Roles for sUAS in the Boundary Layer

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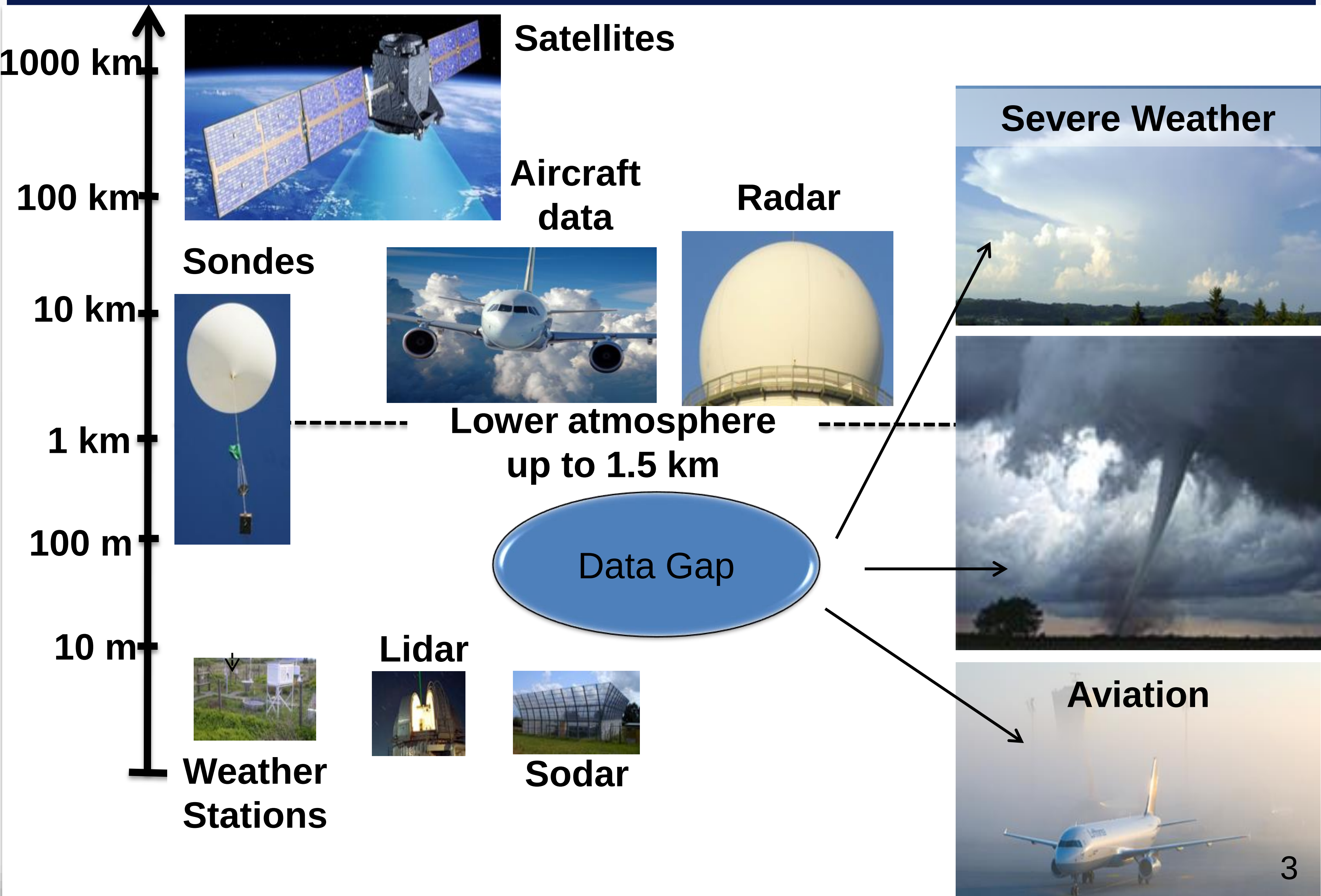
Goal:

Improve scientific understanding of the physical processes occurring within the planetary boundary layer, using novel observational and modeling techniques, so that these processes can be better represented in weather forecast models

Challenges


1000 km
100 km
10 km
1 km
100 m
10 m
Satellites
Aircraft data
Radar
Sondes
Lower atmosphere up to 1.5 km
Data Gap
Lidar
Weather Stations
Sodar
Severe Weather
Aviation

DJI S-1000

Eight-rotor helicopter capable of carrying up to 4.5 kg payload for 10-12 minutes

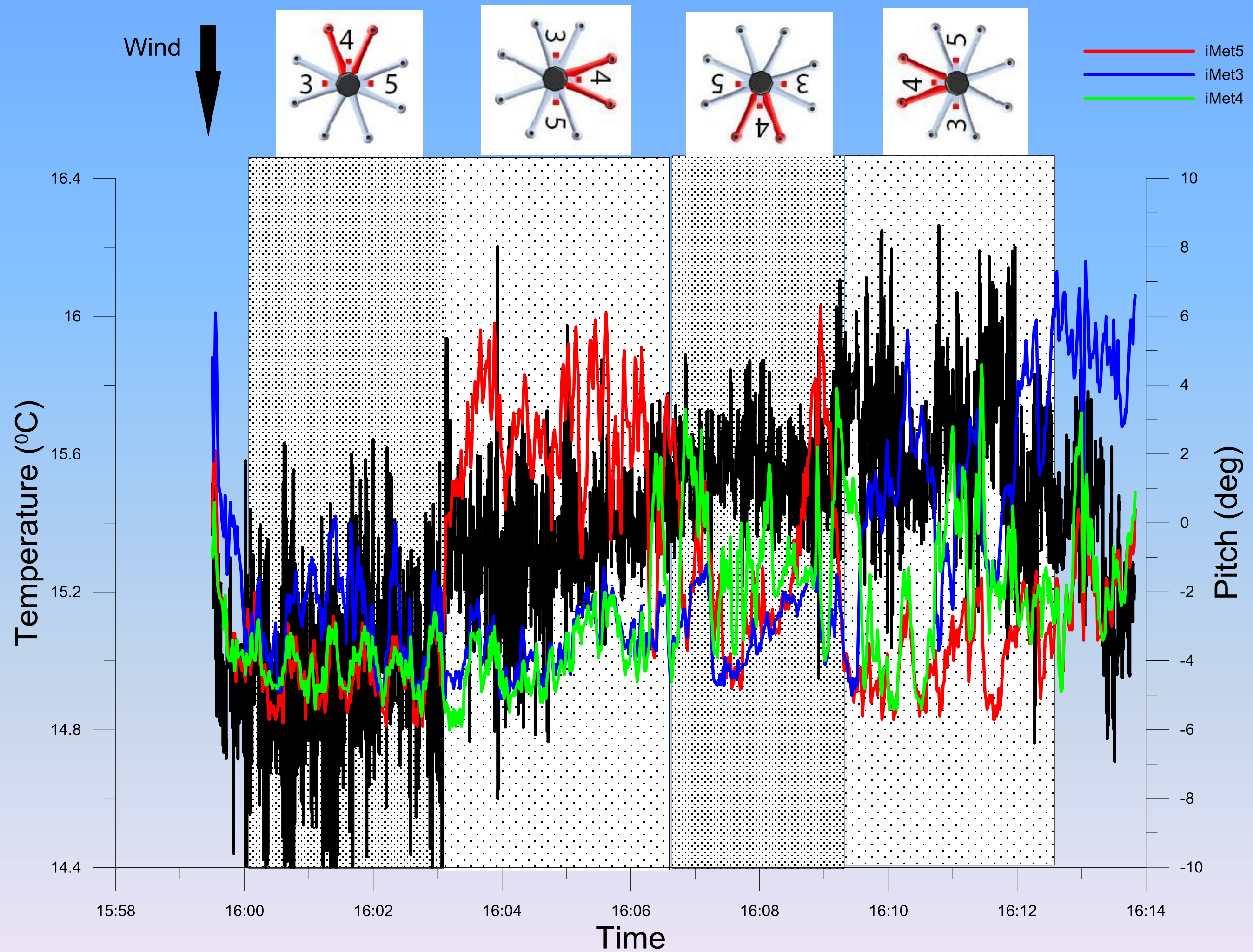
iMet-XQ instruments to sample temperature and humidity attached with Velcro to the top of the central body on the left and right sides of the aircraft

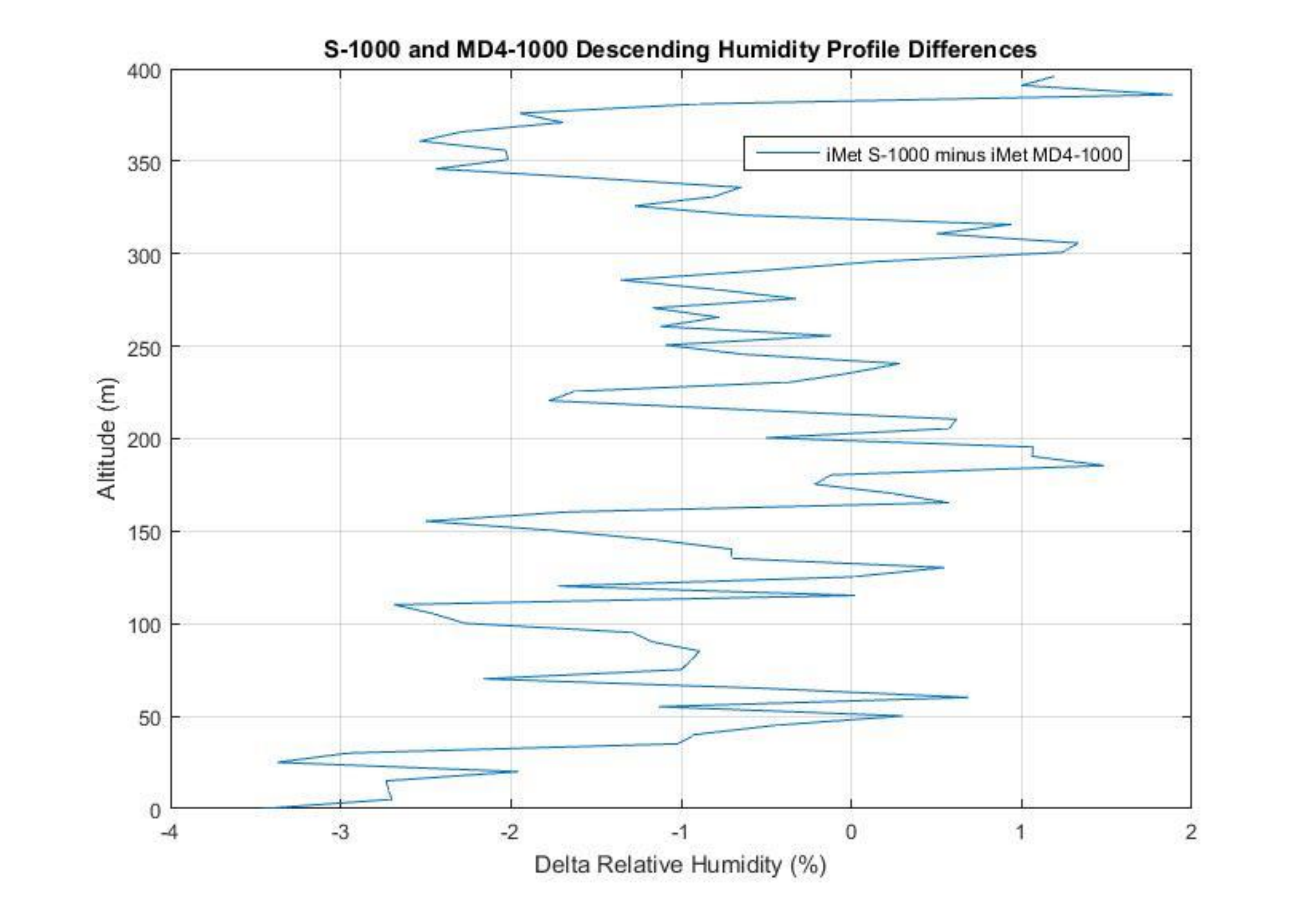
Microdrone MD4-1000

Four-rotor helicopter capable of carrying up to 2 kg payload for 20-45 minutes

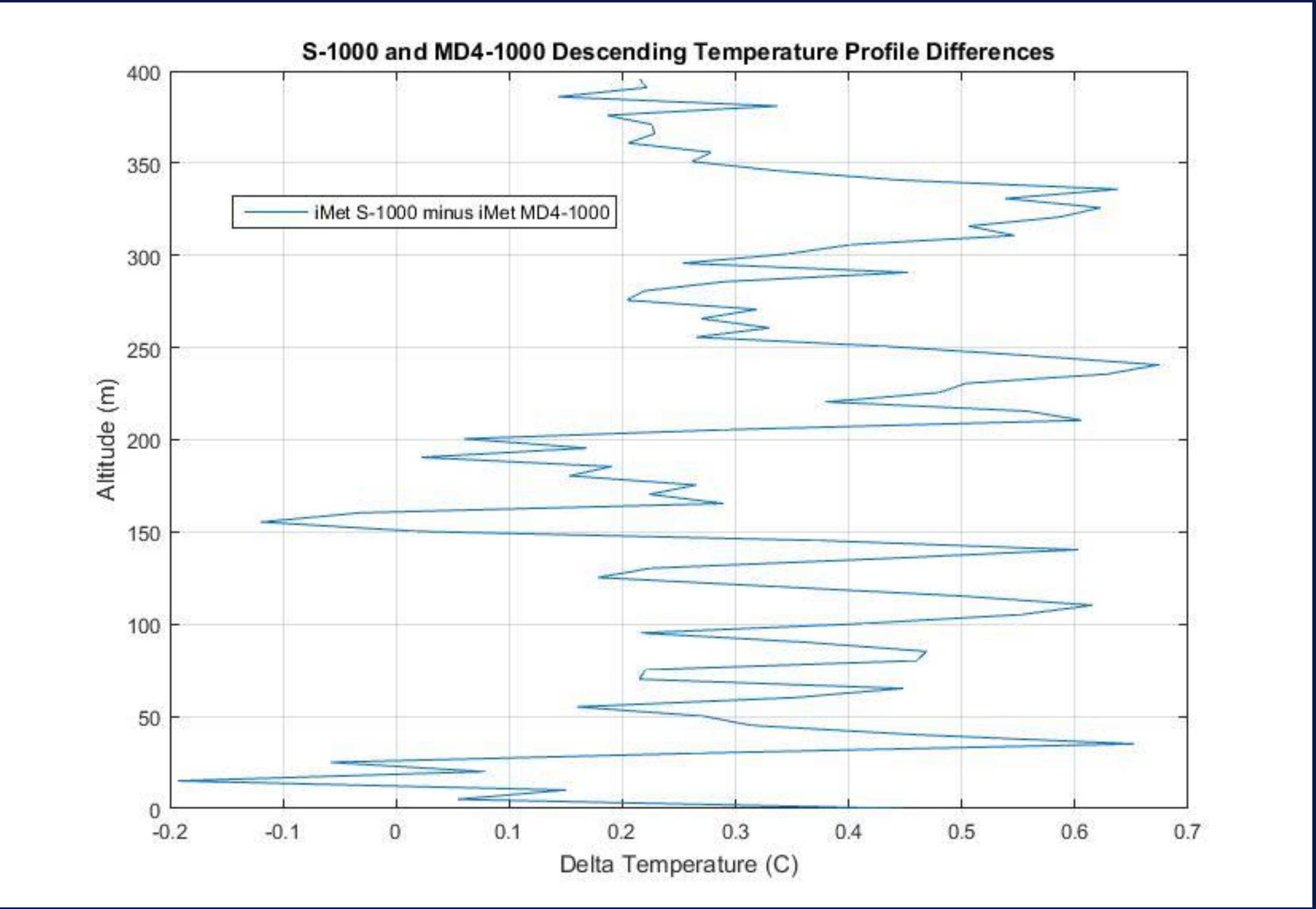
iMet-XQ instruments attached with Velcro into two depressions on the left and right sides of the upper dome of the aircraft

sUAS need: Vertical Profiles



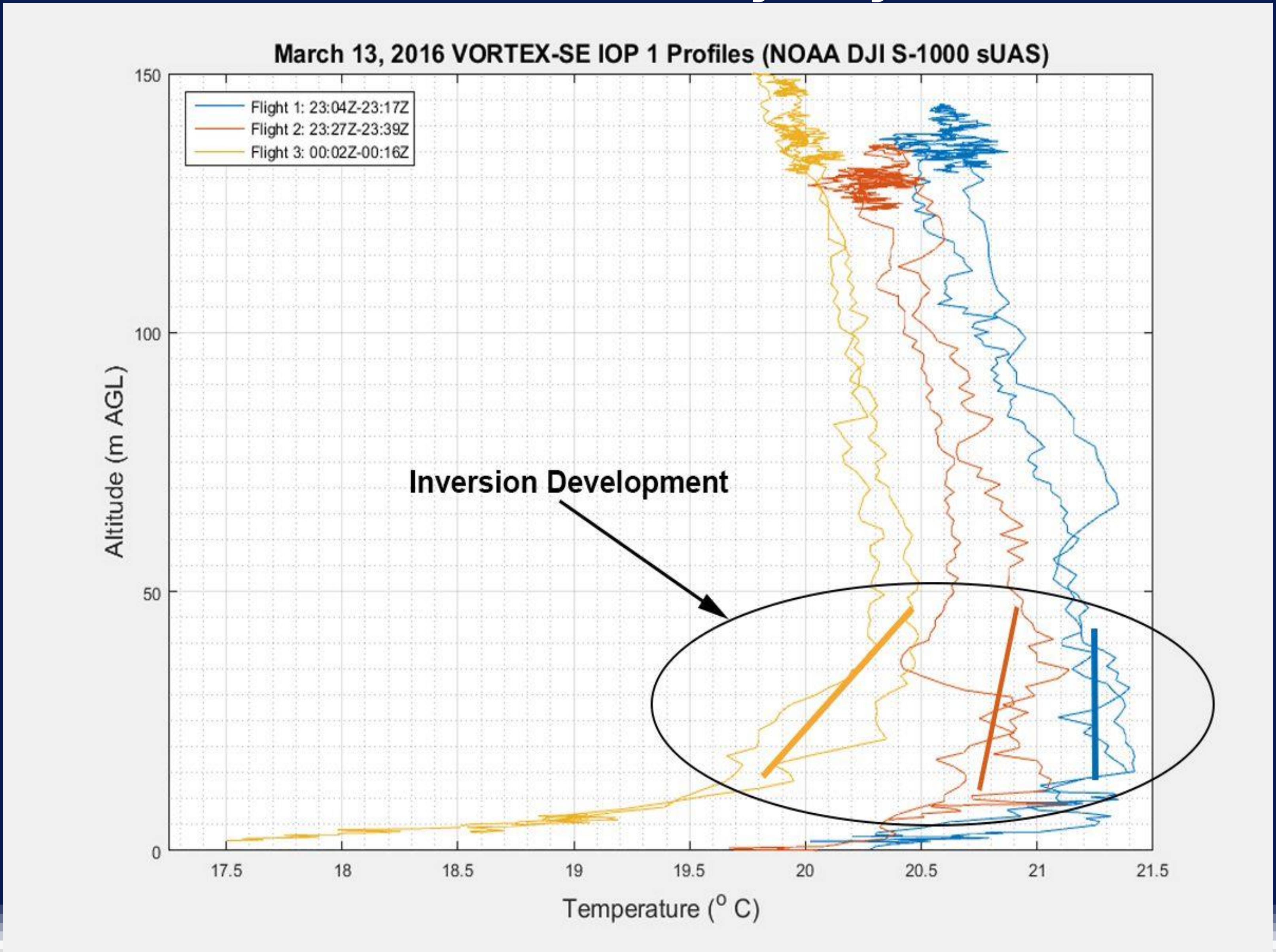


Relative humidity difference versus altitude (m AGL) for the MD4-1000 and S-1000 descending profiles. Note this data are for the descending portion of the second MD4-1000 profile.



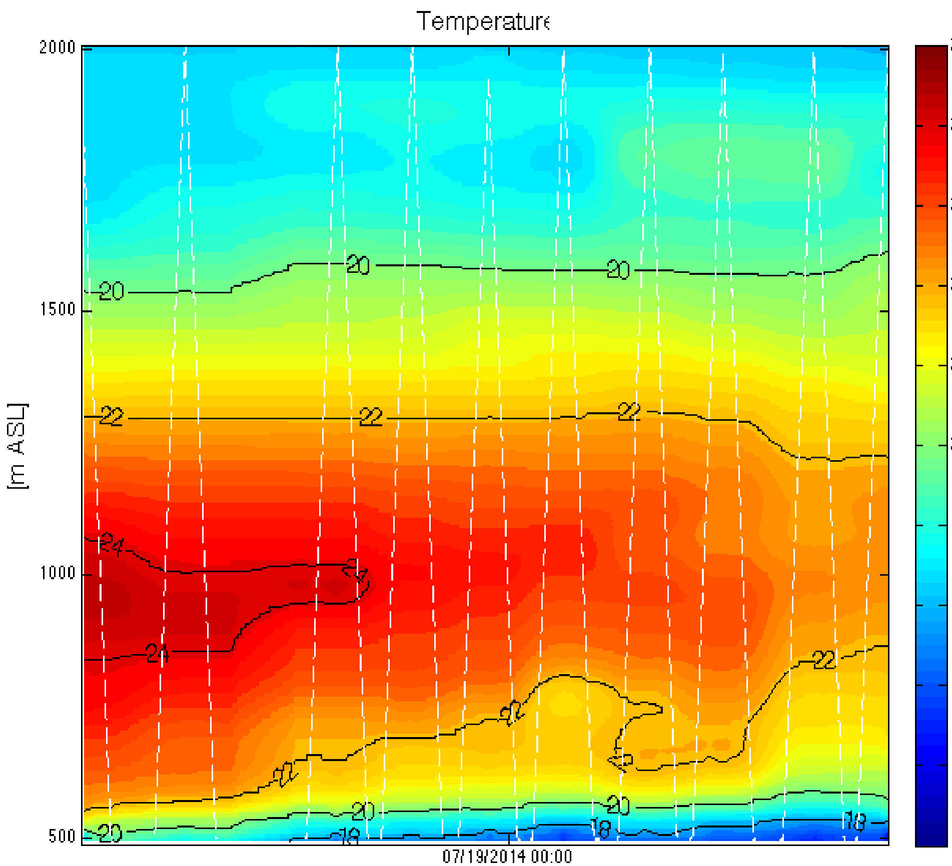
Temperature difference versus altitude (m AGL) for the MD4-1000 and S-1000 descending profiles. Note this data are for the descending portion of the second MD4-1000 profile.

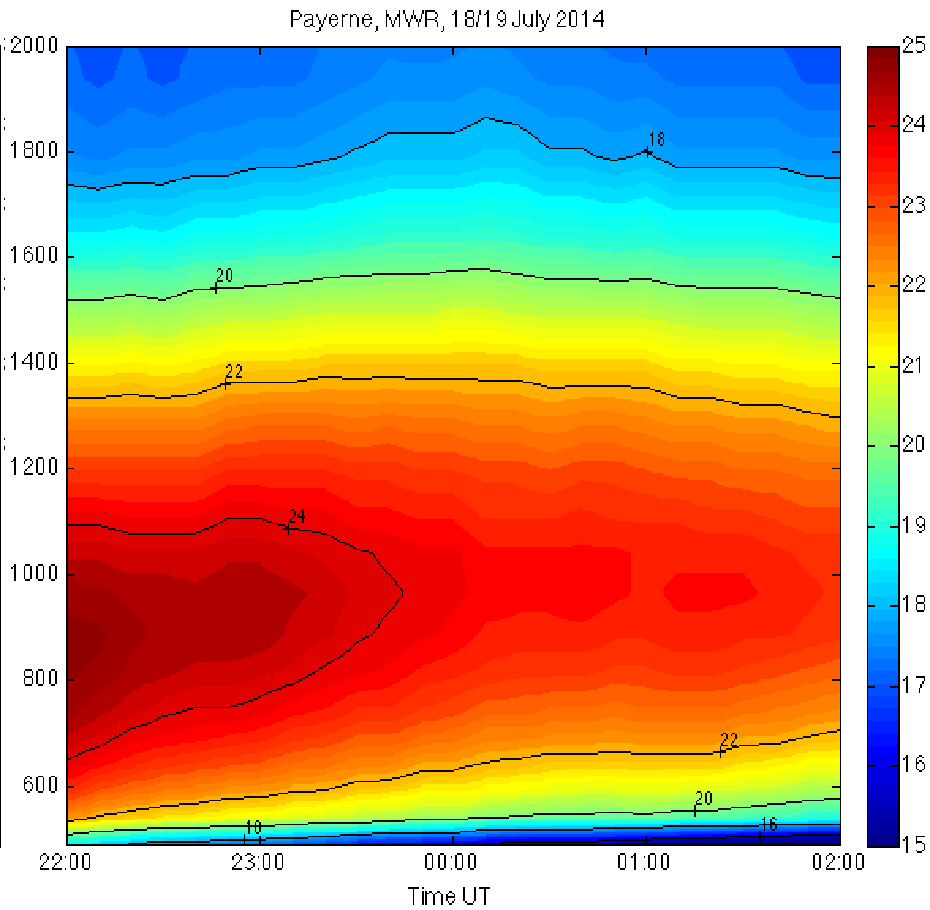
UAS Provides High Resolution Profiles of the Lower Boundary Layer



sUAS Vertical profile

Microwave Radiometer





Graphs Courtesy of Metomatics

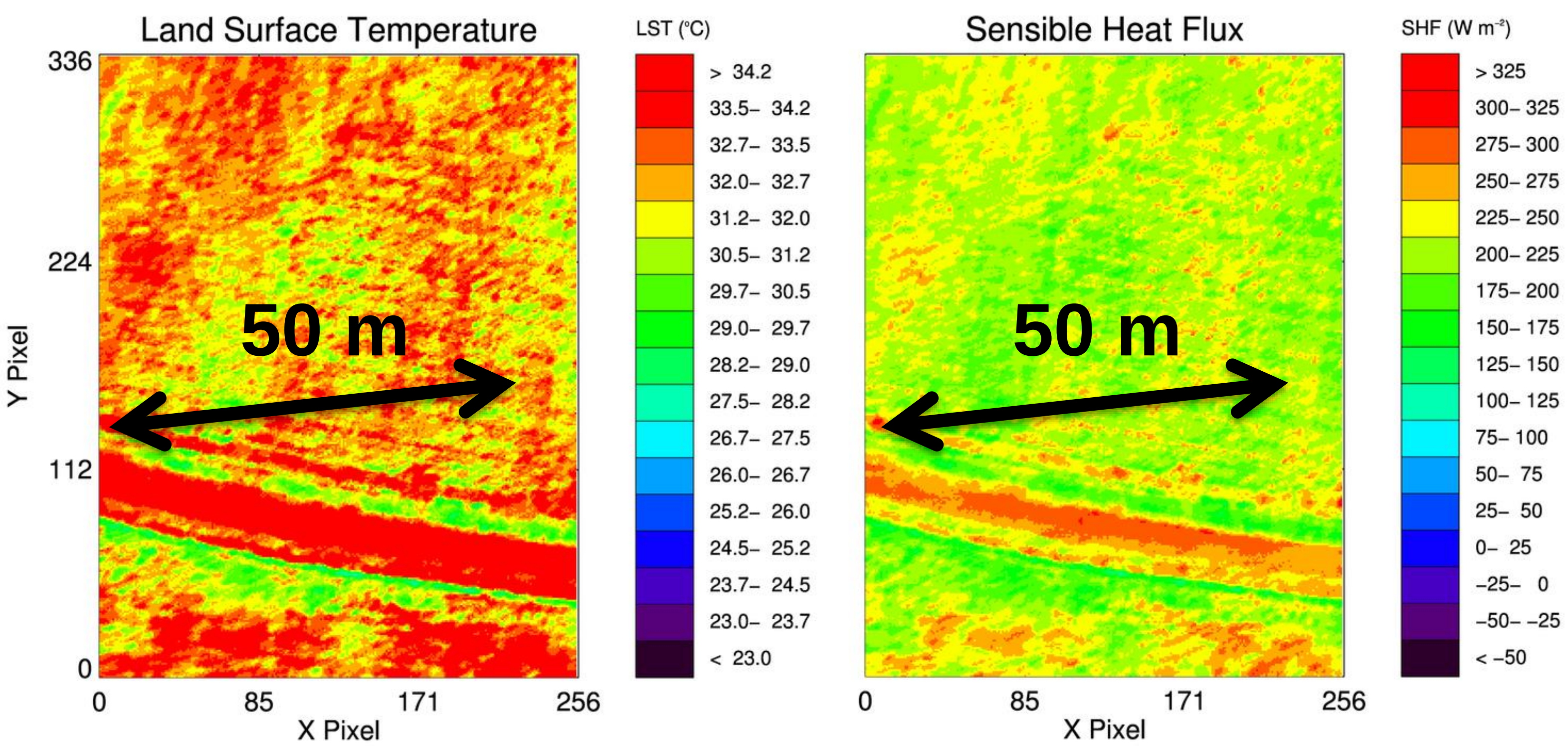
sUAS need: Horizontal transects

- Pre-convection inhomogeneities such as boundaries… broad/diffuse, or focused and readily apparent in satellite and radar.
- The association with variations in land use and terrain.
- Storm-associated boundaries; quantifying gradients of buoyancy and velocity.

- Spatial Scaling from in-situ to 4km for Model Validation.

- Cal/Val for remote sensing and atmospheric parameters, U,V,W,T,RH,P, CO_2, CH_4, and others.

UAS Land Surface Temperatures are being used to Derive Sensible Heat Fluxes



Developing Capability for UAS Observations of Severe Local Storms

Environmental Profiling and Initiation of Convection (EPIC)

Funding: NOAA UAS Program Office

Partnerships in Development:

NSSL; Universities of Oklahoma and Colorado; Meteomatics, Inc.

Capability Brief Description/Status:

- Demonstrated: fixed-wing small UAS can provide detailed profiles of temperature, moisture, and winds within the severe storm boundary layer
- Current: determining combined potential of fixed-wing and VTOL (Vertically Take Off and Landing) UAS for monitoring storm environment
- Multiple UAS systems (platforms, autopilots, sensors, etc.) being adapted, calibrated, validated, and evaluated in effort led by NSSL and ARL.

University of Colorado
Tempest / TTwistor

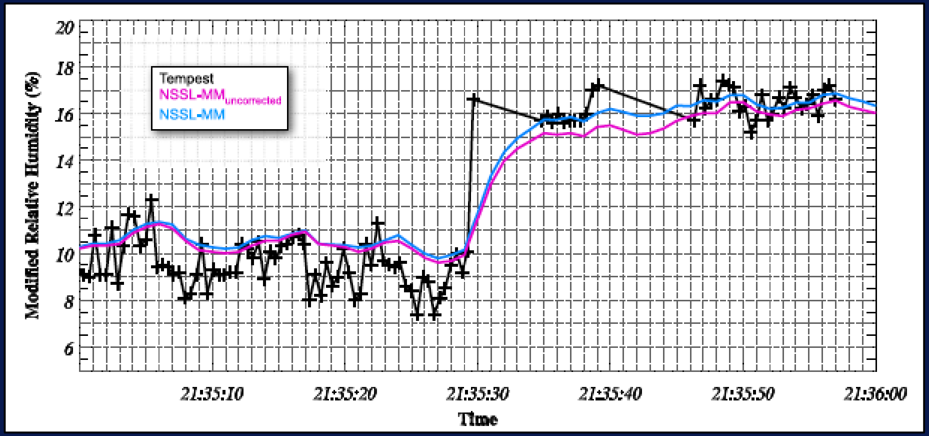
University of Oklahoma
CopterSonde

Meteomatics
Meteodrone

Developing Capability for UAS Observations of Severe Local Storms

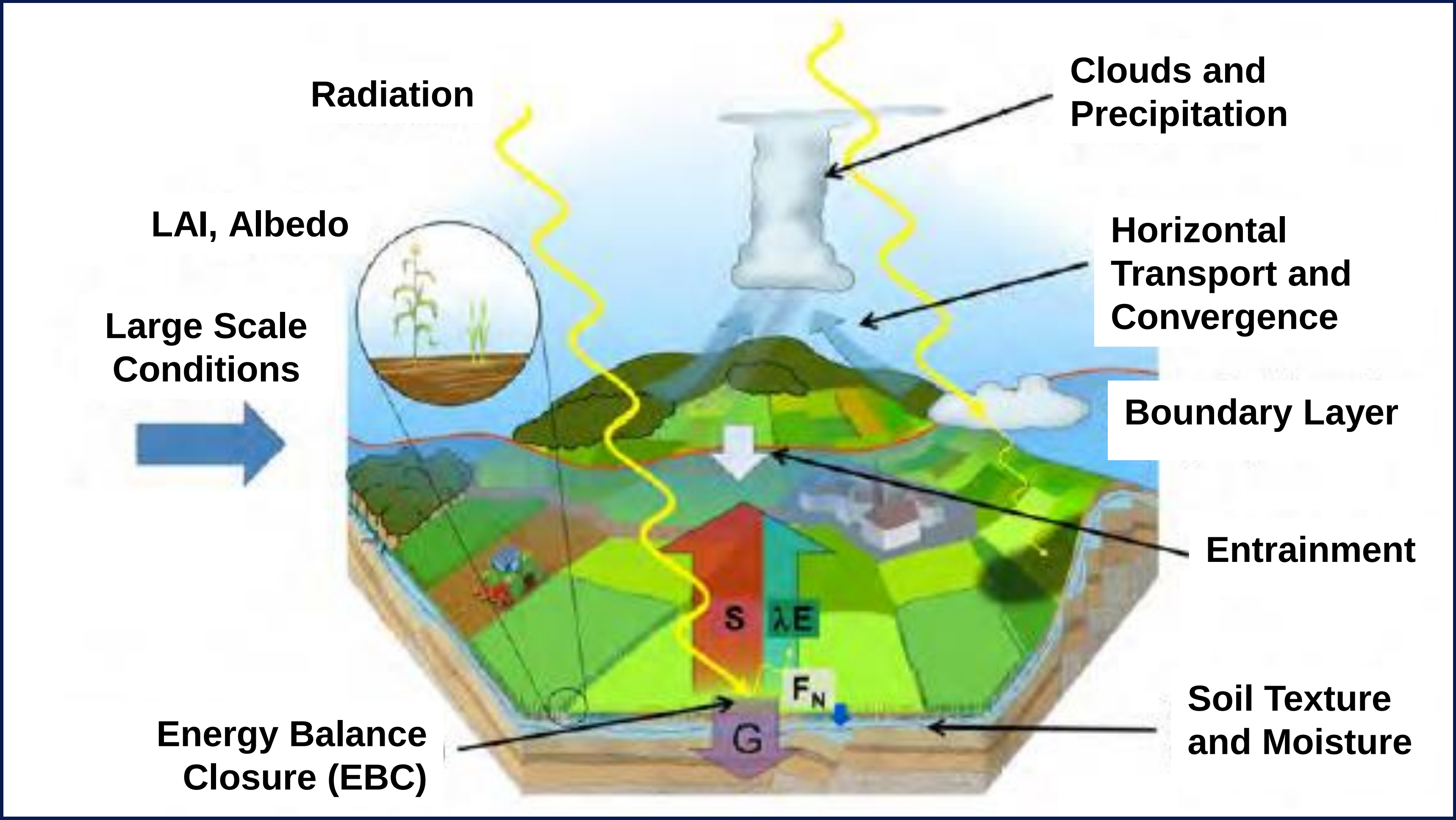
Key capabilities distinguishing innovation:

- CONOPS for operating a fixed-wing UAS in tandem with two types of fixed rotary UAS pairs to characterize the pre-convective ABL
- High-precision, fast-response sensors for accurately profiling boundary layer structure in presence of strong winds
- VTOL sophisticated autopilot systems and Differential GPS positioning
- Determining the value of airborne, mobile observing systems for monitoring rapidly evolving high-impact severe weather conditions not observed with current operational systems
- System will meet National Weather Service data standards, and be available to forecasters within 30 min for evaluation



Tempest UAS (black) vs. NSSL Mobile Mesonet time series of Relative Humidity crossing a gust front. The Tempest humidity sensor (RS92), which has a theoretical response time of 0.5 s, detected a large RH increase in just 0.42 s, whereas the NSSL-MM humidity sensor required 17 s for a 90% response to this change.

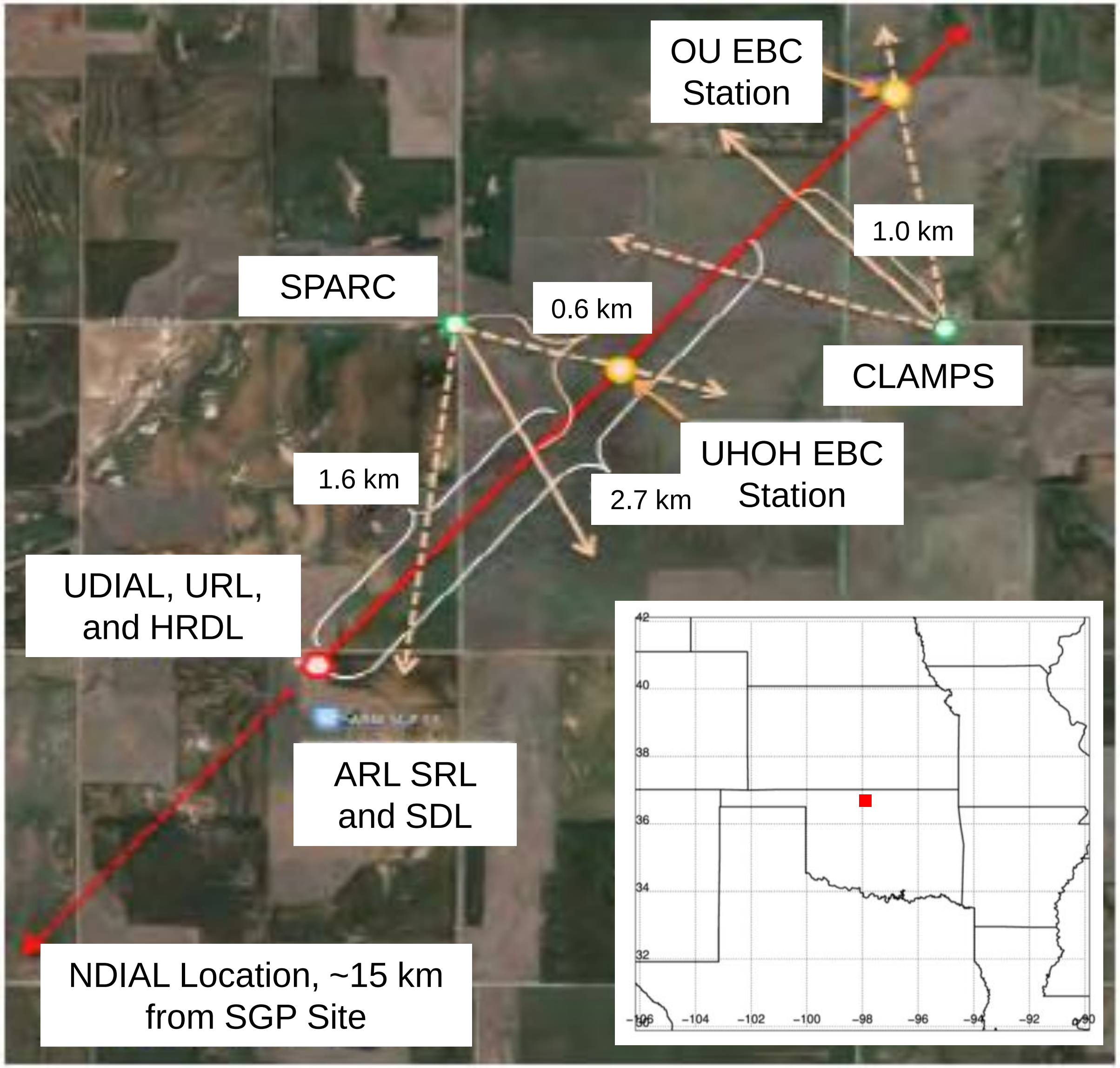
Land System and Feedback Processes



Land-Atmosphere Feedback Experiment (LAFE)

- Collaboration with NOAA ESRL, U. Hohenheim
- Investigate interactions and feedbacks between the land surface and boundary layer to improve their representation in weather forecast models
- August, 2017 experiment at Dept. of Energy Southern Great Plains Atmospheric Radiation Measurement (ARM) site in northern Oklahoma

August 2017 Deployment



Instrument Platforms (ESRL, U. Hohenheim)

- Doppler wind lidars
- Water vapor and temperature lidars
- Atmospheric Emitted Radiance Interferometer (AERI)
- Microwave radiometers

Instrument Platforms (NOAA ATDD)

- 3 flux towers
- Rawinsondes
- UAS
- Plane Transects

sUAS needs: Quality damage surveys

- Where did damage occur?
- How intense was it?
- What are the directional patterns of damage (tree fall, debris transport, etc.?)

EF2 Tornado during VORTEX-SE
Orange arrows indicate direction trees fell.

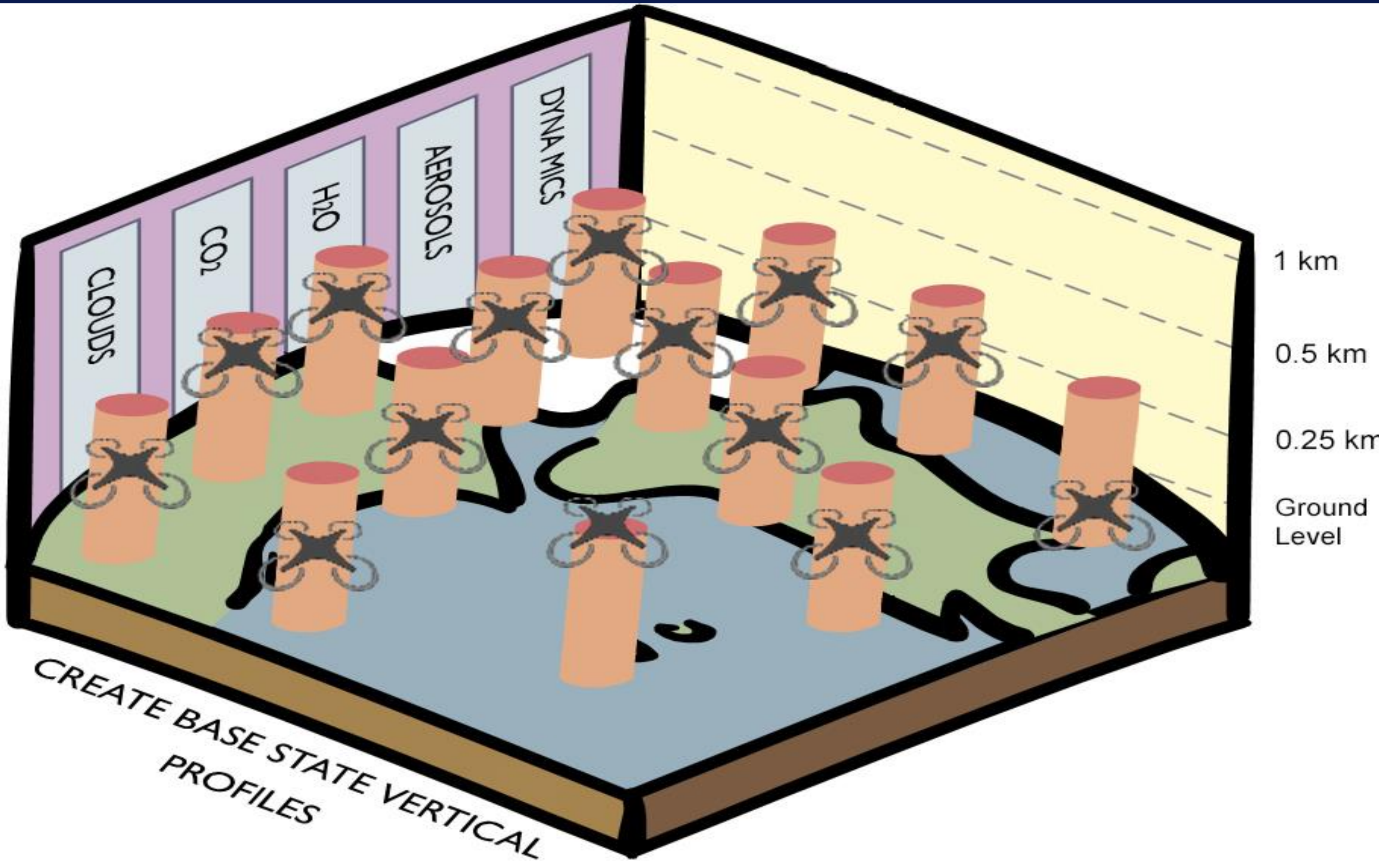
SUMMARY

- UAS
- Evaluate surface fluxes and upscale these fluxes to larger (i.e. ≥4 km) spatial scales (Fixed Wing)
- Expand profiling capabilities
    - Wind speed, wind direction
    - CO_2, CH_4, O_3

- Continue Severe weather research
- Low-level temperature/moisture information for improved short-term winter storm forecasts, severe thunderstorms and tornado potential

- Contributions to other NOAA missions across LO's
- Science planning
- Measurement platforms
- Numerical modeling

FUTURE DIRECTIONS



QUESTIONS??