Ship-Based Measurements of Cloud Microphysics and PBL Properties in Precipitating Trade Cumuli During RICO

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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?*

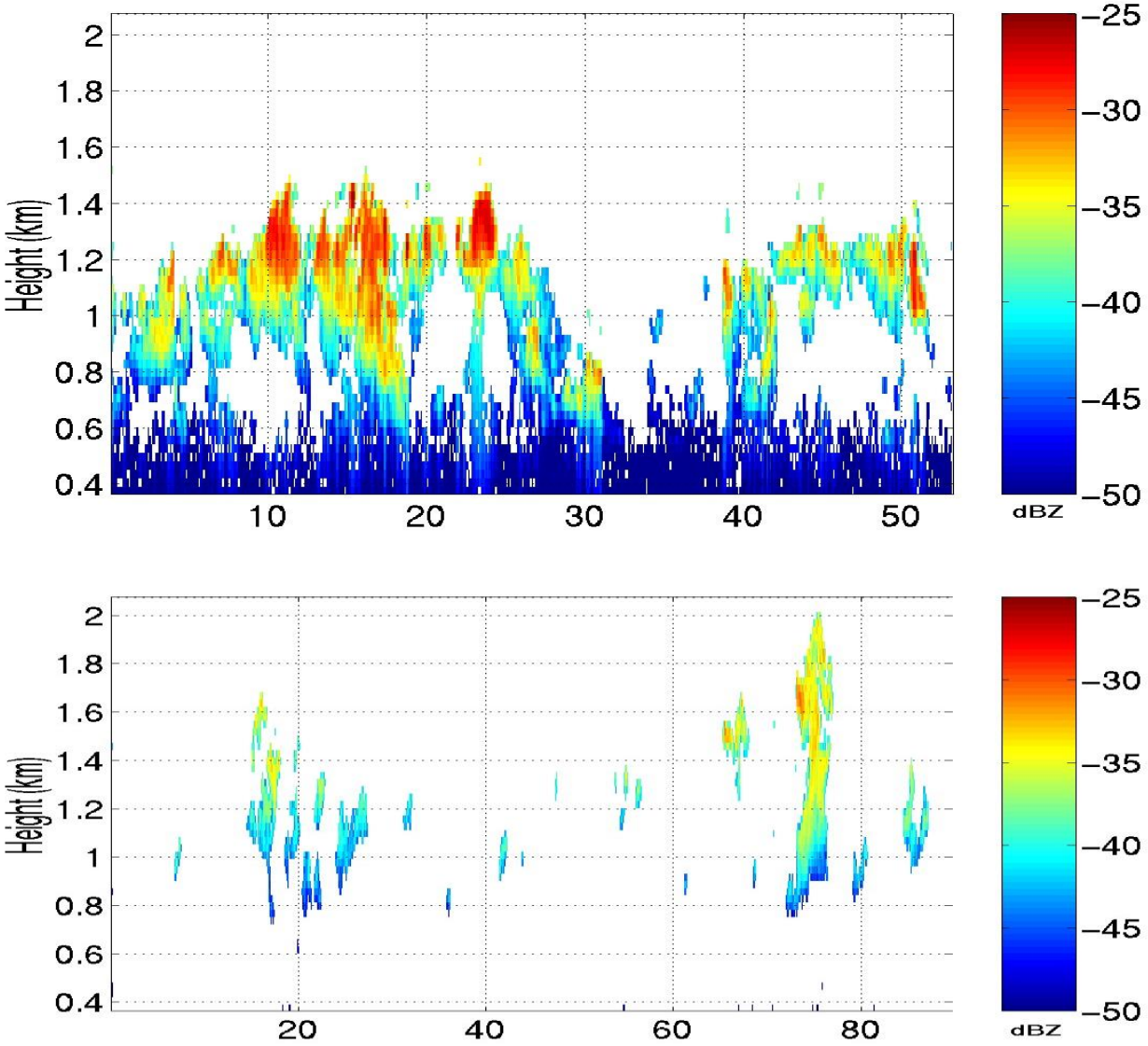
Approaches

- 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

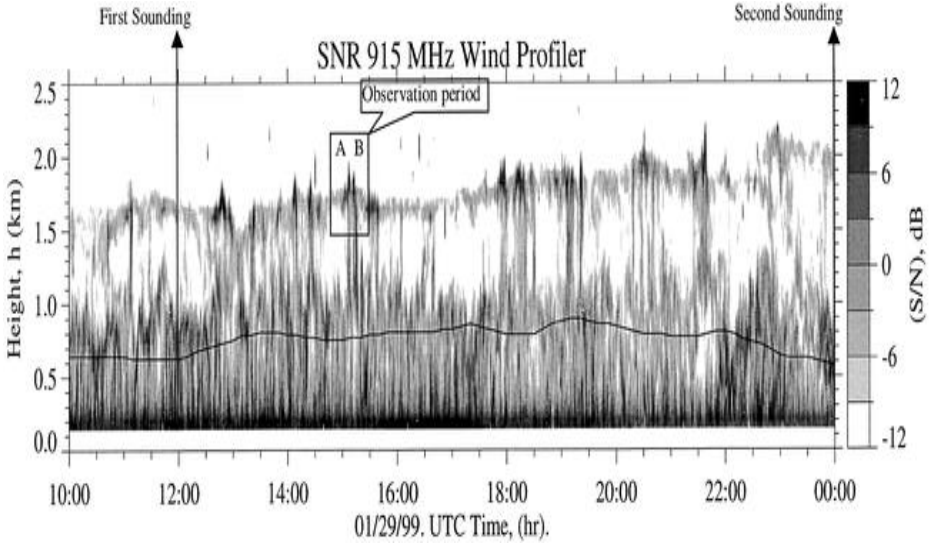


Dynamical and Microphysical Structure of Trade-Wind Cumuli

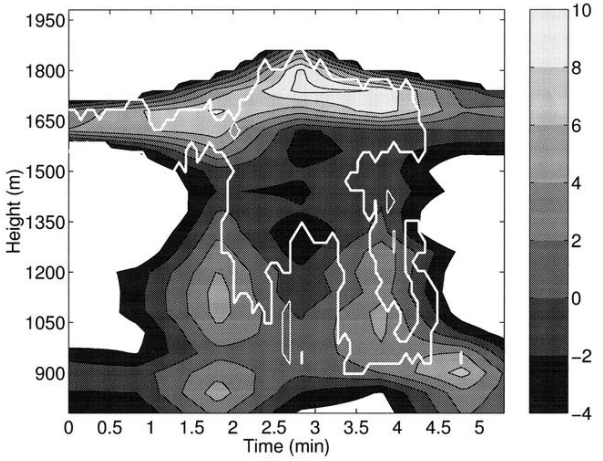
Boundary Layer/Cloud Characterizations

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

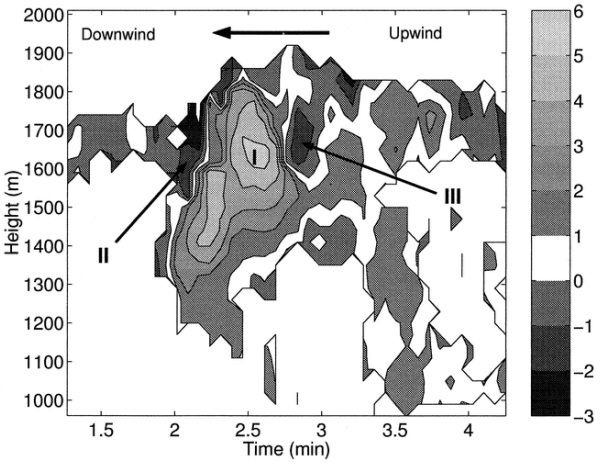
915-MHz wind profiler (SNR)



Bragg "halo", W-band cloud boundaries

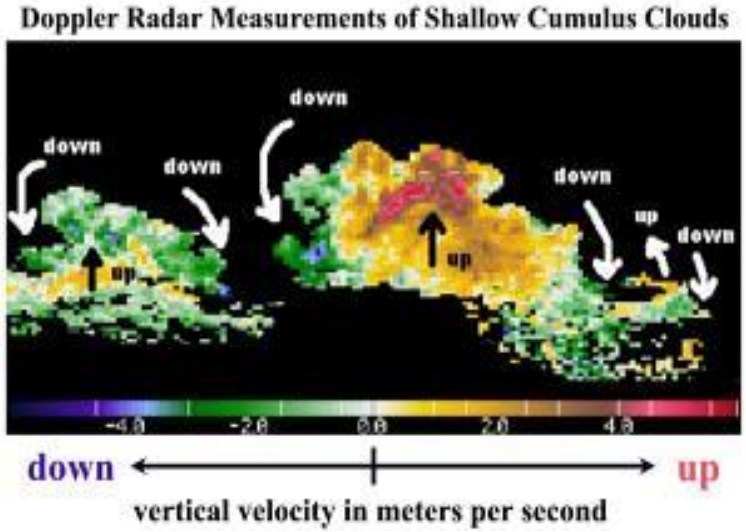


Updraft-Downdraft structures

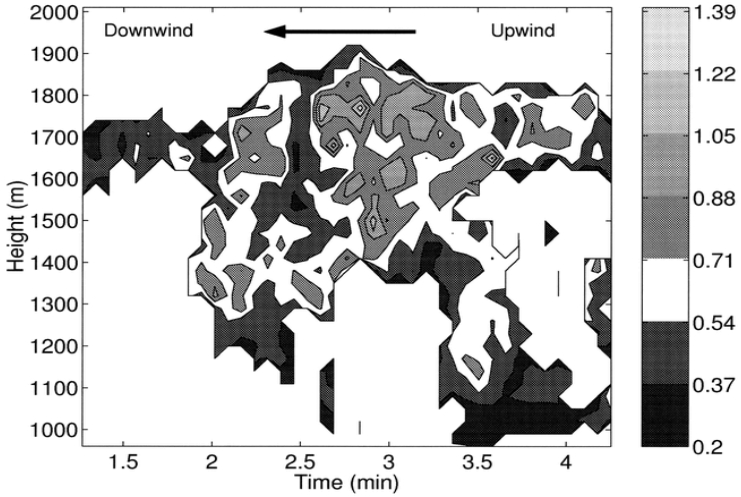


Large drop Formation in Trade-Wind Cumuli

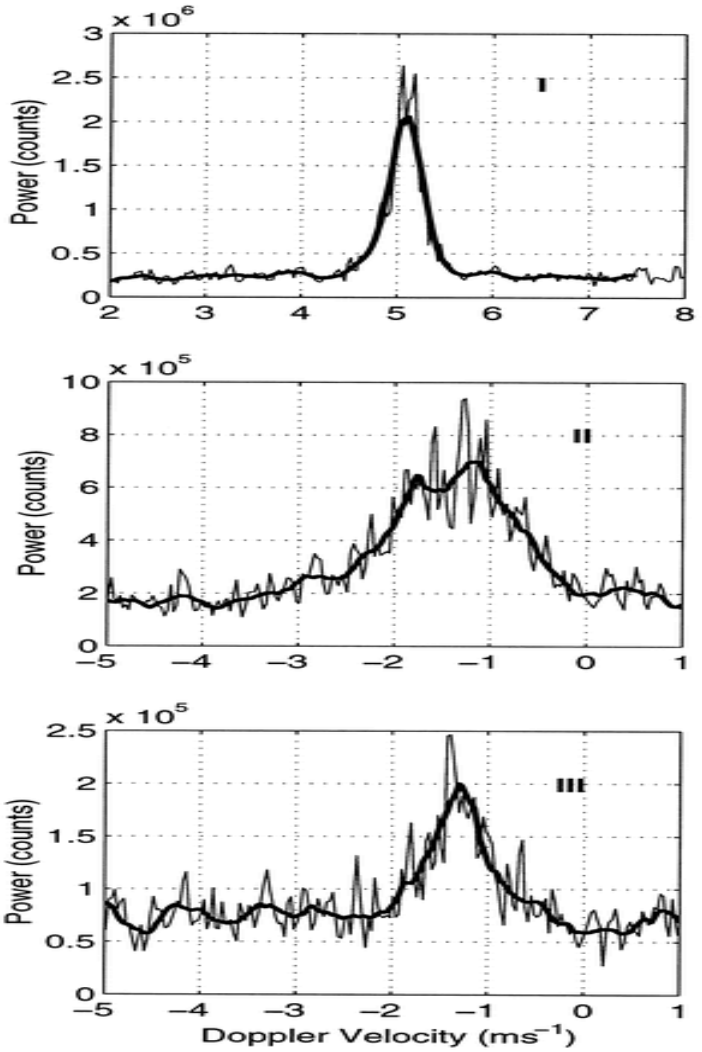
High resolution data from NOAA/K (4 /sec)



Doppler spectrum width from W-band



Detection of large drop production

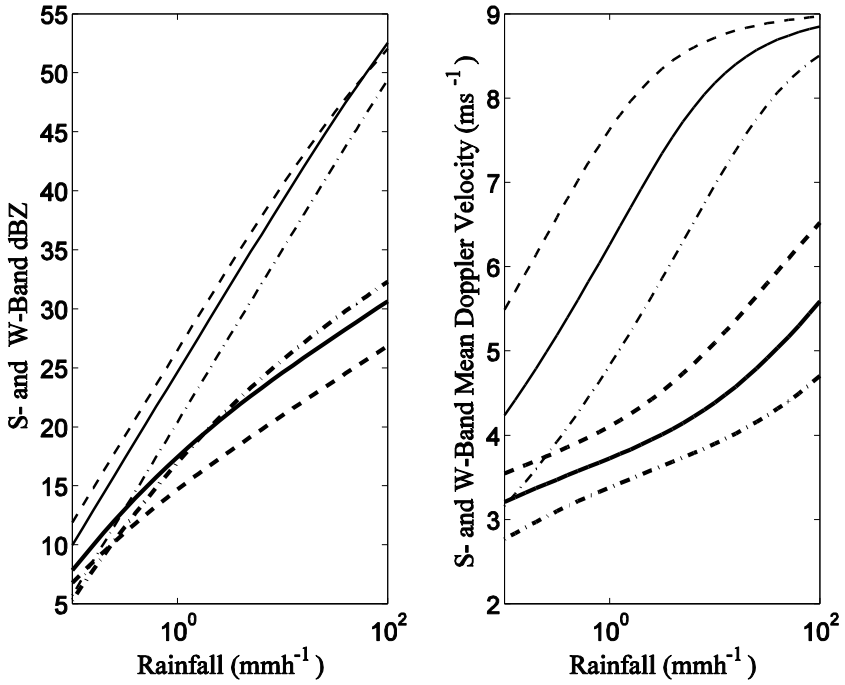


Raindrop DSD evolution in early precipitation stages

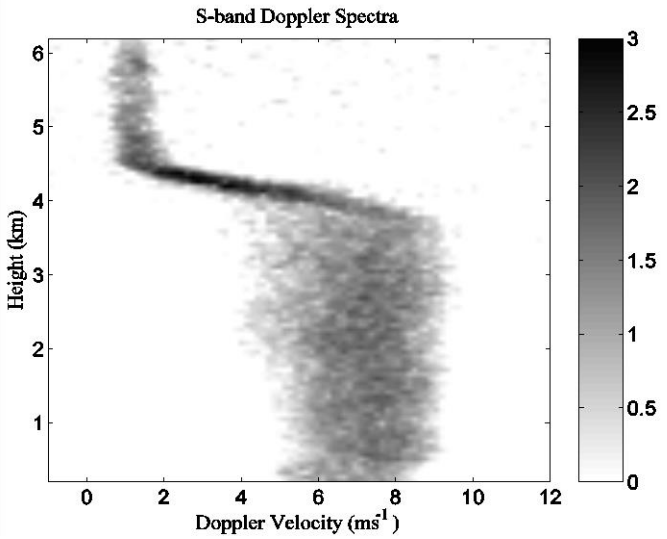
W/X dual wavelength precipitation retrievals

X-band reflectivity (cloud top, morphology)
W-band Mie scattering, Doppler spectra
- Vertical air motion (within 5 cms^{-1})
- DSD retrieval if Dmax > 1.7 mm

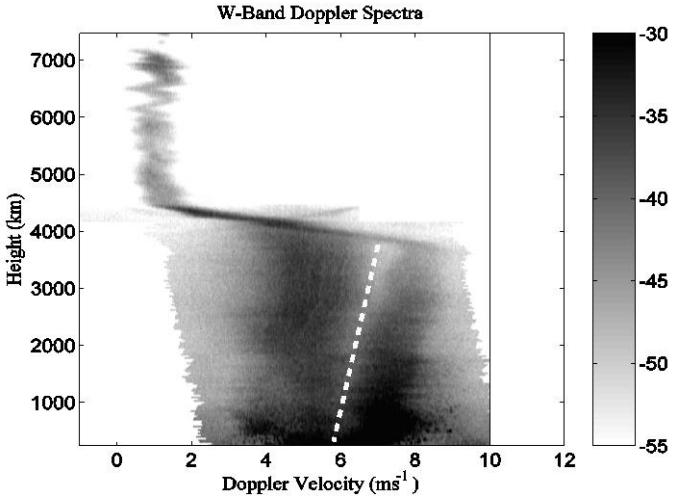
Differential reflectivity and mean Doppler



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^{o} 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^{-1}) 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^{-1}) 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