# Science and Deployment Plan for the DOE 3rd Atmospheric Radiation Measurement Mobile Facility:

## Coupled Observational-Modeling Studies of Land-Aerosol-Cloud Interactions in the Southeastern United States

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# Presentation Outline

- **Background:** ARM and the Southeast United States

- **Science Drivers:** Convective Onset and Development

- **Pre-deployment Activities:** Science-Driven Siting and Instrumentation Planning

- **Engaging with our Science Team**

# Atmospheric Radiation Measurement (ARM): DOE User Facility

- **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: SEUS**, March 2023

# ARM: Comprehensive Sets of Surface and Atmospheric Measurements

**ARM**

Background Atmospheric State

Surface Energy Balance

Aerosol and Hydrometeor Profiles

Near-Surface Aerosol Properties

Aerial Measurements
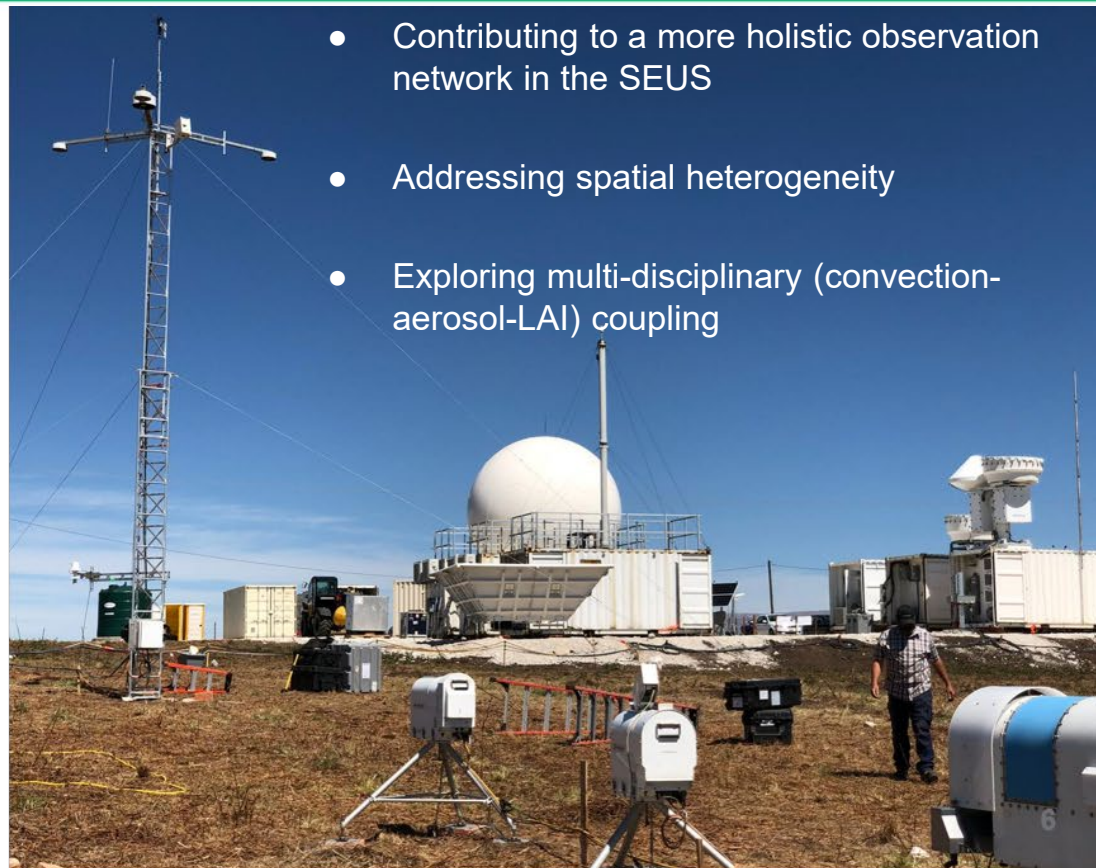
- Contributing to a more holistic observation network in the SEUS

- Addressing spatial heterogeneity

- Exploring multi-disciplinary (convection-aerosol-LAI) coupling

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



- Motivators for going to the SEUS:
  - Large amount of vegetative-driven biogenic emissions
  - Abundant locally-forced shallow to deep convection
  - Strong local coupling of land surface with atmospheric processes

- Expected **5 year** deployment, with operations beginning March 2023.

- Specifics on site location, configuration, instrumentation to be determined in part through a DOE supported **Site Science Team:**
  - Chongai Kuang (aerosol)
  - Scott Giangrande (convection)
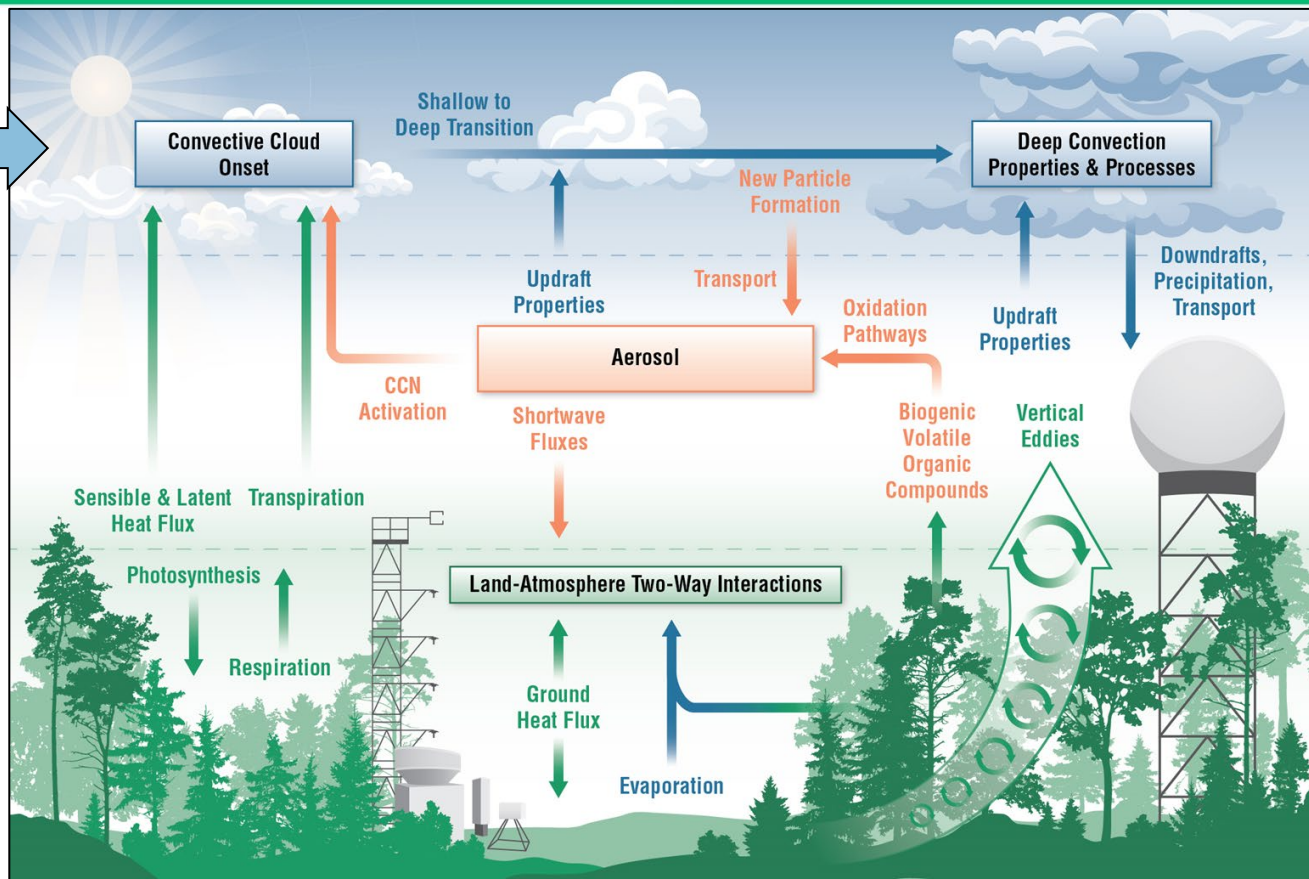  - Shawn Serbin (land-atmosphere interactions)

# AMF3 SEUS: 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 PBL and coverage of convection
  - Nature of convective updrafts, including intensity/size
  - Convective organization and stratiform precipitation

# AMF3 SEUS: Land-Atmosphere Interactions (LAI) Science Drivers

- Process-level local coupling between land and atmosphere

- Impacts of surface heterogeneity on coupling

- Identifying the land-surface biotic and abiotic controls on:
  - fluxes, energy budget, partitioning & closure
  - shallow-to-deep convection processes and spatio-temporal patterns
  - aerosol formation and regional distribution

- Turbulence and boundary layer measurement & modeling

- Two-way interactions between plants and cloud/aerosol radiative impacts
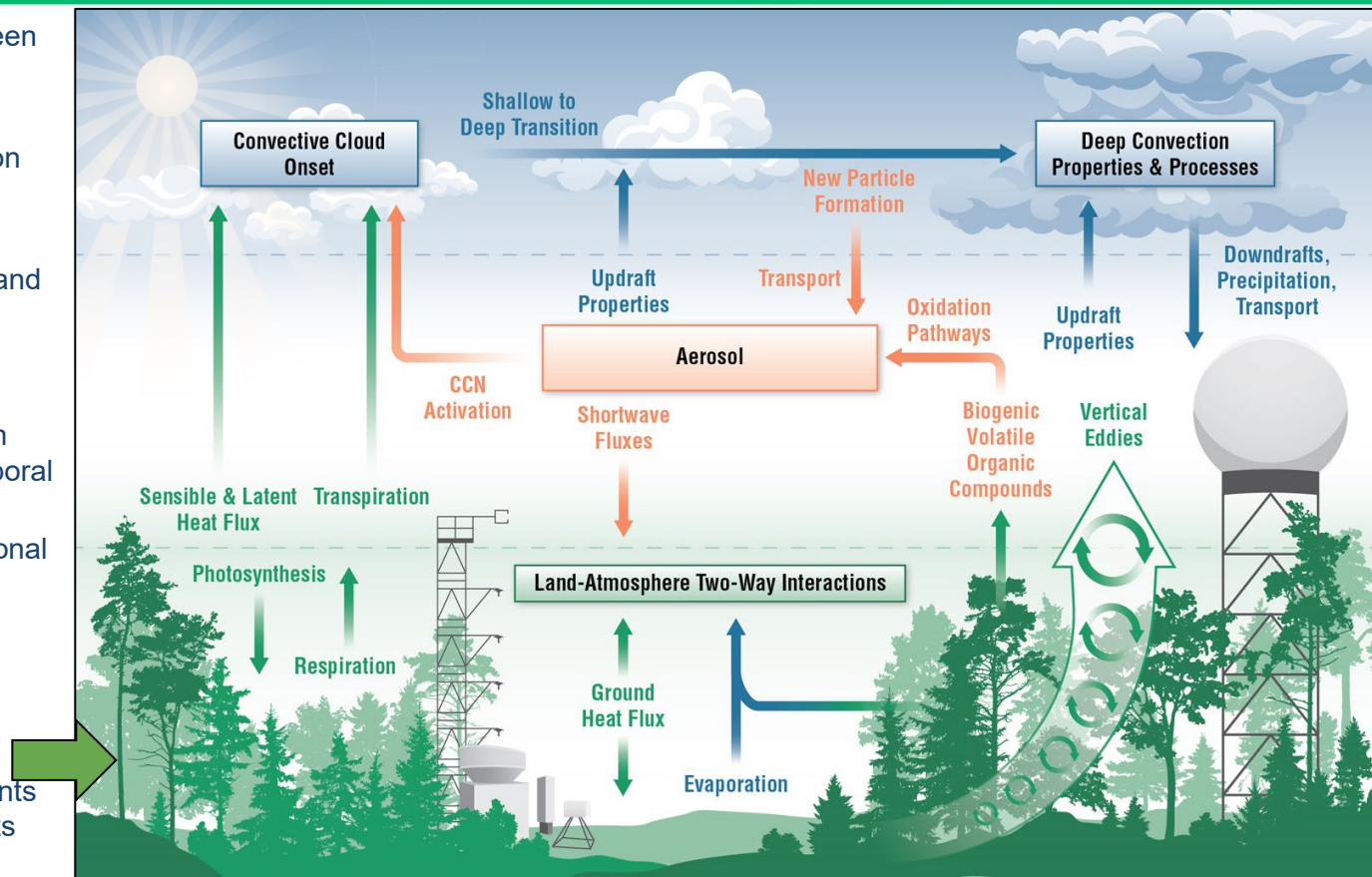
# AMF3 SEUS: Timeline and Deliverables

- **March 2021: Deliver a site "shortlist" - potential sites, site configurations, and instrument priorities**

- September 2021: Site identified

- March 2023: Site operational

- Develop and apply science-driven (aerosol, convection, LAI) criteria for:
  - Potential site locations
  - **Site configurations**
  - **Instrument prioritization and sampling considerations**

# Preferred Siting Criteria for Effective AMF3 SEUS Deployment

- **avoid coastal regions**

- **representative (and low complexity) terrain**

- representative forested sites

- representative air mass sampling

- **representative cloud frequency/diversity**

- allowable air-space for aerial observations

- **proximity to partner facilities**

# Preferred Siting Criteria: Avoid Coastal Regions

**ARM**



155km Coastal Buffer

0  100  200  300  400 km
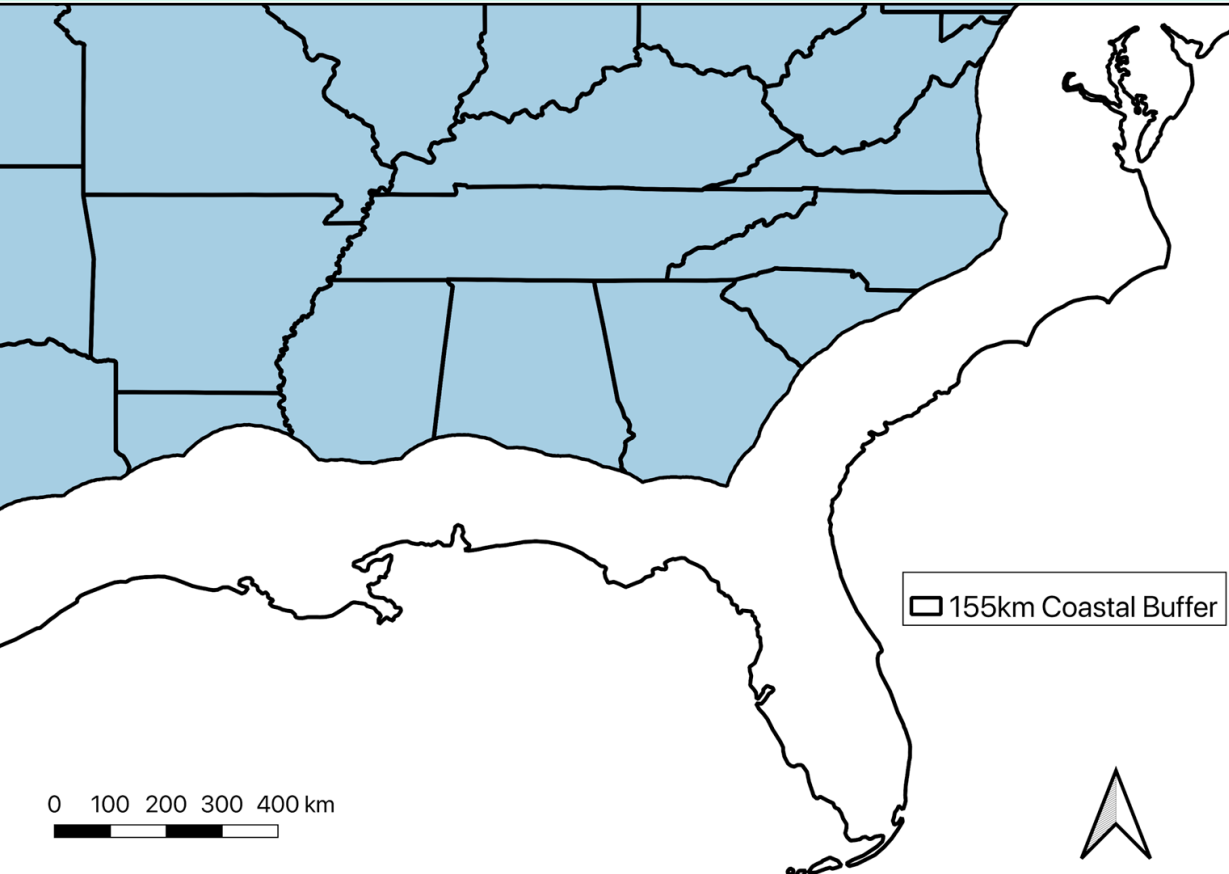
- science drivers prioritize:

  - day-time convection

  - surface-driven cloud-aerosol processes

  - convective cloud transitions

  - synoptically driven deep convection

# Preferred Siting Criteria: Representative Cloud Frequency/Diversity

ARM



**Cumulus Cloud Fraction (Percent)**

> 3.0

2.25

< 1.5
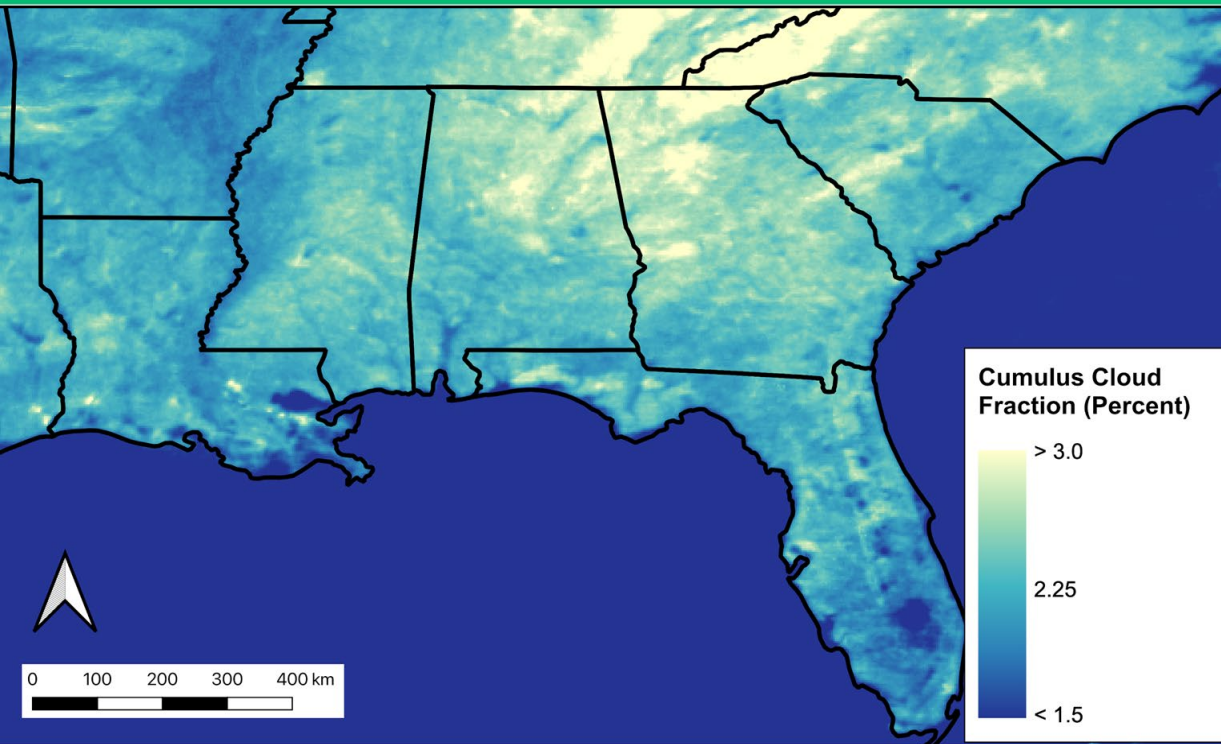
- June through August 'cumulus' cloud fraction (% of time over a 24 hour period) as derived from GOES satellites

dataset courtesy of J. Mecikalsksi (UAH)

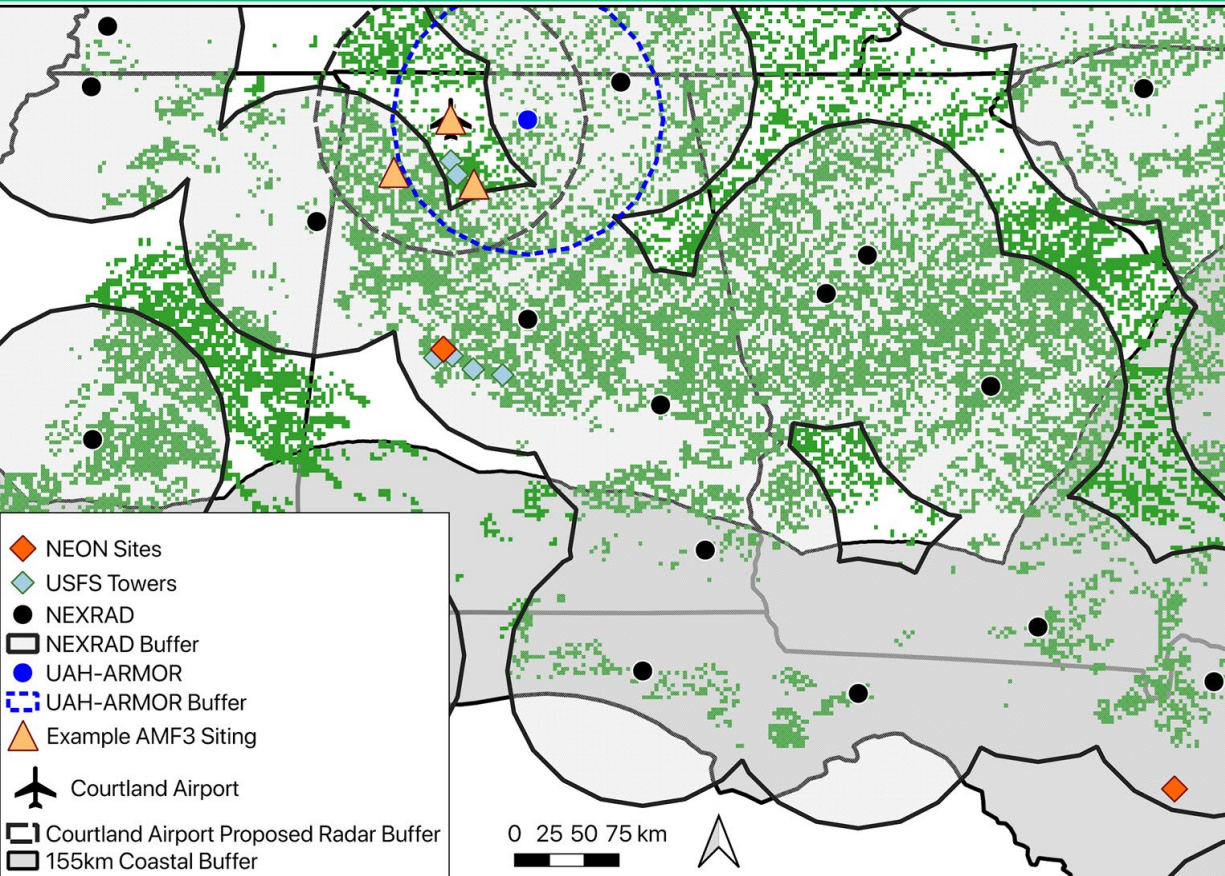# Preferred Siting Criteria: Representative (and Low Complexity) Terrain
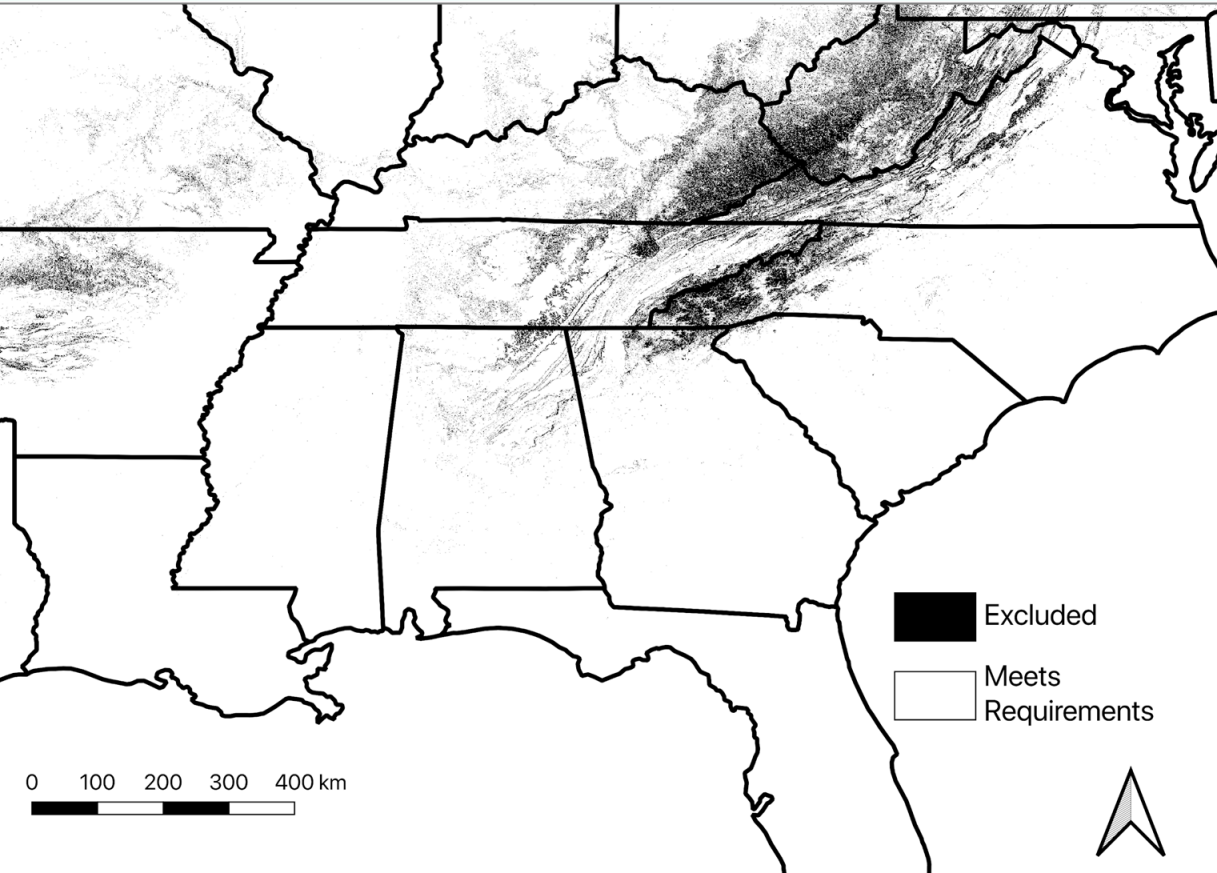


- Digital Elevation Model - derived terrain roughness

- priority for sites in relatively flat locations (low slope, low roughness)
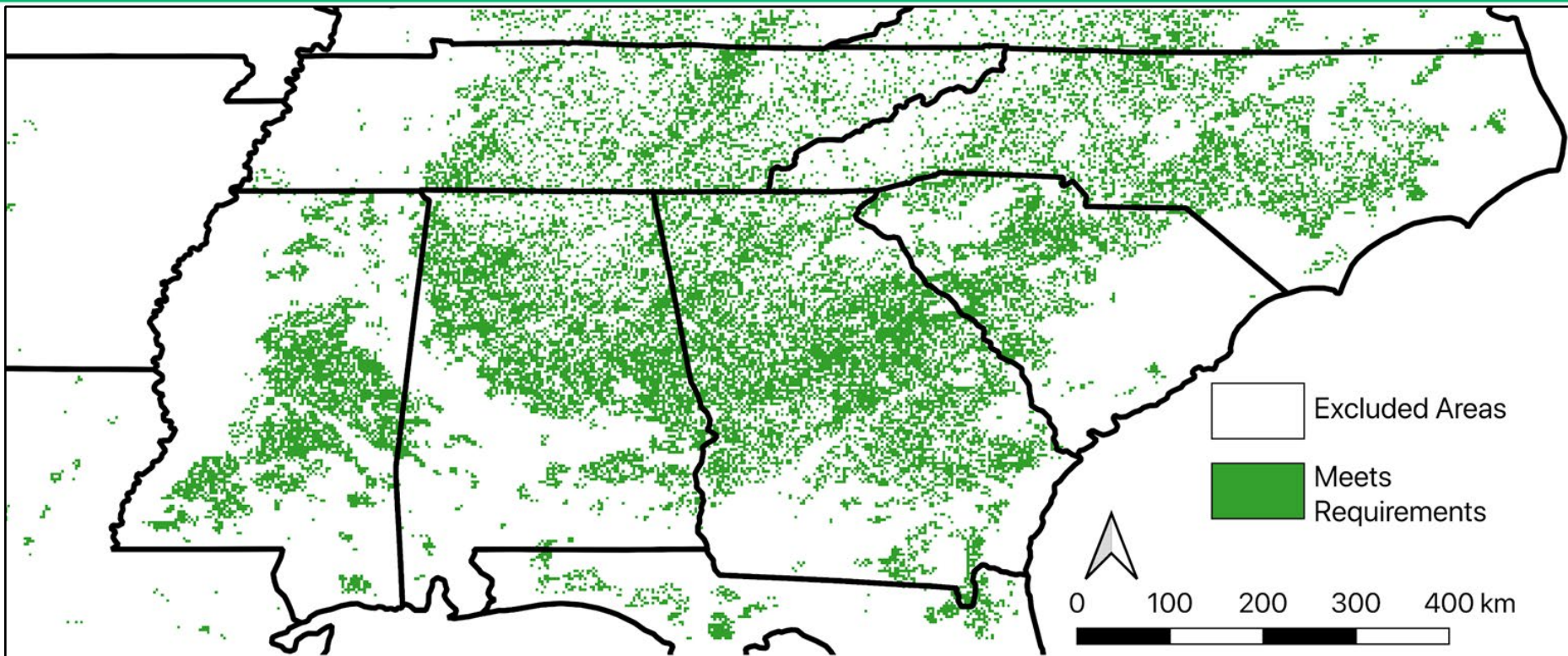
# Example Siting and Configuration Map



- overview SEUS map after applying several filters

- green regions potentially suitable for coupled-science siting

- proximity to potential partner facilities

Legend:
- ◆ NEON Sites
- ◇ USFS Towers
- ● NEXRAD
- ▭ NEXRAD Buffer
- ● UAH-ARMOR
- ⬚ UAH-ARMOR Buffer
- ▲ Example AMF3 Siting
- ✈ Courtland Airport
- ▭ Courtland Airport Proposed Radar Buffer
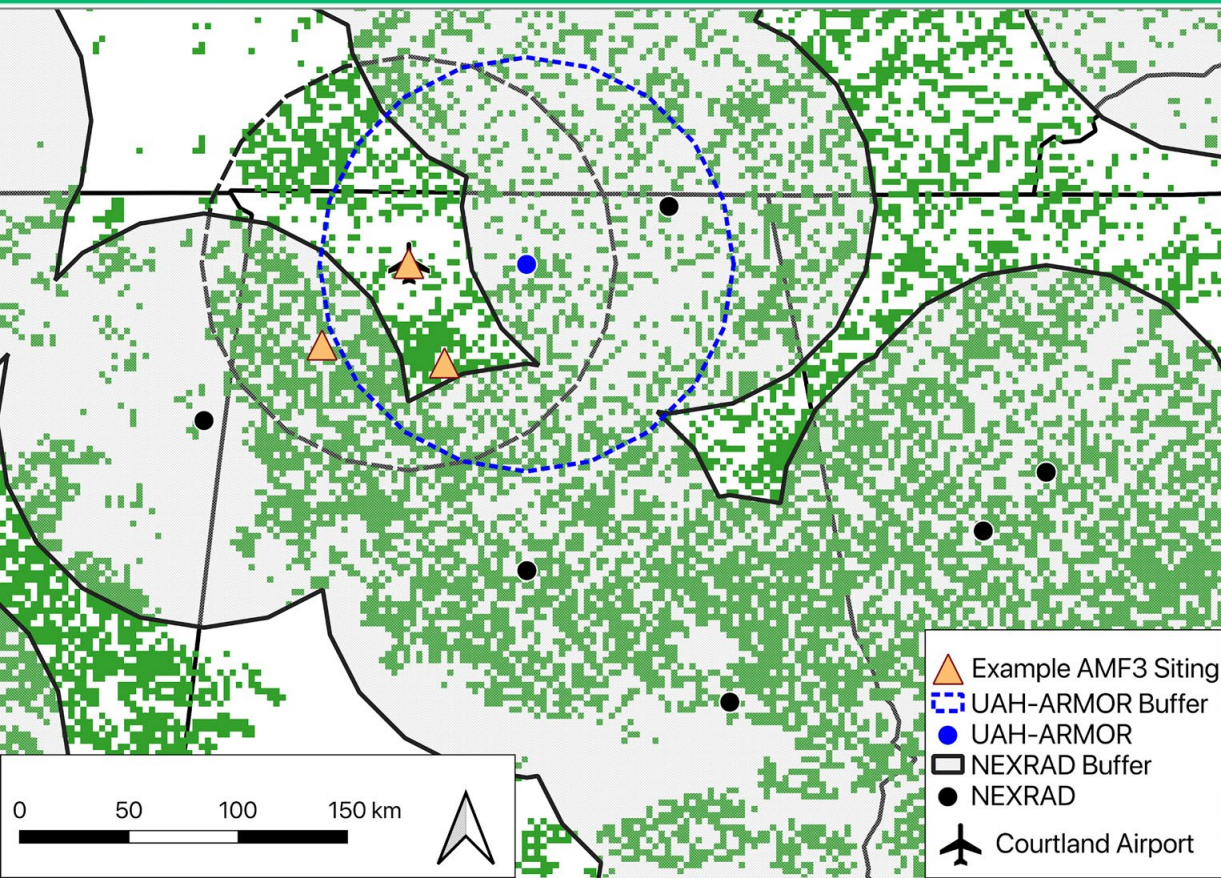- ▭ 155km Coastal Buffer

0 25 50 75 km

# Key Measurement Recommendations



- advanced lidar

- multi-sensor atmospheric thermodynamic profiling

- cloud sampling, imaging (column)

- cloud and precipitation (scanning/surveillance radar)

# Spatially Distributed Observational Network

Legend:
- Example AMF3 Siting
- UAH–ARMOR Buffer
- UAH–ARMOR
- NEXRAD Buffer
- NEXRAD
- Courtland Airport

Scale: 0 — 50 — 100 — 150 km

- recommendations:

  - ≥ 3 non-collinear profiling facilities

  - example triangle of supplemental sites with the center at the main AMF3 facility

  - coupled atmospheric aerosol, cloud and LAI profiling

# Engaging with our Science Team

**ARM**

- 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:
  - ARM, ASR
  - Environmental System Science
  - **Improvement and calibration of clouds in models (You!)**
  - Relevant multi-agency SEUS Field Campaigns
  - SEUS experts, partners, and measurement networks

- Slack channel    amf3seus.slack.com
- email list: seusteam@arm.gov
- webpage: https://www.arm.gov/capabilities/observatories/amf/locations/seus

# Thank You!

**For further campaign information:**
**https://www.arm.gov/capabilities/observatories/amf/locations/seus**