

# Scanning Raman Lidar Measurements During IHOP



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# Outline

- Scanning Raman Lidar
  - Extensive system modifications prior to IHOP
- Data summary by mission type
  - Analysis status
- Results
  - Error analysis
  - Horizontal measurements
  - Cirrus clouds

# Scanning Raman Lidar

- Measurements
  - Water vapor mixing ratio
  - Aerosol scattering, extinction, depolarization
  - Liquid water (nighttime only)
  - Temperature (experimental)
- 0.76 m and 0.25m telescopes
  - High/Low ranges
- Nd:YAG (9 W @ 355 nm)
- Full aperture scanning
- Windows for all-weather operations
- 12 channel AD/PC data acquisition (up to 7.5 m resolution)



# SRL Data Status Versus Mission

<i>CI Missions</i>		<i>BLE Missions</i>	
22-May-02	S-Pol	14-Jun-02	BLE Homestead
2-4 June 02	Three missions	21-Jun-02	BLE Homestead
9-Jun-02	M-LLJ, CI Guymon		
10-Jun-02	Dodge City	<i>Bore Missions</i>	
11-Jun-02	S-Pol		
12-Jun-02	S-Pol	2-4 June 02	
15-Jun-02	Dumas, Tx	19-Jun-02	
18-Jun-02	Sublette, KS		
19-Jun-02	NW Kansas (Cirrus)	<i>S-Pol Comparisons</i>	
<i>BLH Missions</i>		20-May-02	
		10-Jun-02	nighttime
20-May-02	BLH in Homestead area	17-Jun-02	daytime
25-May-02	BLH Homestead area	21-Jun-02	daytime
29-May-02	BLH Homestead area		
30-May-02	BLH East leg (Cirrus)	<i>TAOS Comparisons</i>	
31-May-02	BLH Homestead area		
6-Jun-02	BLH central track	12-Jun-02	
7-Jun-02	BLH Homestead area	21-Jun-02	
17-Jun-02	BLH Eastern track		
<i>LLJ Missions</i>			
1-Jun-02	E LLJ		
2-4 June 02	MLLJ		
9-Jun-02	M-LLJ		

Vertical H<sub>2</sub>O data

Ready for uniform calibration

Has some issues

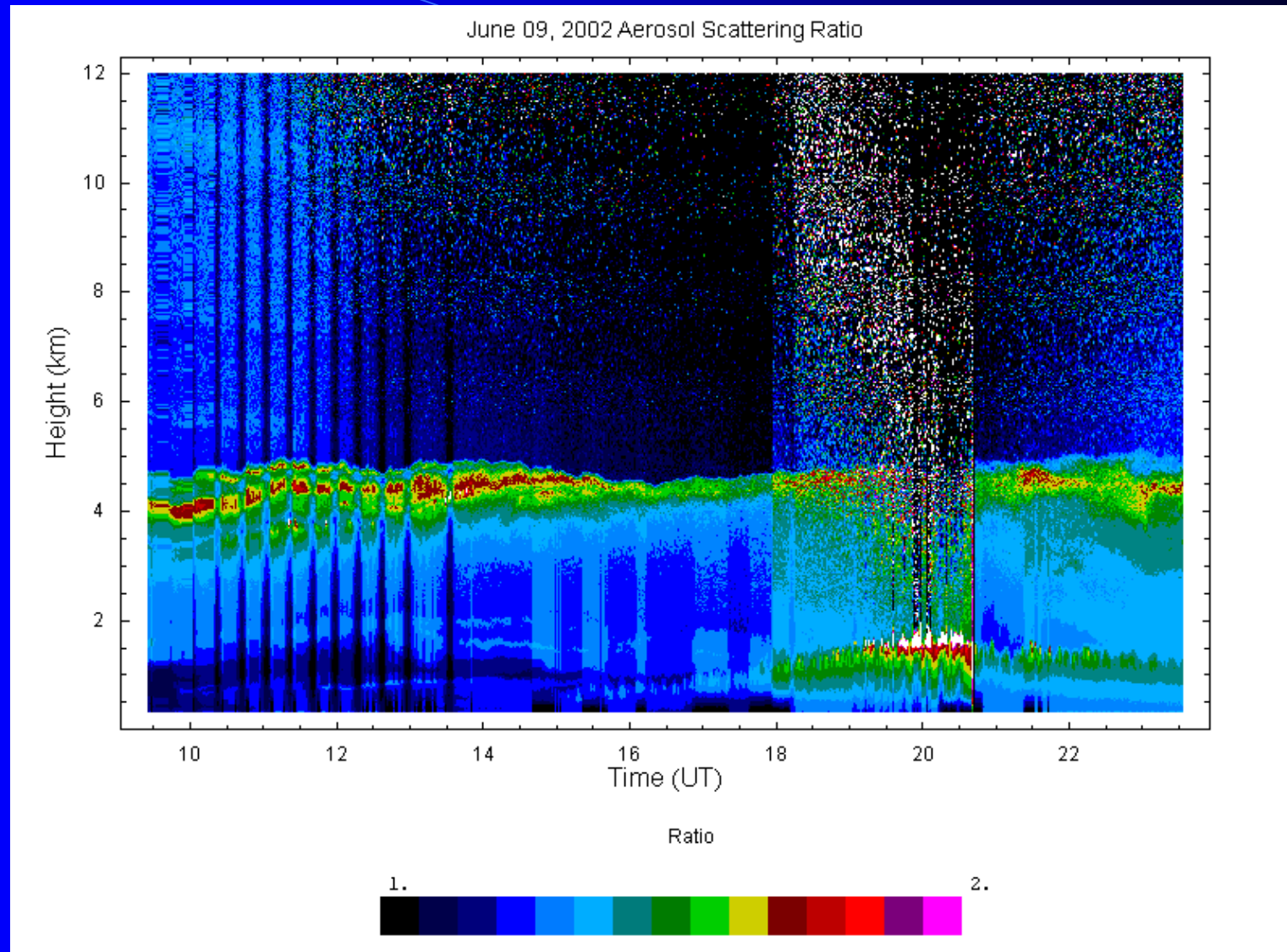
Not started



# SRL Water Vapor Data Overview

- Numerous instrument upgrades prior to and during IHOP
  - Factor of 10 increase in the water vapor signal strength
    - Significant increase in S/N compared with DOE Raman lidar
- Data acquired at 1 minute (10 sec) temporal and 30 (7.5m) vertical resolution
- Data to be delivered at 3 minute temporal and ~60 – 200 meter vertical resolution
- Release of “green” cases after uniform calibration applied
  - Most cases will include aerosol scattering ratio as well. Other products available on a research basis.
  - Distribution of data begins within 2-4 weeks
  - New person to be hired for IHOP analysis

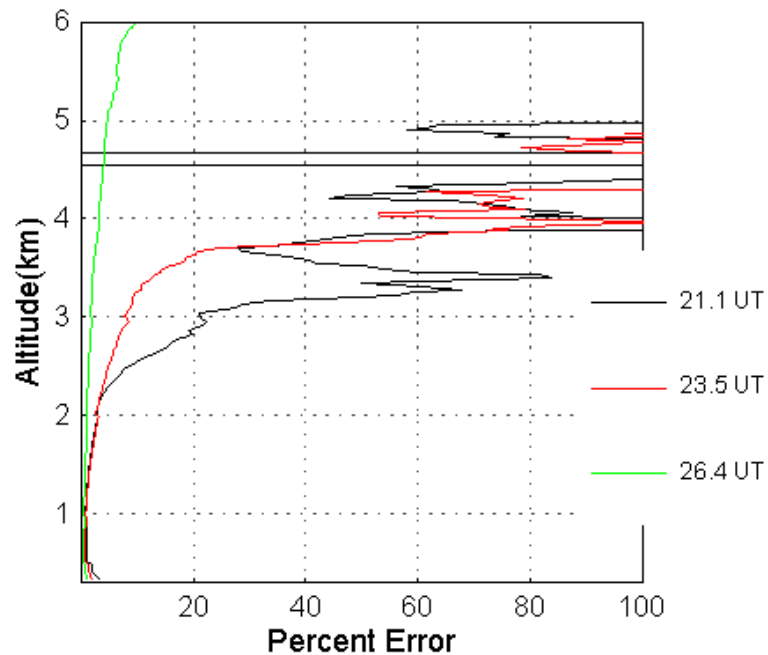
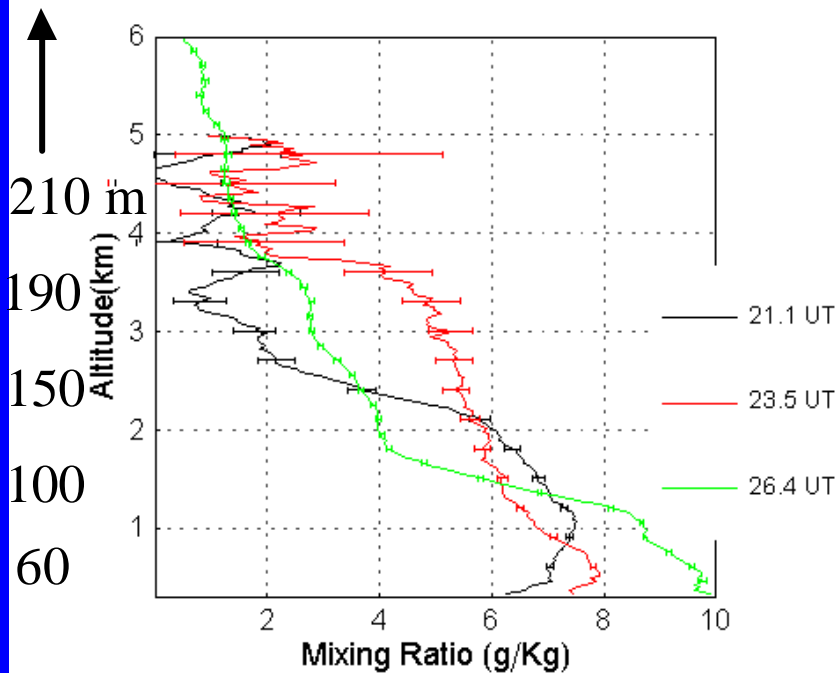
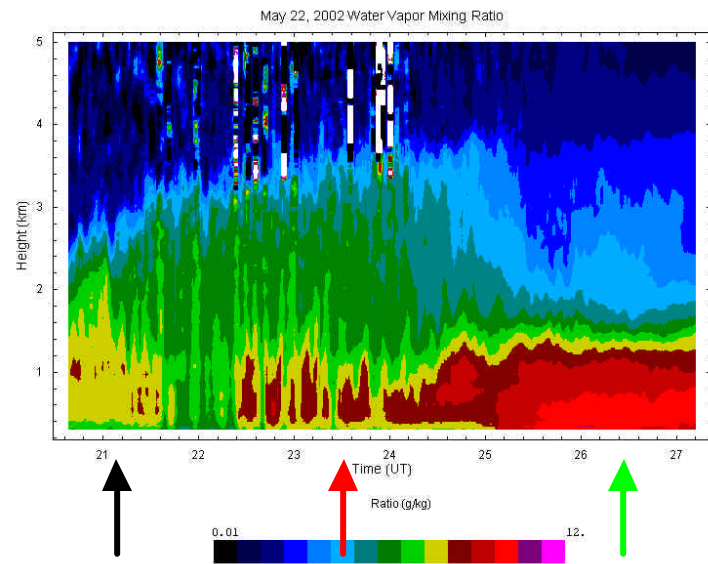
# Data "issues" more apparent in aerosol data



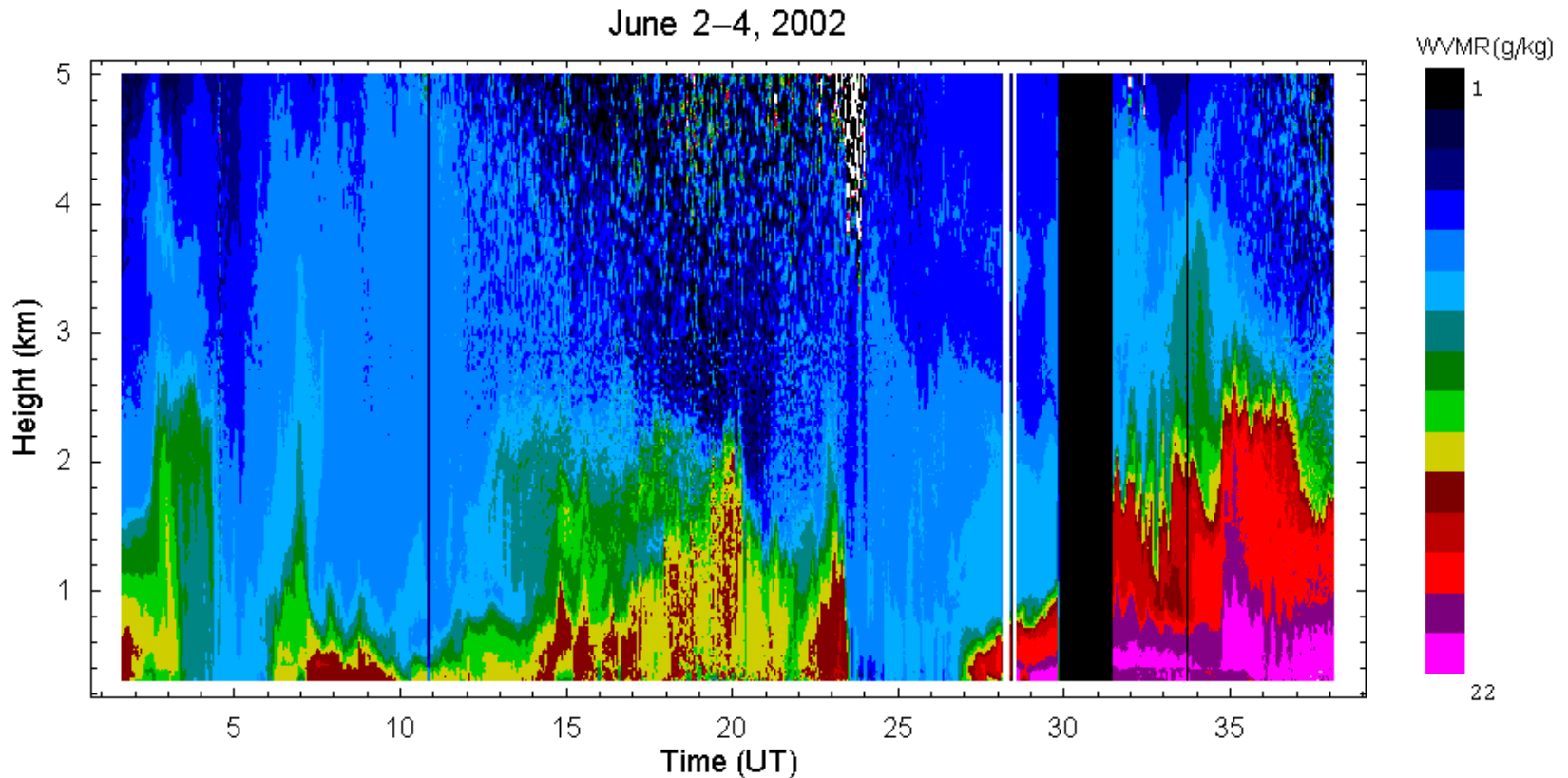
*Automated, eye-safe configuration will permit 24/7 operation and eliminate alignment drift*

# Water Vapor Errors (Dryline May 22, 2002)

- Random error a function time of day, altitude and amount of water vapor
  - day <10% in BL
  - night <2% in BL, <10% to 6km
- Poisson propagated errors agree with FFT technique for both PC and AD data



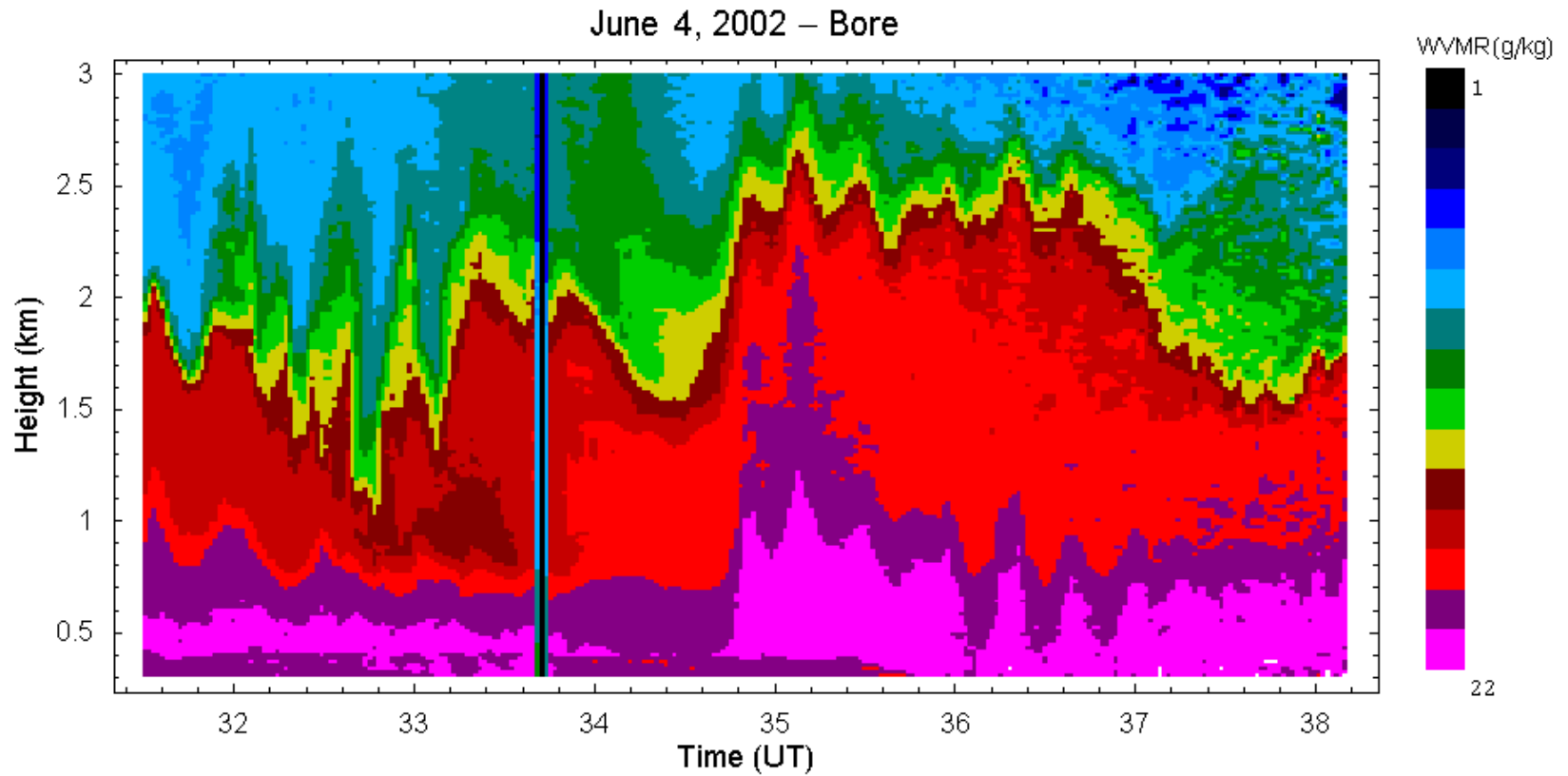
# June 2-4 (3 CI, LLJ, BLE, Bores!) data presented at 1 minute and 30 meter resolution



20 minutes of data available to help fill in gap at ~30 UT



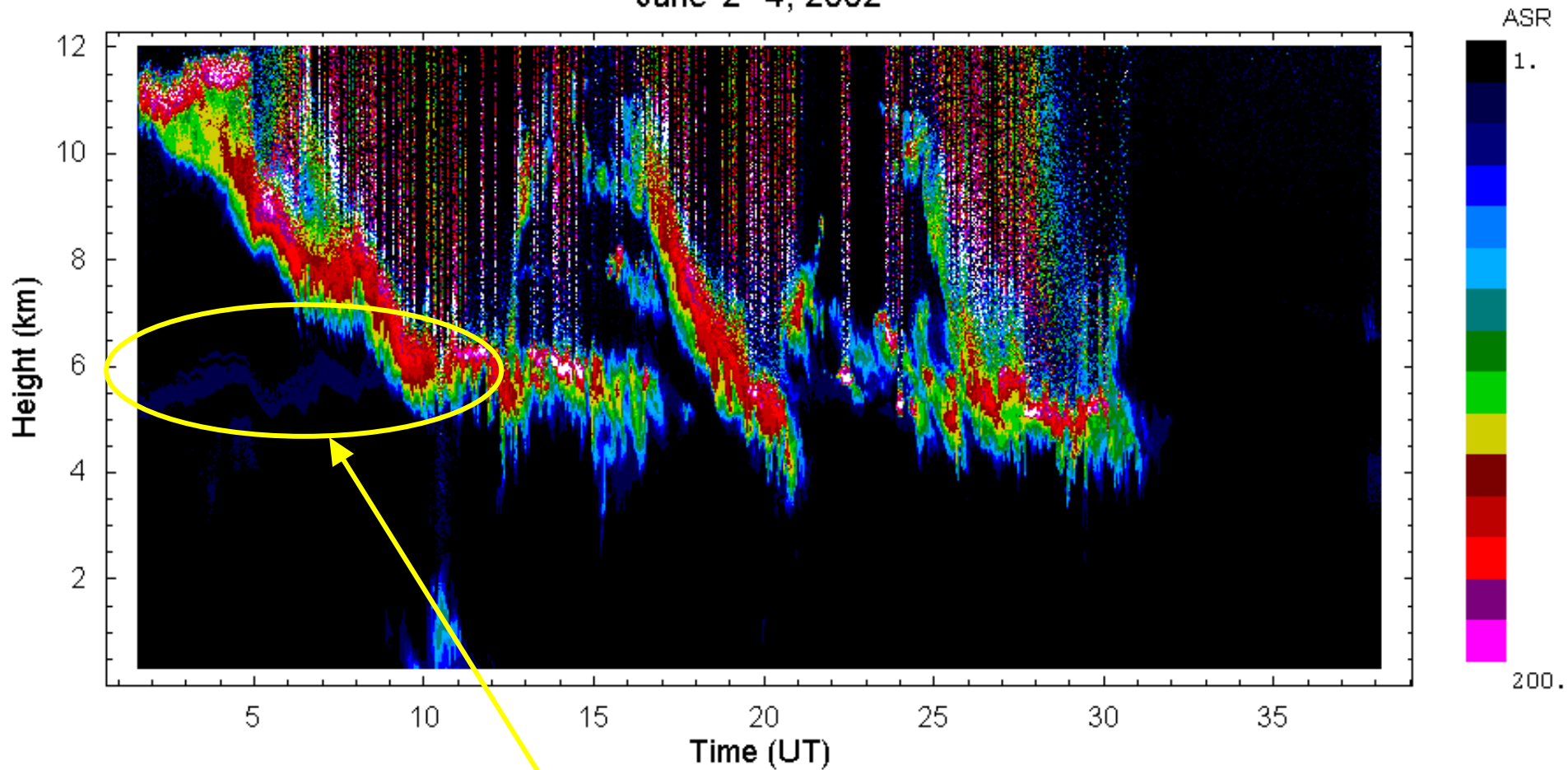
# Focus on the June 4 Bore



13-16 oscillations depending on how you count...

# June 2-4 Clouds

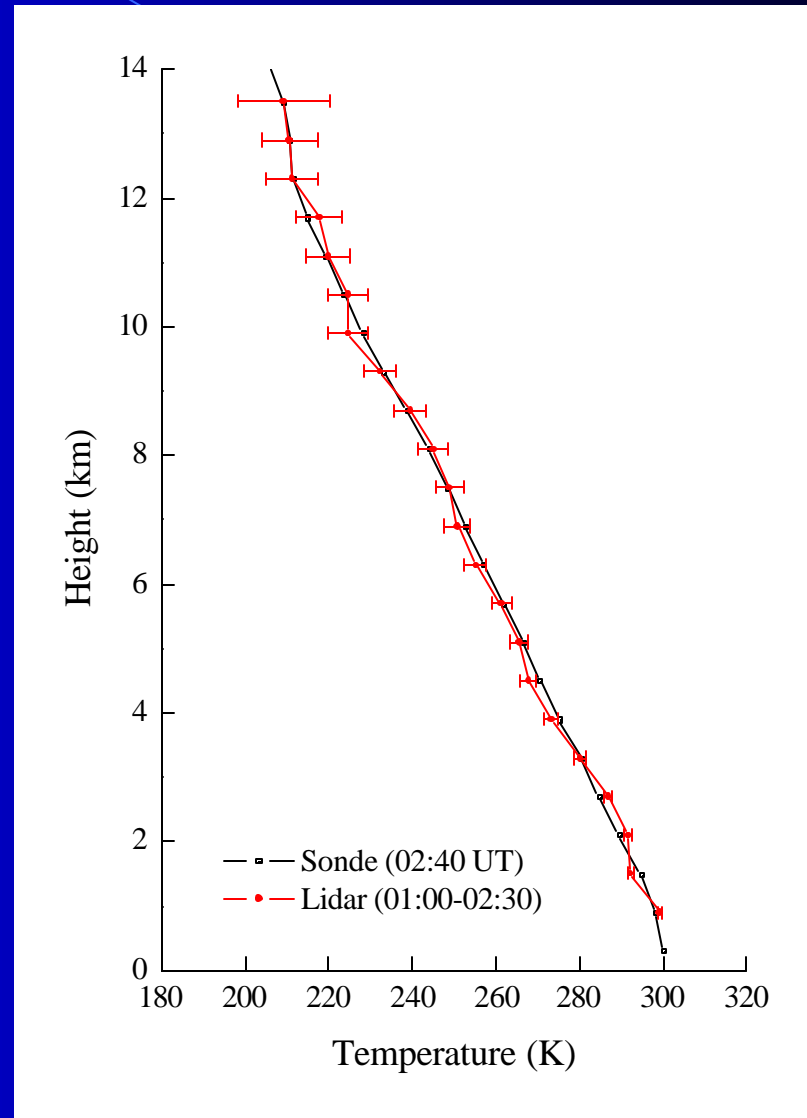
June 2-4, 2002



Oscillations visible at 6 km. Do oscillations persist in the cloud field between 10 and 16 UT?

# Preliminary temperature retrieval (June 2)

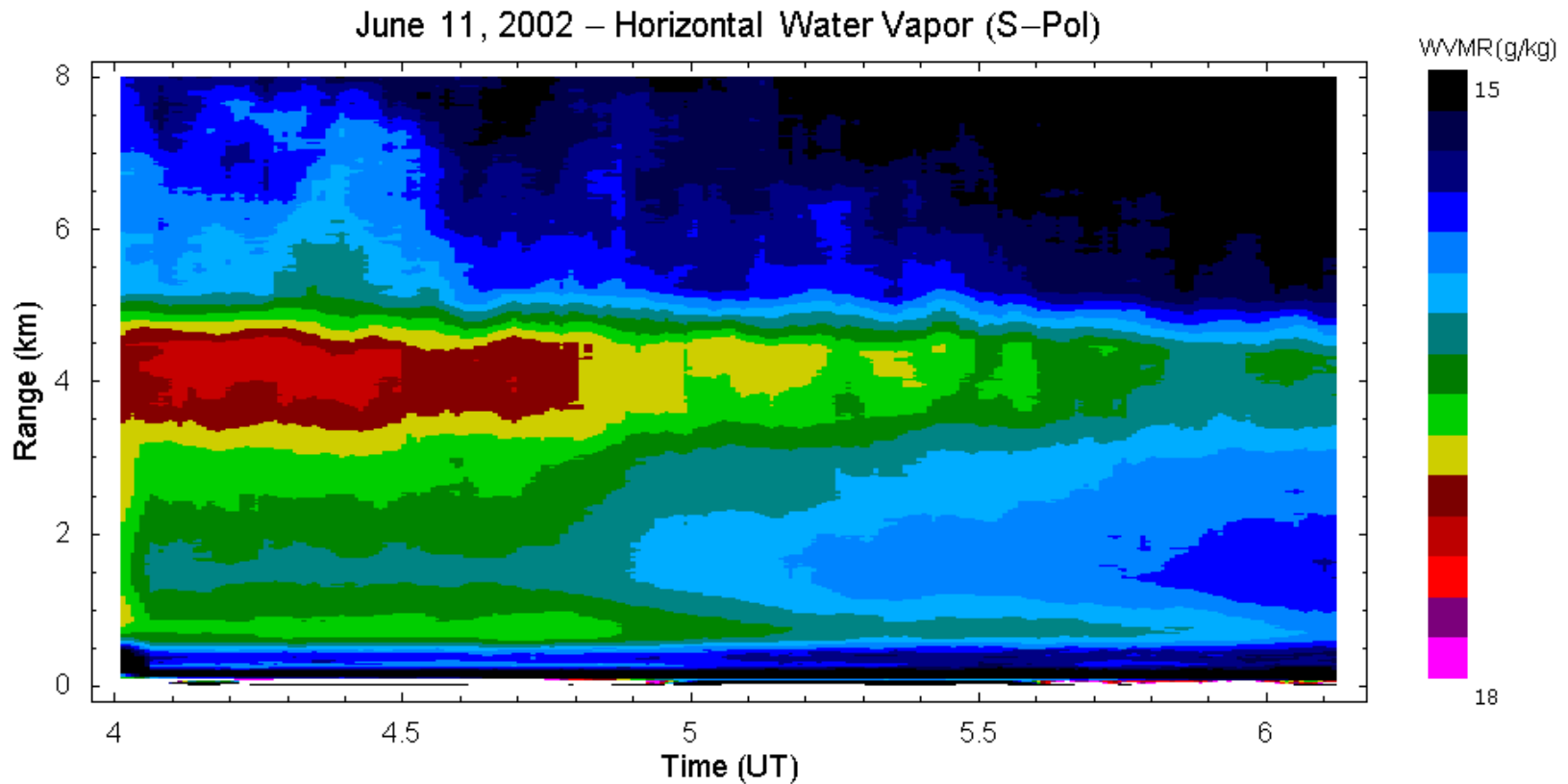
- Rotational Raman technique used during IHOP
- Field configuration unoptimized yielding long averaging times
- Can be made eye-safe



Courtesy: P. Di Girolamo

# Horizontal Toward S-Pol (June 10)

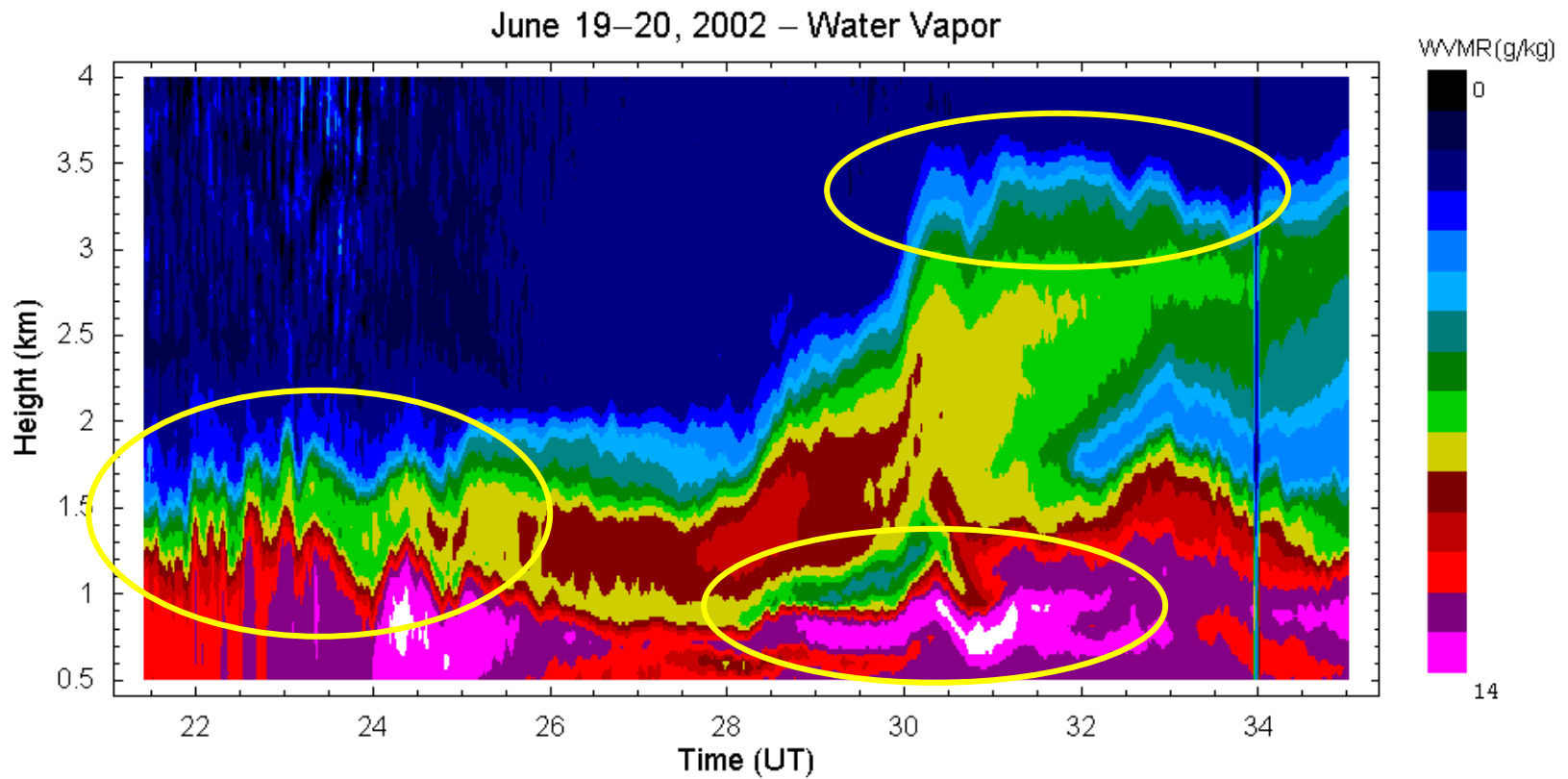
Resolution: 5 minute temporal and ~100 – 500 m spatial



NB: Water vapor scale spans 3 g/kg

Measurements useful for comparison with refractivity based retrievals of water vapor from the radar

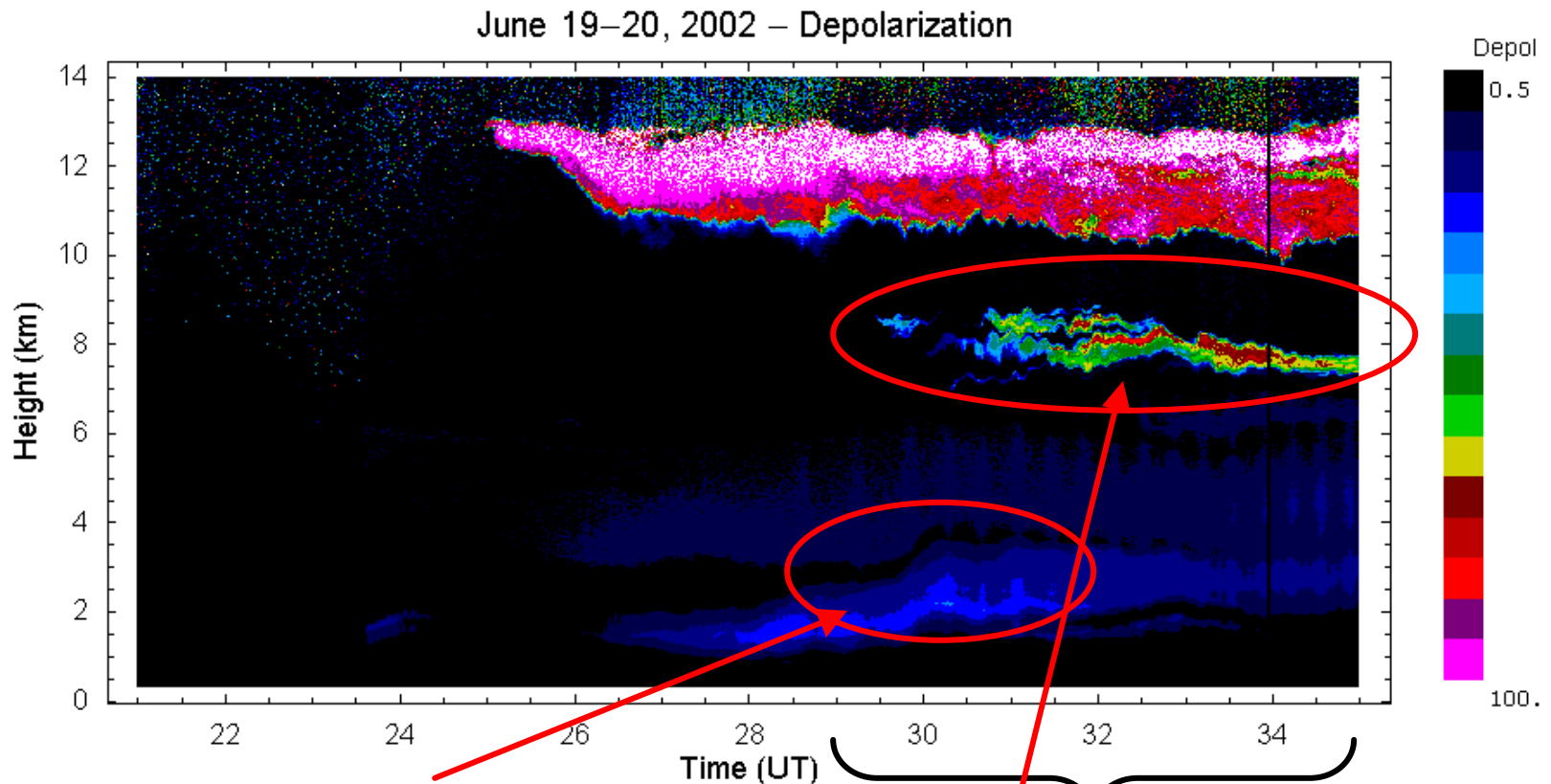
# June 19-20 Bore



Evidence of wave action in several locations



# Energy transported into the upper troposphere?

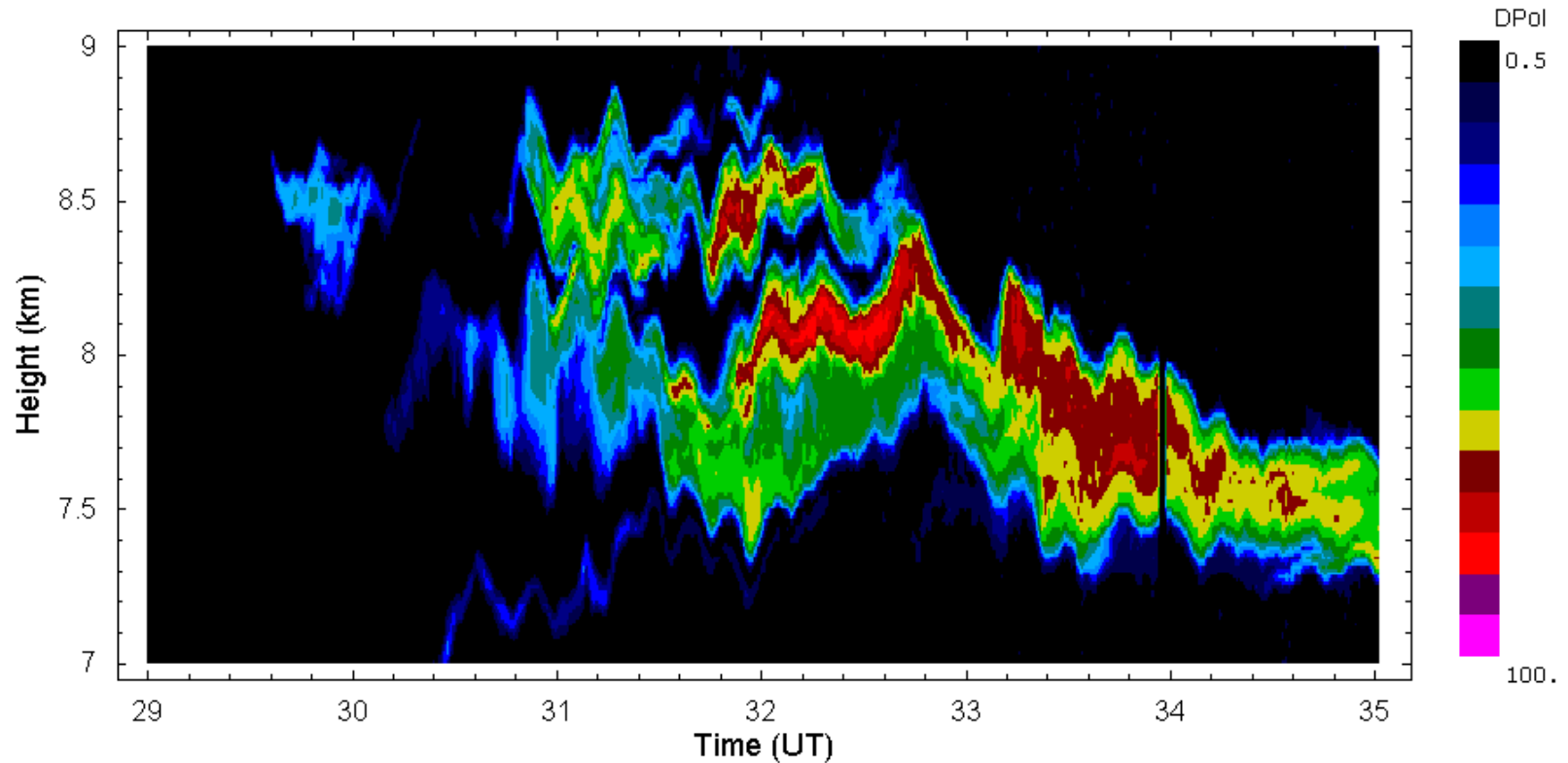


Upward thrust that was visible in water vapor image also visible in this aerosol.

Band structure is interference

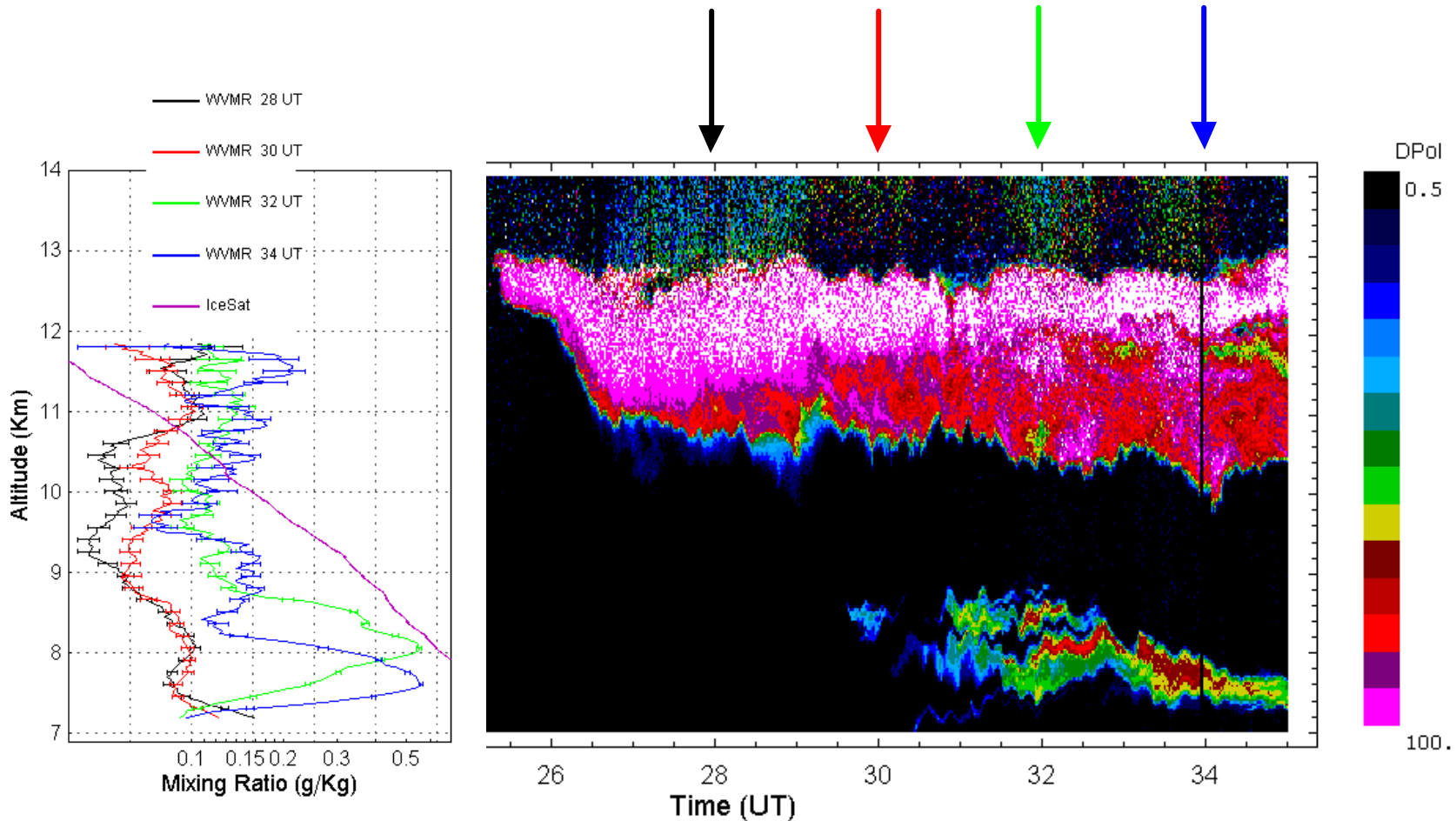
Two cloud levels present in this case. Evidence of wave propagation up to the lower cloud level.

# A closer look at the oscillations in the lower cloud layer



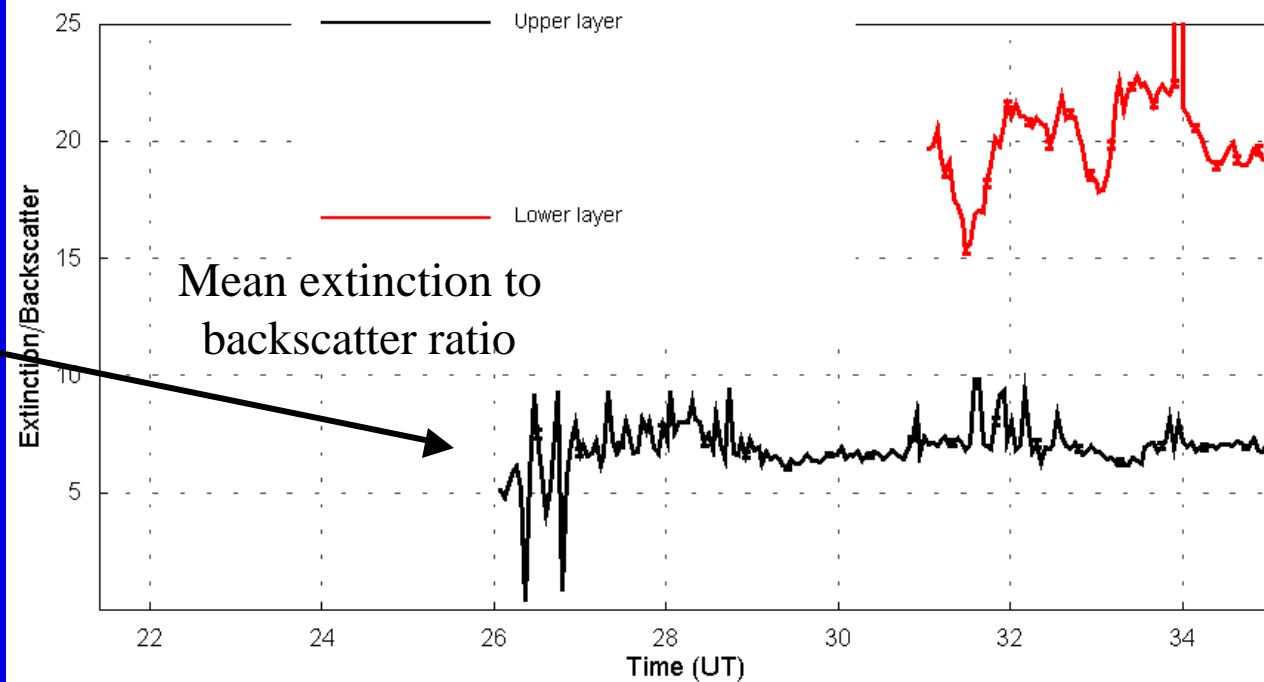
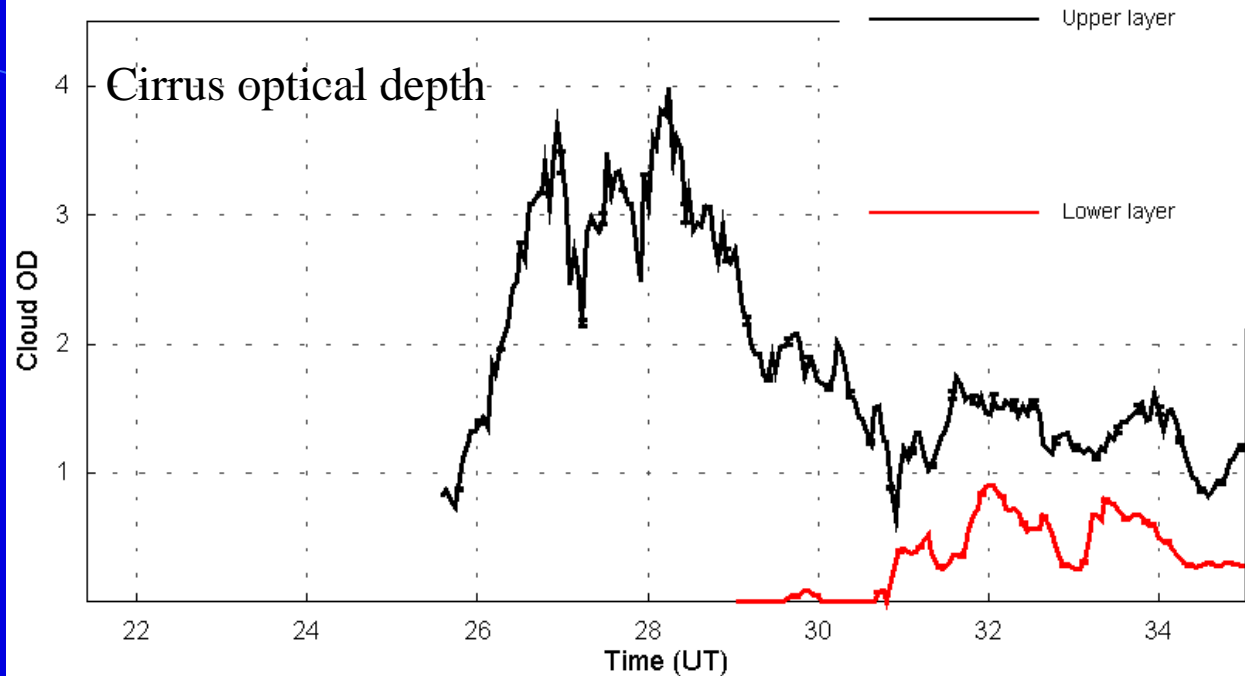
The Scorer parameter can help to determine if the atmosphere supported vertical wave propagation up to cloud level at this time.

# Upper troposphere humidification

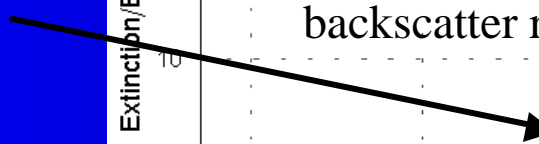


Water vapor profiles up to 12 km trace the humidification of the UT due to cirrus precipitation. Atmosphere is saturated wrt ice at cloud base, super saturated in cloud. Lower cloud level does not show saturation due to vertical smoothing used.

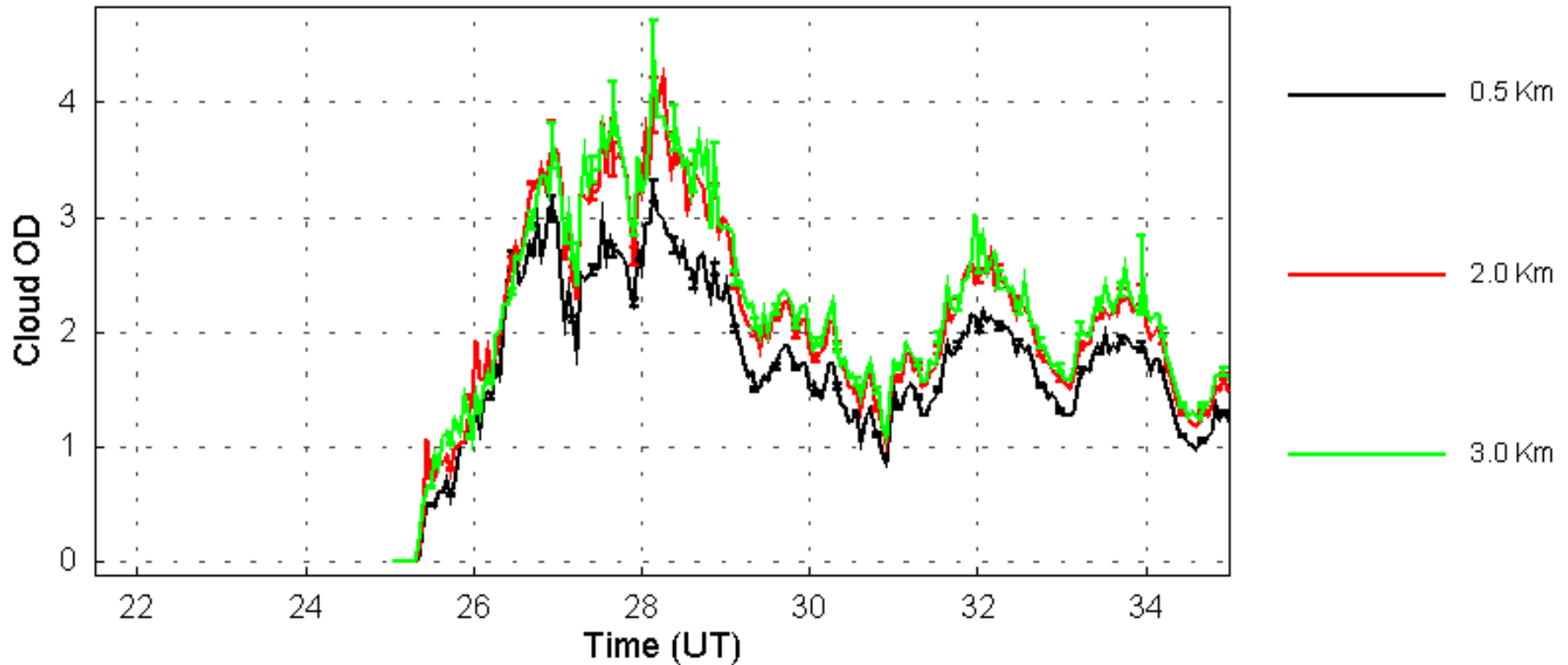
# Cirrus optical properties for the June 19-20 case



Anomolously low values in the upper cirrus layer



## Toward IWC...



Difference in OD calculated at different heights evidence of multiple scattering. With the other parameters measured by Raman lidar, particle size retrievals possible. Knowledge of particle size improves ice water estimates based on cloud optical depth.



# Summary

- NASA/GSFC Scanning Raman Lidar (SRL) successfully deployed to IHOP in new configuration
  - Factor of 10 increased water vapor signal strength improves temporal and spatial resolution versus DOE CART Raman Lidar
- Numerous cases of interest to IHOP measured
  - Bores, dryline, boundary layer evolution
- Data being processed based on priority
  - Get your requests in!
- Data processing ongoing with initial release of data to begin within 4 weeks
- Detailed study of the performance of the SRL will be undertaken once the data processing tasks are complete.