SRT Status and Plans for Version-7

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NASA GSFC Sounder Research Team (SRT)

AIRS Sounder Science Team Meeting
Pasadena, CA

May 22, 2013
Outline

• Status of Version-6 at GSFC
  GSFC Version-6 must match JPL Version-6 before we can improve it
• Short-range plans – evolutionary improvements
• Mid-range plans – new thrusts
  Higher spatial resolution retrievals
  Cloud spectral emissivity
• Long-range plans – more challenging ideas
Accomplishments since November 2012 Meeting

• Delivered to Ed Olsen documentation for release of Version-6
• Delivered draft ATBD to JPL
• Version-6 development at JPL outpaced GSFC system – we are catching up
  – Neural Network first guess (Blackwell) installed
    Neural-Net guess at SRT matches results at JPL
  – ECMWF based climatology (Manning) installed
  – MODIS climatological emissivity (Hulley, Manning) installed
  – Various limit checks (Manning) installed
• Some known code differences remain
  Some previously unknown differences were found and corrected
  More small differences probably still exist
Known Differences between GSFC and JPL V-6

- V-6 microwave RTA and microwave tuning*
- Use of dynamic noise in MW retrieval*
- Use of AMSU land fraction instead of AIRS to determine surface classification*
- Doppler shift in frequency adjustment
- Use of MODIS emissivity in polar regions

* Does not affect AIRS Only (AO) retrievals

One might expect differences in JPL and GSFC AO results to be smaller than AIRS/AMSU differences
Testing of GSFC Version-6

Approach

Use same error estimate coefficients and QC thresholds we derived for JPL Version-6

Compare JPL Version-6 and GSFC Version-6 yields and errors
  The ability to match yields is a tight test of GSFC Version-6

Compare spatial plots of JPL Version-6 and GSFC Version-6
  Indicates spatial areas where results may differ

Comparisons done in both AIRS/AMSU and AIRS Only modes
  Shows importance of MW RTA and MW tuning differences

These types of tests led John and Lena to identify and correct many small differences at JPL and SRT that led to differences in results

The goal is to make JPL Version-6 and GSFC Version-6 essentially identical

If the unchanged result at SRT is actually better, this change goes into Version-7 – we don’t want to change Version-6
Surface Skin Temperature Difference from ECMWF September 6, 2002  Version-6 Daytime and Nighttime Combined 50°N to 50°S  Non-Frozen Ocean

<table>
<thead>
<tr>
<th>AIRS/AMSU</th>
<th>Mean</th>
<th>STD</th>
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<tbody>
<tr>
<td>JPL Climate</td>
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<th>AIRS Only</th>
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<tr>
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<tr>
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<tr>
<td>GSFC DA</td>
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<table>
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<th></th>
<th>%</th>
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<td>GSFC DA</td>
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<td>GSFC DA</td>
<td>38.89</td>
<td>0.70</td>
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</tbody>
</table>

AIRS/AMSU agreement is very good. AIRS Only agreement is even better.

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Agreement of QC’d $T_{\text{skin}}$ is excellent. Differences in AO are even smaller than in AIRS/AMSU.

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Agreement is very good - biggest differences near poles. AIRS Only agreement is better.

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Global Temperature September 6, 2002 Statistics use their own QC

Percent of All Cases Accepted

Layer Mean RMS (°K) Differences from ECMWF

Layer Mean BIAS (°K) Differences from ECMWF

JPL V6 AIRS Only DA (QC=0; PBest)
JPL V6 AIRS Only Climate (QC=0,1; PGood)
GSFC V6 AIRS Only DA (QC=0; PBest)
GSFC V6 AIRS Only Climate (QC=0,1; PGood)

AIRS Only T(p) statistics are in perfect agreement.

Joel Susskind, John Blaisdell, Lena Iredell
Global Temperature  September 6, 2002  Statistics use their own QC

Percent of All Cases Accepted

Layer Mean RMS (°K)
Differences from ECMWF

Layer Mean BIAS (°K)
Differences from ECMWF

AIRS/AMSU T(p) statistics are in close agreement. Differences are the result of different MW RTA and tuning.

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Total precipitable water agreement is very good. Differences are smaller in AIRS Only mode.

Joel Susskind, John Blaisdell, Lena Iredell
Agreement is total CO is very good. AO agreement is even better.
Short Range SRT Plans for Version-7

• Differences between GSFC and JPL are very small
  Congratulations to John and Lena!
• Resolve remaining discrepancies between GSFC and JPL Version-6
  John expects to complete this by the end of June
  This is critical for optimal development and testing of further improvements
Re-optimize details of retrieval steps
  Most optimization was done using 2 regression start up state
  q(p) retrieval has not been modified since Version-4
  Current q(p) retrieval degrades Neural-Net guess
  We will revisit channels, functions, and damping parameter
  We will consider a second pass q(p) retrieval step
  Not found useful in Version-5 and never tested in Version-6

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Layer Mean Differences from ECMWF 9-Day Global Average

Physical retrieval improves $T(p)$ Neural-Net guess. Physical retrieval degrades $q(p)$ Neural-Net guess.
More Short Range SRT Plans for Version-7

We will evaluate the use of the difference in brightness temperature between 2 channels on and off weak CO$_2$ and H$_2$O lines as single pieces of information

- This decreases the contribution of uncertainties in cloud-clearing as well in the contribution of surface leaving radiance to the channel noise covariance matrix – may enhance sensitivity in boundary layer

• Improve temperature profile retrieval by using tropospheric 15 μm CO$_2$ channels that do not see clouds.

  Theory says that 15 μm CO$_2$ channels that see clouds should not be used in T(p) retrieval. Version-6 assures this by using only stratospheric sounding CO$_2$ channels in T(p) retrieval

  Many tropospheric 15 μm do not see clouds depending on the scene and can (should) be used in T(p) retrieval for that case

• Further stabilize cloud parameter retrievals
Mid Range Plans for Version-7- Higher Resolution (HR) Retrievals

- Implement 1 (cross track) x 3 (along track) FOV retrieval system
  This triples the spatial resolution and density of the AIRS soundings
Cloud clearing allows for up to two cloud formations in FOR

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<tr>
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<th>Nadir FOR</th>
<th>Largest Zenith Angle FOR</th>
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<tbody>
<tr>
<td>Version-6</td>
<td>40.6 km x 40.6 km</td>
<td>115.0 km x 63.3 km</td>
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<tr>
<td>HR</td>
<td>13.5 km x 40.6 km</td>
<td>38.3 km x 65.3 km</td>
</tr>
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Cloud clearing should improve, especially over land, because spatial variability of $T_{\text{skin}}$, $\varepsilon_{\nu}$, $q(p)$ is less in FOR

Retrievals should also improve, especially over land, because quantities to be retrieved vary less in FOR

  Boundary layer temperature and boundary layer water vapor should improve as well

SRT will investigate generation of 0.5 degree x 0.5 degree level-3 products using HR system
Mid Range SRT Plans for Version-7 Cloud Spectral Longwave Cloud Spectral Emissivity

Version-6 uses 57 channels to retrieve cloud parameters for each of two cloud layers \( k=1,2 \) for each AIRS Field of View (FOV)

\[
\alpha \varepsilon_1, p_c_1, \alpha \varepsilon_2, p_c_2
\]

where \( \alpha \varepsilon_k \) is the product of a spectrally independent cloud emissivity and the geometric fractional cloud cover for a cloud at pressure \( p_c_k \) as seen from above.

We plan to determine a cloud spectral emissivity ratio \( \alpha \varepsilon_y / \alpha \varepsilon^\circ \) for the upper level cloud in a form analogous to longwave surface spectral emissivity – surface retrieval uses 77 channels.

This can be done either

- Sequentially after current cloud retrieval step, using the current 77 surface longwave emissivity channels or
- Concurrently with cloud retrieval using 57 channels + 77 channels (134) channels

Cloud spectral emissivity will be used in spectral OLR calculation.
Longer Term Plans

1) Including CO$_2$ retrieval as part of retrieval process
   CO$_2$ retrieval is currently a post processing step
   Does not interact with anything else
   We plan to work with Ed Olsen to examine feasibility of:
   • doing CO$_2$ retrieval after pass 1 and using retrieved CO$_2$ in recomputation of T(p), OLR, everything else
   • This is a big if: attempting coupled CO$_2$, T(p) retrieval
     Mous said this cannot be done – I am not so sure

2) Incorporating dust retrieval as part of retrieval process
   • Including dust score as part of error estimate procedure
     Could help flag poor dusty retrievals
   • Including dust into the RTA used in second pass
     Could potentially improve retrievals in dusty cases