological temperature	1 Hz		✓	✓
2D wind speed & direction	1 Hz		✓	✓
Barometric pressure	1 Hz	4.95 m above ground		

# Science-Driven Siting Examples From the Field: Evaluating Radar Locations For Cloud Process Studies



The SE US receives abundant & severe thunderstorms, locally-forced shallow to deep convective clouds. However, the complex topography poses challenges for sampling clouds, optimal placement of remote sensors to capture convective properties and processes.



Visited several locations in northern AL looking for amenable power, space, and blockage (tree, terrain).

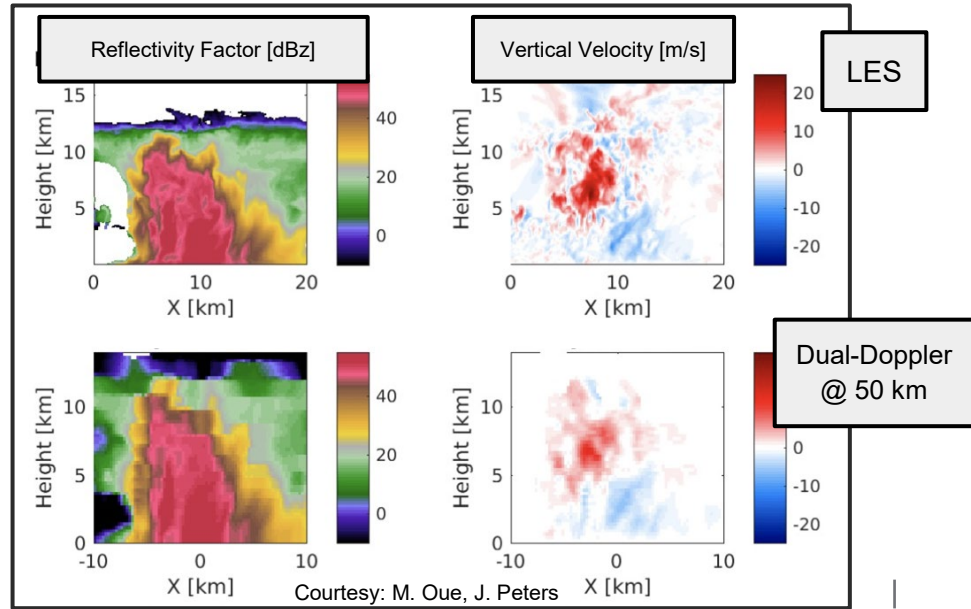
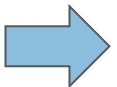
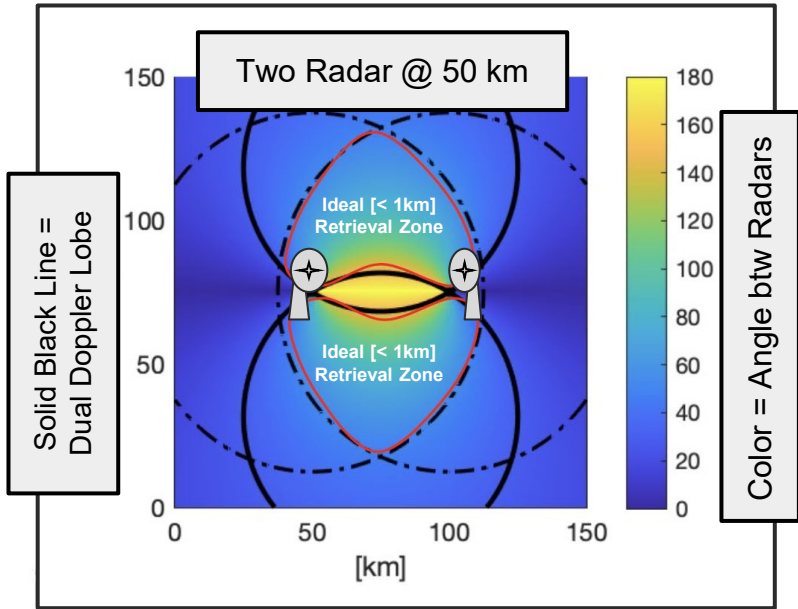
A priority is proximity to partner radar assets to improve key geophysical retrievals (i.e., vertical velocity).

# Science-Driven Siting Example: Why Radar Siting Matters for Key Convective Properties Such as Vertical Velocity?




**Science Question:** “What factors regulate the nature of convective updrafts or the size of thermals within cumulus updrafts above the PBL?”

**Doppler Radar Simulator Studies w/ LES Output:** Determine critical proximity, co-designs for scanning patterns with existing radars, profilers to achieve highest-quality vertical velocity (key quantity) retrievals.



# Engaging with our Science & Operations Team



- ARM has always sought community feedback -- continuous improvement, flexibility to identify high priority science needs -- often gathered through workshops, Working Groups, Field Campaign PIs, and other mechanisms.
- We strive for a very active community outreach. This includes outreach to:
  - **AGU community (you!)**
  - ARM, ASR
  - Environmental System Science
  - Relevant multi-agency SE US Field Campaigns
  - SE US experts, partners, and measurement networks
-  Slack channel: [amf3seus.slack.com](https://amf3seus.slack.com)
- email list: [seusteam@arm.gov](mailto:seusteam@arm.gov)
- webpage: <https://www.arm.gov/capabilities/observatories/amf/locations/seus>



# Question and Answer Break

For further campaign information:

<https://www.arm.gov/capabilities/observatories/amf/locations/seus>

# Thank You!

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