An evaluation of COSMIC and CHAMP data in the hurricane environment

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Dropsonde data courtesy of Sim Aberson and Jason Dunion
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Outline

1. Description of radio occultation method

2. Validation against dropsondes in 2006 tropical cyclones

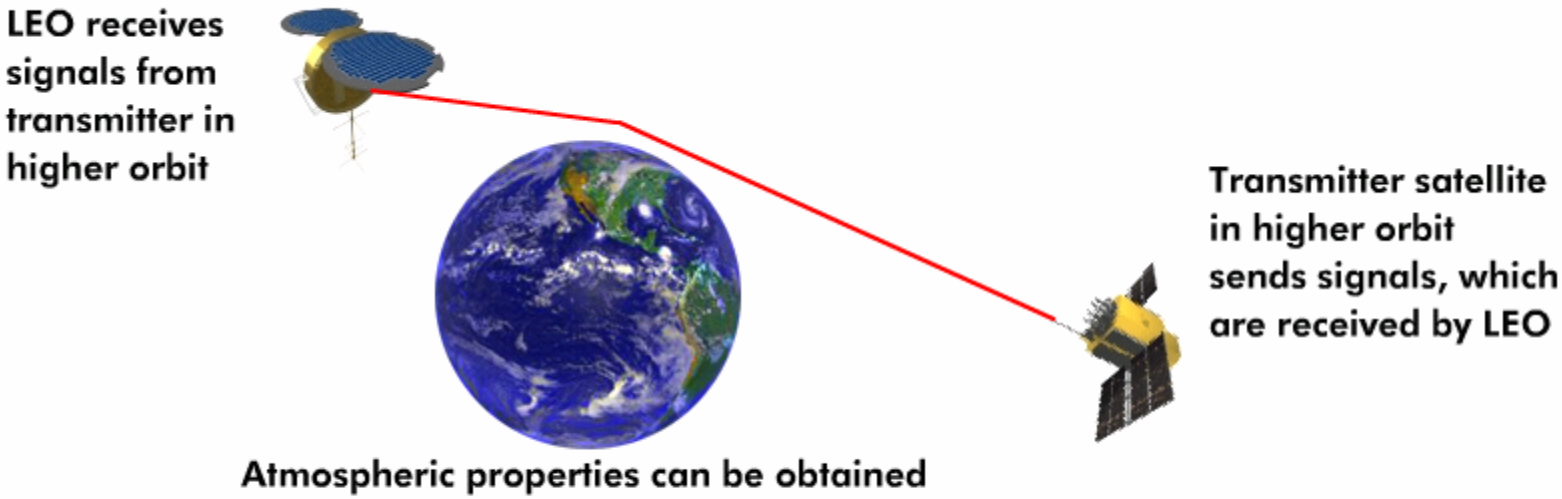
3. Example – Hurricane Helene

4. Conclusions

Radio occultation method

f1

Radio occultation (limb sounding) method



COSMIC (The Constellation Observing System for Meteorology, Ionosphere, and Climate): Launched with 6 LEOs on April 14, 2006; joint Taiwan-U.S. project

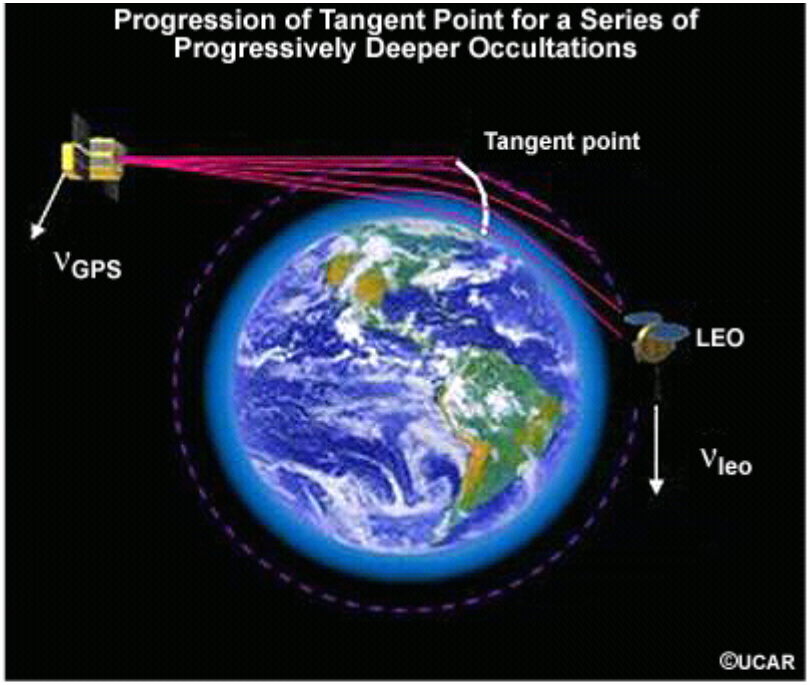
CHAMP (CHAllenging Minisatellite Payload) : Prototype for COSMIC, 1 LEO, launched on July 15, 2000; Germany project

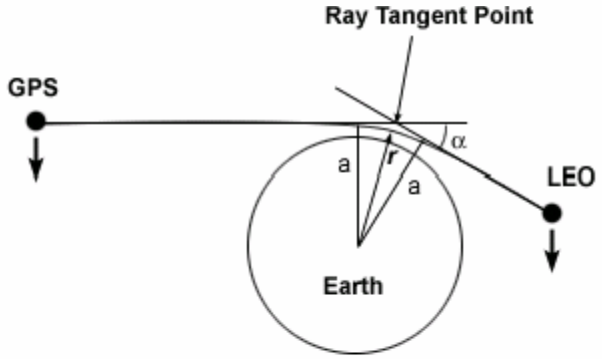
Following figures courtesy of COSMIC webcast module

f1

The Constellation Observing System for Meteorology, Ionosphere, and Climate

fitz, 1/7/2007





- GPS receiver in LEO "sees" the GPS set or rise behind the Earth's limb

- Delay of the signal between the GPS and the LEO is observed

- The change of the delay allows for reconstruction of the bending angle

- The vertical refractivity profile at the ray tangent point is reconstructed

- Refractivity allows for reconstruction of the pressure, temperature, and humidity in the neutral atmosphere and electron density in the ionosphere

Radio Occultation Method

$$N = 77.6\frac{p}{T} + 3.73\times10^{5}\frac{e}{T^{2}} + correction\ \ for\ ionospheric\ effects$$

$$[\text{dry term}] \quad [\text{wet term}]$$

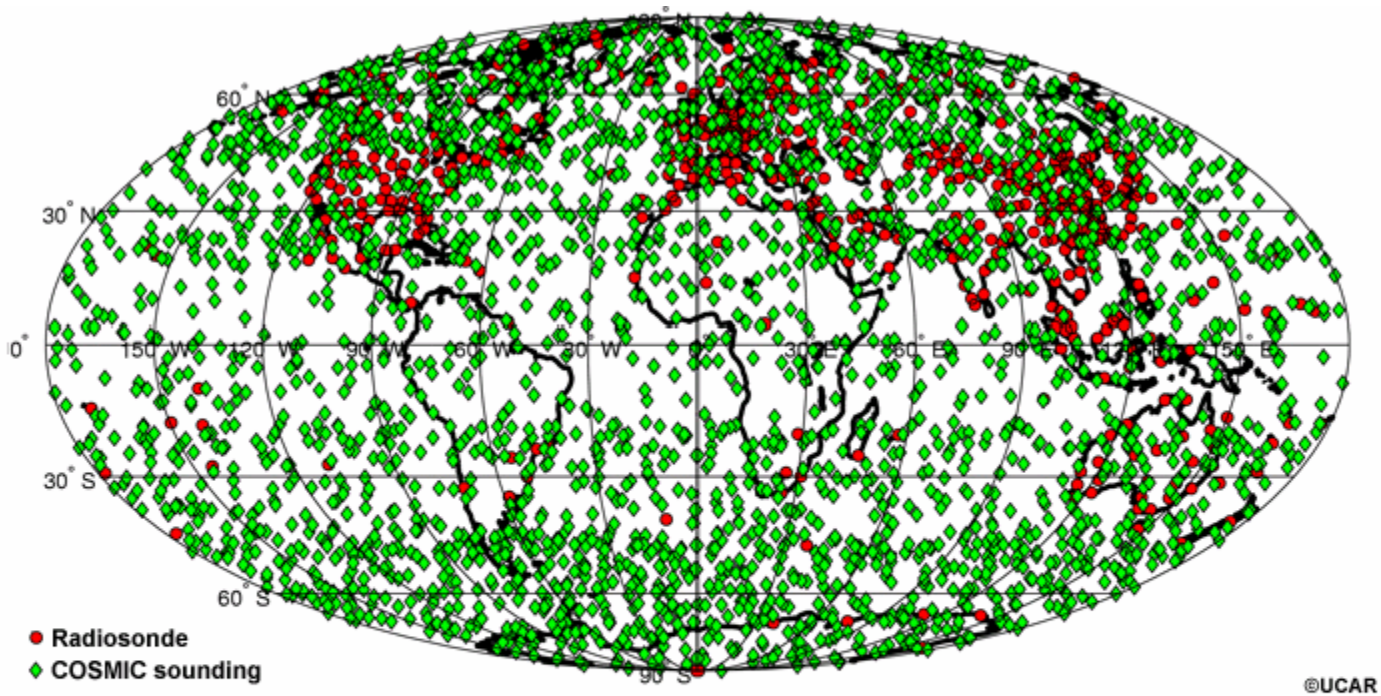
Given N, solve for T and T_d

Advantages:

- *High vertical resolution (0.1 km)*
- *No calibration needed*
- *Not affected by clouds or rain*
- *Global coverage*

Disadvantages:

- *Horizontal resolution coarse (200 km)*
- *Refractivity equation an unclosed system where moisture abundant (lower troposphere). Additional background information or data assimilation scheme needed.*

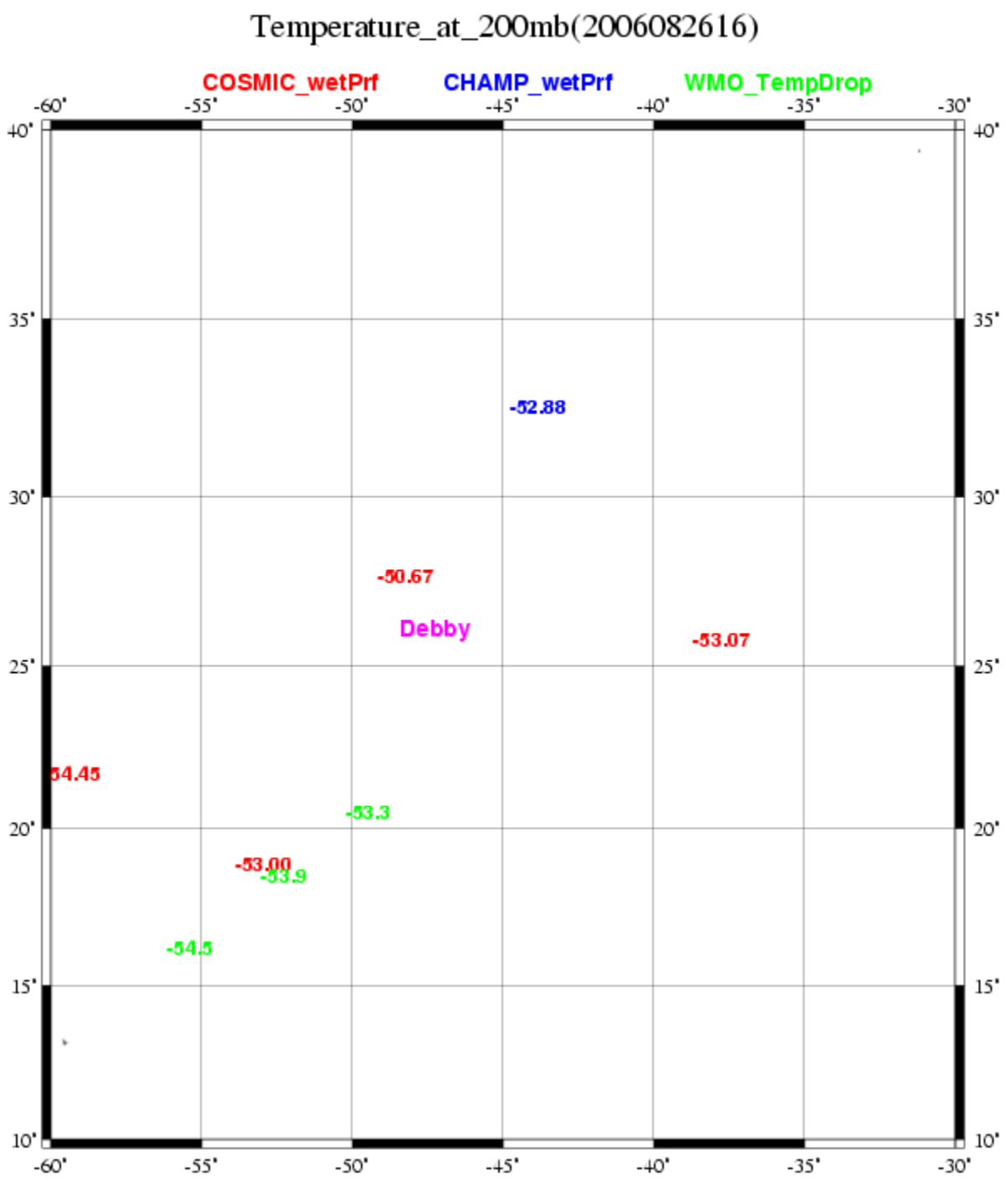


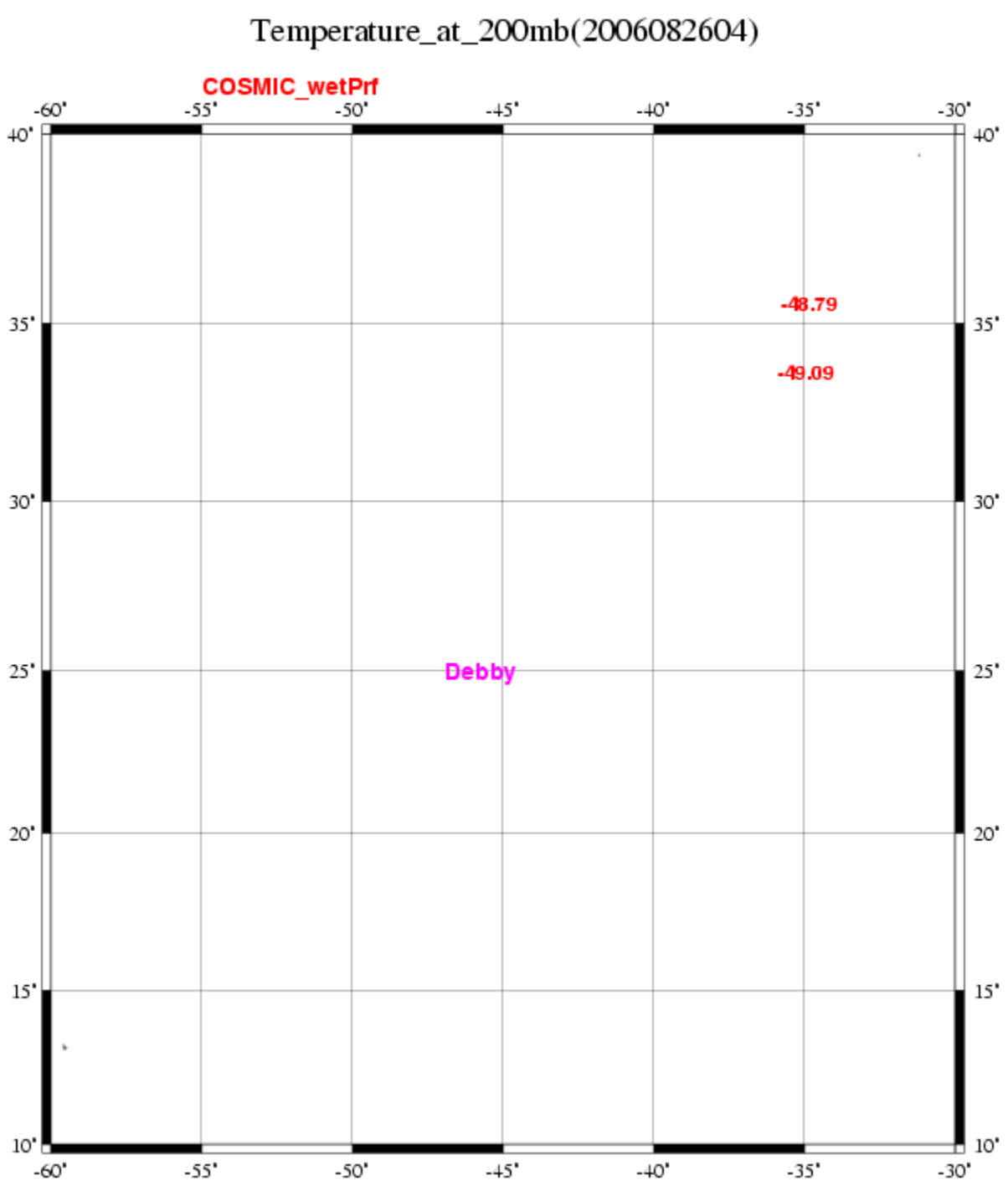
- Comprehensive daily coverage of RO soundings across globe once constellation complete

- Radiosondes heavily focused on Northern Hemisphere land masses

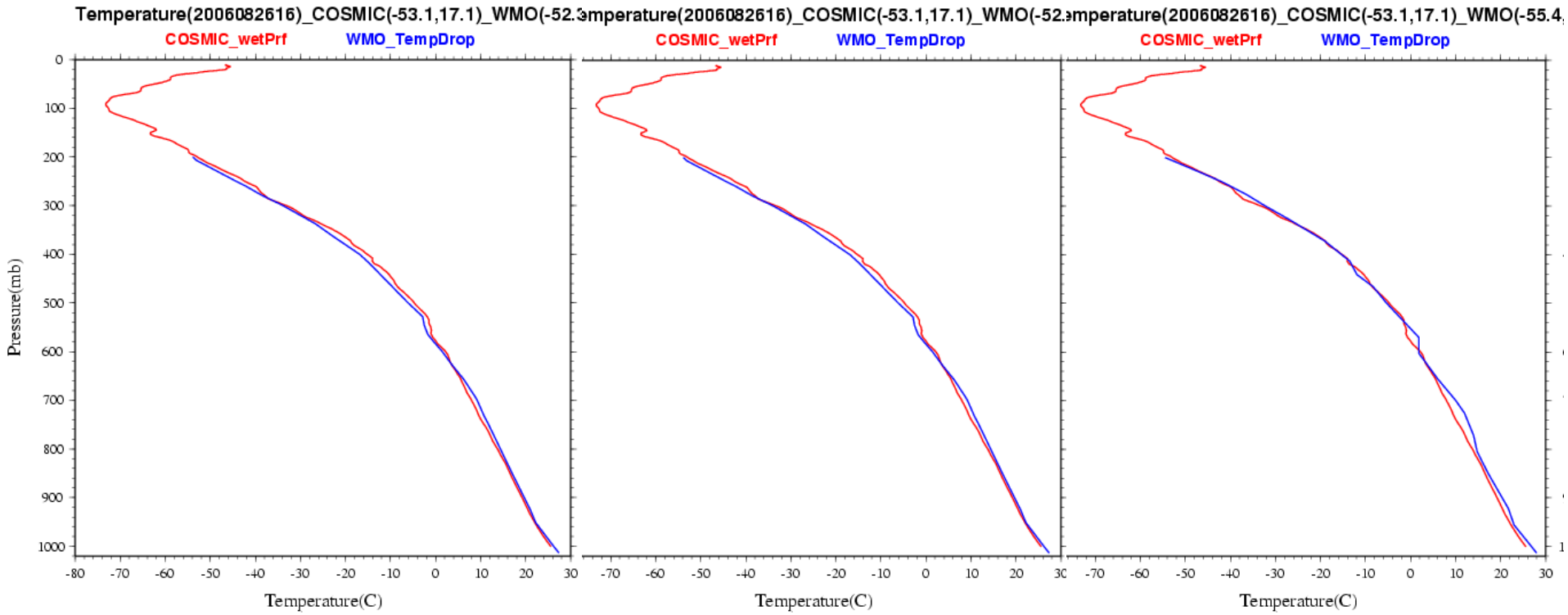
- Radio occultations will provide much more uniform measurement sampling of Earth's atmosphere

Validation in hurricane environment

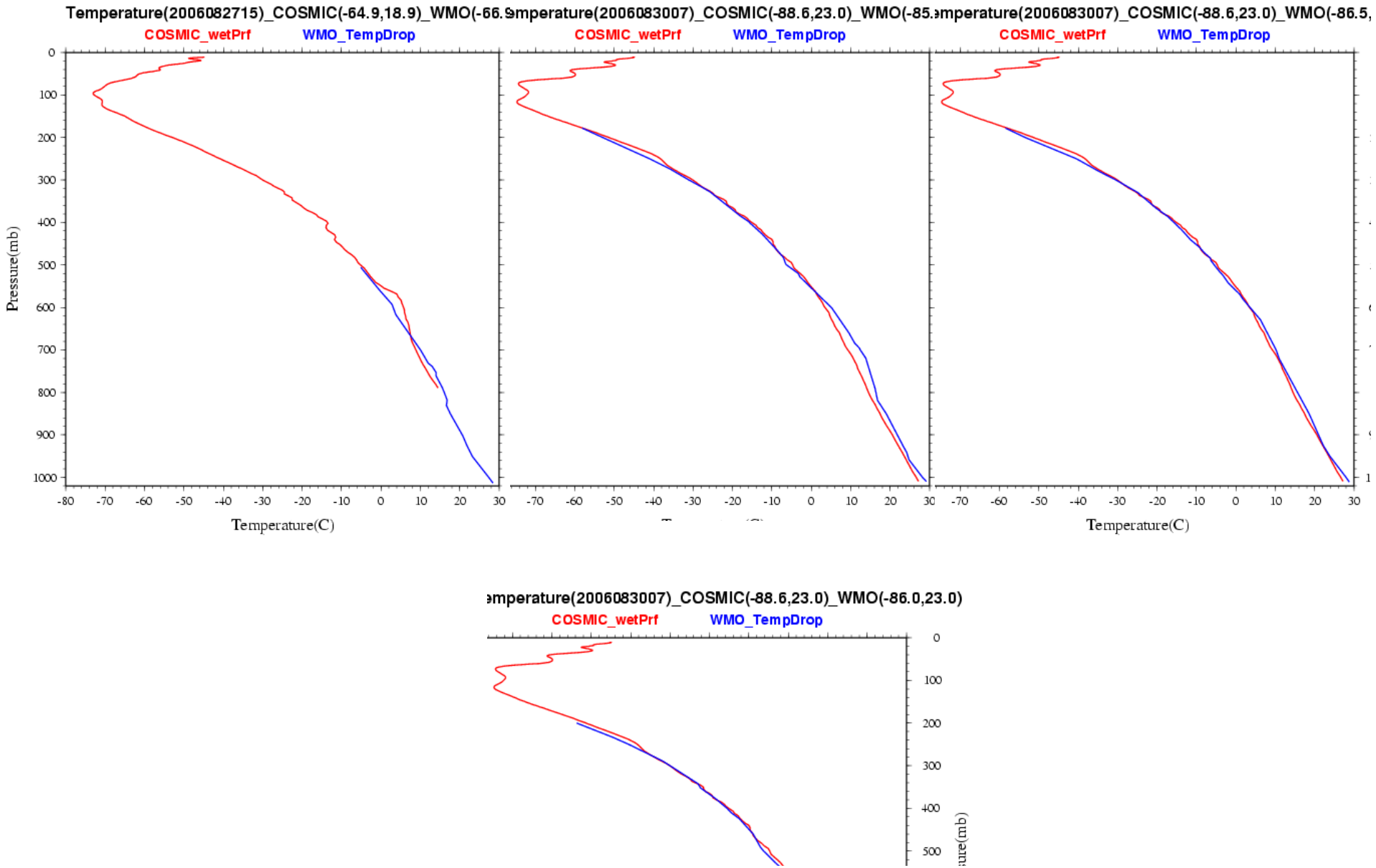

Temperature_at_200mb(2006082616)
COSMIC_wetPrf
CHAMP_wetPrf
WMO_TempDrop
-60°
-55°
-50°
-45°
-40°
-35°
-30°
40°
35°
30°
25°
20°
15°
10°
-52.88
-50.67
Debby
-53.07
54.45
-53.3
-53.00
-53.9
-54.5


Temperature_at_200mb(2006082604)
COSMIC_wetPrf
-60°
-55°
-50°
-45°
-40°
-35°
-30°
40°
35°
30°
25°
20°
15°
10°
-48.79
-49.09
Debby

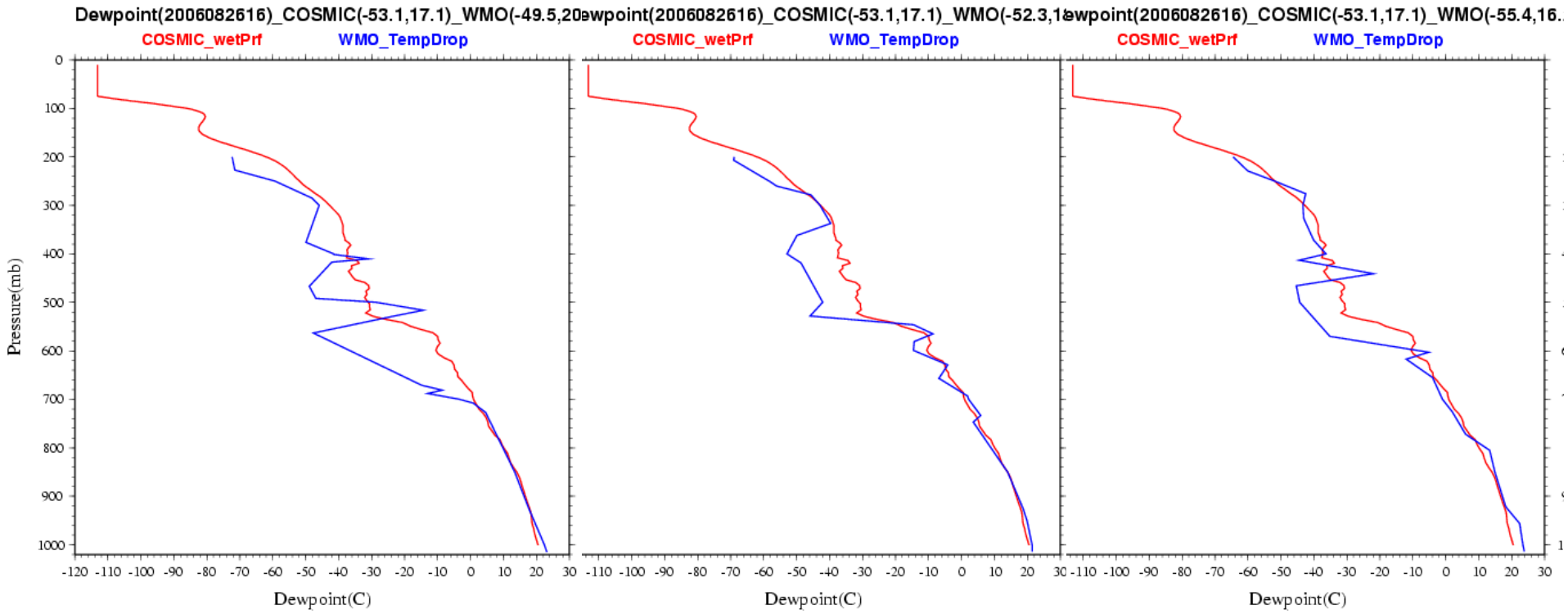
Tropical Storm Debby - Temperature



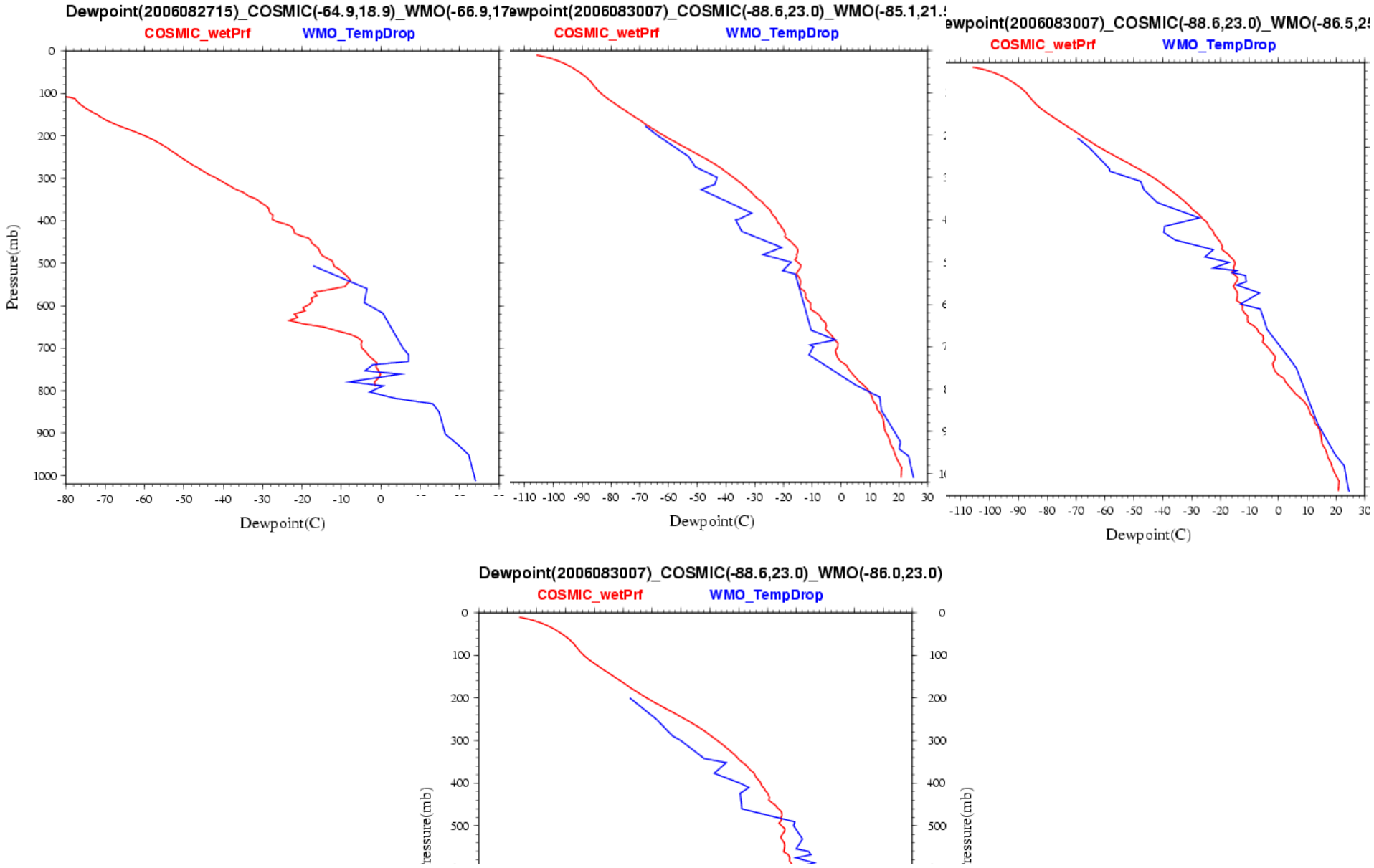
Hurricane Ernesto - Temperature



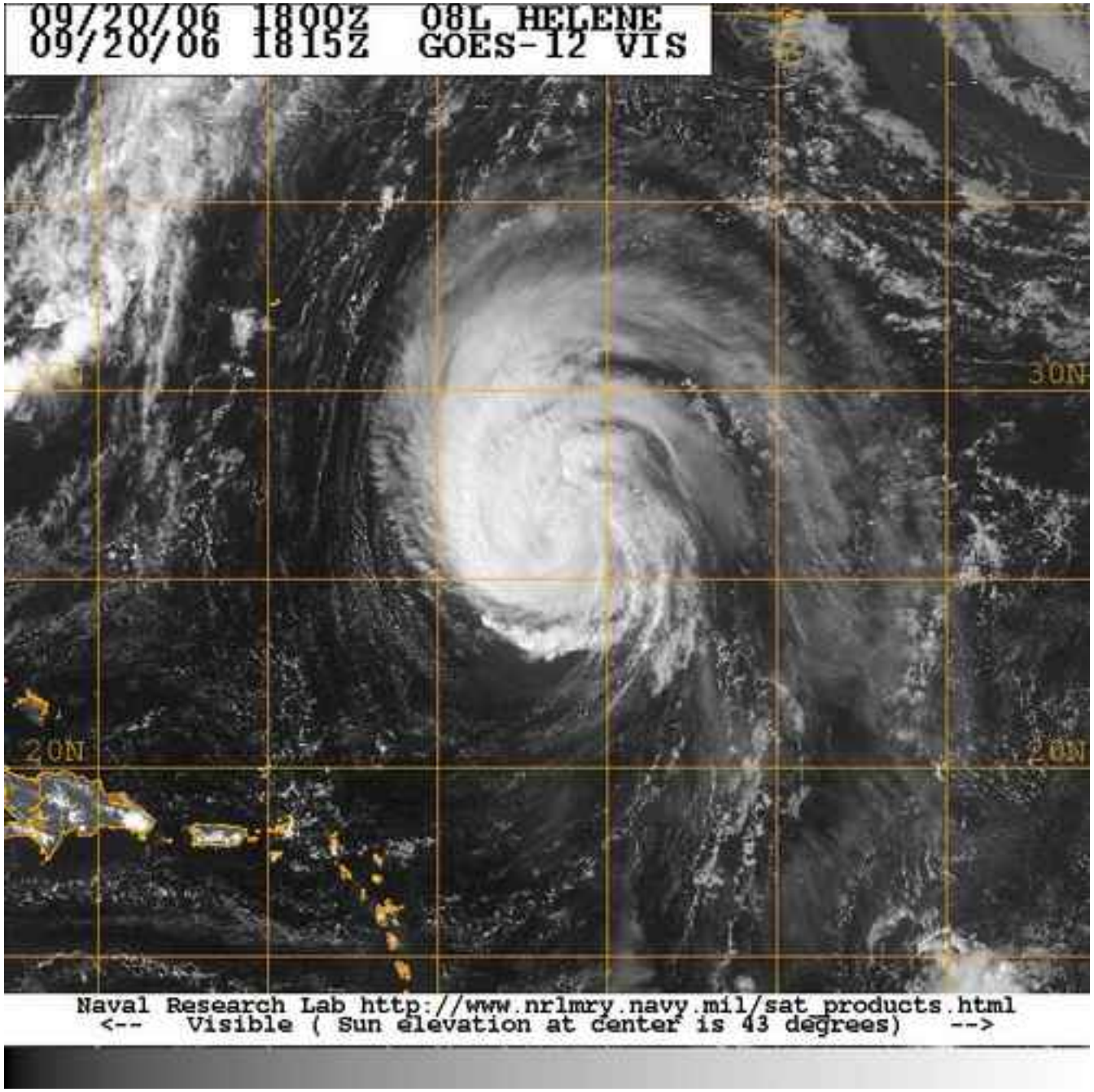
Tropical Storm Debby - Dewpoint

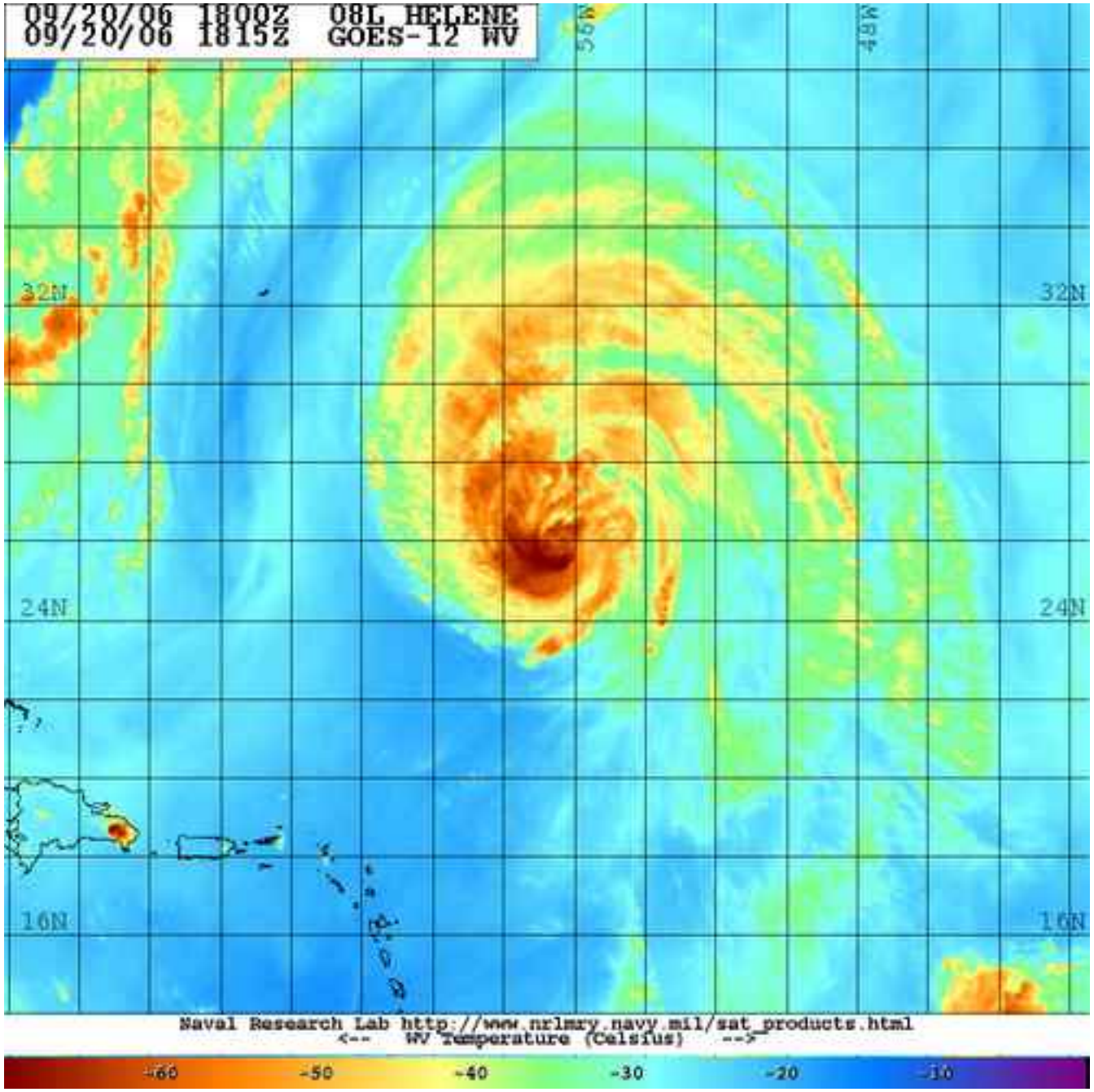


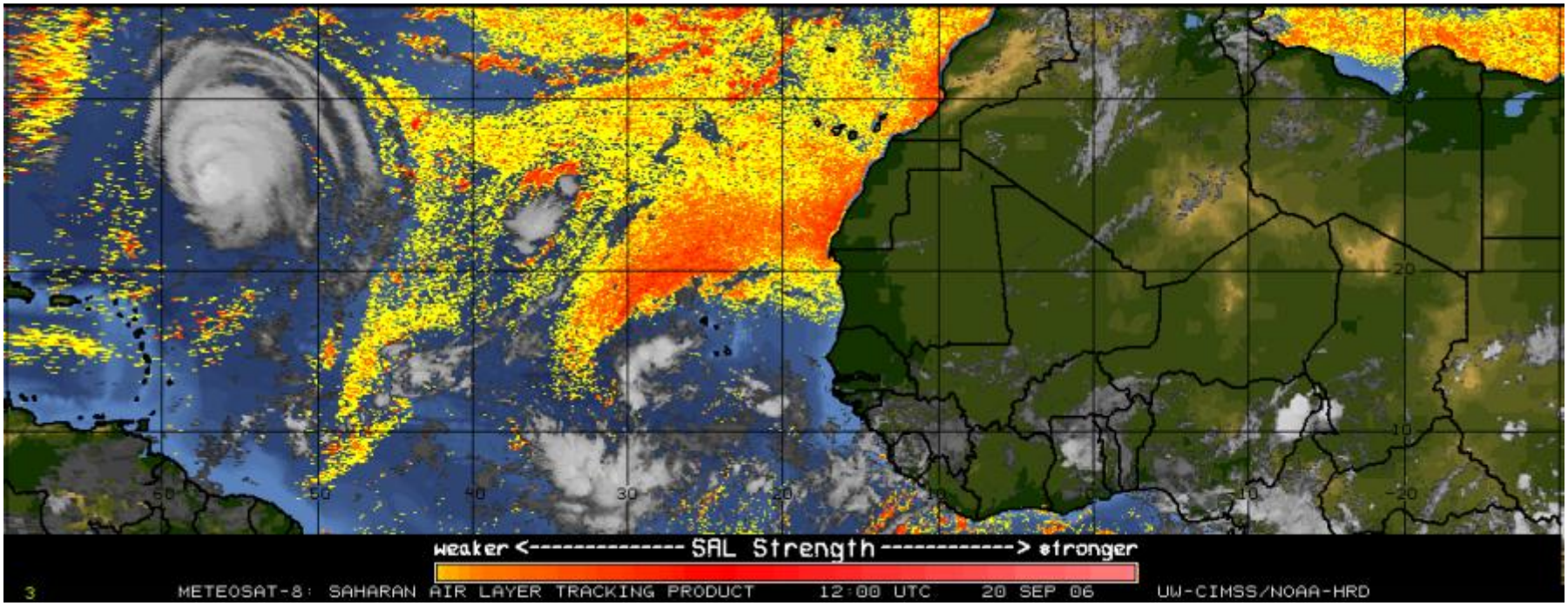
Hurricane Ernesto - Dewpoint

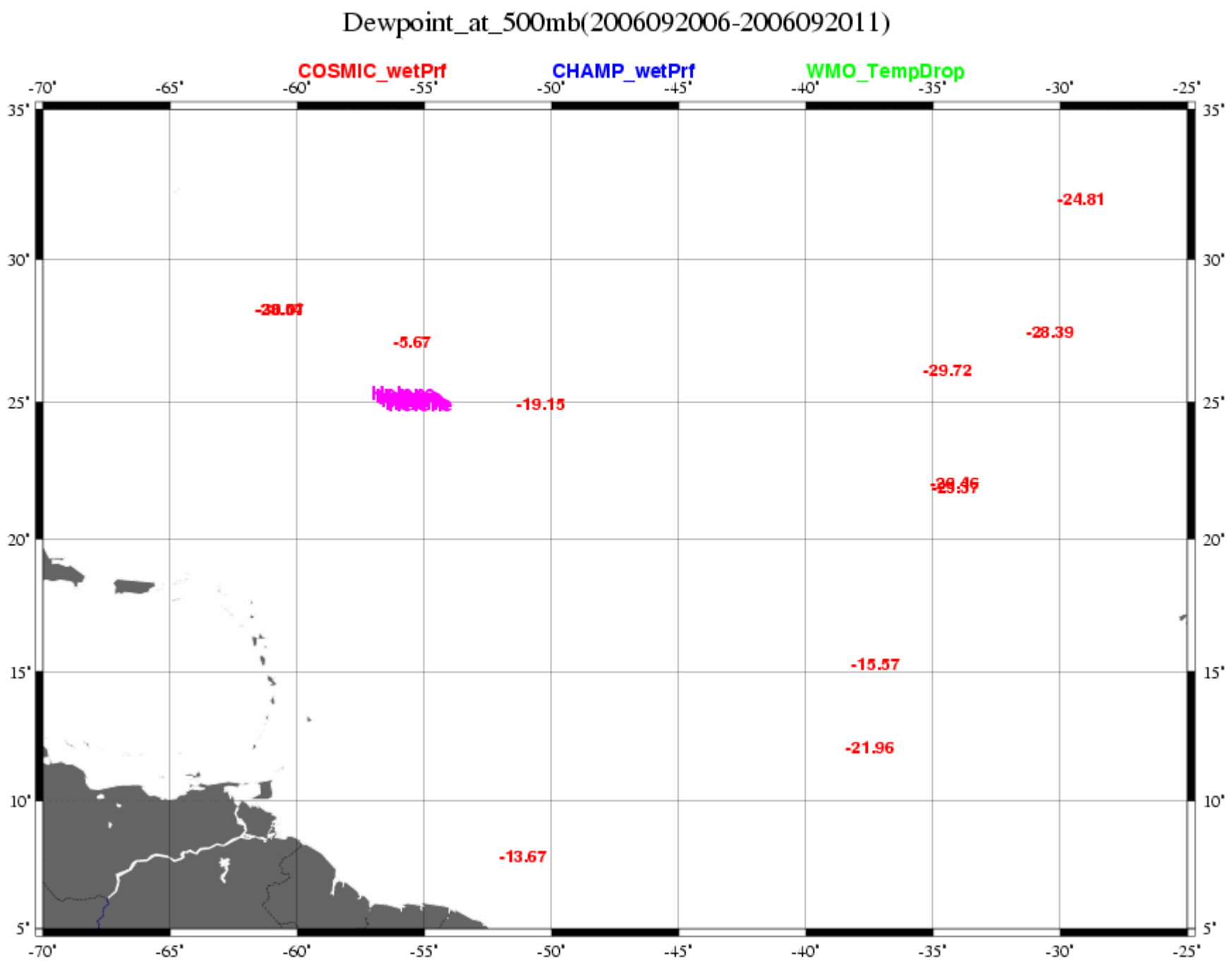


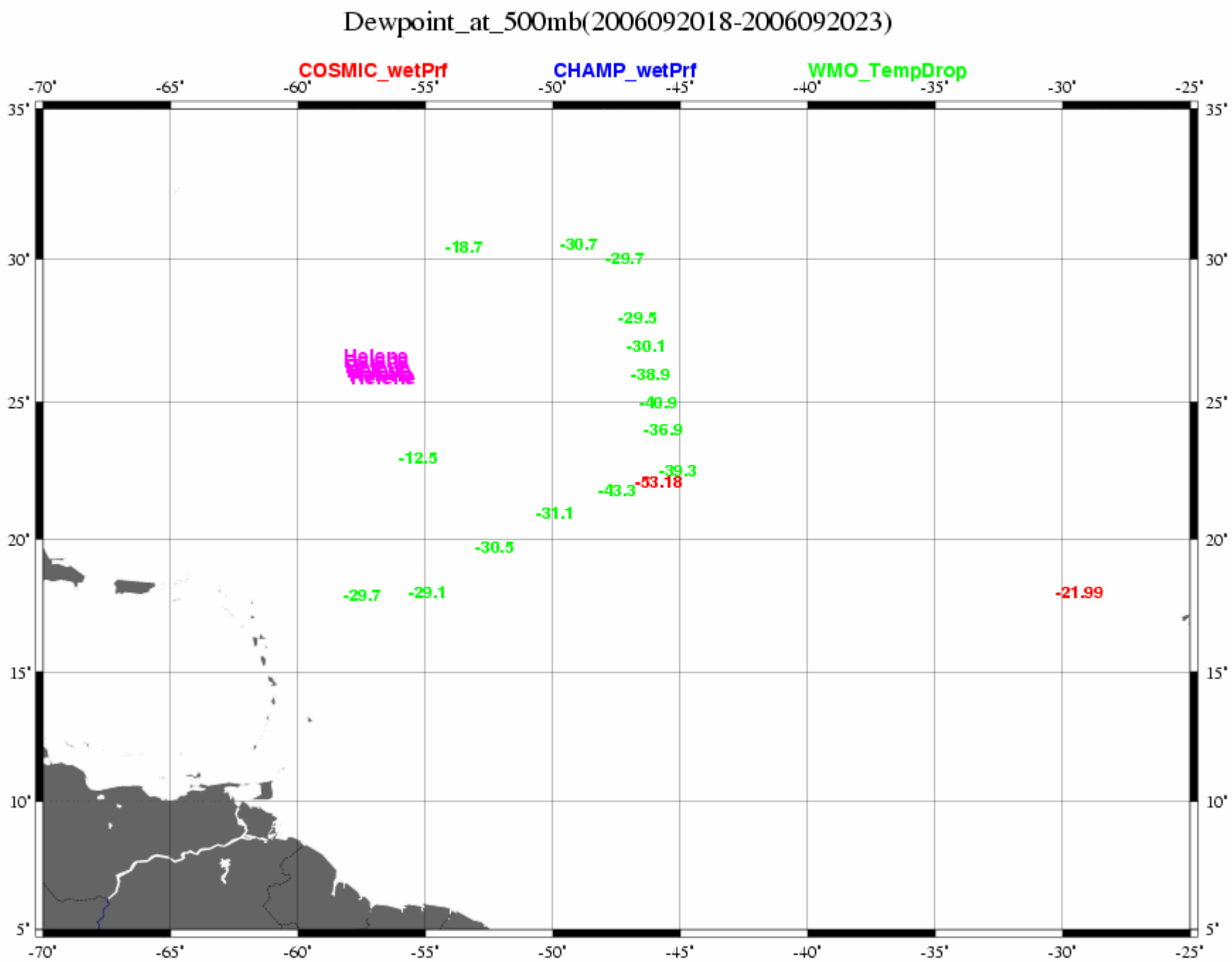
Case study: Hurricane Helene


09/20/06 1800Z 08L HELENE
09/20/06 1815Z GOES-12 VIS
30N
20N
20N
Naval Research Lab http://www.nrlmry.navy.mil/sat_products.html
<-- Visible (Sun elevation at center is 43 degrees) -->


09/20/06 1800Z 08L HELENE
09/20/06 1815Z GOES-12 WV
56W
48W
32N
32N
24N
24N
16N
16N
Naval Research Lab http://www.nrlmry.navy.mil/sat_products.html
<-- WV Temperature (Celsius) -->
-60
-50
-40
-30
-20
-10


weaker <---------- SAL Strength ----------> stronger
3
METEOSAT-8: SAHARAN AIR LAYER TRACKING PRODUCT
12:00 UTC
20 SEP 06
UW-CIMSS/NOAA-HRD

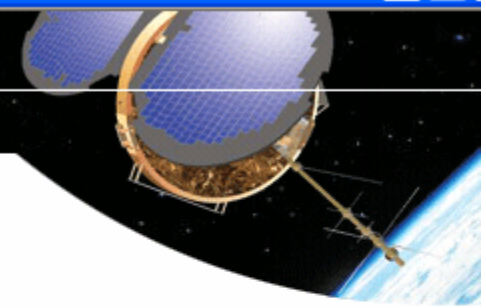

Dewpoint_at_500mb(2006092006-2006092011)
COSMIC_wetPrf
CHAMP_wetPrf
WMO_TempDrop
-70°
-65°
-60°
-55°
-50°
-45°
-40°
-35°
-30°
-25°
35°
30°
25°
20°
15°
10°
5°
-24.81
-28.39
-29.72
-5.67
-19.15
-15.57
-21.96
-13.67


Dewpoint_at_500mb(2006092018-2006092023)
COSMIC_wetPrf
CHAMP_wetPrf
WMO_TempDrop
-70'
-65'
-60'
-55'
-50'
-45'
-40'
-35'
-30'
-25'
35'
30'
25'
20'
15'
10'
5'
-18.7
-30.7
-29.7
-29.5
-30.1
-38.9
-40.9
-36.9
-12.5
-39.3
-53.18
-43.3
-31.1
-30.5
-29.7
-29.1
-21.99

6. Conclusions on COSMIC in hurricane environment (with a limited data sample)

- Temperature profiles in hurricane environment are reasonable; provides tropopause and stratosphere information not available from dropsondes
- Dewpoint profiles in hurricane environment shows a moist bias in mid and upper troposphere; low levels appear reasonable
- Horizontal distribution is coarse, but temperature useful in data sparse locations or between reconnaissance flights.
- Dewpoint still requires more examination and (apparently) refinement. Should still be useful, especially in dry regions.

Bonus slides (not used in talk)
but could be useful for questions



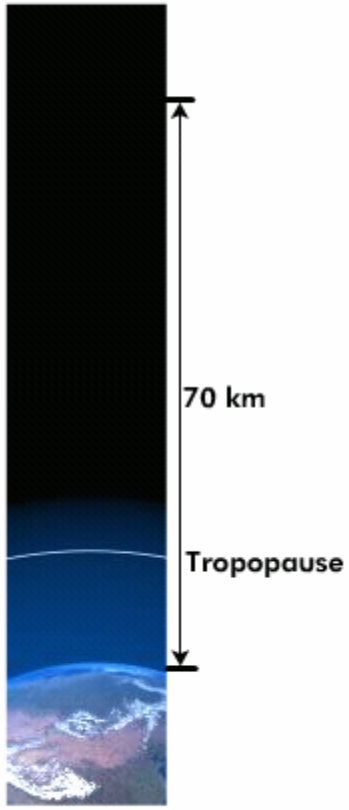
$n = c / v$, where c = speed of light in a vacuum
and v = light velocity in atmosphere

$$N = 10^6 (n - 1)$$

Refractivity Equation

$$N = 77.6 \frac{P(hPa)}{T(K)} + 3.73 \times 10^5 \frac{P_w(hPa)}{T^2(K)} - 40.3 \times 10^6 \frac{n_e(m^{-3})}{f^2(Hz)}$$

Dry Term | Wet Term | Ionospheric Term

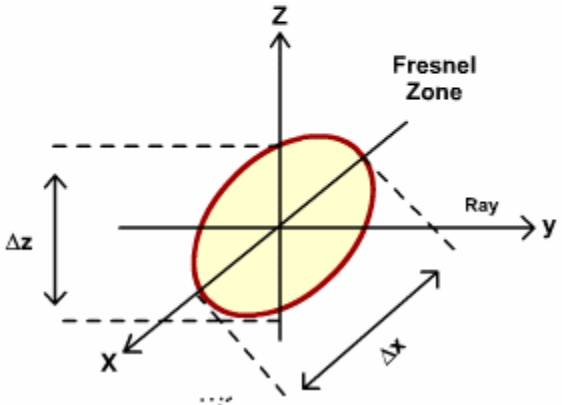


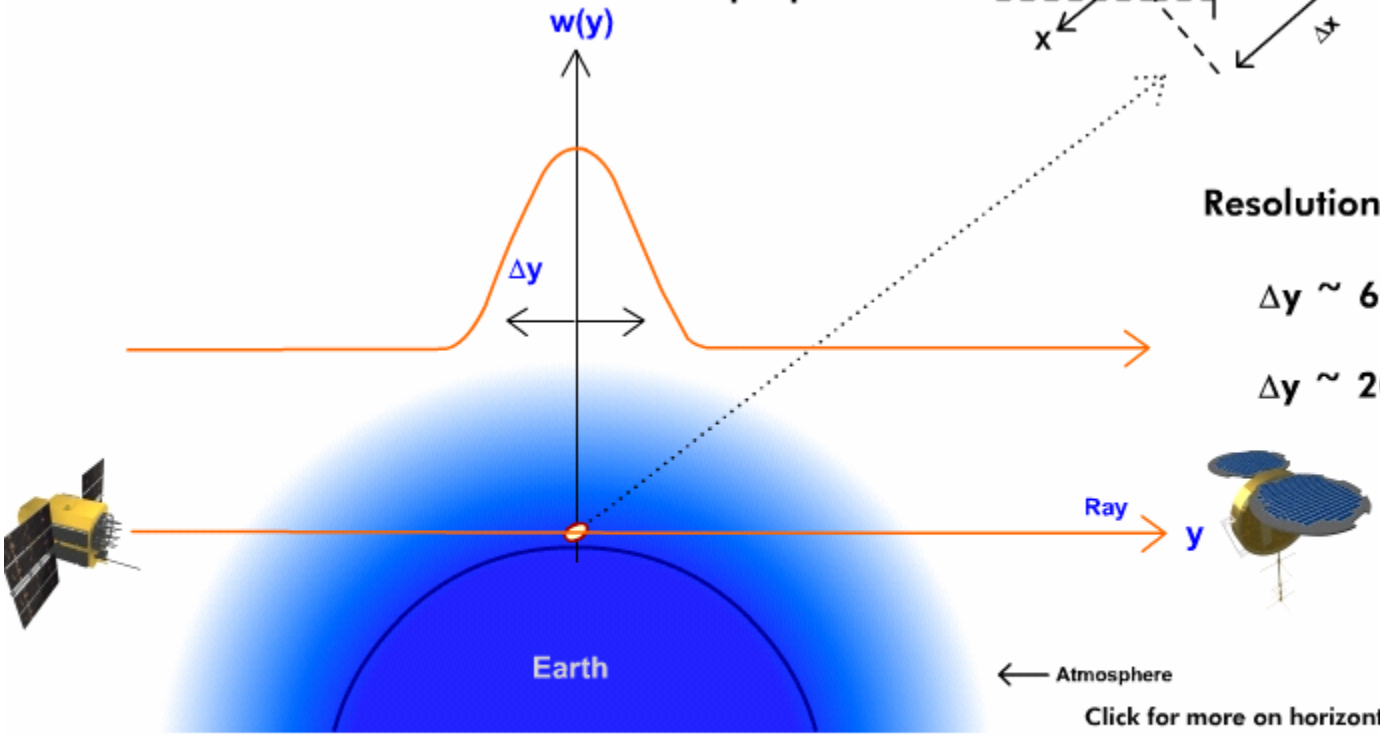
Resolution across the ray:

$\Delta x \sim 1.5$ km

$\Delta z \sim 1.5$ km above the troposphere

$\Delta z \sim 0.1$ km to 0.5 km in lower troposphere





Resolution across the ray:

$\Delta y \sim 600$ km above the troposphere

$\Delta y \sim 200$ km in lower troposphere

Click for more on horizontal resolution and the weighting function.