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
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

• The Equator is much colder at 100 mb than the mid-latitudes and polar regions
• Both positive and negative trends are predicted up to 0.05 K/yr.
~ 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.
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”
Example #1: “typical COSMIC”
Example #2: “vertical COSMIC”
Example #2: “vertical COSMIC”
Example #3: “flat COSMIC”
Example #3: “flat COSMIC”
For a single day, the Raypath and Circle methods are superior to the CLOSEST profile method.
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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
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.
• 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
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.

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
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
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 (24/35)

GPS comparisons: N.H. Mid-Lat (30N-60N)

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

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

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 (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.