A New Reprocessing Scheme to Improve the Aqua AIRS Global Temperature and Water Vapor Retrievals using GPS Radio Occultation Measurements: Preliminary Results

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Motivation:

-A new proposal entitled “A New Reprocessing Scheme to Improve the Aqua AIRS Global Temperature and Water Vapor Retrievals in the Lower Troposphere and Stratosphere using GPS Radio Occultation Measurements” : a new approach for combined active + passive data

- Monitoring the long term stability of AIRS retrievals/measurements

- Improving AIRS Temperature and Moisture Retrievals in Lower Troposphere, and Upper Troposphere and Lower Stratosphere using GPS RO data

Outlines:
1. Characteristics of RO data
2. Monitoring the long term stability of AIRS retrievals/measurements
3. Improving AIRS Temperature and Moisture Retrievals in Lower Troposphere, and Upper Troposphere and Lower Stratosphere using GPS RO data
I : Characteristics of GPS RO Data

- Measure of time delay: no calibration is needed
- Requires no first guess sounding
- Not affect by clouds
- Uniform spatial/temporal coverage
- High precision (<0.05K)
- No mission dependent bias
- Insensitive to clouds and precipitation

Precision < 0.05 K
Using FM3-FM4 pairs in early mission

(Ho et al., TAO, 2009, Ho et al., JGR, 2009
Anthes et al., BAMS, 2008)

CHAMP (launched in 2001) –COSMIC (launched in 2006)

COSMIC

Within 60 Mins and 50 Km
The accuracy of the RO temperature

Using RO data to assess the quality of radiosonde data

<table>
<thead>
<tr>
<th>Region</th>
<th>Sonde Type</th>
<th>Matched Sample</th>
</tr>
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<tbody>
<tr>
<td>Russia</td>
<td>AVK-MRZ</td>
<td>2000 (20%)</td>
</tr>
<tr>
<td>China</td>
<td>Shang</td>
<td>650 (6.1%)</td>
</tr>
<tr>
<td>USA</td>
<td>VIZ-B2</td>
<td>600 (5.9%)</td>
</tr>
<tr>
<td>Others</td>
<td>Vaisala</td>
<td>3140 (30%)</td>
</tr>
</tbody>
</table>

Shu-peng Ben Ho, UCAR/COSMIC   http://www.cosmic.ucar.edu/~spho/
Using RO data to Identify Diurnal variation of Radiosonde Temperature Anomalies

Solar absorptivity = 0.15
IR emissivity = 0.85
USA VIZ-B2 150 hPa

Mean Bias = 0.217
Abs(Mean) Bias = 0.511
MeanSD = 1.441

Solar absorptivity = 0.15
IR emissivity = 0.02
Vaisala 150 hPa

Mean Bias = -0.053
Abs(Mean) Bias = 0.097
MeanSD = 1.563
2. a Using RO data to monitoring quality of AIRS Measurements

![AIRS Temperature Weighting Functions](image1)

![AIRS Tbs](image2)

![AIRS Noises](image3)
2. a Using RO data to monitoring quality of AIRS Measurements

**Distance difference = 100km, Time Difference = 30 minutes**
2.a Using RO data to monitoring quality of AIRS Measurements

Brightness Temperature Bias (AIRS-COSMIC), Wave Number = 654.42 cm⁻¹
2.a Using RO data to monitoring quality of AIRS Measurements
50 mb [ECMWF–RO] Temperature Difference (90S–60S)

- Annual Cycle Fit
- Fit Mean
- Data 30 Day Running Mean

CLEAR Conditions

OCEAN Surface

CLOUDY Conditions

LAND Surface
2. b Using RO data to validate AIRS data and retrievals
DFS is a function of atmospheric and surface conditions.
So AIRS temperature retrievals depend on the a priori profile and atmospheric/surface conditions, and also the retrieval methods.

\[ T_{AIRS}^{Ret} = A_{AIRS} T_{True} + (I - A_{AIRS})T_{AIRS}^{Apr} \]
2.b Approach: Smooth RO temperature to eliminate effects of AIRS priori profiles and vertical resolution mismatch defined by averaging kernels -- examine the AIRS temperature
2.b
Results: eliminate effects of AIRS priori profiles and vertical resolution mismatch defined by averaging kernels (Eric Maddy’ method)

\[ T_{\text{AIRS}}^{\text{New}} = A_{\text{AIRS}}^{\text{Effective}} T_{\text{COSMIC}} + (I - A_{\text{AIRS}}^{\text{Effective}}) T_{\text{AIRS}}^{\text{Apr}} \]

\[ A_{\text{AIRS}}^{\text{Effective}} = F A_{\text{AIRS}} F^* \]

\[ \Delta T_{\text{AIRS}} = T_{\text{AIRS}} - T_{\text{AIRS}}^{\text{New}} \]
We can use the defined slope and offset to calibrate AIRS temperatures.

Corr ~ 1.0

150 mb AIRS vs. smoothed COSMIC Temperature (K)

Q-level=0
All Latitudes
Cloudy and Clear
Land and Ocean

Mean Bias= -0.21379
Slope= 1.02600

Mean Bias vs. Latitude
60N-90N 0.1095
30N-60N 0.0328
30N-30S -0.4189
30S-60S -0.1171
60S-90S -0.2344
2.b

Biases are dependent on geo-location and and season?

July, August and September, 2006, 30N-30S

AIRS-Smoothed COSMIC Temperature (K)
2.b Biases drift with years?

60S - 90 S

Q-level = 0
Latitudes 60S-90S
Cloudy and Clear
Land and Ocean

DEC Means
Bias = -0.03245 +/- 0.01197
Trend = -0.11110 +/- 0.00654

JUNE Means
Bias = 0.24247 +/- 0.01044
Trend = -0.08374 +/- 0.00556
3a: Improving AIRS Temperature and Moisture Retrievals in Lower Troposphere, and Upper Troposphere and Lower Stratosphere using GPS RO data

From surface to 300 hPa
3a: Improving AIRS Temperature and Moisture Retrievals in Lower Troposphere, and Upper Troposphere and Lower Stratosphere using GPS RO data

From 250 hPa to above
3b: A Fusion Approach to Simultaneously Retrieving Global Temperature and Water Vapor Profiles and Hydrological Data Products using MiRS from the Combined COSMIC and SNPP/ATMS

MiRS: Microwave Integrated Retrieval System
3b: A Fusion Approach to Simultaneously Retrieving Global Temperature and Water Vapor Profiles and Hydrological Data Products using MiRS from the Combined COSMIC and SNPP/ATMS

![Graphs showing clear and cloudy water vapor bias for sea and land]
Conclusions and Future Work

- In UCAR CDAAC a consistent inversion Algorithm is used to process SAC-C, GRACE, CHAMP, COSMIC, and GRAS
- Uniformly distribution RO profiles + coincident measurements from polar orbiting Satellites
- Improved inversion from coincident Active + passive measurements
- COSMIC II will be launched on 2016
- 12,000 uniformly distributed RO profiles per day

Ho et al., (BAMS 2013)