

# Examination of the tropical cyclone environment through comparison of COSMIC with other satellite data

Christopher M. Hill, Patrick J. Fitzpatrick, and Yee Lau  
Geosystems Research Institute / Northern Gulf Institute  
Mississippi State University

March 3, 2009

63rd Interdepartmental Hurricane Conference

# Motivation to use COSMIC

- Tropospheric sounding data are provided:
  - in the absence of reconnaissance flights or other satellite data
  - in cloudy or rain-filled regions, where other satellite data are contaminated
- Regions or layers of contrasting moisture content can be identified within:
  - the span and depth of a Saharan Air Layer (SAL)
  - the core of a tropical cyclone

# Motivation to use COSMIC

The radio occultation method gives refractivity ( $N$ ) from GPS signal delay

$$N = 77.6 \frac{p}{T} + 3.73 \times 10^5 \frac{e}{T^2} + \{ \textit{correction for ionospheric effects} \}$$

[dry term]            [wet term]

Given  $N(p)$ , it is possible to solve for  $T$  and/or  $e$  (and therefore  $T_d$ )

According to Ware et al. (1996), the error of  $e$  in terms of the error of  $T$  is:

$$\Delta e \approx \frac{(2TN - 77.6p)}{3.73 \times 10^5} \Delta T \approx 0.23 \Delta T$$



With  $N$  and  $p$  known,  
a value of  $T$  known within  $\pm 3$  K can typically provide  
a value of  $e$  within  $\pm 1$  hPa

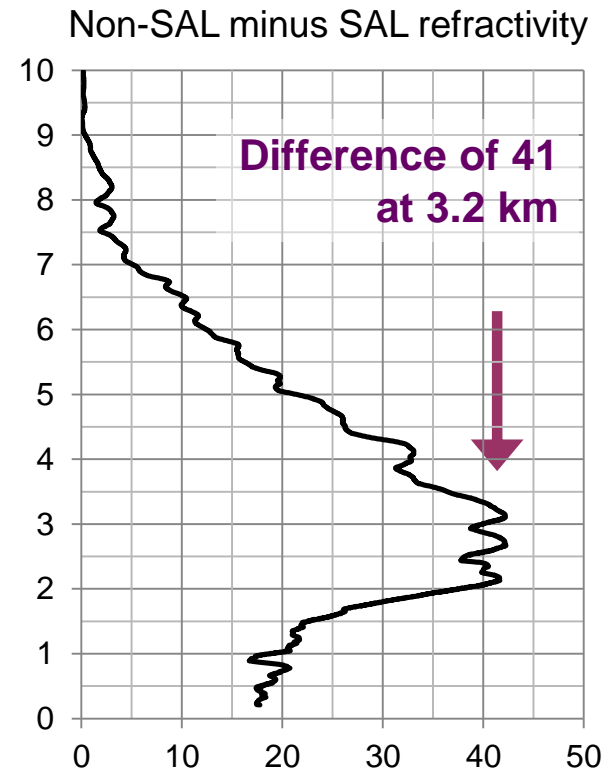
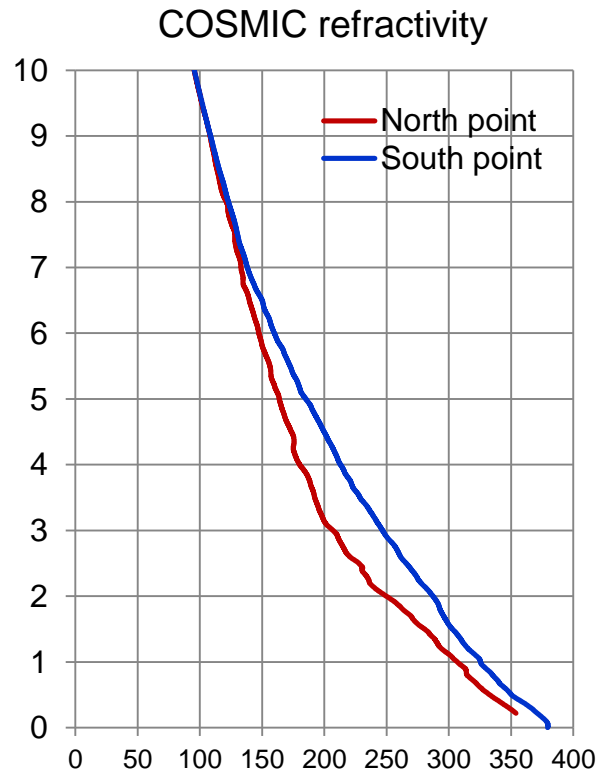
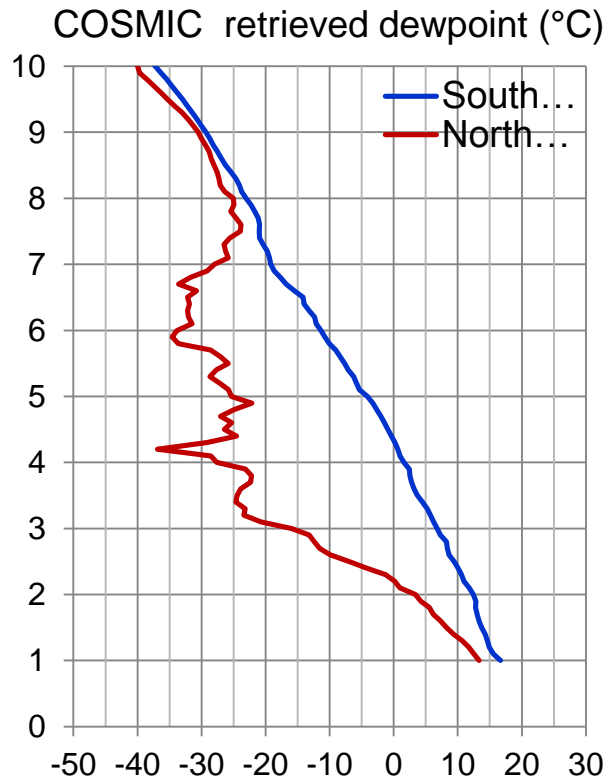
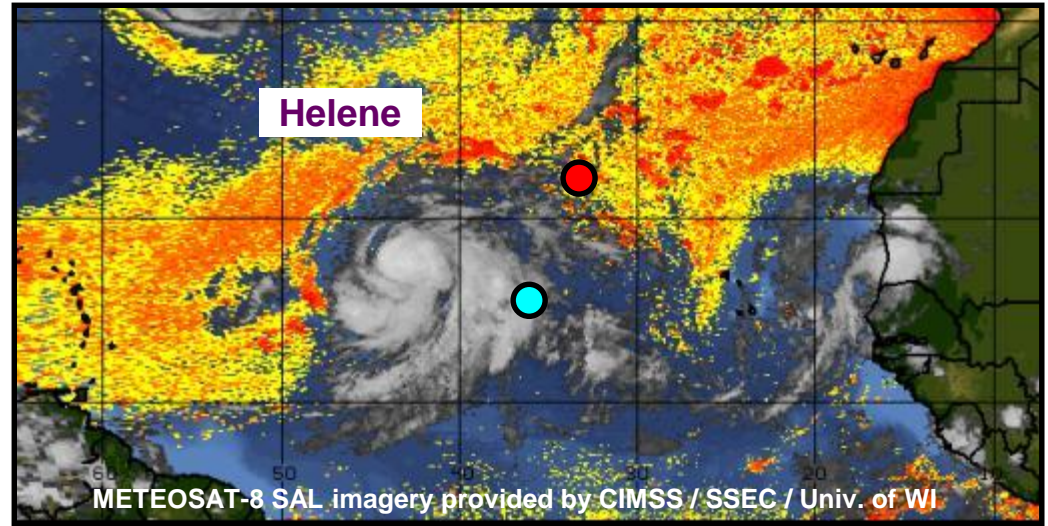
# Methodology

- Within the environment of the tropics, where temperature differences are small, the analysis of refractivity ( $N$ ) alone can provide useful information regarding the distribution of moisture within one of the profiles
- COSMIC data are collected in the vicinity of recent tropical cyclones
  - Helene 2006, Dean 2007, Bertha 2008
- Based on water vapor imagery and METEOSAT SAL ( $12.0 \mu\text{m}$  minus  $10.8 \mu\text{m}$ ) imagery, likely “dry” and “moist” profiles are qualitatively identified and differenced
- To detect SALs, COSMIC refractivity data are compared against CALIPSO aerosol subtype data

# Differences of COSMIC refractivity between SAL and non-SAL columns

(approx. 00 UTC 16 Sept 2006)

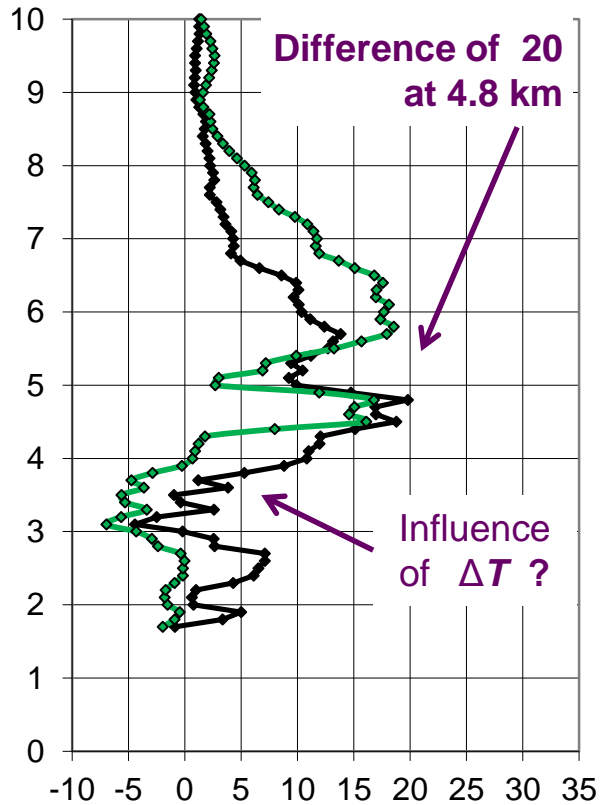
-  SAL column point
-  non-SAL column point



# COSMIC and CALIPSO data near Dean 2007

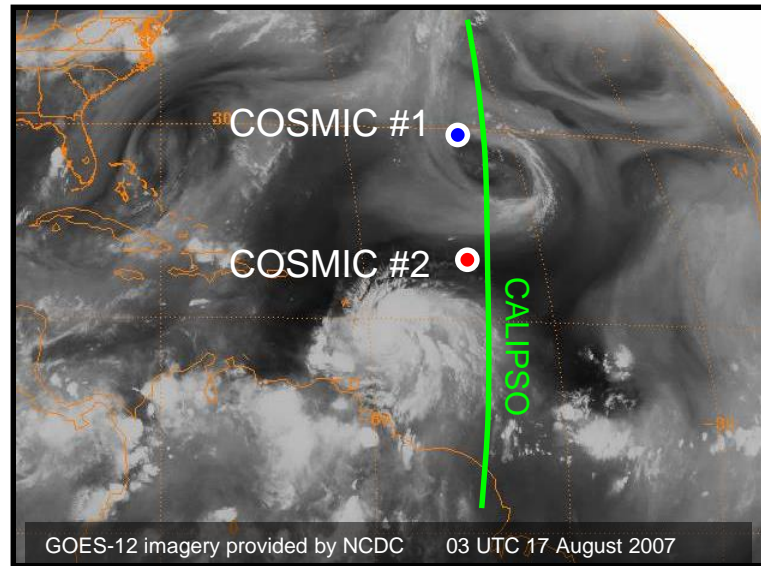
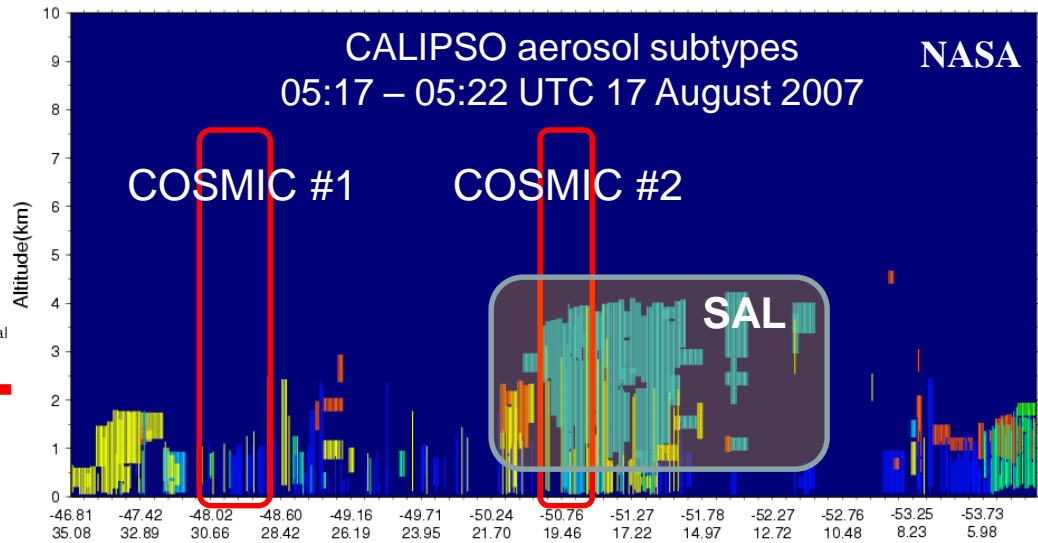
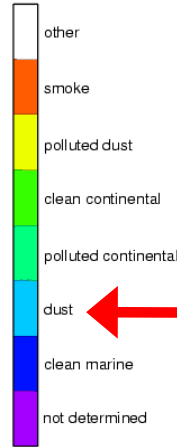
17 Aug 2007

COSMIC refractivity difference [ C1 – C2 ]  
Retrieved  $T_a$  difference [ C1 – C2 ]  
~ 04:30 UTC 17 Aug 2007



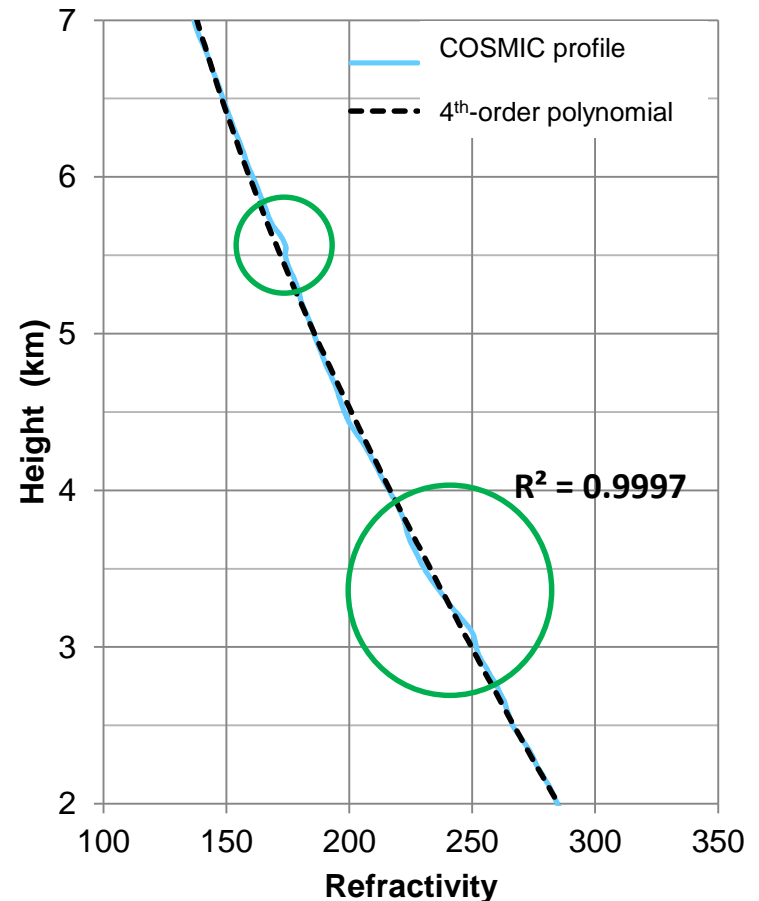
COSMIC point #1: 29.0°N 50.6°W

COSMIC point #2: 20.3°N 51.9°W



# Methodology

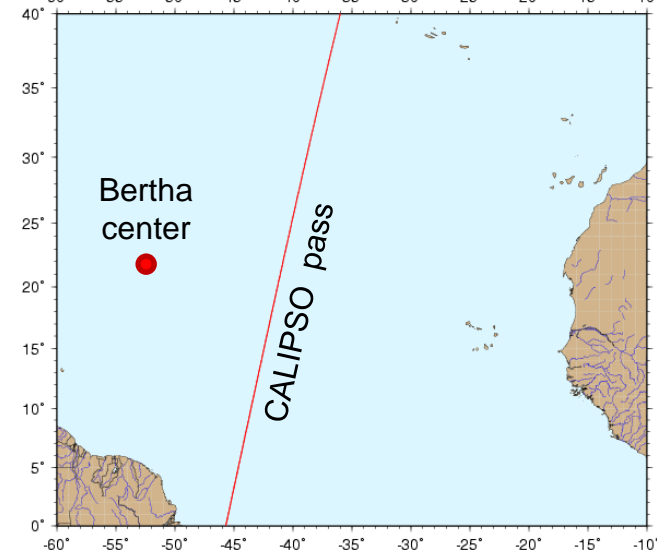
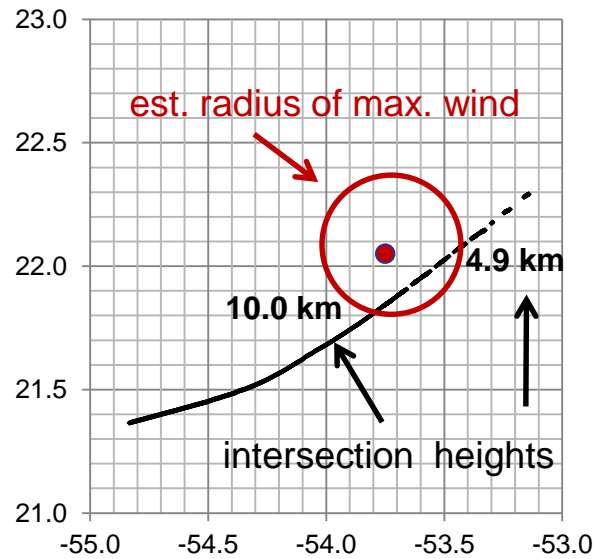
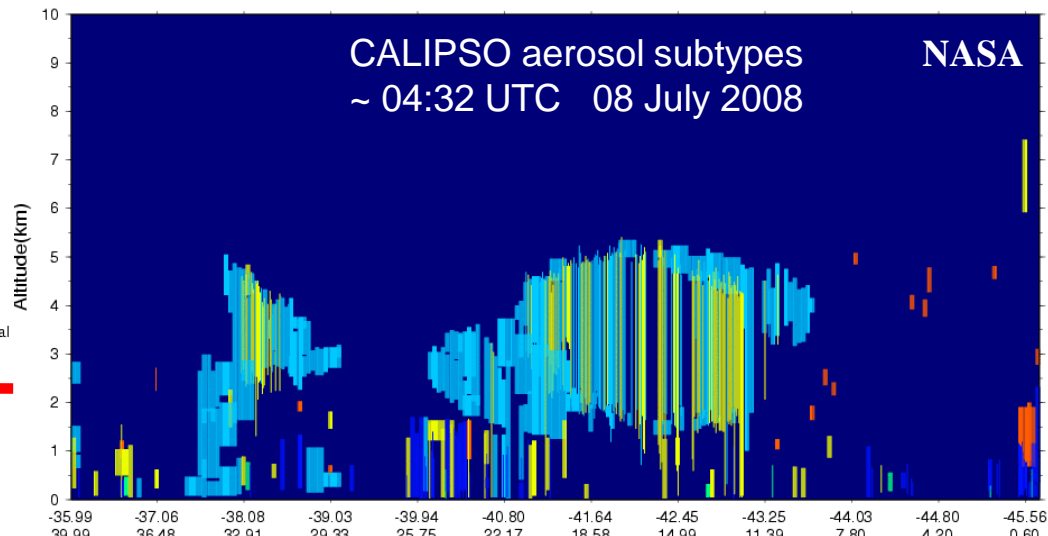
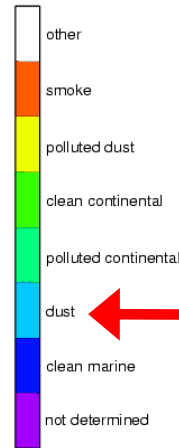
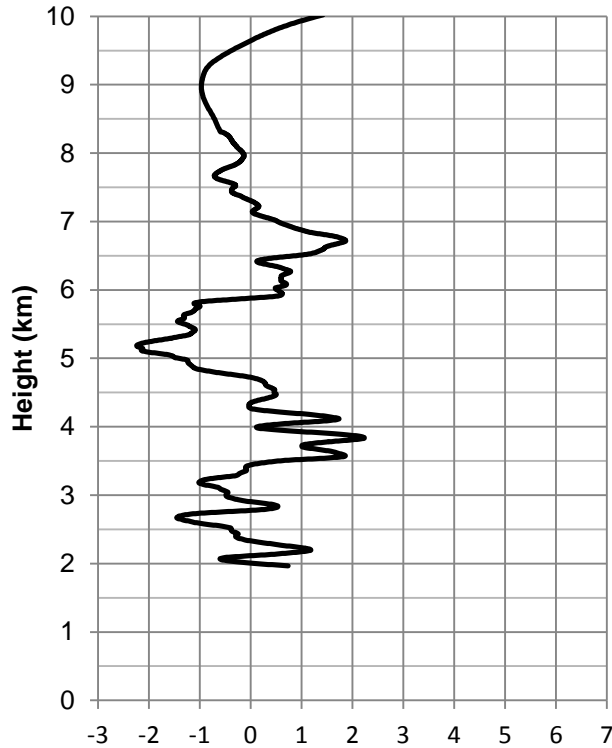
- COSMIC data are found within the circulation area of recent tropical cyclones
  - STY Sepat 2007, Bertha and Ike 2008
- 4<sup>th</sup>-order polynomial curve fitted against COSMIC profile
- difference between profile and fitted curve should show refractivity (moisture) anomalies
- COSMIC data are compared against water vapor and microwave imagery to determine cyclone structure



# COSMIC and CALIPSO data near Bertha 2008

08 July 2008

Difference of COSMIC refractivity profile  
and 4<sup>th</sup>-order fitted curve  
14:19 UTC 08 July 2008

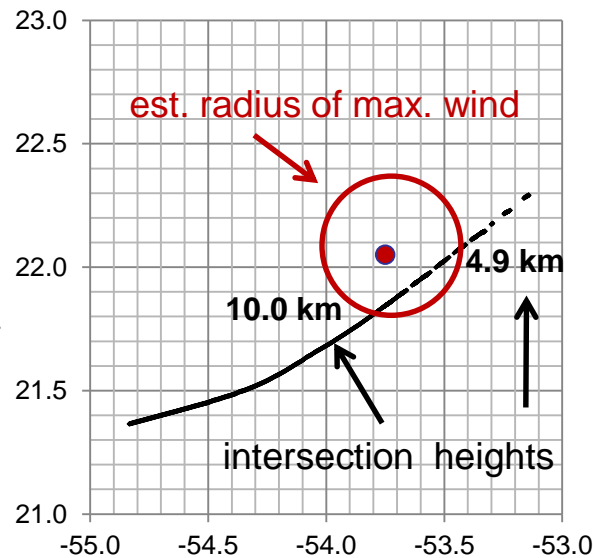
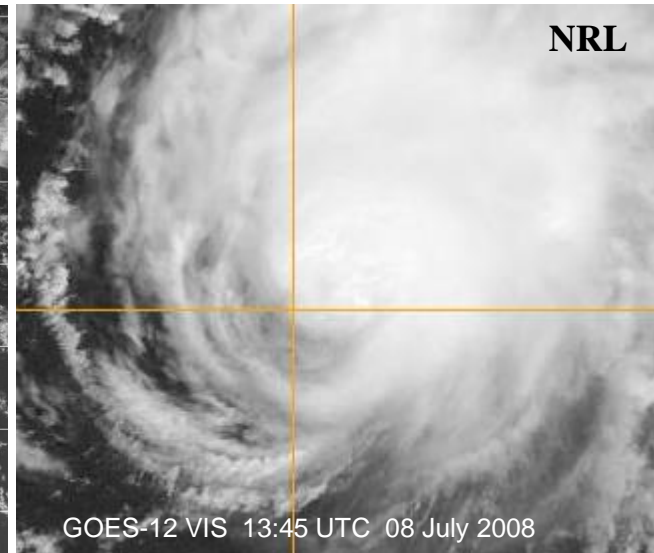
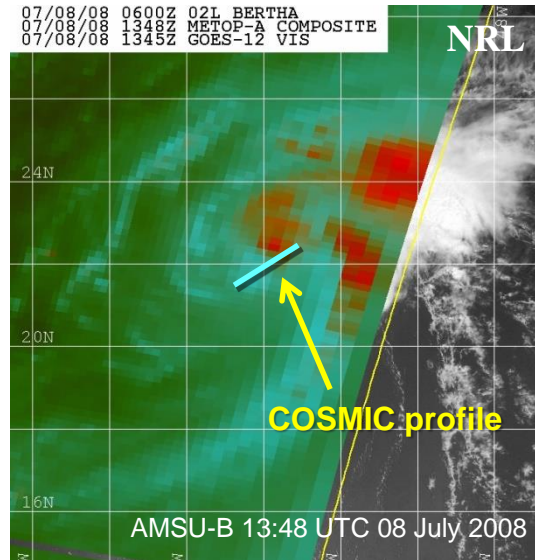
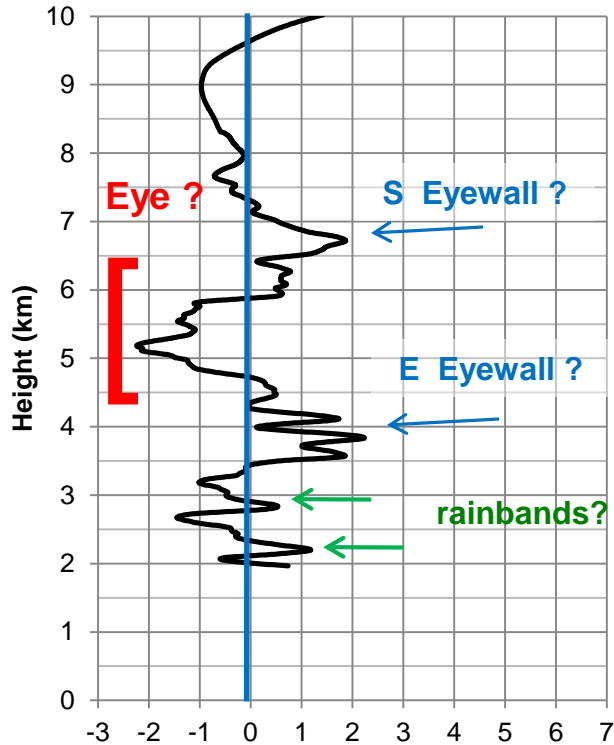




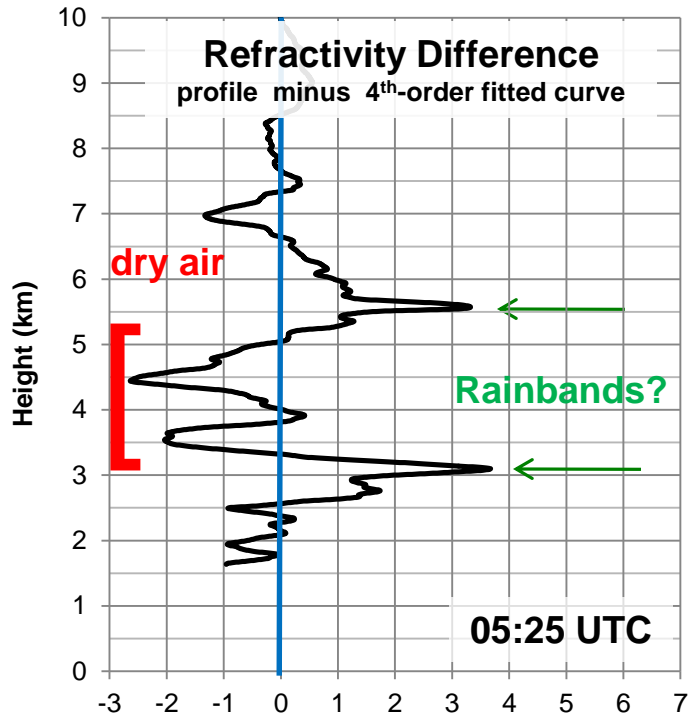
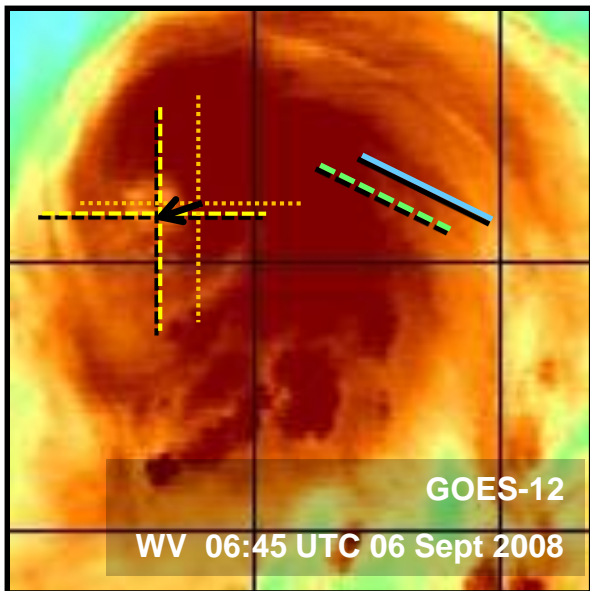
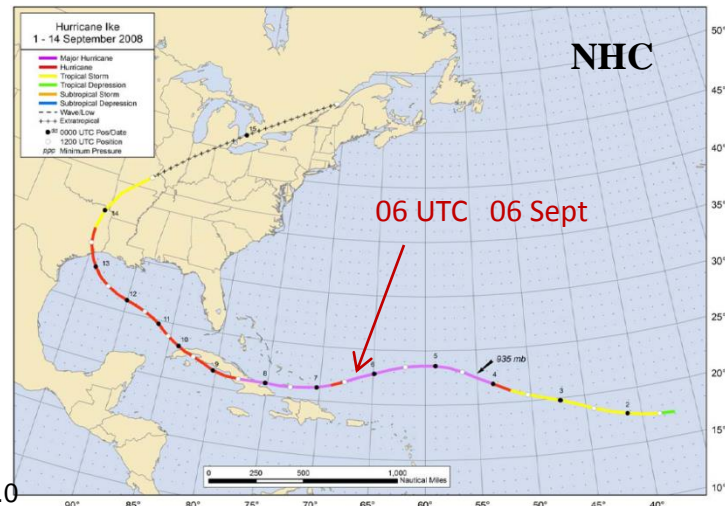
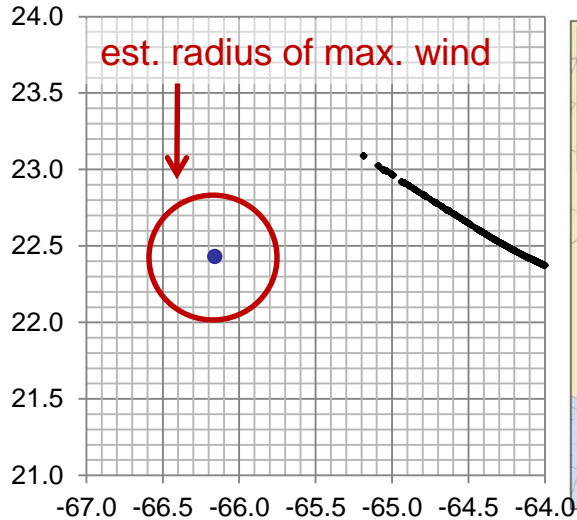
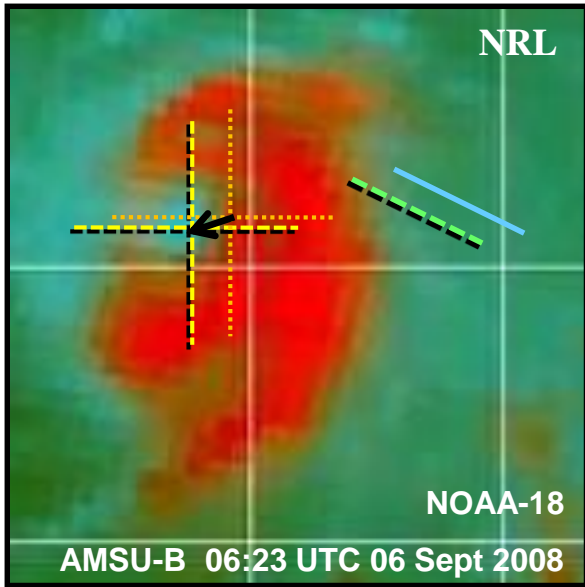
# COSMIC and CALIPSO data near Bertha 2008

08 July 2008

Difference of COSMIC refractivity profile and 4<sup>th</sup>-order fitted curve  
14:19 UTC 08 July 2008

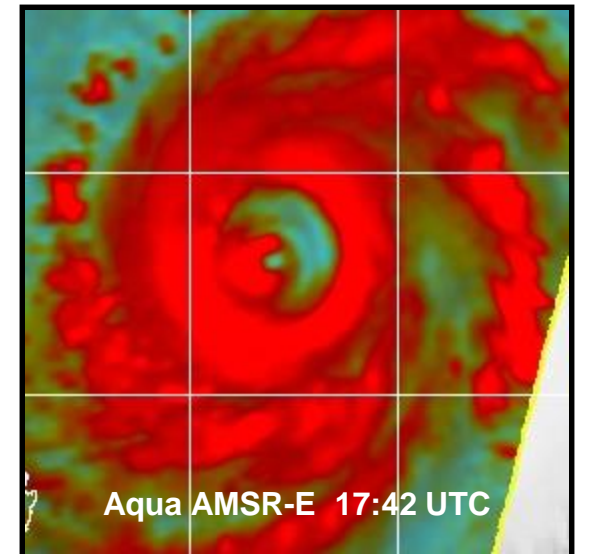
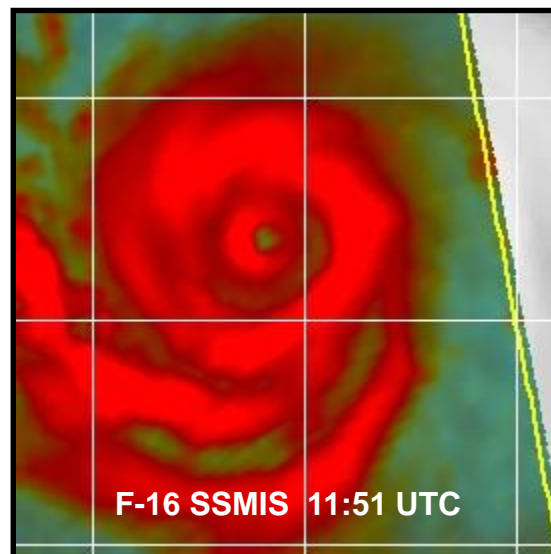
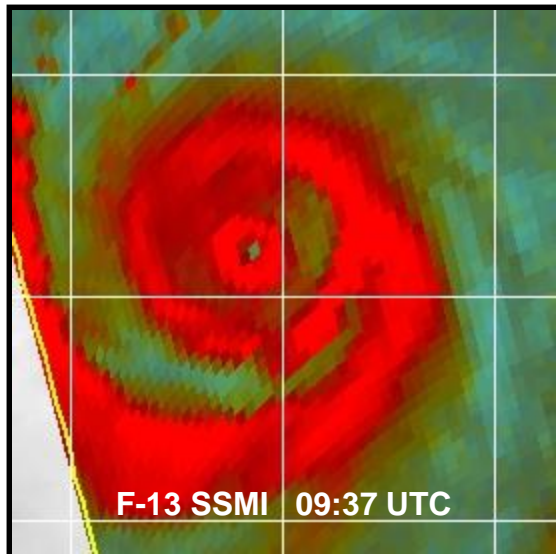
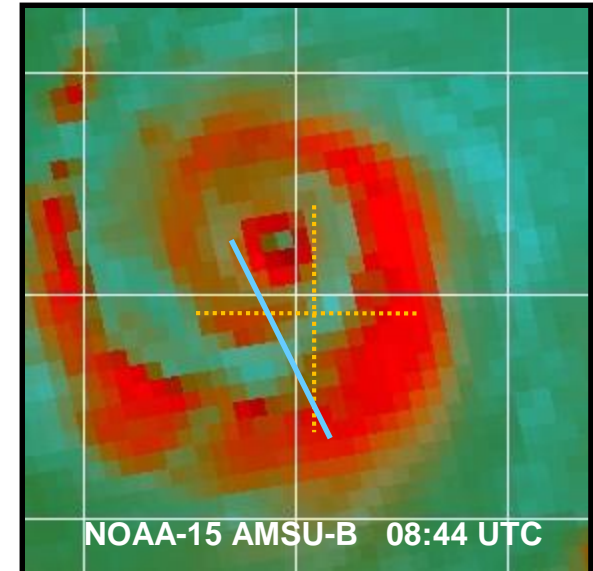
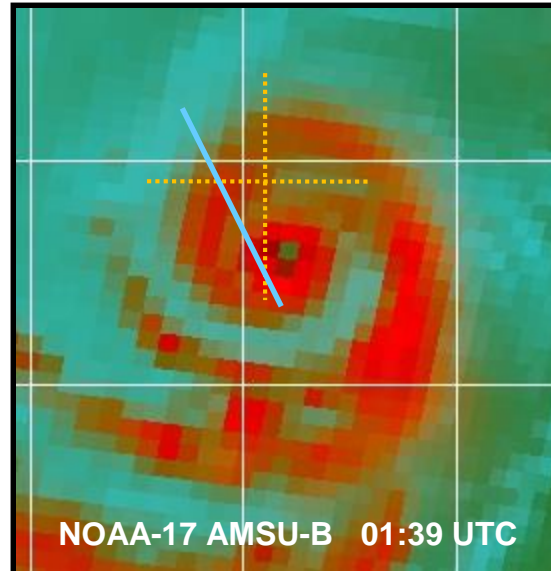
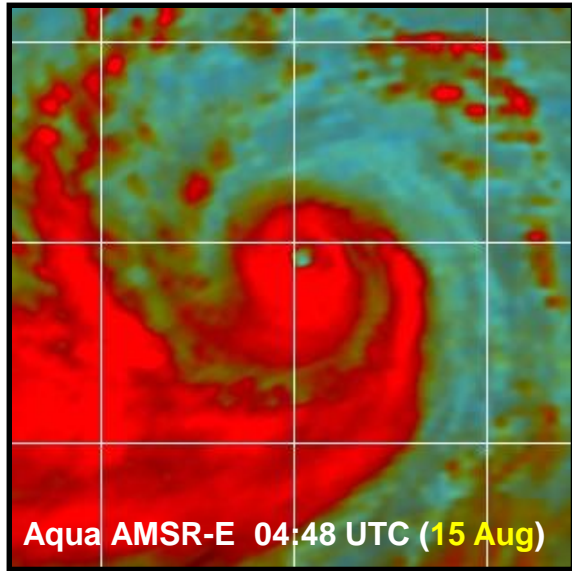


# COSMIC analysis of Hurricane Ike 2008

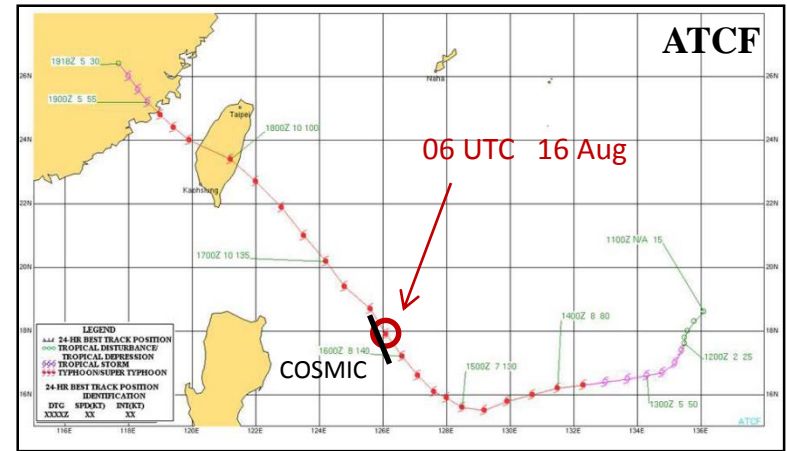
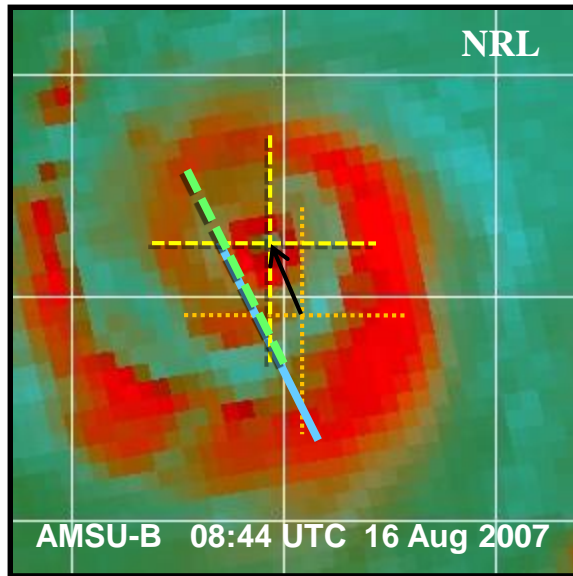


# Eyewall replacement cycle with Supertyphoon Sepat 08/16/2007

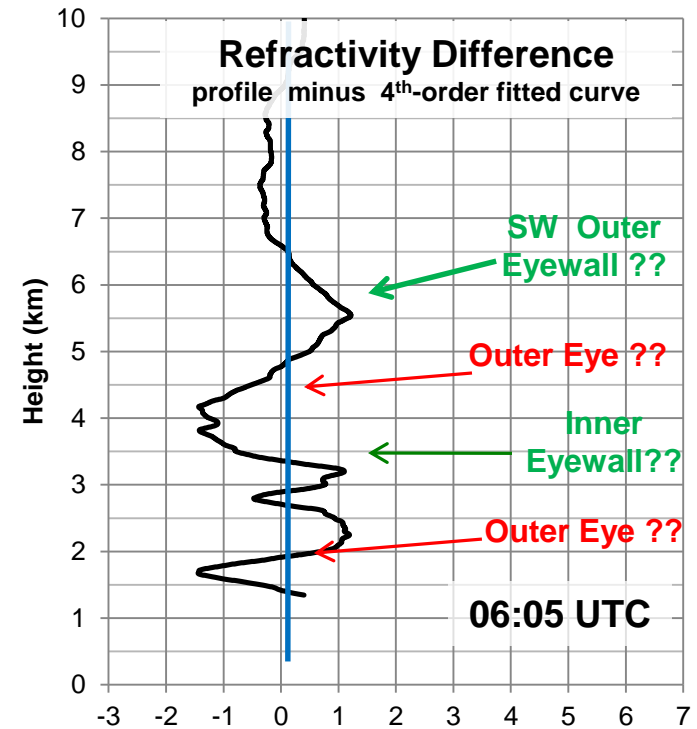
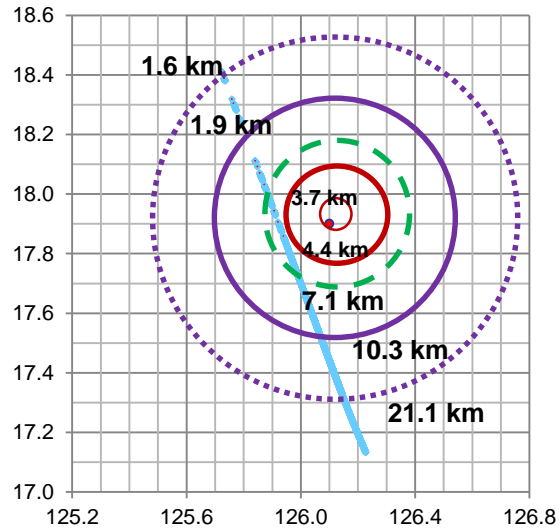
microwave imagery archived at the Naval Research Laboratory



# COSMIC analysis of Supertyphoon Sepat 2007



COSMIC profile relative to estimations of the storm center and the radii of concentric eyes



# Some conclusions on use of COSMIC near tropical cyclones

- Difference of COSMIC refractivity can show dry air signature of SAL
- Combined use of COSMIC and CALIPSO can definitively show SAL
- COSMIC can detect inner core features of a cyclone hidden under the cirrus canopy (precise matching with other data is crucial !)
- COSMIC may help to determine the stage of eyewall replacement cycle

## **Acknowledgments**

The organization of COSMIC for the COSMIC profile data

CIMSS / SSEC / Univ. of WI, NRL, NCDC, and NASA for satellite data

Dr. Eric Hendricks for a helpful poster discussion