The Mobile Atmospheric Profiling Network (MAPNet): Capabilities and Research Applications

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Abstract

The development of mobile profiling facilities at the University of Alabama in Huntsville has led to the formation of the Mobile Atmospheric Profiling Network (MAPNet), which is now available to the broader scientific community as part of the NSF supported Community Instruments and Facilities (CIF). The MAPNet consists of the following four mobile platforms (commercially available instruments are defined within parentheses): MIPS – Mobile Integrated Profiling System (915 MHz Doppler wind profiler, X-band Profiling Radar, Microwave Profiling Radiometer, lidar ceilometer); RaDAPS – Rapidly Deployable Atmospheric Profiling System (915 MHz Doppler wind profiler, Micro-Rain Radar, Microwave Profiling Radiometer, and lidar ceilometer); MoDLS – Mobile Doppler Lidar and Sounding System (Doppler wind lidar, Microwave Profiling Radiometer); and MAX – Mobile Alabama X-band scanning dual polarization radar. All four systems include near-surface in situ measurements of state variables and balloon sounding capabilities. This presentation will review the measurement capabilities of each instrument, and the research capabilities of the MAPNet. A unique concept of this suite of platforms is the combination of sensors that can provide high temporal-resolution (<5 min) profiles of wind, temperature, humidity, aerosols, cloud base, and precipitation over a broad range of conditions. Therefore, both boundary layer and precipitation research can be supported. Examples of measurements will include the following: Utilization of the MAPNet in a network mode to document the spatiotemporal variability of boundary layer and associated stratocumulus clouds preceding cool season, severe quasi-linear systems; Comparisons of wind profiles and vertical motion among the individual instruments; Measurements of bores and gust fronts within the planetary boundary layer; Integration of data from disparate profiling systems to promote understanding of complex boundary layer evolution within precipitation, including landfalling hurricanes; Examples of educational deployments that have utilized the MAPNet in the past, and may serve as a prototype for educational deployments in the future.

MAPNet: Mobile Atmospheric Profiling Network

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MAPNet is funded under a new NSF program:
Community Instruments and Facilities (CIF)
https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=505785

Goal: Make MAPNet available to the NSF-sponsored scientific and academic community for research, education, and outreach.
https://www.nsstc.uah.edu/mapnet/

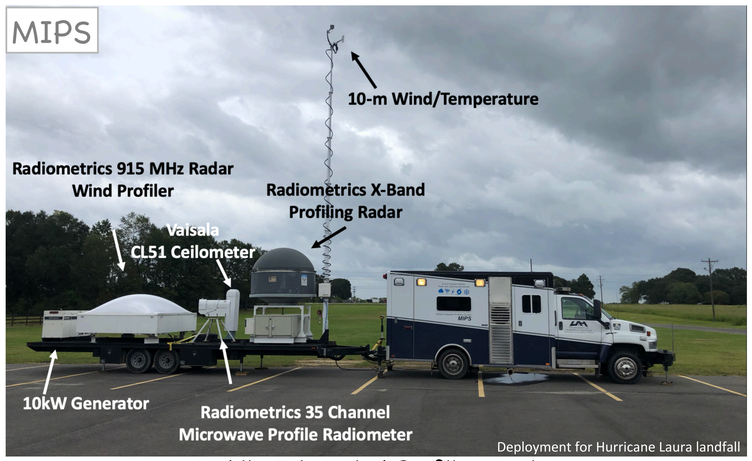
A quickly deployable network of profilers designed to describe vertical structure of wind, thermodynamics, aerosols, clouds, and precipitation

Research

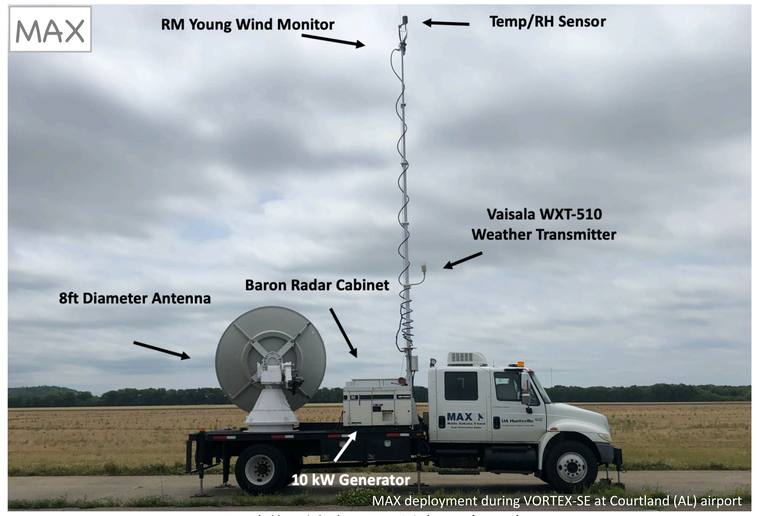
- Boundary Layer processes
- Severe storms
- Precipitation processes
- Cloud structure and evolution
- Mesoscale processes
- Landfalling tropical systems
- Supporting measurements for Air Quality studies
- Entomology and Ornithology

Education and Outreach

- Development of educational modules for:
  - K-12
  - Undergraduate
  - Graduate: similar to research themes
- Weather Fests
- Other science or technology activities (e.g., Earth Day)
- Hands-on activities



Mobile Integrated Profiling System



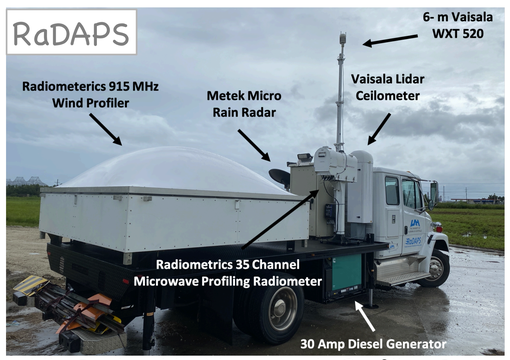
Mobile Alabama X-band radar

MIPS instruments

- 915 MHz Radar Wind Profiler
- Doppler sodar (option)
- X-band Profiling Radar
- Microwave Radiometer (35 channel)
- Vaisala CL51 ceilometer
- iMet sounding system
- Surface: T/RH (2 m), p, solar, wind (10 m)
- Parsivel disdrometer

RaDAPS instruments

- 915 MHz Radar Wind Profiler
- Doppler sodar (option)
- Micro Rain Radar (Metek)
- Microwave Radiometer (35 channel)
- Vaisala CL51 ceilometer
- iMet sounding system
- Surface: T/RH (2 m), p, solar, wind (4 m)
- Parsivel disdrometer



Rapidly Deployable Atmospheric Profiling System

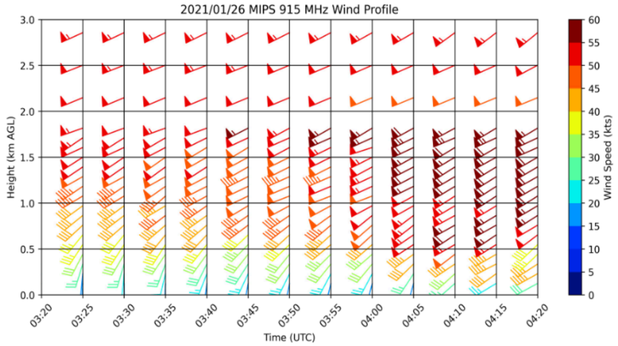
Mobile Doppler Lidar and Sounding system

MoDLS instruments

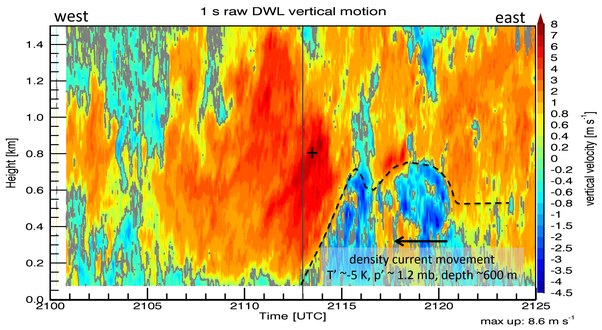
- Halo scanning Doppler lidar (1.5 μm)
- Microwave Radiometer (35 channel)
- iMet sounding system
- Surface: T/RH (2 m), p, solar, wind (7 m)
- Sonic anemometer (7 m)
- Vertically pointing K_a band radar (future, desired)

MAX instruments

- Scanning X-band dual polarization radar
- Windsond sounding system (option)
- Surface: T/RH, p (3 m), solar, wind (10 m)
- Parsivel disdrometer (future)



Rapid change in wind profile (5-min temporal resolution) in a severe storms environment on 26 Jan 2021. In this case, a corresponding signature in surface pressure or T/T_d was absent.



Vertical motion associated with a gust front from a thunderstorm over Huntsville on 30 Aug 2013. The maximum updraft of 8.6 m/s is near 800 m AGL, labeled with "+". The time vs. height section can be viewed as a vertical section in the E-W plane (east on the right) The dashed line shows the inferred structure of the boundary based on vertical motion and radiometer measurements.

Wind profiles

915 MHz Radar Wind Profiler (Radiometrics XBS-BL)

- 7 beam configuration
- Winds determined via a quasi-VAD routine
- Winds produced at 5 min intervals, up to heights of:
  - 5 km (moist conditions)
  - 1-2 km (dry, stable conditions)
  - High vertical resolution in the BL (oversampling)
- Recorded moments (backscatter power, velocity, spectrum width) along each beam

Doppler sodar (Remtech PA-0)

- 5 beam configuration
- Winds produced at 5-min intervals up to 300-700 m agl
- High vertical resolution of 10-20 m, starting at 20 m agl

Doppler lidar (Halo Streamline)

- Multiple scanning options: Fixed beam (zenith), discrete beam sampling, continuous scanning
- Gate samples at ~1 Hz frequency
- Wind profile mode (5-6 beam configuration)
- Horizontal winds at 5 min intervals with vertical resolution of ~25 m (adjustable)

MAX (Baron Services)

- VAD scans provide wind profiles, but with a larger footprint
- High resolution VAD will produce winds at 50 m vertical intervals
- Mesoscale divergence and vertical motion over the VAD circle (~10 km diameter)

Thermodynamic and Precipitation Profiles

915 MHz Radar Wind Profiler (Radiometrics XBS-BL)

- Backscatter power, velocity, spectrum width along each beam

Doppler lidar (Halo Streamline)

- Multiple scanning options
- Volume backscatter measurements of aerosols
- Cloud characteristics (backscatter, extinction, velocity)

Lidar ceilometer (Vailsala CL51, 0.9 μm)

- Profiles of volume backscatter (uncalibrated) every 10 s
- Relative aerosol loading
- Precipitation characteristics from lidar extinction

X-band profiling radar

- Profiles of reflectivity factor, velocity, spectrum width
- 6 Hz measurements → high temporal resolution

Micro Rain Radar (Metek MRR-2, 24 GHz)

- Profiles of reflectivity factor, velocity, derived water content
- Temporal resolution is adjustable (typically 60 s)

MAX

- Volume scanning to provide context for profile measurements
- Precipitation profiles from VAD scans or zenith measurements
- Retrieval of dual polarization variables over a profiling site for value-added information

Thermodynamic and cloud information from radiometer (Radiometrics MP3000A)

- Profiles of T, water vapor, liquid water
- Integrated values of water vapor and liquid water
- Sky temperature (IR radiometer)

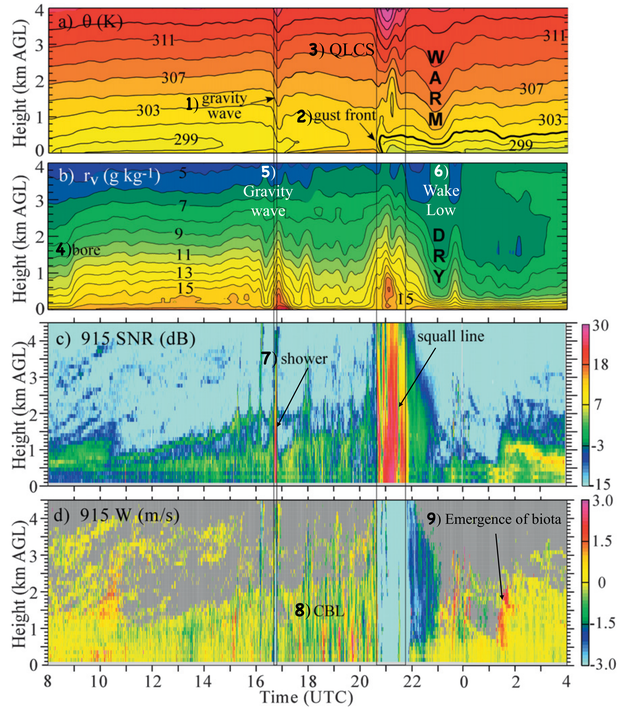


Illustration of features detected by MIPS measurements (based on radiometer (panels a and b) and 915 MHz profiler (panels c and d) on 8 Jun 2007. Ceilometer backscatter and surface measurements are not shown. Features are annotated and labeled with bold numbers, 1-9. Adapted from Knupp et al. (2009).

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