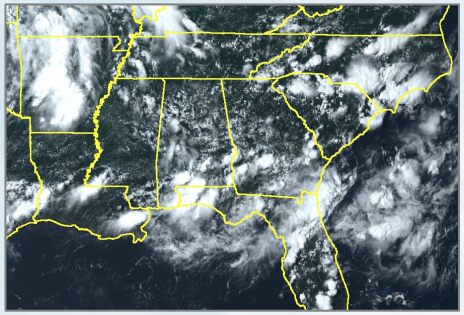
The 3rd ARM Mobile Facility (AMF3): Future Plans in the Southeast US

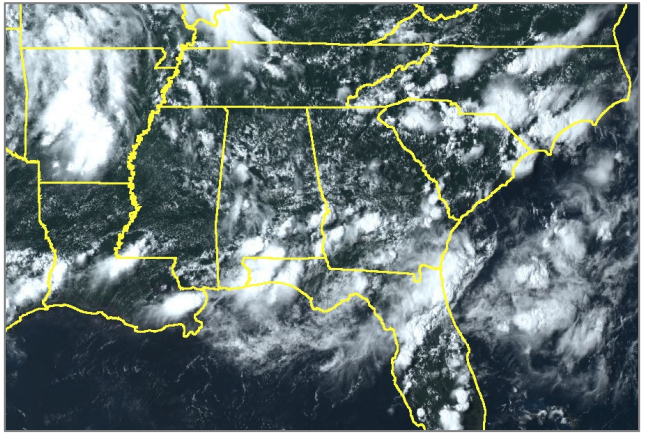
Site Science Team Leads (BNL): **Chongai Kuang**, Scott Giangrande, Shawn Serbin

Site Operations Team Leads (ANL): **Patty Campbell**, Mike Ritsche, Mark Spychala, Nicki Hickmon



Relocation of the 3rd ARM Mobile Facility to the Southeast U.S.

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



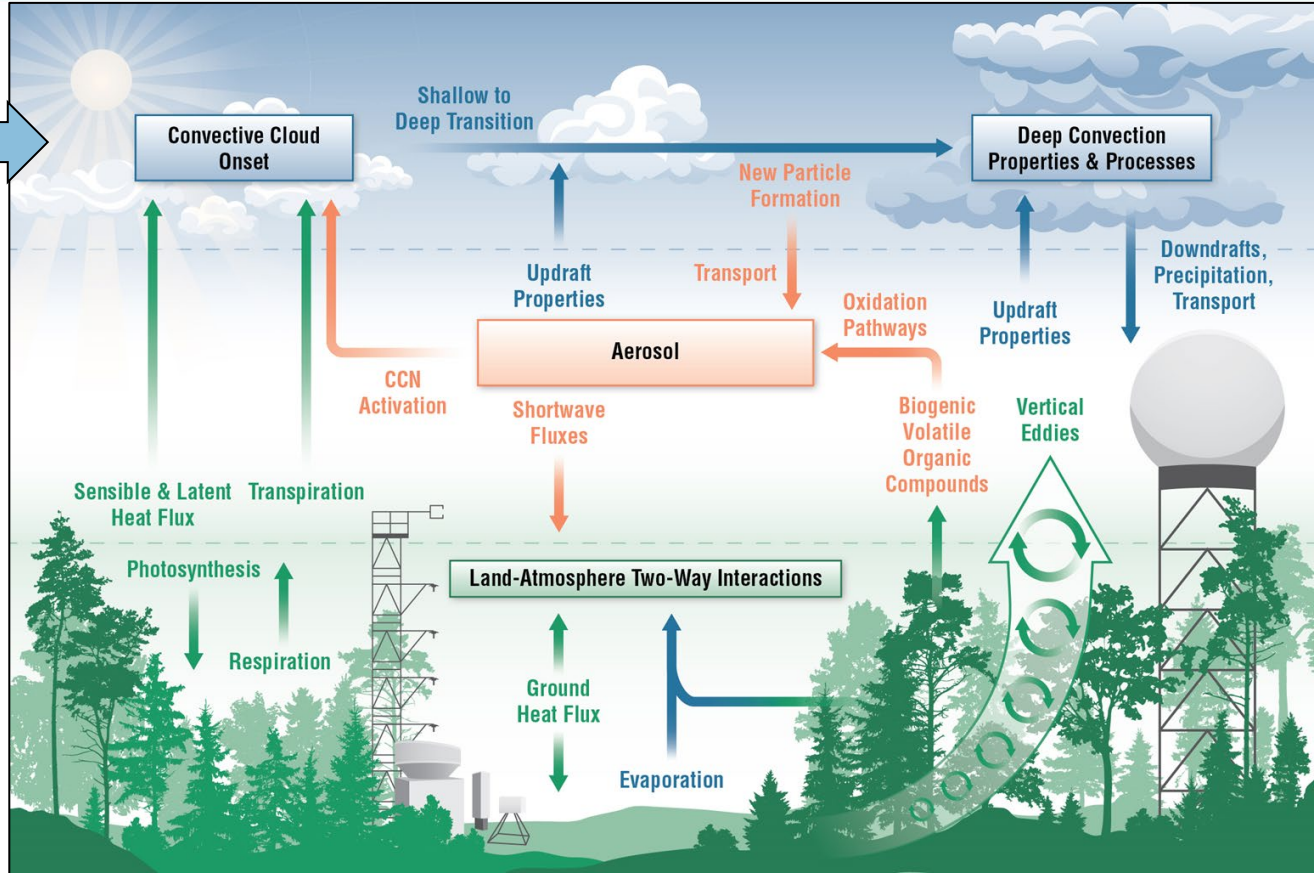
- Expected **5 year** deployment, operations beginning summer 2023.
- Joint ARM, ASR-funded project.
- Specifics on site location, configuration, and instrumentation to be determined in part through coordination between a DOE supported **Site Science Team** and the **Site Operations Team**.

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: The Pennsylvania State University
- Mariko Oue: Stony Brook University, NY
- Thijs Heus: Cleveland State University
- Pierre Gentine: Columbia University

Convective Cloud Process 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



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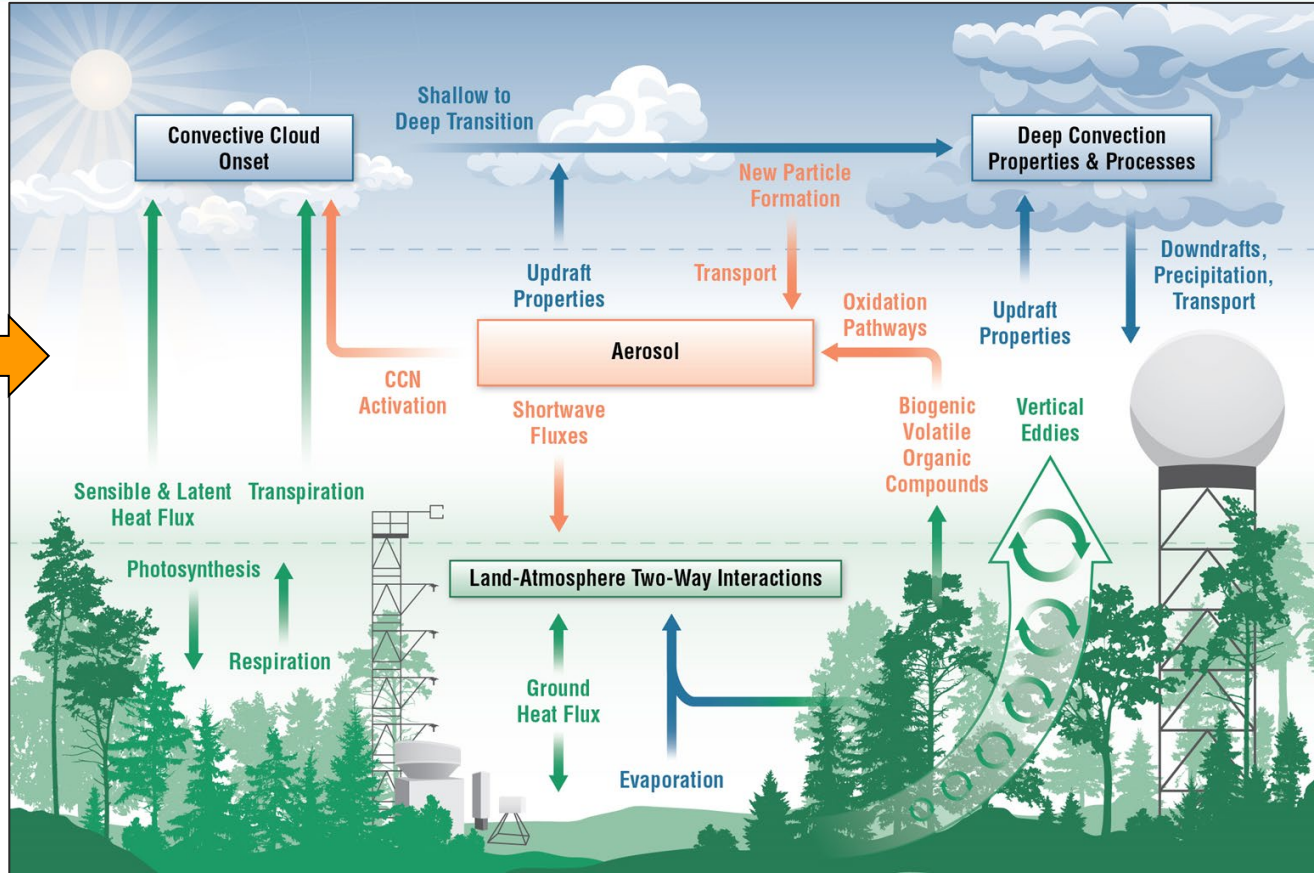
Aerosol Process Science Drivers

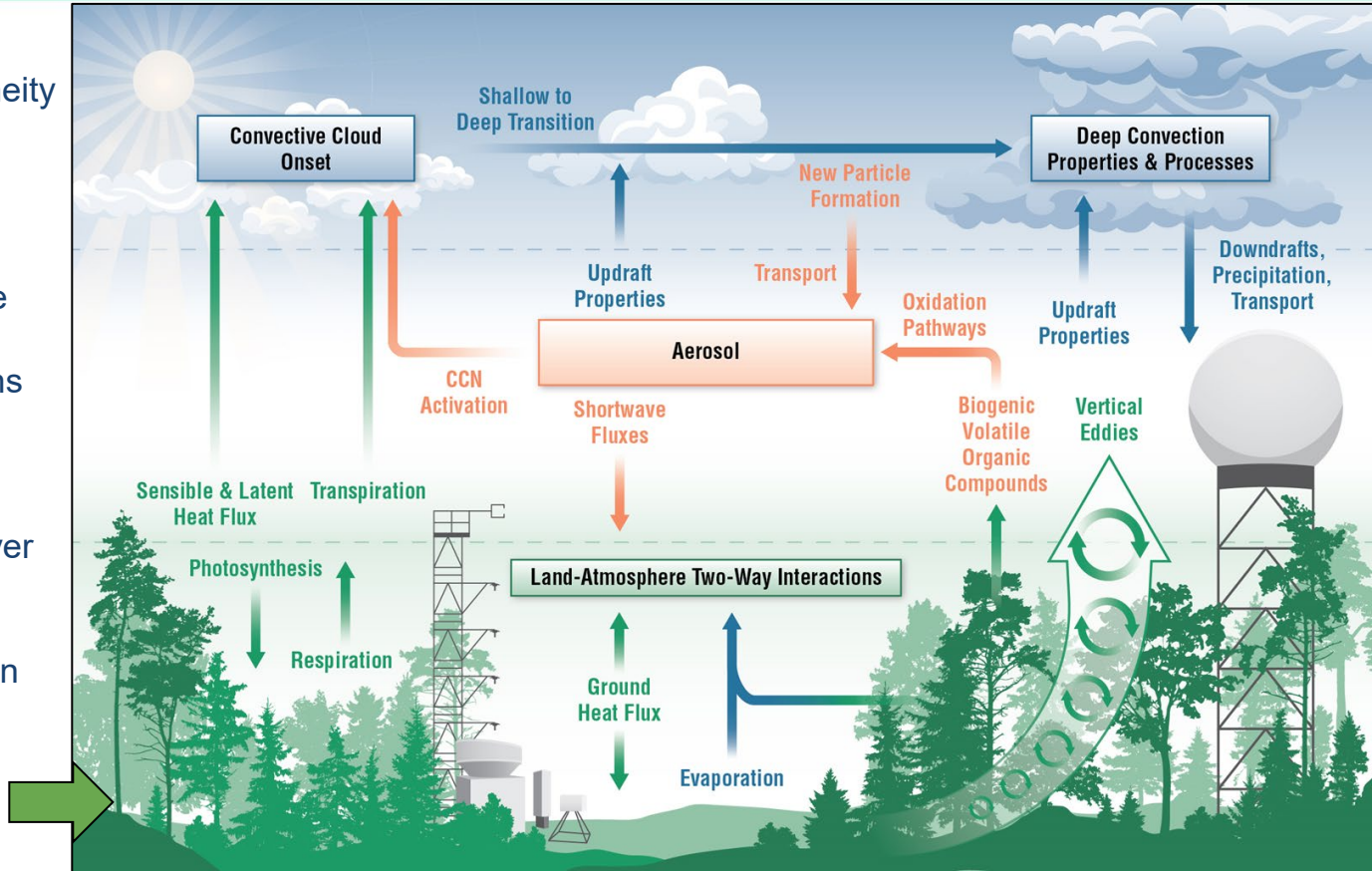
- **Properties/processes that control the cloud condensation nuclei budget:**
  - New particle formation and transport
  - Secondary organic aerosol
  - Spatio-temporal variability in aerosol hygroscopicity

- **Aerosol optical properties:**
  - Particle water uptake
  - Biomass burning
  - Brown carbon

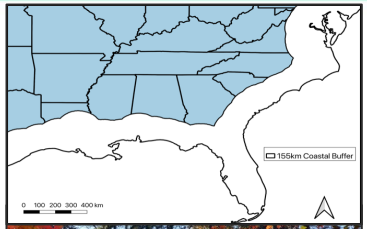


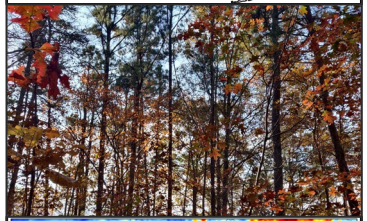
Land-Atmosphere Interactions Science Drivers

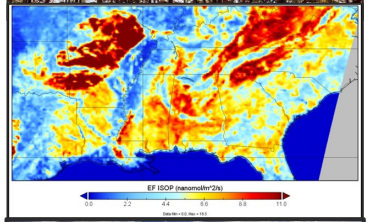
- Impacts of surface heterogeneity on land-atmosphere coupling
- Land-surface biotic / abiotic controls on:
  - Fluxes, energy balance
  - Cloud processes and spatio-temporal patterns
  - Aerosol formation and regional variability
- Turbulence and boundary layer measurement & modeling
- Two-way interactions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



Preferred Siting Criteria for Effective AMF3 Deployment in the Southeast U.S.







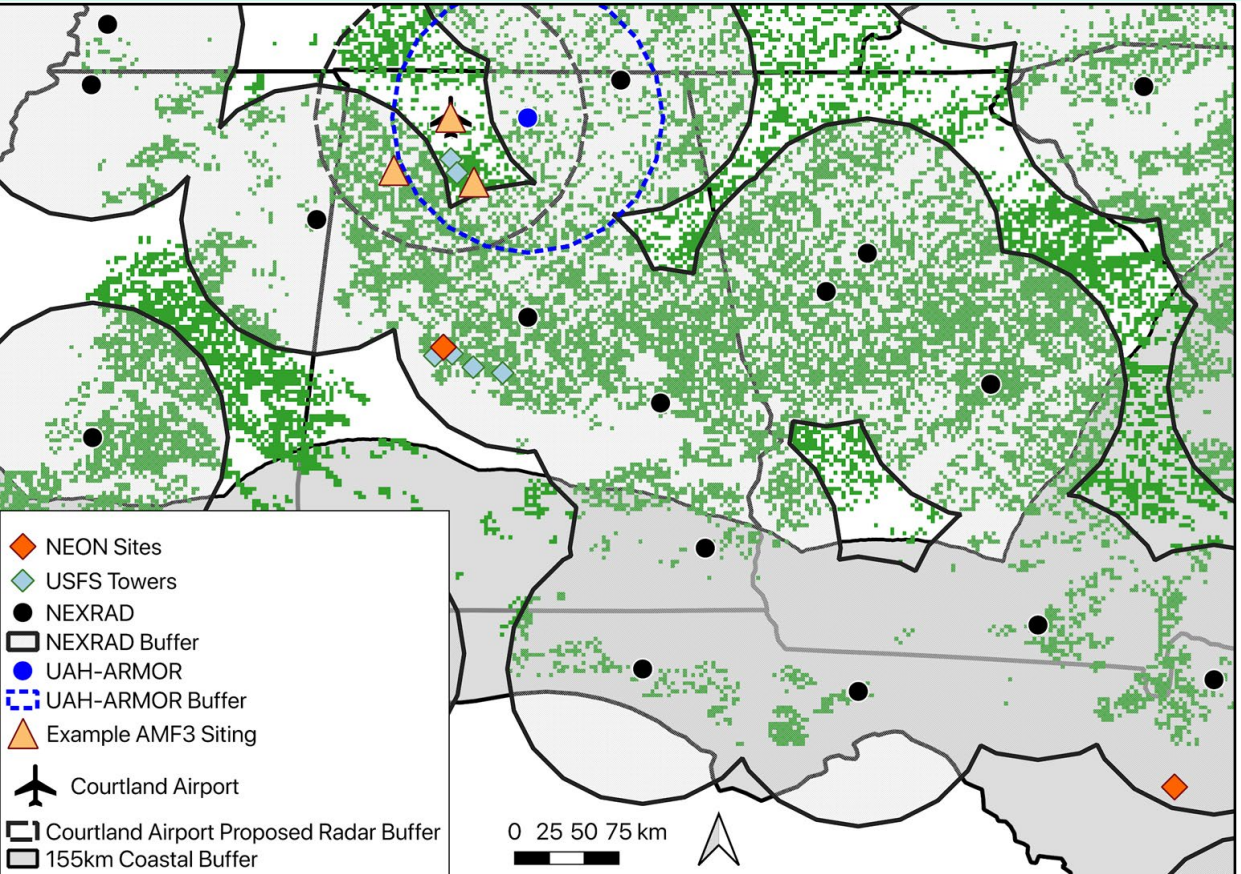
Avoid coastal regions and similar complexities

Representative terrain and forested locations

Representative air mass sampling

Frequent clouds, shallow to deep convection

GIS Spatial Analysis: Example Siting and Site Configuration



- Green regions are potentially suitable for cross-cutting science 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

AMF3 BNF

Bankhead National Forest in North Central Alabama

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The Joint Site Operations and Site Science Team!





Site Operations

Nicki Hickmon – ARM Associate Director for Operations

Mike Ritsche – AMF3 Observatory Manager

Patty Campbell – AMF3 Site Operations Manager

Mark Spychala – AMF3 Operations Specialist

Site Science Team

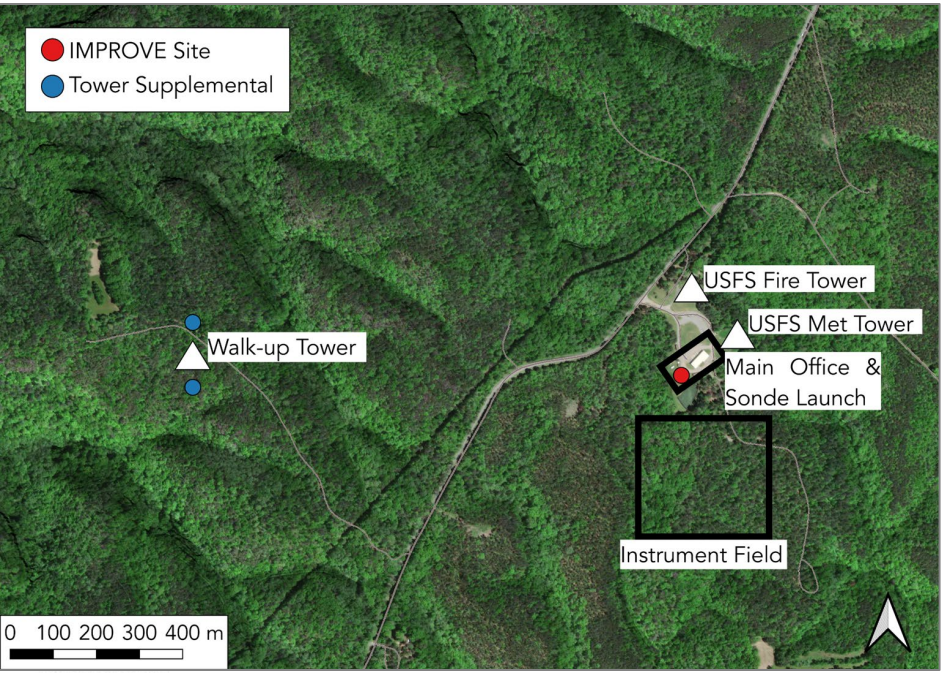
Chongai Kuang – Aerosol PI

Scott Giangrande – Convection co-PI

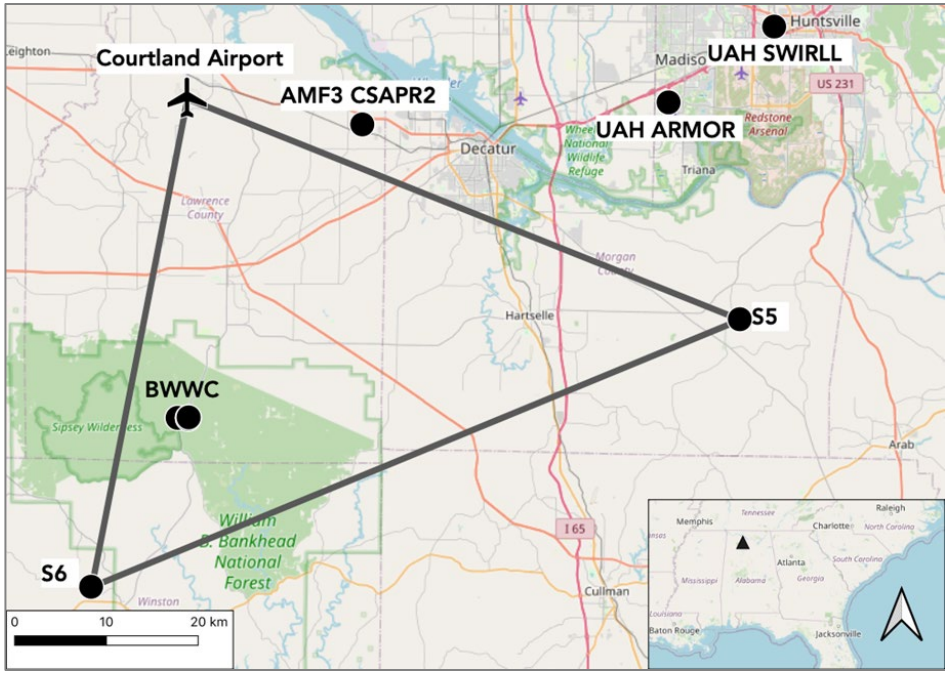
Shawn Serbin – Land-atmosphere interactions co-PI

Preferred Region: Northern Alabama - Main + Supplemental Sites

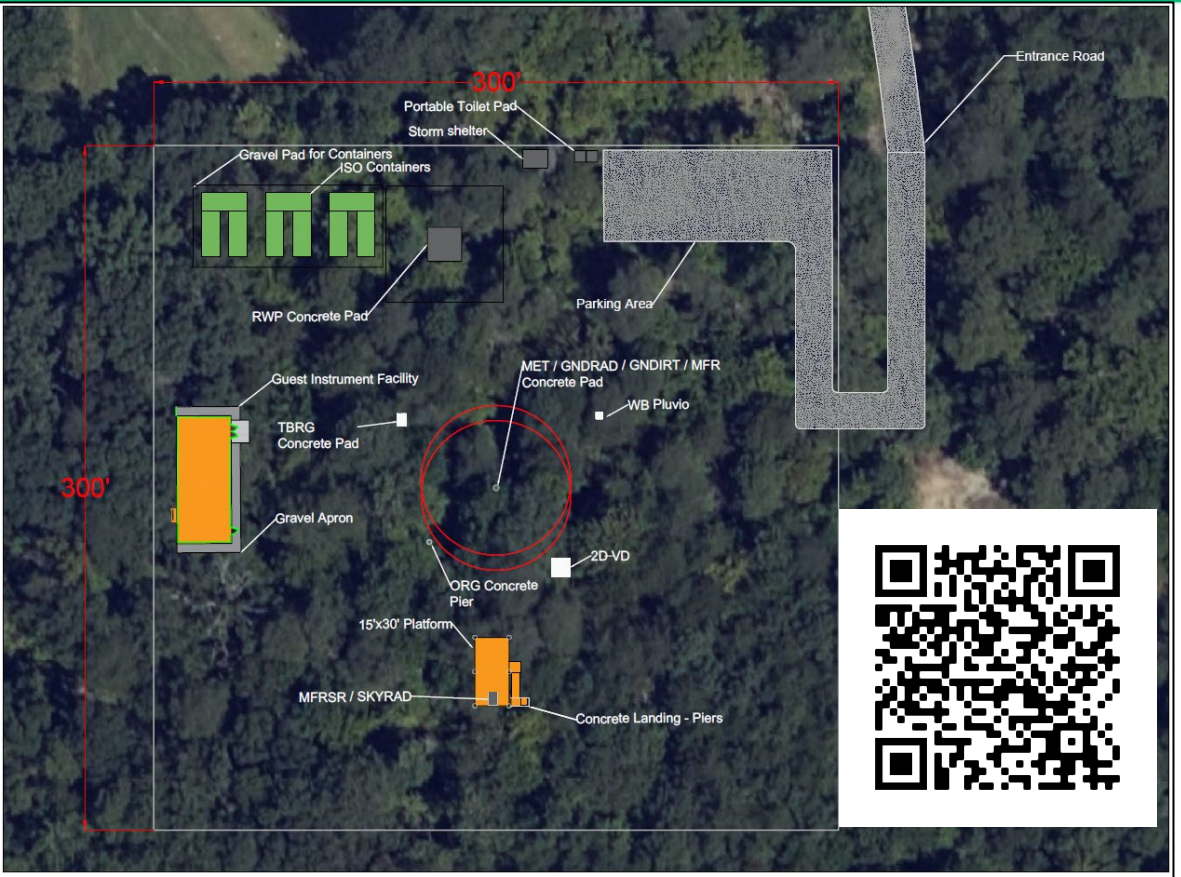
Bankhead National Forest: Black Warrior Work Center (BWWC) - Main Site (Phase 1 FY23)



Planned Partner Facilities & ARM Supplemental Sites (Phase 2 FY24)



Phase 1, Main site: Planned Layout and Instrumentation

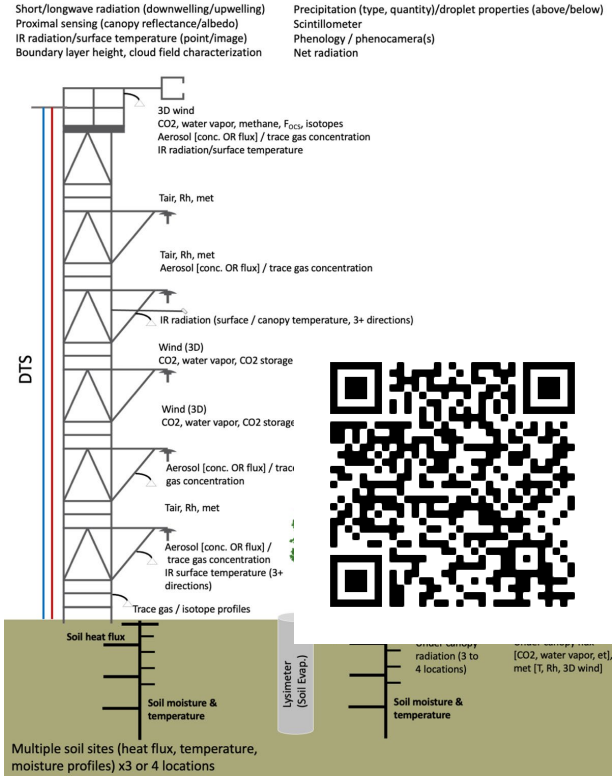


- **Aerosol Observing System (AOS)**
  - Water-uptake, chemical composition
  - Absorption, extinction, scattering
  - Concentration, size distribution
  - Trace gases
- Radiometry (upwelling/downwelling short/long-wave radiation)
- Aerosol Profile Retrievals
- Cloud Properties and Microphysics (Profiling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

Phase 1, Main Tower Site: Planned Design & Configuration

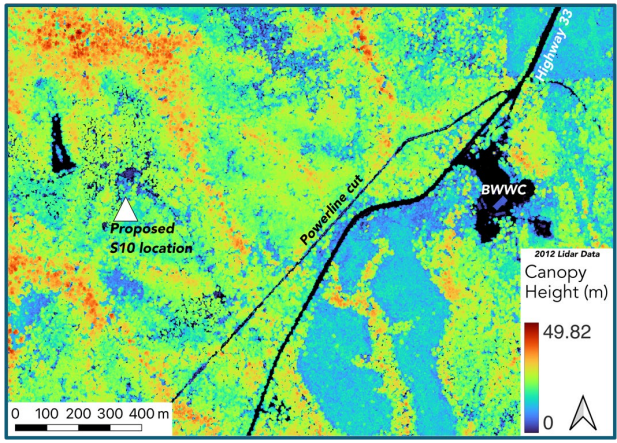
- **Measurement Heights:**
  - Top of tower
  - Above/Below Canopy
  - 10 meter/4 meter
  - Surface
- **Planned Measurements:**
  - 3D winds, T/RH, precipitation
  - Greenhouse Gases
  - Radiation: full-range, direct/diffuse, incident/reflected, profiles
  - Fluxes: C, H2O, energy (vertical/ecosystem)
- **Under Review / IOP Measurements:**
  - Aerosol flux - ENG0004574
  - Biological aerosol (WIBS/EMSL)
  - Biogenic VOC concentration + flux
  - AmeriFlux CO2 Flux & Storage System
  - Distributed Temperature Sensing

Concept



Siting

- mixed pine-oak forest, west of the BWWC
- determined via consideration of dominant winds, fetch, forest cover, and terrain



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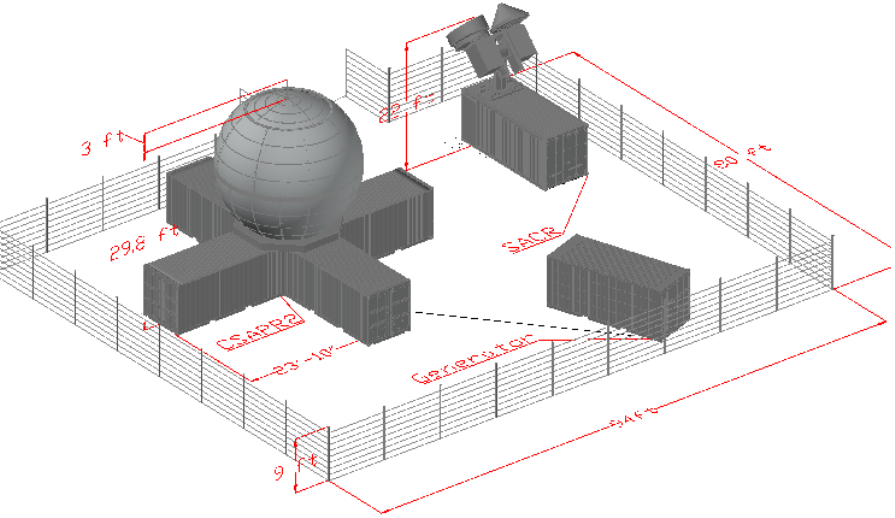
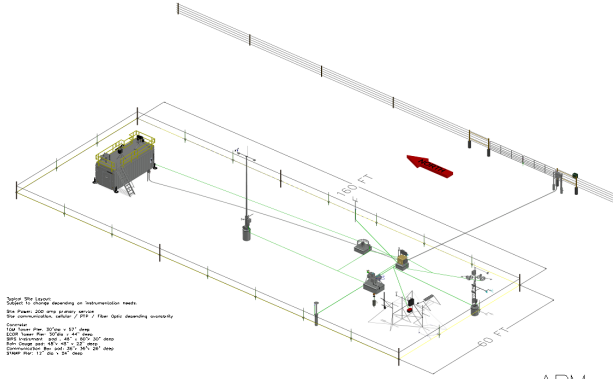
Supplemental and Radar Sites



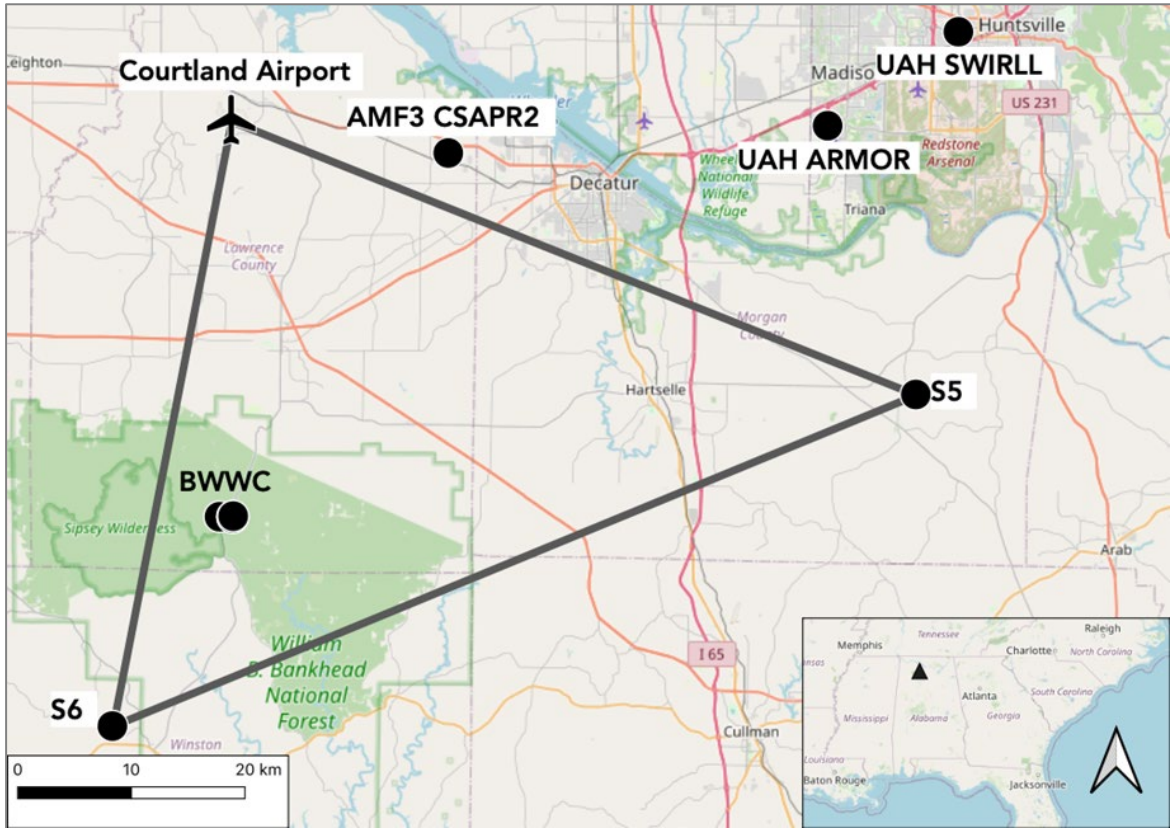
Instruments

- AERI
- DL
- MWR3C
- Camera
- Aerosol Node (In Discussion)
- Small tower (2 In Discussion)
  - Ecor/SEBS
  - SIRS
  - MFRSR
  - STAMP
  - IRT
  - Met



Phase 2, Aerial Platforms and Supplemental Sites: Planned Configuration and Measurements

- **Supplemental Sites:**
  - 3 sites: Courtland Airport + 2 TBD
  - boundary layer profiles (T, wind, water vapor, liquid water path)
  - surface fluxes (atmosphere and soil)
  - surface meteorology and radiometry
  - supplemental flux towers
- **Partner Facilities:** University of Alabama, Huntsville (ARMOR radar and SWIRLL)
- **Aerosol Sensor Node Network** (in design - ENG0004533)
- **Aerial Measurement Platforms** (e.g., tethered balloon systems, uncrewed aerial systems)
- **ARM Cloud/Precipitation Radar(s)** (e.g., CSAPR2, Ka-XSACR)



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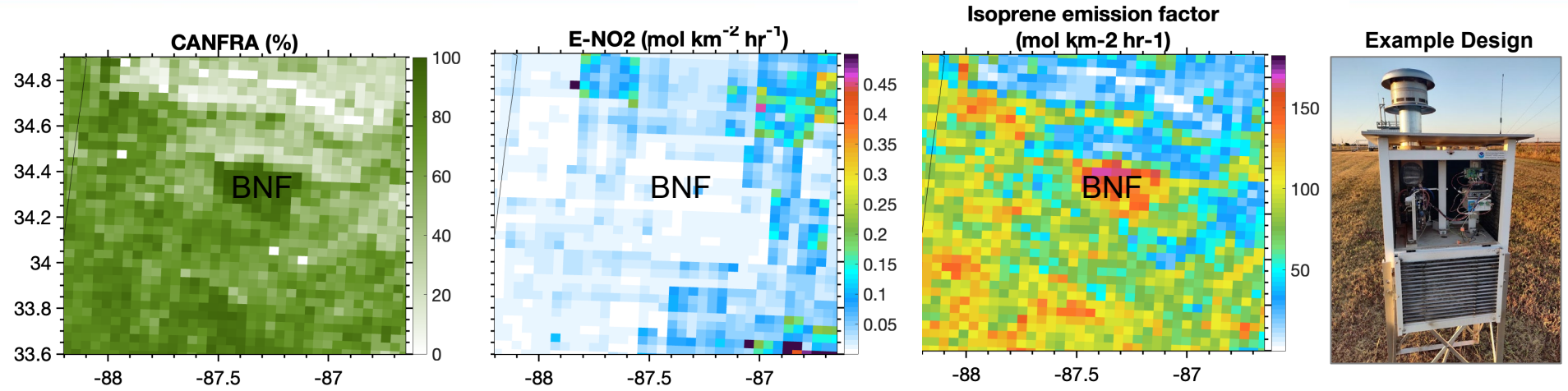
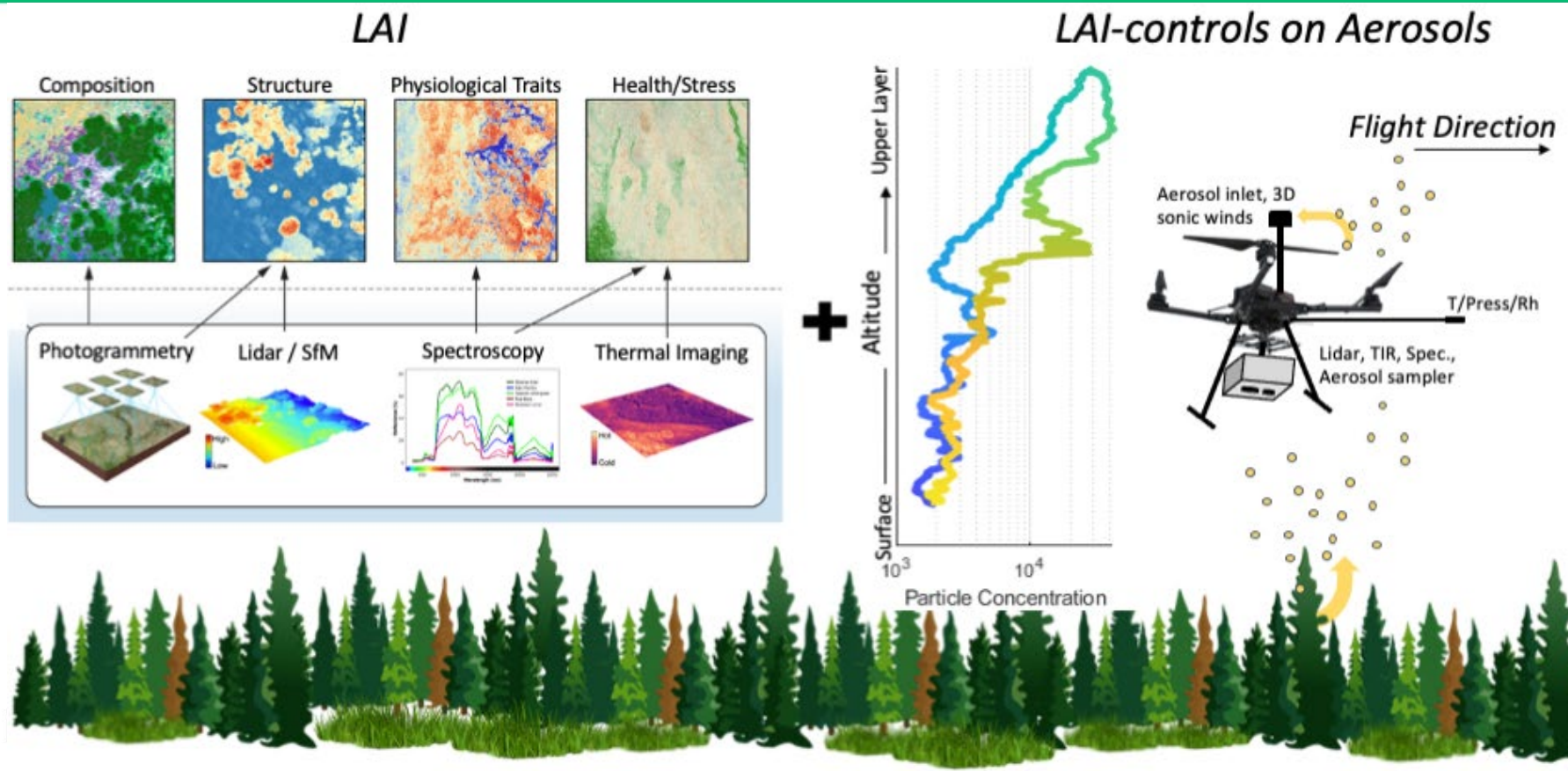
Aerosol Sensor Node Network - ENG0004533



- "Typical" global climate grid cell over Northern Alabama domain exhibits high aerosol variability due to heterogeneous surface controls on: aerosol sources (e.g., BVOCs, anthropogenic emissions), aerosol sinks (e.g., wet / dry deposition), and aerosol transformations (e.g., water up-take).
- Initially develop 2+ aerosol sensor nodes that meet measurement requirements (e.g., aerosol number, size, composition) and operational requirements (e.g., lower cost / complexity), targeting aerosol variability in AMF3 domain.

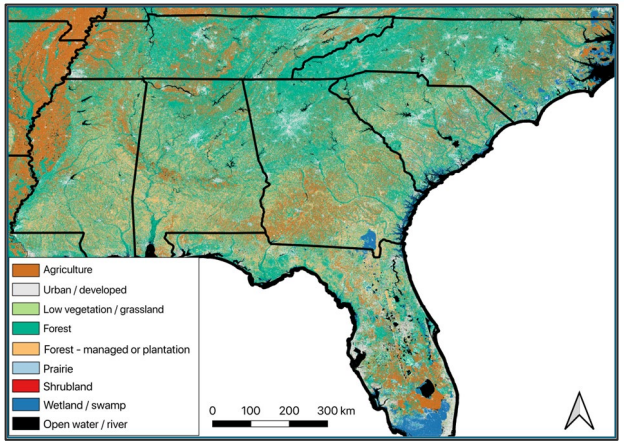
analysis courtesy of Tamanna Subba

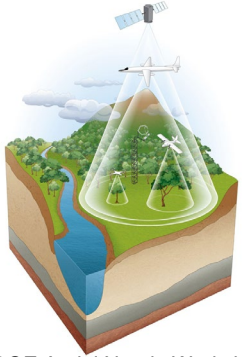
Novel Aerial Platforms for Coupled LAI Science



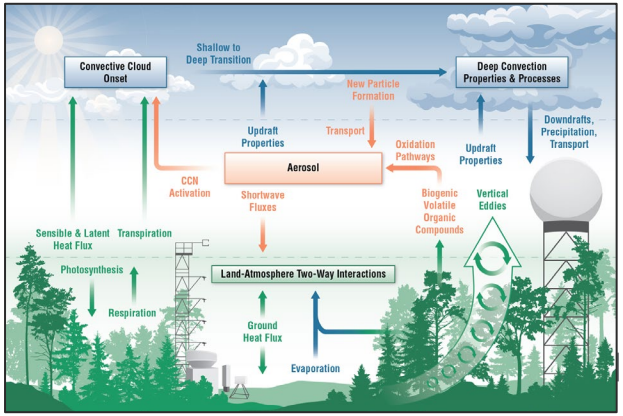
AMF3 Southeast US: Goals and Opportunities

- Improve understanding of Southeast U.S. land-atmosphere two-way interactions and surface controls on aerosol and convective processes.
- Explore environmental transitions: forest - rural - agricultural - urban.
- Upscale surface point/network, vertically-resolved, and remotely-sensed observations using novel datasets, statistical and process modeling approaches.
- Advance model-data integration of ARM and partner-agency observations.
- Test-bed for emerging measurement technologies (e.g., spatially-distributed sensing) and AI/ML applications for climate science (e.g., edge-enabled).





DOE Aerial Needs Workshop: image courtesy of Shawn Serbin



Engaging with our Site Science Team

- We strive for a very active community outreach. This includes outreach to:
  - ASR, Environmental System Science
  - ARM and EMSL Research Community
  - Relevant multi-agency Southeast U.S. Field Campaigns
  - Southeast U.S. experts, partners, and measurement networks

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