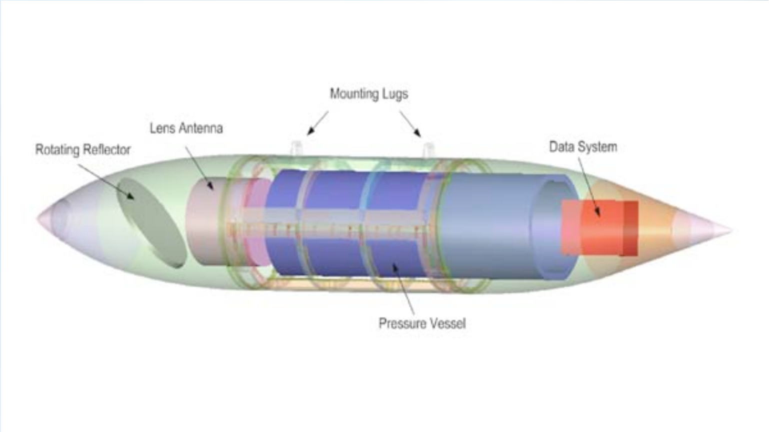
HIAPER Cloud Radar (HCR)

Vivek, Eric Loew, Gordon Farquharson, Scott Spuler and Wen-Chau Lee

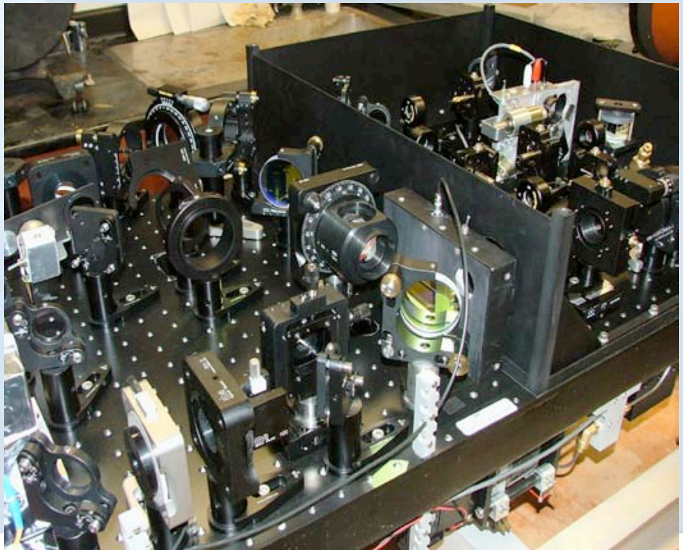
Earth Observing Laboratory

NCAR, Boulder, Colorado



NCAR maintains and deploys a suite of world-class remote sensing instruments (radars and lidars) in support of the atmospheric science community

Develops innovative and state of the art “next-generation” remote sensors



Motivation for Observational Instruments

NCAR

Key scientific challenges:

When and where convection will be initiated?

How to improve accuracy of a NWP model in describing on set of precipitation process?

What factors control intensity and track of an hurricane?

How does convection influence UTLS chemistry?

How to parameterize aerosol and cloud interaction in an earth system model?

Dual Use: Instruments should be deployable on airborne and ground-based platforms

Motivation for Observational Instruments (cont.)

Aerosol and cloud:

Aerosol type: Particle composition, size and shape

Differences in cloud parametrizations lead to variations in climate model predictions

- cloud detection -optically thin clouds (-50 to -20 dBZ)
- cloud fraction without reference to opacity

Cloud microphysics

- Phase
- size

Depolarization by Regular Crystals and Drizzle*

SLDR*-45,
Constant scale
(top of each frame)
Ze,
Variable scale
(bottom of each frame)

Data collected and processed
NOAA ETL
Boulder, Colorado.

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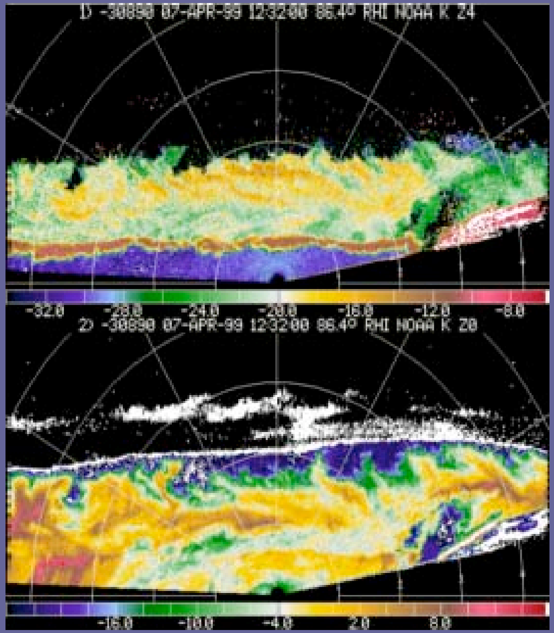
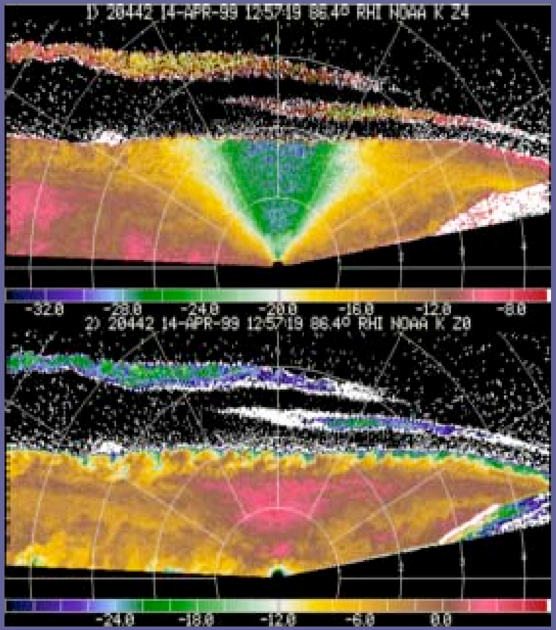
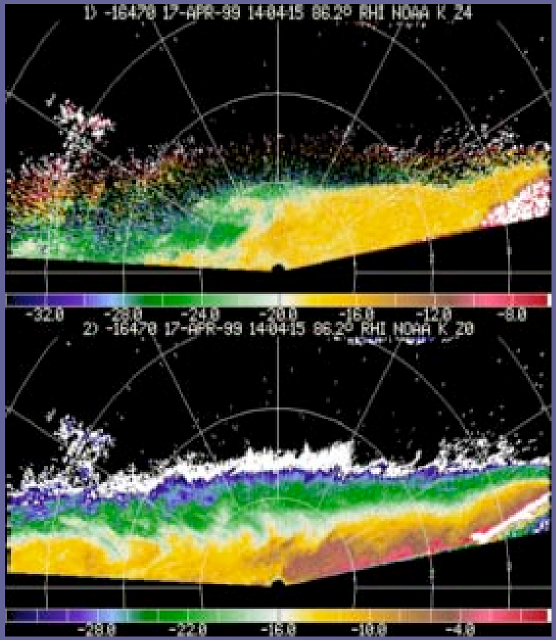
(a) Ice crystals, melting level, drizzle



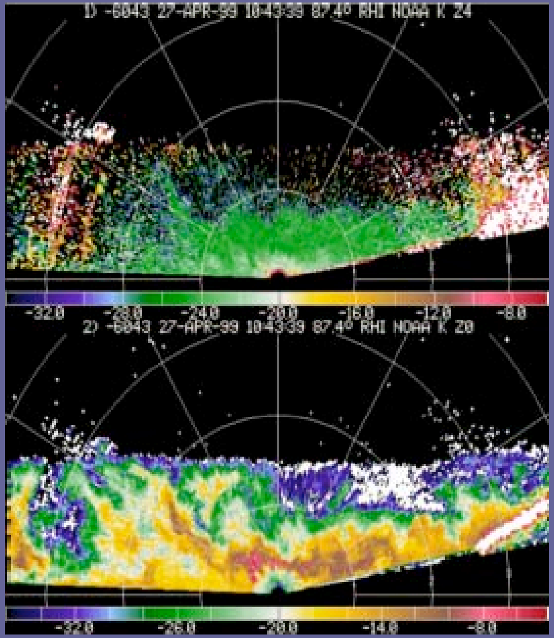
(b) Planar crystals (dendrites)



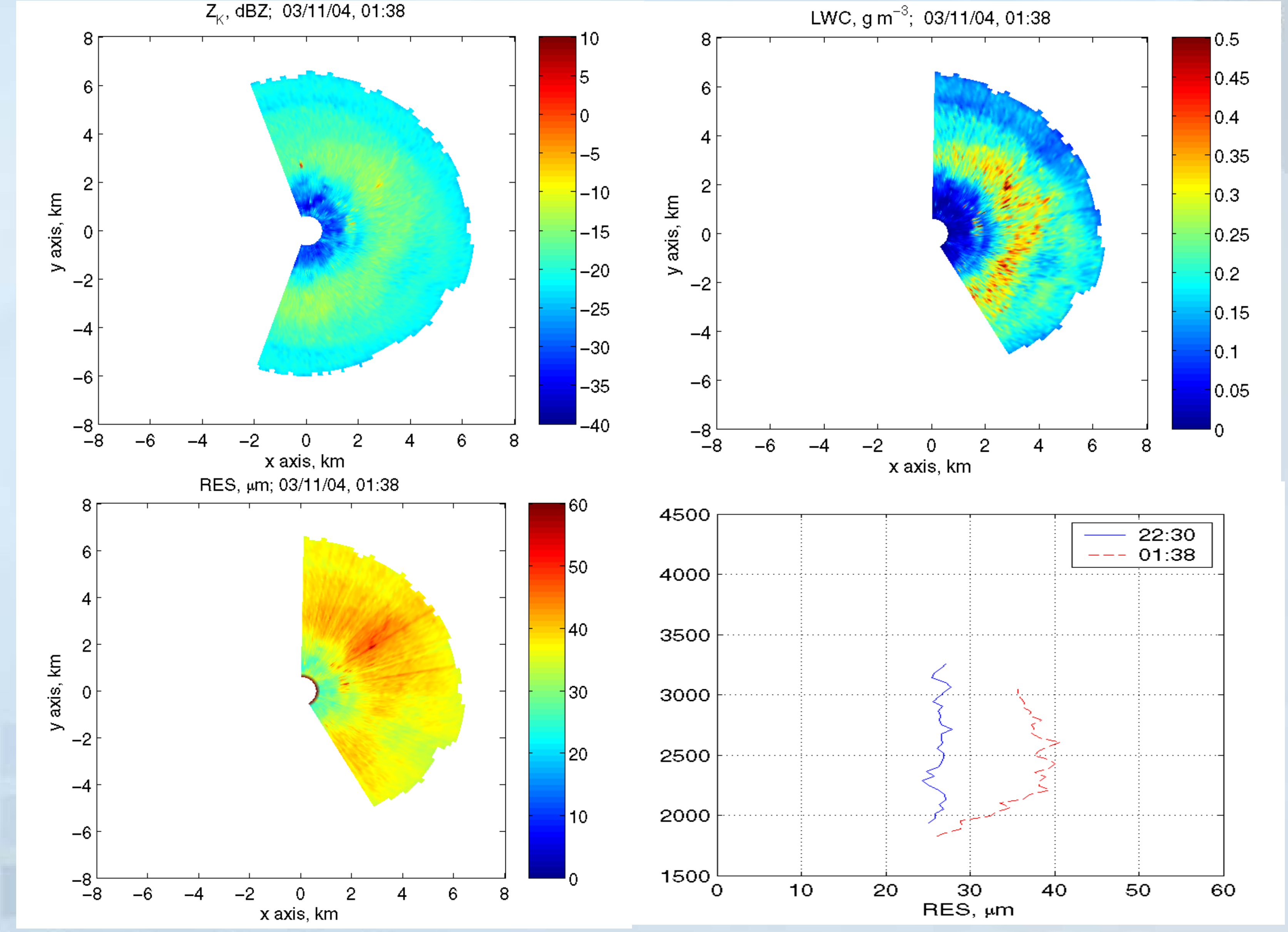
(c) Long columnar crystals

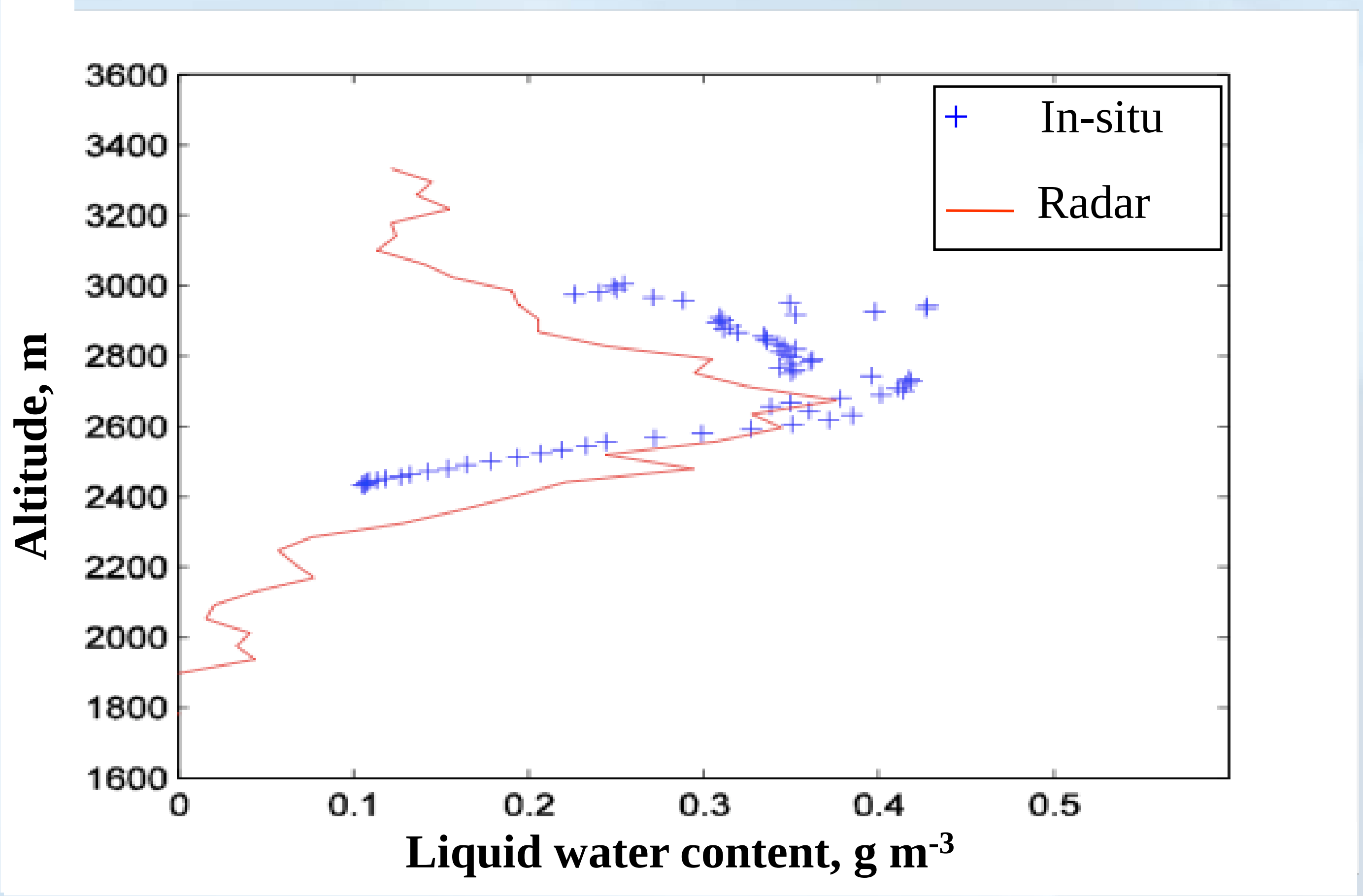


(d) Blocky columnar crystals



Retrieval of particle size (RES), LWC from Ka-band reflectivity and microwave Radiometer observations.





Comparison of liquid water content between radar/radiometer retrievals and in-situ measurements during WISP04. In-situ measurements are from a liquid water probe on board the UND Citation research aircraft.

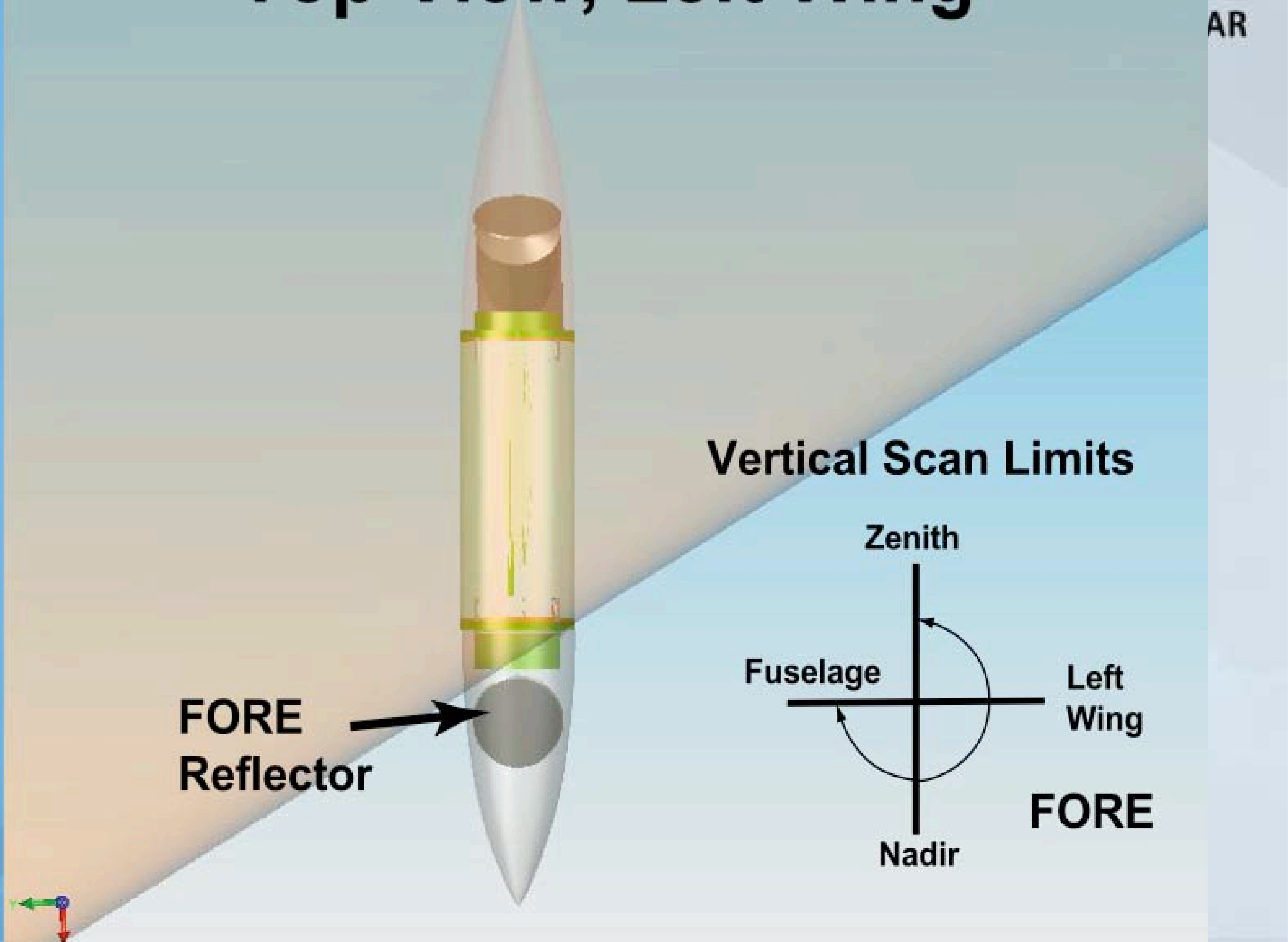
HCR Characteristics

NCAR

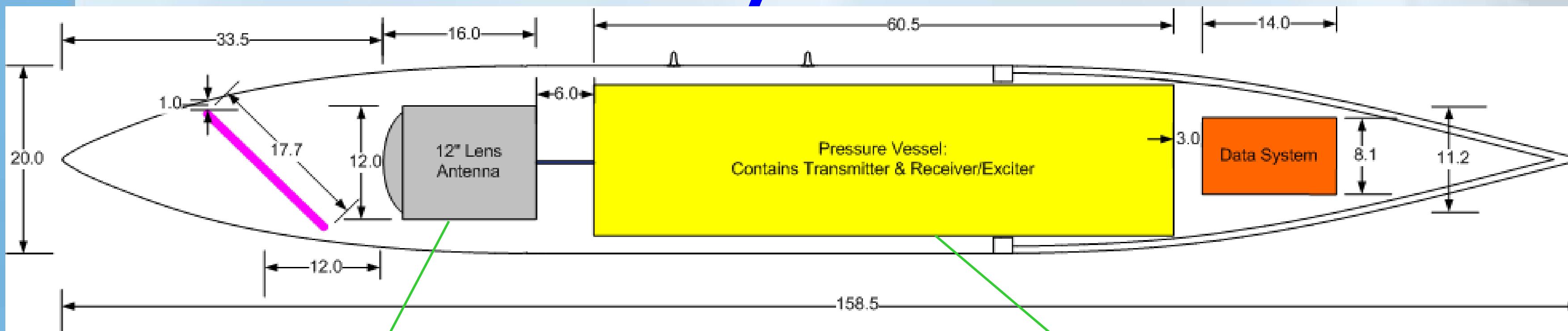
- Scanning, airborne, W-band Doppler radar for Gulfstream V (GV) mid-altitude jet (51kft ceiling)
  - Phase A: system to be ready for test flights in summer 2010
  - Phase B: Adds Polarimetry (H-V), pulse compression – unfunded
  - Phase C: Adds Second wavelength (Ka-band) – unfunded
  - Initial system design incorporates electro-mechanical infrastructure of phases B and C
  - Radar electronics housed in un-pressurized wing-mounted pod, with data archiving and real-time display inside aircraft

PARAMETER	Spec.
Frequency	94.46 GHz
Polarization	H
Peak Transmit Power	1.7 kW
Sensitivity @ 5 km (60m volume size, 0dB SNR)	-28 dBZ
Antenna Diameter	0.305 m
Antenna Gain	46 dB
3 dB Beamwidth	0.7°
PRF	1 – 20 kHz
Range Resolution	30 – 150 m

Top View, Left Wing

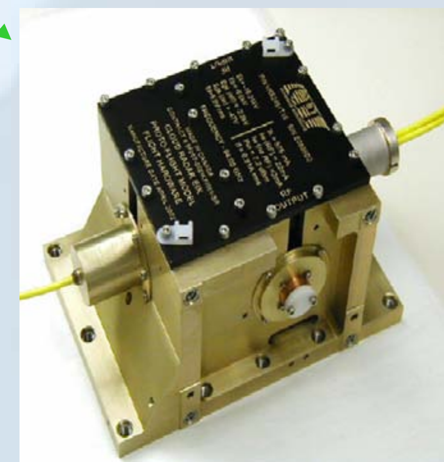


Pod Based Radar System Layout



Pod:

- Length = 158.5"
- Diameter = 20"
- Payload = 800 lbs



Extended Interaction Klystron Amplifier (EIKA)

- Based on the rugged, reliable Klystron
- Conduction cooled, similar to version produced for CloudSat

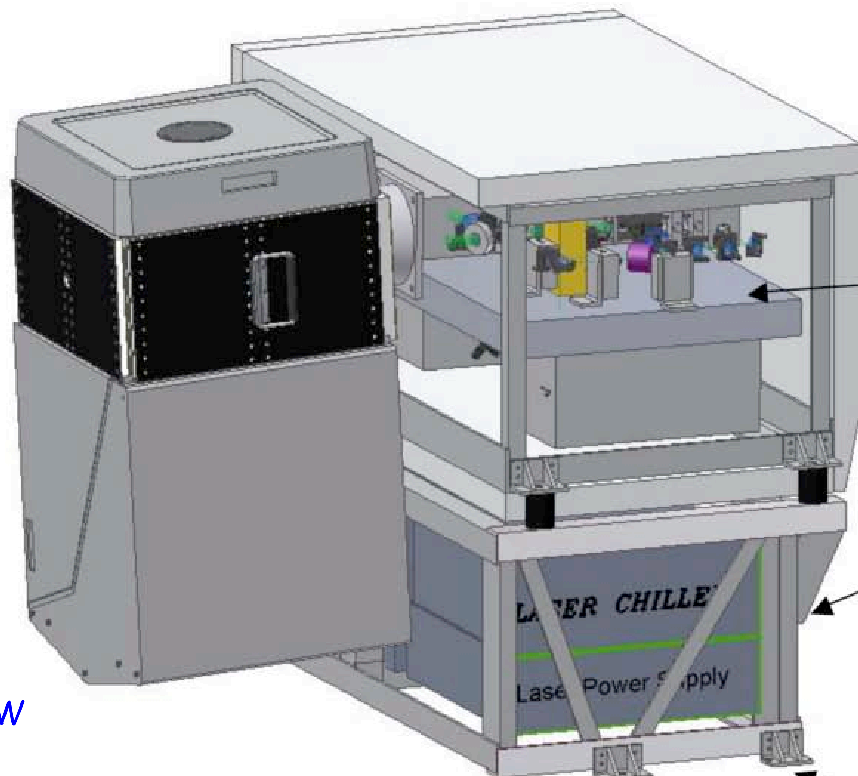
System Calibration

- Absolute Calibration
  - Corner reflector
  - Sea surface
  - Noise/signal sources used to measure gain and dynamic range of the receiver
- Dynamic Calibration
  - Transmitted signal continuously switched into the receiver during operation while the radar is “blind”
  - Noise floor measurement possible periodically during aircraft turns, etc.

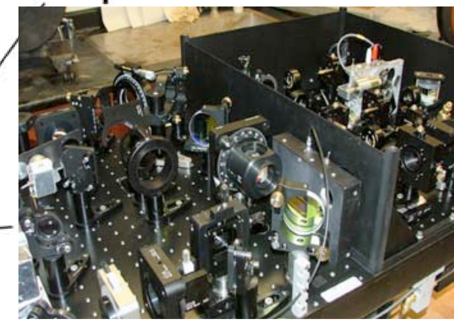
GV HSRL Overview

Model of HSRL for operation on the NCAR GV

Telescope can rotate to view up or down GV view port



Optics Frame

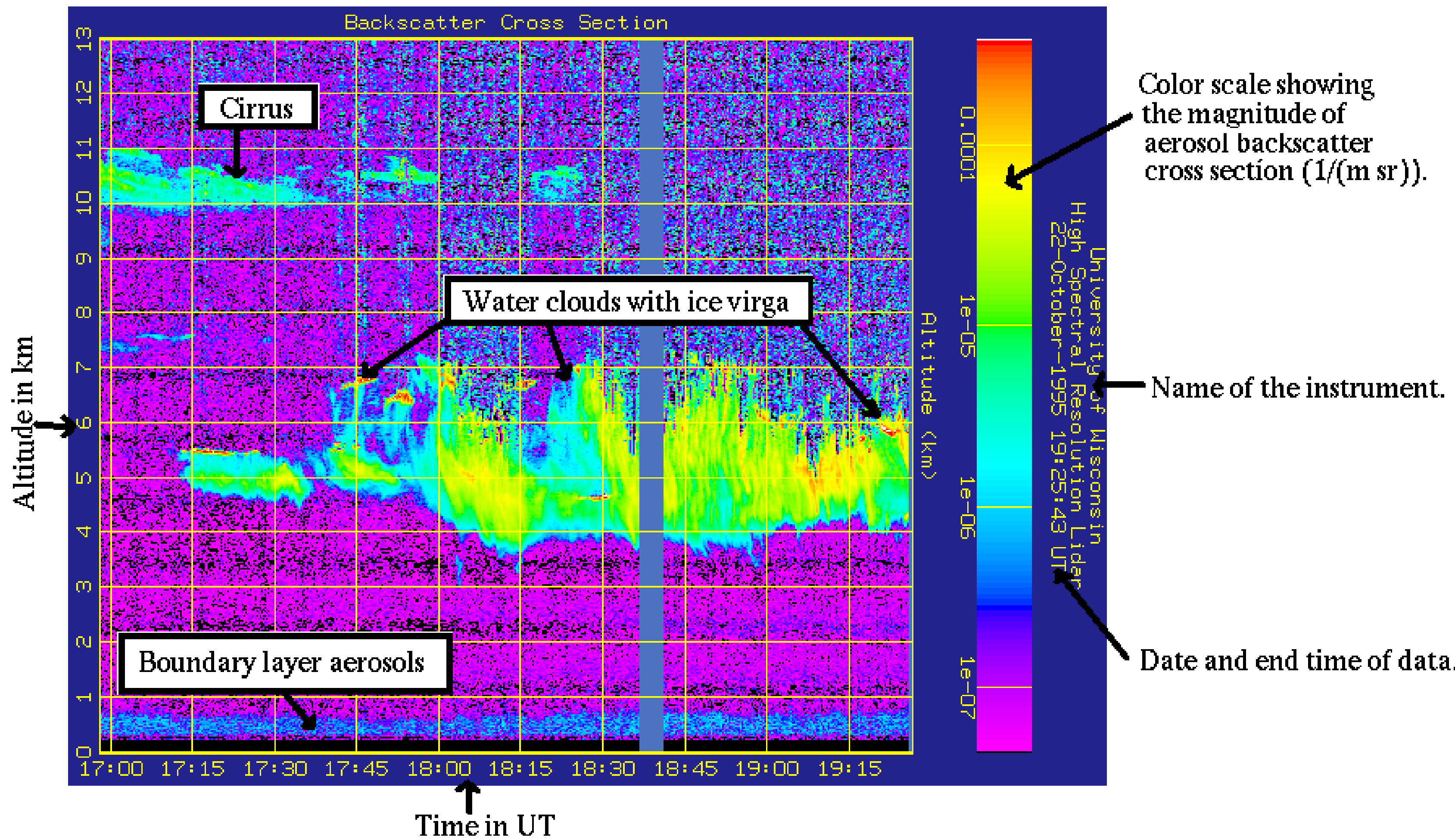


System optics bench

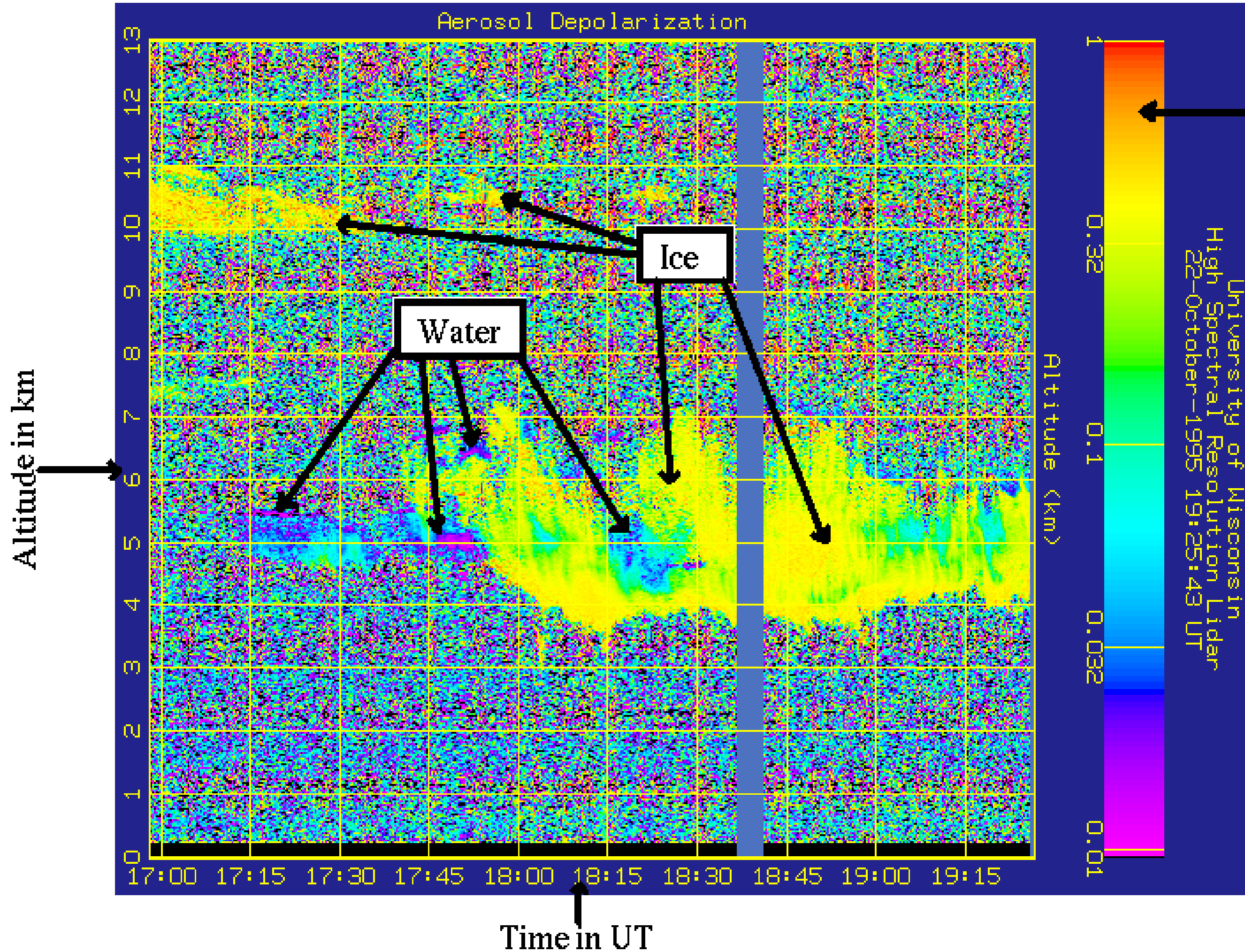
Support Electronics mounts to Base Frame

Base Frame mounts to seat tracks

Wavelength: 532 nm
Pulse repetition rate: 6 KHz
Average power: up to 400 mW
Range resolution: 7.5 m
Telescope diameter: 40 cm
Angular field of view 0.025 deg
Filter bandwidth: 1.8 GHz



Backscatter cross section as a function of time and altitude.



Color scale showing the magnitude of the depolarization ratio.

Ice crystals and other irregularly shaped particles give 0.17 – 0.5 depolarization (yellow).

Mixtures of water and ice give depolarization values between pure water and ice (blue and cyan).

Water clouds with small optical depths have low depolarization (purple). Multiple scattering at larger optical depth increases the depolarization with the penetration depth (from purple to blue).

Depolarization ratio as a function of time and altitude

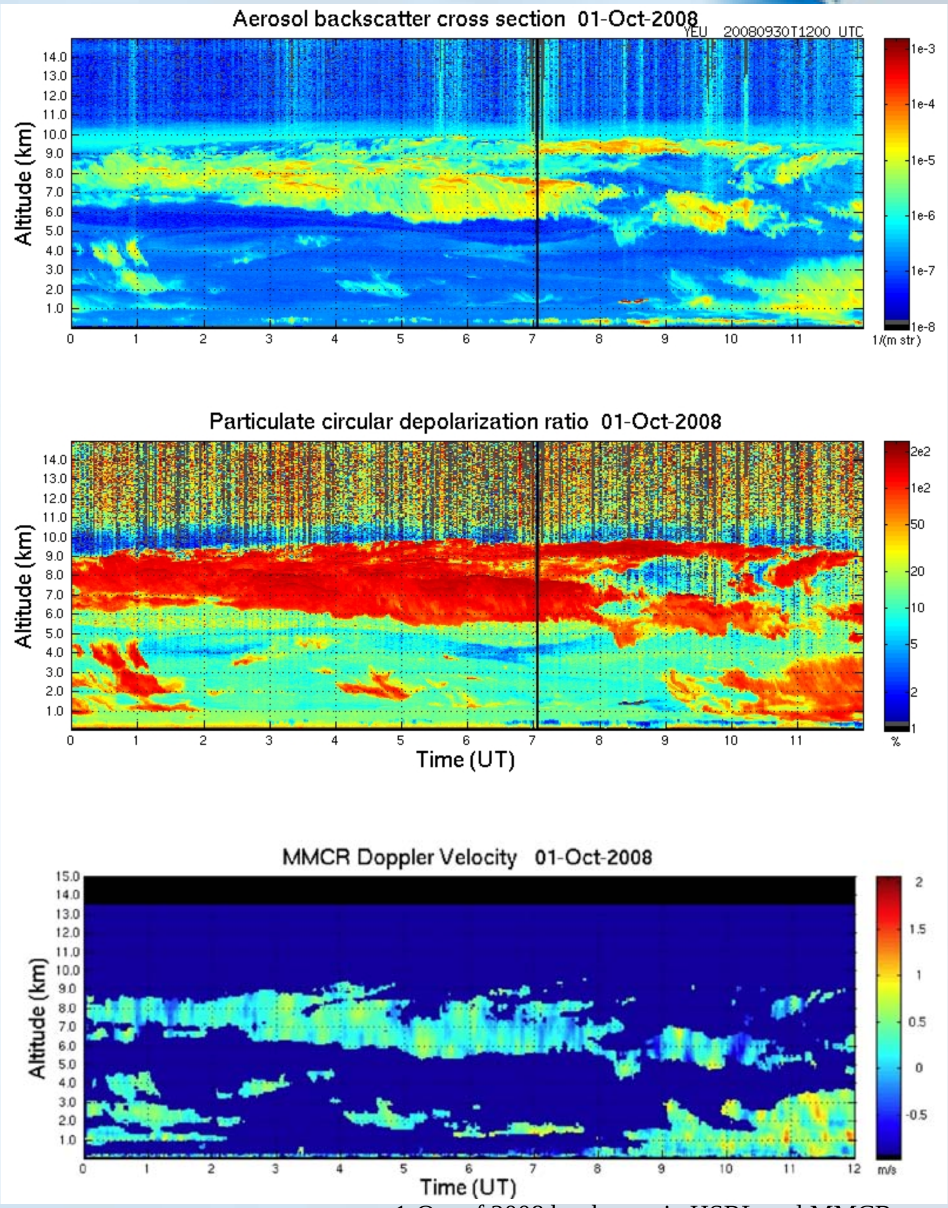
HCR with High Spectral Resolution Lidar (HSRL)

NCAR

Physical parameters	Kinematics	Microphysics: Phase and size	Ice and/or liquid water content	Aerosol Characteristics
Single wavelength HCR With LIDAR	•Radial wind	•Good •Optically thin cloud	•Larger uncertainty •Assumptions are needed	Yes
Dual-wavelength HCR with LIDAR	•Radial wind	•Very good •Optically thin and thick clouds	•Lower uncertainty •Optically thin and thick clouds	Yes

High Spectral Resolution Lidar

- GV HSRL Designed and built by University of Wisconsin – Madison
- Provides accurate measurement of optical depth, extinction and backscatter cross sections of aerosols and thin clouds
- Eye-safe at the exit port (532-nm wavelength operation)
- GV HSRL is already operational operation as ground based instrument
- To be used to in combination with HCR to measure:
  - –cloud fraction, precipitation rate, scattering cross sections, particle shape
  - –Scheduled for GV test flights in late 2009 early 2010



measurements on 1-Oct of 2008 by the arctic HSRL and MMCR
Courtesy of University of Wisconsin