The Role of sUAS for Boundary Layer Measurements

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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


PUSH THE
BOUNDARIES

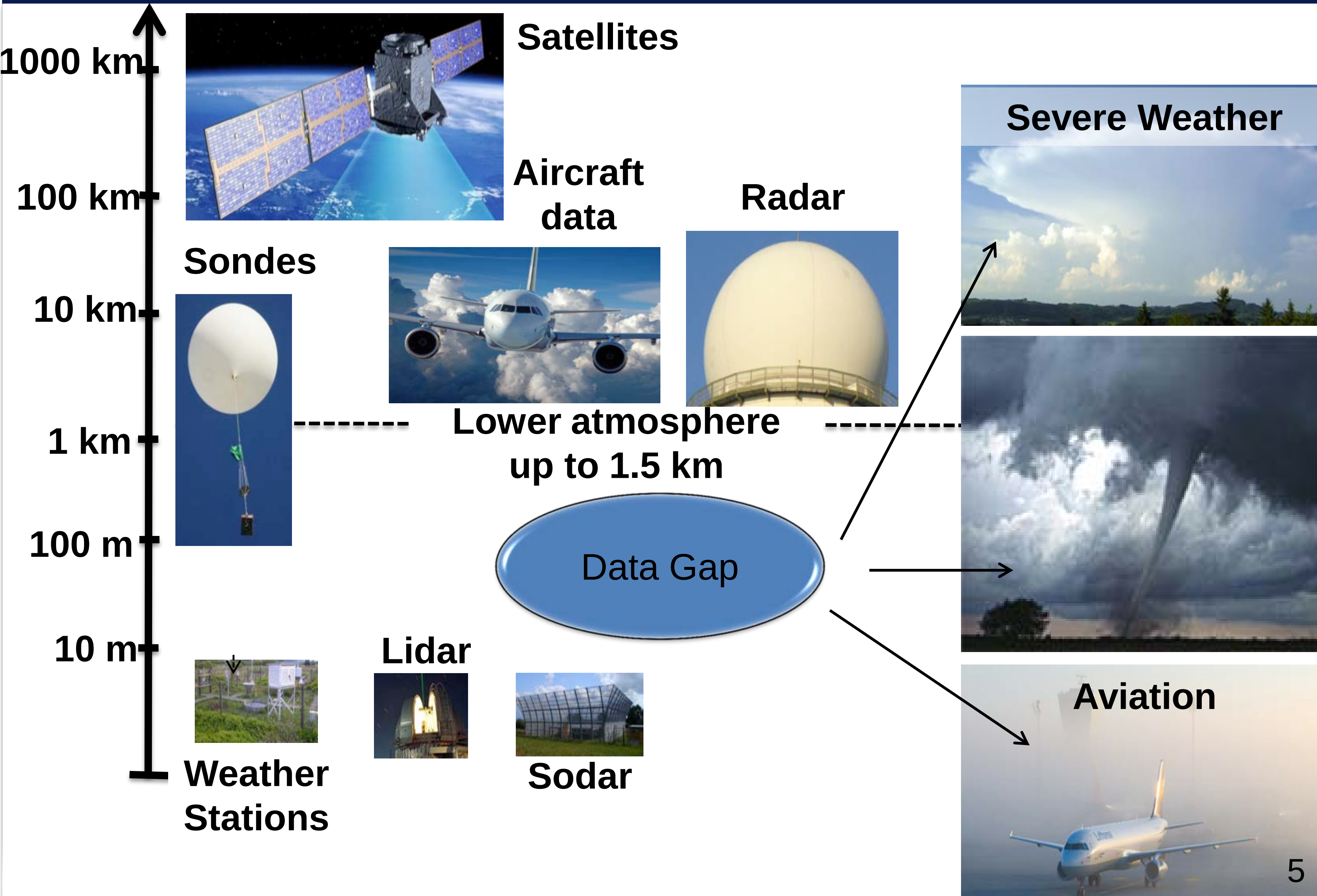
Relevance

Using state-of-the-art methods and techniques to better understand atmospheric boundary layer structure and processes in order to improve prediction of near-surface weather and climate conditions.

Performance

Identify critical surface and boundary layer processes associated with Convective Initiation and Tornadogenesis Utilizing small unmanned aircraft systems (sUAS) for Boundary layer profiling

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

UAS Platforms

DJI S-1000

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

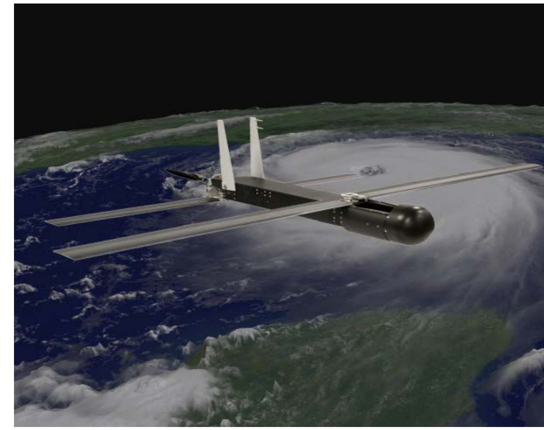
iMet-XQ instruments to sample T, RH attached to the top of the central body on the left and right sides of the aircraft

Microdrone MD4-1000

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

iMet-XQ instruments attached on the left and right sides of the upper dome of the aircraft

Coyote



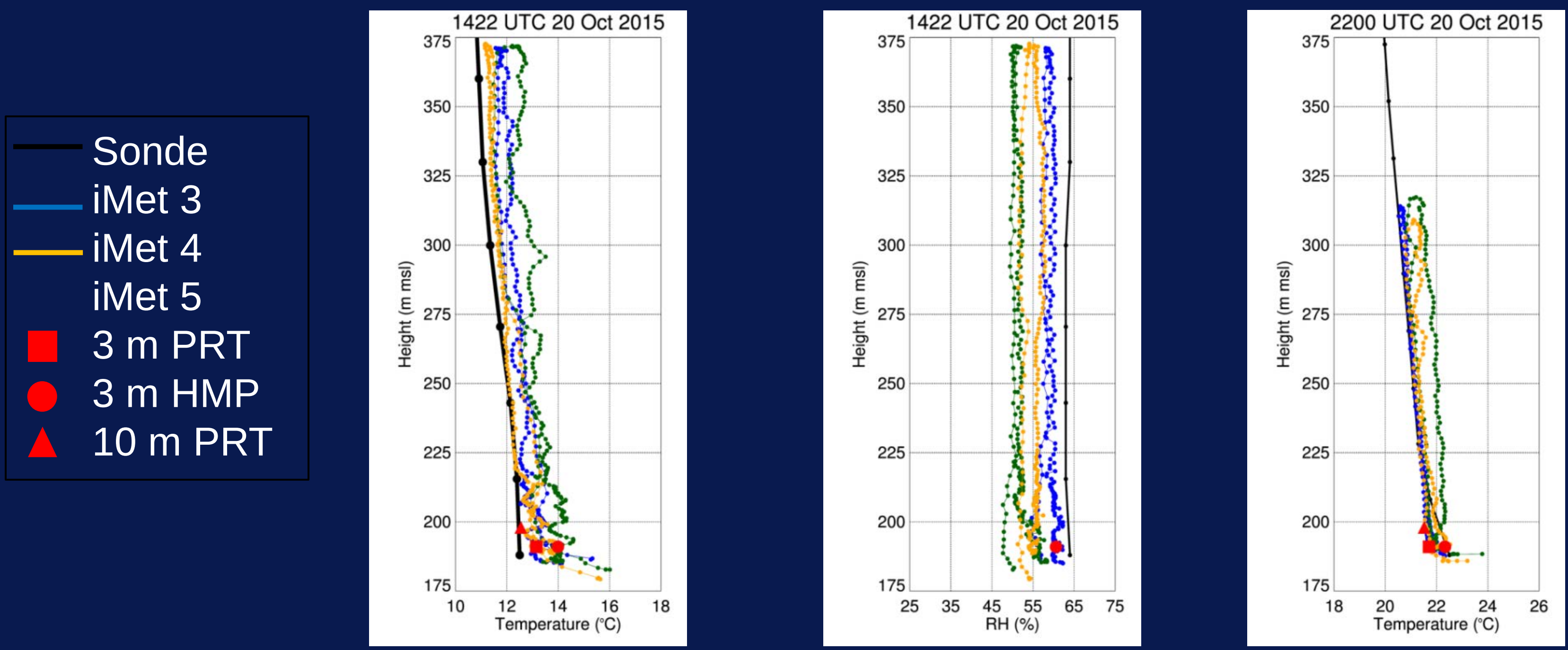
Small, expendable UAS that can be tube-launched from the ground or in the air

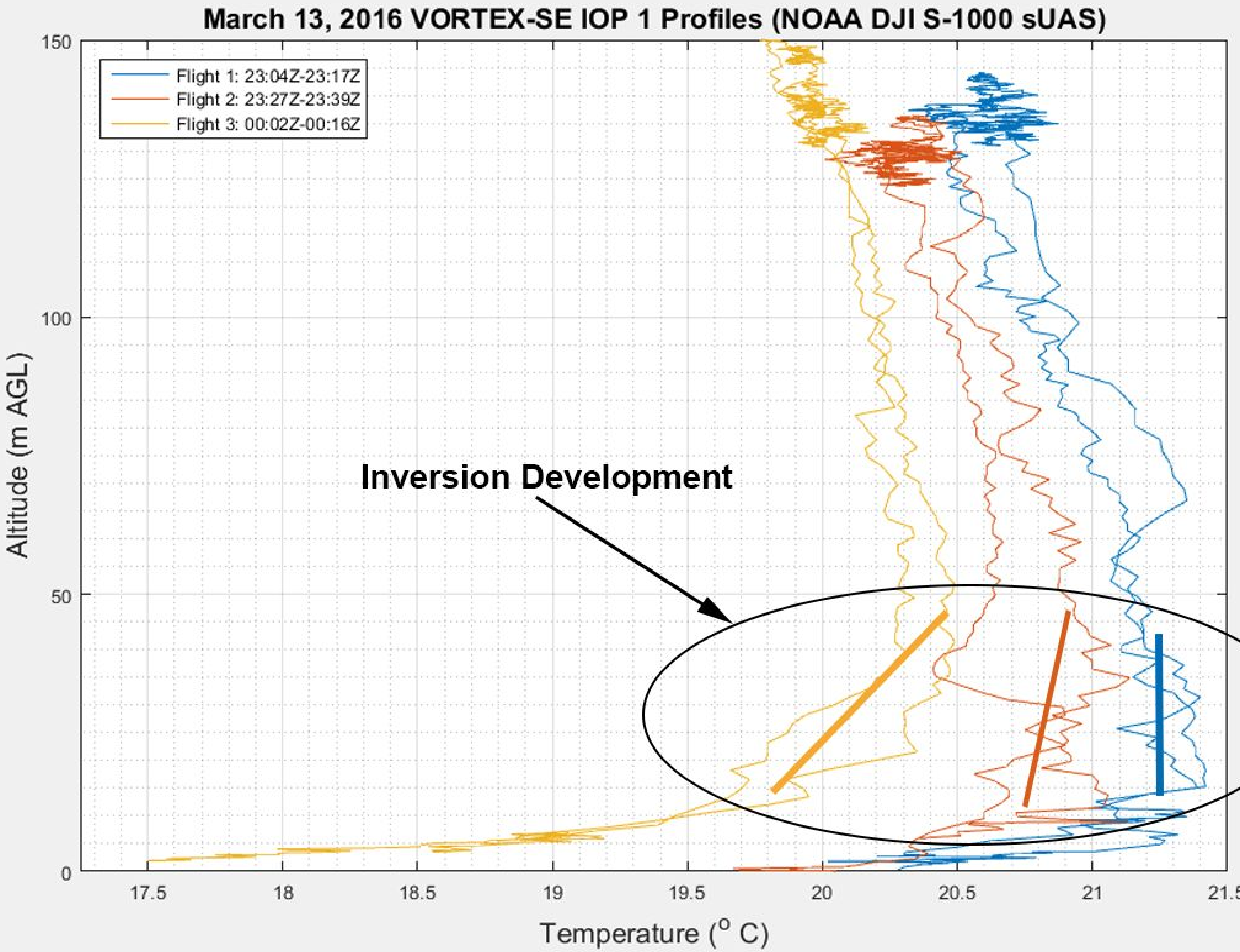
ARL will be integrating into the Coyote instruments to measure T, RH, pressure, and wind

Verification of the Origins of Rotation in Tornadoes EXperiment-Southeast (VORTEX-SE)

Goal: Understand how environmental factors in the southeastern US affect the formation, intensity, structure and path of tornadoes

A sUAS flown by ARL/ATDD will be used to survey storm damage and provide key atmospheric data that can be used to understand how the land surface may play a role in tornadogenesis.




March 13, 2016 VORTEX-SE IOP 1 Profiles (NOAA DJI S-1000 sUAS)
Flight 1: 23:04Z-23:17Z
Flight 2: 23:27Z-23:39Z
Flight 3: 00:02Z-00:16Z
Inversion Development
Altitude (m AGL)
150
100
50
0
17.5
18
18.5
19
19.5
20
20.5
21
21.5
Temperature (° C)

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.

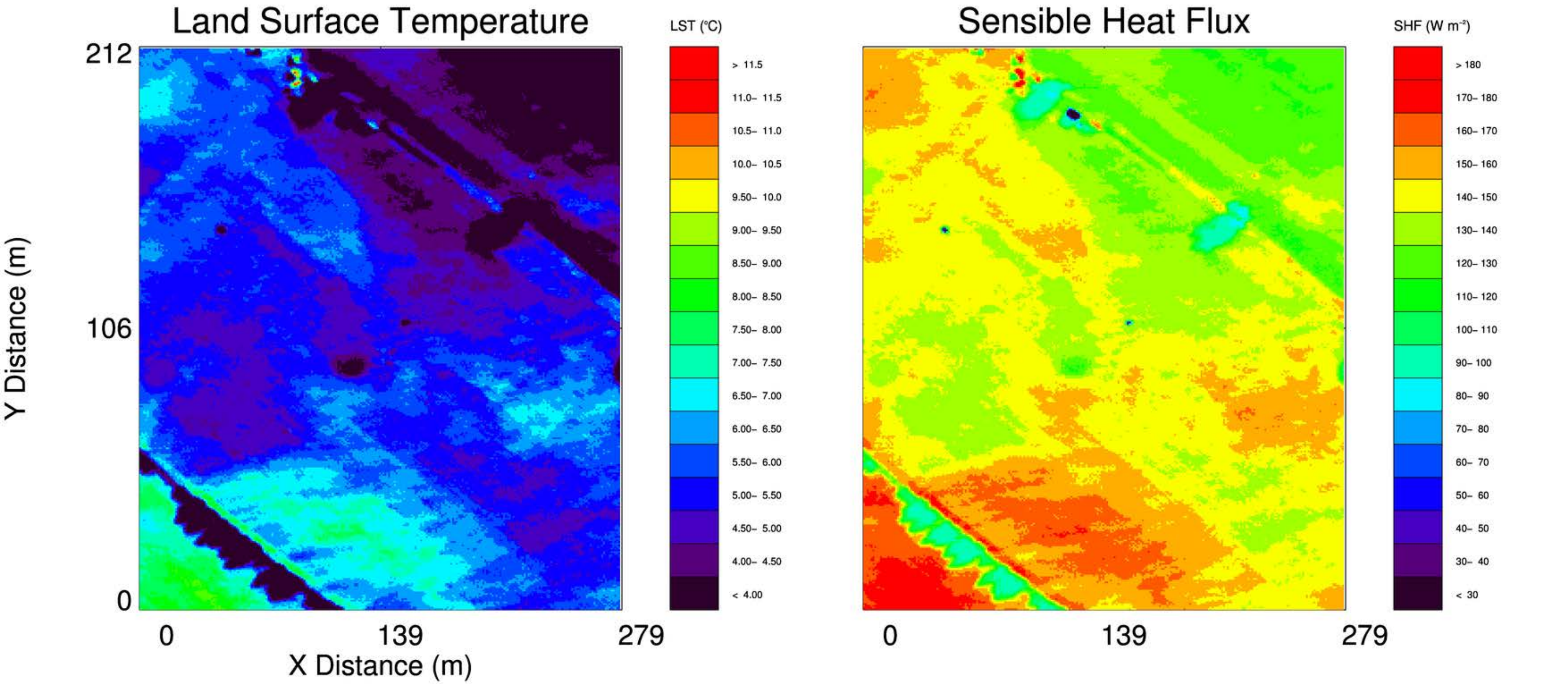
- Cal/Val for remote sensing and atmospheric parameters, U,V,W,T,RH,P, CO_2, CH_4, and others.

Sample Application of Technique during Flight 1 on 15 Dec 2016 near House Mountain

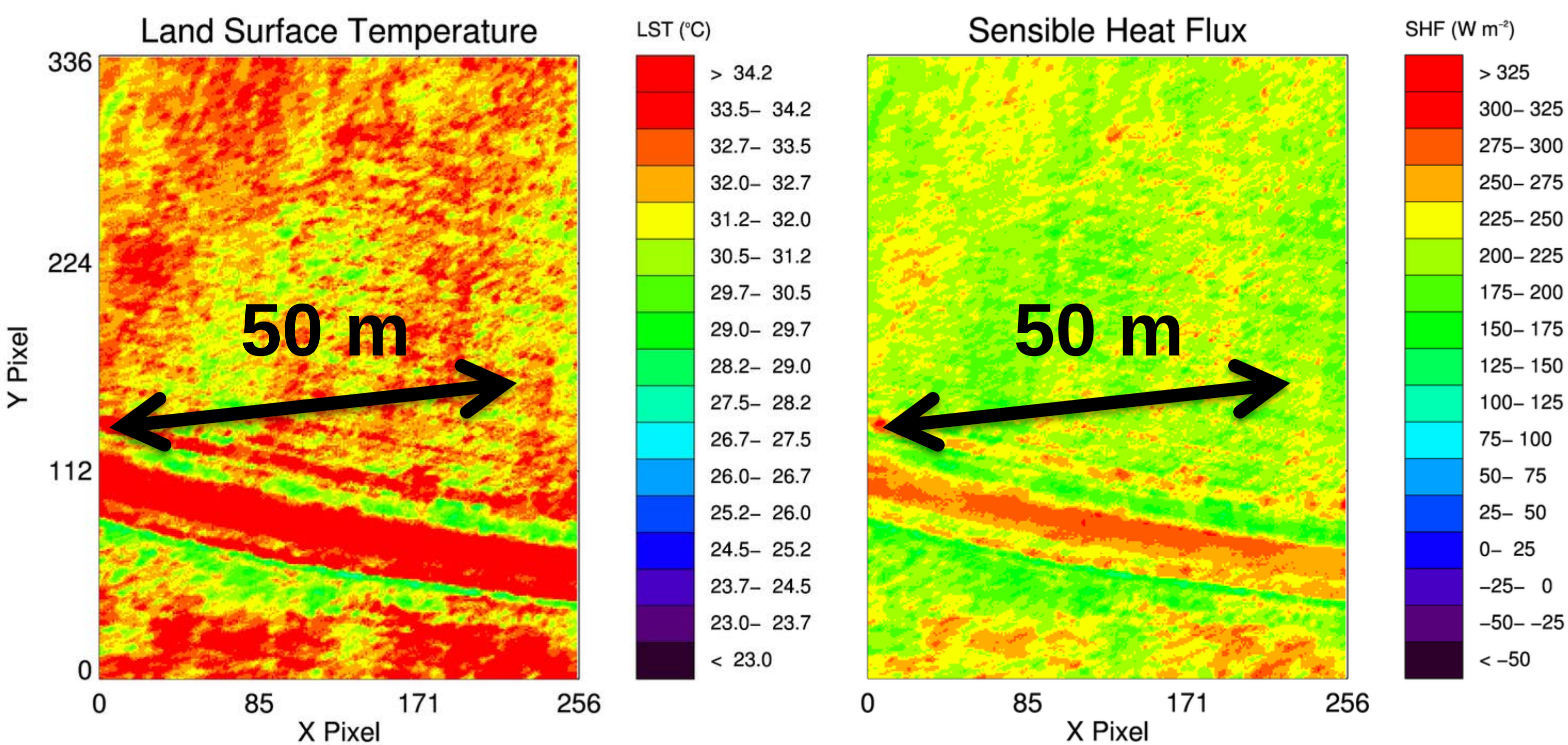
Flight 1: Vertical Profile at Tower 1

Height: 345 m agl

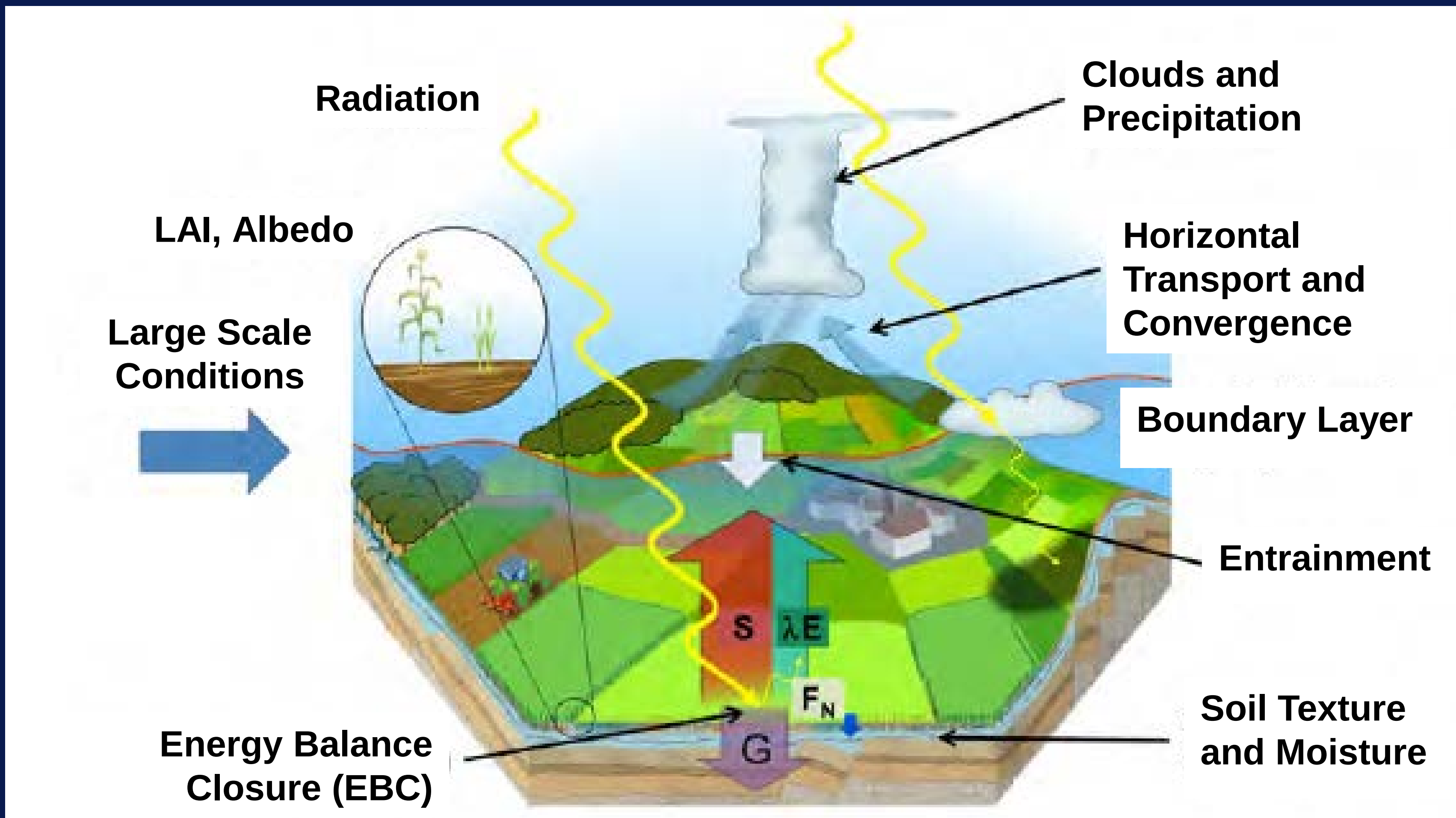
Time: 1119 LST



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



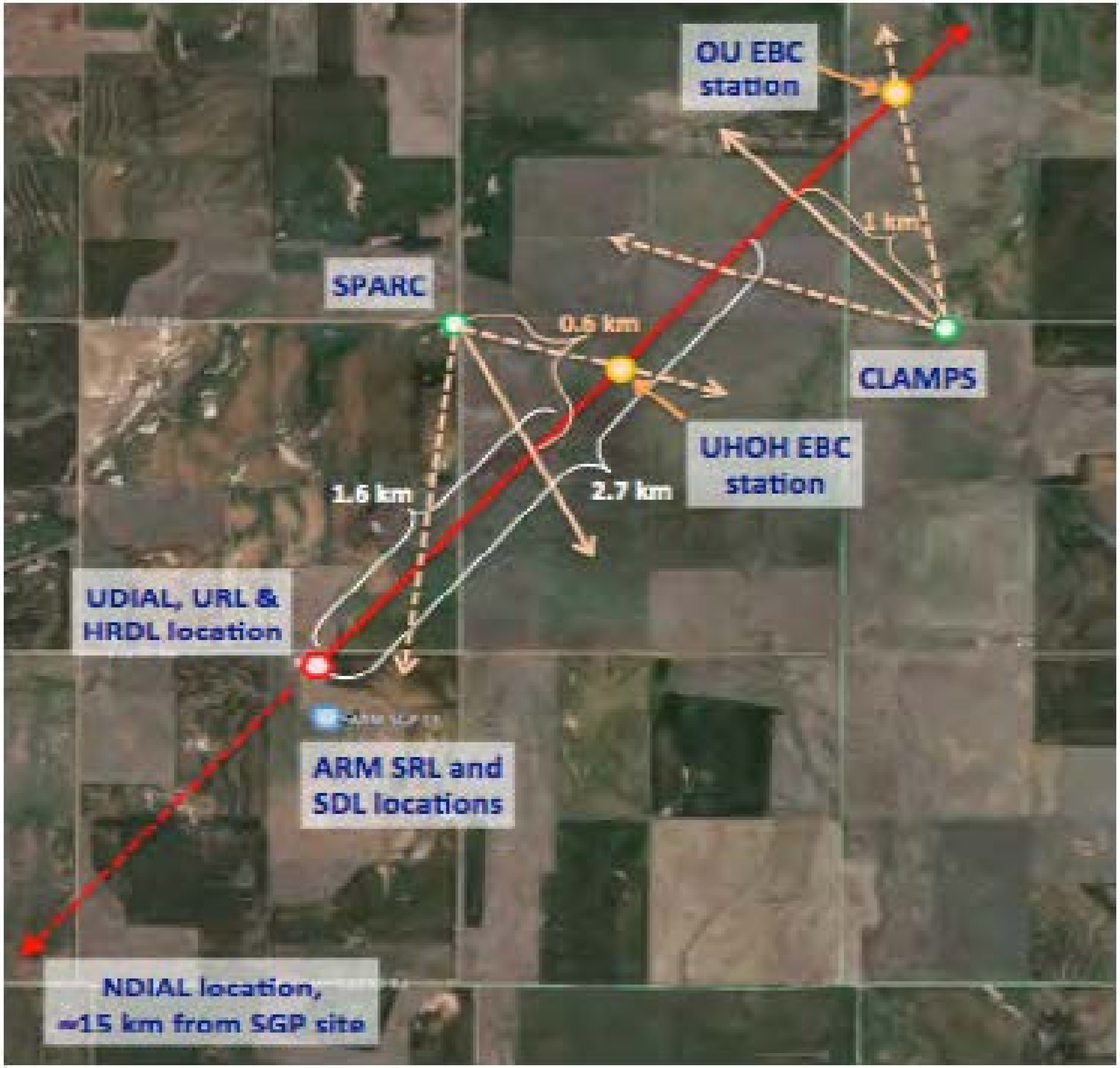
Land System and Feedback Processes



Land-Atmosphere Feedback Experiment (LAFE)

- Collaboration with ESRL, NSSL, GSD , U. Hohenheim, & DOE
- 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



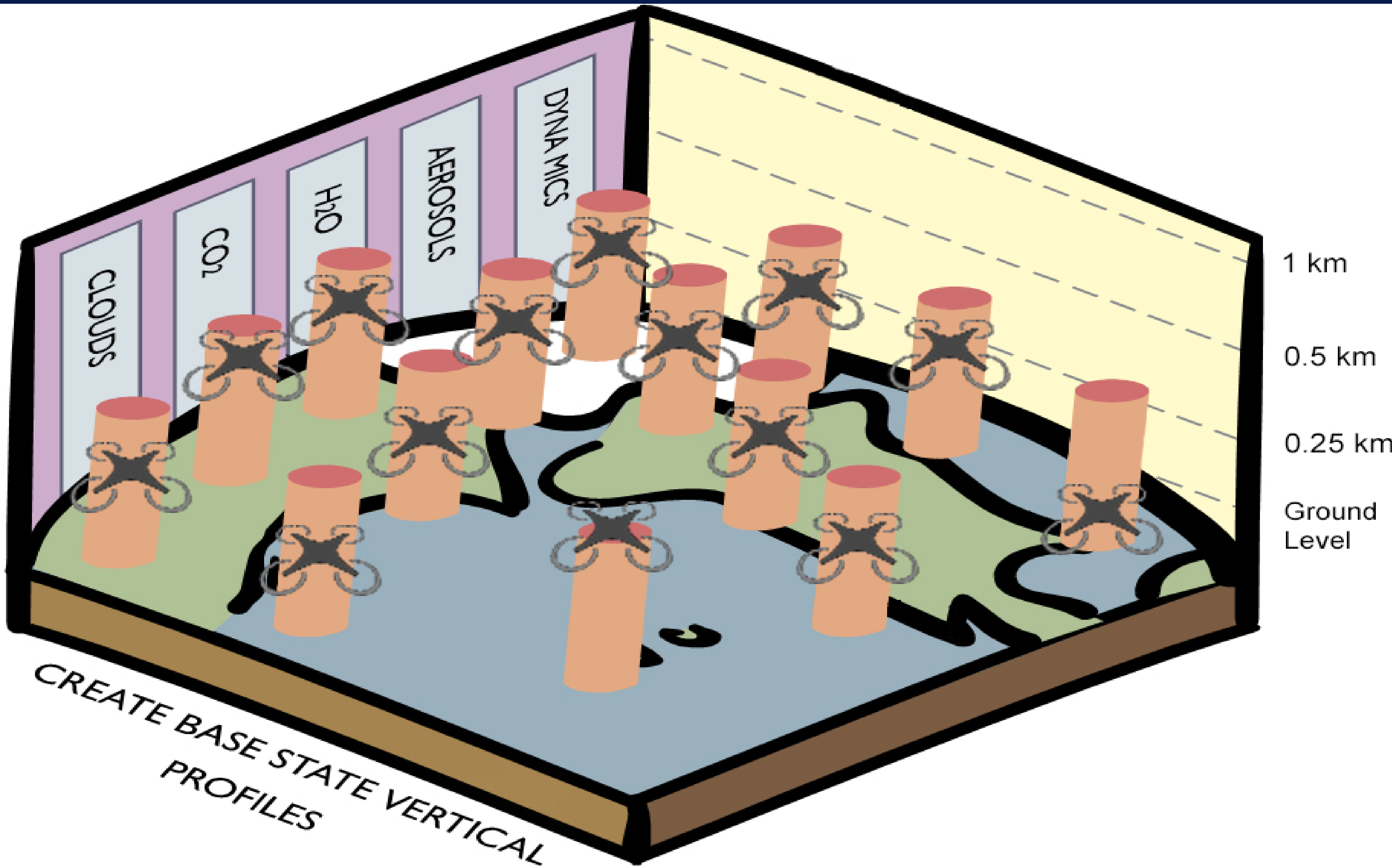
Instrument Platforms (ESRL, U. Hohenheim)

- 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

FUTURE DIRECTIONS



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