

Radar observations of the kinematic, microphysical, and precipitation characteristics of two MCSs in TRMM LBA

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Cifelli, R. W. A. Petersen, L.D. Carey, S. A. Rutledge, And M.
A. F. da Silva Dias, 2002: Radar observations of the
kinematic, microphysical and precipitation characteristics of
two MCSs from TRMM LBA. *J Geophys. Res.*, 107,
doi:10.1029/2000JD000264

Overview

- TRMM and TRMM LBA
 - Objectives
 - Methodology
 - Meteorological Regimes
 - Results
 - Summary
- 

TRMM and TRMM LBA

- TRMM - NASA Tropical Rainfall Measuring Mission

Objective – Characterization of the vertical structure of convection and corresponding latent heat distribution in tropical convection

- TRMM LBA – Tropical Rainfall Measuring Mission Large-Scale Biosphere-Atmosphere

Objective – Provide detailed information on precipitation characteristics in the interior of a tropical continent.

TRMM LBA

➤ Where and When

From January 10 to February 28, 1999 in the southwestern Amazon.

➤ Instrumentation

Airborne platforms with microphysical, radar, and passive microwave instrumentation;

Atmospheric Sounding Stations;

Boundary layer tethered sonde and meteorological tower;

Rain gauge networks and disdrometers;

Precipitation Profilers;

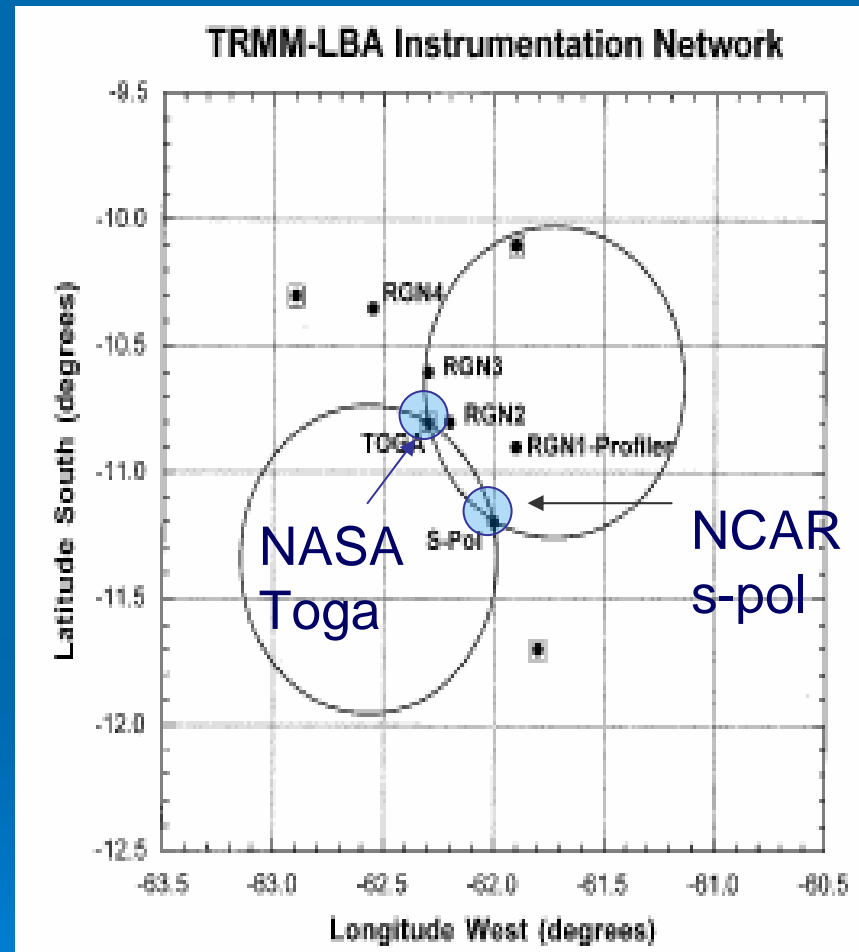
Ground based C-band doppler (NASA TOGA) and S-band polarimetric (NCAR S-pol) radars.

Objectives of Study

- Emphasize the detailed kinematic and microphysical characteristics observed in two convective systems, January 26 and February 25 MCSs, in the Amazon Basin.
- Examine the vertical structure of the MCSs using dual-Doppler and polarimetric radar analyses.

Methodology-Radar

- Synchronized (start times within 30 s) radar scans were done
- A total of 34 radar volume scans were done for the two cases. A continuous 2.5 hour period for the January 26 case and a continuous 3 hour period for the February 25 case.



- NASA TOGA and NCAR s-pol were located 62 km apart in mixed forest and deforested region.

Methodology- Partitioning Algorithm

- A partitioning algorithm was used to separate convection from nonconvective regions. The partitioned precipitation category is referred to as weak convective-stratiform (WCSF) due to the fact that it is a mixture of decaying convection (no bright band signature) and stratiform echo.



Methodology – Polarimetric Observables

$$M_r = 3.44 \times 10^{-3} [Z_H^{\text{rain}}]^{0.70} \text{ (g m}^{-3}\text{)},$$

$$M_{\text{ice}} = 1000\pi\rho_i N_0^{2/3} \left(\frac{5.28 \times 10^{-10} Z_H^{\text{ice}}}{720} \right)^{4/3} \text{ (g m}^{-3}\text{)},$$

Used if there is a presence (detected using the Z_{dp} method *Carey and Rutledge [200]*) of mixed phase precipitation for rain and ice mass, respectively

$$M_r = 0.70 \times 10^{-3} (Z_H^{0.886}) (e^{-4.19Z_H}) \text{ (g m}^{-3}\text{)},$$

Used if the presence of pure rain is indicated (Z_{dp} method) for the calculation of rain mass

Table 1. Polarimetric Radar Rain Rate Estimators^a

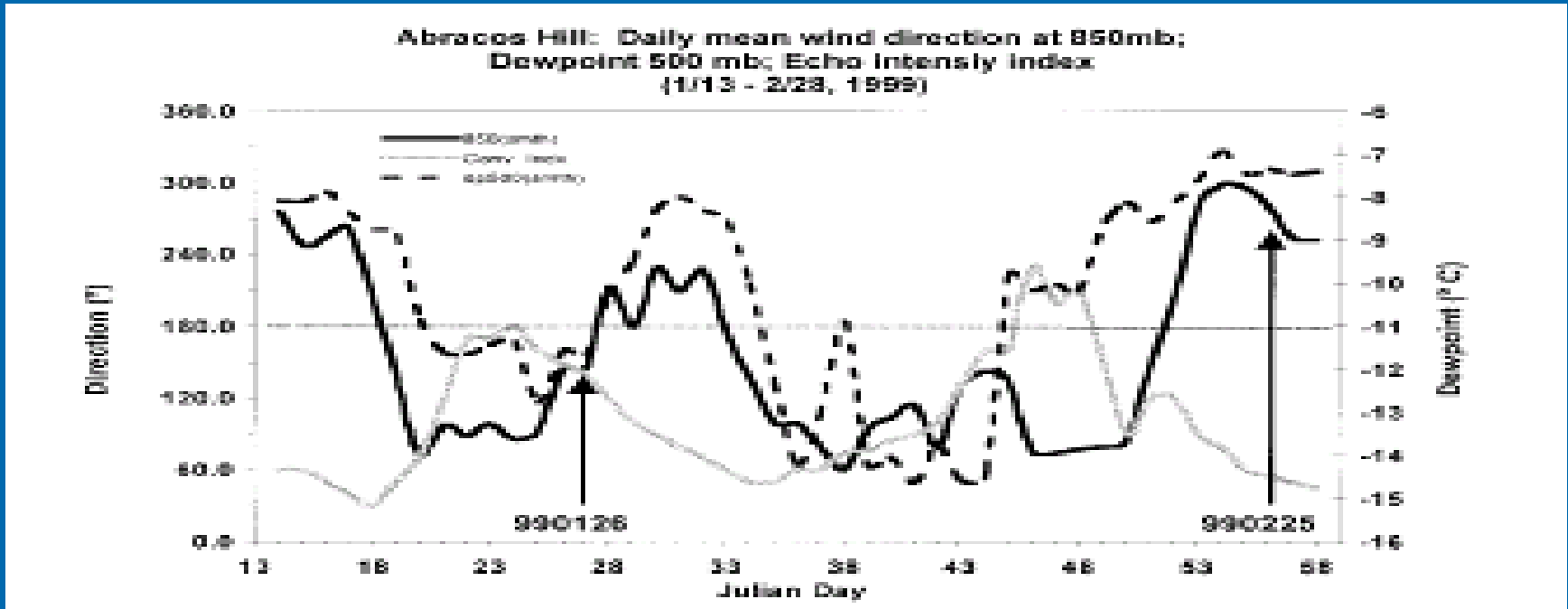
Equation	Unit
(1) $R(K_{DP}, Z_{DP}) = 87.6 \cdot (K_{DP})^{0.034} \cdot (10)^{(0.1 \cdot -1.59 \cdot Z_{DP})}$	mm h ⁻¹
(2) $R(Z_H, Z_{DP}) = 6.70 \times 10^{-2} \cdot (Z_H)^{0.927} \cdot (10)^{(0.1 \cdot -2.043 \cdot Z_{DP})}$	mm h ⁻¹
(3) $R(K_{DP}) = 53.8 \cdot (K_{DP})^{0.85}$	mm h ⁻¹
(4) $R(Z_H) = 0.02180 \cdot (Z_H)^{0.70}$	mm h ⁻¹

Rain-rate estimations for polarimetric variables

$$D_{\text{ms}} = 1.619 + Z_{\text{DR}}^{(0.4885)}.$$

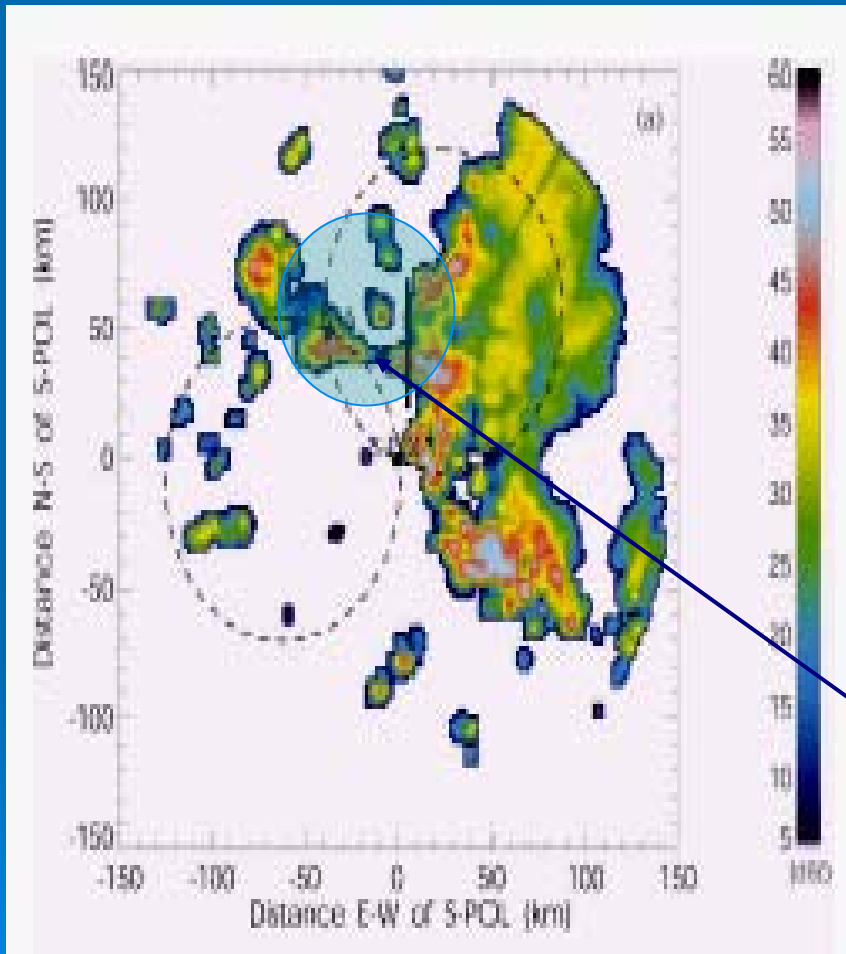
Mass-weighted mean diameter

Meteorological Regimes



- Western Regime- February 25
 - low-level west to northwest flow and relatively moist troposphere
 - convection less vertically developed
 - lower daily peak lightning flashes, lower maximum rain rates
- Eastern Regime- January 26
 - low-level easterly flow and slightly drier troposphere
 - enhanced vertical development
 - highly electrified

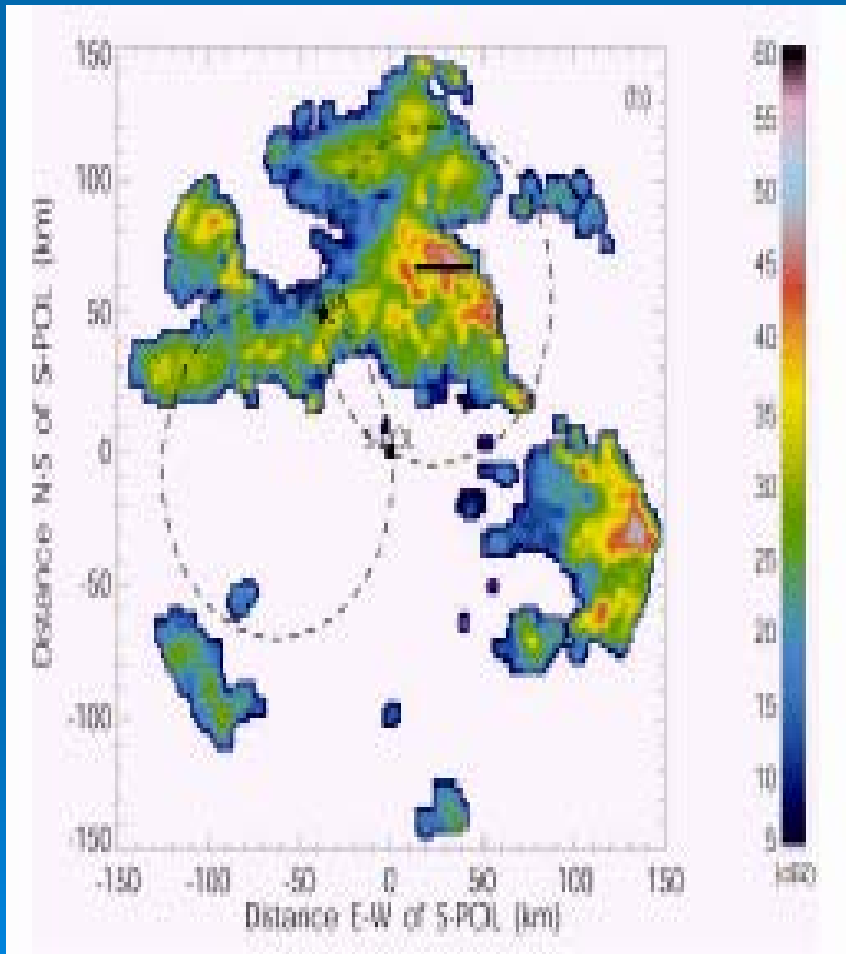
Results – January 26 MCS



- A squall line with leading convection and a trailing region of decaying convection and stratiform precipitation
- Entered dual-Doppler lobe around 1950 UTC oriented N-S
- Peak reflectivity exceeding 60 dBZ and peak updrafts of 20 ms^{-1}

At 2100 UTC, merged with An east-west oriented cell.

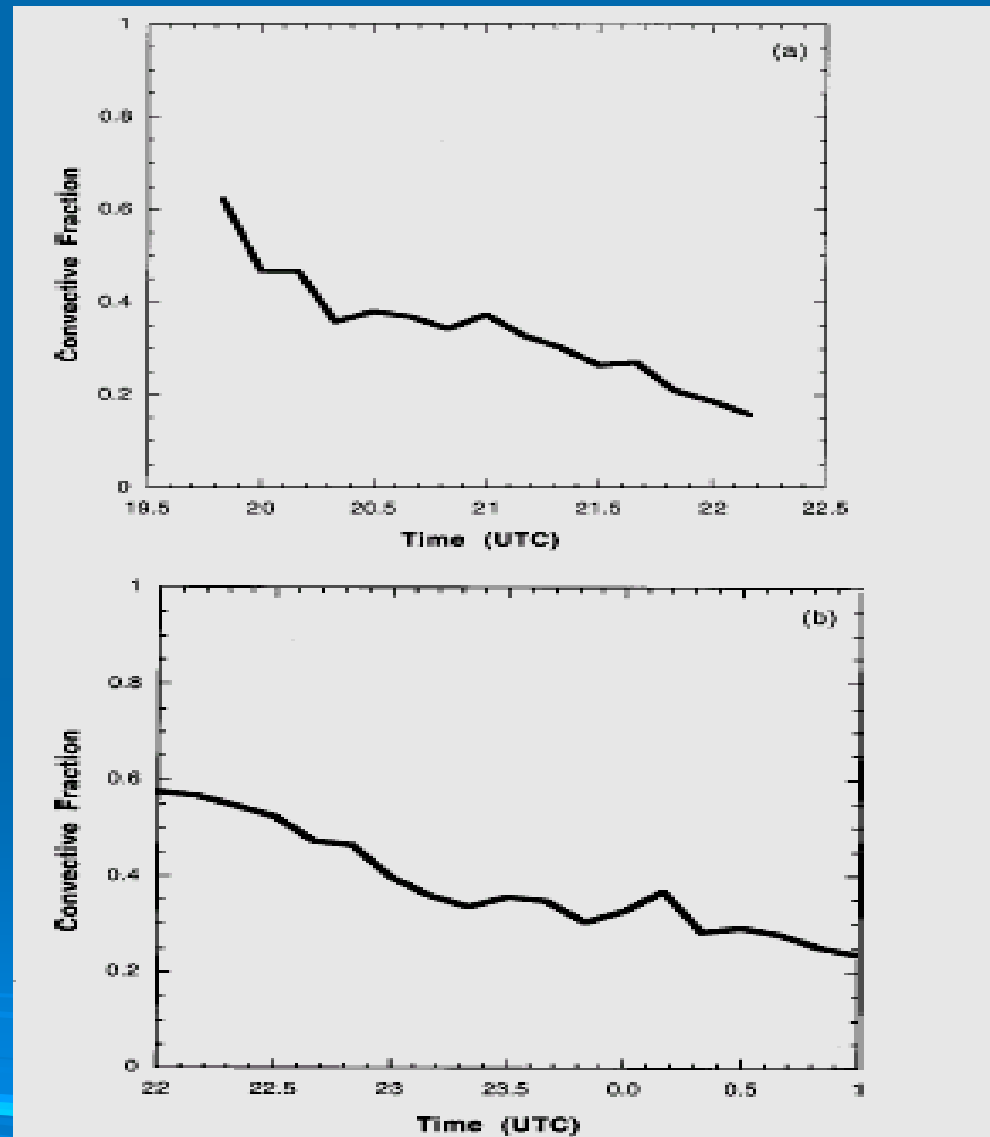
Results – February 25 MCS



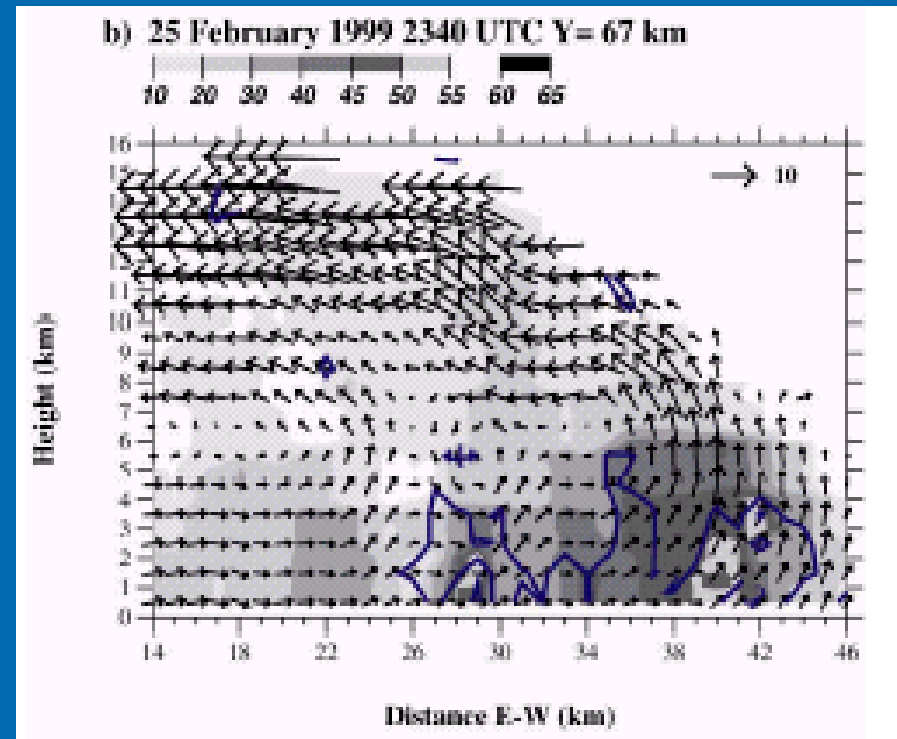
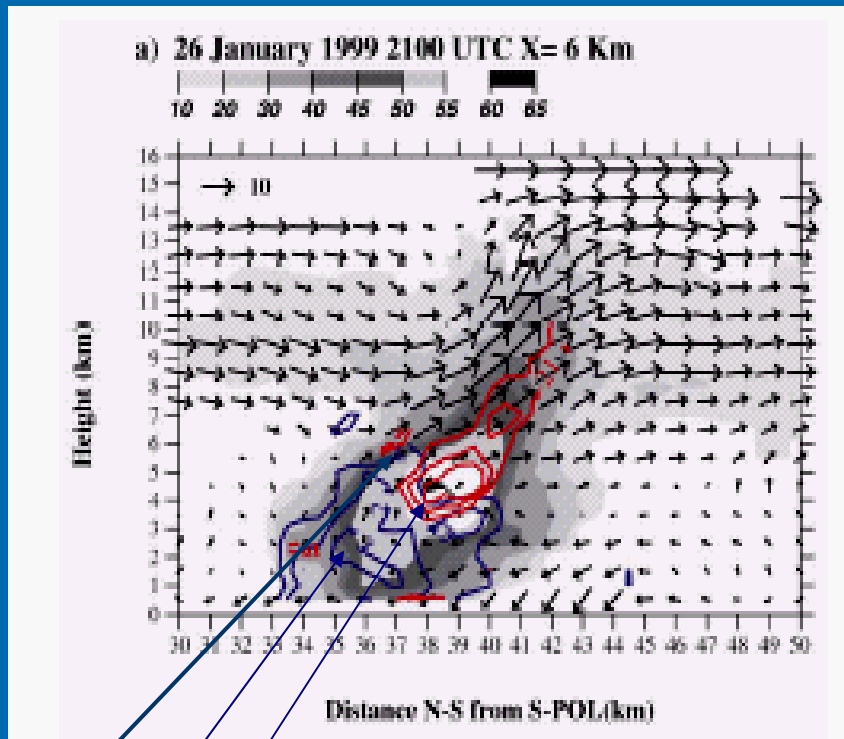
- Began as a cluster of cells north of the s-pol around 2000 UTC.
- Cells grew and merged in the northwest-southeast direction.
- Relatively homogeneous precipitation
- Remained in dual-Doppler lobe for over 9 hours, began to dissipate after 0200 UTC.

Results

- Both MCS had the same fraction of convective echo during their sampling periods indicating both were in mature stages of growth.



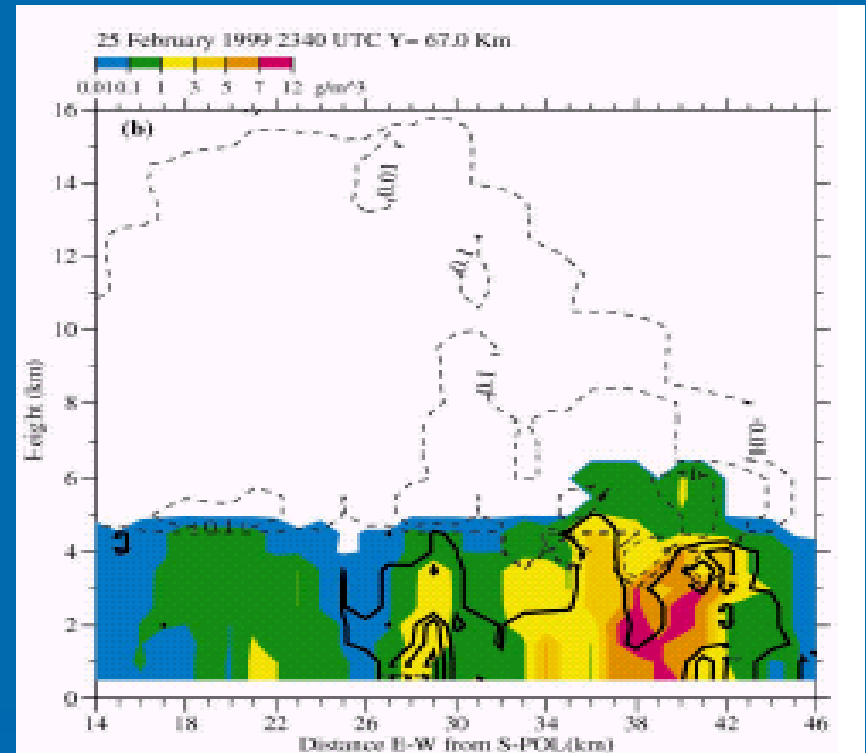
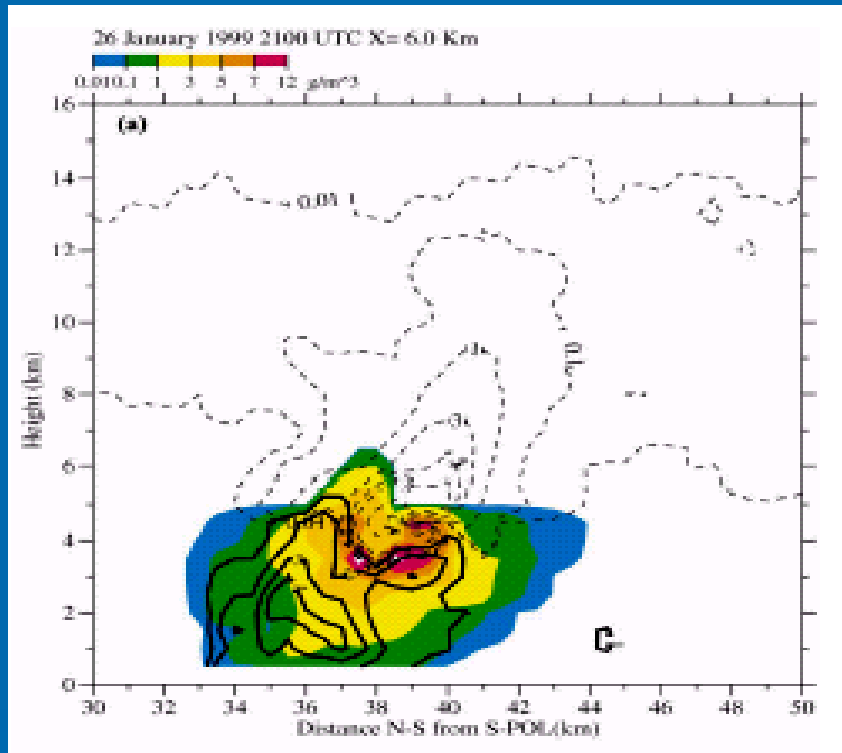
Results - Storm Cross Sections



- Z_{dr} column extending above 5 km
- Z_{dr} exceeding 3db near 2 km
- LDR enhancement near Z_{dr} dip on right suggest hail production

- Weak Z_{dr} levels (1 db)
- Almost complete absence of LDR

Results – Cross Sections

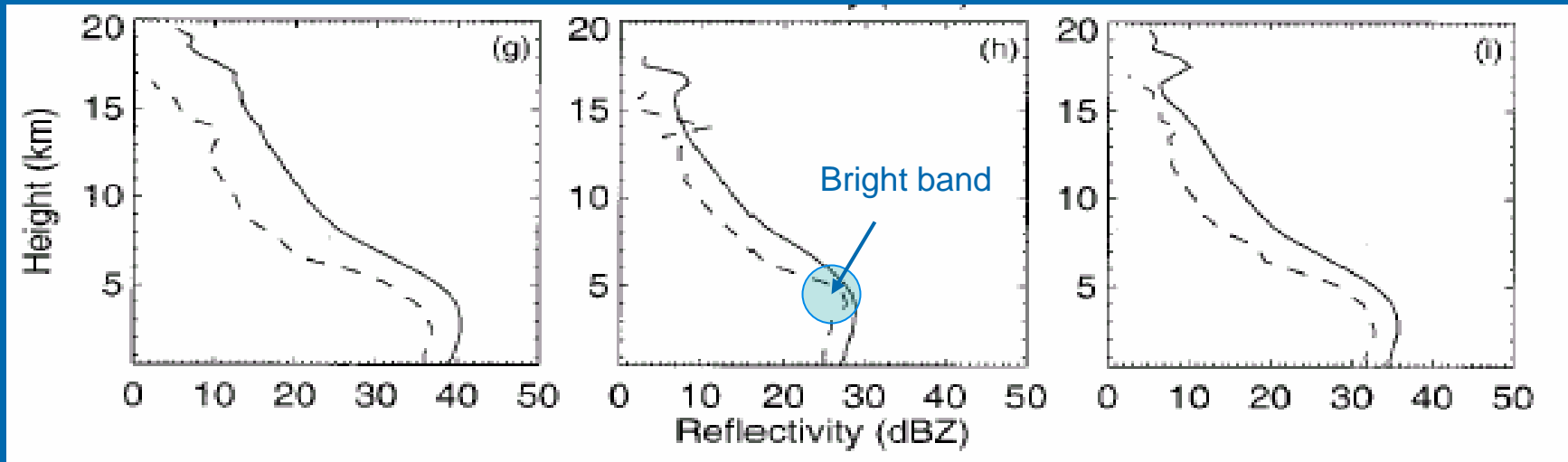


- High liquid water contents, over 12 g/m^3
- Large drop diameters, up to 4 mm

- Sharp Reflectivity Gradient
- Lower ice water content
- Smaller drop sizes

Results – Mean Reflectivity

Convective WCSF Total

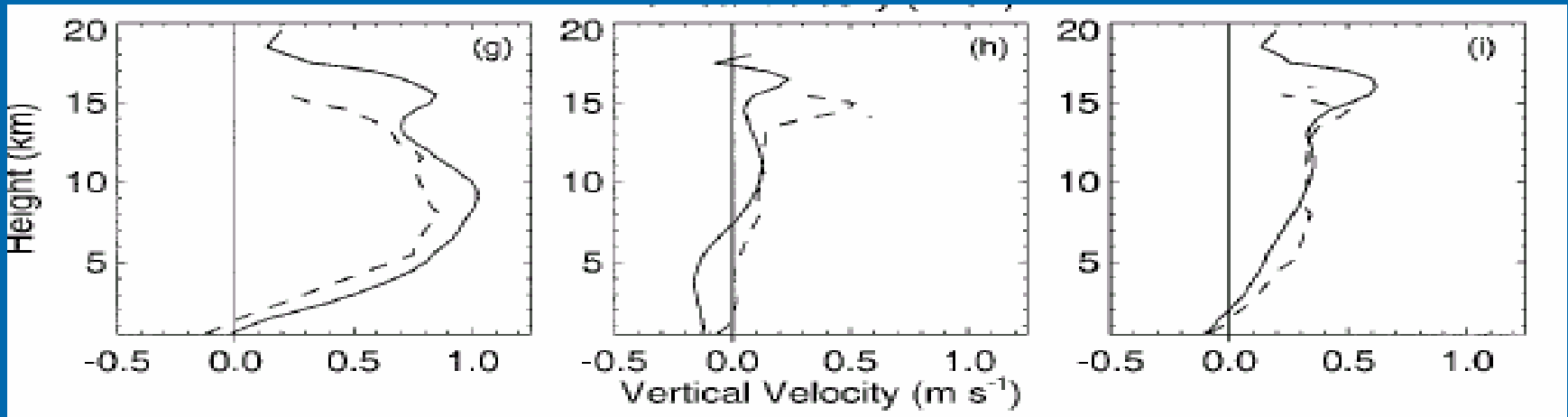


January-solid line; February – dashed line

- January case had higher frequency of high reflectivities
- January case had smaller gradient in mixed phase region
- Bright band feature in February case

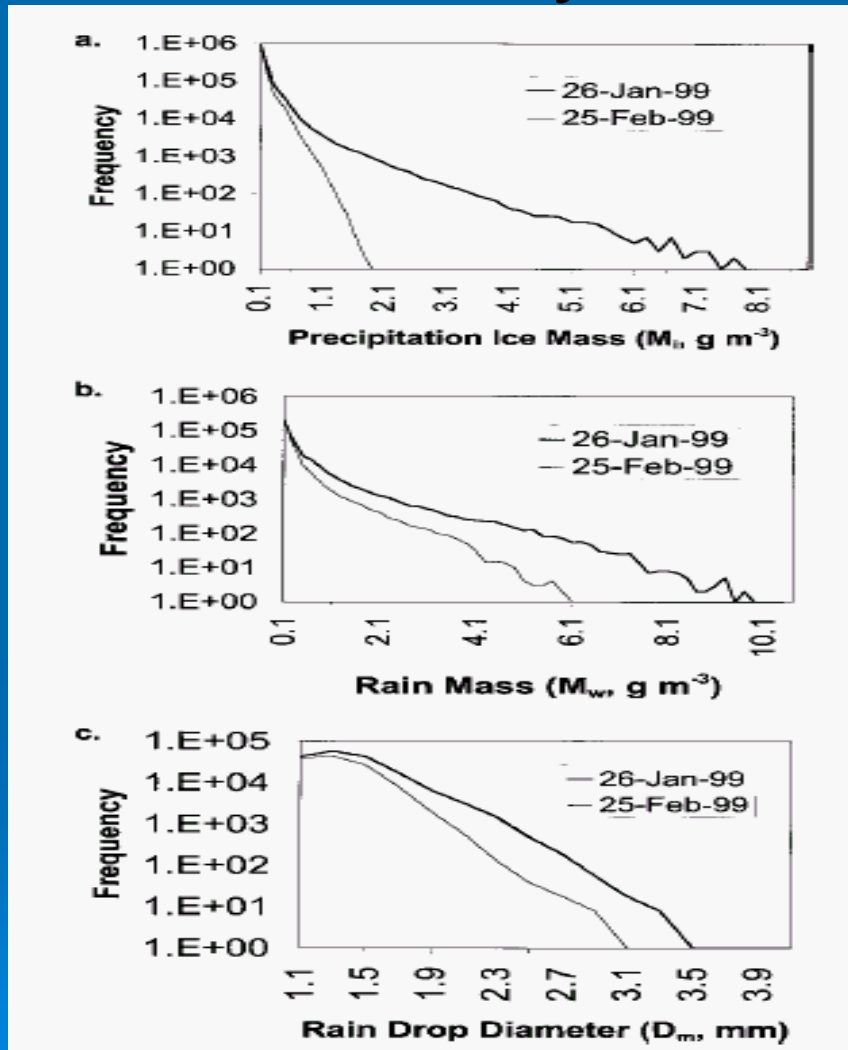
Results – Mean Vertical Motion

Convective WCSF Total



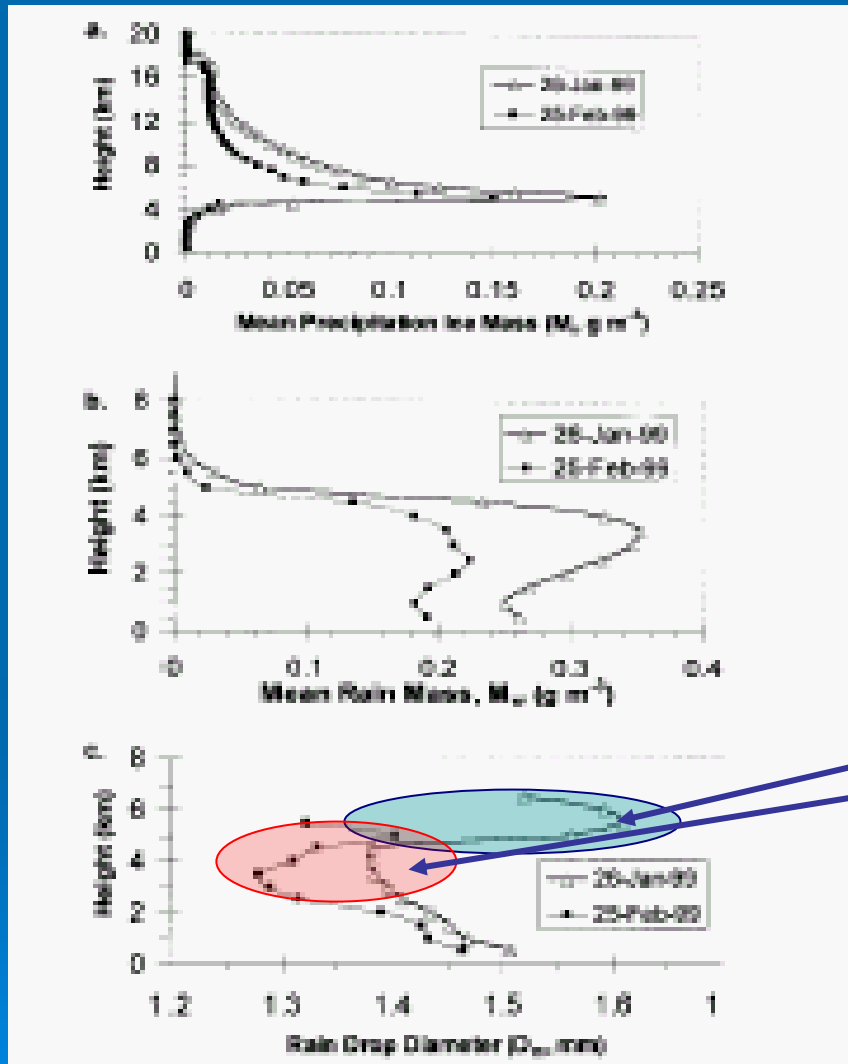
- Higher relative frequency of intense vertical velocities at all heights in January case
- In WCSF, January case shows larger low-level descent

Results – Hydrometeor Characteristics



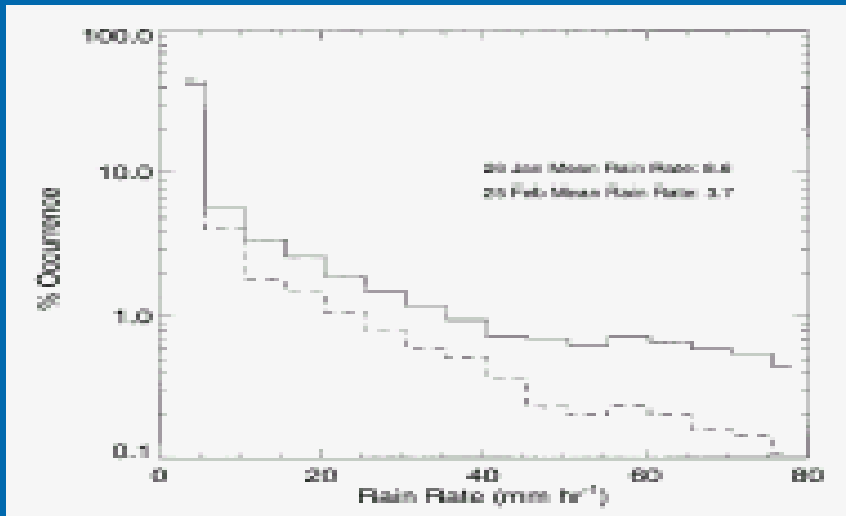
- Higher frequency of large drops (both ice and water) in easterly MCS
- Large difference in frequency between large ice masses between MCSs

Results – Hydrometeor Characteristics

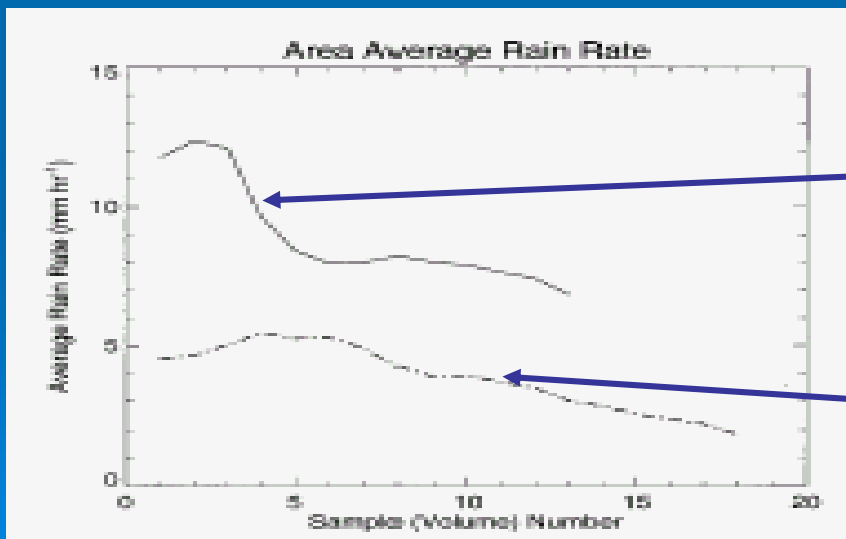


Offset of mean drop diameter above and below melting level

Results – Rainfall Characteristics



- Easterly MCS had higher occurrence of intense rain rates



A period of life cycle evolution

No evolution, steadily decreasing rain rate

Summary

- The MCSs were distinctly different in vertical structure and rain rate
- Easterly, January event was characterized by strong updrafts and strong reflectivity structure above the freezing level, similar to continental convection
- Westerly, February case was weaker in reflectivity and similar to monsoon convection
- Observations from this event can be used to provide validation for models and passive microwave algorithms to estimate latent heating in the Amazon