

# Deriving Microphysical Cloud Profiles using Airborne Active and Wideband Passive Microwave Observations

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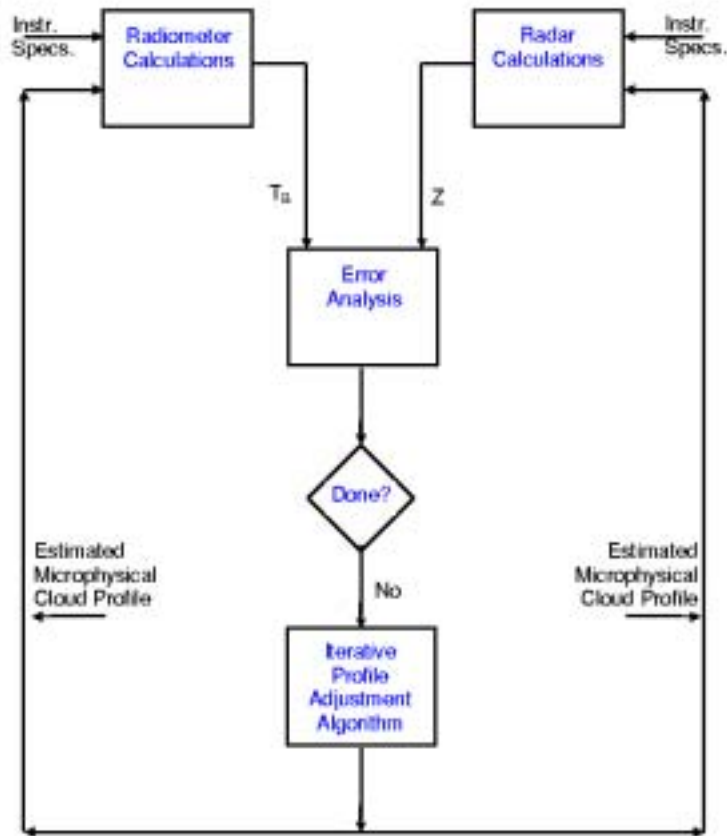
# Presentation Outline

- Research Objectives
- Hydrometeor Profile Retrieval Algorithm
- CAMEX-3 Retrieval Results
  - Anvil, Convective, Quasi-Stratiform cloud retrievals
  - Reduced channel set retrievals
- CAMEX-4 Plans and Ongoing Research
- Summary

# Research Objectives

- **Goals:**
  - Retrieve hydrometeor profiles of liquid and frozen particles
  - Incorporate active and passive observations
  - Determine benefits of high frequency channels
- **Challenges:**
  - Relating frozen hydrometeor characteristics to high frequency observations
  - Correlating high to low frequencies and to radar data
  - Handling hydrometeor and surface variability
- **Status:**
  - High frequency usefulness noted
  - Retrieval algorithm developed, results validated (CAMEX-3 data)
  - Relationships being resolved

# Retrieval Algorithm



- Physically-based
- Initialization uses radar and cloud model data
- Error convergence criteria ( $Z_{\text{diff}} < 2.5 \text{ dBZ}$ ,  $T_{\text{Bdiff}} < 10 \text{ K}$ )
- Flexible

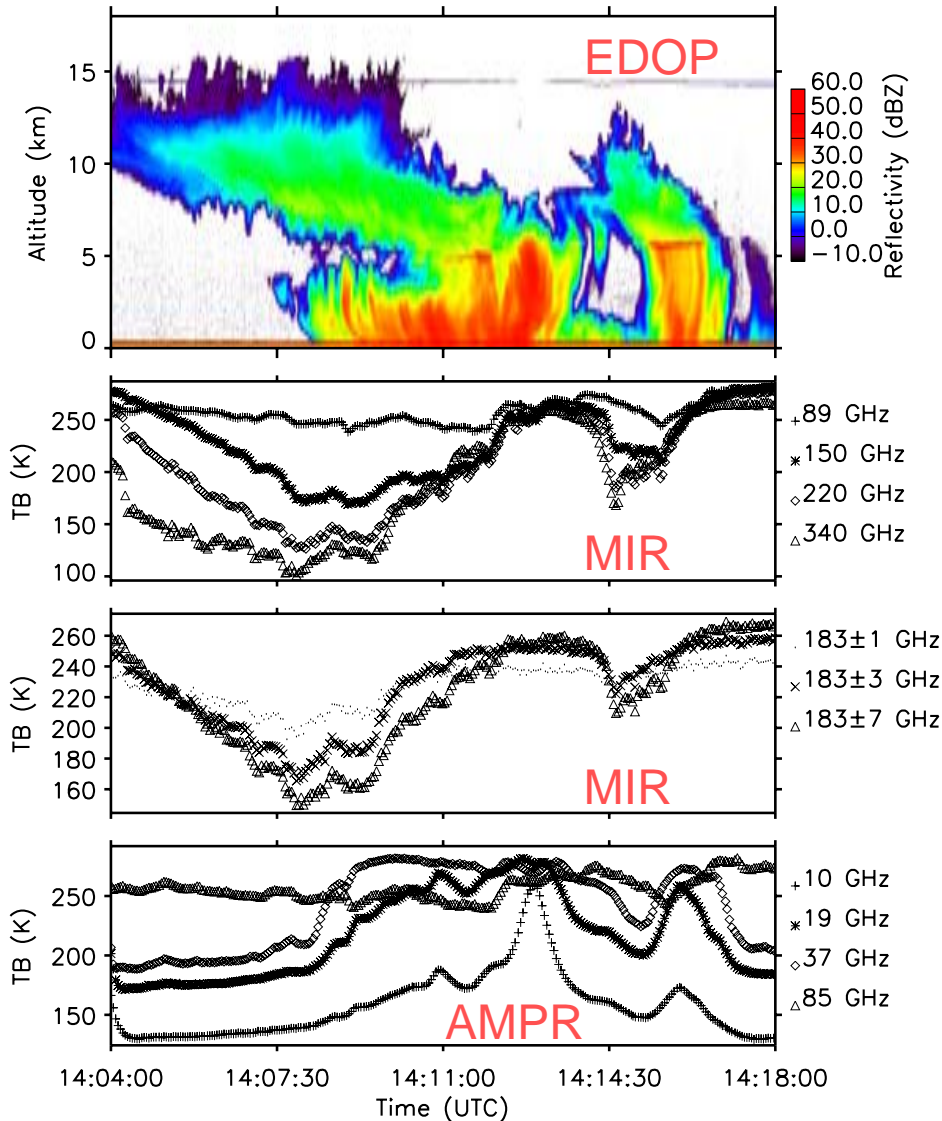
2.5

# CAMEX-3 Instrumentation

- **Millimeter-wave Imaging Radiometer (MIR)**
  - 89, 150, 183±1, 183±3, 183±7, 220, 340 GHz
- **Advanced Microwave Precipitation Radiometer (AMPR)**
  - 10.7, 19.35, 37, 85.5 GHz
- **ER-2 Doppler Radar (EDOP)**
  - 9.6 GHz
- **Microwave Temperature Sounder (MTS)**
  - 16 channels near 50 and 118 GHz
- **2-D PMS Probe (on DC-8 aircraft)**
  - In situ particle size distribution measurements

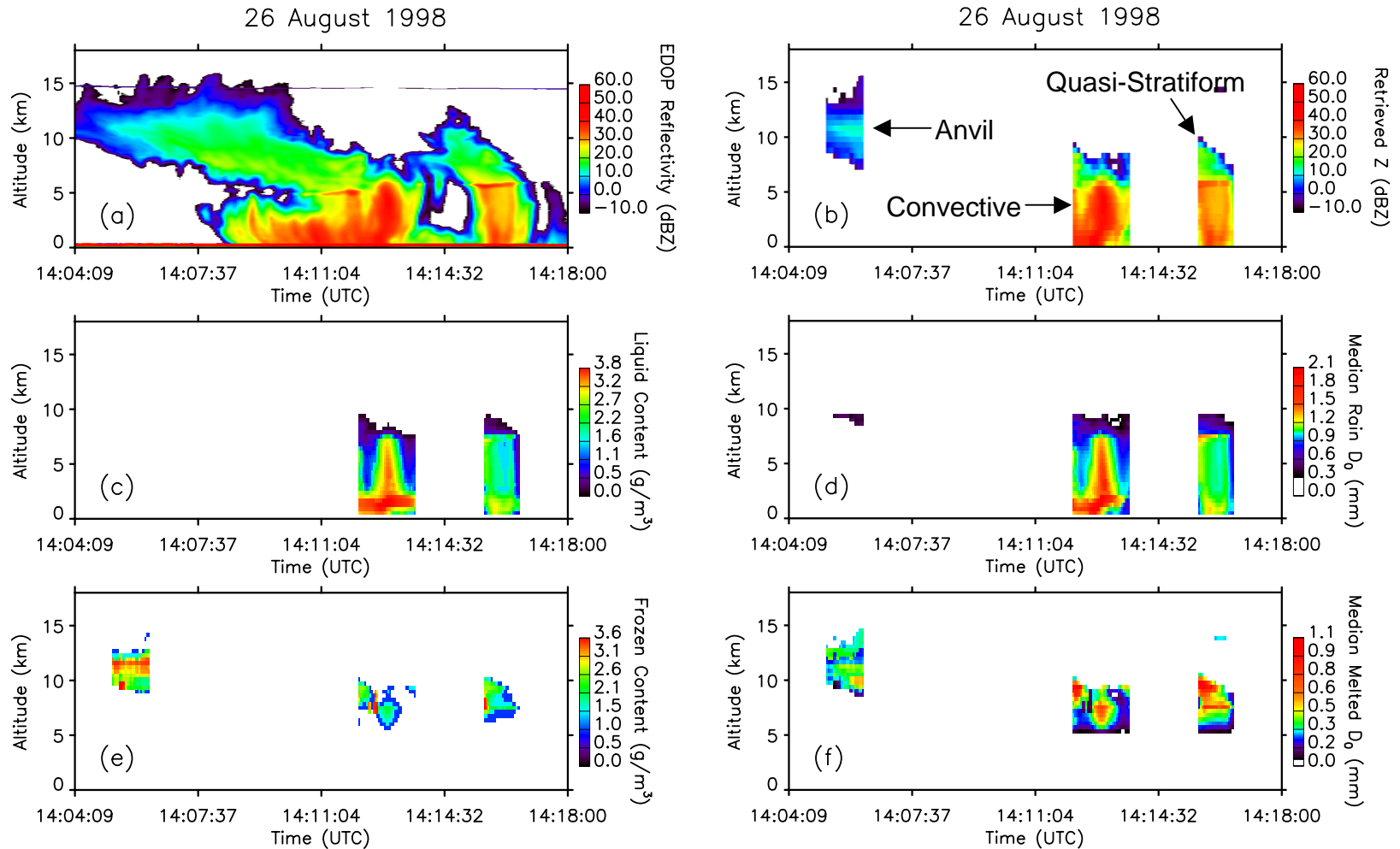
# Hurricane Bonnie (CAMEX-3)

August 26, 1998 – ER-2 Overpass



- Hurricane eye ~ 55 km (~4.5 flight mins) to the right of the image
- Note sensitivity of 150, 220, 340 GHz to anvil ice cloud
- Retrievals for:
  - **Anvil** Cloud (~210 km from eye, assumes a 15 m/s surface wind speed)
  - **Convective** (~110 km from eye, 30 m/s wind speed)
  - **Quasi-Stratiform** (~75 km from eye, 35 m/s wind speed)

# Retrieval Results



(a) EDOP observations, (b) retrieved Z, (c) liquid content, (d) median rain diameter, (e) frozen content, (f) median melted diameter

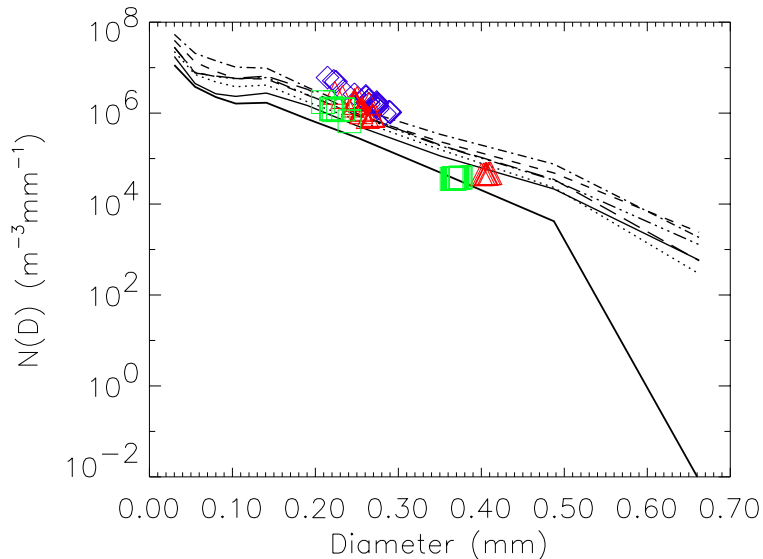


# Retrieval Validation

## 1. NAST-MTS (on ER-2, 20 km)

At  $50.3 \pm 0.09$  and  $118.75 \pm 3.5$  GHz calculated  $T_B$  are within 10 Kelvin (the convergence criterion) of the NAST-MTS values

## 2. 2-D PMS Cloud Probe (on DC-8, 12 km)



### Anvil validation only

Solid lines: Observed  
PMS size distributions

◇ : Retrieved at 11.5 km

△ : Retrieved at 12.0 km

□ : Retrieved at 12.5 km

# Summary of Results

## Liquid hydrometeors

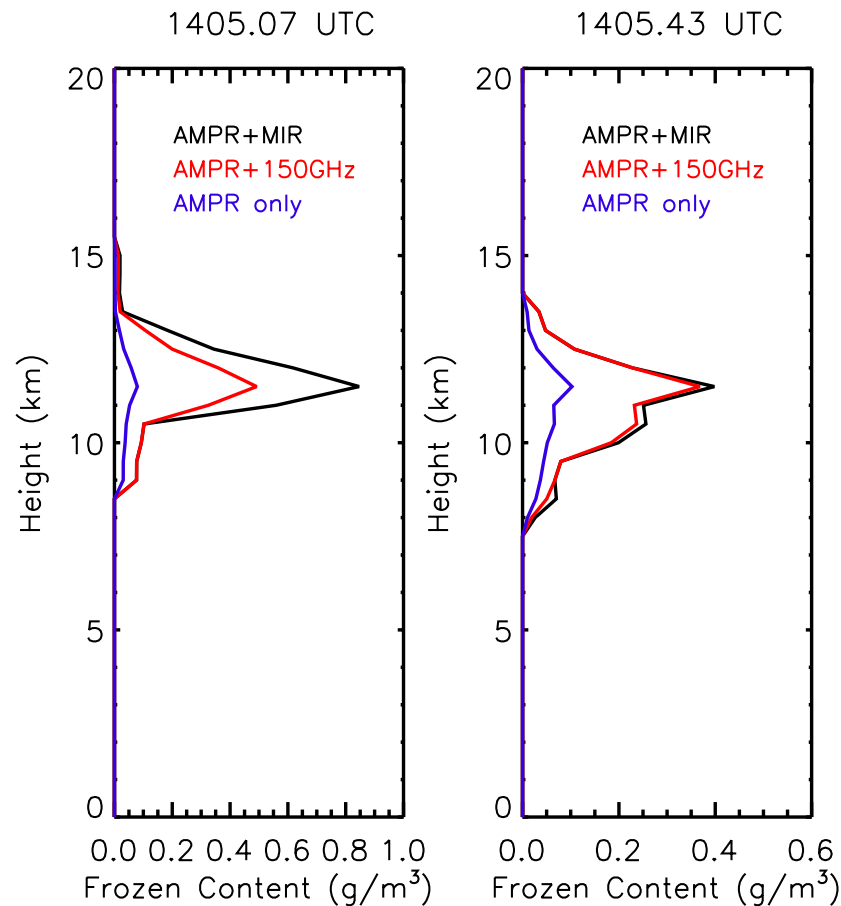
- Below 500m liquid content not adjusted due to surface radar return issues
- Content patterns follow EDOP patterns
- TB comparisons validate retrieved size distributions

## Frozen hydrometeors

- Frozen content variability due to difficulties reaching convergence for high frequencies
- Frozen drops assumed solid ice
- PMS probe validates anvil size distributions

# Retrieval Results for Two Anvil Profiles using Reduced Channel Sets

26 August 1998



# CAMEX-4/Ongoing Research

1. Retrieval algorithm has been revised for the HAMSR high frequency channel set
2. Gather CAMEX-4 instrument data and co-register for priority days (initial focus on Hurricane Erin)
3. Investigate retrieval performance using HAMSR channel set
4. Include dielectric mixing for inhomogeneous frozen hydrometeors
5. Algorithm enhancements

# Summary

- High frequencies are necessary to obtain frozen hydrometeor details at higher altitudes
- CAMEX-3 results encouraging
- Mechanisms in place for analysis of CAMEX-4 data
- Fluffy and melted frozen precipitation are being incorporated

# Acknowledgments

J. Wang, G. Heymsfield, R. Hood, R. Pueschel, A. Strawa, R. Black, and P. Rosenkranz for CAMEX-3 data  
J. Weinman and W. Manning for analysis/processing  
Dr. Kakar for CAMEX-4 funding

## Related Papers:

1. Influence of Microphysical Cloud Parameterizations on Microwave Brightness Temperatures by Skofronick-Jackson, Wang, and Gasiewski, *IEEE Transactions on Geosci. and Remote Sens.*, pp. 187-196, Jan. 2002.
2. The Estimation of Hydrometeor Profiles from Wideband Microwave Observations by Skofronick-Jackson and J. R. Wang, *J. Applied Meteor.*, pp. 1645-1656, Oct. 2000.
3. Combined Radiometer-Radar Microphysical Profile Estimations with Emphasis on High Frequency Brightness Temperature Observations by Skofronick-Jackson et. al. submitted Jan. 2002 *J. Applied Meteorology*.