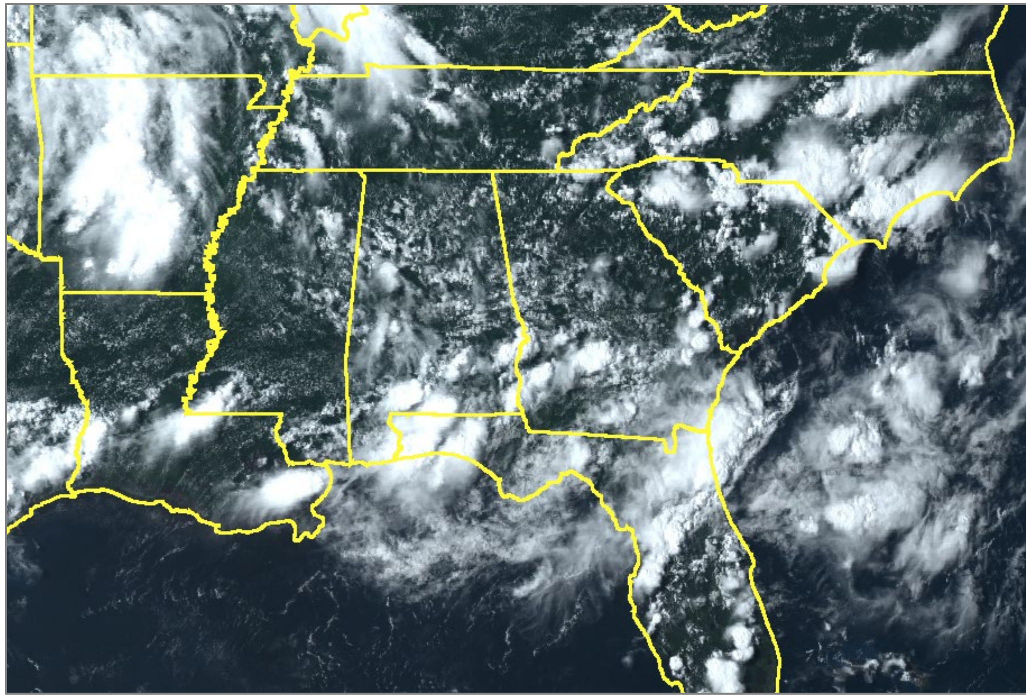
Deployment of the DOE 3rd ARM Mobile Facility (AMF3) to Northern Alabama: *An Update to the Aerosol Processes WG*

AMF3 Site Science Team Leads:
Chongai Kuang: PI, Aerosol Processes Lead
Scott Giangrande: co-PI, Convective Processes Lead
Shawn Serbin: co-PI, Land-Atmosphere Interactions Lead

Environmental & Climate Sciences Department, Brookhaven National Laboratory

Looking west from a fire tower located at the USFS work center in Bankhead National Forest

Relocation of the 3rd ARM Mobile Facility to the Southeastern US



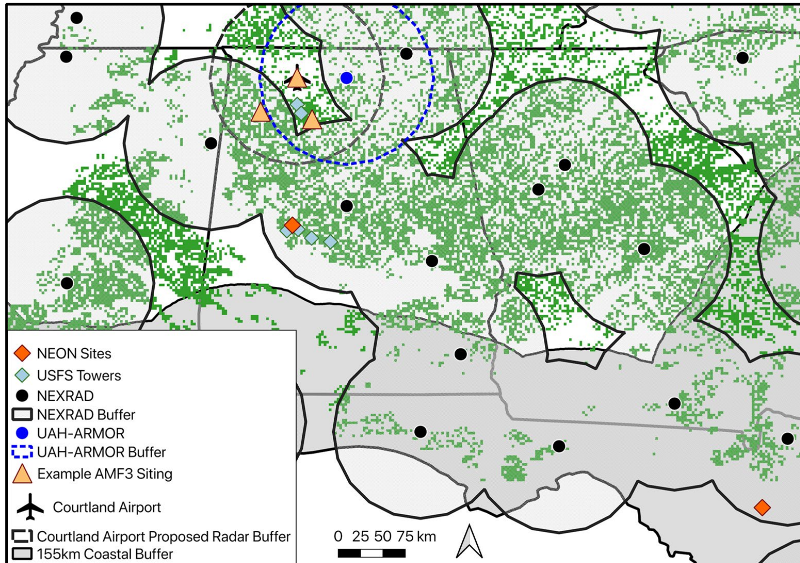
- Motivators for going to Northern Alabama:
  - Abundant locally-forced shallow to deep convection
  - Large amount of vegetative-driven biogenic emissions
  - Strong local coupling of land surface with atmospheric processes

- Expected **5 year** deployment, with planned operational start in **Fall 2023**.

- Joint ARM, ASR-funded project.

ASR Atmospheric System Research

ARM



- Specifics on site location, configuration, and instrumentation determined via a joint DOE-supported **Site Science Team** and **Site Operations Team**.

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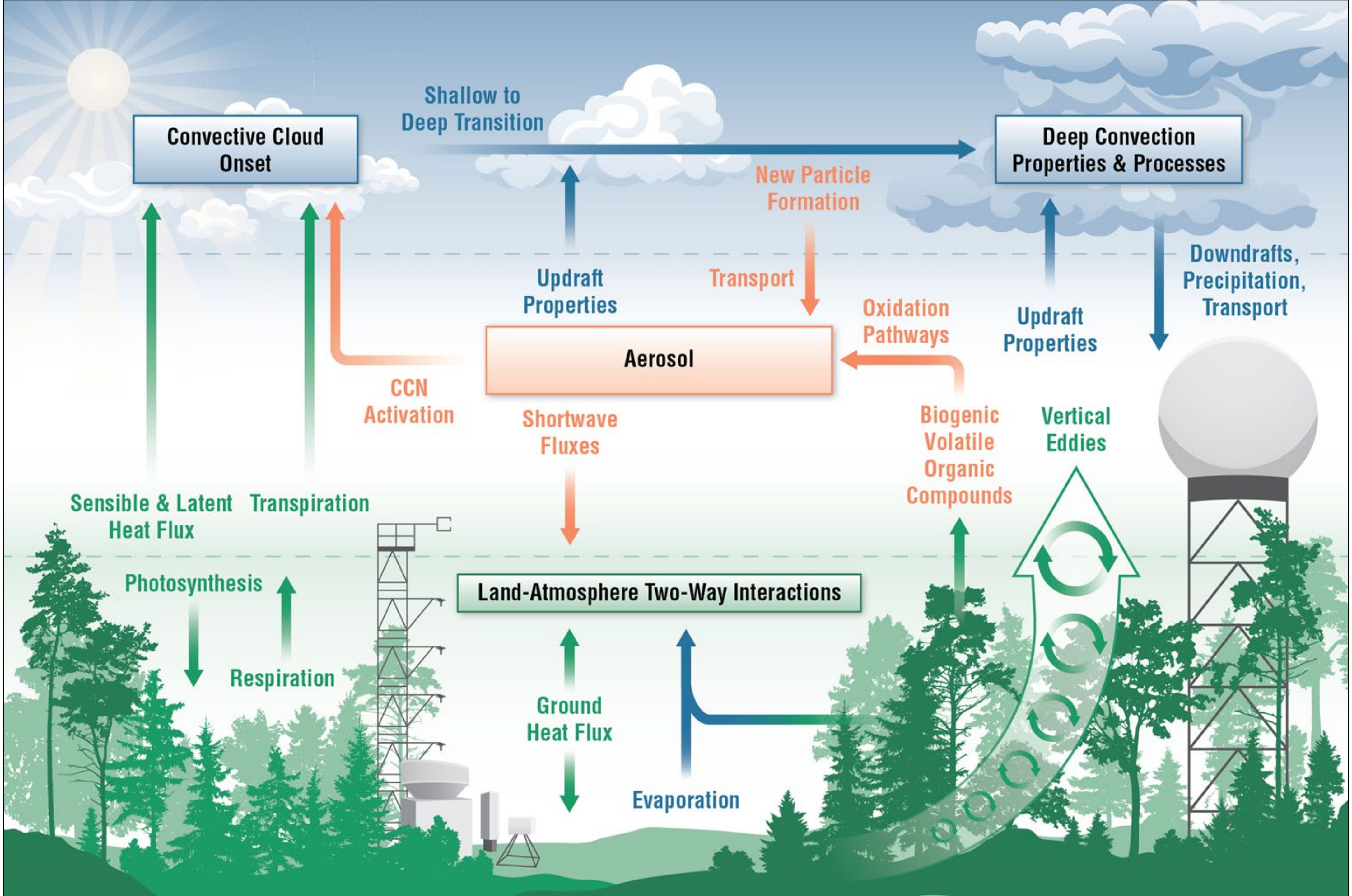
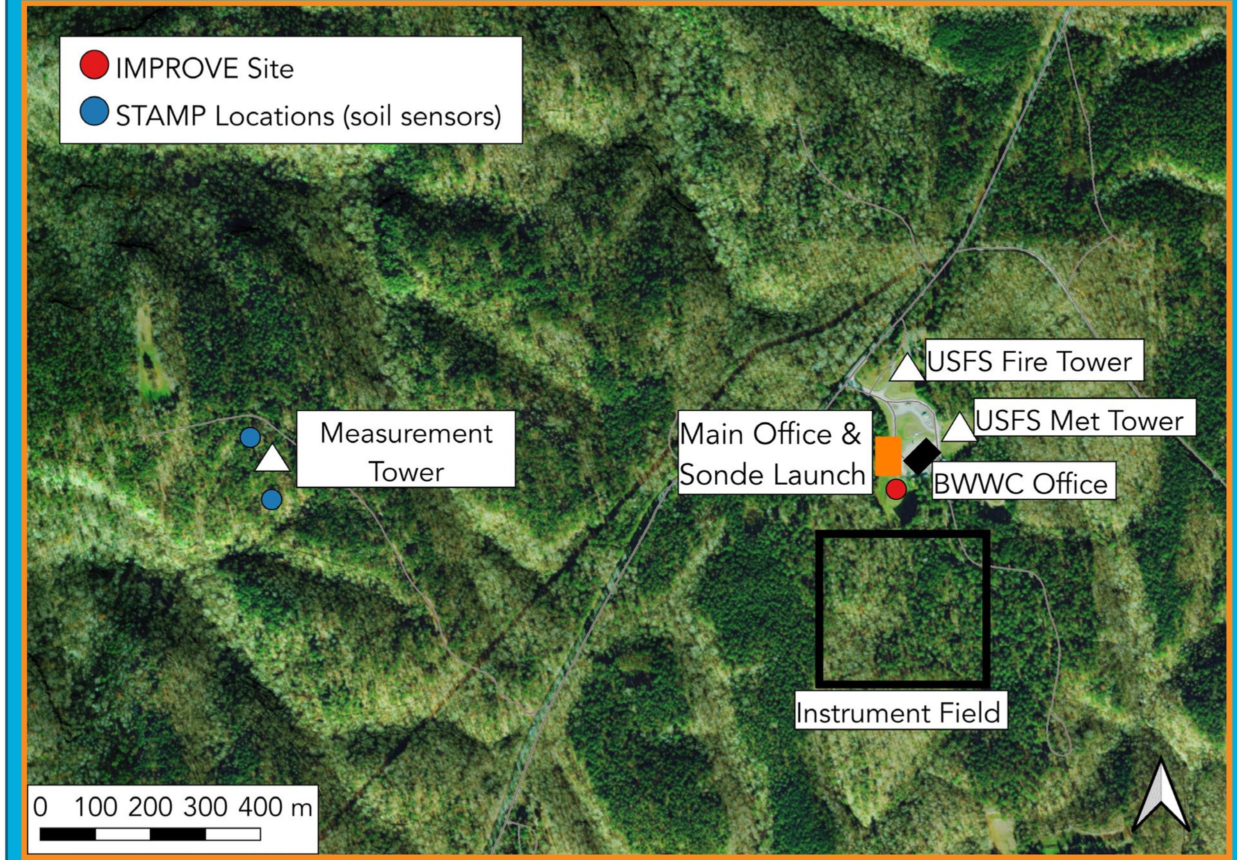
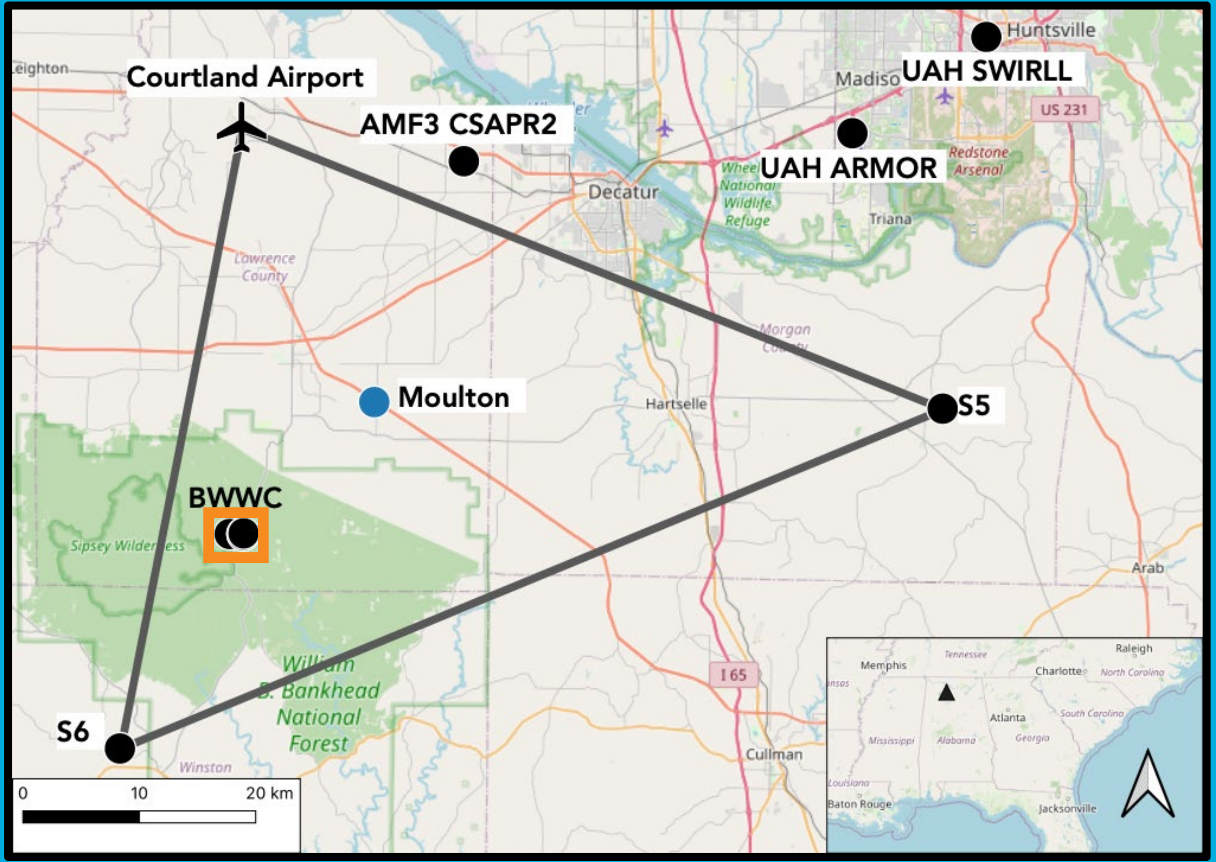
AMF3 Site Science Project: Core Team

- **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 Onset
Shallow to Deep Transition
Deep Convection Properties & Processes
New Particle Formation
Updraft Properties
Transport
Oxidation Pathways
Updraft Properties
Downdrafts, Precipitation, Transport
Aerosol
CCN Activation
Shortwave Fluxes
Biogenic Volatile Organic Compounds
Vertical Eddies
Sensible & Latent Heat Flux
Transpiration
Photosynthesis
Respiration
Land-Atmosphere Two-Way Interactions
Ground Heat Flux
Evaporation

AMF3 BNF Domain: Northern Alabama

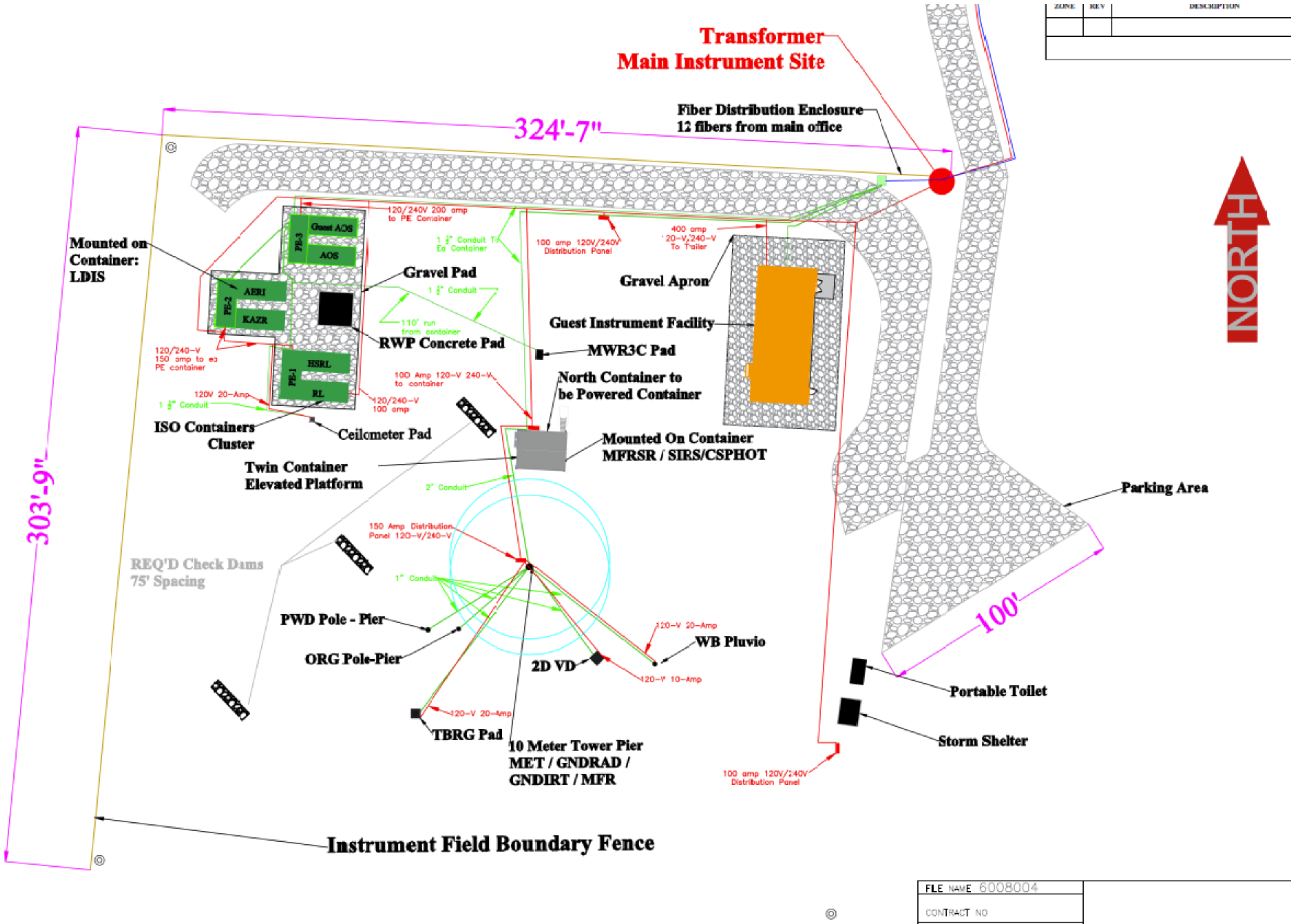




Bankhead National Forest (BNF): Black Warrior Work Center (BWWC) - Main Site (Phase 1 FY23)

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

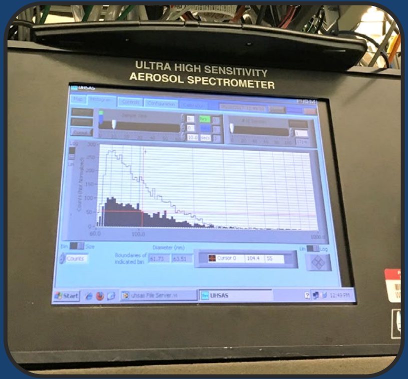
Phase 1, Instrument Field: Planned Layout and Measurements

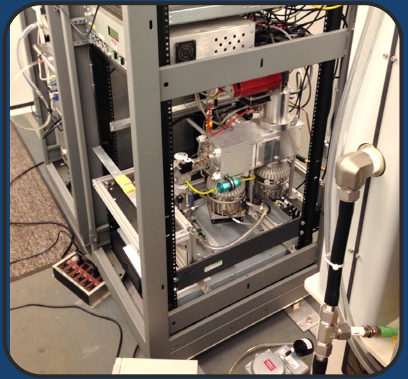


- Radiometry (upwelling / downwelling, short / long-wave radiation)
- Aerosol Profile Retrievals
- Cloud Properties and Microphysics (Profiling Radar)
- Radiosondes
- Surface Carbon, Water, Energy Fluxes
- Soil Moisture and Temperature
- Surface Meteorology
- Thermodynamic Profiles

- **Aerosol Observing System (AOS)**
  - Water-uptake, chemical composition
  - Absorption, extinction, scattering
  - Concentration, size distribution
  - Trace gases

AMF3 AOS: Measurements / Instrumentation





Number concentration and size (3 nm – ~35 µm)

- CPCU, CPCF
- SMPS (3083)
- UHSAS / OPC*
- APS

Water-uptake (sub- and super-saturated)

- CCN
- HT-DMA*
- Humidigraph*

Chemical composition

- TOF-ACSM
- SP2-XR

Optical properties

- CAPS
- Nephelometer
- PSAP

Trace gases & precursors

- CO
- O_3
- SO_2
- NO_x*

MIRO MGA^{10}– Specifications

MGA^{10}

Option 1) NO, NO2, CO2, N2O, NH3, H2O, O3, CO, CH4, SO2 – replaces all the current gases

Option 2) NO, NO2, CO2, N2O, NH3, H2O, O3, CO, CH4, OCS – No SO_2

Option 3) NO, NO2, CO2, N2O, NH3, H2O, O3, CO, HONO, OCS – No SO_2

Option 4) NO, NO2, CO2, OCS, NH3, H2O, O3, CO, CH4, SO2 – replaces all the current gases EXCEPT N_2O

Contact: Rebecca Trojanowski

Performance

	Option 1		Common		
Species	Precision @ 1s	Precision @ 100-200s	Max. Drift*	Specification range	Measurement Range (ppm)
CH_4 (ppb)	1	0.2	5	1'000-3'000	0-200
CO (ppb)	0.4	0.1	1	0-1'000	0-20
CO_2 (ppm)	0.9	0.09	1	300-500	0-8'000
SO_2 (ppb)	2	0.2	5	0-300	0-150
NH_3 (ppb)	0.1	0.02	1	0-50	0-15
N_2O (ppb)	0.5	0.05	2	300-400	0-20
NO (ppb)	0.8	0.1	2	0-400	0-100
NO_2 (ppb)	0.4	0.04	1	0-200	0-40
H_2O (ppm)	20	2	120	0-30'000	0-100'000
O_3 (ppb)	1	0.2	10	0-300	0-300
OCS (ppb)	-	-	2	0-100	0-2
HONO (ppb)	-	-	10	0-300	0-5

Specifications

Parameters	Technical Specifications	
	1 Hz	10 Hz
Ambient Temperature	15-30 °C	
Ambient Humidity	< 90% RH, non-condensing	
Sample Pressure	700-1050 mbar	
Sample Flow Rate	0.5 to 1.5 slpm	15 slpm
Sample Inlet Fittings	6 mm-Swagelok	12 mm-Swagelok
Dimensions	48 w x 18 h x 70 d (cm)	
Accessories required	Chiller unit, Vacuum pump	
Weight	20 kg (Analyzer), 11 kg (Chiller unit), 9 kg (Vacuum pump)	20 kg (Analyzer), 11 kg (Chiller unit), 32 kg (Vacuum pump)
Power	110-220 VAC / 50-60 Hz; <100 W Analyzer, <230 W (Pump and Chiller unit)	110-220 VAC / 50-60 Hz; <100 W Analyzer, <530 W (Pump and Chiller unit)

Vacuum pump

Water chiller

Technical Specifications Continued	
Installation	19" Rack mountable or benchtop
Digital ports	RS232, USB, Ethernet
Connectivity	The instrument provides remote access and control of its main functionalities. It contains a PC which is running the instrument software. If a network access is provided, the instrument's full functionality can be accessed via a remote control software.
Electrical and Laser Savety	CE-Mark (IEC 61010-1: 2010, IEC 61326-1: 2012, IEC 60825: 2019)
Service Interval	The instrument is suitable for operation without on-site interventions for a period of at least three weeks.

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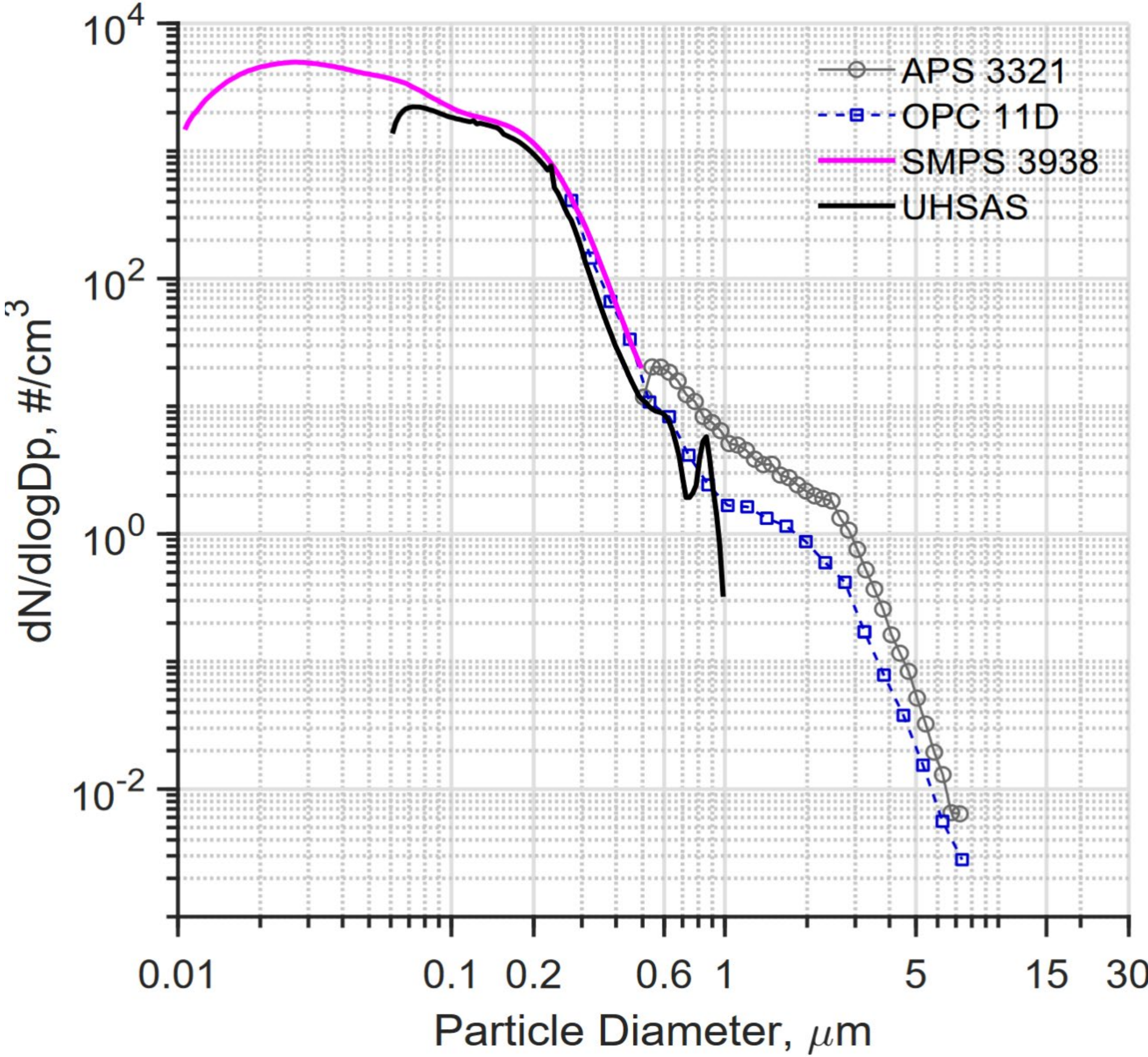
AMF3 AOS: Size Distribution Measurement Approaches



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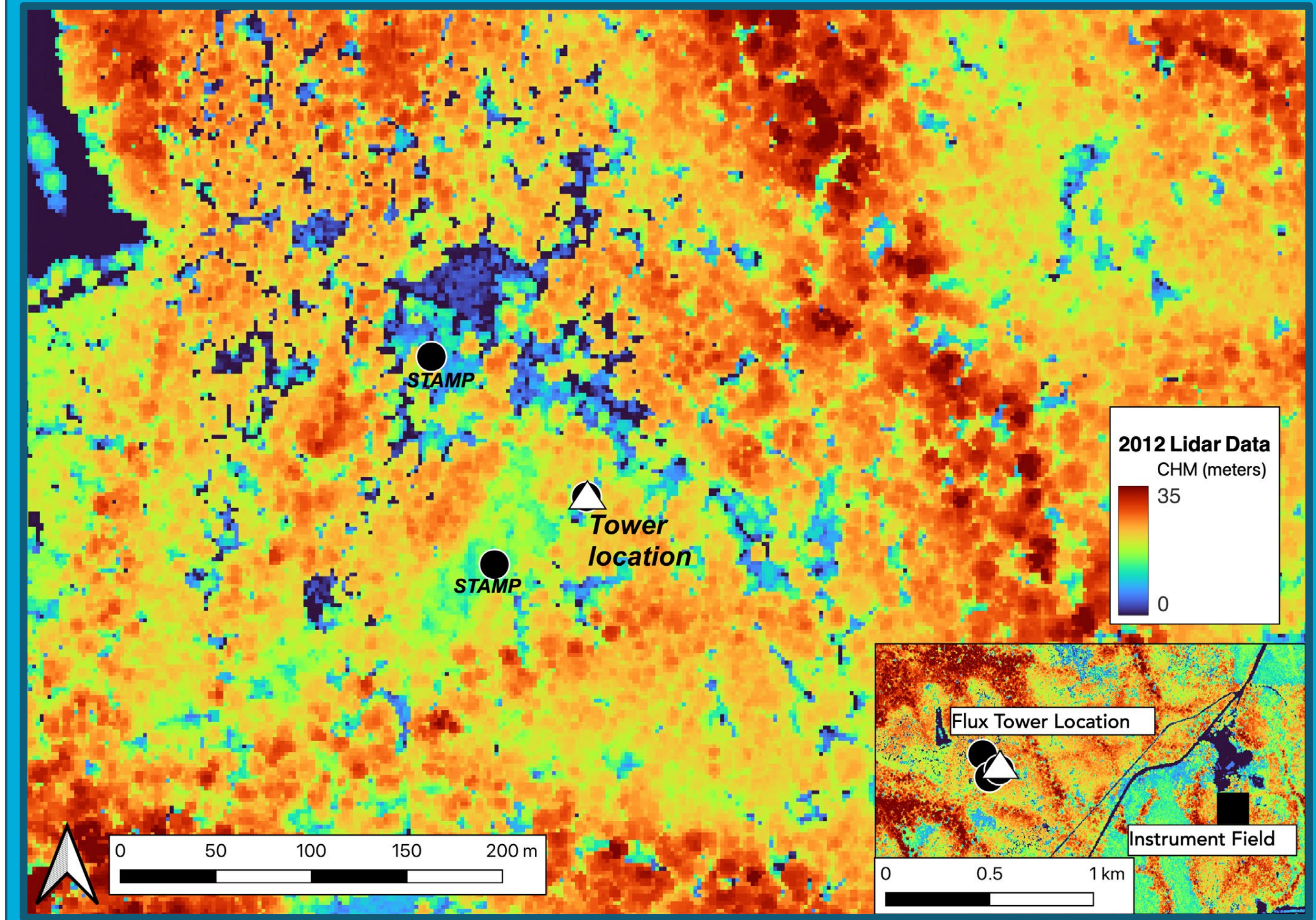
AMF3 BNF Updates: Facility Testing & Site Preparation

Facility Testing

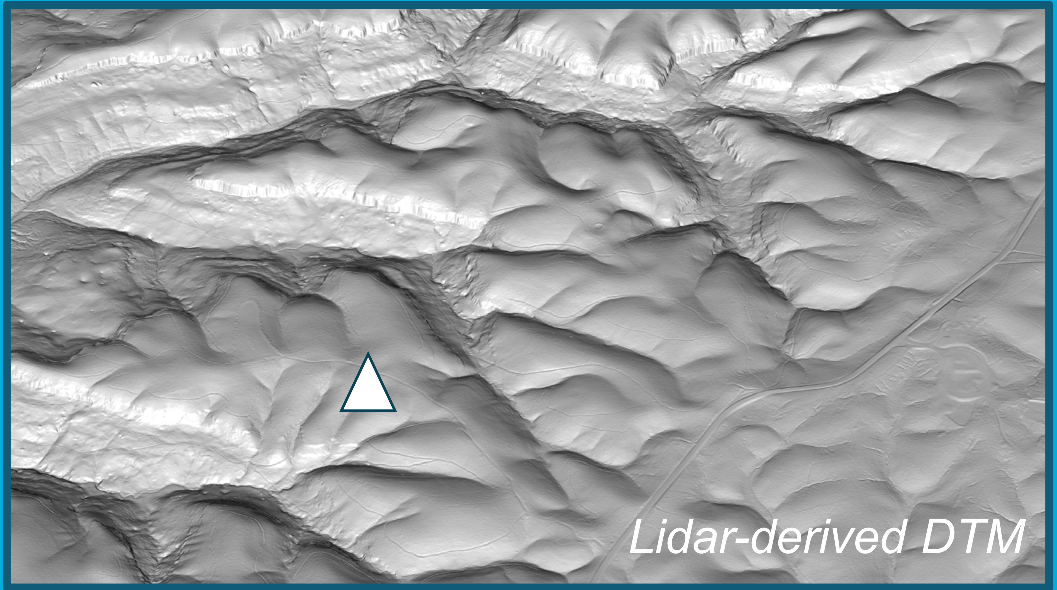
Instrument Field Site Preparation

Surface-Atmosphere Flux Tower: Studying forest controls on boundary layer dynamics



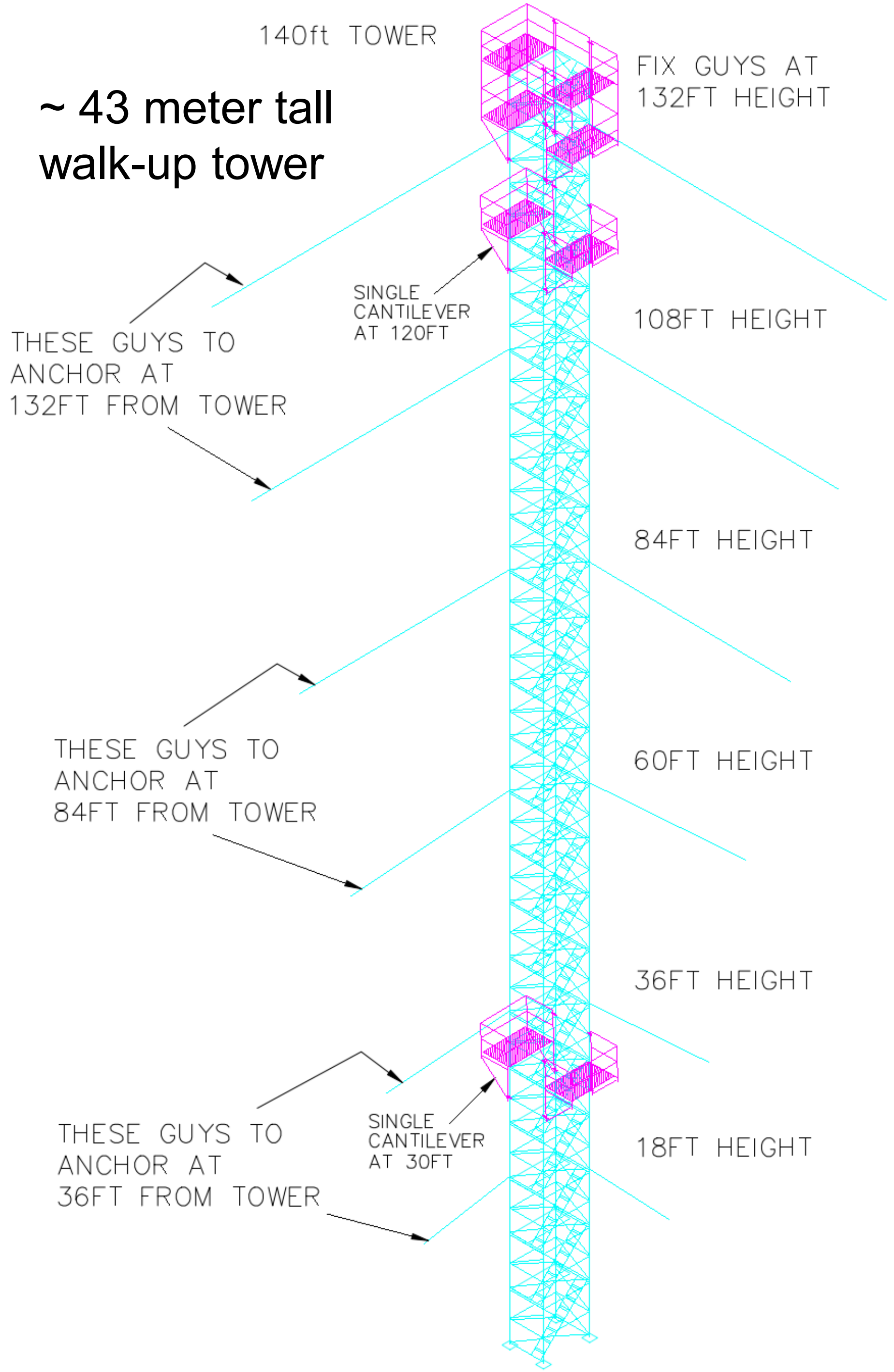
The main flux tower location represents a mixed pine-oak forest - west of the BWWC,

The location was determined based on dominant winds, fetch, forest cover, and terrain,



Tower measurements

~ 43 meter tall walk-up tower



Planned Instruments:

- CEIL
- LDIS
- T/RH
- 3D WINDS
- IR Radiometers
- Cameras
- MFR
- PGSISO
- PAR
- RADIOMETERS
- STAMP
- SEBS
- TBRG
- Barometer

Partner and new measurements:

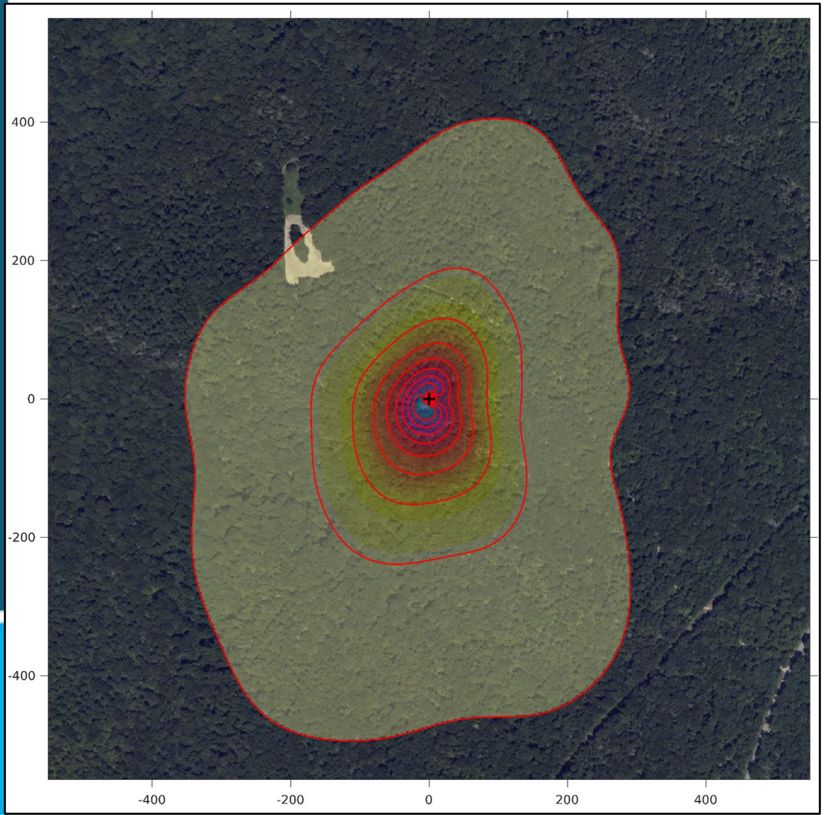
- **Ameriflux** Eddy Covariance & AP200 CO_2 / H_2O Profiling System
- BVOCs* (**EMSL**)
- Biological aerosol* / WIBS (**EMSL**)
- Distributed temperature sensing
- Phenocameras

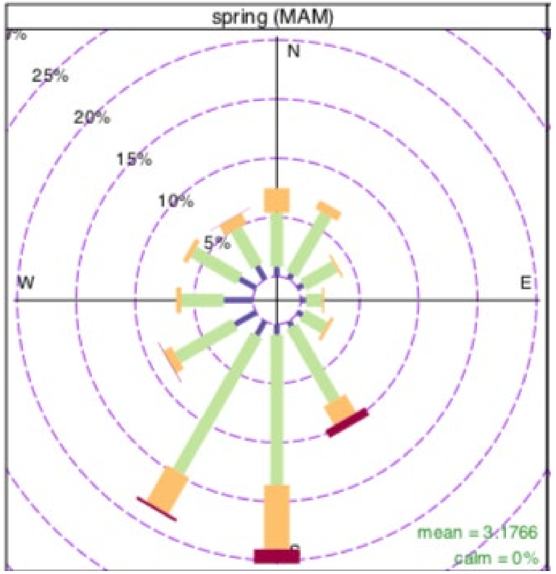
Planned Measurements:

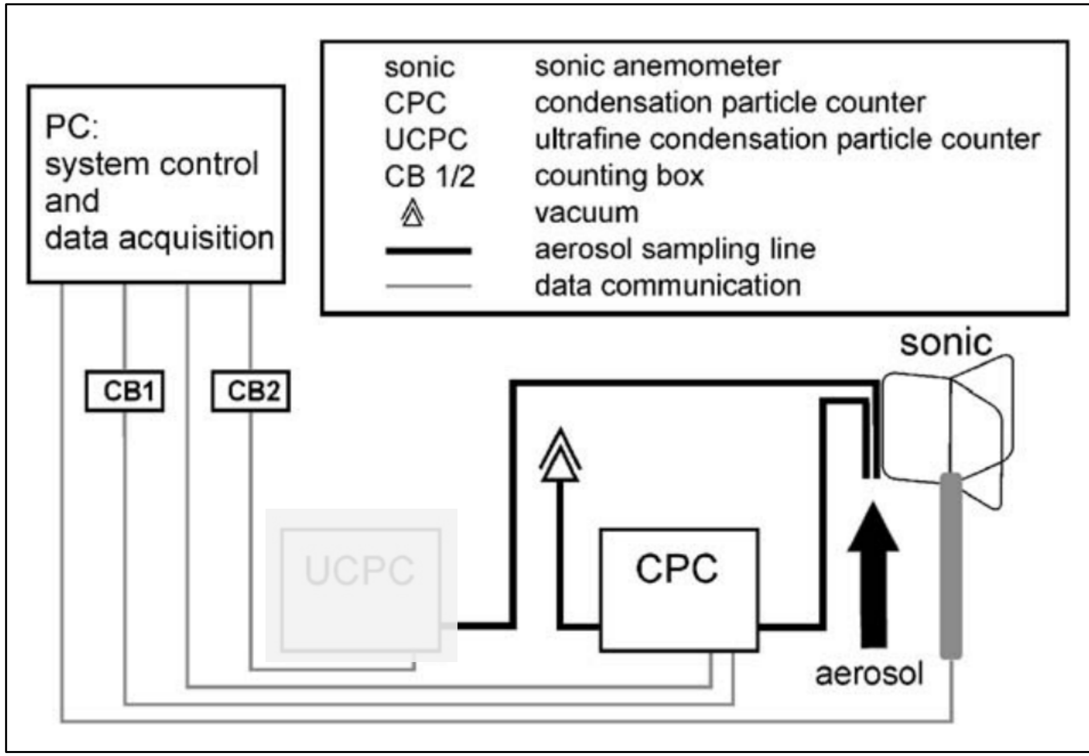
- 3D winds, T/RH, precipitation & throughfall
- Radiation (direct / diffuse), incident / reflected, profiles
- Fluxes of CO_2, H_2O, & energy + aerosols* (CPC)
- Canopy CO_2 / H_2O storage
- Greenhouse gas profiles and mixing ratios
- Isotopic fractionation
- Turbulence profiles
- Vegetation phenology
- Surface temperature
- Soil heat flux, temperature, moisture

Aerosol Flux System: Biosphere – Atmosphere Exchange

- Atmosphere and biosphere are linked via **vertical fluxes of momentum, sensible / latent heat, and fluxes of atmospheric trace gases and aerosol**. Vertical exchange between the land surface and the atmospheric boundary layer established mainly through turbulence. **Goal: Develop an aerosol flux system to be deployed at the AMF3 BNF**.
- Design Review participants: Markus Petters, Nicholas Meskhidze, Delphine Farmer, Tuukka Petaja







Contact: Ashish Singh

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

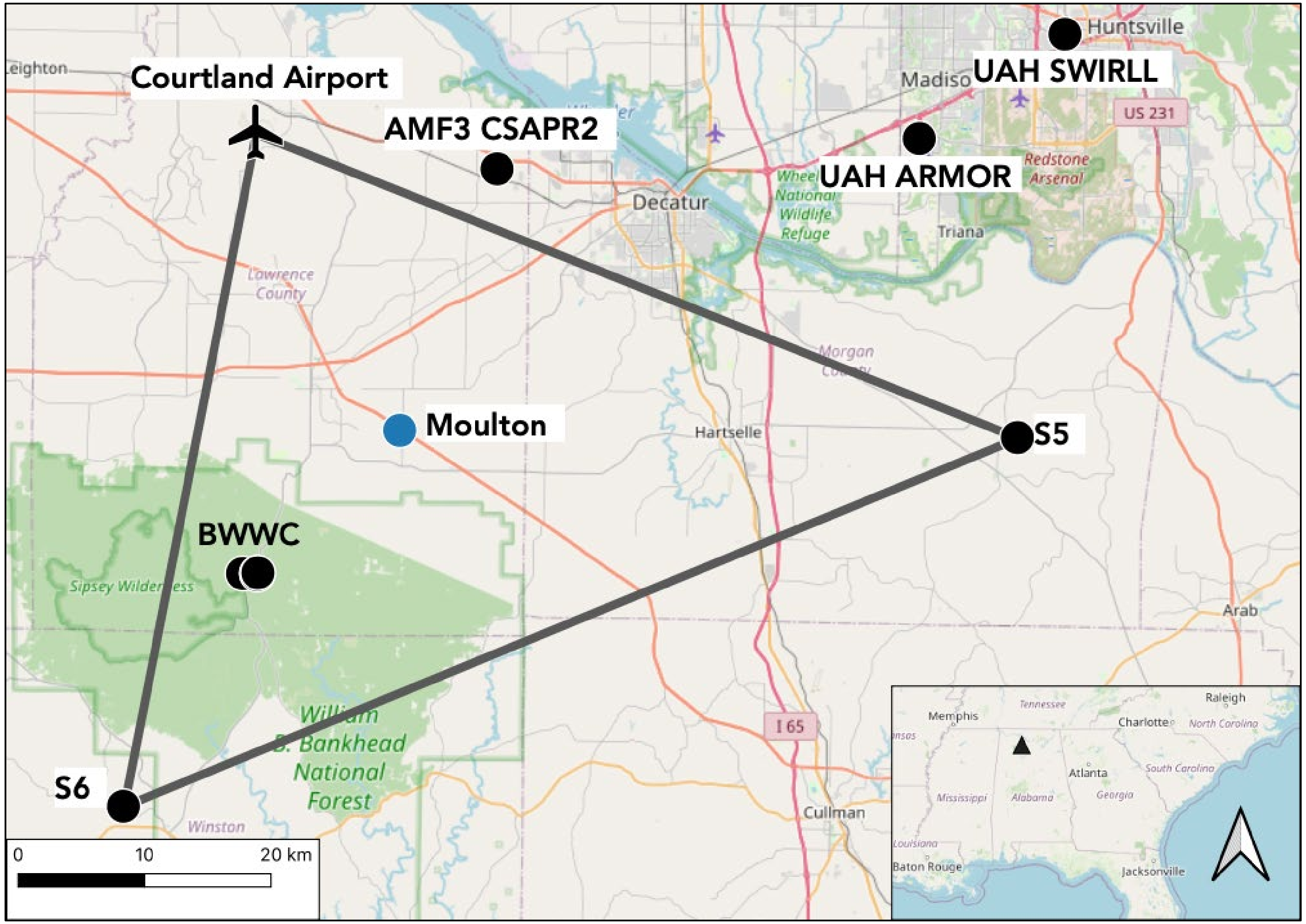
- **Supplemental Sites:**
  - 3 sites: Courtland Airport + 2 TBD
  - boundary layer profiles (T, wind, water vapor, liquid water path)
  - surface fluxes (atmosphere and soil)
  - surface meteorology and radiometry
  - supplemental flux towers

- **Partner Facilities:** University of Alabama, Huntsville (ARMOR radar and SWIRLL)

- **Aerosol Distributed Sensor Node Network**

- **Aerial Measurement Platforms**: Tethered Balloon System, Uncrewed Aerial System

- **ARM Cloud/Precipitation Radar(s)** (e.g., CSAPR2, Ka-XSACR)



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Supplemental sites and land-atmosphere interactions research

Potential locations

Target endmembers: Deciduous forest, pine forest/plantation, agricultural, grassland/prairie

Measurements:

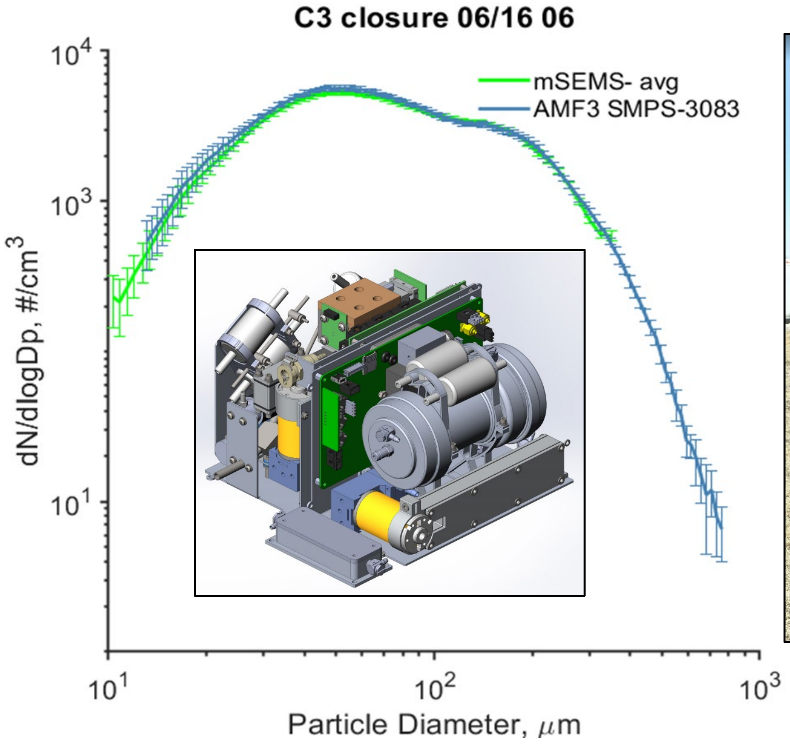
- Surface meteorology and radiometry
- Boundary layer profiles (T, wind, water vapor, liquid water path)
- Surface CO_2, H_2O and energy fluxes
- Soil properties (heat flux, temperature, moisture)
- Aerosol Distributed Sensing Node
- Sonde/TBS/UAS

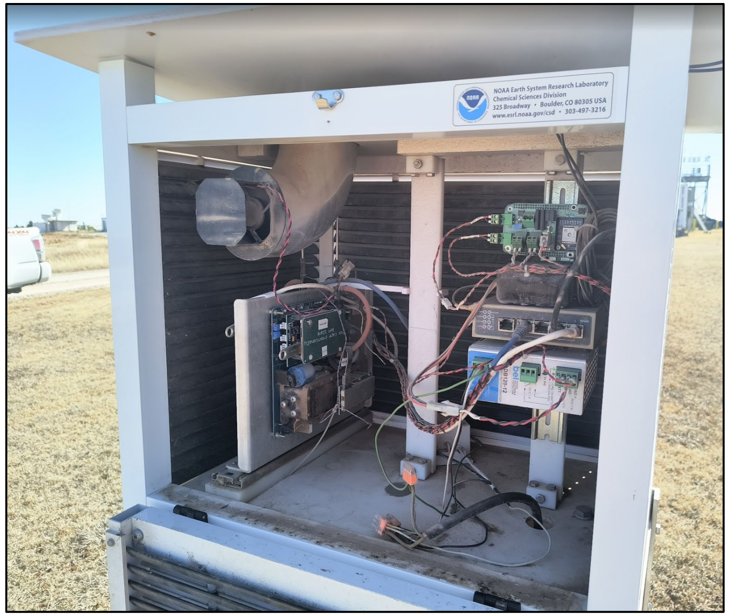
LAI objective: Characterize regional fluxes and seasonal variation across representative land types to inform statistical and process model upscaling; enable coupled regional studies

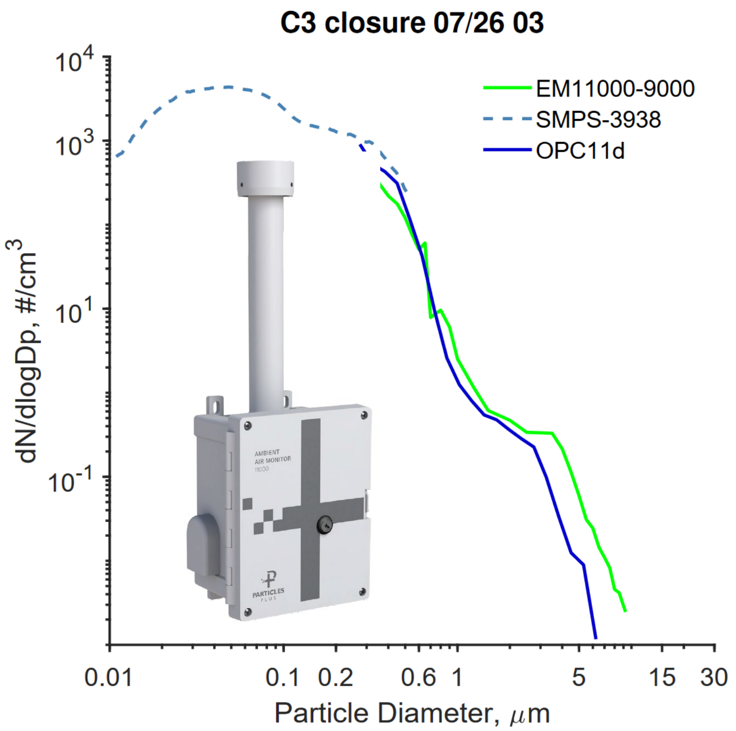
Aerosol Distributed Sensing Network

- Over a climate grid cell, aerosols can exhibit high spatial variability due to **spatially-heterogeneous land-surface controls** on **aerosol sources** (vegetative BVOC emissions, anthropogenic emissions, biomass burning) and **aerosol sinks** (deposition over different land-surface types). **Aerosol advection** further obscures these land-surface controls.

- **Spatially-distributed aerosol measurements are needed** to resolve these land-atmosphere controls on aerosol-climate impacts in the Southeastern US and other environments (e.g., urban, coastal).



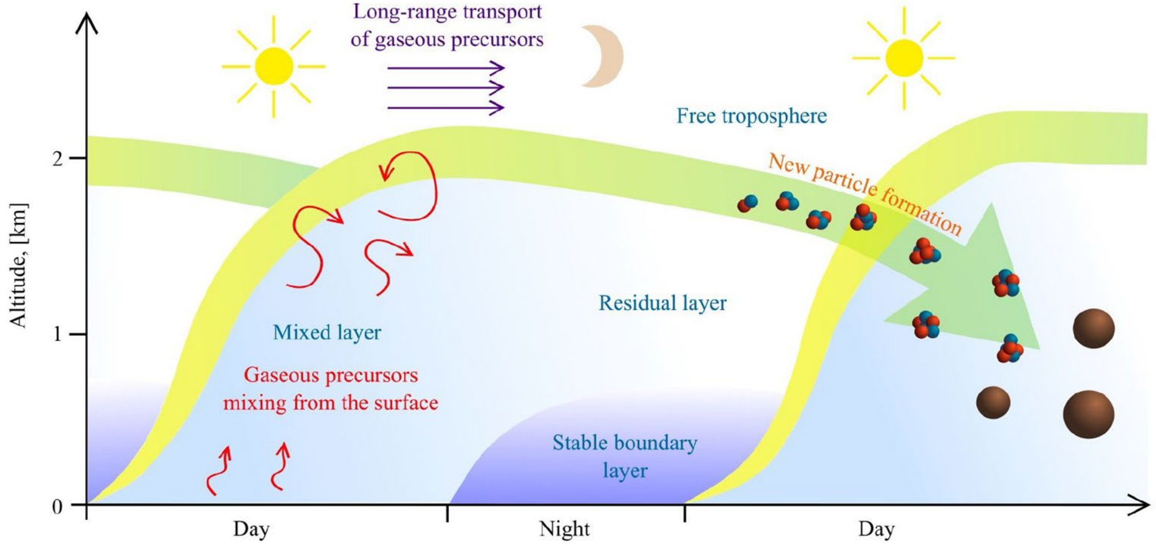


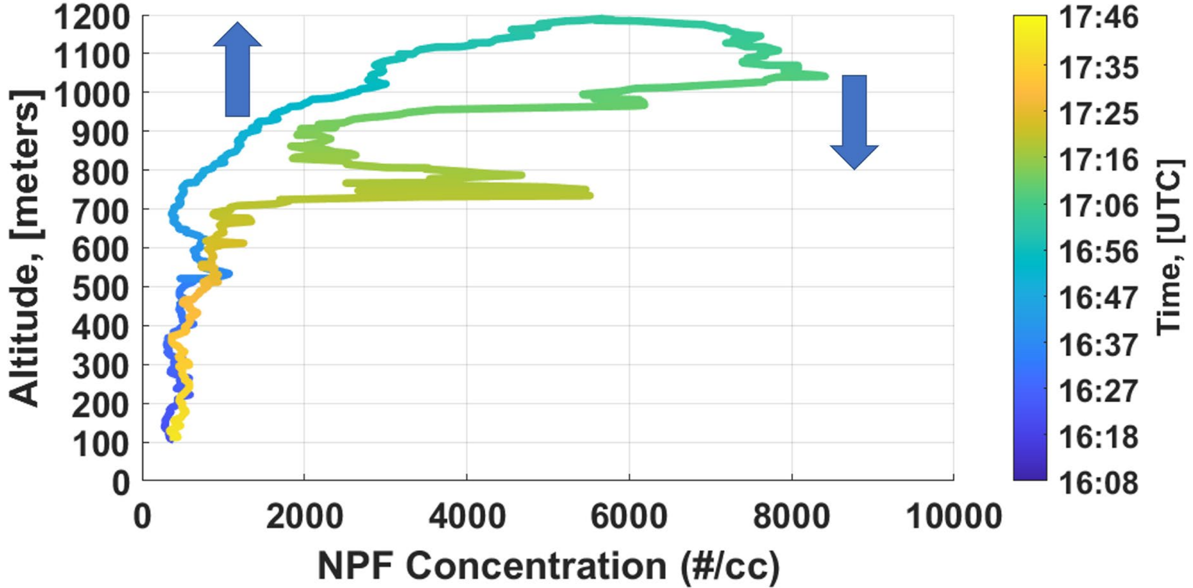


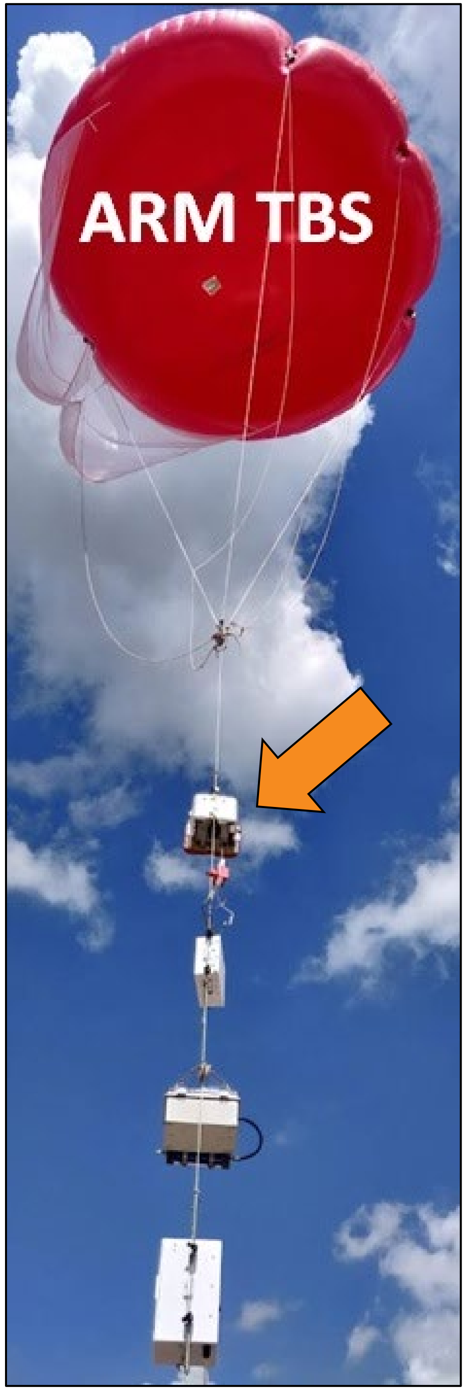
Contact: Ashish Singh

Aerial Measurement Opportunities

- TBS call for 2025 deployment
- Arctic Shark call #2 for 2025 deployment








Deployment Webpage