USING GPS RADIO OCCULTATION IN THE VALIDATION OF IR SOUNDINGS FROM IASI, AIRS, AND CRIS

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OUTLINE

- CLARREO climate benchmark concept
- Space/Time L2 Matchup Approach
- Spatial Analysis
- Temporal Analysis
- Preliminary Results
- Conclusions

CLARREO IR and GPS Benchmark Concept

- **GPS and IR have independent SI traceability paths (Time standard vs Temperature standard)**

- **GPS and IR have unique sampling characteristics which are complementary.**

- **A combined IR and GPS dataset could be used to assess the accuracy of a UTLS temperature climatology in either dataset individually.**

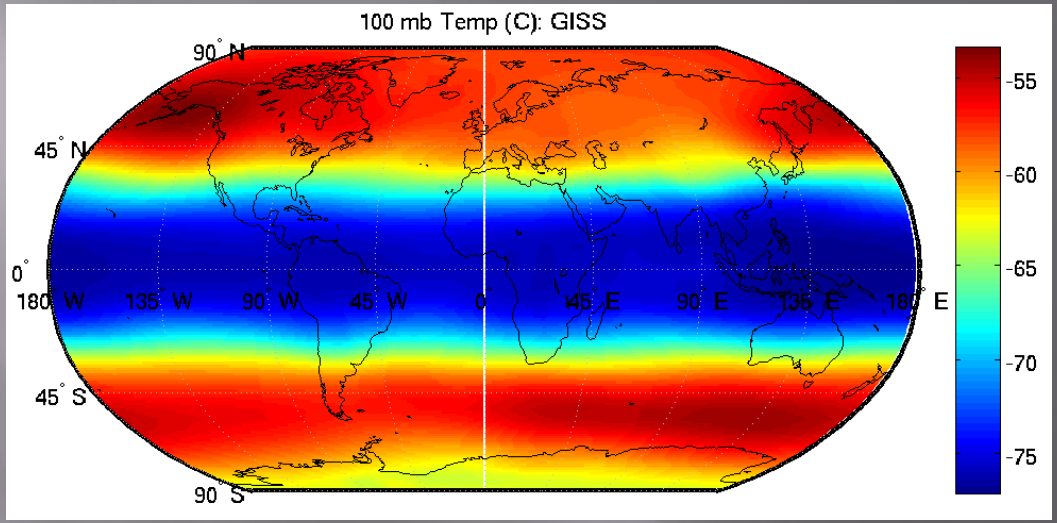
- **These are essential elements for making irrefutable claims about atmospheric temperature trends.**

UTLS Temperature

- CMIP3 and CMIP5 provide Global Climate Model (GCM) predictions for 2000-2100
- Both positive and negative trends are predicted up to 0.05 K/yr at 100 mb.
- To detect a trend of 0.5 K/decade requires measurement accuracy between multiple satellite sensors of about 0.1 K (not to exceed).
- How can we PROVE we are achieving this with IR soundings? Compare with a completely independent measurement methodology, i.e. GPS radio occultation.

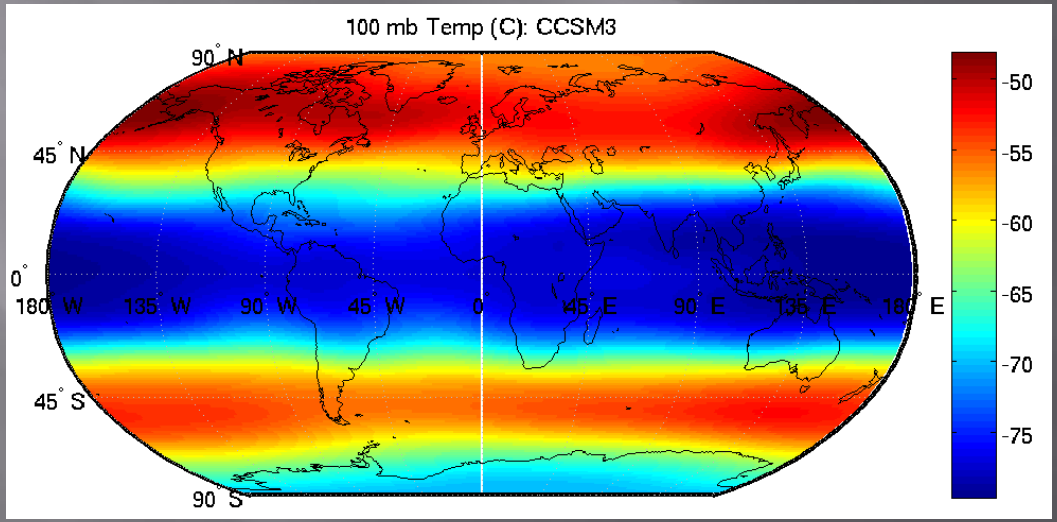
UTLS Temperature: 100 mb level

GISS



°C

CCSM3

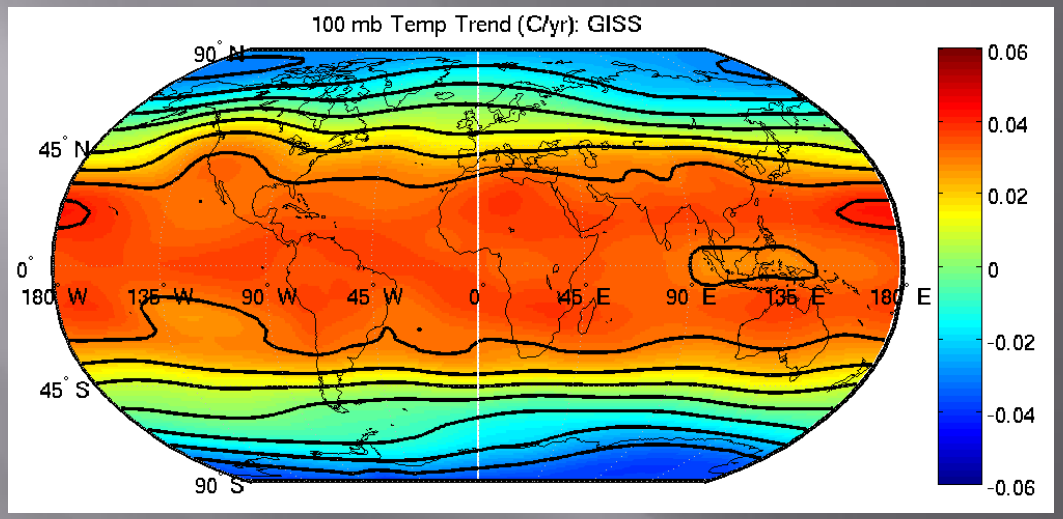


°C

- The Equator is much colder at 100 mb than the mid-latitudes and polar regions

UTLS Temperature 100 mb Trends: 100 years (2000-2100)

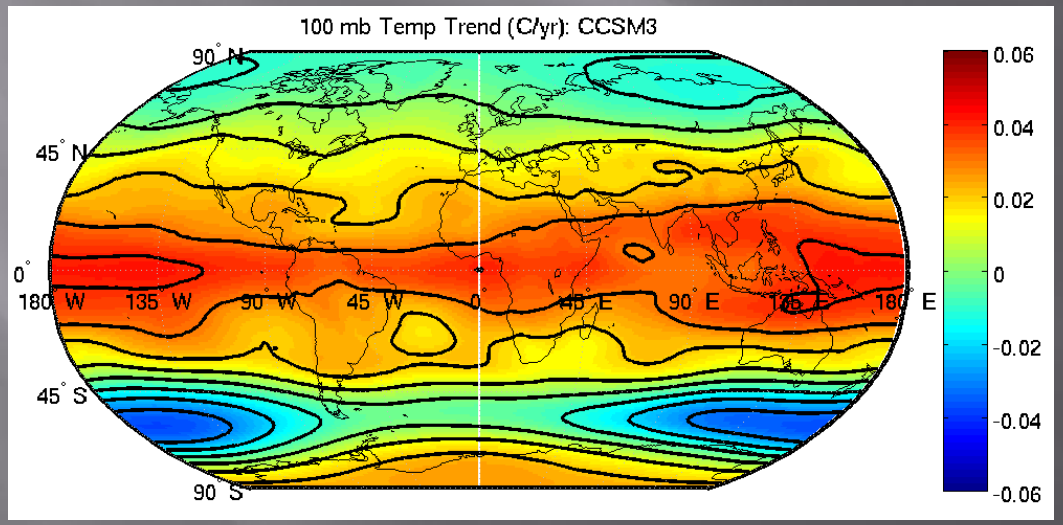
GISS



warming

cooling

CCSM3

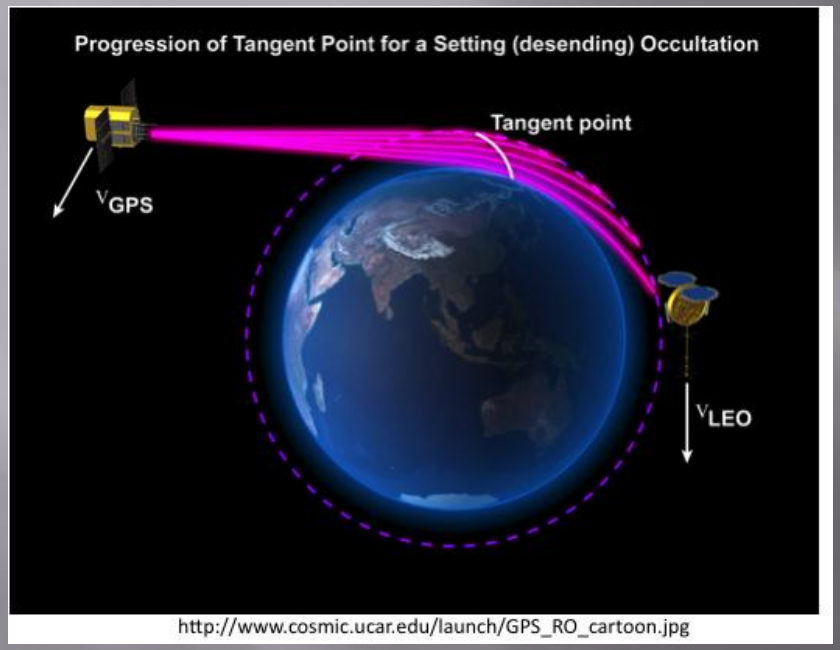


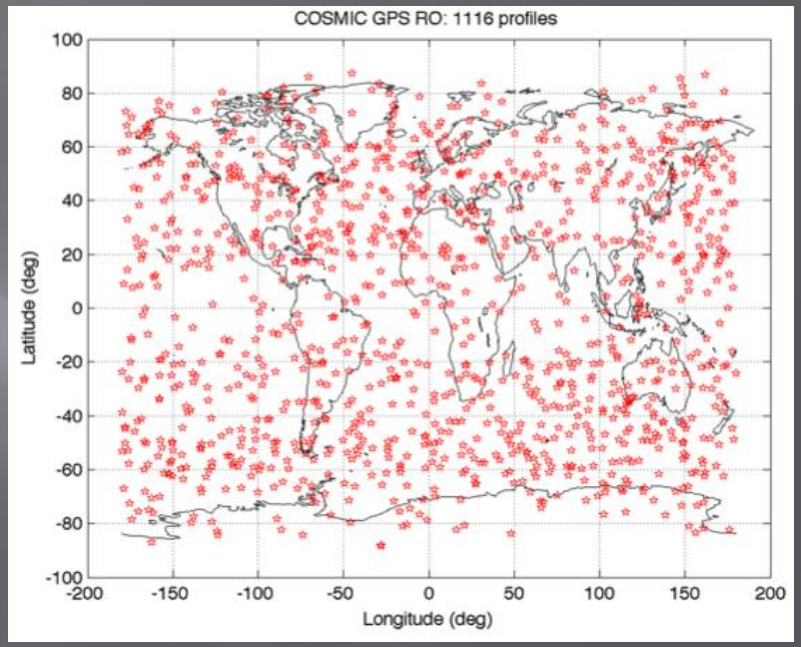
warming

cooling

- **Both positive and negative trends are predicted up to 0.05 K/yr.**

COSMIC GPS RO Network (U.S./Taiwan)





~ 1000 vertical Temperature profiles per day in 2007-2011

COSMIC stated "dry" temperature accuracy is 0.1 K
in the range 30 mb to 300 mb (above the effect of H2O)

Spatial/Temporal L2 Matchup

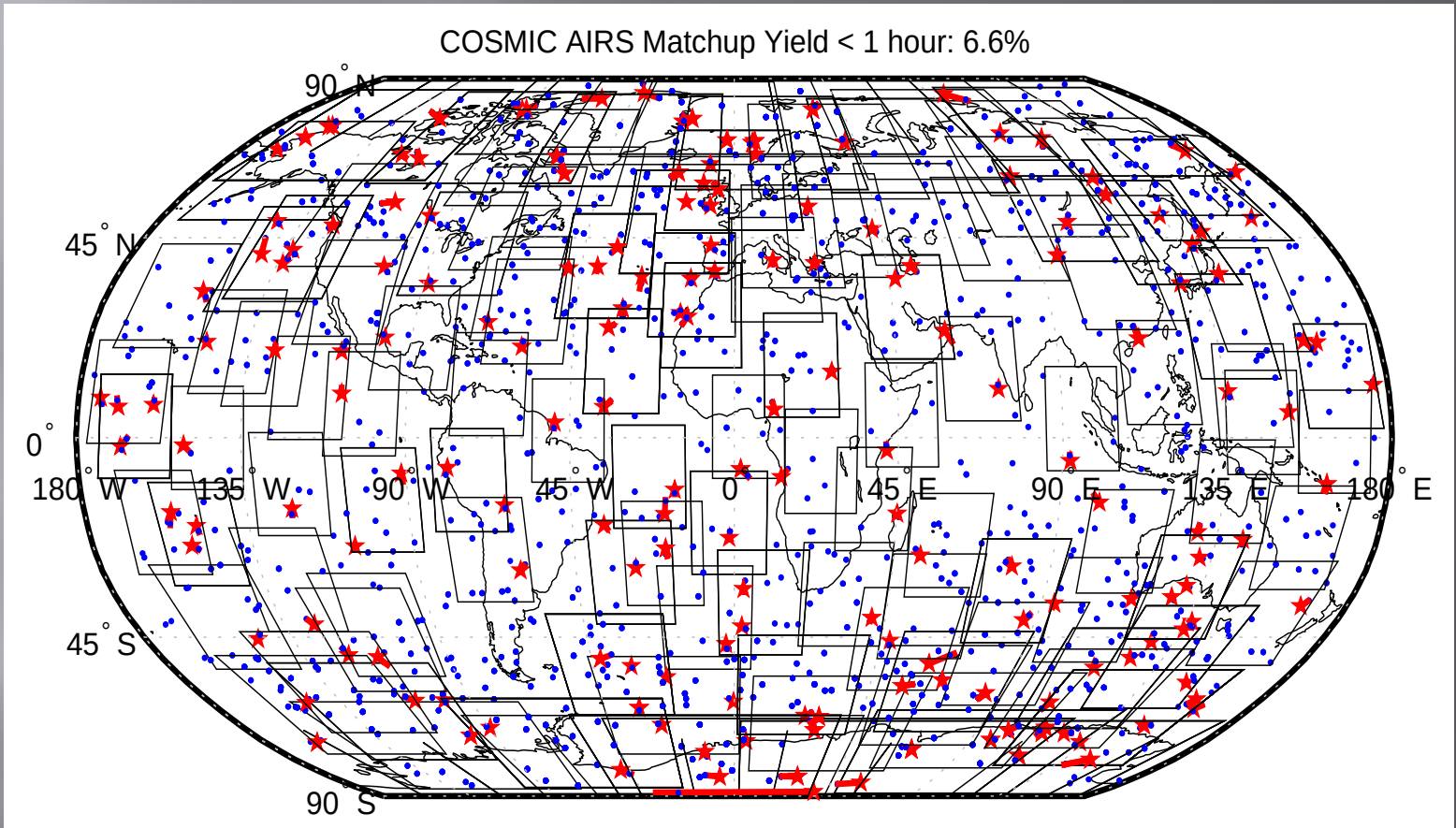
File-based Matchup Method

1) **Step through each COSMIC data file.**

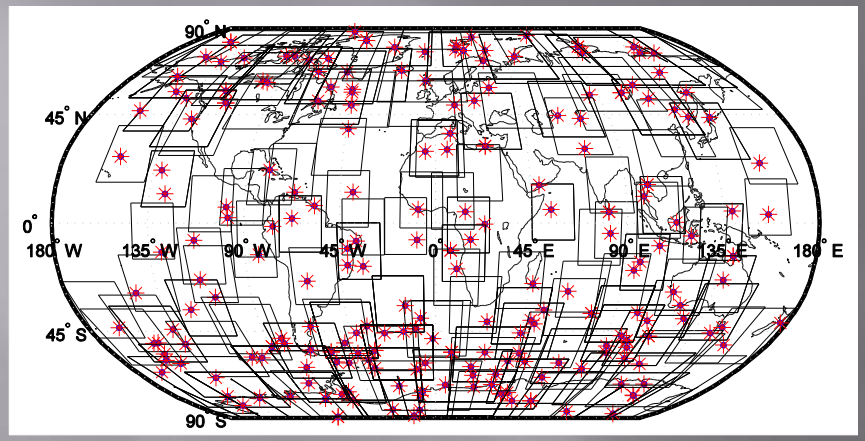
2) **Find sounding data granule where COSMIC profile lat/lon is within granule bounding box.**

3) **Check that COSMIC profile is within 1 hour of sounding granule (if not then reject profile).**

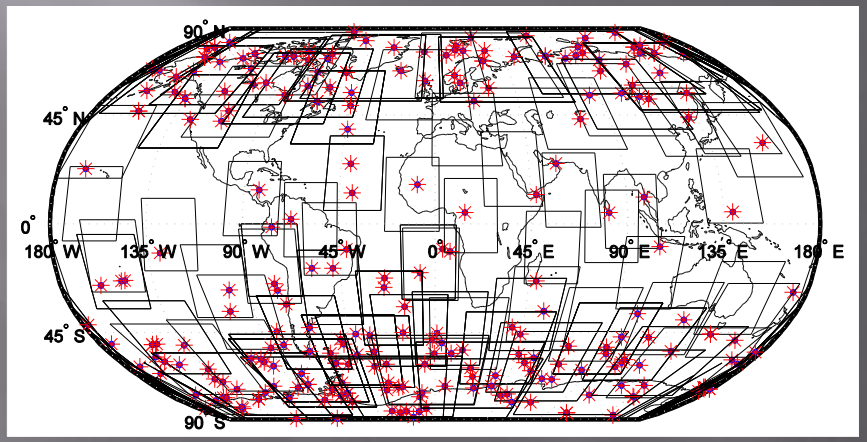
4) **Record COSMIC profile data file and sounding data file as a "matchup".**



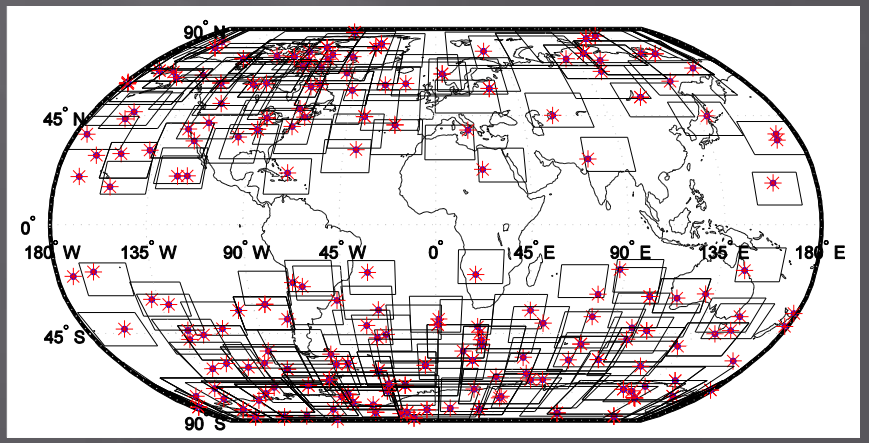
- 6.6% of the COSMIC profiles on this day are within 1 hour of a coincident AIRS observation.



AIRS/Aqua



CrIS/NPP



IASI/Metop-A

Spatial Analysis

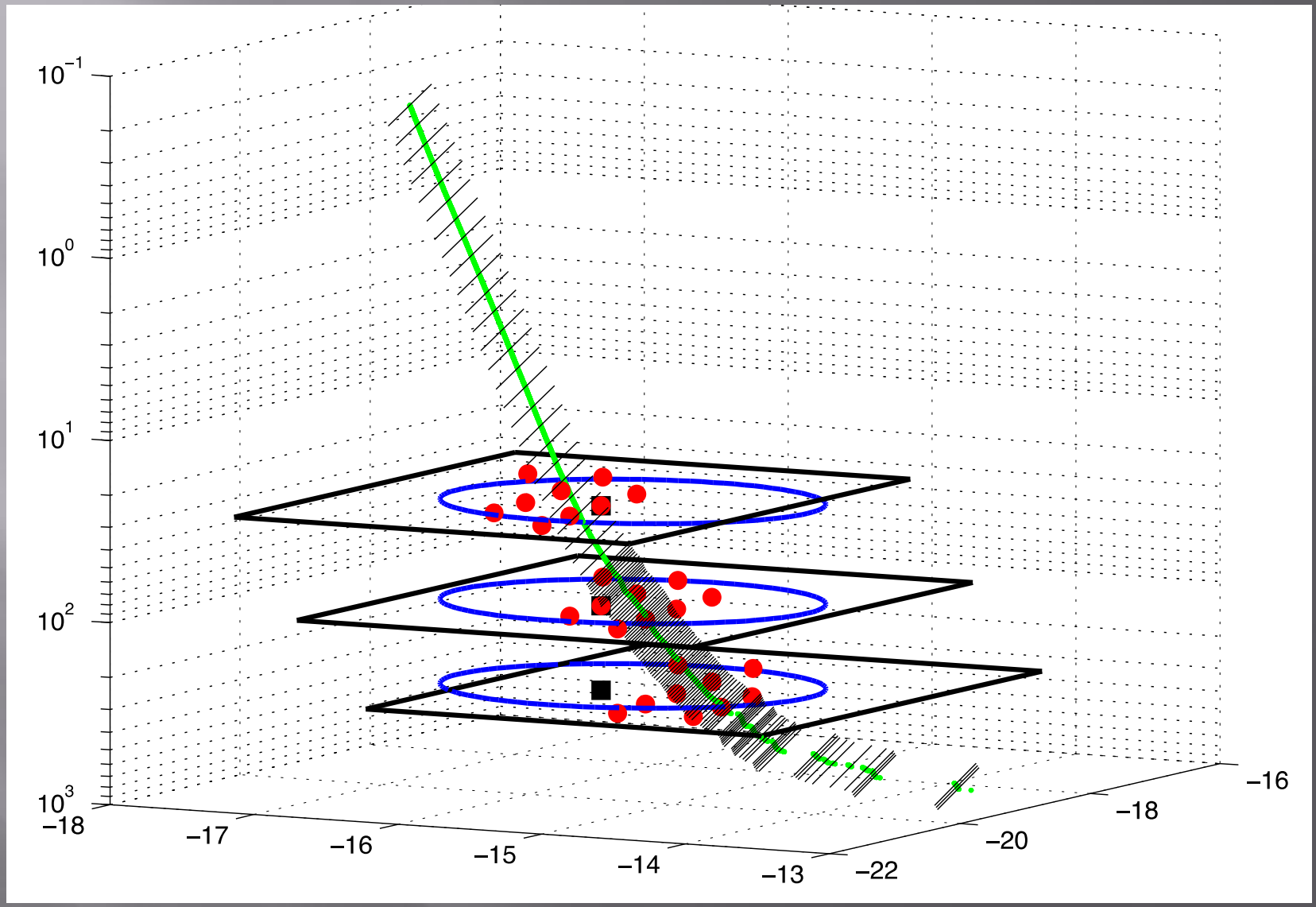
Consider three spatial matchup methods:

1) **Closest sounding to the COSMIC 100 mb level**
   Note: the perigee point reported in the COSMIC profile file header can be hundreds of km away from the 100 mb level!

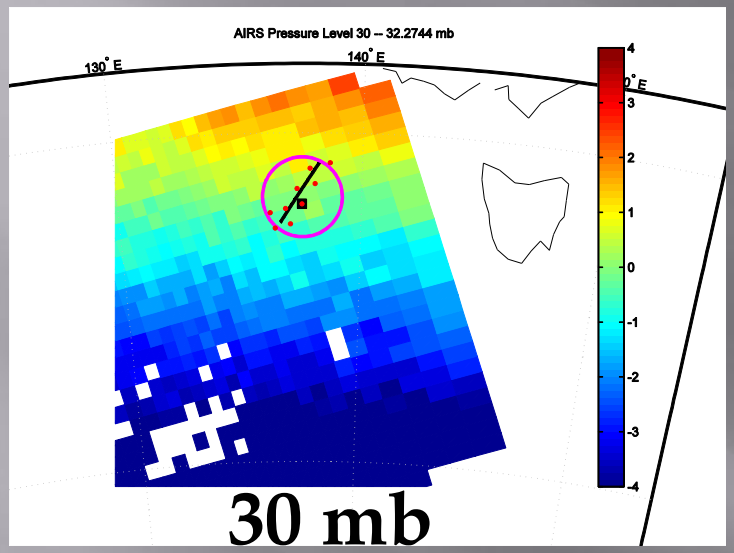
2) **Circle of radius 150 km center centered on closest sounding (approx. accounts for horizontal averaging).**

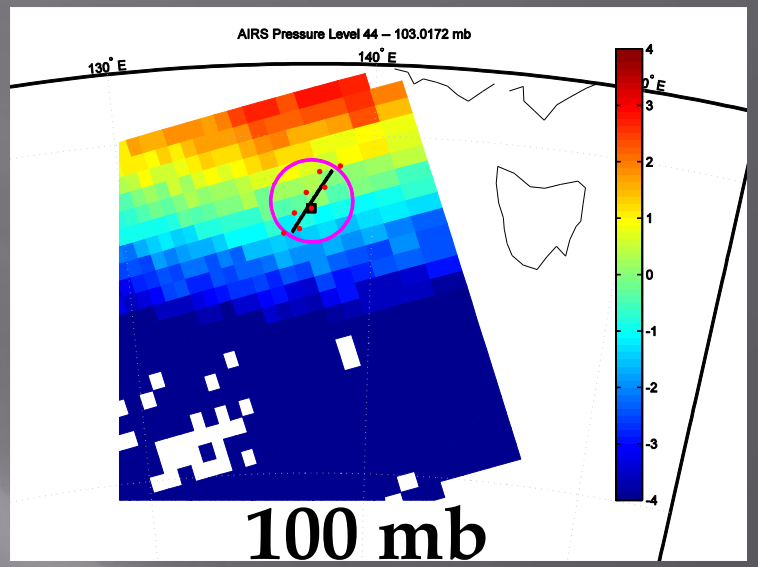
3) **Ray path "ribbon" method**
   (accounts for both horizontal averaging (300 km) and GPS RO profile lat/lon change versus height (500 km).

GPS RO Profile matchup with IR sounding (30, 100, 300 mb)

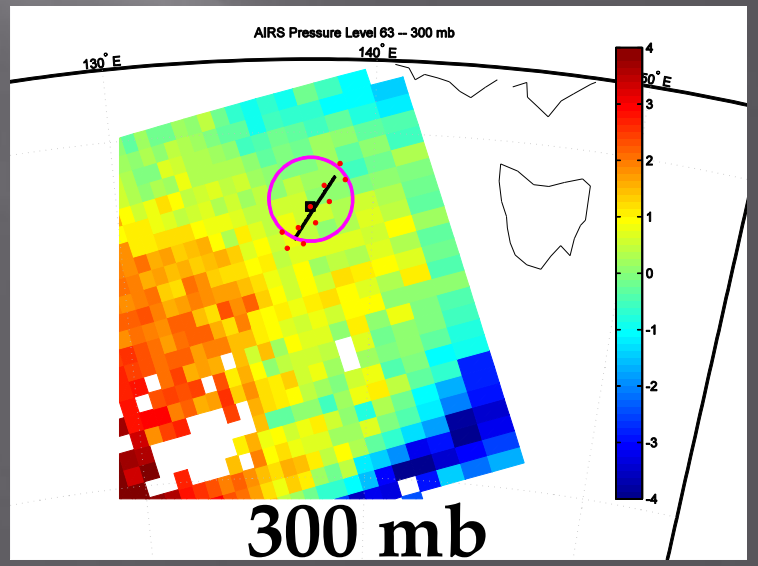


GPS RO Profile matchup with IR sounding (30, 100, 300 mb)

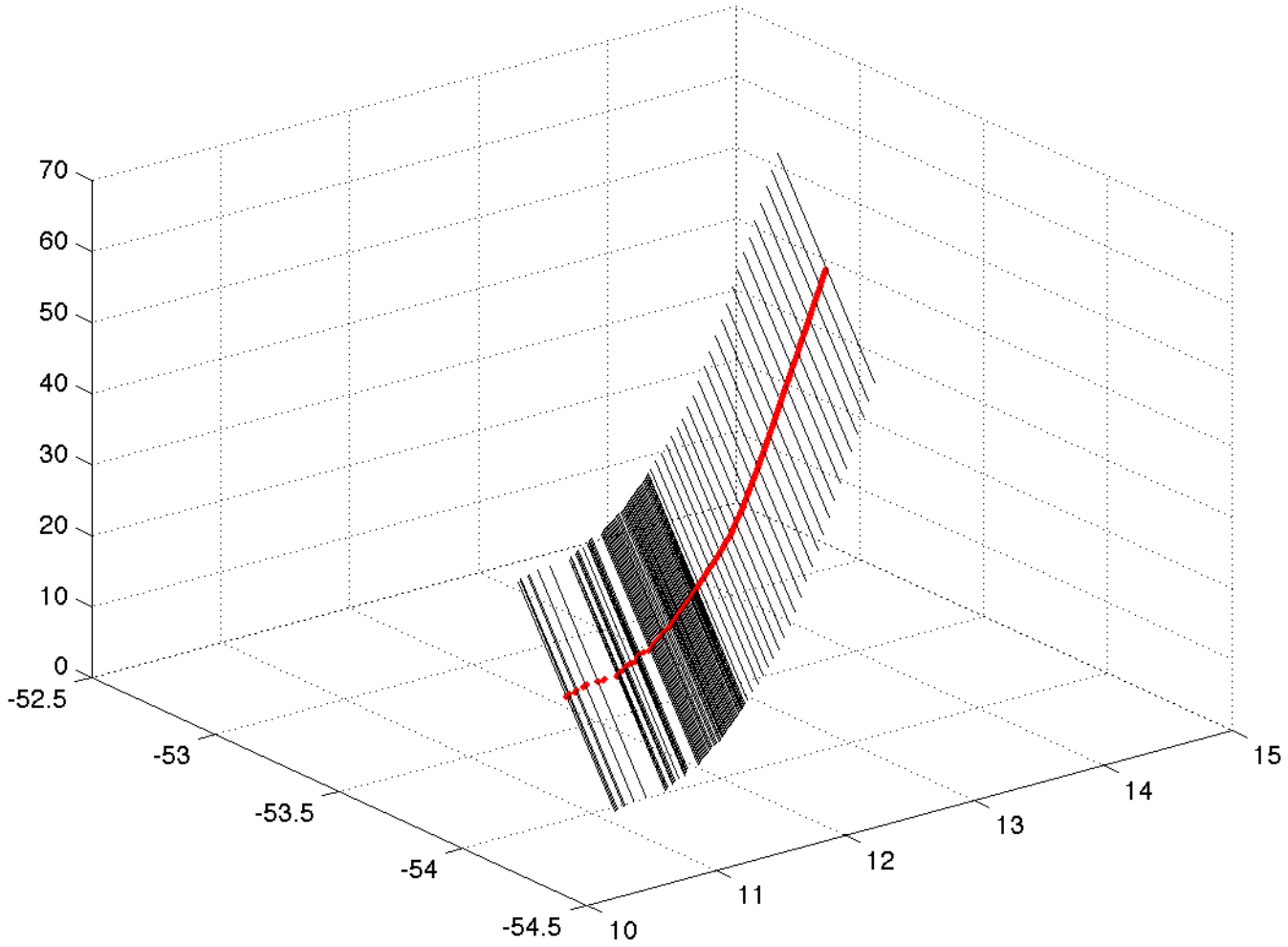




- The black square is the closest IR profile to the COSMIC at 100 mb.
- The pink circle has radius of 150 km centered at the closest profile.
- The black line is the ray path and the red dots are the ray path IR soundings



Example #1: “typical COSMIC”



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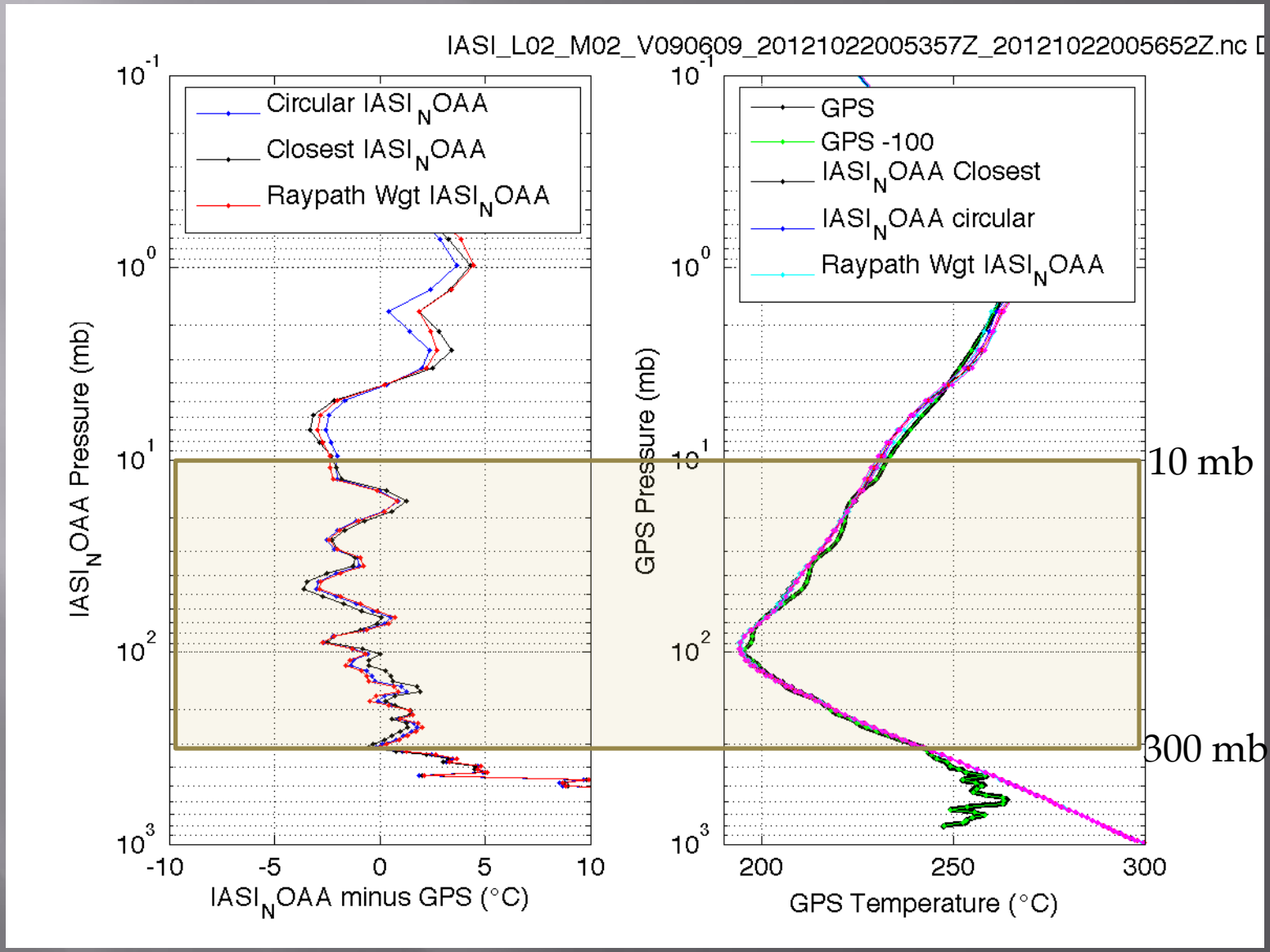
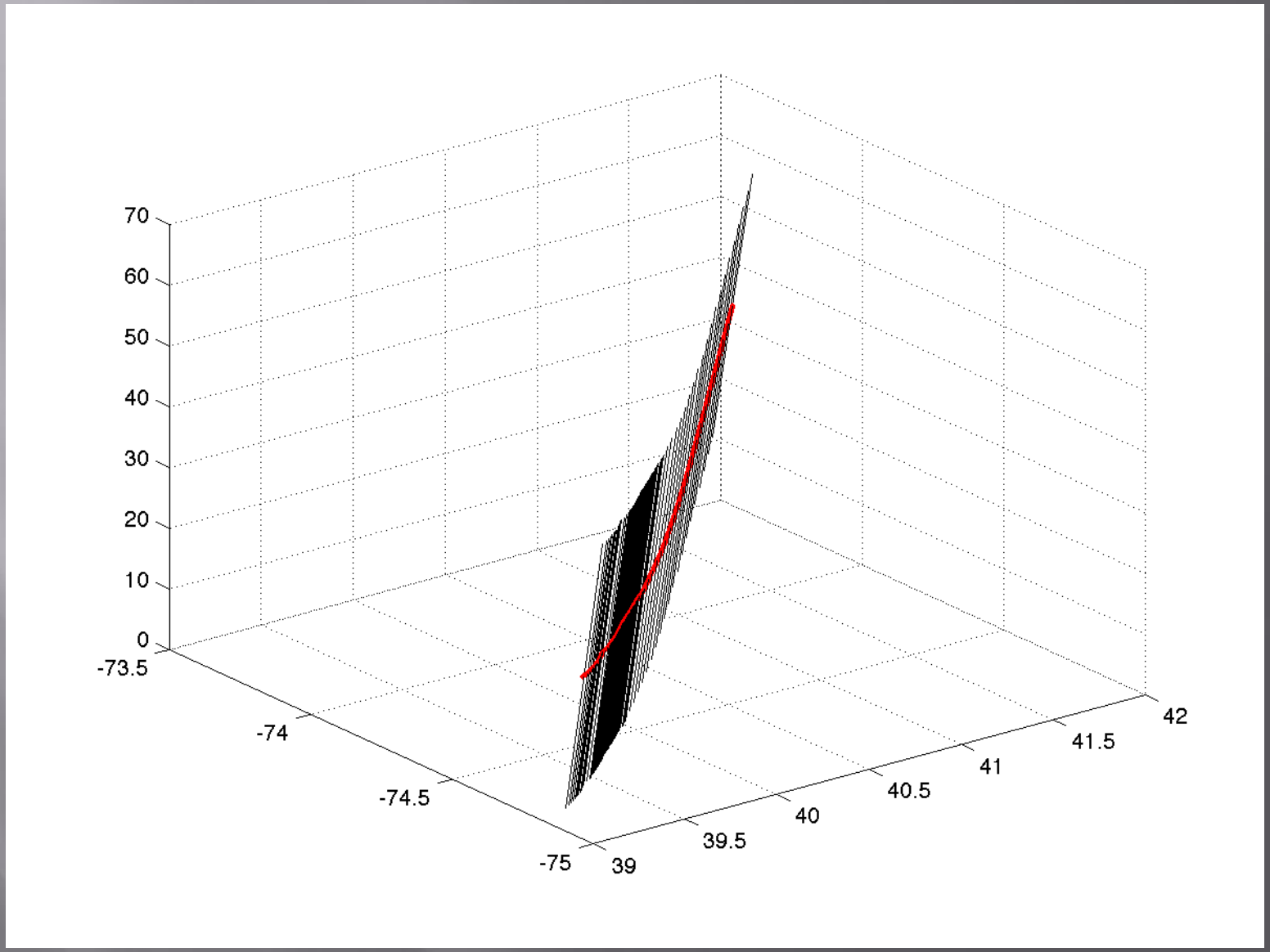
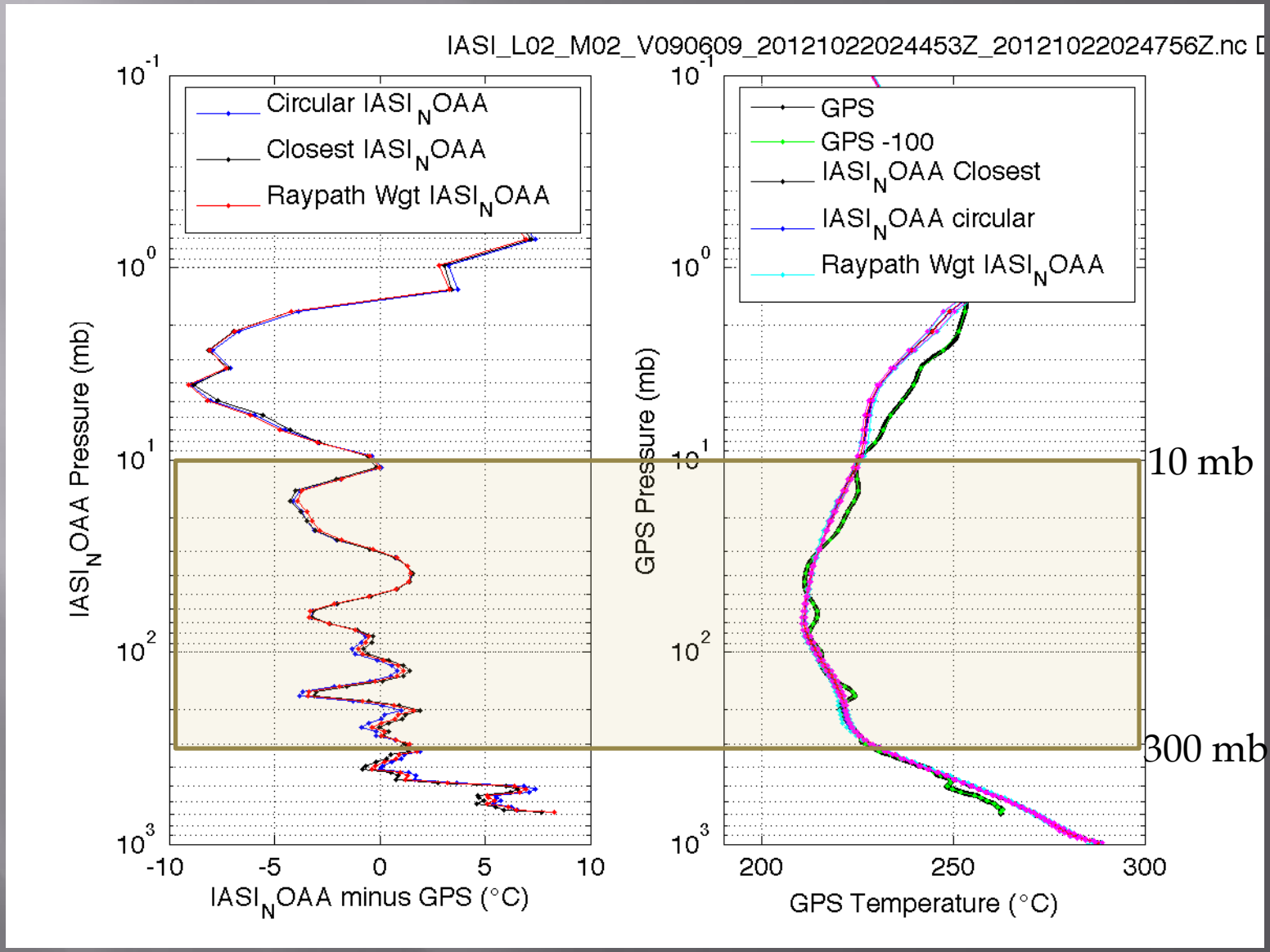


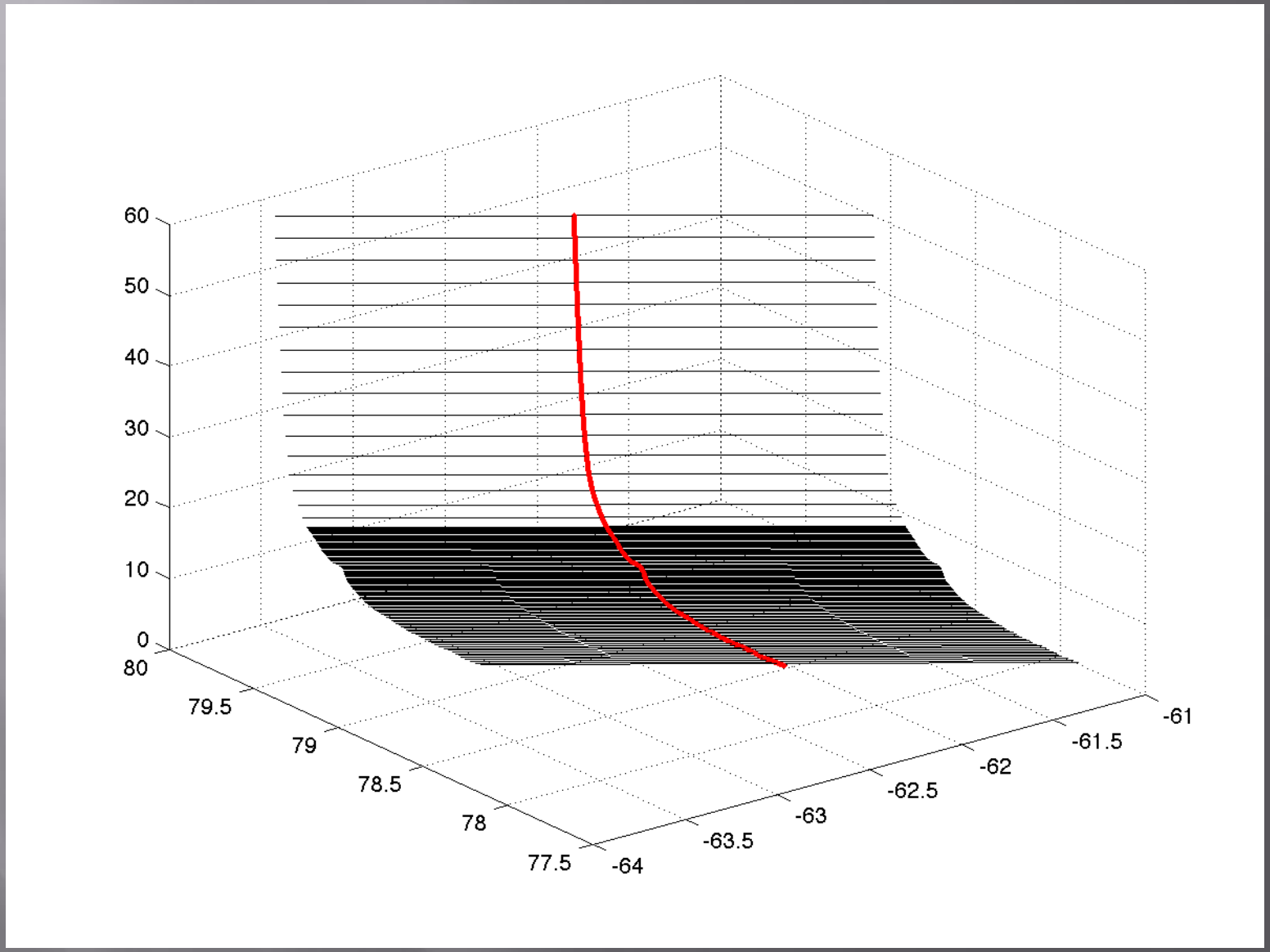
Example #2: “vertical COSMIC”



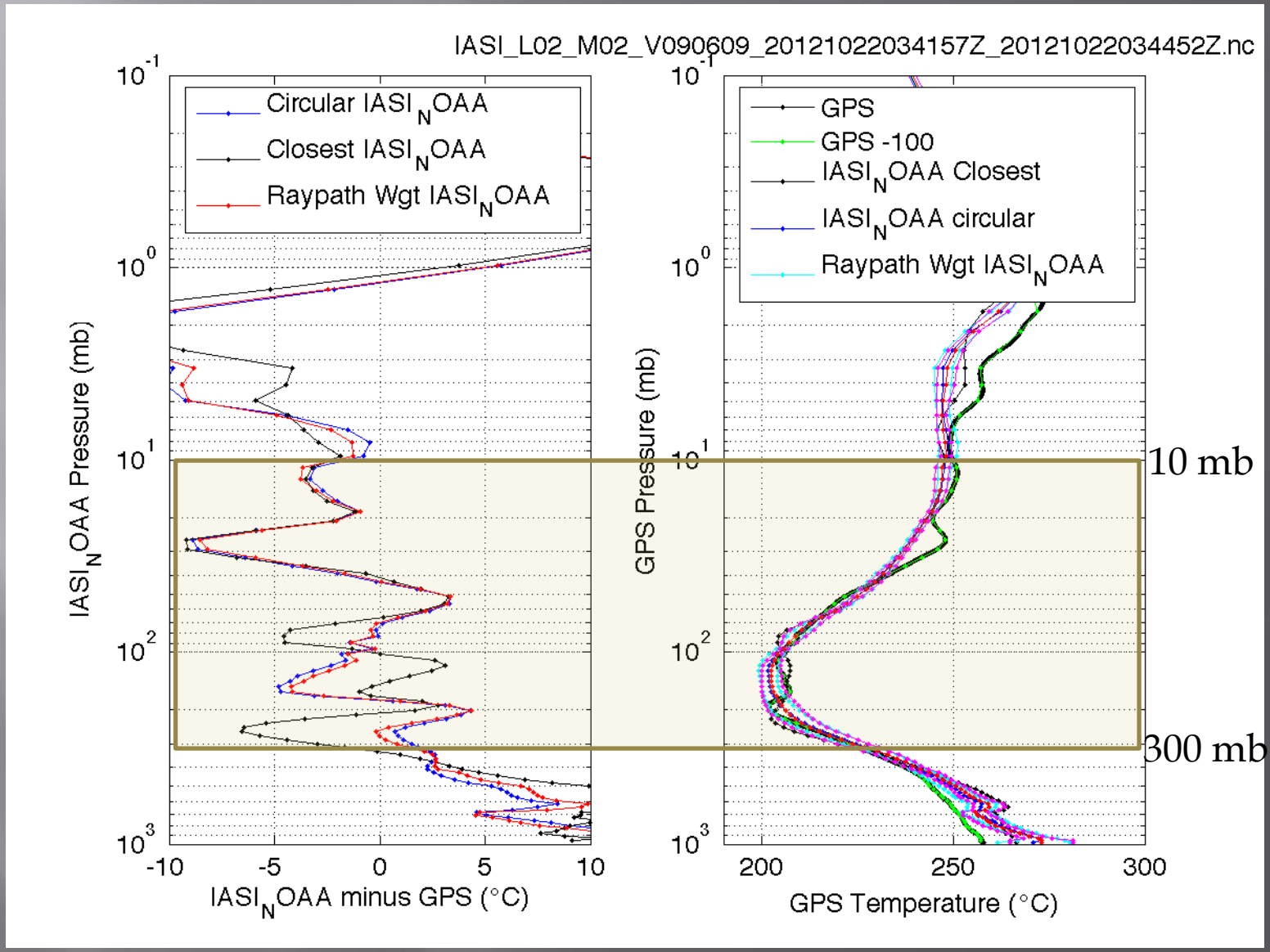
Example #2: "vertical COSMIC"



Example #3: “flat COSMIC”

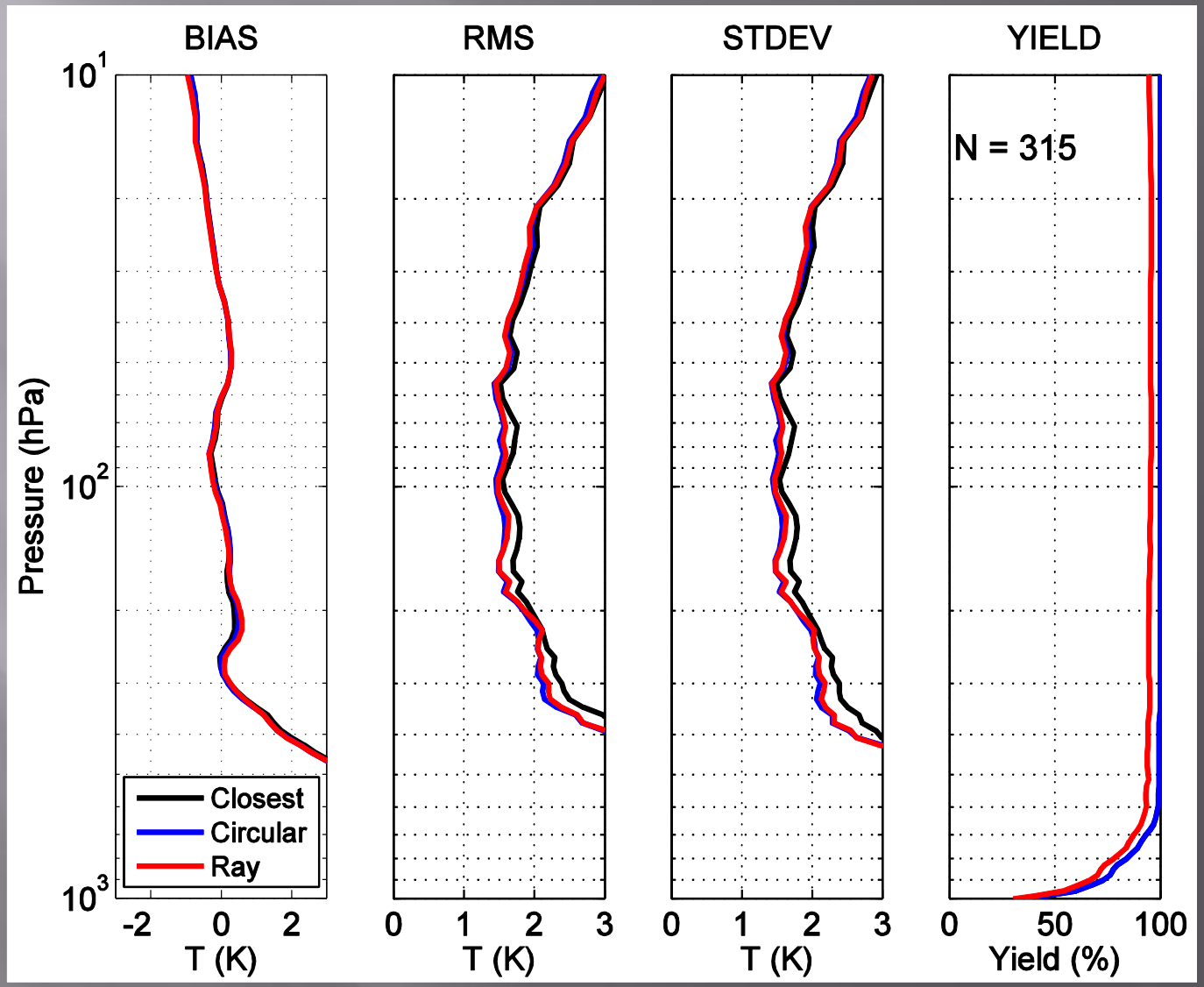


Example #3: "flat COSMIC"



NOAA IASI - COSMIC (90S-90N) GLOBAL

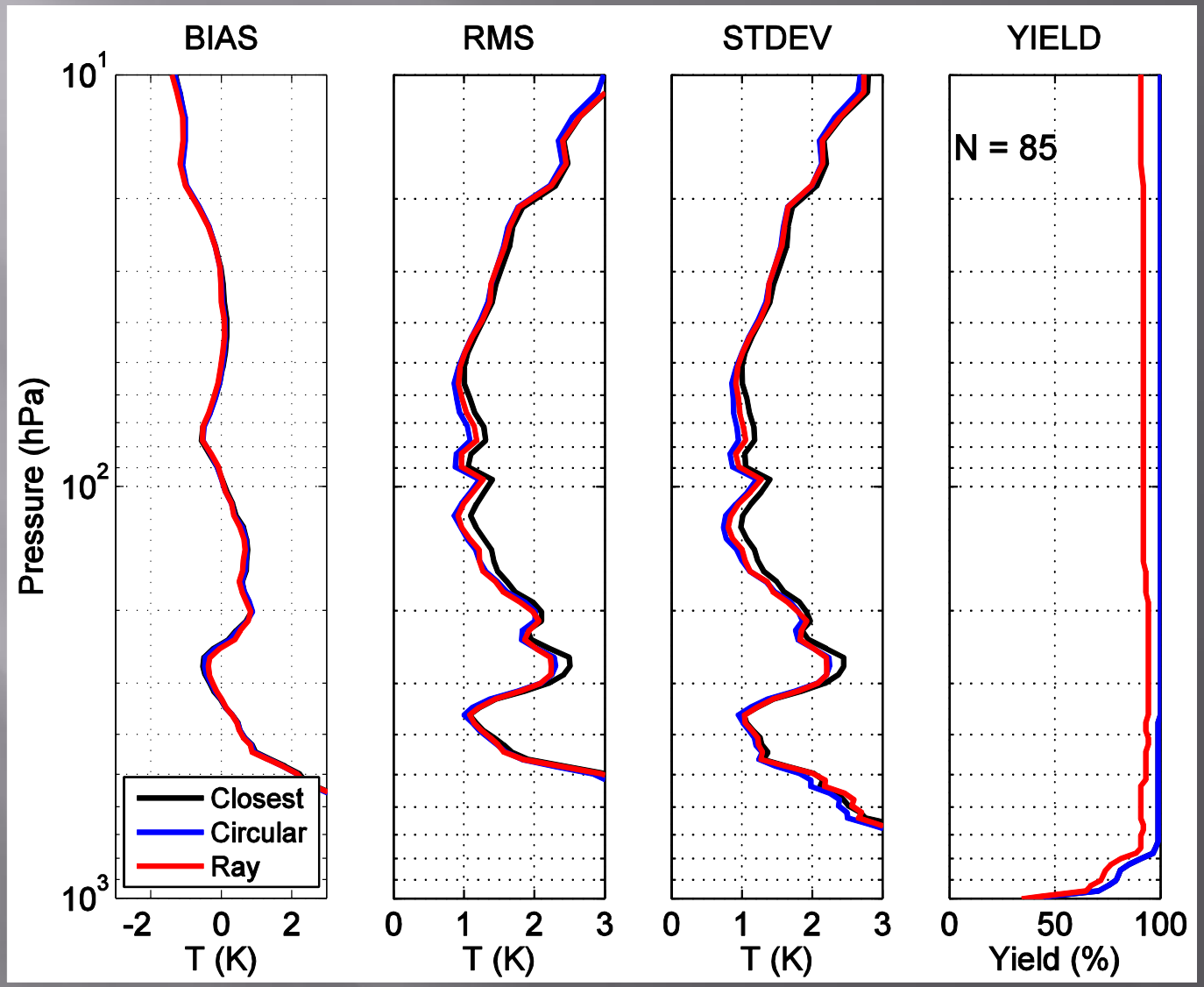
22 Oct. 2012 (1 day)



- For a single day, the Raypath and Circle methods are superior to the CLOSEST profile method.

NOAA IASI - COSMIC (60N-90N) ARCTIC

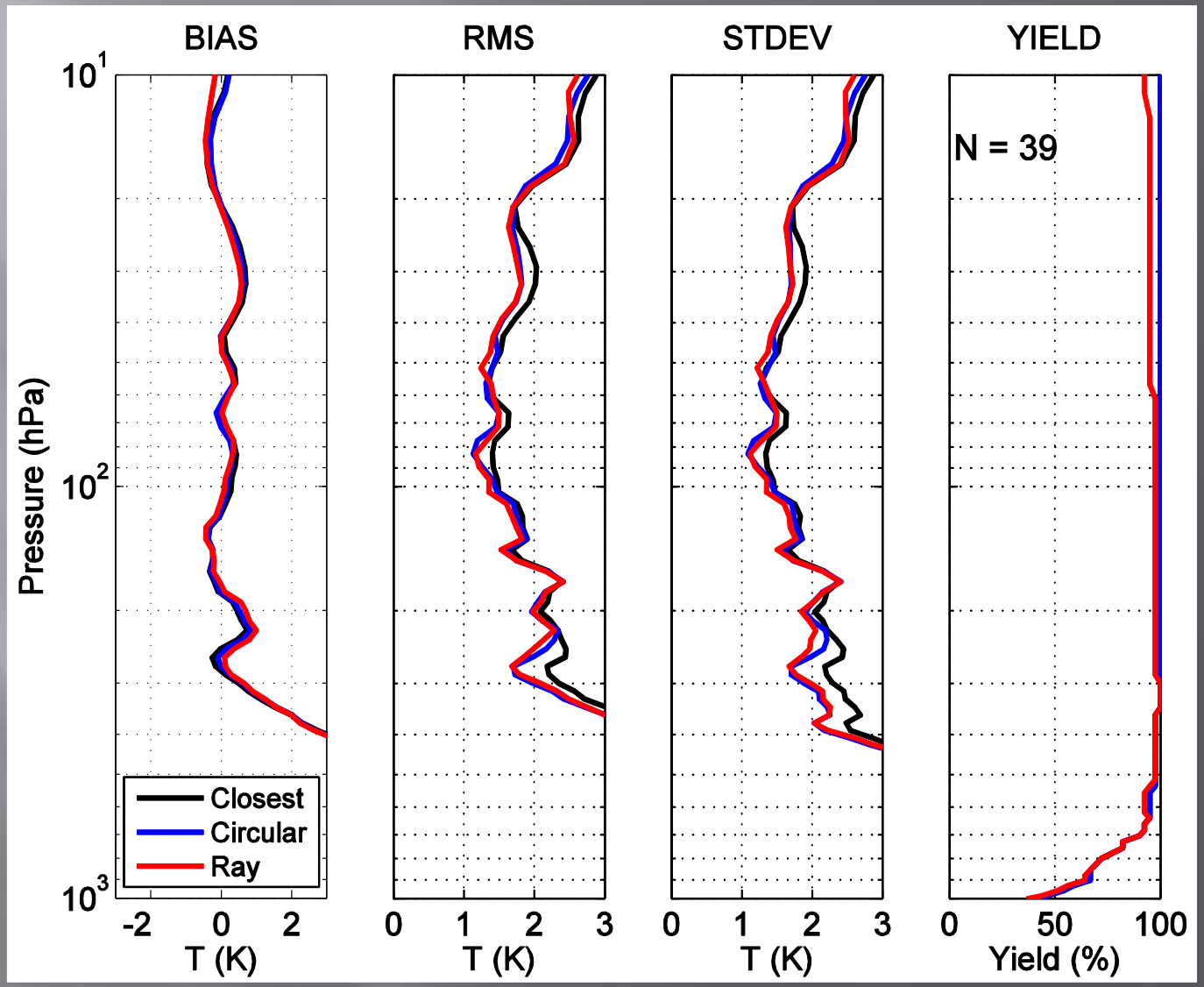
22 Oct. 2012 (1 day)



- For a single day, the Raypath and Circle methods are superior to the CLOSEST profile method.

NOAA IASI - COSMIC (30N-60N) N. Mid-Lat

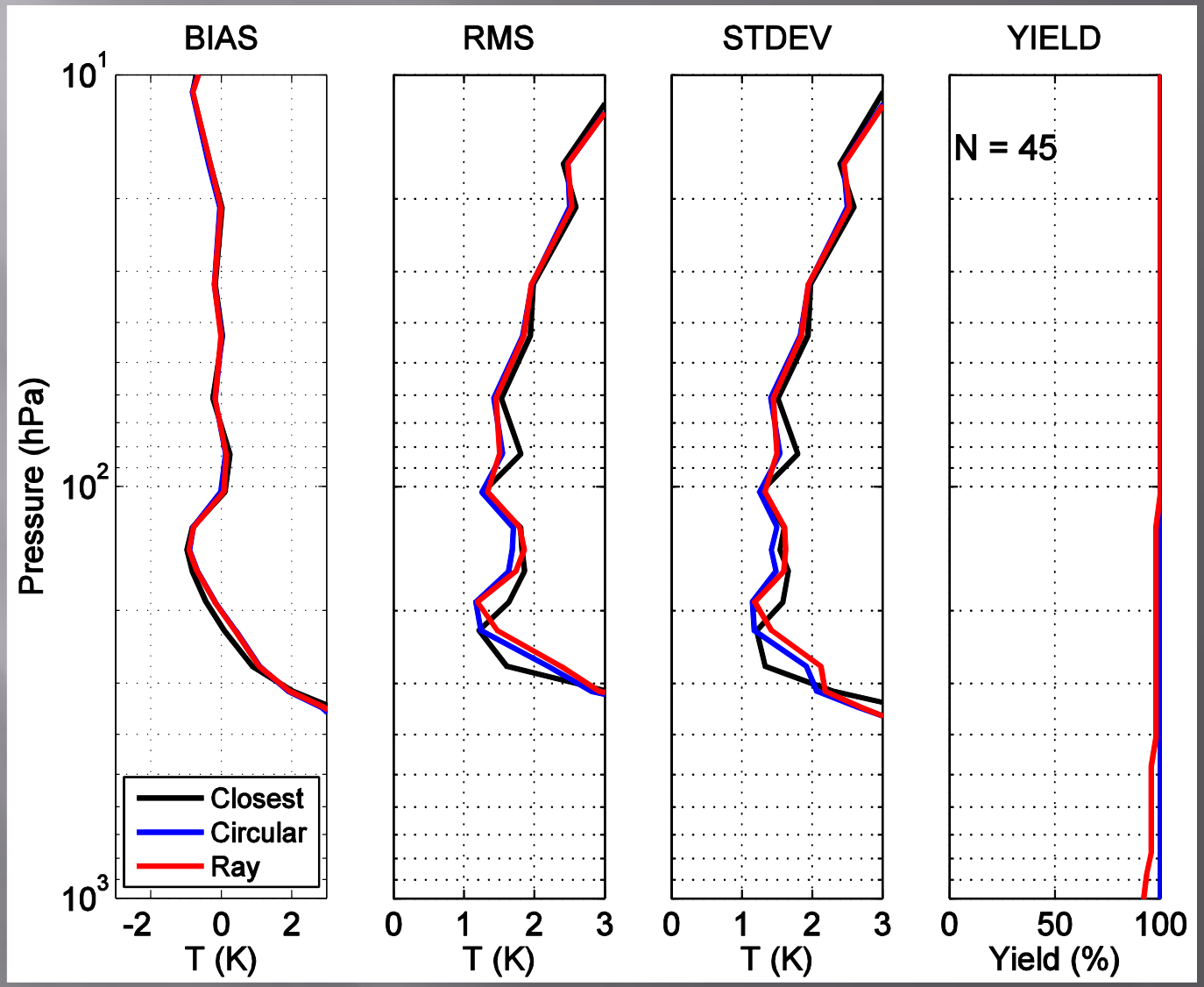
22 Oct. 2012 (1 day)



- For a single day, the Raypath and Circle methods are superior to the CLOSEST profile method.

NOAA IASI - COSMIC (30S-30N) TROPICS

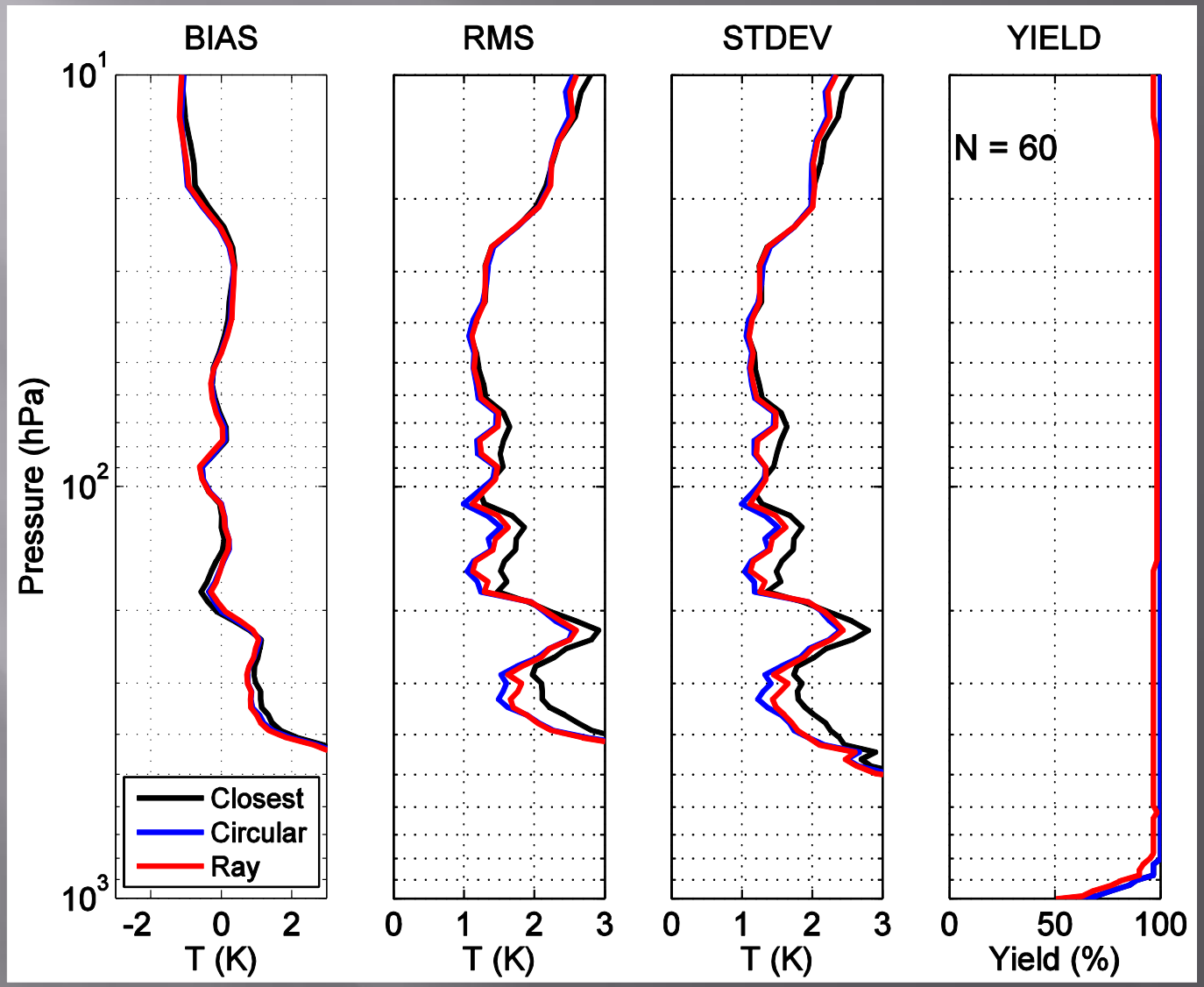
22 Oct. 2012 (1 day)



- For a single day, the Raypath and Circle methods are superior to the CLOSEST profile method.

NOAA IASI - COSMIC (30S-60S) S. Mid-Lat

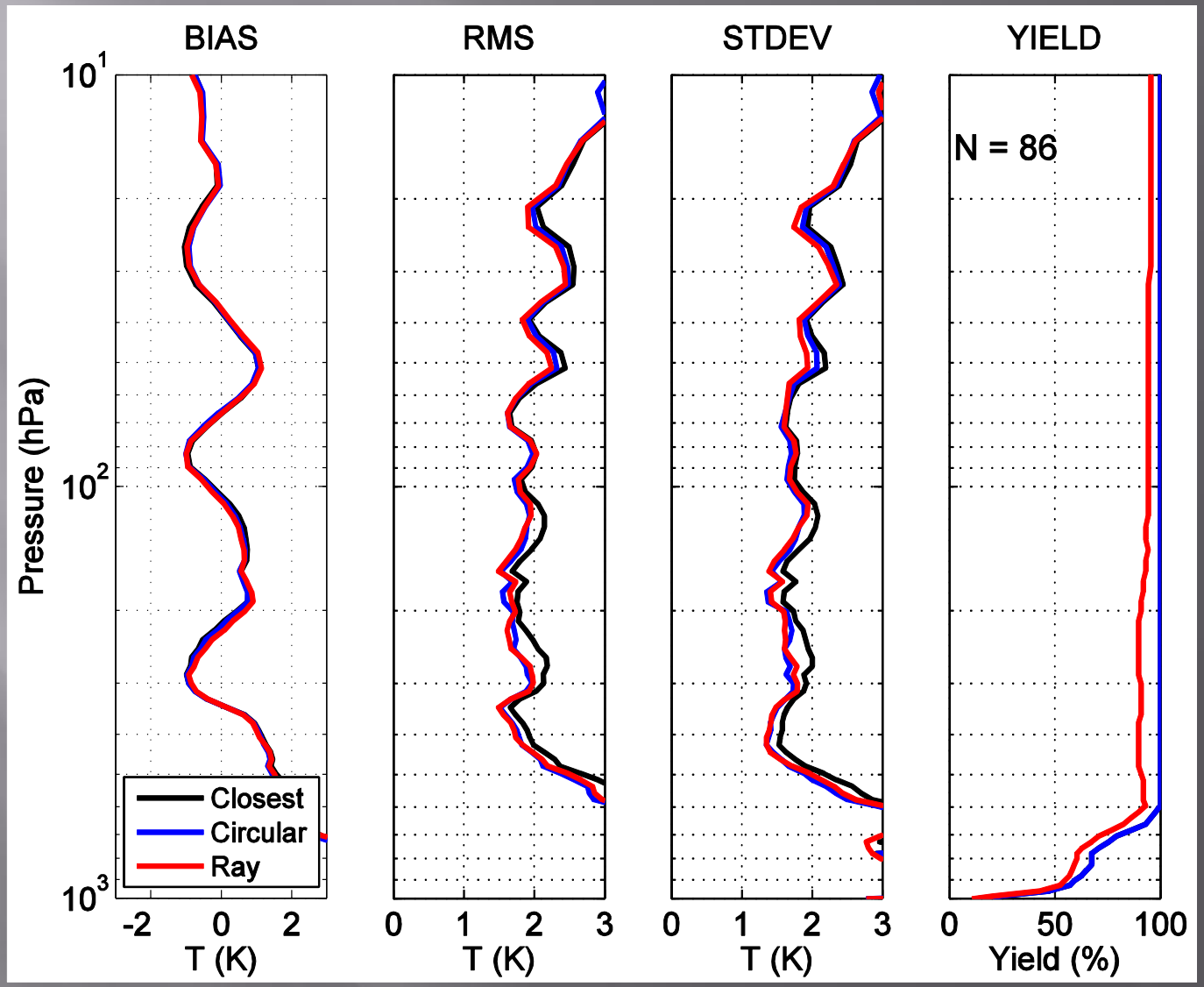
22 Oct. 2012 (1 day)



- For a single day, the Raypath and Circle methods are superior to the CLOSEST profile method.

NOAA IASI - COSMIC (30S-60S) Antarctic

22 Oct. 2012 (1 day)



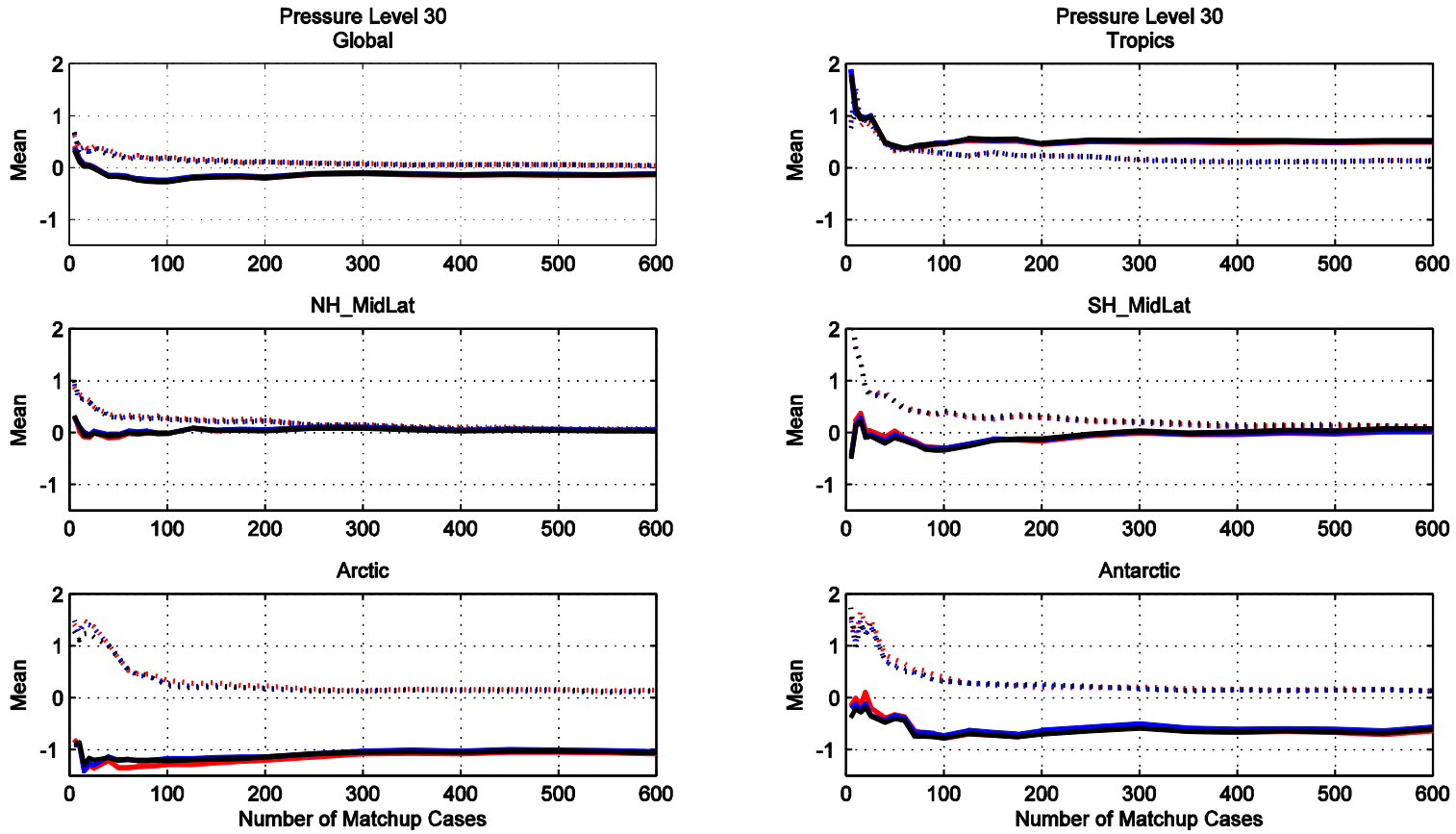
- For a single day, the Raypath and Circle methods are superior to the CLOSEST profile method.

Temporal Analysis

Uncertainty in the Estimated Bias & RMS

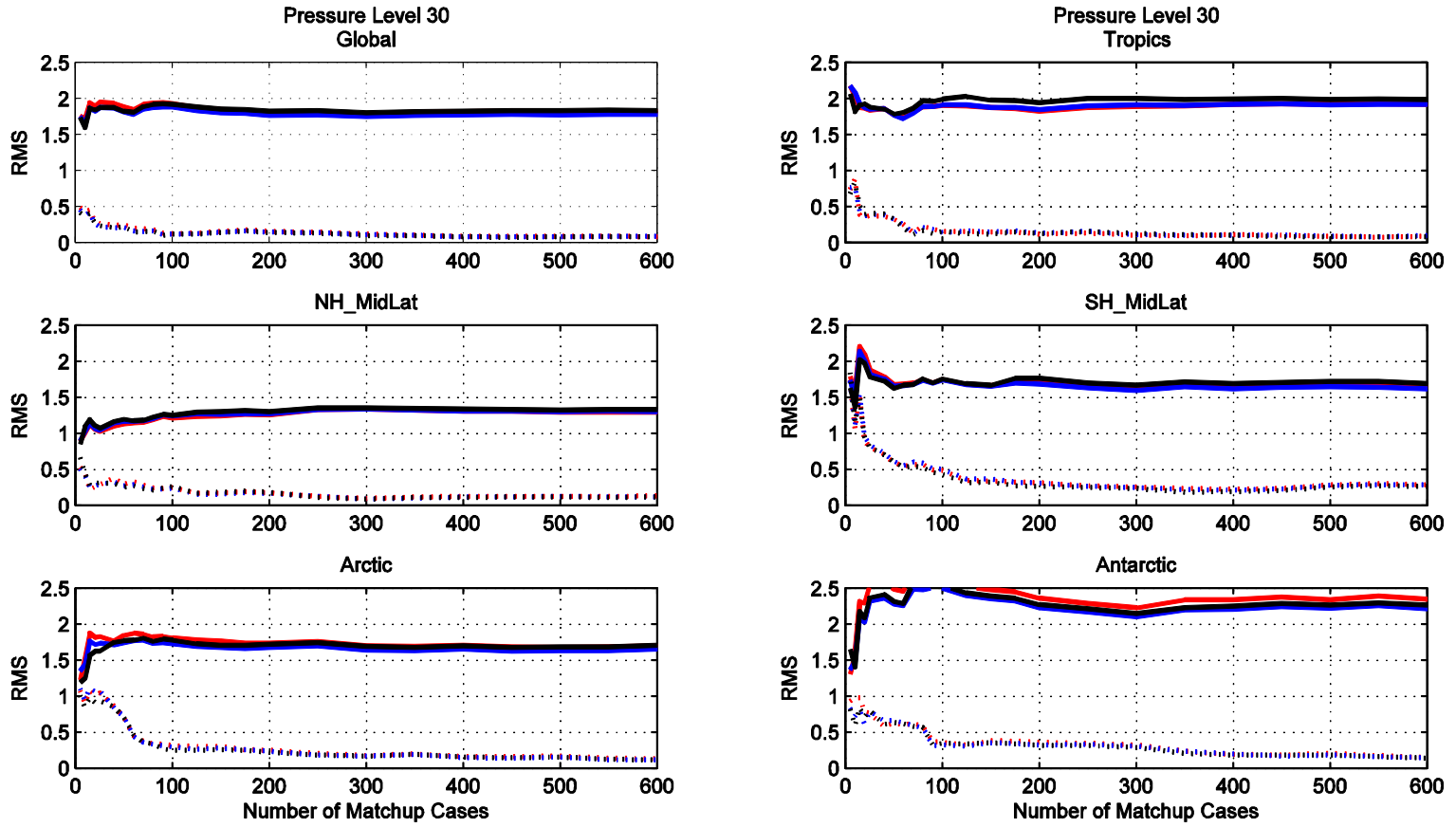
as a function of number of samples (time)

Temporal Analysis: Uncertainty in the Estimated Bias AIRS – COSMIC Temperature (30 mb level)



- 100 samples (1.5 days) for statistical fluctuations in bias to damp out
- 300 sample (5 days) to converge to stable bias value

Temporal Analysis: Uncertainty in the Estimated RMS AIRS – COSMIC Temperature (30 mb level)



- 100 samples (1.5 days) for statistical fluctuations in RMS to damp out
- 300 sample (5 days) to converge to stable RMS value

Preliminary Results: CrIS + ATMS = CrIMSS

The following slides were presented by Chris Barnet of NOAA to a JPSS review panel on the status of the CrIMSS data product in January 2013.

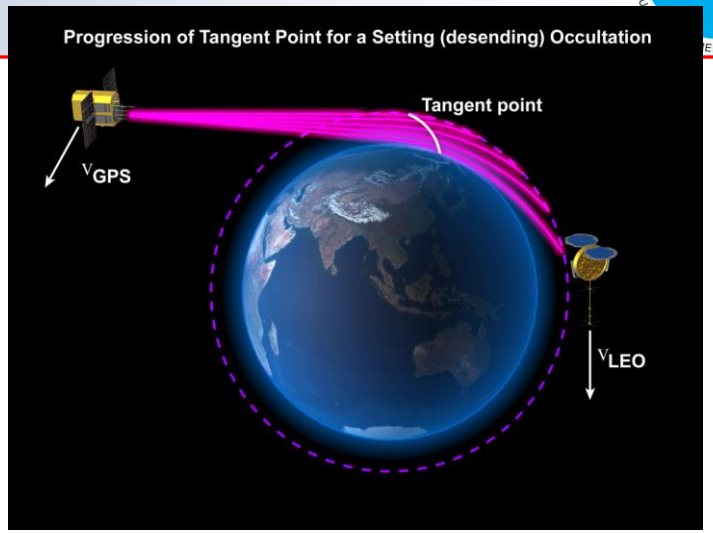
Provisional Maturity Evaluation (20/35) Introduction to COSMIC Comparison

- Next Set of slides (courtesy of Bob Knuteson and Michelle Feltz, Univ. of Wisconsin) show IDPS CrIMSS EDR products relative to co-located GPS sondes
  - AIRS results are shown in top panels
  - CrIMSS results from Mx5.3 and Mx6.4 are shown in bottom panels
- GPS comparisons are only valid from ~300 hPa to 30 hPa
  - In general, GPS results are an independent confirmation of what we have shown relative to ECMWF
  - Statistics are similar to the heritage AIRS EDR products
    - CrIMSS EDR has larger biases
      - Because IDPS system does not have ATMS bias corrections
    - CrIMSS EDR has slightly larger standard deviation (SDV)
      - IDPS code is not fully optimized

Slide courtesy of Michelle Feltz and Robert Knuteson (see AMS presentation for details).

Provisional Maturity Evaluation (21/35)

Matchups were found between COSMIC and CrIMSS retrievals of temperature (collocated and within 1 hour). The COSMIC data is used a common reference to compare CrIMSS and AIRS retrievals on a daily basis. The COSMIC dry temperature is valid in the range 30 – 300 mb.



http://www.cosmic.ucar.edu/launch/GPS_RO_cartoon.jpg

COSMIC Dry Temperature Profile

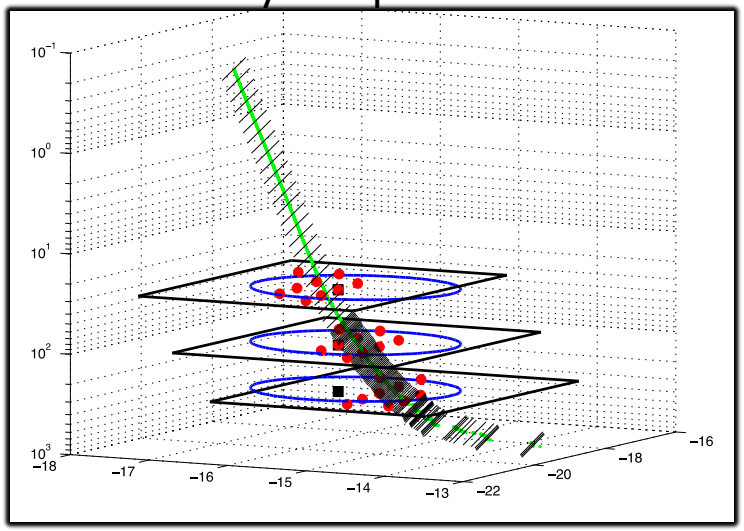
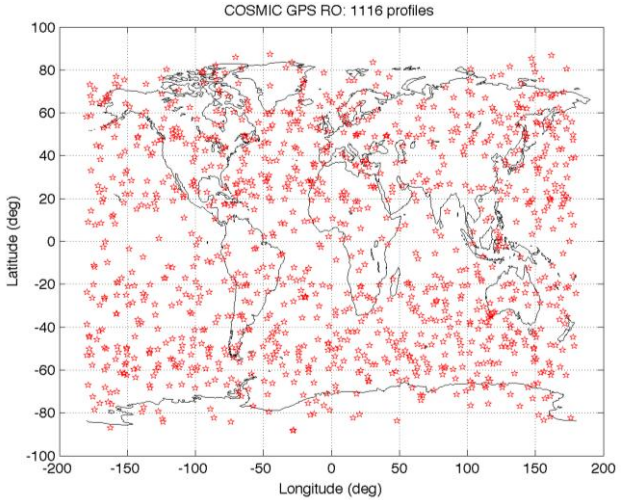


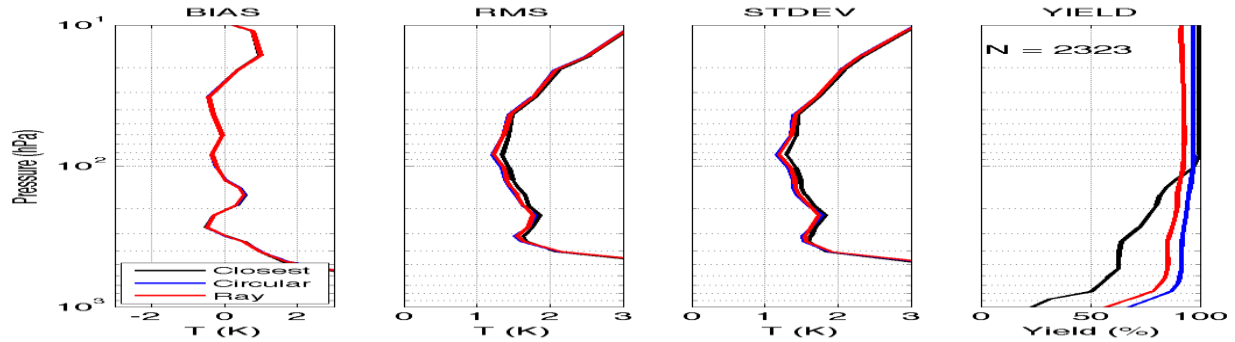
Illustration of the closest (black square), circular (blue circle), and ray path (red dots) methods for a single GPS profile (green) for the circle centered at the GPS RO level of 100 hPa



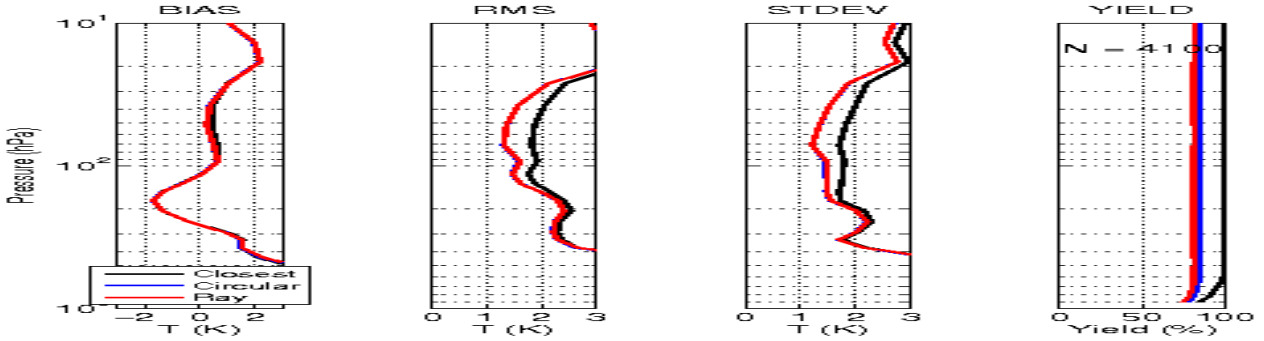
One Day of COSMIC Profiles

Provisional Maturity Evaluation (22/35)
GPS comparisons: Global (90S-90N)

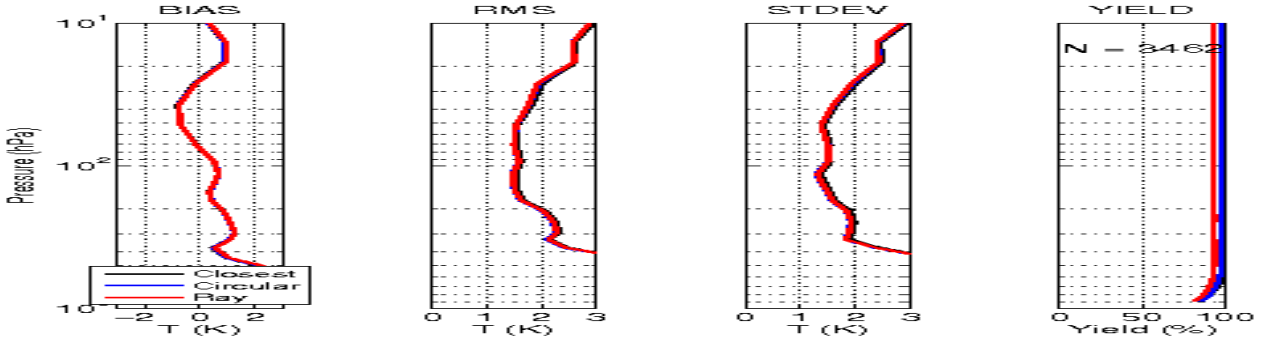
AIRS - COSMIC



CLASS
Mx 5.3
Product
Oct. 1-10



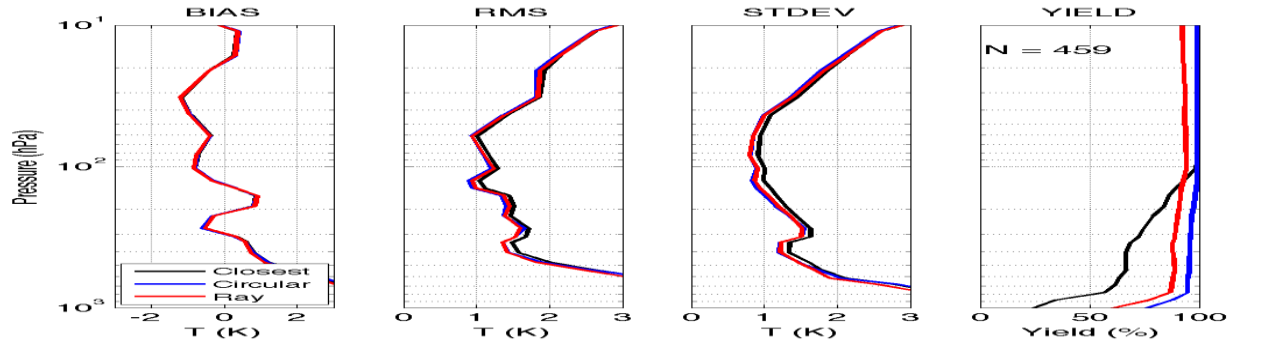
CLASS
Mx 6.4
Product
Oct. 22-31



Slide courtesy of Michelle Feltz and Robert Knuteson (see AMS presentation for details).

Provisional Maturity Evaluation (23/35)
GPS comparisons: N.H. Polar (60N-90N)

AIRS - COSMIC



CLASS
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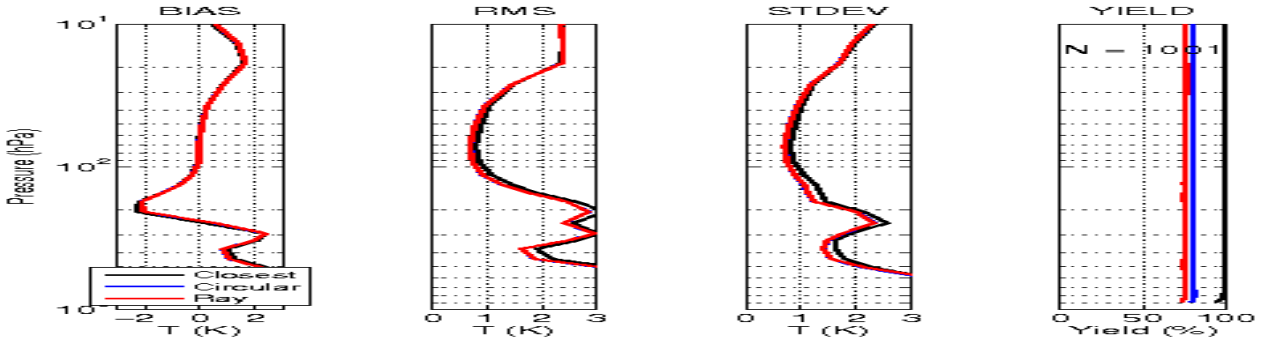
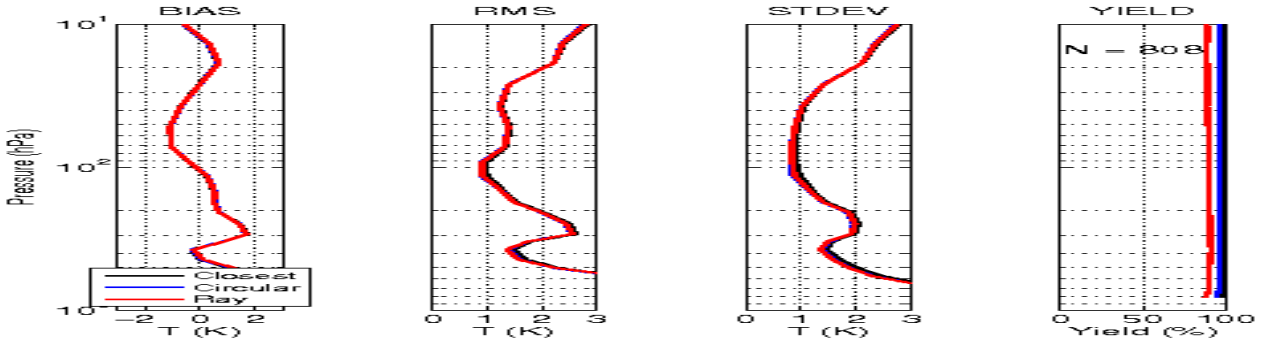
Oct. 1-10



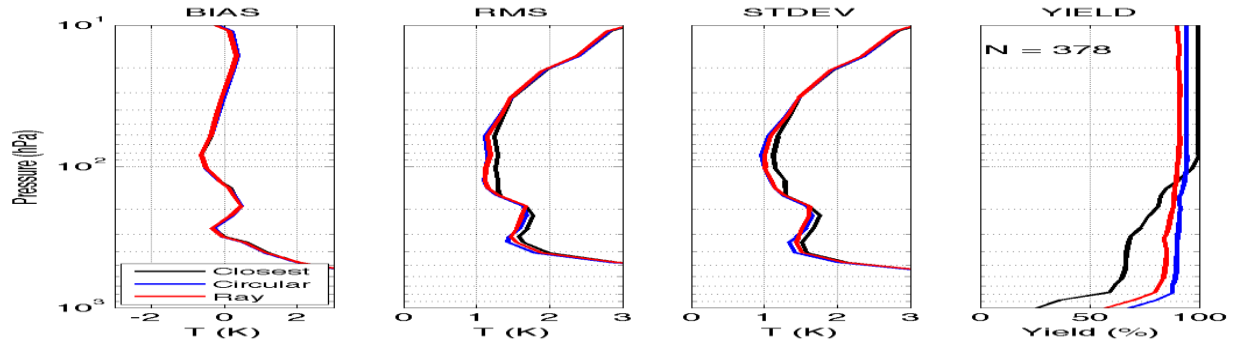
CLASS
Mx 6.4
Product
Oct. 22-31



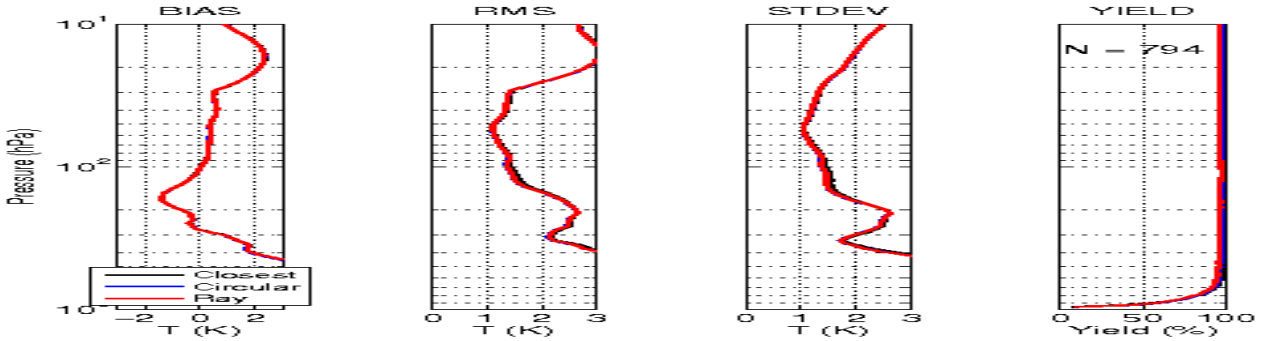
Slide courtesy of Michelle Feltz and Robert Knuteson (see AMS presentation for details).

Provisional Maturity Evaluation (24/35)
GPS comparisons: N.H. Mid-Lat (30N-60N)

AIRS - COSMIC



CLASS
Mx 5.3
Product
Oct. 1-10



CLASS
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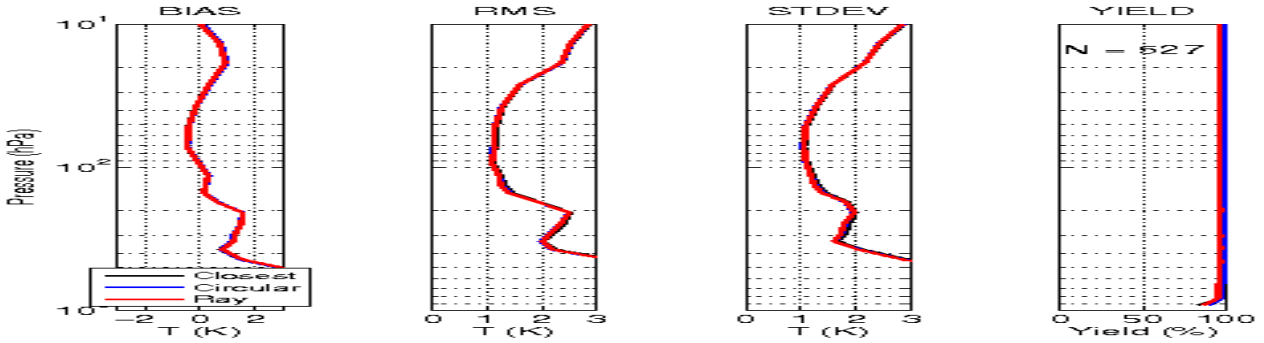
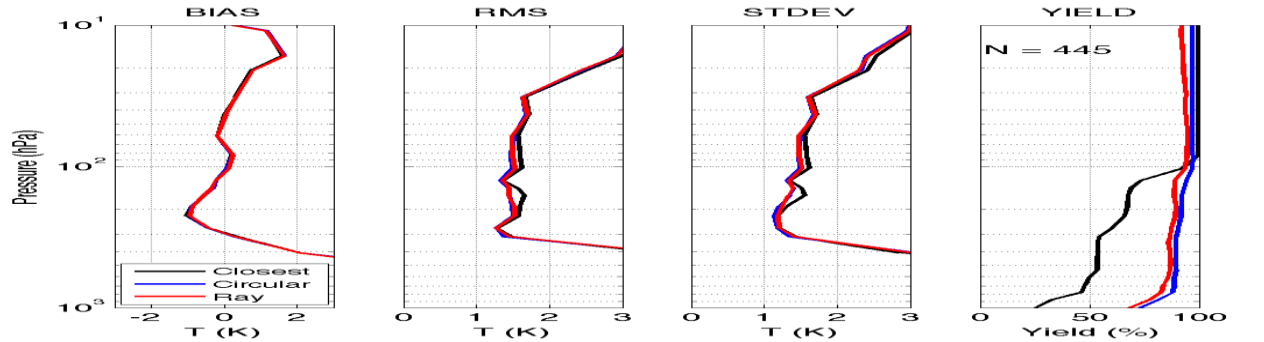
Oct. 22-31



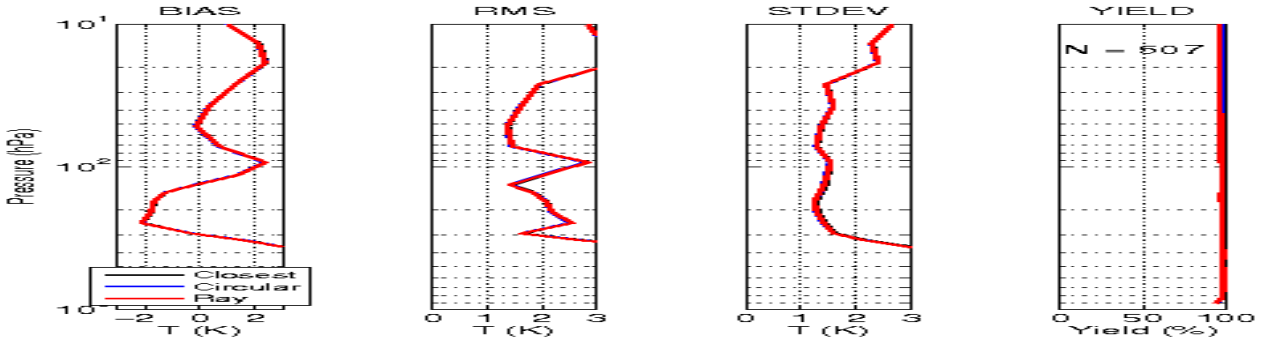
Slide courtesy of Michelle Feltz and Robert Knuteson (see AMS presentation for details).

Provisional Maturity Evaluation (25/35)
GPS comparisons: Tropical (30S-30N)

AIRS - COSMIC



CLASS
Mx 5.3
Product
Oct. 1-10



CLASS
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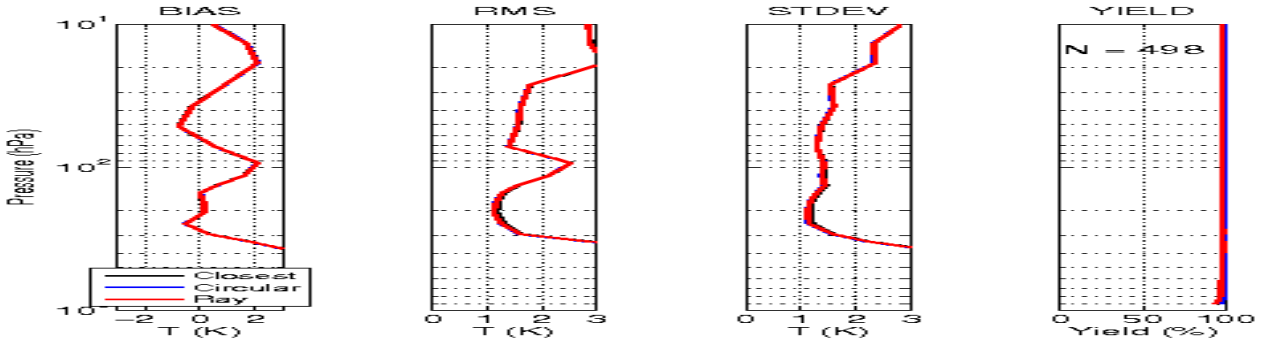
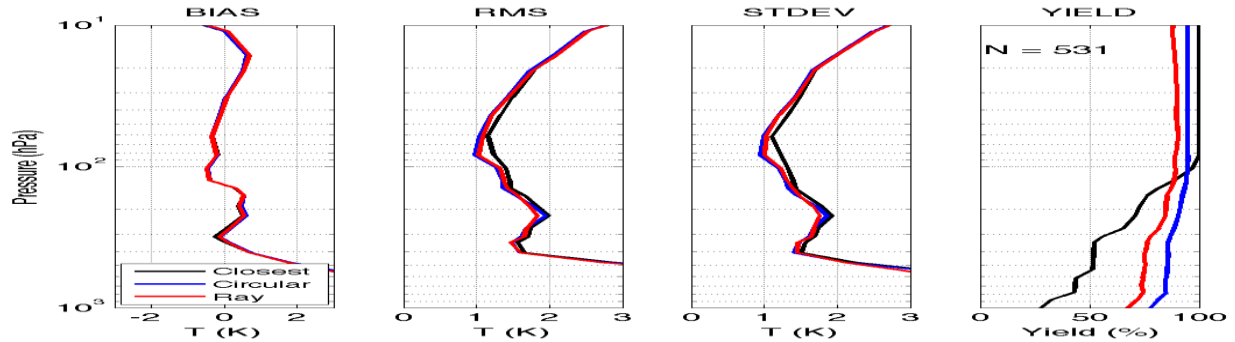
Oct. 22-31



Slide courtesy of Michelle Feltz and Robert Knuteson (see AMS presentation for details).

Provisional Maturity Evaluation (26/35)
GPS comparisons: S.H. Mid-Lat (30S-60S)

AIRS - COSMIC



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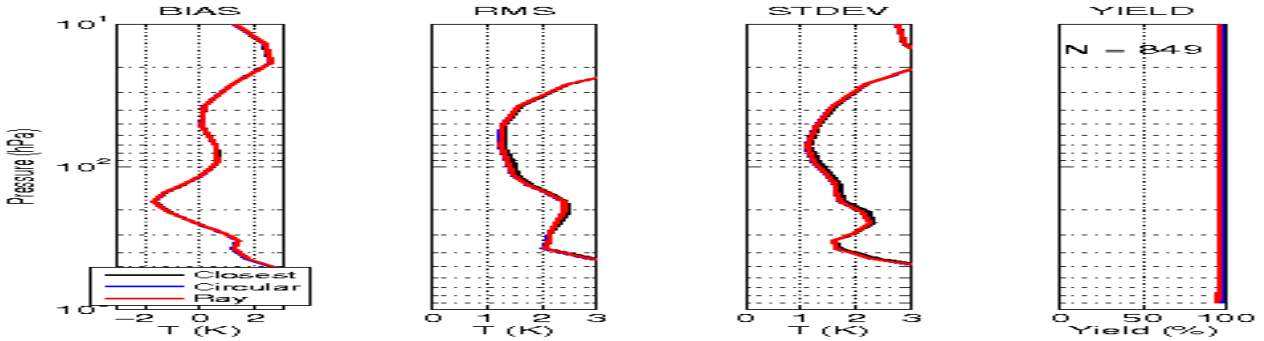

CLASS
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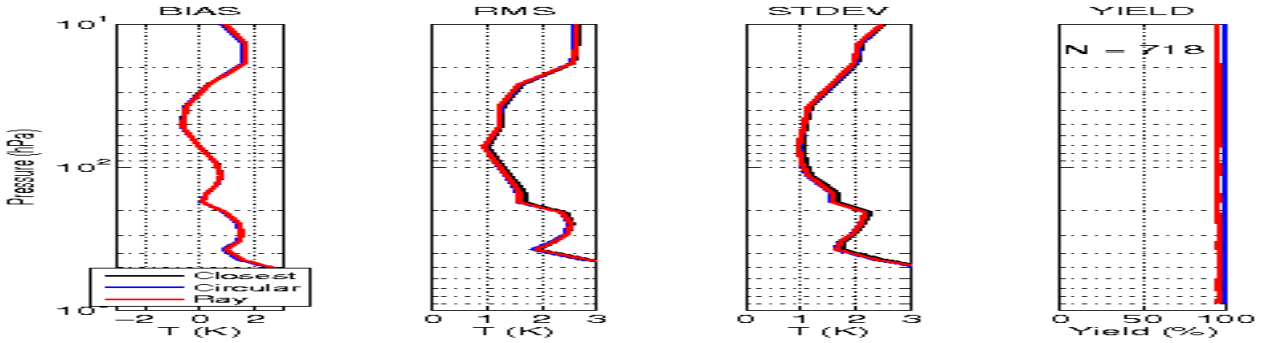
Product
Oct. 22-31



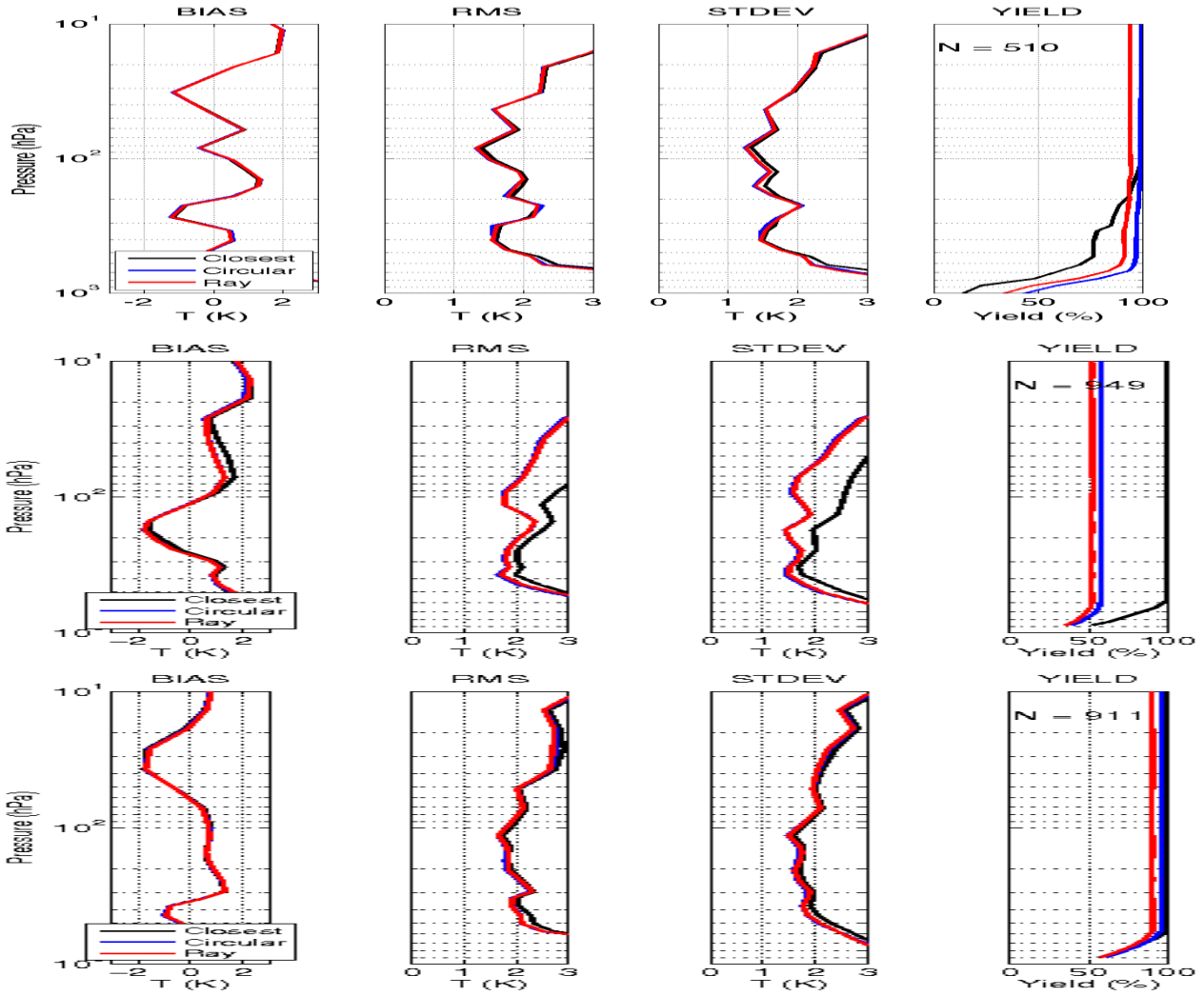
Slide courtesy of Michelle Feltz and Robert Knuteson (see AMS presentation for details).

Provisional Maturity Evaluation (27/35)
GPS comparisons: S.H. Polar (60S-90S)

AIRS - COSMIC

CLASS
Mx 5.3
Product
Oct. 1-10

CLASS
Mx 6.4
Product
Oct. 22-31



Slide courtesy of Michelle Feltz and Robert Knuteson (see AMS presentation for details).

CONCLUSIONS

• Careful comparison of the spatial geometry of the L2 matchup as a function of height is important for individual matchup comparisons but this effect is less important for large sample numbers.

• The current COSMIC network provides sufficient number of samples to allow for daily global statistical monitoring however 30 degree latitude zones require 3-5 days or more for stable statistics.

• The GPS RO has already contributed to CrIMSS (CrIS+ATMS) product validation and has been applied successful to AIRS and IASI data records.

• Using matched IR/GPS RO profiles shows promise for estimating an unbiased measurement uncertainty of a combined GPS/IR dataset with accuracies suitable for detecting temperature trends in the UTLS region.