NASA LASE Observations of Convective Events
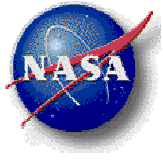
Syed Ismail[1], Edward V. Browell[1], Richard Ferrare[1], Susan Kooi[2], Vincent Brackett[2], Hank Revercomb[3], Bob Knuteson, and Paolo Antonelli[3]

[1]Atmospheric Sciences, NASA Langley Research Center, Hampton, VA 23681
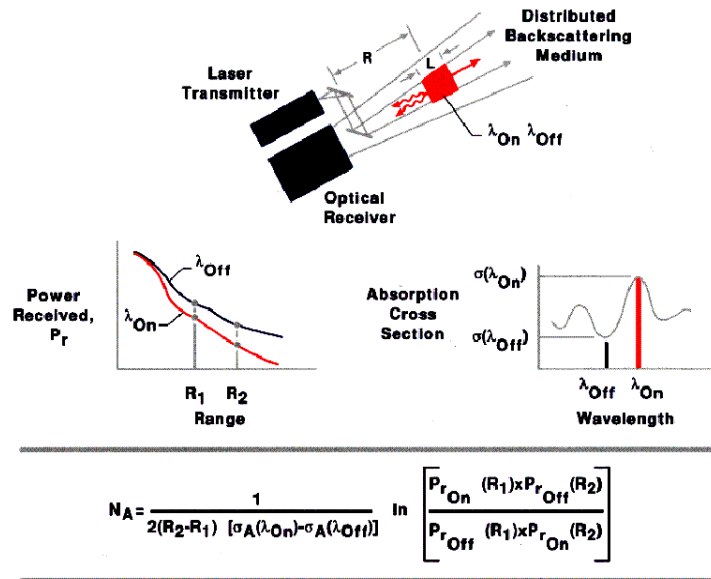*[2]Science Application International Corporation, Hampton, VA 23666*
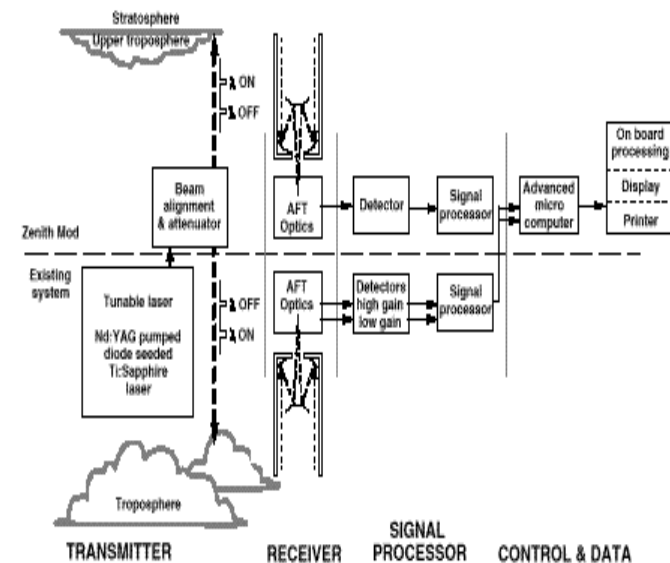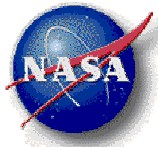*[3]SSEC, University of Wisconsin, Madison, WI, 53706*

Lidar Atmospheric Sensing Experiment (LASE)

Airborne Water Vapor DIAL

- Laser
    - 5 Hz doubled-pulsed Ti:sapphire
    - 100 mj at λ_{on} and λ_{off}
- Wavelengths
    - 815 nm (λ_{on}- λ_{off} = 40-70 pm)
    - Two separate line pairs
- NASA ER-2, P-3, <u>DC-8</u> aircraft
- Simultaneous nadir, zenith operations
- Real-time data analysis and display

LASE Water Vapor, Aerosol, & Cloud Profiling on NASA DC-8

Water vapor profiles
- daytime and nighttime
- surface to upper trop.
- 0.01 to 25 g/kg
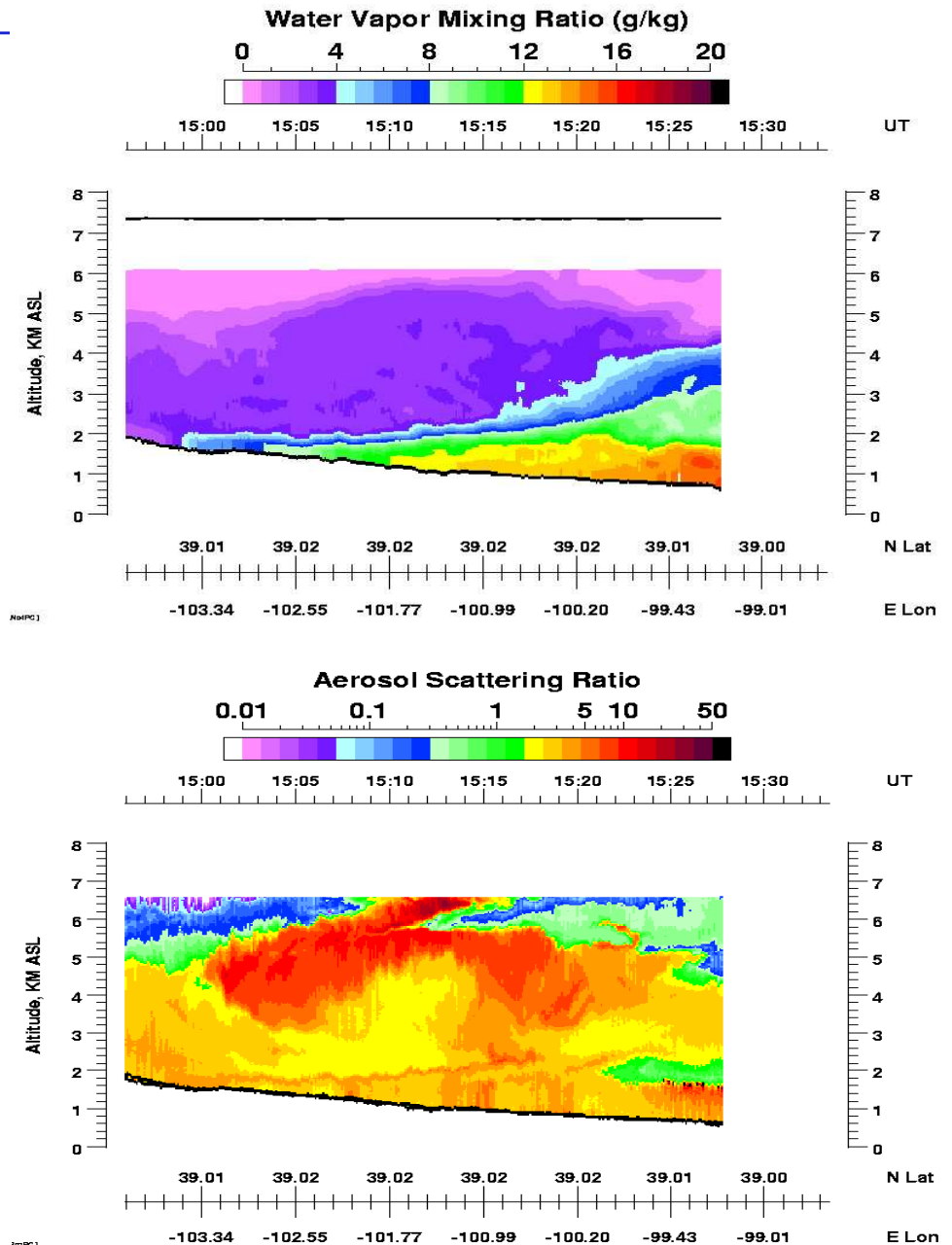- accuracy: 6% or 0.01 g/kg
- resolution (variable)
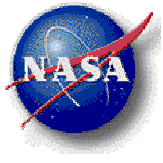   vertical: 330 m
   horizontal: 14 km (1 min)

• **Aerosol/cloud profiles**
- daytime and nighttime
- 0.03 to 25 km
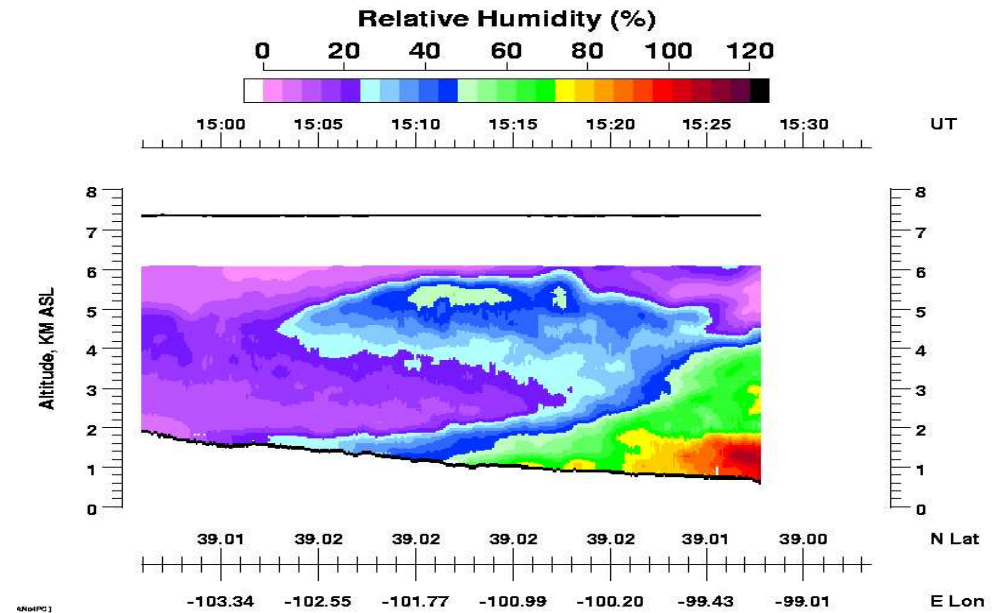- resolution (variable)
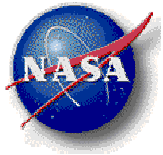   vertical: 30 m
   horizontal: 200 m

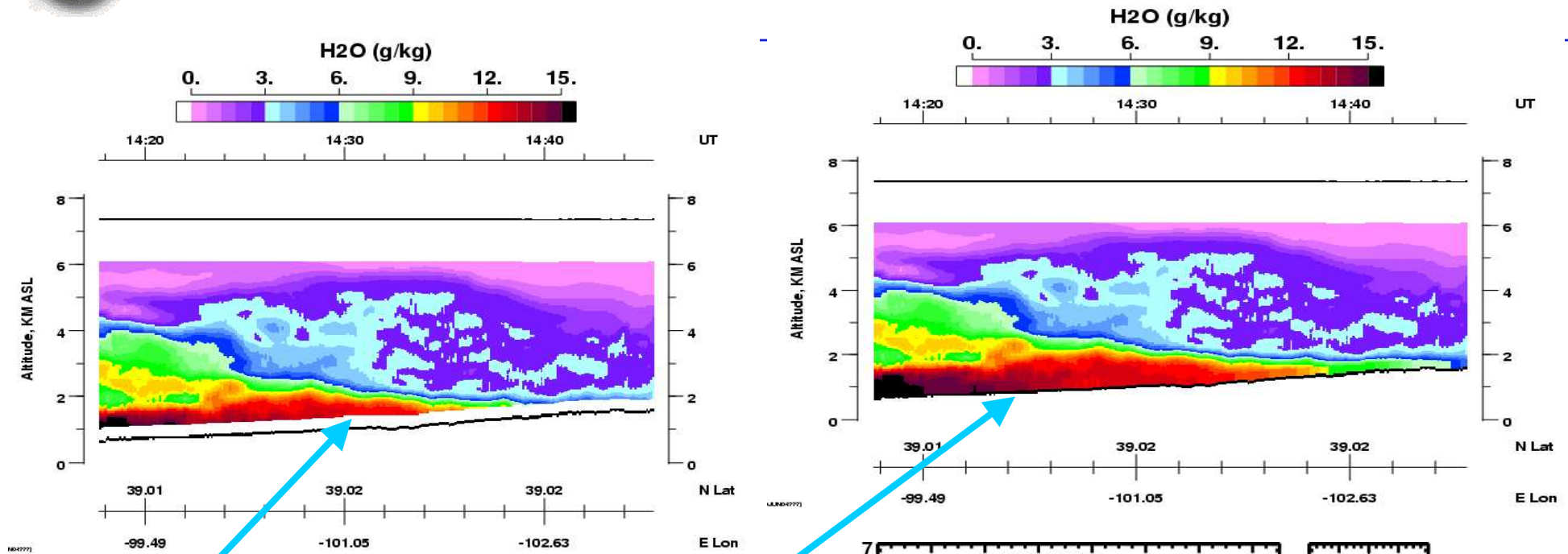Water Vapor Mixing Ratio (g/kg)

Aerosol Scattering Ratio

- **Relative humidity profiles - derived using temperature profiles from Scanning-HIS or radiosondes/dropsondes**
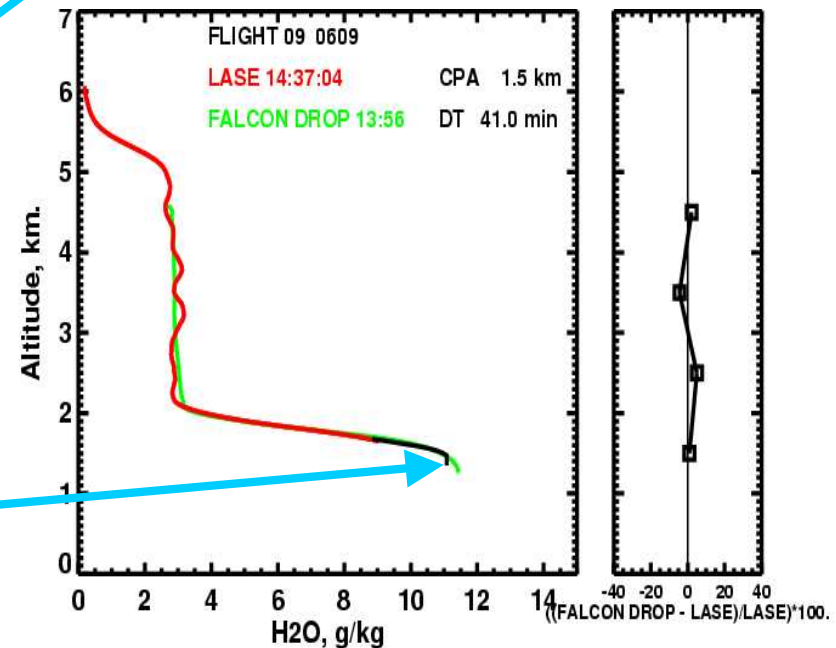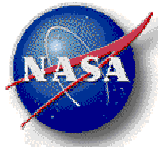
LASE Ground Return Water Vapor Estimation

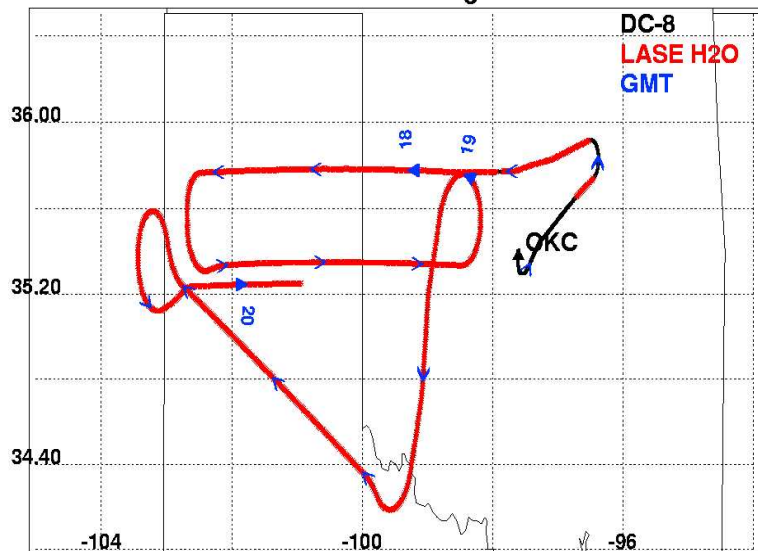**Routine DIAL processing leaves gap above the ground**

•**Ratios of on to off ground returns and atmospheric signals above the gap are used to calculate optical depth and water vapor concentrations**

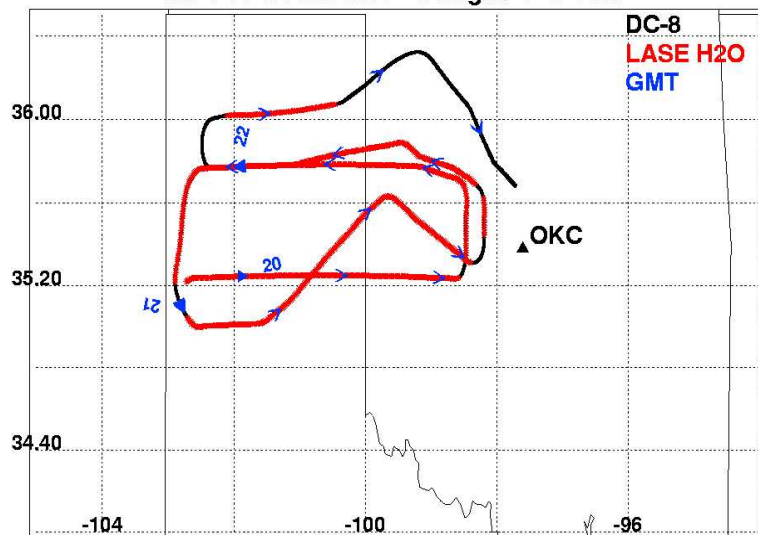•**Good agreement of ground return water vapor with dropsonde**

May 24, 2002 DC-8 Flight 5 CI #1 Flight Tracks
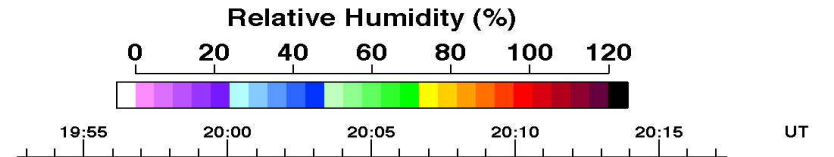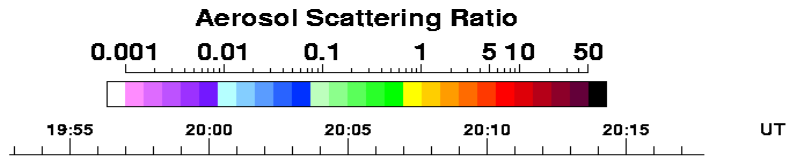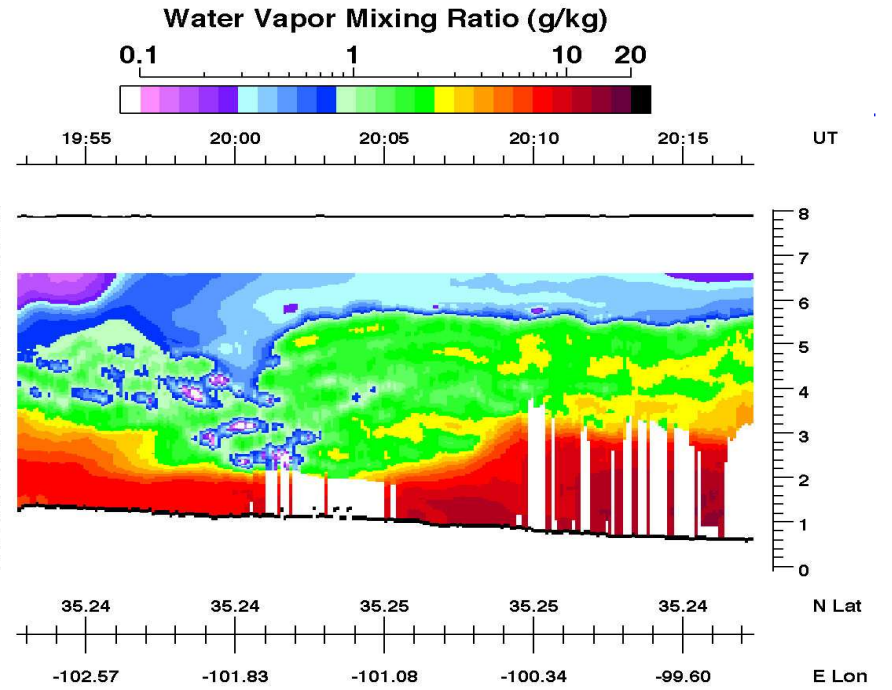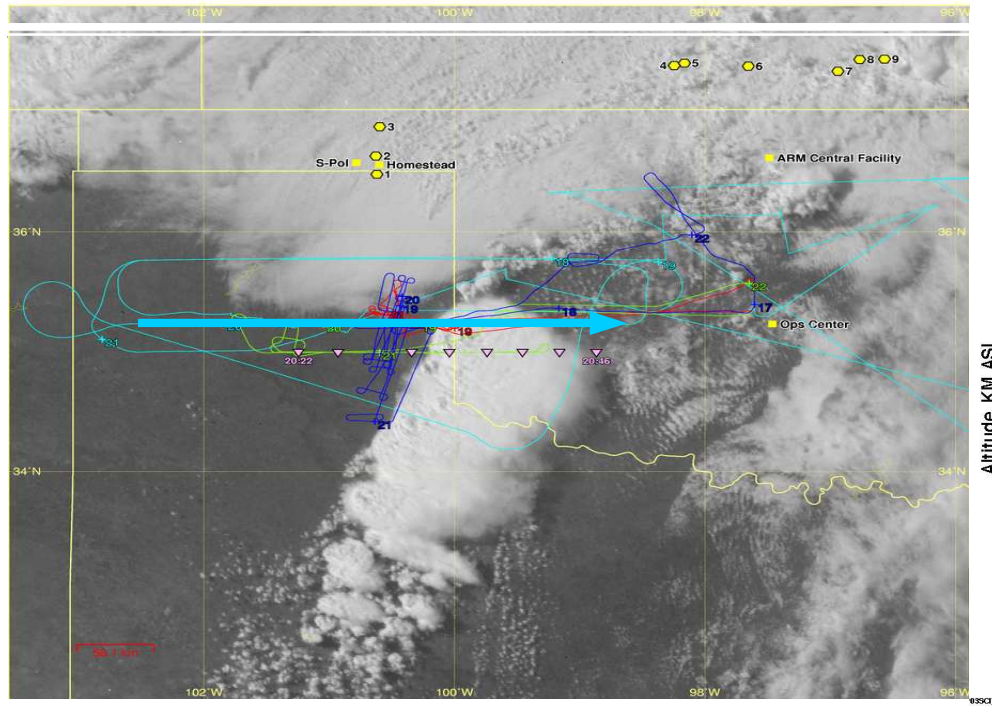
CI Mission 2002/05/24 1500-2300 UTC
GOES-8 1km visible 2002/05/24 21:25 UTC

○ NCAR Integrated Surface Flux Facility
▽ Learjet Dropsondes(8) 05/24 20:22:21 - 05/24 20:46:42 UTC

NASA DC-8 05/24 16:58 - 05/24 22:58 UTC
King Air 05/24 18:01 - 05/24 21:53 UTC
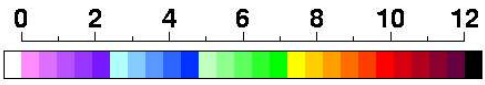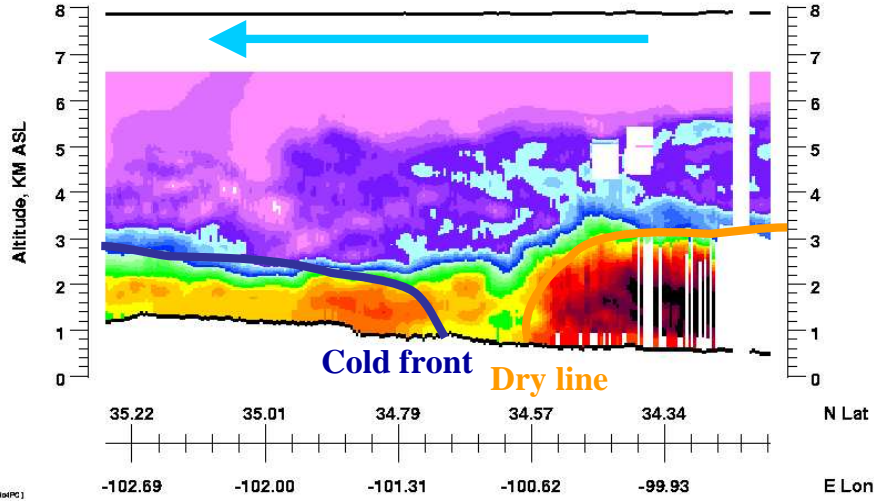Falcon 05/24 18:27 - 05/24 22:04 UTC
NRL P-3 05/24 16:49 - 05/24 22:42 UTC
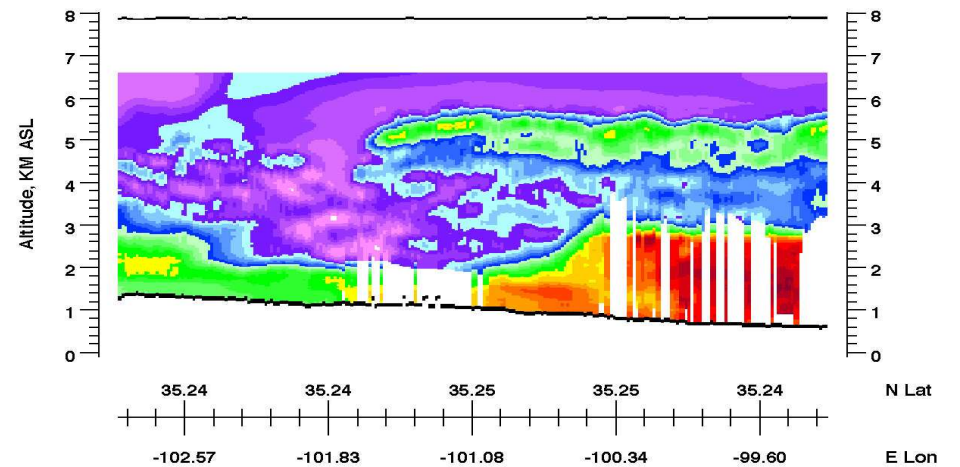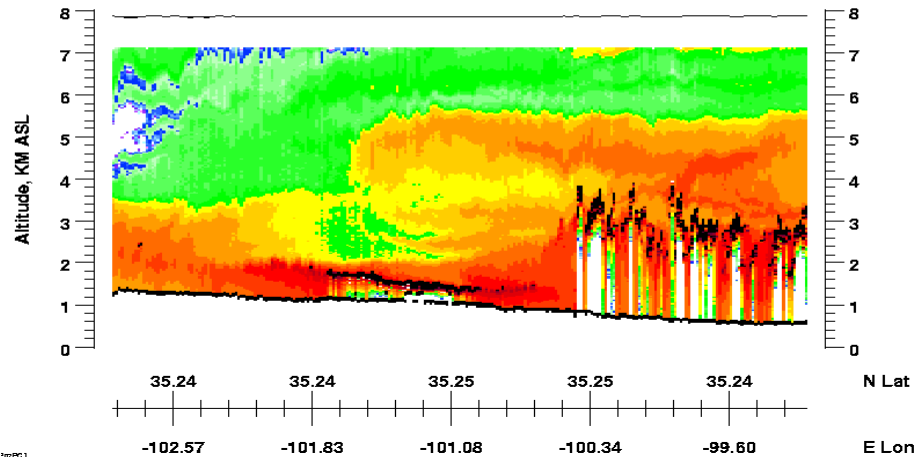
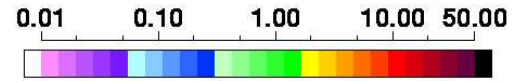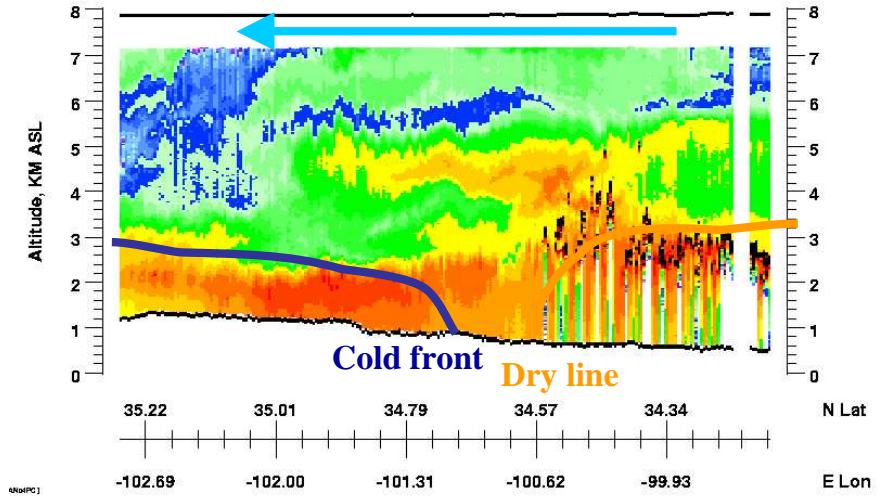**Water Vapor Mixing Ratio (g/kg)**

Aerosol Scattering Ratio

Relative Humidity (%)

Water Vapor Mixing Ratio (g/kg)

Aerosol Scattering Ratio
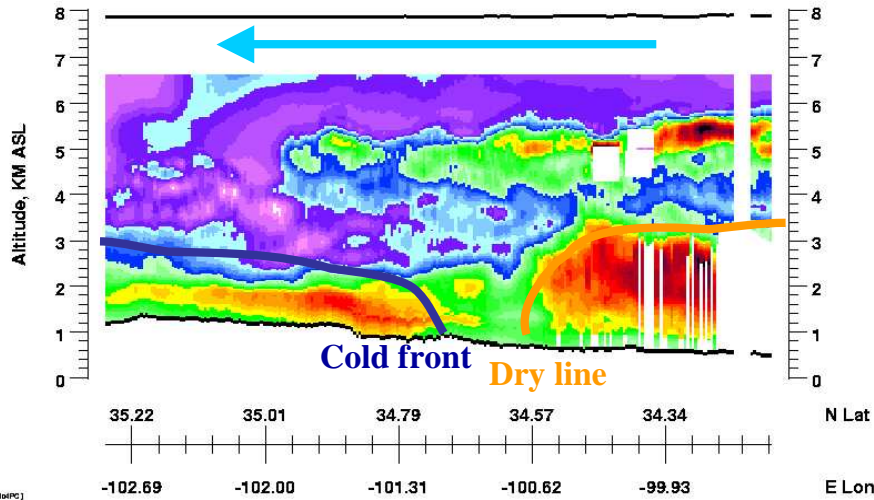
Relative Humidity (%)

Equivalent Potential Temperature (K)
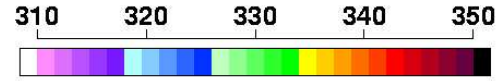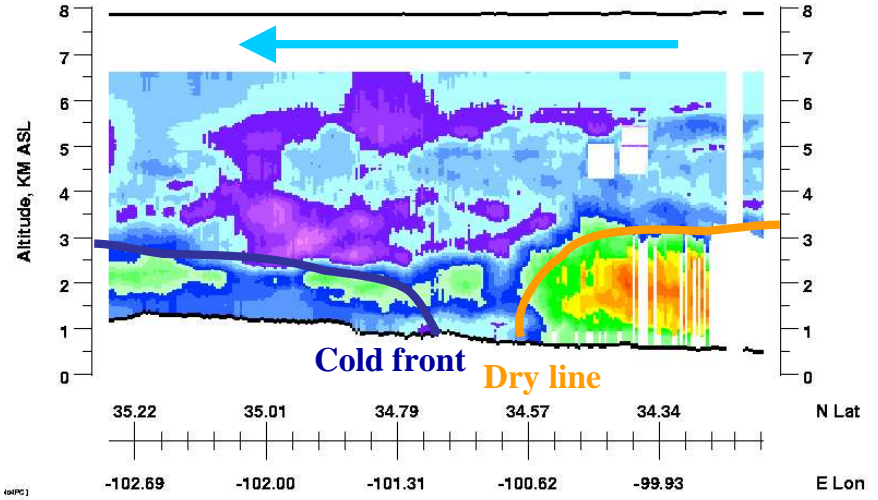
Deep convection requires:

- moist layer in low to mid troposphere
  - high water vapor mixing ratio, relative humidity
- steep lapse rate to allow for large buoyant energy
  - high Convective Available Potential Energy (CAPE)
  - Equiv. Pot Temp – θ_e decreases with height – convectively unstable
- sufficient lifting to allow parcel to reach Level of Free Convection (LFC)
  - small Convective Inhibition (CIN)
  - lifting mechanism

Use IHOP airborne profile data to evaluate potential for deep convection

- Examined test cases of May 24, and June 9
- Water Vapor Profiles – LASE
- Temperature Profiles – SHIS and dropsondes
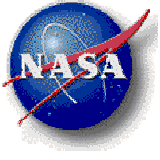
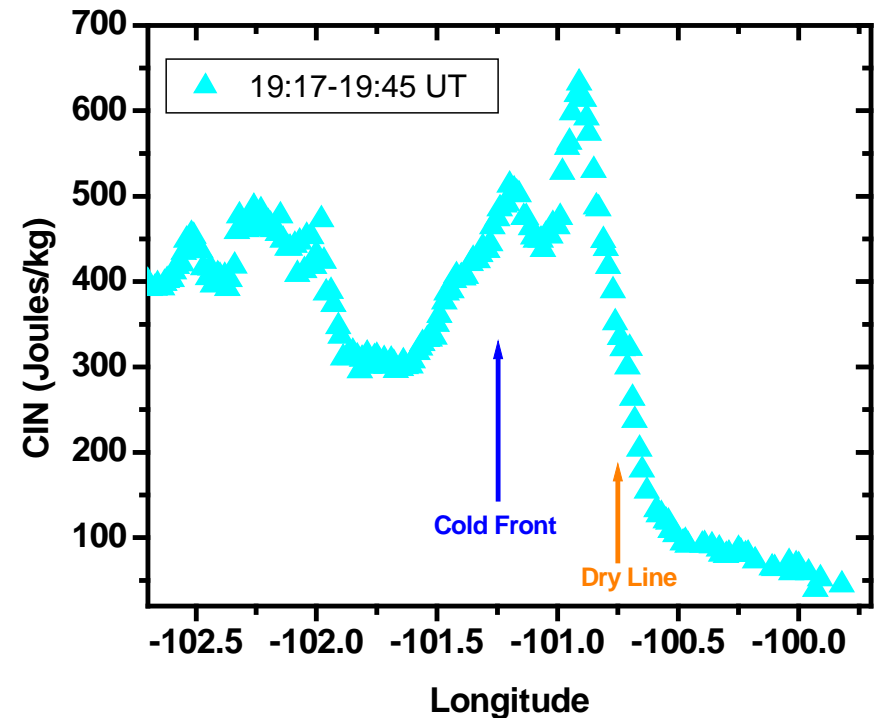- **High values of CAPE (2000-2500) indicate moderate to high instability ahead of dry line; low values of CAPE behind dry line and cold front**
- **Low values of CIN (<100) indicate weak cap ahead of dry line**
- ➤ **Deep convection occurred ahead of dry line and cold front in southwest Oklahoma**
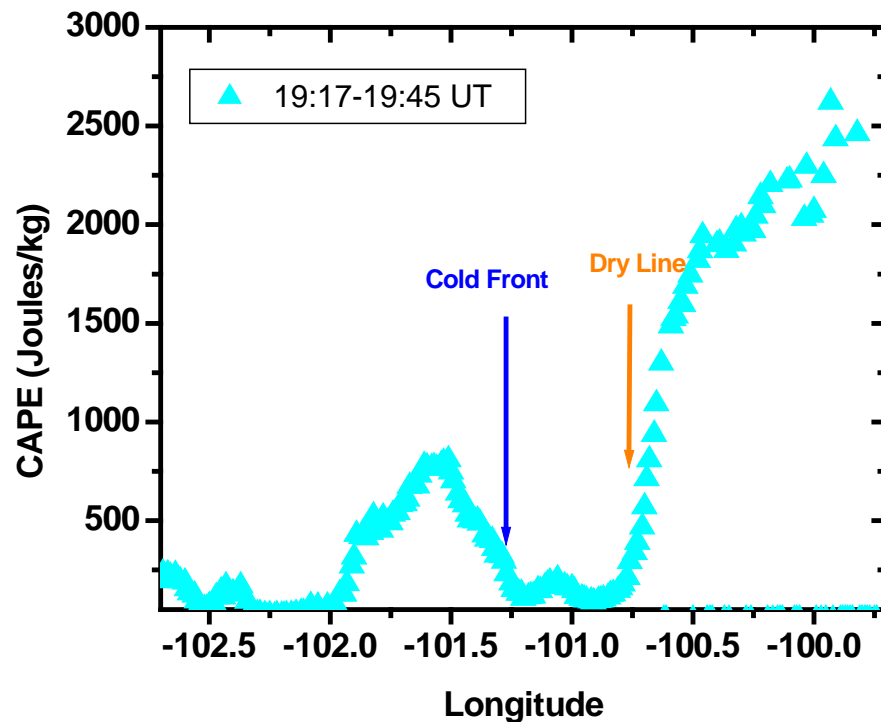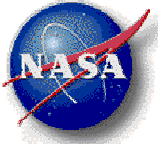
Potential for Deep Convection

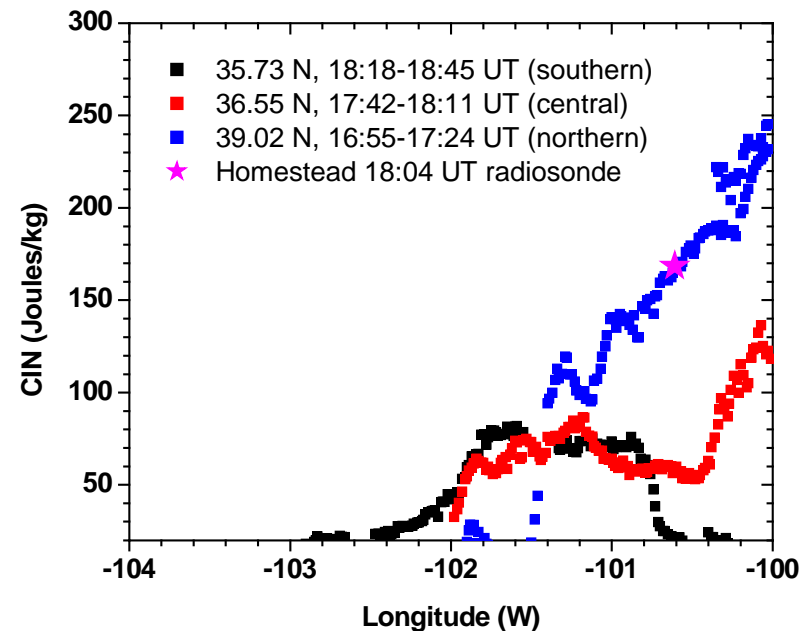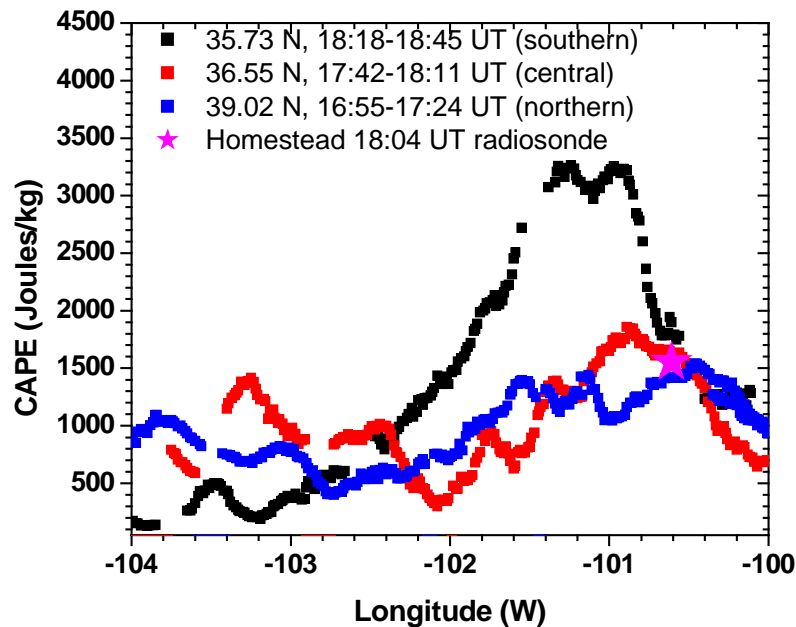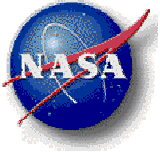- **High values of CAPE (1500-3000 indicate moderate to high instability)**

- **But high values of CIN (50-200) indicate strong cap that inhibits convection**

- **Unlikely to get deep convection without strong lifting mechanism**

➢ **Deep convection occurred south of region (west-central Texas) where weaker cap was present**

Summary

- **Airborne LASE capable of large-scale variability of water vapor, aerosols, and clouds across the lower troposphere**

- **Demonstrated LASE water vapor profile accuracy of $\leq$10%.**

- **LASE data can be used to identify location of fronts, boundaries, and locations of CI**

- **Thermodynamic variables like RH, θ_e, CAPE, & CIN can be obtained from combination of of LASE and temperature profiles over experiment regions.**

- **LASE data have been used in data assimilation and forecast models.**

- **LASE data data images available on Lidar Group Web Page http://asd-www.larc.nasa.gov/lidar/lidar.html**