Collaboration Leading Operational UAS Development for Meteorology and Atmospheric Physics

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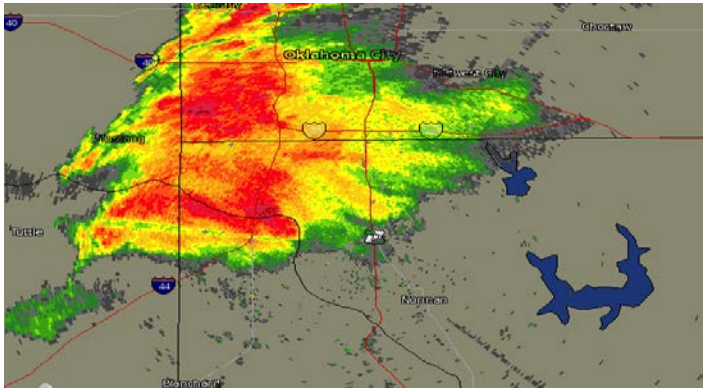
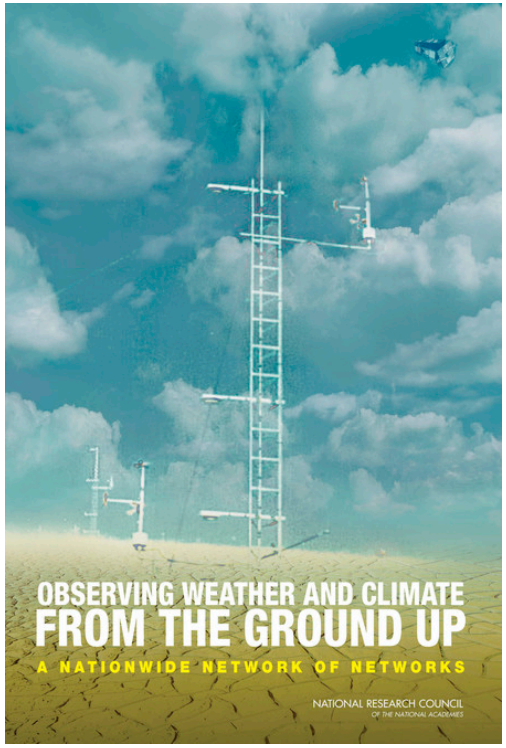


Supported by the National Science Foundation

2009 NRC Report



"The vertical component of U.S. mesoscale observations is inadequate. Assets required to profile the lower troposphere above the near-surface layer (first 10m) are too limited in what they measure, too sparsely or unevenly distributed, sometimes too coarse in vertical resolution, sometimes limited to regional areal coverage, and clearly do not qualify as a mesoscale network of national dimensions. Likewise, vertical profiles below the Earth's surface are inadequately measured in both space and time. The solutions to these particular deficiencies require leadership and infrastructure investments from each of the pivotal federal agencies."

Current Direct Atmospheric Measurement Methods


Towers


Balloons

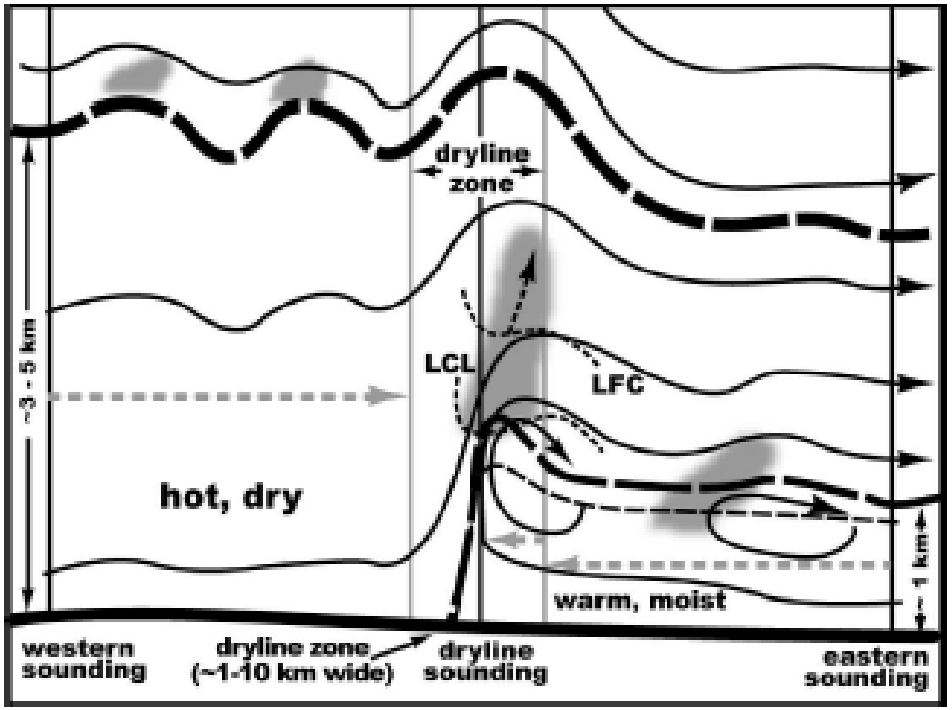

Radar


Manned aircraft

Storm Environmental Monitoring Needs

- **Radar:** cannot measure thermodynamic near-storm environment (variability of moisture, convective instability) nor monitor the structure of low-level boundaries in clear air where moist, unstable air is rising

- **Convection Initiation:** strength and depth of mesoscale updrafts, near-storm thermodynamics and storm-relative flow, parcel residence time sufficient to reach their LFC before leaving the mesoscale updraft regions

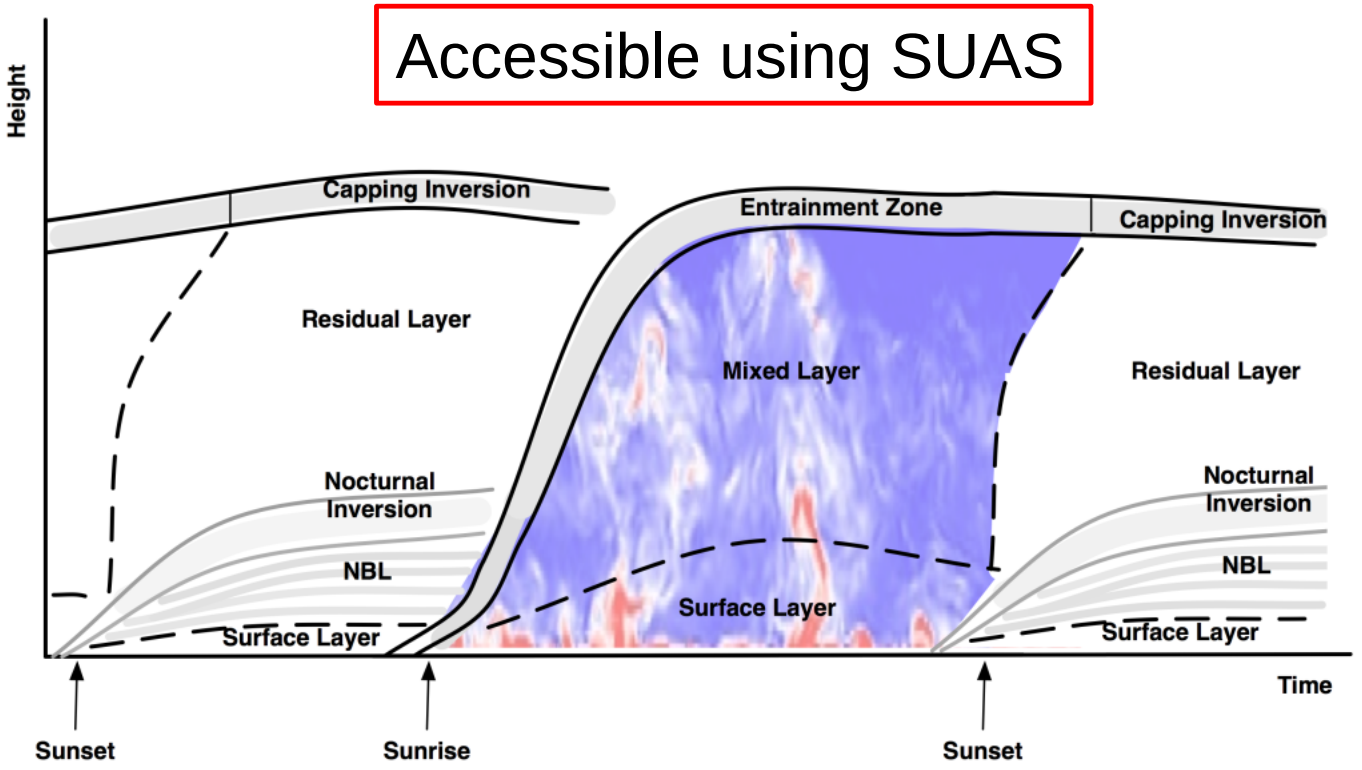


LFC: Level of Free Convection

Weckwerth, T., and D. B. Parsons, 2006: A review of convection initiation and motivation for IHOP-2002.

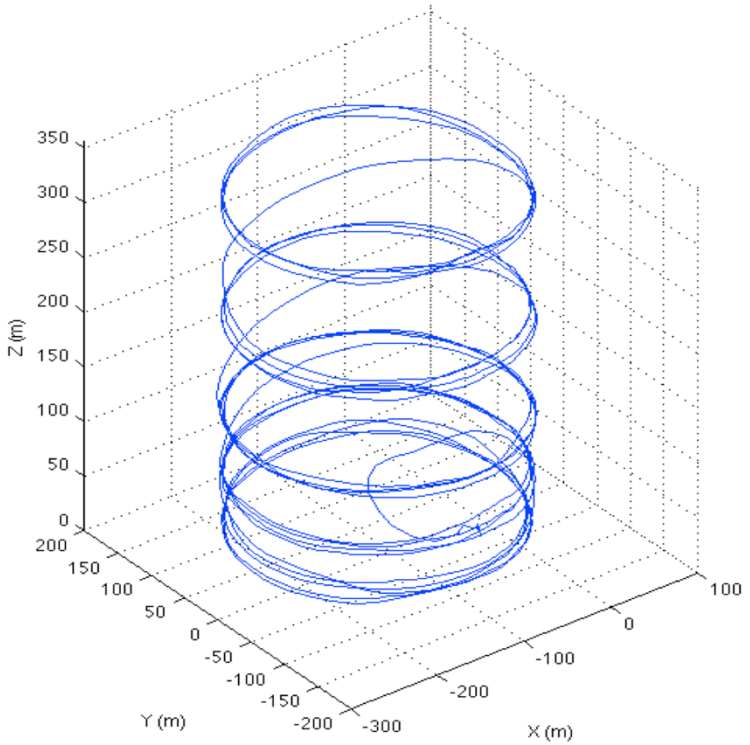
SUAS In Boundary Layer Meteorology

- Lowest part of the atmosphere (boundary layer) is directly influenced by terrain and diurnal cycle; includes heat transfer, pollution dispersion and advection, turbulence, agricultural, and urban meteorology
- Difficult to measure with radar, balloons, and towers

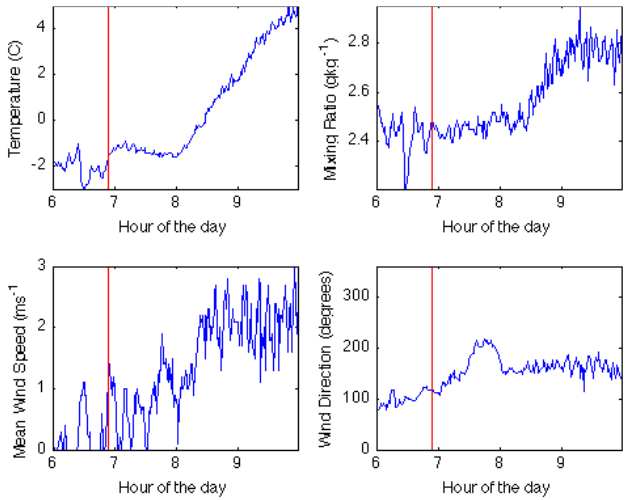


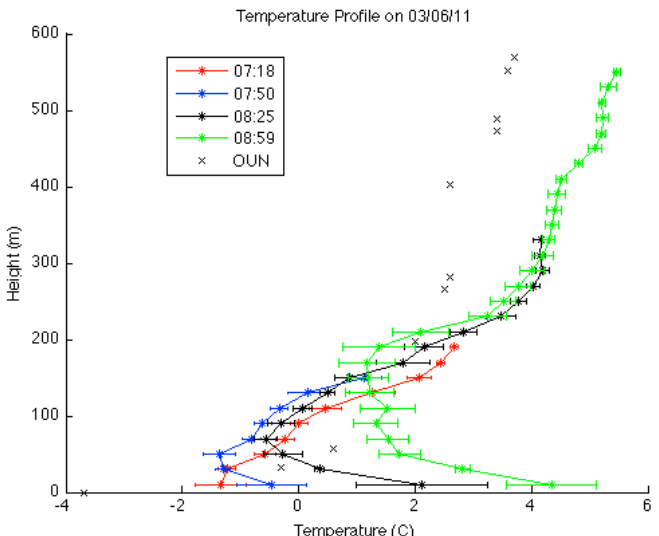
Meteorological SUAS

SUAS Meteorological Data Gathering



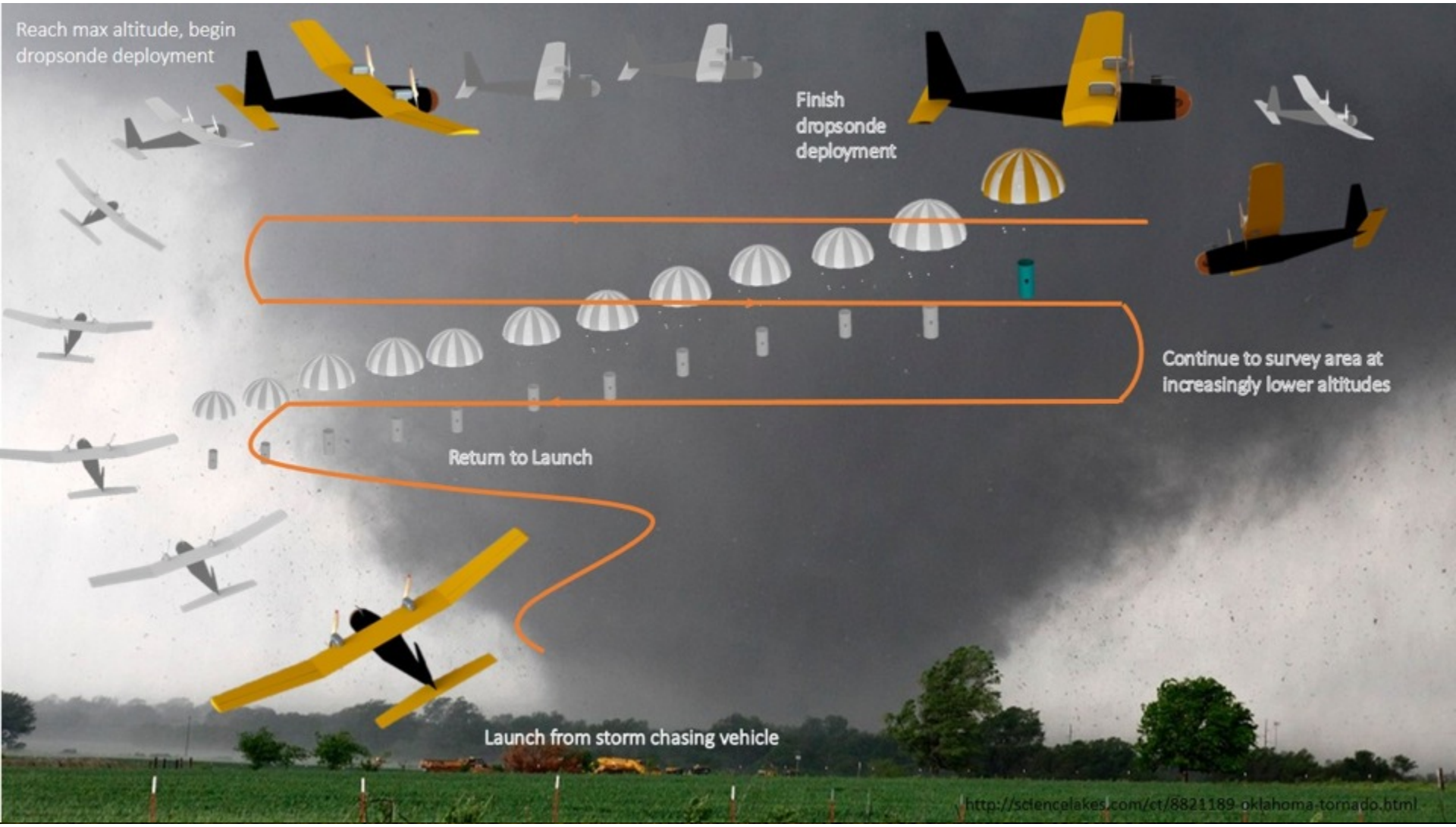
- Quantifying boundary layer profile and turbulence to compare with other instruments on ground & air
- Important for determining mixing in the air
- Sample air at each station for 3-4 minutes; temp., pressure, humidity, wind, etc.



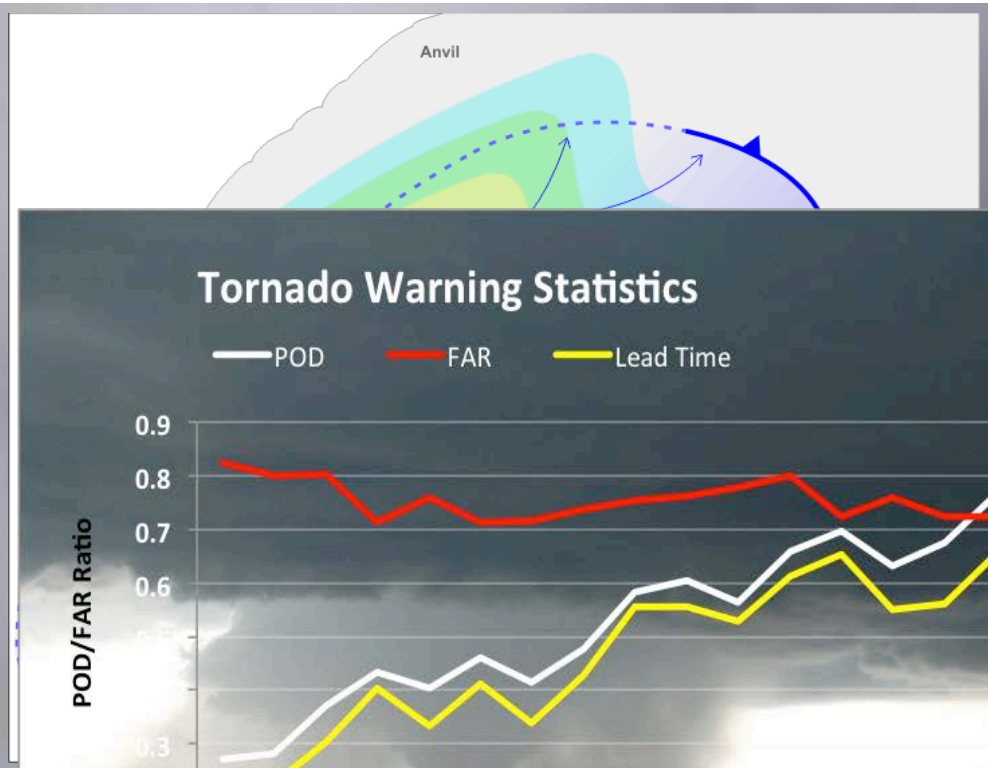


Chilson

SUAS Weather Profiling Concepts



Severe Weather - Anatomy of a Supercell

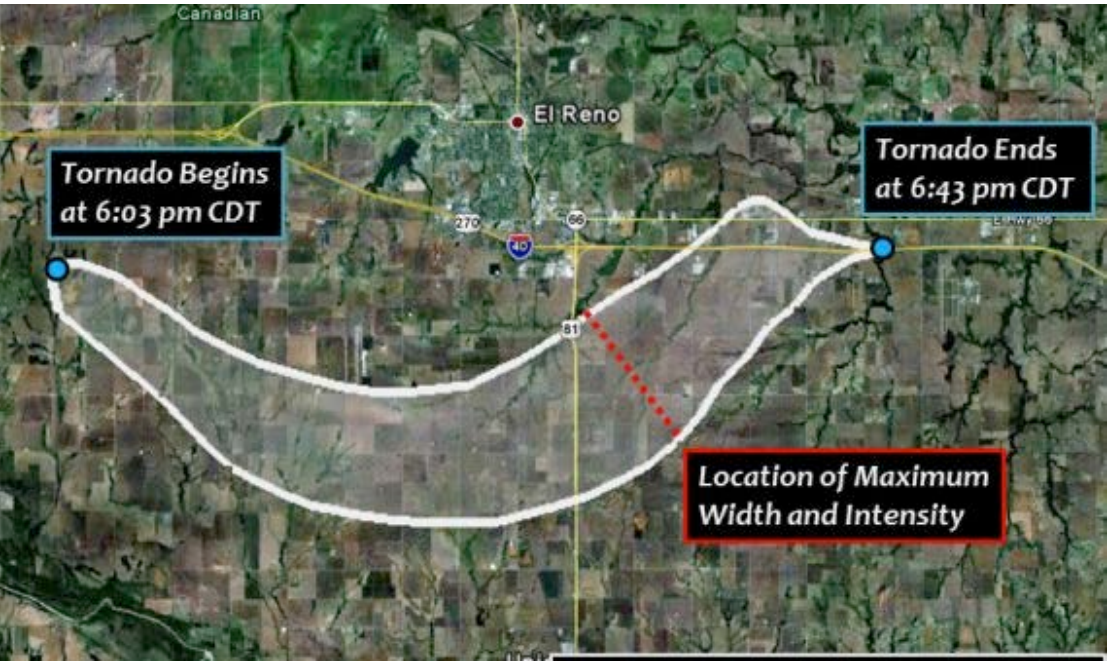


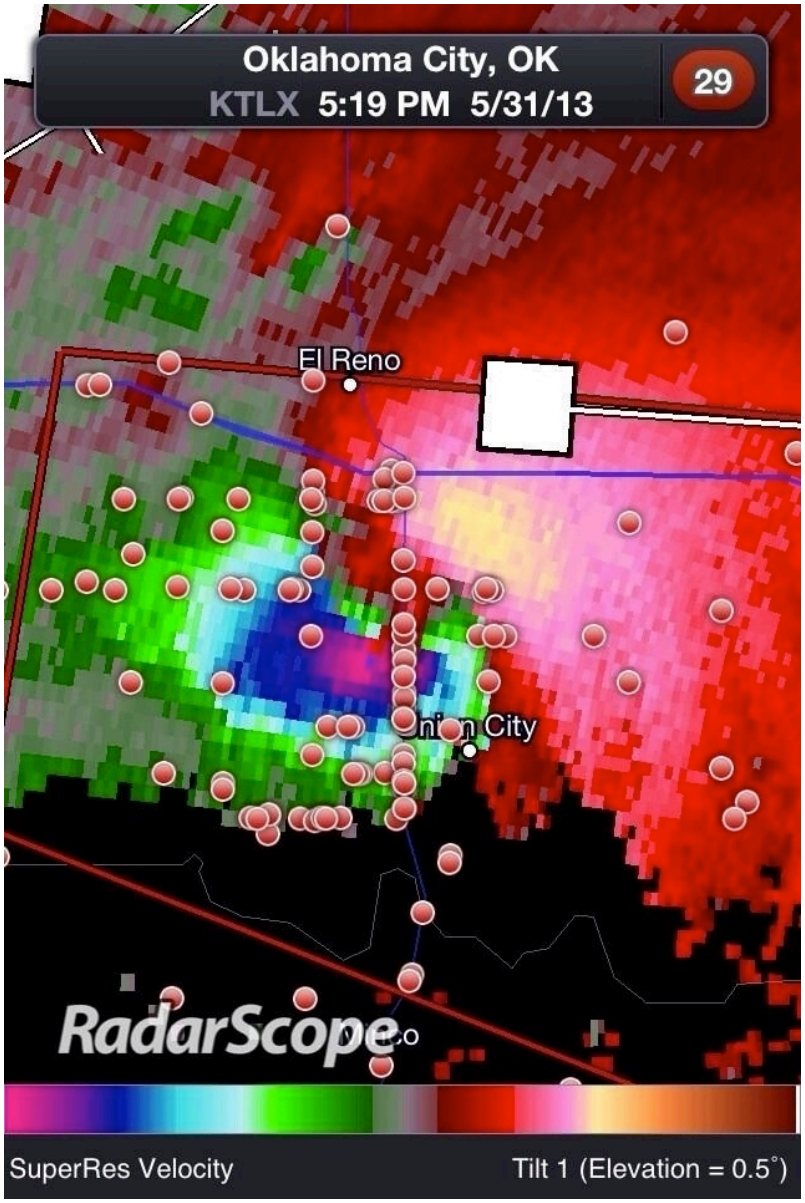
We need a new paradigm shift!

Introduction of WSR-88D

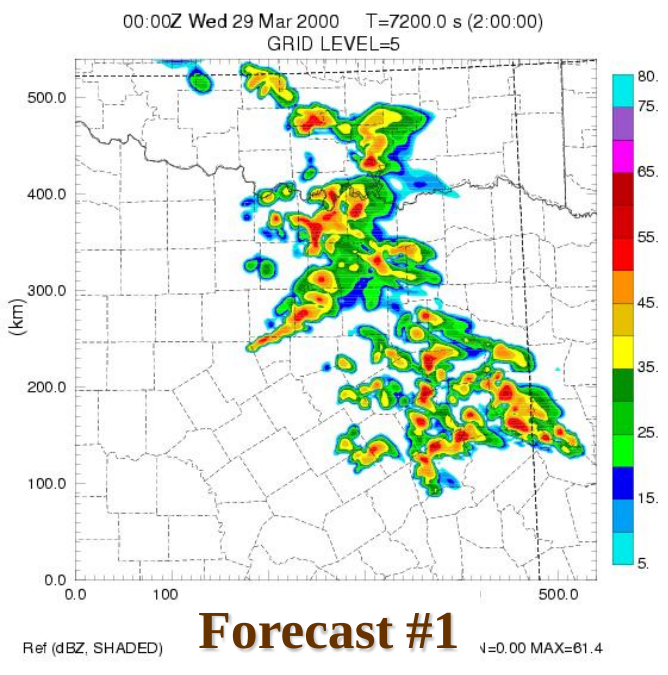
El Reno, May 31, 2013

El Reno Tornado Path (Initial Cyclone)





The Million Dollar Question: With the Right Data Will Forecasting Models Ever Be Able to Predict Tornados?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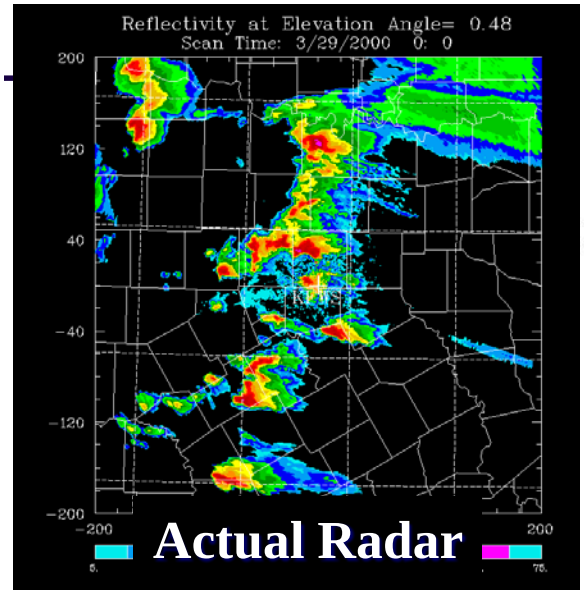
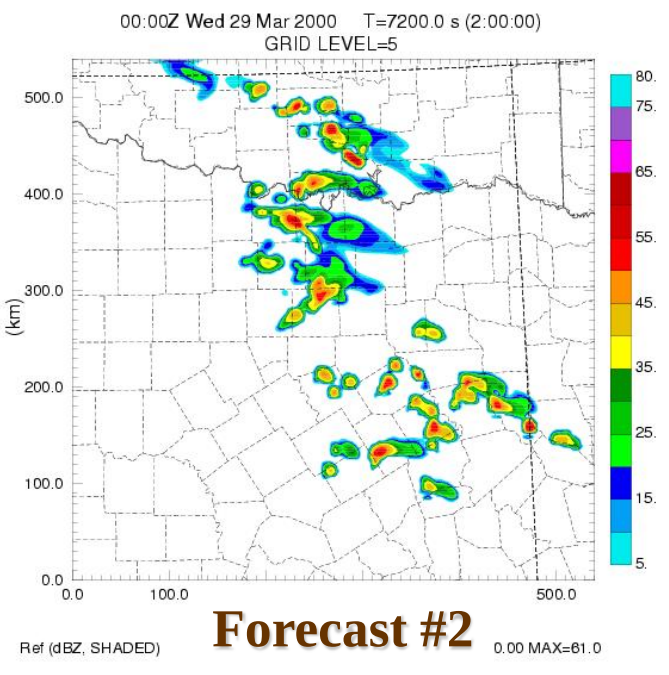
GRID LEVEL=5
Ref (dBZ, SHADED)
Forecast #1


Reflectivity at Elevation Angle= 0.48
Scan Time: 3/29/2000 0: 0
Actual Radar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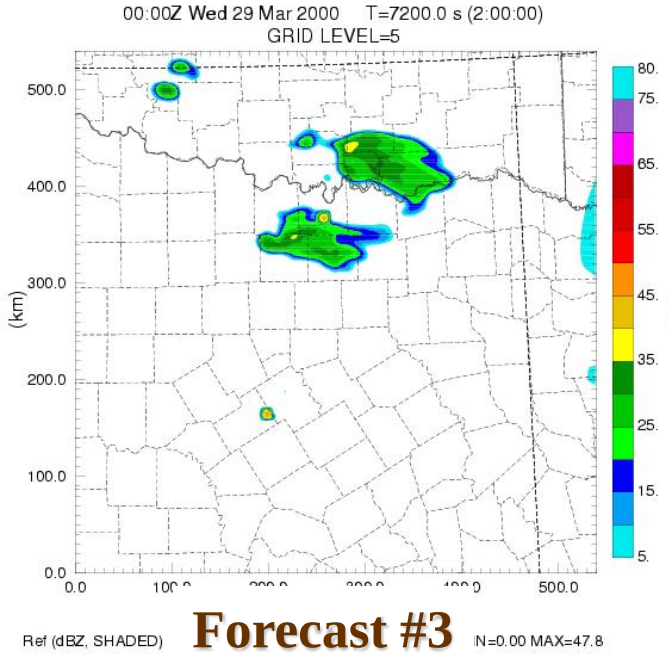
Forecast #2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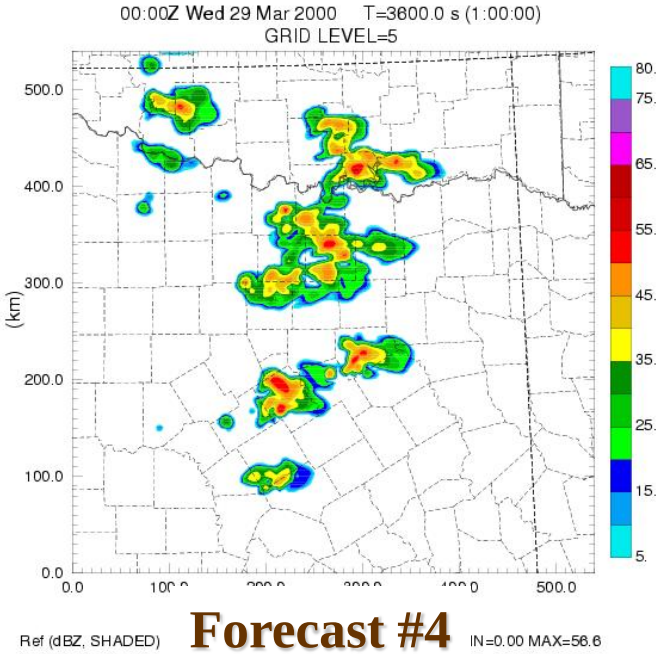
Forecast #3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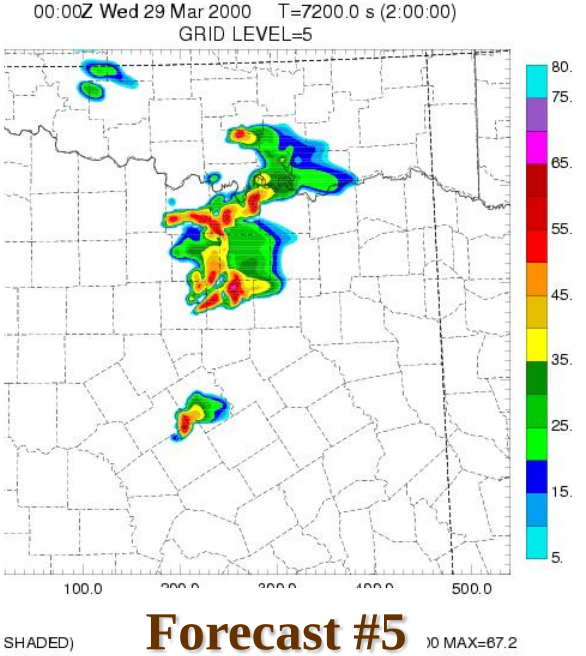
Forecast #4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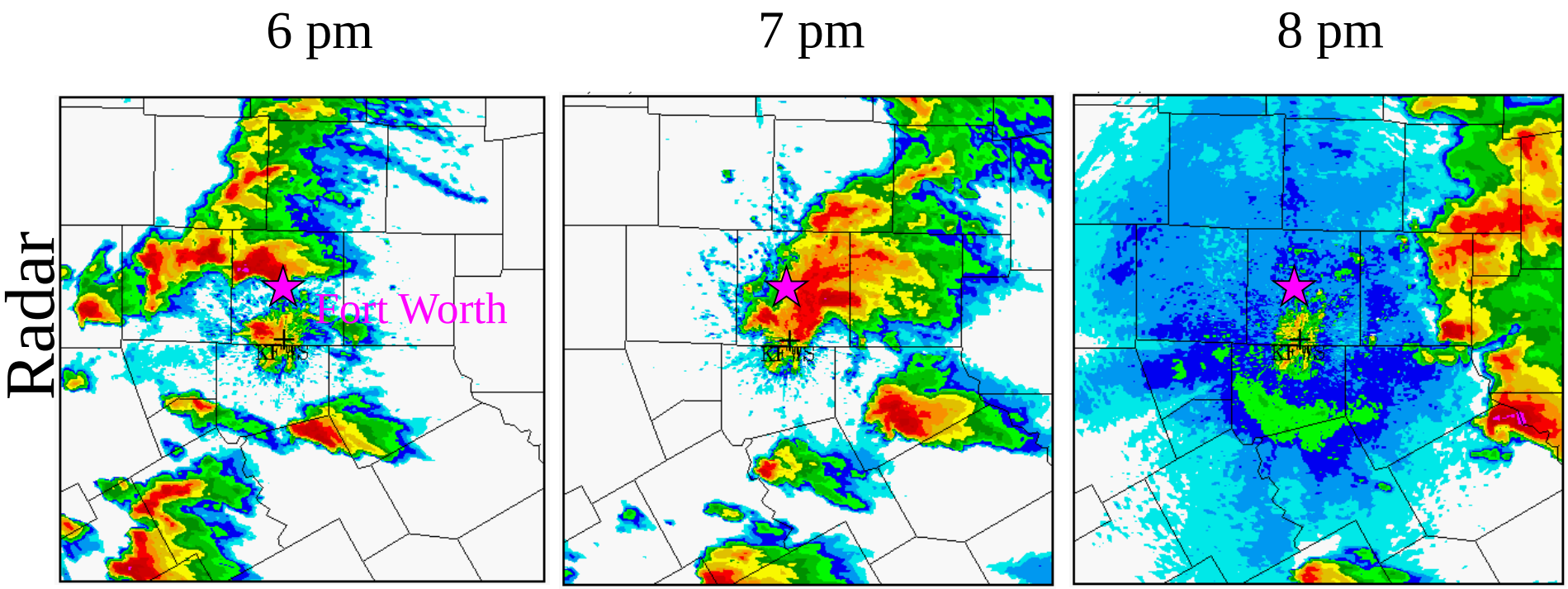
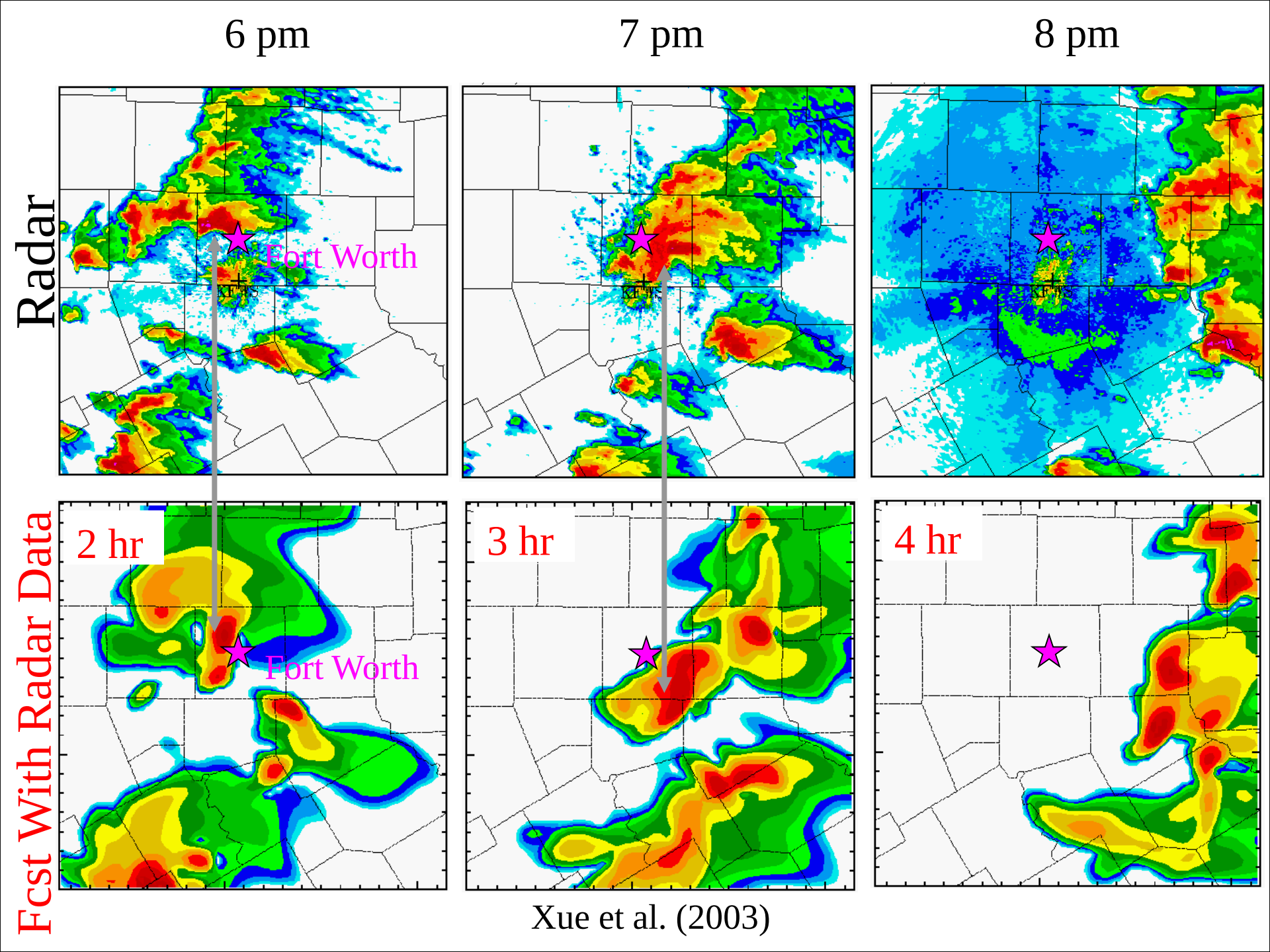
Forecast #5

NOAA



Hourly Radar Observations (Fort Worth Shown by the Pink Star)

Xue et al. (2003)

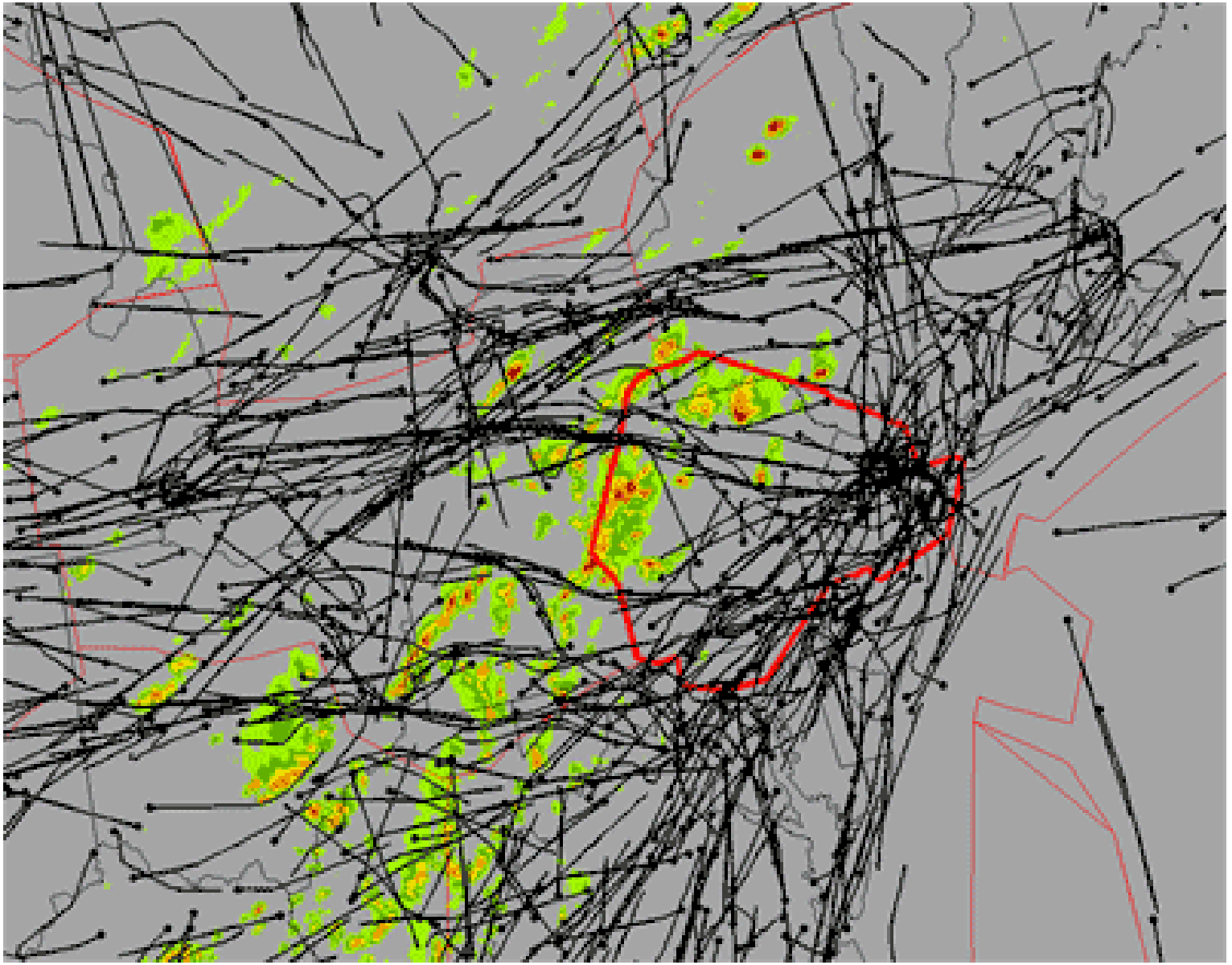

6 pm
7 pm
8 pm
Radar
Fort Worth
2 hr
3 hr
4 hr
Fort Worth
Fcst With Radar Data
Xue et al. (2003)

Summary of Broader Impacts

The project will

1) develop UAS autonomous control systems, advanced atmospheric sensors and robust data management systems to allow innovative, expansive **use of SUAS for atmospheric science and meteorology increasing scientific understanding of the atmosphere and increasing public safety**;
2) produce graduates with value added experience to fill technology-based needs in UAS operations and atmospheric sciences;
3) and **educate the public and enhance the perception of safe operation and adoption of UAS technology** through workshops and outreach events.

Impact on Traffic



SUPPLEMENTAL

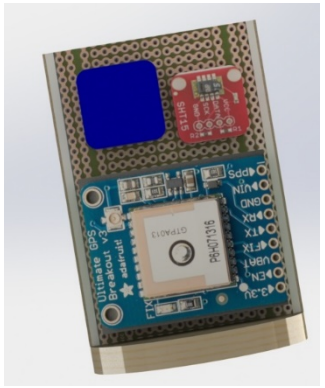
Relation to Oklahoma Mesonet

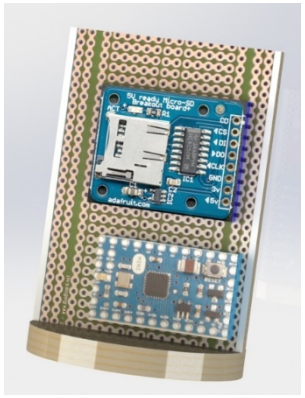
- Mesonet data can be used as validation data and indicators of when to fly – e.g., looking for incoming fronts – UAS will be part of a larger nationwide network

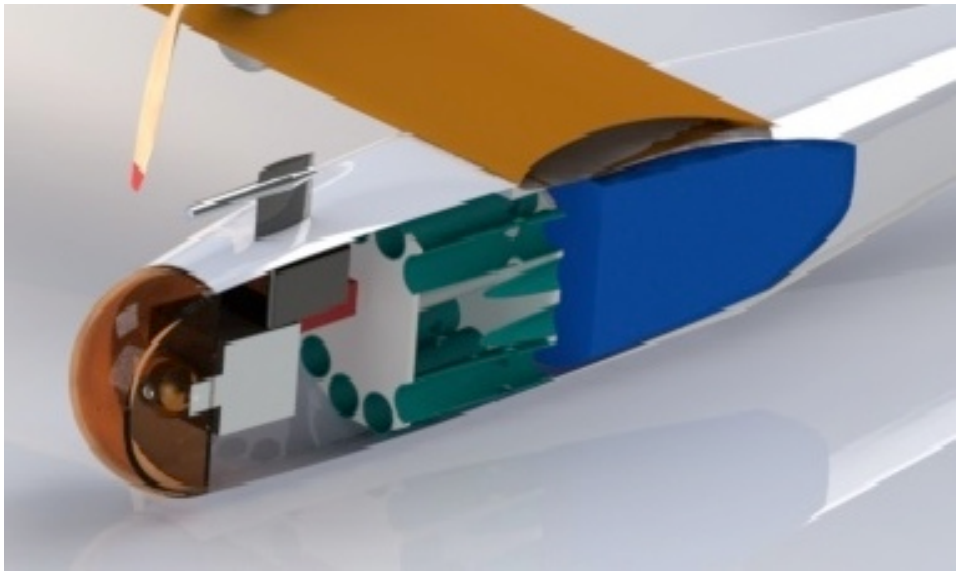
- Current sites measure meteorological variables at 2 and 10 m above ground level (2D) – a UAS would provide **3D** "Mesonet like" capability
- If temperature, humidity, pressure, and wind could be measured all the way through the boundary layer 1-2 times an hour with a UAS, it would
  - *Provide a better understanding of the boundary layer with a wealth of data*
  - *Be able to monitor the erosion of the "cap" to determine if/when/where severe storms might initiate*
  - *Retrieve wind profiles to determine if tornadoes are likely to form*

MARIA Sensors

- MARIA carries a TAMDAR sensor suite, EO/IR cameras and dropsondes
- Dropsonde sensors are made of small inexpensive breakout boards that will send data to mothership and are stored in a rotating dispenser that deploys on command

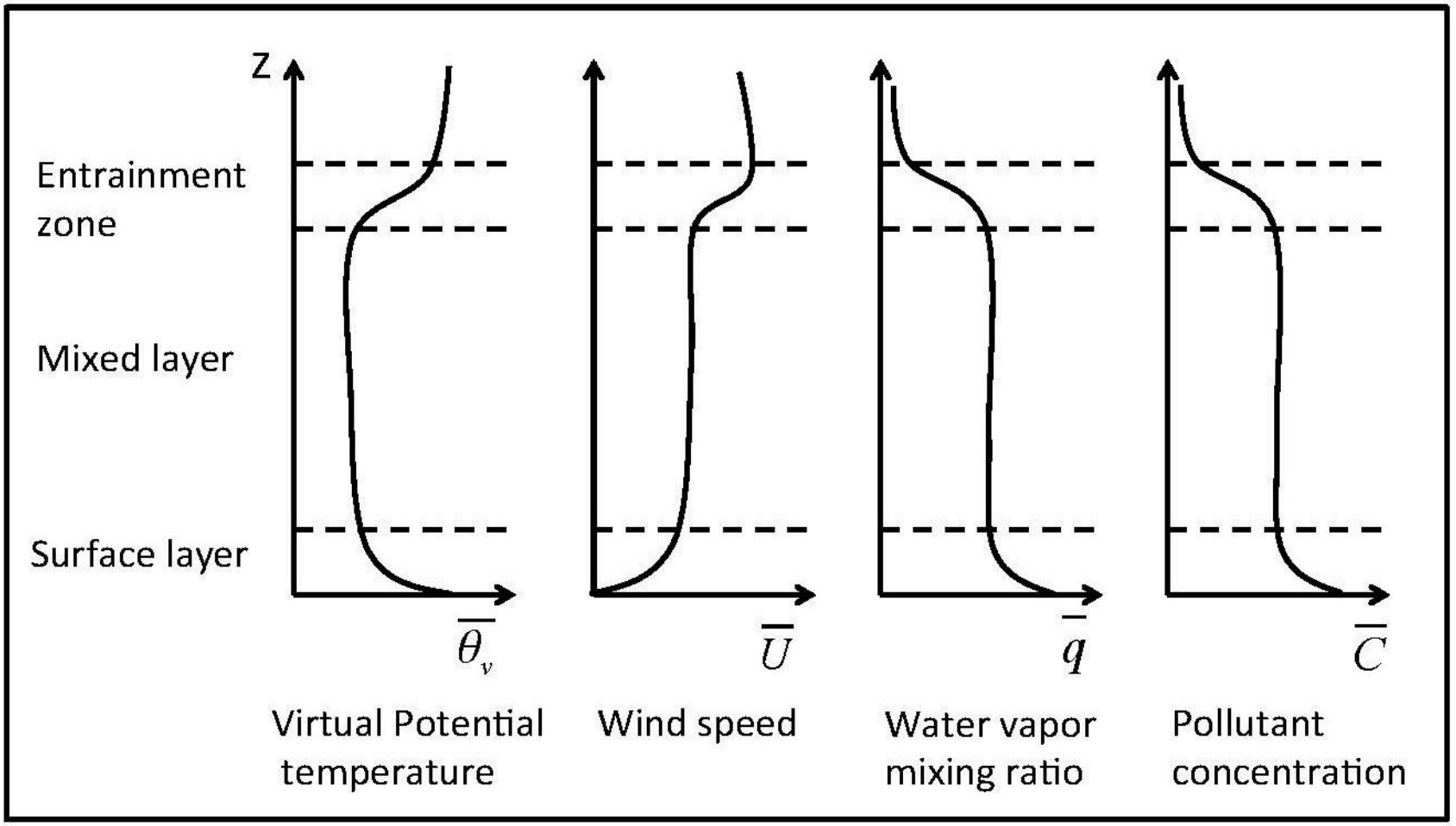






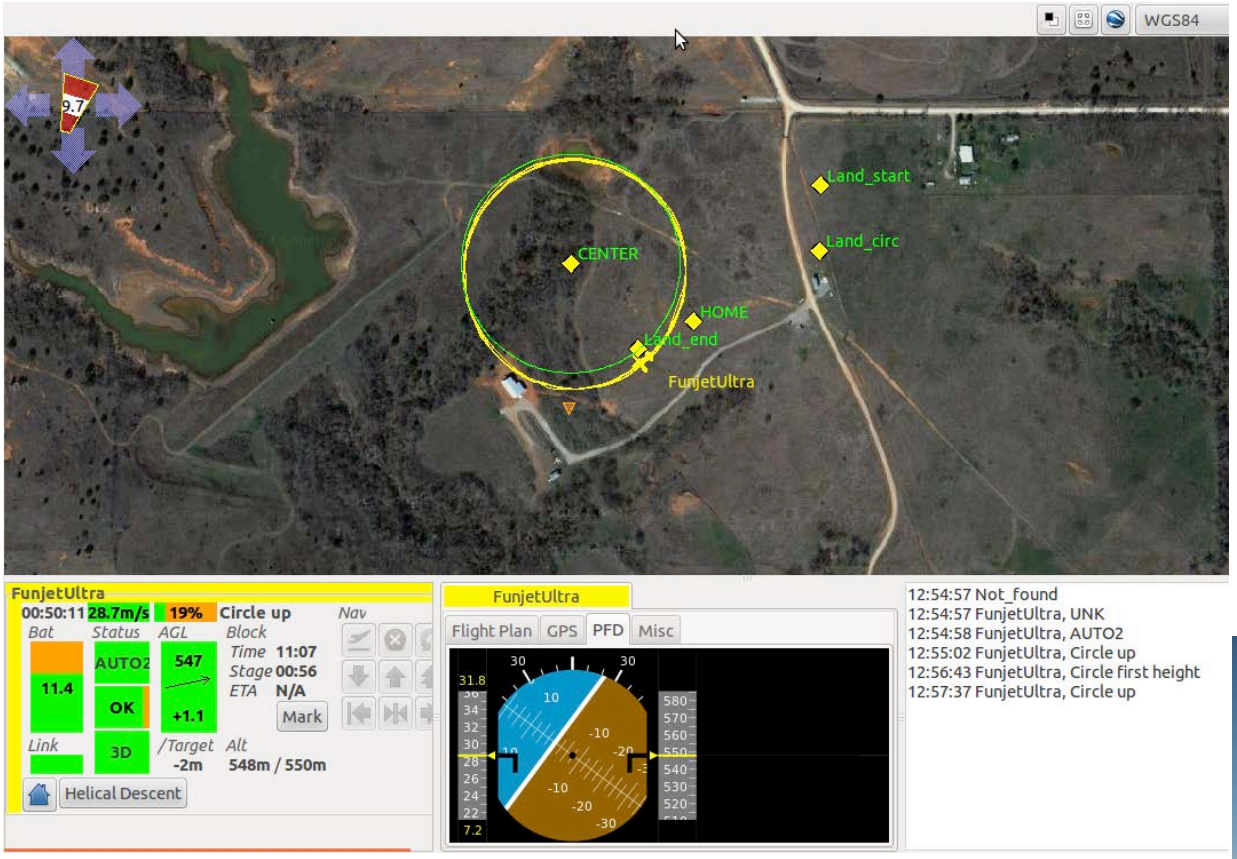
- Dropsonde weight: 10 oz., and size: 1.6 dia x 6”
- On-board data collection
  - *Wind speed and direction*
  - *Pressure*
  - *Temperature*
  - *Humidity*
  - *GPS location and time*

Convective Boundary Layer



Characterizing the convective boundary layer

SMARTSonde



Small

Multi-function

Autonomous

Research &

Teaching

Sonde

- Paparazzi open source autopilot
- IMU and gyro for attitude, upgraded from IR thermopiles
- Currently measures temperature, humidity, pressure, capable of retrieving winds accurately

Photos: Gabe Wingfield