

# **Ship-Based Measurements of Cloud Microphysics and PBL Properties in Precipitating Trade Cumulus During RICO**

**Institutions: University of Miami;  
University of Colorado; NOAA ETL**

**Investigators:**

**P. Kollias (UM); J. Hare and A. White (CU); C.  
Fairall, G. Feingold, and R. Hill (ETL)**

# Understanding the Dynamics and Microphysics of Small Cumuli and Precipitation Onset



# Scientific Questions to Be Addressed

1. *What is the range of the dynamical and microphysical structures in trade-wind cumuli, and how do these structures affect the lifecycle of clouds under varying wind shear, stability, and aerosol conditions?*
2. *What microphysical / dynamical factors and time scales are involved in the production of large-drop concentrations in fair-weather cumulus clouds?*
3. *How do the raindrop size distributions evolve from the initial to mature precipitating stages of shallow cumuli?*

# Scientific Questions to be Addressed

- 4. How is the marine boundary layer altered by precipitation from trade-wind cumuli?*
- 5. What are the statistical properties of precipitating trade-wind cumuli from the cloud to mesoscale scale?*

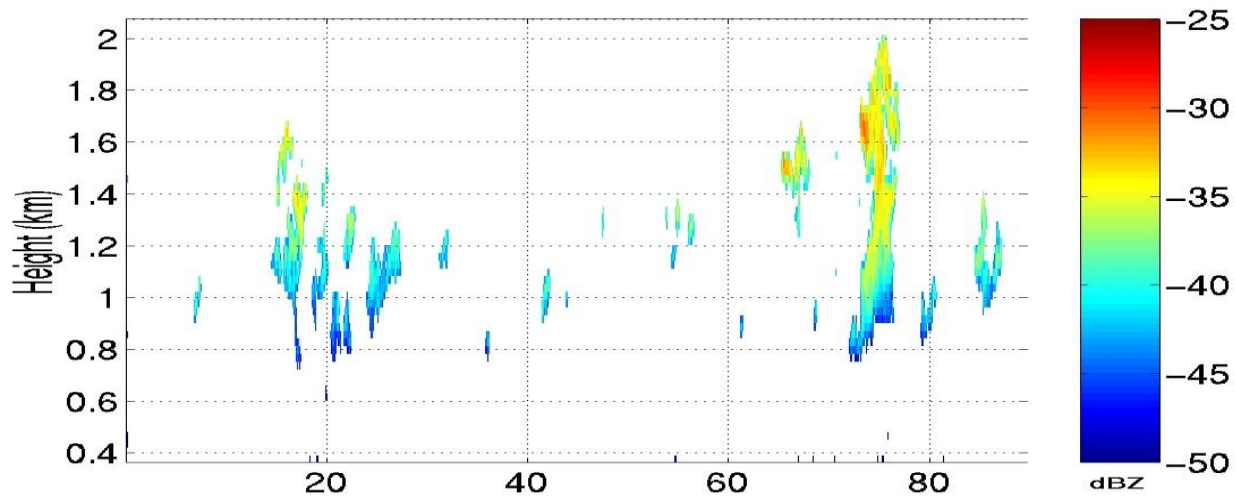
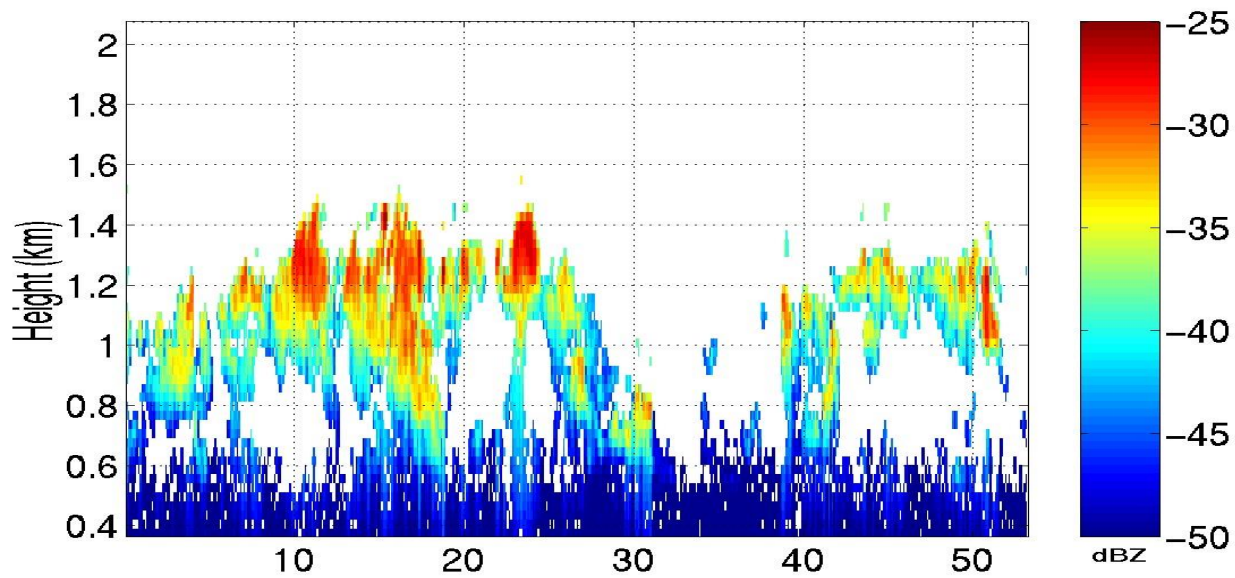
# Approaches

- Coordination with Surface-Based Radars and Aircraft and Integration of Observations
- Continuous Monitoring for Cloud Statistics
- Intensive Process Studies
- LES Studies

# Ship-Based Radars

- 915-MHz wind profiler--PBL 3-D winds, inversion height, cloud and precipitation structure
- 9.4 GHz Doppler Radar (upward pointing)—Reference reflectivity; Doppler spectra
- 35 GHz Scanning Doppler cloud radar—Reflectivity and Doppler moments; Cloud mapping and microphysical properties; precipitation mapping
- 94-GHz Doppler radar (stabilized/scanning)--High resolution Doppler spectra; cloud and precipitation microphysics

# W-Band Cloud Reflectivities

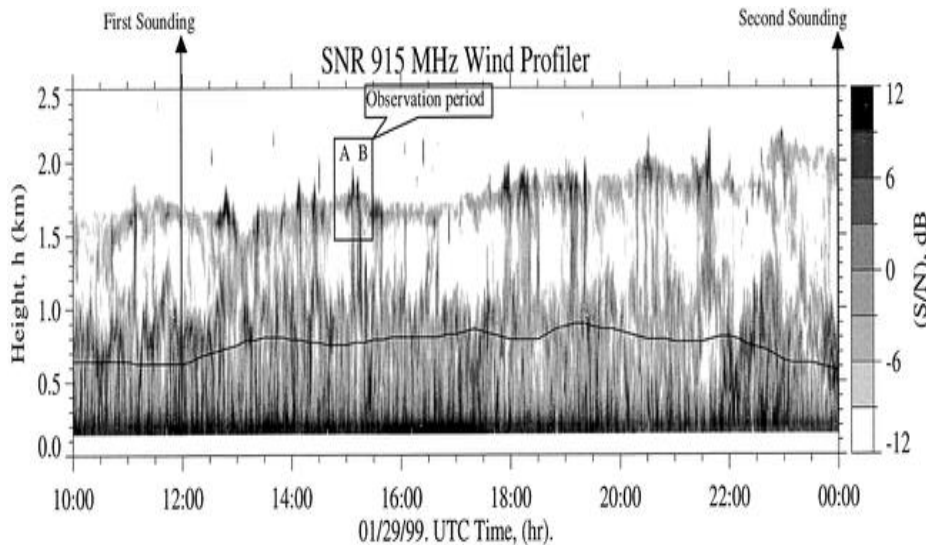


# Dynamical and Microphysical Structure of Trade-Wind Cumuli

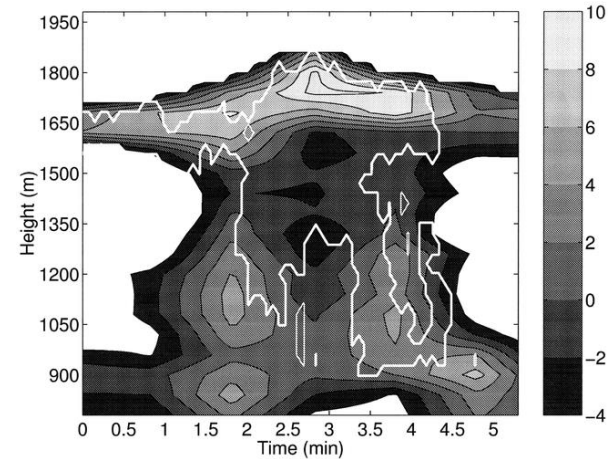
## Boundary Layer/Cloud Characterizations

- Inversion Height
- Horizontal wind
- Bragg/Rayleigh scattering
- Updrafts/Downdrafts
- Entrainment

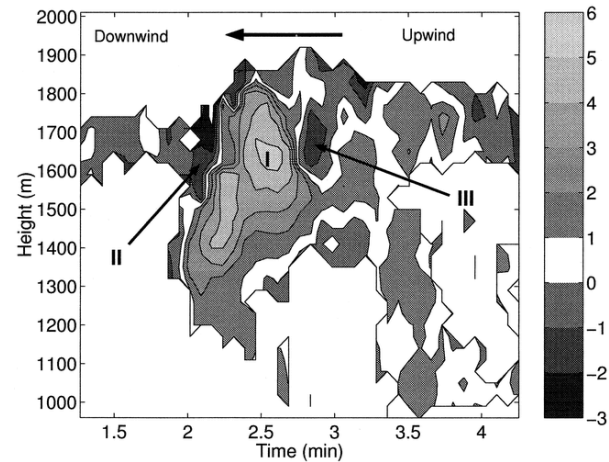
## 915-MHz wind profiler (SNR)



## Bragg "halo", W-band cloud boundaries



## Updraft-Downdraft structures



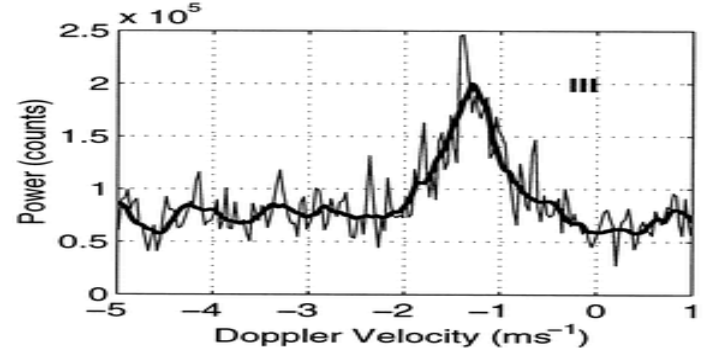
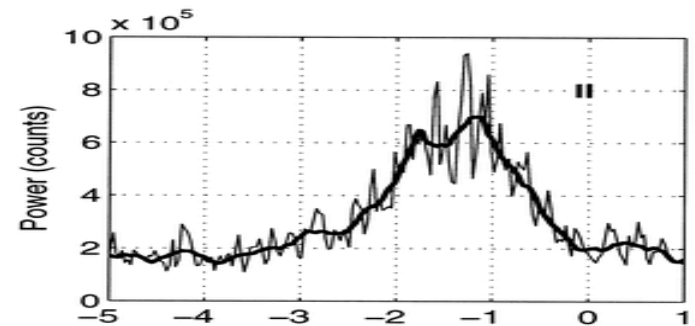
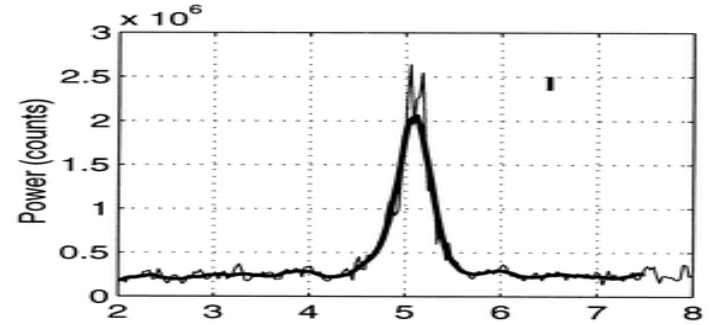
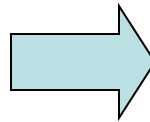
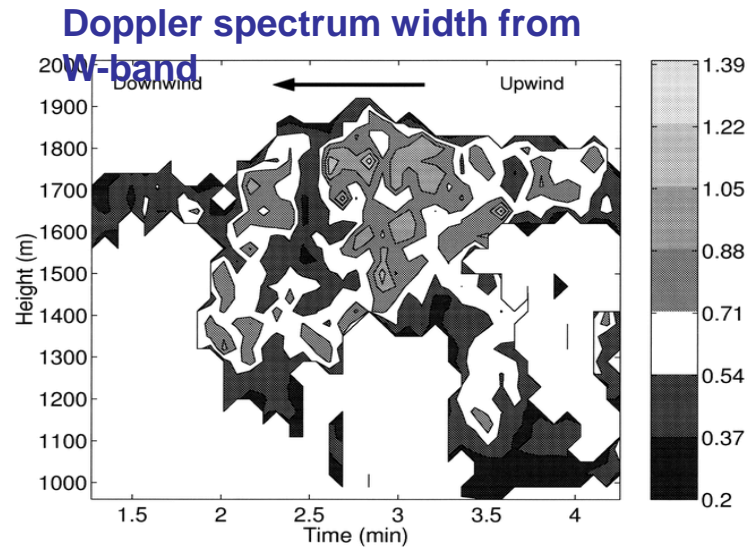
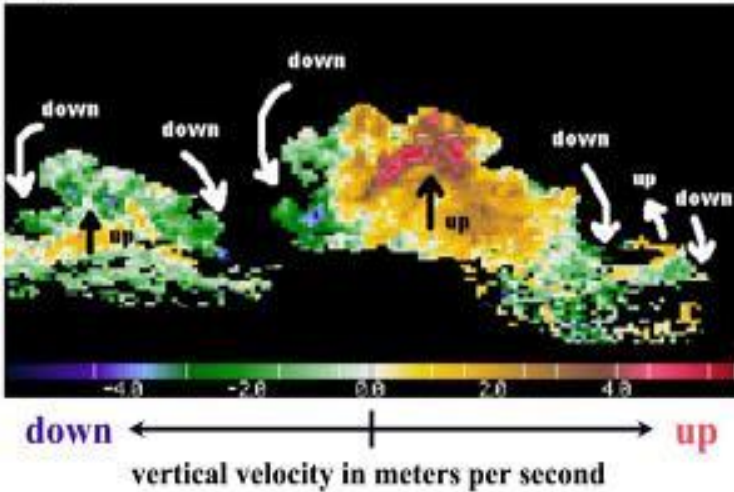


# Large drop Formation in Trade-Wind Cumuli

High resolution data from NOAA/K (4 beams/sec)

Detection of large drop production

Doppler Radar Measurements of Shallow Cumulus Clouds



# Raindrop DSD evolution in early precipitation stages

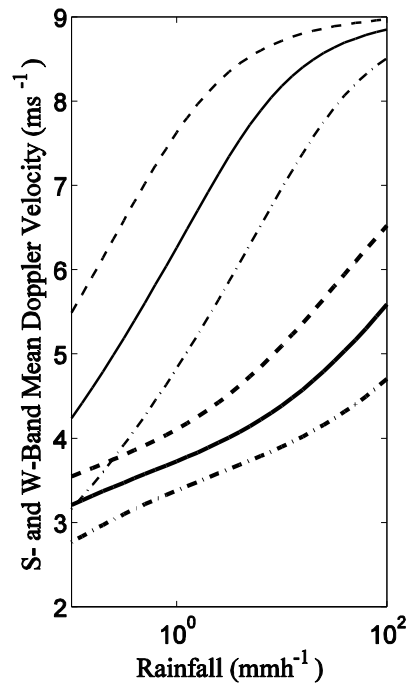
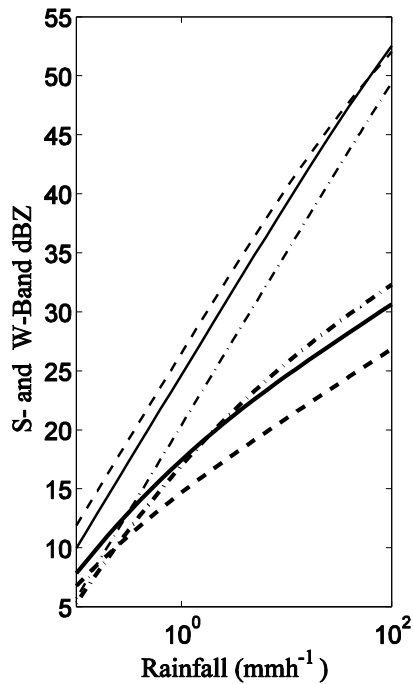
W/X dual wavelength precipitation retrievals

X-band reflectivity (cloud top, morphology)

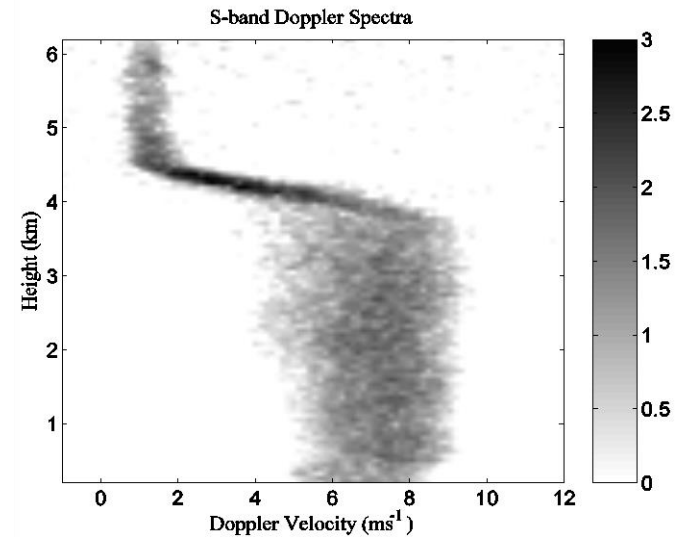
W-band Mie scattering, Doppler spectra

- Vertical air motion (within  $5 \text{ cm s}^{-1}$ )
- DSD retrieval if  $D_{\text{max}} > 1.7 \text{ mm}$

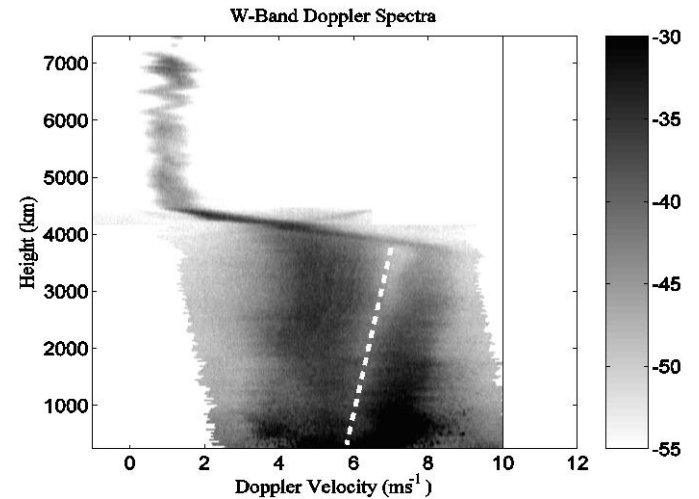
## Differential reflectivity and mean Doppler



## X-band Doppler spectra



## W-band Doppler spectra



# Cloud Scale to Mesoscale

Radar data collection at the highest of temporal and spatial resolution are expected providing a detail 2-D or 3-D mapping of cloud entities

The NOAA/K scanning radar is expected to sample a 60-100 km swath around the ship providing the link between the individual cloud observed overhead and the mesoscale organization of precipitating and non-precipitating trade-wind cumuli.

Despite strong gaseous attenuation in a tropical environment (0.5 dB/km) we anticipate that the NOAA/K will be able to observe "first rain echoes" (-5 to 0 dBZ) at 50 km range.

# Observing Strategies and Coordination with Other RICO Observing Systems

- Aircraft
- Surface-Based Radars

# UM Cloud and Precipitation Mobile Observatory

## UM W-band Doppler radar

**Frequency:** 94.2 GHz (wavelength = 3.19 mm)

**Antenna:** 0.91 m, Cassengrain

**0.24° beamwidth** (8-10 m at 1 km range)

**Vertical resolution:** 30 m, **Temporal Resolution:** 0.5 -1 sec

**PRF:** 5-10 kHz (4-8 ms<sup>-1</sup>) Nyquist

**Doppler spectra, raw I/Q**

**Sensitivity:** -52 dBZ @ 1 km

## UM X-band Doppler radar

**Frequency:** 9.4 GHz (wavelength = 3.2 cm)

**Antenna:** 2 m, Cassengrain

**Vertical resolution:** 60 m, **Temporal Resolution:** 0.5 -1  
sec

**PRF:** 1-2.5 kHz (8-20 ms<sup>-1</sup>) Nyquist

**Doppler spectra, raw I/Q**

**Sensitivity:** -25 dBZ @ 10 km

Ceilometer

Broadband radiometers

IRT

Surface Met.

Rain gauge

\*\* NOAA/ETL 2 channel Microwave Radiometer