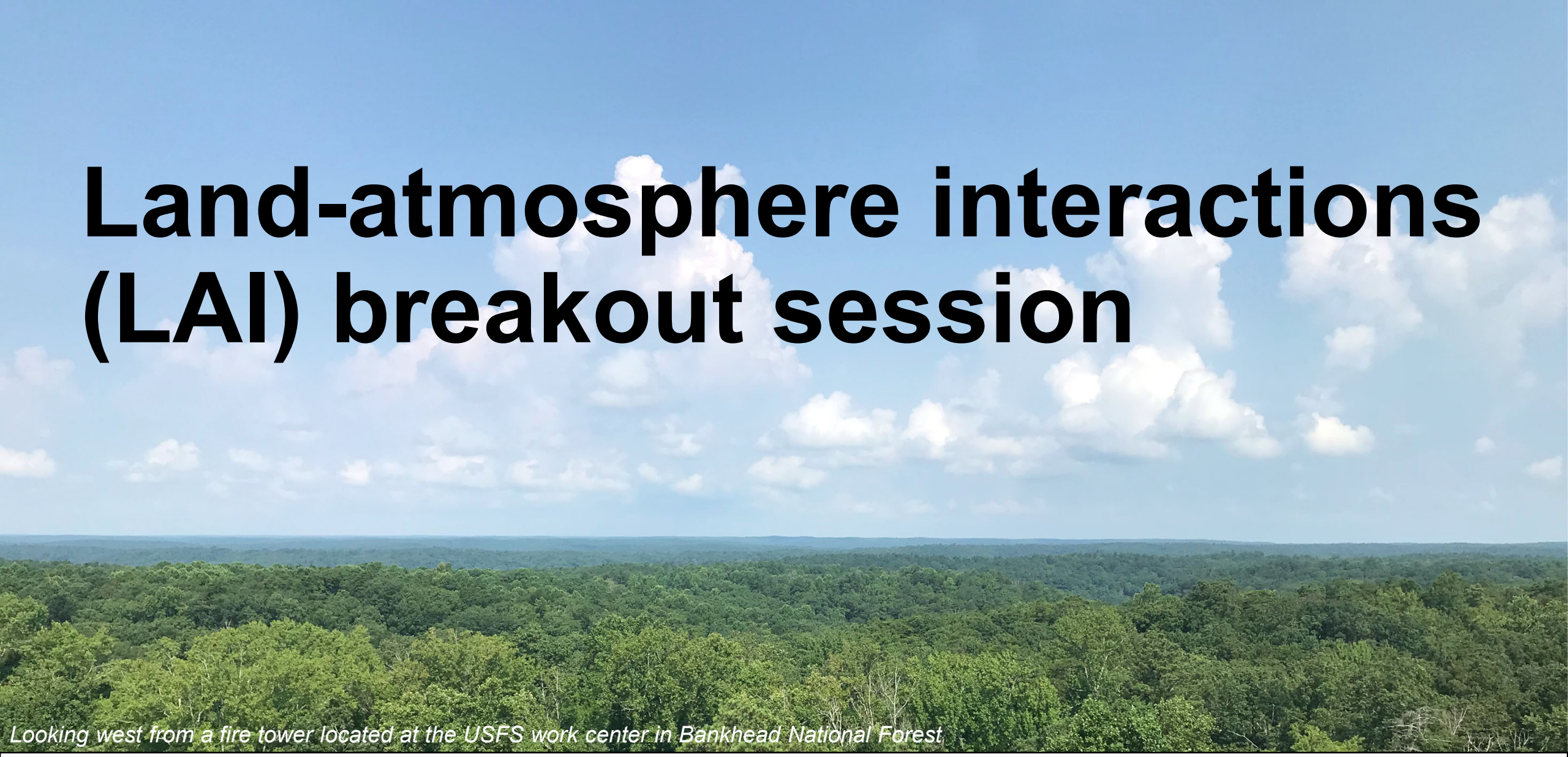
Land-atmosphere interactions (LAI) breakout session



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

Argonne NATIONAL LABORATORY

Brookhaven National Laboratory

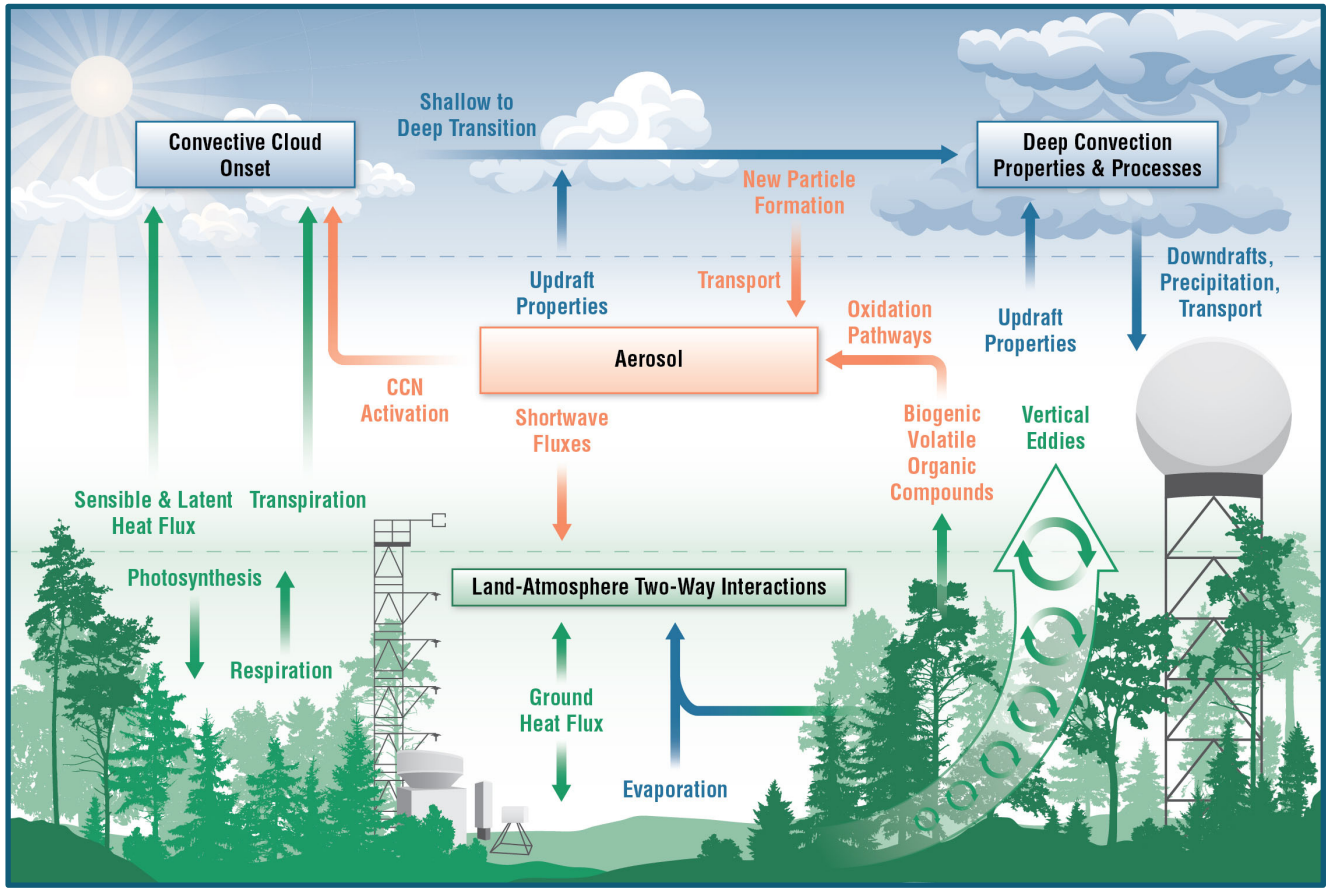
U.S. DEPARTMENT OF ENERGY

ARM

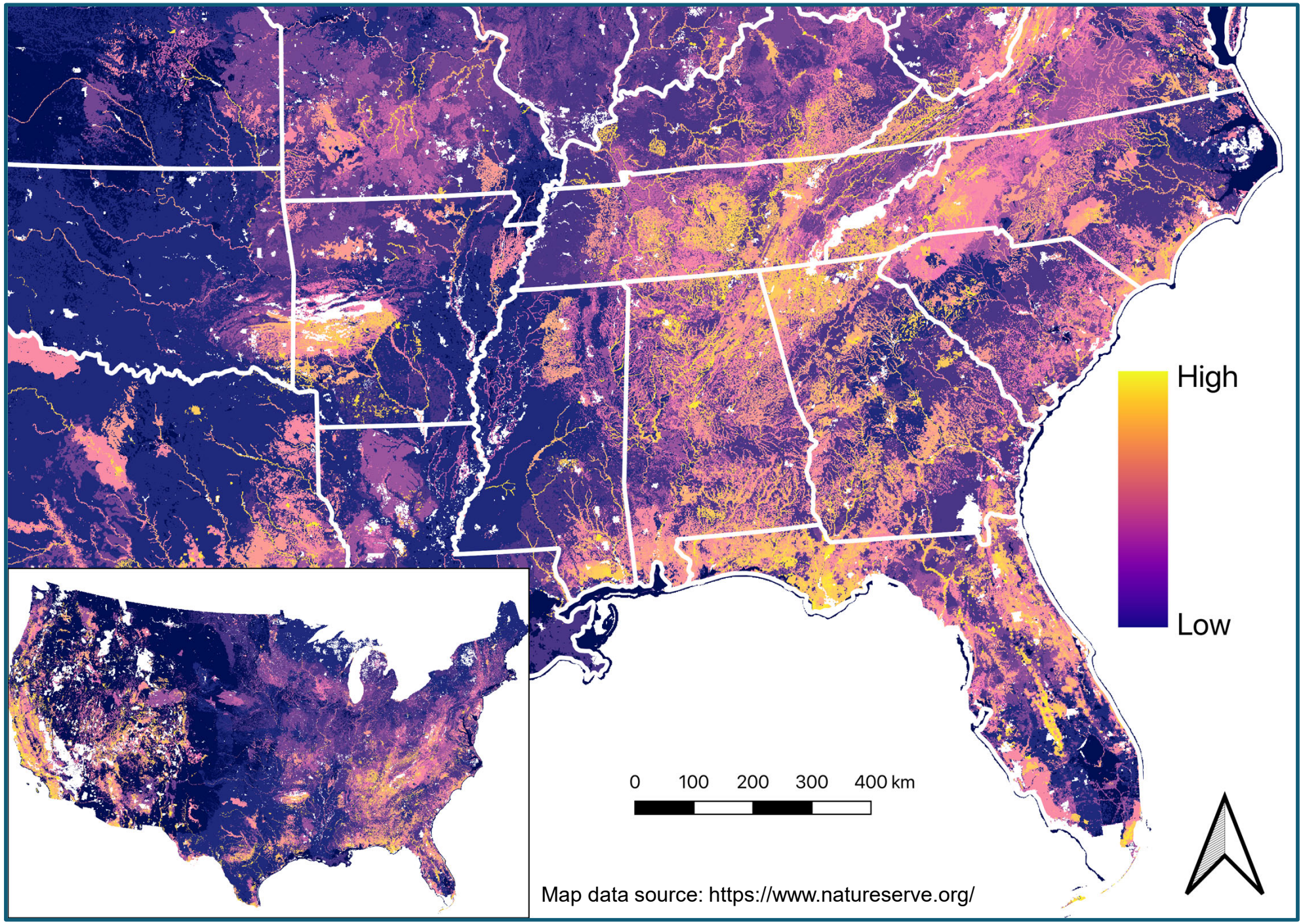
ASR Atmospheric System Research

Why it's important to study land-atmosphere coupling in the Southeast U.S.

- A region with high ecological and economic importance that is threatened by climate change
- The land surface acts as a primary control on boundary layer dynamics, aerosol evolution and convective processes
- Uncertainty in the role of surface heterogeneity and seasonality on the magnitude and patterns of surface-atmosphere coupling and emergent weather
- Significant vegetative-driven biogenic emissions
- Important two-way land-atmosphere interactions between plants and cloud / aerosol radiative feedbacks



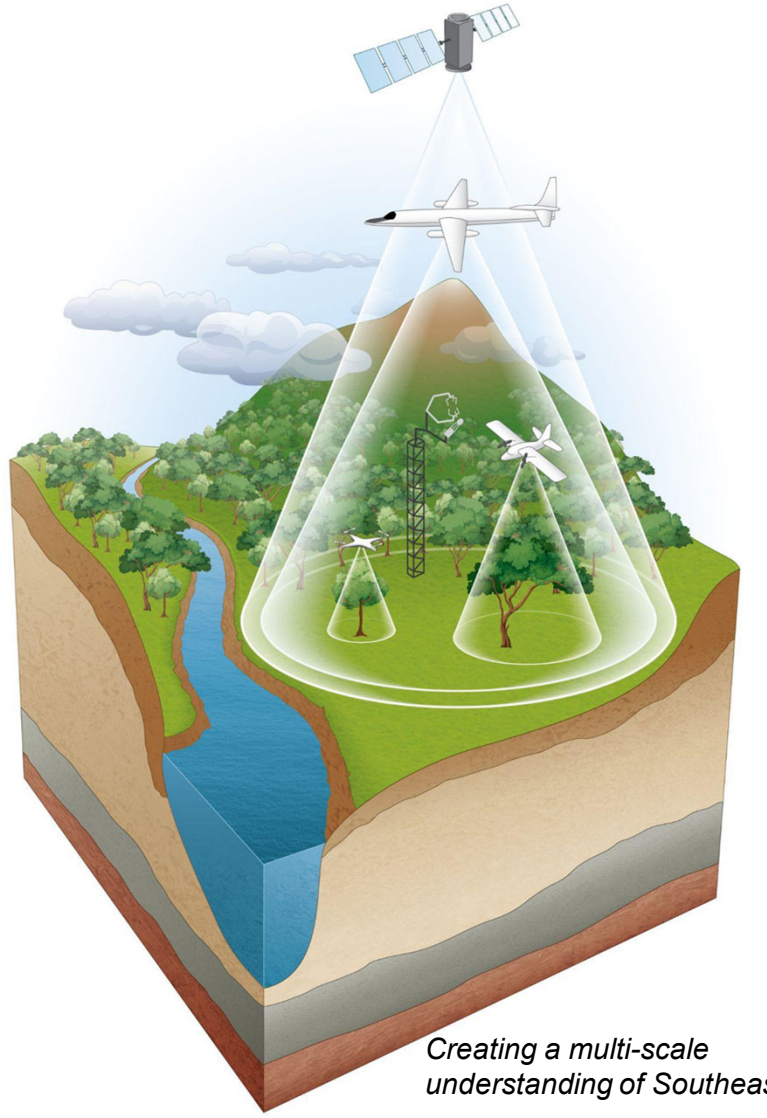
Biodiversity Importance



Hamilton H, Smyth RL, Young BE *et al.* (2022) Increasing taxonomic diversity and spatial resolution clarifies opportunities for protecting US imperiled species. Ecological Applications, **32**, e2534.

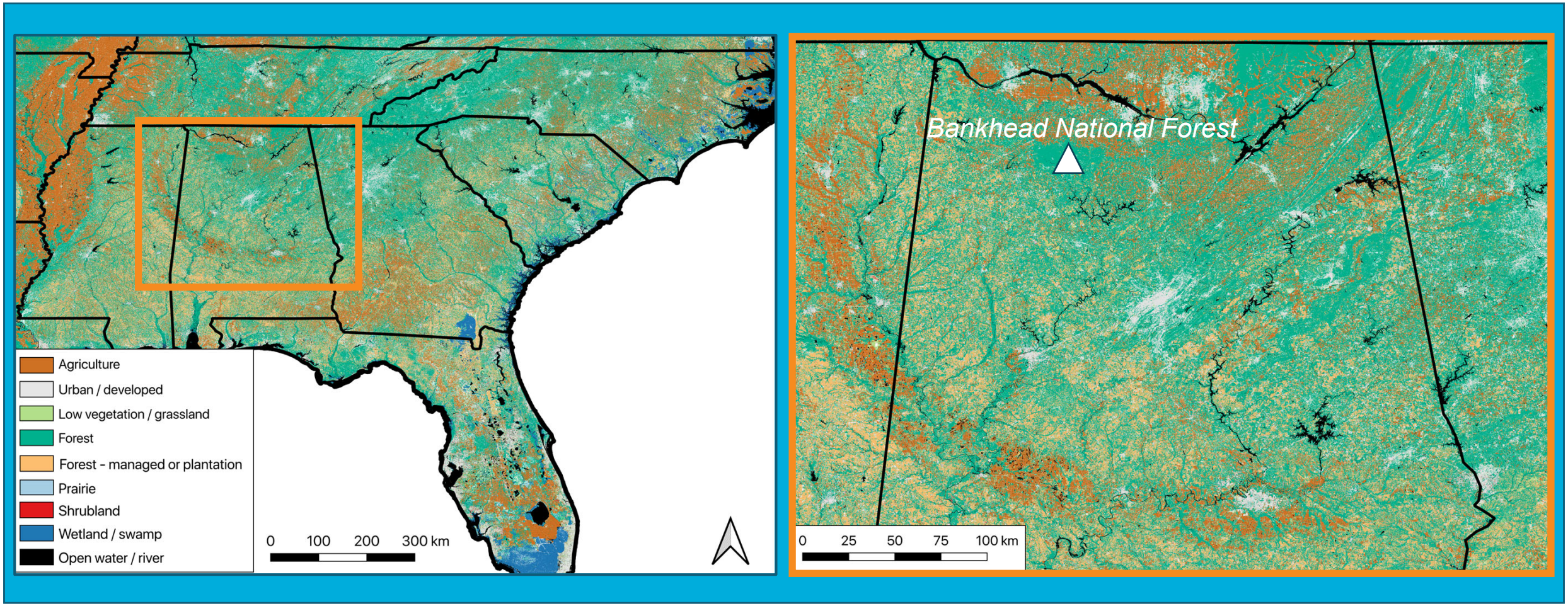
LAI goals within the AMF3 campaign

- Improve the understanding of Southeast U.S. land-atmosphere two-way interactions and surface controls on aerosol and convective processes
- Explore impacts of surface heterogeneity and seasonality on land-atmosphere coupling
- Improve representation of the land surface in models, including energy partitioning, turbulence processes, and contributions to aerosol formation and regional variability
- Upscale surface point/network, vertically-resolved, and remotely-sensed observations using novel datasets, statistical and process modeling
- Advance land/LES model-data integration of ARM and partner-agency observations
- Build research partnerships within the region, across agencies, universities and scientific domains to address Southeast U.S. climate research needs



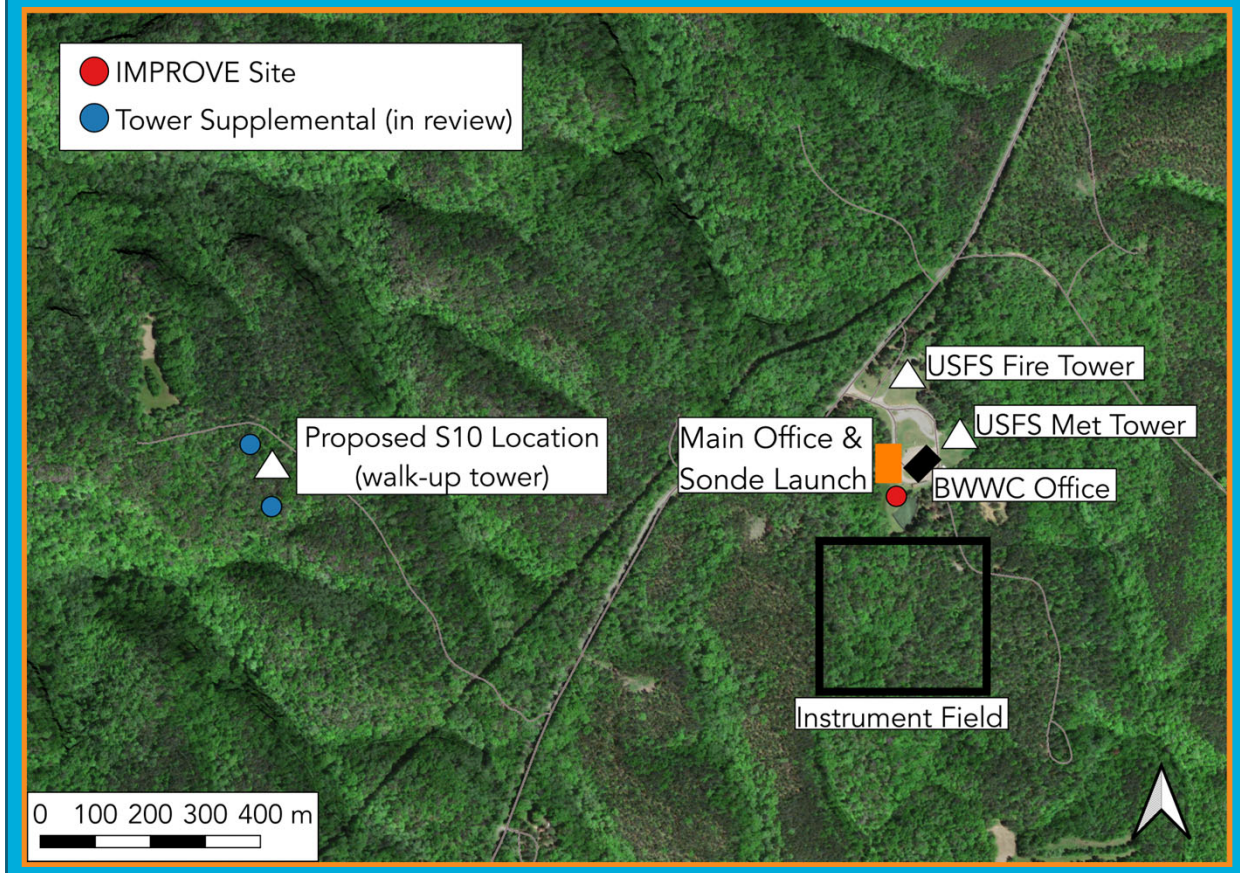
Creating a multi-scale understanding of Southeast US

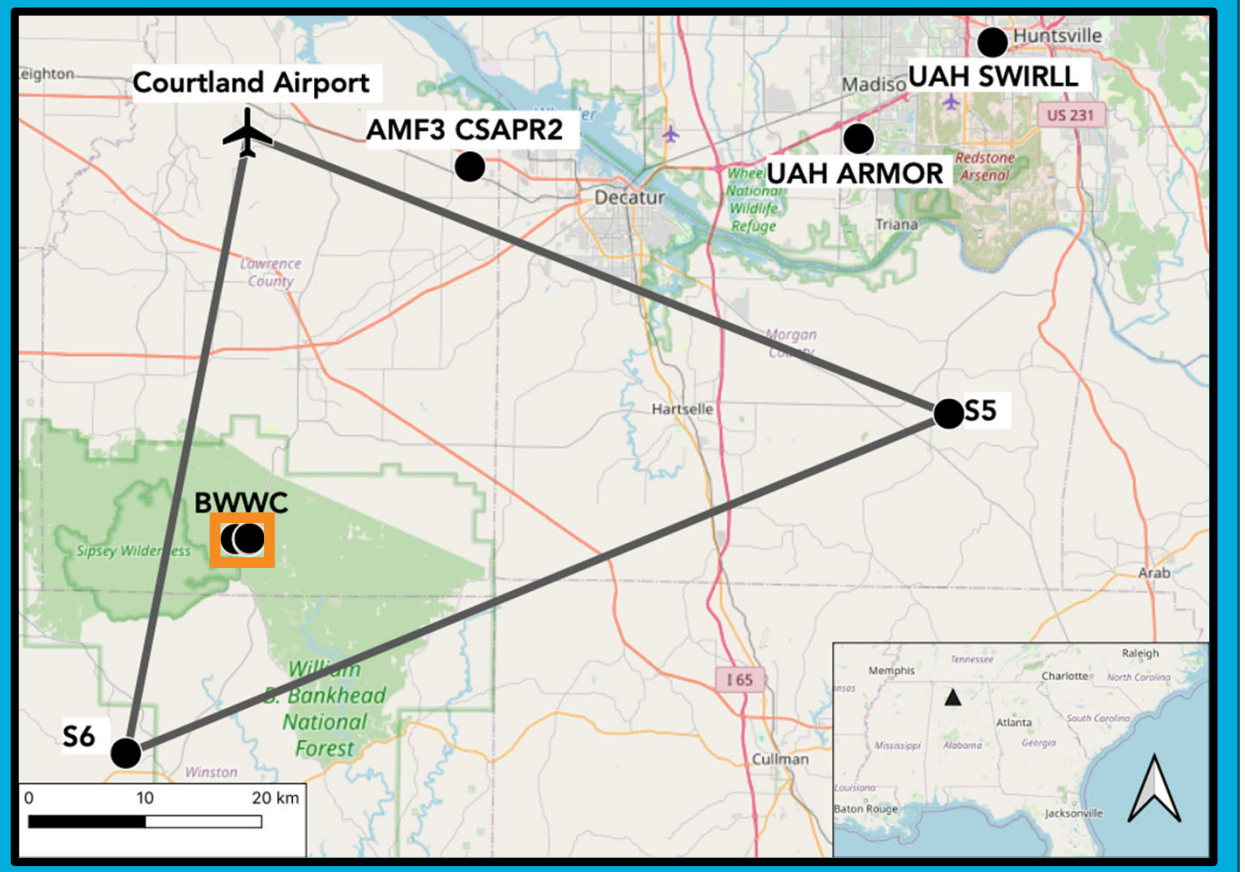
Surface heterogeneity in the Southeast U.S.



LandFire 30m landcover product

Preferred region: Northern Alabama

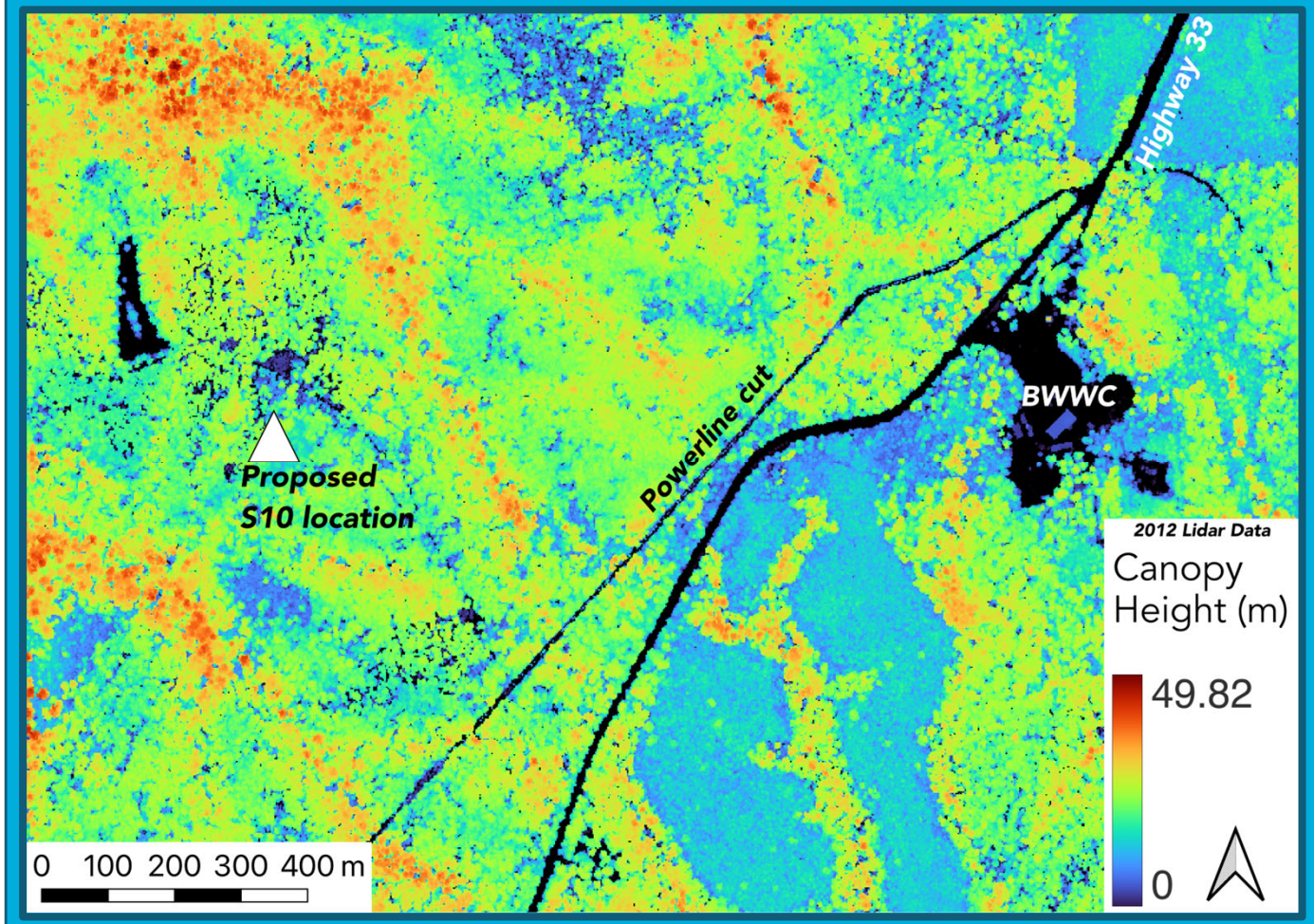




Bankhead National Forest: Black Warrior Work Center (BWWC) - Main Site (Phase 1 FY23)

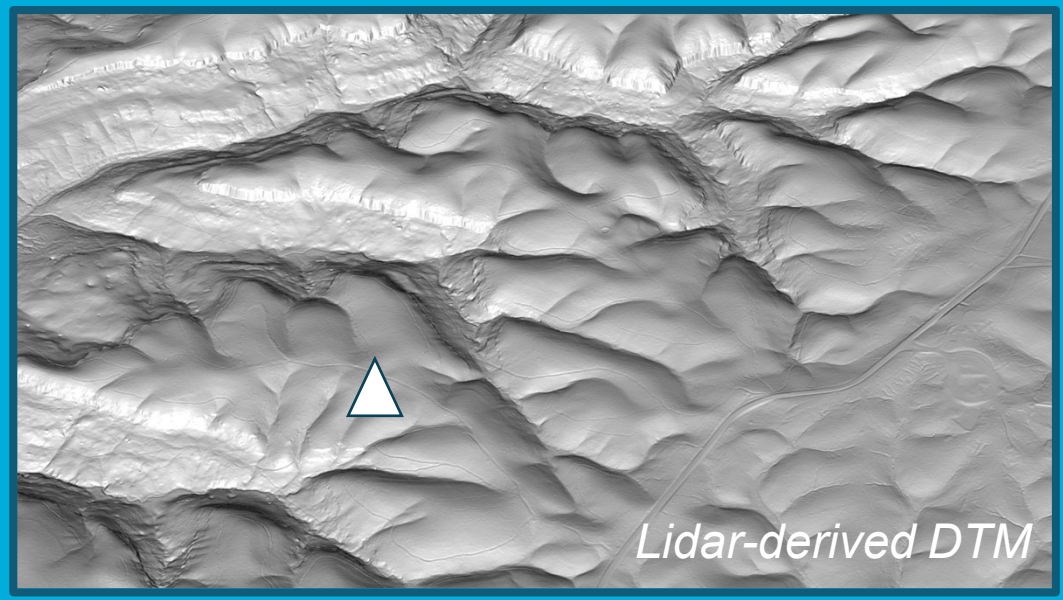
Planned Partner Facilities & ARM Supplemental Sites (Phase 2 FY24)

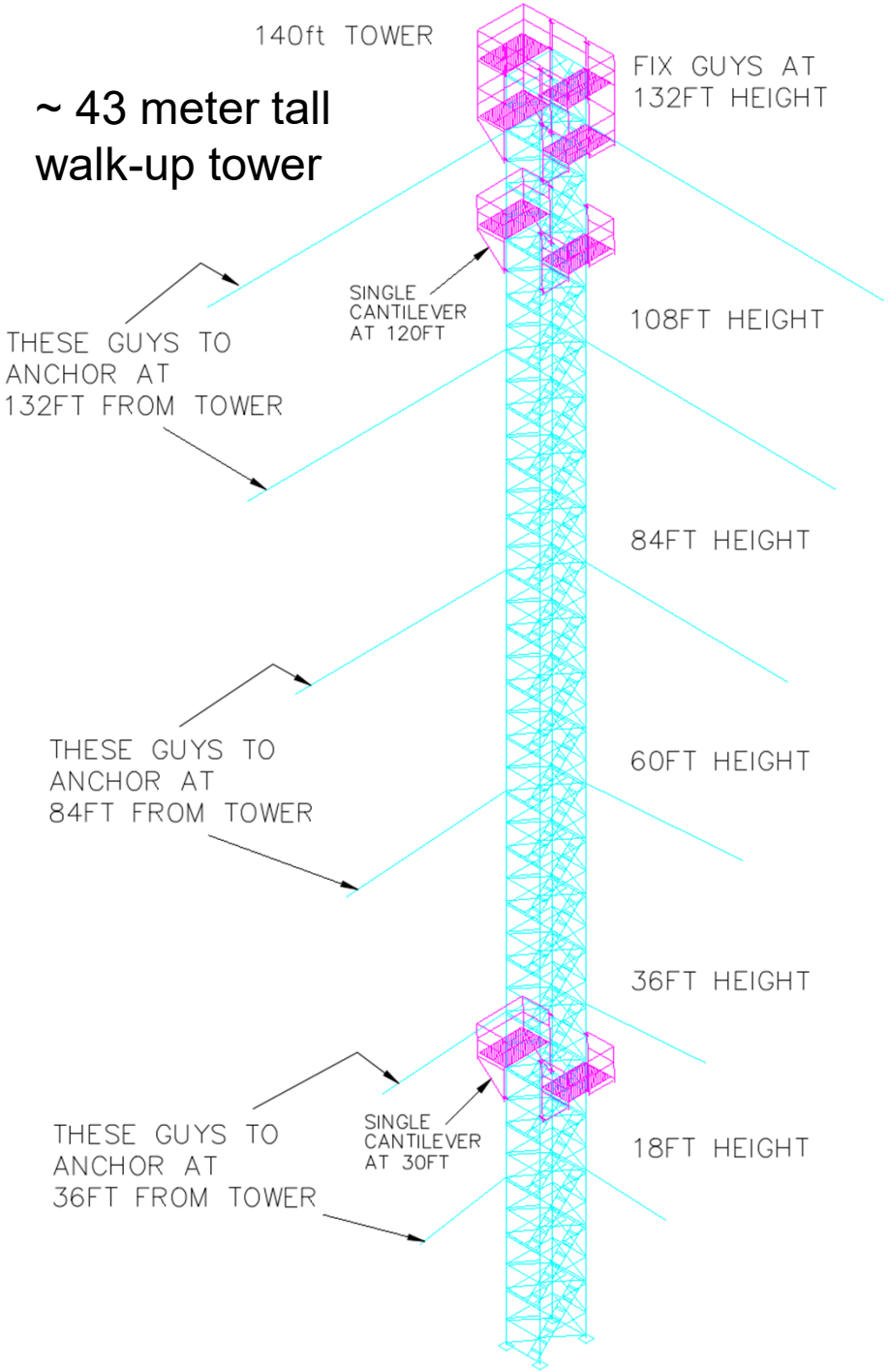
S10 location – studying forest controls on boundary layer dynamics



The expected location of the S10 (main flux tower) site is a mixed pine-oak forest, west of the BWWC

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





S10 – Tower measurements

Planned Instruments:

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

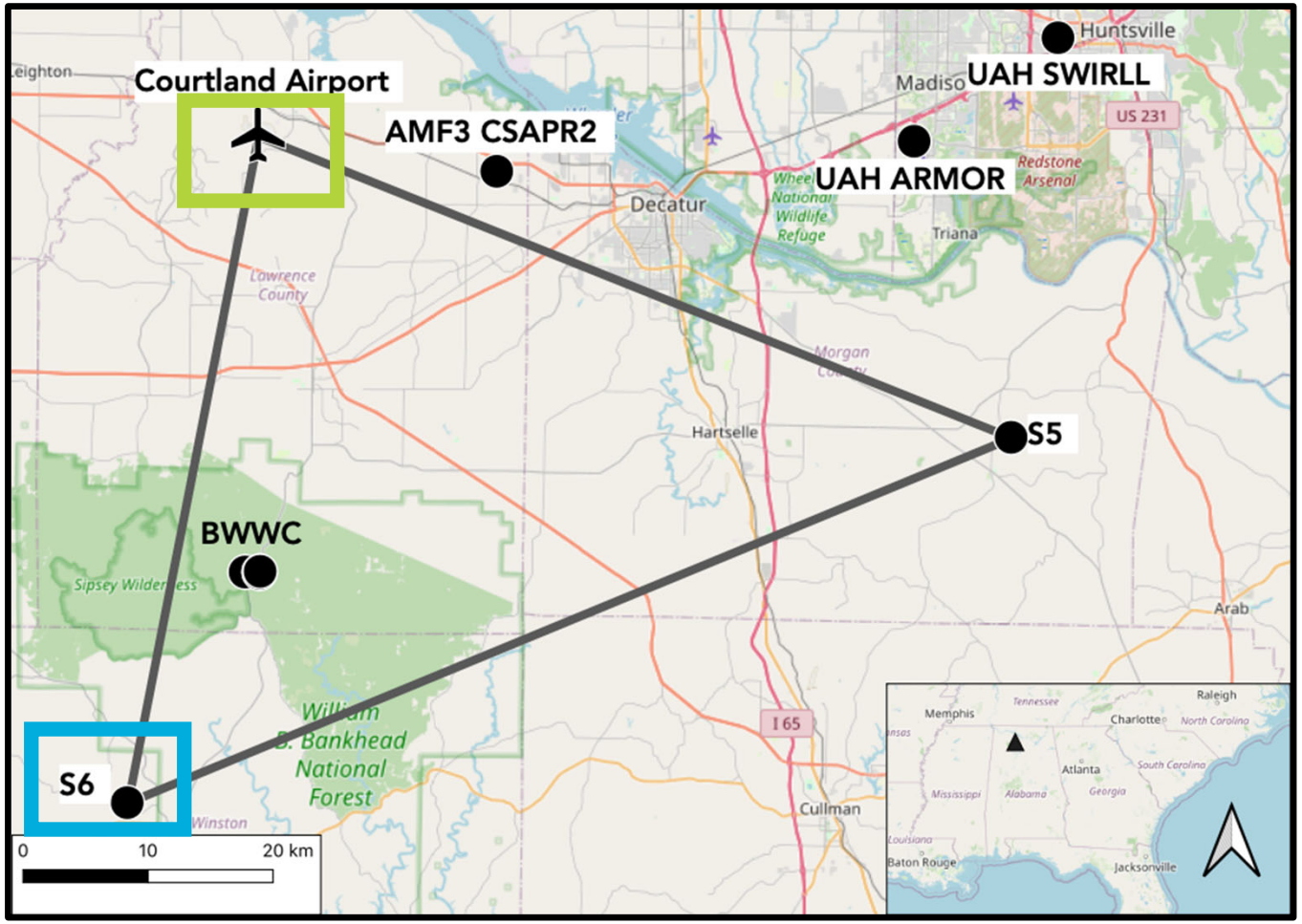
Under review/IOPs:

- Ameriflux Eddy Covariance & CO_2/H_2O Profiling System
- BVOC concentration & flux
- Biological Aerosols (WIBS/EMSL)
- Distributed Temperature Sensing
- Phenocameras
- COS, CO_2/H_2O isotopes

Planned Measurements:

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

Supplemental sites and LAI research



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

Potential locations

Supplemental sites and LAI research

Potential locations

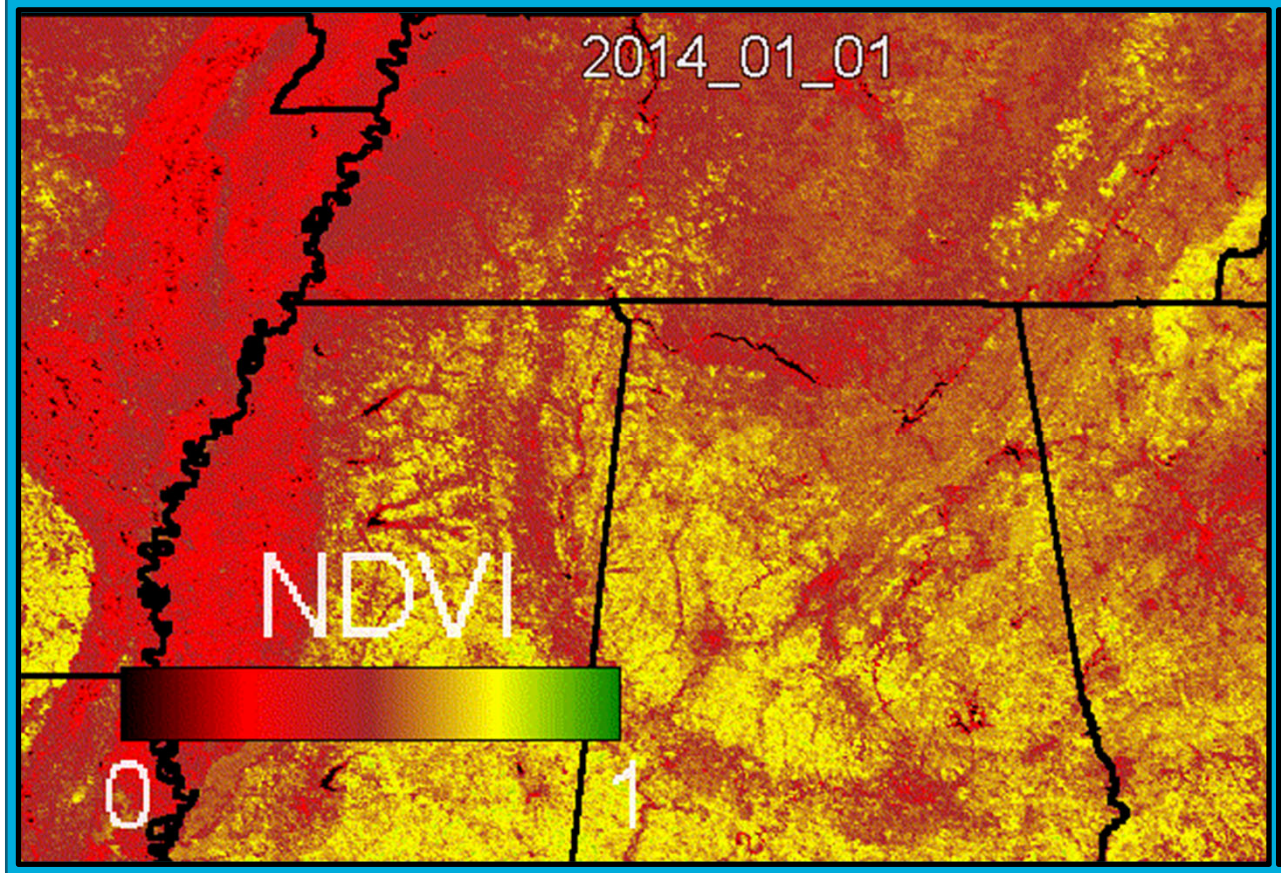
Target endmembers: Deciduous forest, pine forest/plantation, agricultural, grassland/prairie

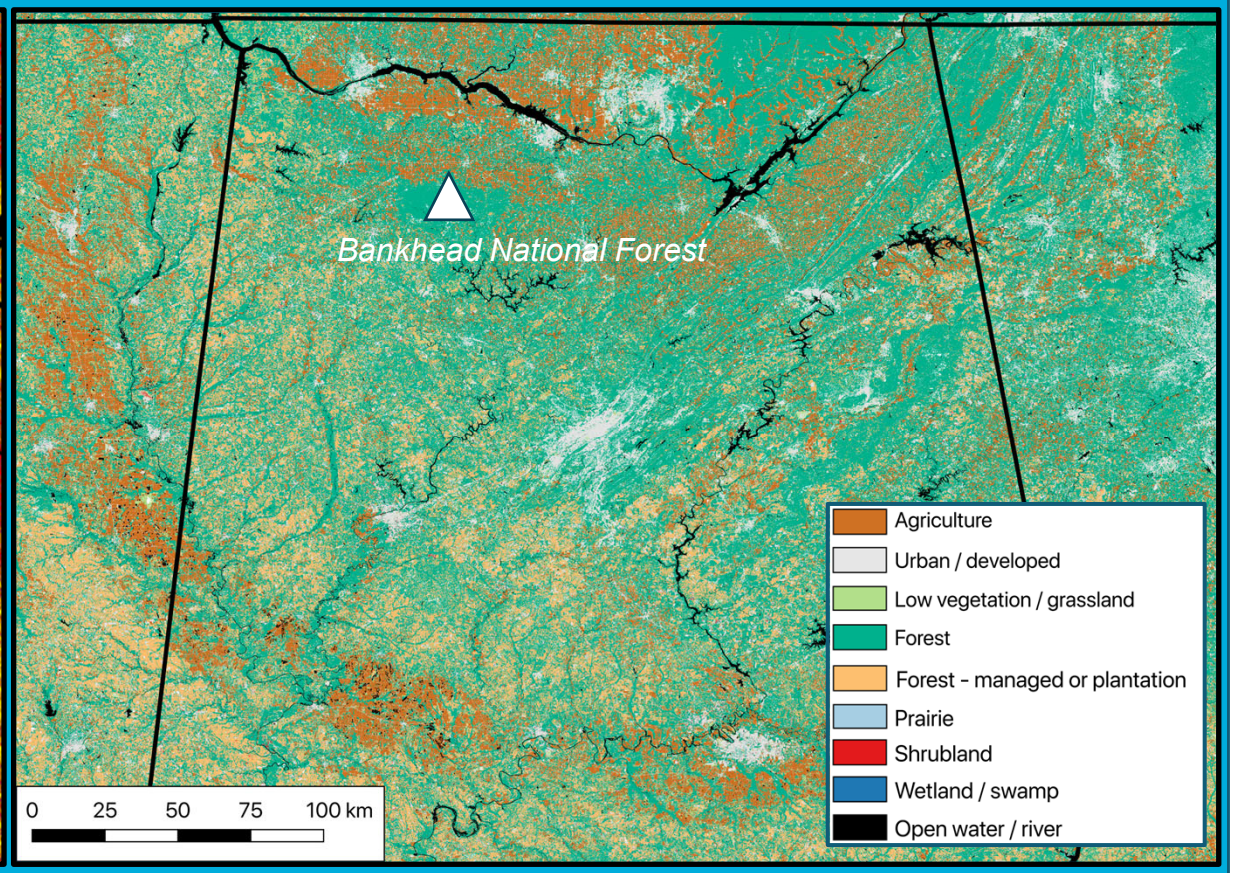
Measurements:

- 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 node (*in dev*)
- 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

Pre-Deployment: How do “green waves” modulate cloud fields?

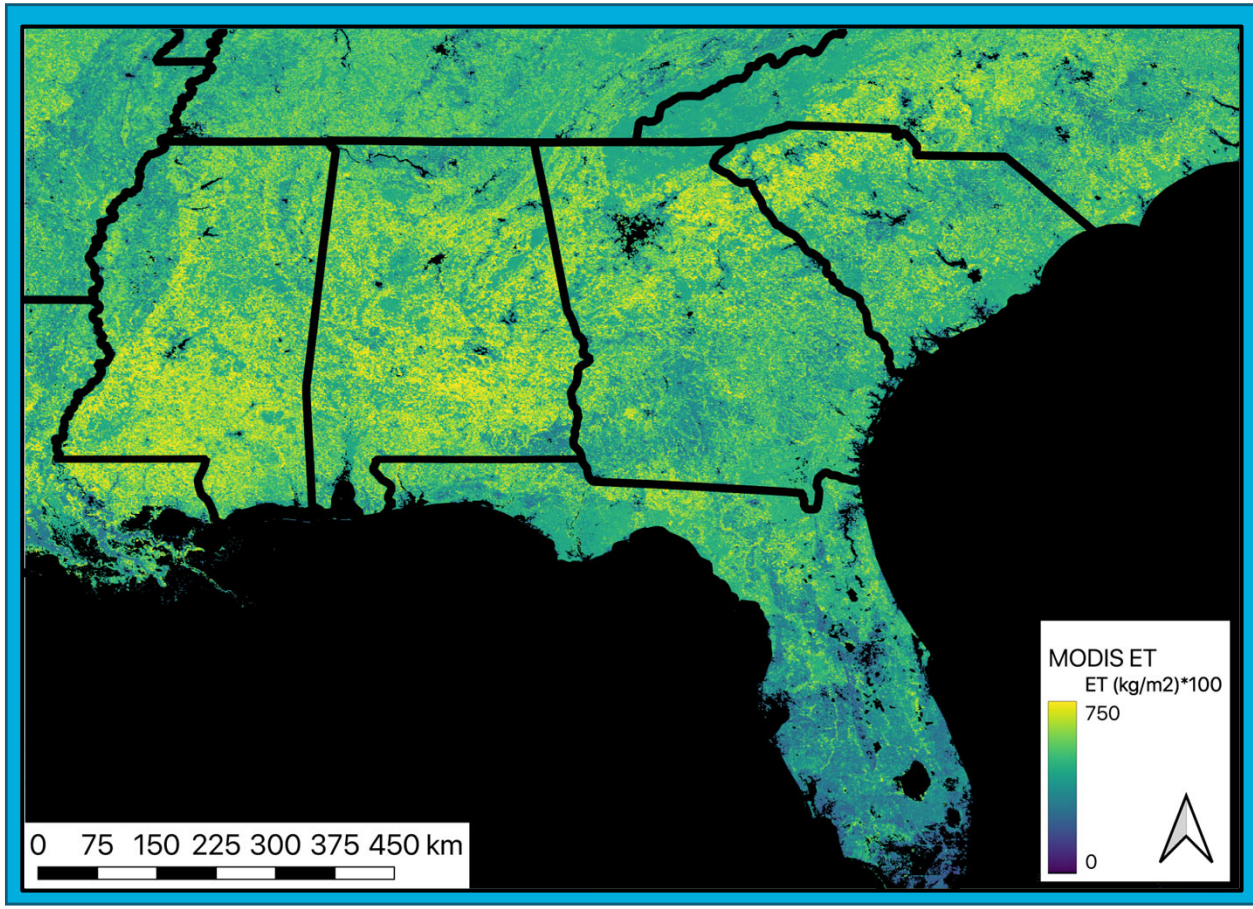


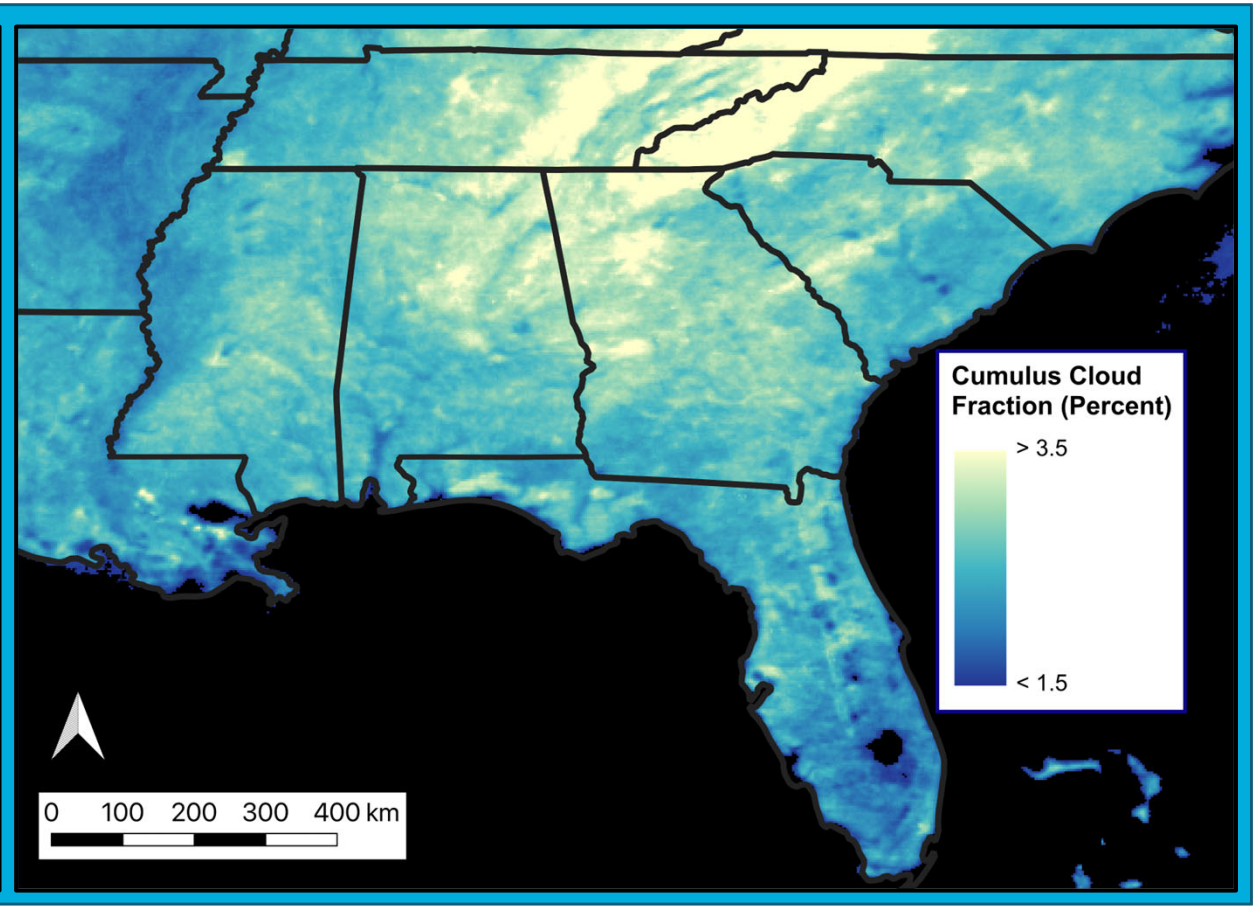


MODIS NDVI timeseries (2014-2015)

LandFire 30m landcover product

Pre-Deployment: How do “green waves” modulate cloud fields?





MODIS total evapotranspiration (maximum value composite over the 2014-2015 period)

June through August cumulus cloud fraction (% of time over a 24 hour period) as derived from GOES satellites. Satellite data provided by J. Mecikalski (UAH)

Analysis-ready AMF3 surface flux and forcing data for the community

- Multi-scale observation and model synthesis activities will require “analysis-ready” datasets to enable wider adoption by the community and simplify usage across scientific domains

- The AMF3 Site Science Team is developing a plan to create ***ready-to-use*** surface flux (CO_2, H_2O, latent/sensible heat, aerosols/BVOCs) datasets for the main and supplemental sites, Ameriflux Rapid Response System(s), and partner tower locations (e.g. Alabama A&M)

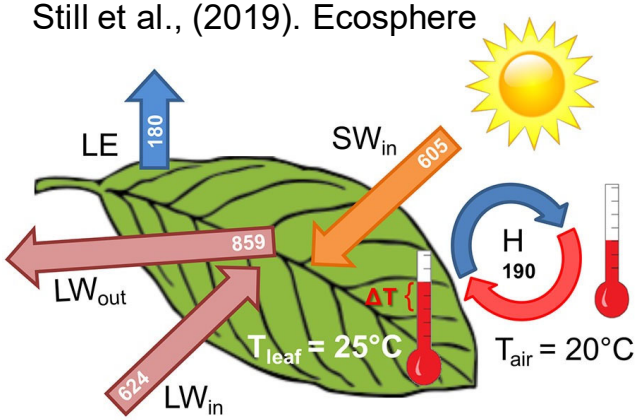
- The planned datasets would provide basic flux calculations for each tower location and vertical position, gap filled and partitioned ecosystem flux products (e.g. NEE, GPP, R_{eco}, ET/LE) with uncertainties by timestep, and standardized Ameriflux/FLUXNET compliant output in netCDF format

- Flux datasets linked with meteorological variables (e.g. T/Rh, radiation, surface temperature) to simplify data ingest, analysis, and model integration

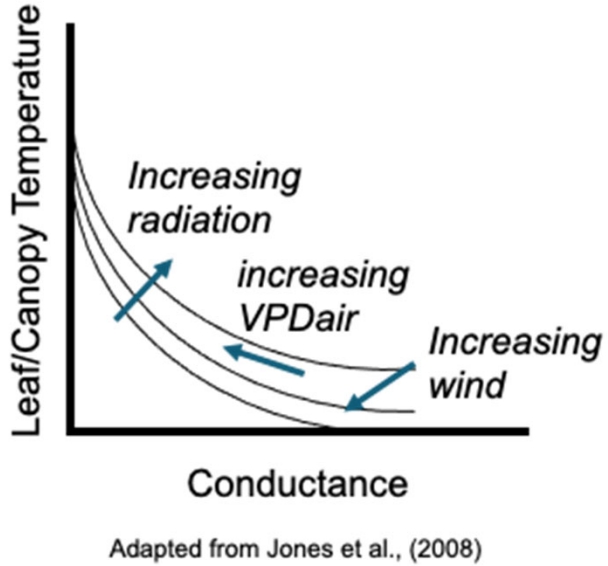
Other ways to expand LAI research in AMF3

- Fluxes of Carbonyl Sulfide [F_{COS}], carbon, and water isotopes as tracers to assist with ecosystem flux partitioning; TCCON node; SIF measurements at tower locations
- Tree physiology / sap flux network; co-located with eddy covariance, IR radiometers, and boundary layer profiling
- Distributed temperature sensing (DTS) at supplemental sites to support broader turbulence research across land types
- Measurements of soil fluxes and emissions within tower footprints; across an urban to rural transect
- Soil moisture / groundwater network; water cycle studies and satellite retrieval validation
- Unoccupied and piloted surface-atmosphere aerial campaigns; e.g. NEON AOP collections over the AMF3 domain

Still et al., (2019). Ecosphere

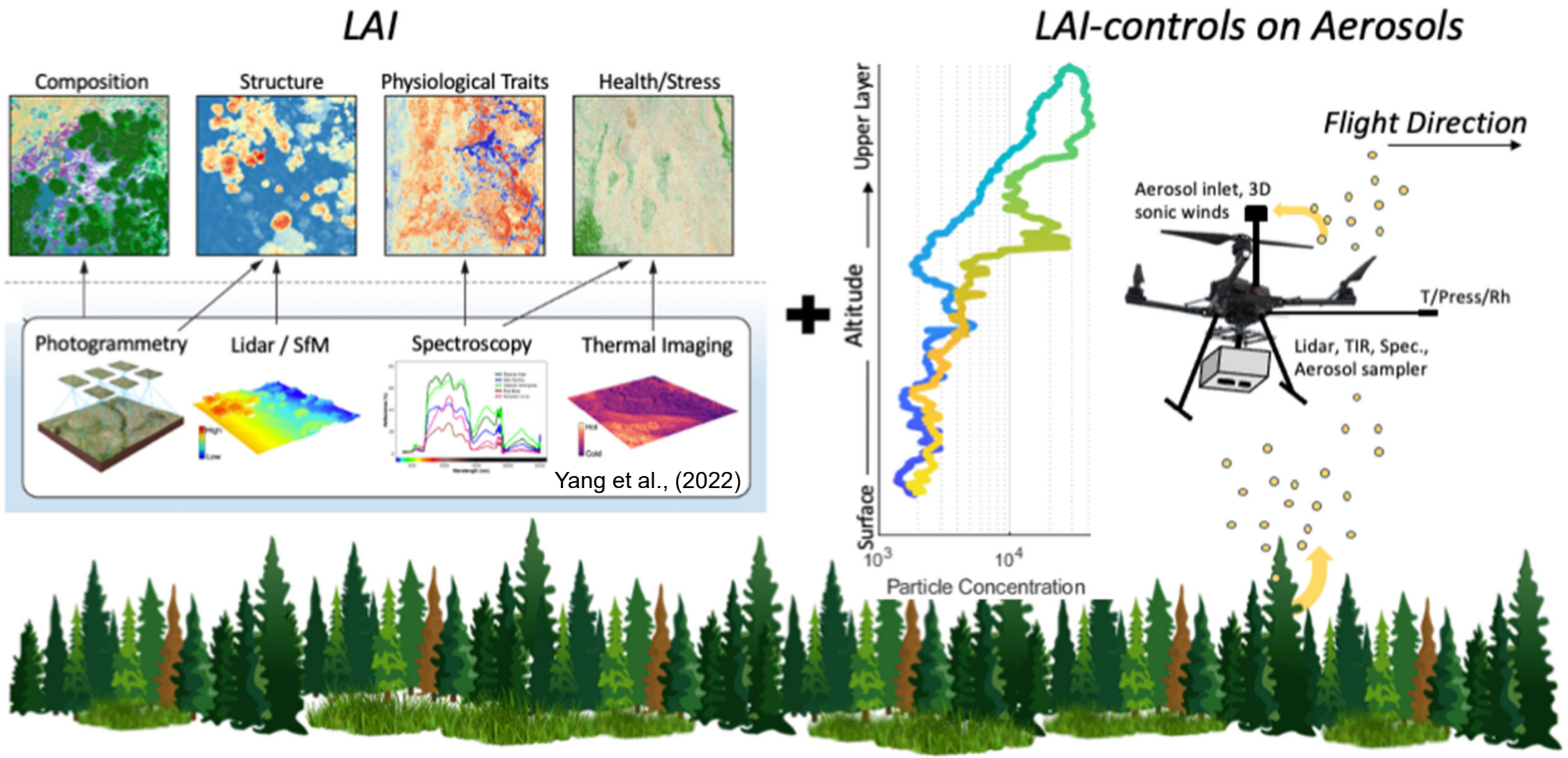


$$R_{net} = \alpha SW_{in} + \varepsilon_{IR}(LW_{in}) - 2\varepsilon_{IR}\sigma(T_{leaf})^4$$



Adapted from Jones et al., (2008)

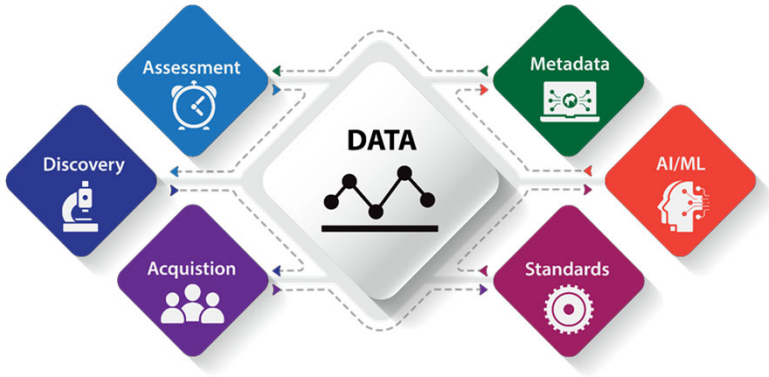
Novel Aerial Platforms for Coupled LAI Science



Prototyping new approaches at AMF3

- Test-bed for emerging measurement technologies (e.g., spatially-distributed sensing) and AI/ML applications for climate science (e.g. edge-enabled)
- Development of multi-scale data products for model evaluation; application of AI-assisted data curation approaches
- Creation of “model-ready” forcing data for offline simulations within the AMF3 domain
- Accessible analysis and modeling workflows for domain scientists / non-modelers to engage with the models and modeling community

AI4ESP



Discussion & Questions

Deployment Webpage