Inter-comparison and Assessment of AIRS Version-5 and Version-6 Temperature, Water Vapor, Surface Emissivity, and Cloud Products

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NASA GSFC Sounder Research Team (SRT)

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Comparisons of V6.07, V6.07 AO, and V5.0

Two types of evaluation

- 9 focus days, September 6, 2002 through September 14, 2012, validated against ECMWF truth
  Evaluated $T_s^*$, surface spectral emissivity $\varepsilon_v^*$, $T(p)^{**}$, $q(p)^{**}$
  Mean* and trends** of yields, RMS differences, and biases

- 12 monthly means for 4 different months in 3 different years
  Evaluated biases as well as trends of V6.07 $T_{500}$, $q_{500}$, $W_{TOT}$, $\alpha \varepsilon$, OLR and OLR$_{CLR}$ compared to V.5
Surface Skin Temperature Difference
9-Day Average  Daytime and Nighttime combined
50 N to 50 S  Non-Frozen Ocean

Temperature Difference

<table>
<thead>
<tr>
<th>Version</th>
<th>QC</th>
<th>Mean</th>
<th>STD</th>
<th>% Cases</th>
<th>Percent greater than</th>
<th>3 from mean</th>
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</thead>
<tbody>
<tr>
<td>Version-6.07</td>
<td>0.1</td>
<td>-0.32</td>
<td>0.95</td>
<td>53.39</td>
<td>1.40</td>
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<tr>
<td>Version-6.07</td>
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<td>0.84</td>
<td>41.59</td>
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<td>Version-6.07</td>
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<td>Version-6.07</td>
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<tr>
<td>Version-5</td>
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<tr>
<td>Version-5</td>
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<td>-0.49</td>
<td>0.56</td>
<td>10.20</td>
<td>0.50</td>
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</tr>
</tbody>
</table>

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Percent Accepted QC=0,1 SST vs. Cloud Fraction
50° North to 50° South  9-Day Average

AIRS RMS SST Temperature Difference from ECMWF
Vs. Effective Cloud Fraction  9-Day Average

Version-6 accepts many more cases than Version-5, especially at moderate to high cloud fraction
RMS errors of both Version-5 and Version-6 SST grow slowly with increasing cloud fraction
9-Day Surface Skin Temperature (K) Non-Frozen Ocean Retrieved minus ECMWF AM/PM Average

Version-6.07

Version-5

Version-6 Level-3 SST product has much better accuracy and spatial coverage than Version-5
Ocean Surface Emissivity vs. Zenith Angle

Mean 950 cm$^{-1}$ Emissivity minus Masudo
50 North to 50 South Ocean
9-Day

Mean 2400 cm$^{-1}$ Emissivity minus Masudo
50 North to 50 South Ocean
9-Day

STD 950 cm$^{-1}$ Emissivity
50 North to 50 South Ocean
9-Day

STD 2400 cm$^{-1}$ Emissivity
50 North to 50 South Ocean
9-Day

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Day/night differences of land surface emissivity are much smaller in Version-6 compared to Version-5
Version-6 T(p) retrievals with Data Assimilation QC have RMS errors ≤1K throughout troposphere
Version-6 T(p) retrievals with Climate QC have much greater yield than Version-5 with small biases
Differences between V6.07 and V6.07 AO are small
Version-6 errors are smaller than Version-5, and Version-6 yields are higher than Version-5, especially at larger cloud fractions.
Global Temperature 9-Day Two Common Ensembles

Percent of All Cases
Accepted

Layer Mean RMS (°K)
Differences from ECMWF
9-Day Mean Statistics Tropospheric Temperature Metric (TTM) and Boundary Layer Metric (BLM)

### Cases in Common Using the Version-5 Tight Ensemble

<table>
<thead>
<tr>
<th></th>
<th>Global TTM</th>
<th>Land ±50° TTM</th>
<th>Ocean ±50° TTM</th>
<th>Poleward of 50°N TTM</th>
<th>Poleward of 50°S TTM</th>
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</thead>
<tbody>
<tr>
<td>Version-5</td>
<td>1.14</td>
<td>1.22</td>
<td>1.06</td>
<td>1.18</td>
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<tr>
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<td>0.94</td>
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<td></td>
<td>1.35</td>
<td>1.49</td>
<td>1.00</td>
<td>1.54</td>
<td>1.95</td>
</tr>
</tbody>
</table>

### Cases in Common Using the Version-6.07 Climate Ensemble

<table>
<thead>
<tr>
<th></th>
<th>Global TTM</th>
<th>Land ±50° TTM</th>
<th>Ocean ±50° TTM</th>
<th>Poleward of 50°N TTM</th>
<th>Poleward of 50°S TTM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Version-5</td>
<td>1.56</td>
<td>1.75</td>
<td>1.43</td>
<td>1.51</td>
<td>1.70</td>
</tr>
<tr>
<td></td>
<td>2.84</td>
<td>2.92</td>
<td>2.70</td>
<td>2.95</td>
<td>2.96</td>
</tr>
<tr>
<td>Version-6.07</td>
<td>1.11</td>
<td>1.05</td>
<td>1.02</td>
<td>1.11</td>
<td>1.33</td>
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<tr>
<td></td>
<td>1.69</td>
<td>1.72</td>
<td>1.35</td>
<td>1.92</td>
<td>2.09</td>
</tr>
</tbody>
</table>

TTM is the average T(p) RMS difference from ECMWF over all 1 km layers from surface to 100 mb
BLM is the average T(p) RMS difference from ECMWF over the lowest 6 0.25 km layers
All Version-6 metrics are much better than Version-5, especially for the difficult climate ensemble.
Global Temperature Trends 9-Day

Percent of All Cases Accepted

Layer Mean BIAS (°K) Differences from ECMWF

Version-5 had significant negative yield and tropospheric T(p) bias trends. These are significantly improved on in Version-6 and Version-6 AO.
Global Water Vapor 9-Day Statistics use their own QC

1 Km Layer Mean Precipitable Water

Percent Yield

RMS % Differences from ECMWF

BIAS % Differences from ECMWF

Version-6 has higher yield than Version-5 and performs better in the lower troposphere

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9-Day Surface Total Precipitable Water (cm)  
Retrieved minus ECMWF  AM/PM Average 
Version-6.07  Version-5

Version-6 Level-3 total precipitable water is more accurate than Version-5
Global Water Vapor Trends (%/yr) 9-Day Statistics use their own Climate QC

1 Km Layer Mean

Percent Yield

Precipitable Water Bias vs. ECMWF

Negative yield and tropospheric water vapor trends are improved in Version-6 compared to Version-5

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Assessment of Differences in Version-6.07 and Version-5 Trends

Version-5 Level-3 products are known to have some spurious trends. We have compared global mean Level-3 Version-5 and Version-6.07 products to see how much Level-3 trends might improve in Version-6.

The following plots show monthly mean global mean time series of select Version-5 products and Version-6.07 products for the 12 months January, April, July, and October 2003, 2007, and 2011 which have been run.

We also show the “trendline” of Version-5 and Version-6.07 products defined as the linear least squares fit of the time series passing through the 12 months sampled by Version-6.

What is most important is the difference between Version-6 and Version-5 trendline slopes.

These results are shown for:
- $T_{500}$, $q_{500}$, $W_{TOT}$, $αε$, OLR, and OLR$_{CLR}$
Global Time Series January 2003 through October 2011

- 500 mb Temperature (K/yr)
- 500 mb Water Vapor Mixing Ratio (g/kg)
- Total Precipitable Water

Effective Cloud Fraction (%)

- AIRS V5 January 2003 through October 2011
- AIRS V6.07 12 Months
- AIRS V5 12 Months
- V5 trendline
- V6.07 trendline
- V5-V6.07 trendline

AIRS V5 minus AIRS V6.07

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### Trendline slopes of Global Mean Time Series
January 2003 through October 2011

<table>
<thead>
<tr>
<th></th>
<th>OLR W/m²/yr</th>
<th>Clear Sky OLR W/m²/yr</th>
<th>Cloud Fraction %/yr</th>
<th>500 mb Temp K/yr</th>
<th>Wₜₒₜ mm/yr</th>
<th>q₅₀₀ g/kg/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIRS V5</td>
<td>-0.104</td>
<td>-0.040</td>
<td>0.260</td>
<td>-0.058</td>
<td>-0.039</td>
<td>-0.00325</td>
</tr>
<tr>
<td>V6.07</td>
<td>-0.038</td>
<td>-0.054</td>
<td>0.049</td>
<td>-0.006</td>
<td>0.012</td>
<td>0.00001</td>
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<tr>
<td>AIRS V5 minus AIRS V6.07</td>
<td>-0.066</td>
<td>0.014</td>
<td>0.211</td>
<td>-0.052</td>
<td>-0.050</td>
<td>-0.00326</td>
</tr>
</tbody>
</table>

V6.07 trendline slopes are closer to zero than those of V5
Comparison Summary

Version-6 is significantly improved with regard to Version-5 in every way with regard to $T_s$, $\varepsilon_v$, $T(p)$, $q(p)$, $\alpha\varepsilon$

$\text{OLR, OLR}_{\text{CLR}}$ both agree better with CERES (not shown today)

Version-6 AO is roughly comparable to Version-5

Version-6 gets my blessing for release

Congratulations to the entire AIRS Science Team and supporting cast!