AIRS V6 CO2 Interim Product Testing and Plans for Future Development

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• Released V5 CO2 Product
  – 2002 – 2010 ingest AIRS/AMSU Level 2 product
  – 2011 – present ingest AIRS-Only Level 2 product
• Interim Product Testing (V6 L2 product ingest)
  – Comparison of V6R107, V6R108 and V6 for 1 January 2007
    • SARTA V107 – uses fixed “at launch” coefficients
    • SARTA V108 – uses fixed coefficients derived after 28 Oct 2003 CME forced Aqua shutdown and the subsequent AIRS recovery cool down
    • V6 – uses interpolated coefficients incorporating scan-dependent Doppler shifts and orbit-dependent module shifts
  – Profile Analysis Tool for Optimal Channel Selection
    • Ingests models and AIRS L2 products
    • Computes 100-layer profiles of Jacobians, Contribution Functions and Weighting Functions for all AIRS channels using any of the 3 RTAs
  – V6R108 Product Testing
    • Zonal comparison of V6R108 and V5 product to collocated airborne in situ measurements
• Plans for Future Development
• Summary
Current Released AIRS CO2 Products
(V5 AIRS-Only vs V5 AIRS/AMSU)

Shift from AIRS/AMSU to AIRS-Only
V5 CO2 based on AIRS/AMSU radiances
Sept 2002 through Dec 2010
V5 CO2 based on AIRS-Only radiances
Jan 2011 through current date
(By mid-year 2011 the progressive degradation of AMSU channel 5 reached the point that CO2 product yield was noticeably impacted)

Left Column:
Retrieved CO2 difference (AIRS_Only – AIRS_AMSU)
in 1°x1° grid smoothed to 5°x5°
• Differences are small except at the highest northern latitudes

Right Column:
CO2 retrieval yield difference (AIRS_Only – AIRS_AMSU)
In 1°x1° grid smoothed to 5°x5°
• Increased yield for AIRS_Only in areas dominated by low stratus (off West coasts of North & South America and Africa) indicates that additional cloud filtering is advisable for the CO2 retrieval algorithm when operating in AIRS_Only mode
Compared to V5 (AIRS-Only) Operational Product, V6R108 mid-trop product exhibits:
- Reduced variation with latitude
- Smaller diurnal contrast
- Smaller contrast between land and ocean
V6R108/V5 CO2 Yield Zonal Variation
2013 Monthly Average Diurnal Yield
Combined Land and Ocean

RATIO of V6R108 Yield to V5 Yield

- V6R108 combined land/ocean yield is greater than that of V5 AIRS-Only, except in the tropics
  - High altitude (~300 hPa) thick clouds predominate in the tropics
  - V5 AIRS-Only has excessive yield compared to V5 AIRS/AMSU in areas where
    low stratus predominates (low mid-lats, west of North and South America, and Africa)
- Daytime V6R108 yield enhancement over V5 generally greater than at nighttime
The 5 HIPPO campaigns flew roughly equivalent latitude ranges over the mid-Pacific, but at different seasons

- AIRS AK profiles hardly change location in column or magnitude with season north of 60S
- The shape of the AIRS AK profiles and location of peak sensitivity in column do change with latitude
On the other hand, the pressure at which the tropopause occurs changes with both latitude and season

- AIRS AK peak sensitivity is well separated from the tropopause in the tropics
- At high latitudes, the separation is much less and is a strong function of season
Validating collocated AIRS retrieved CO2 with HIPPO measured CO2 profiles is thus complicated because:

- AIRS AK tails extend well above the highest altitude of HIPPO in situ measurements
- Tropopause shifts closer to pressure of AK maximum at higher latitudes
  - More so in the SH winter time at the mid-latitudes
- Tropopause pressure is very close to that of AK peak for |lat| > 45°

Thus measured profile must be augmented with model data above highest altitude attained for accurate comparison.
Example

- Interpolate HIPPO measurements over range of aircraft altitude to AIRS support pressure levels
- Fill profile above highest altitude point
- Fill profile below lowest altitude point
- Convolve profile with AIRS sensitivity function to arrive at a value to compare to collocated AIRS retrieved value
- Extension of HIPPO “Deep Dip” profile at high altitude results in a calculation overestimate for HIPPO comparison of ≤ 3 ppm depending upon season and latitude
- Developing realistic profile fill including stratospheric fall-off using model forecast (MACC-II)

https://www.gmes-atmosphere.eu/news/co2_forecasts
V6R108 AIRS and V5 AIRS vs HIPPO

V5 AIRS/AMSU - HIPPO-I
9 Jan - 22 Jan, 2009
Collocation: ±24hr; ΔR ≤ 500km

V5 AIRS/AMSU - HIPPO-2
30 Oct - 22 Nov, 2009
Collocation: ±24hr; ΔR ≤ 500km

V5 AIRS/AMSU - HIPPO-3
23 Mar - 16 Apr, 2010
Collocation: ±24hr; ΔR ≤ 500km

V5 AIRS/AMSU - HIPPO-I
V5 AIRS/AMSU - HIPPO-I
V6013L2 VS AIRS/AMSU - HIPPO-I

V5 AIRS/AMSU - HIPPO-2
V5 AIRS-Only - HIPPO-2
V6013L2 VS AIRS/AMSU - HIPPO-2

V5 AIRS/AMSU - HIPPO-3
V5 AIRS-Only - HIPPO-3
V6013L2 VS AIRS/AMSU - HIPPO-3

V5 AIRS/AMSU - HIPPO-4
V5 AIRS-Only - HIPPO-4
V6013L2 VS AIRS/AMSU - HIPPO-4

V5 AIRS/AMSU - HIPPO-5
V5 AIRS-Only - HIPPO-5
V6013L2 VS AIRS/AMSU - HIPPO-5

V6013L2 VS AIRS/AMSU - HIPPO-I
V5 AIRS/AMSU - HIPPO-I
V6013L2 VS AIRS/AMSU - HIPPO-2
V5 AIRS/AMSU - HIPPO-2
V6013L2 VS AIRS/AMSU - HIPPO-3
V5 AIRS/AMSU - HIPPO-3
V6013L2 VS AIRS/AMSU - HIPPO-4
V5 AIRS/AMSU - HIPPO-4
V6013L2 VS AIRS/AMSU - HIPPO-5
V5 AIRS/AMSU - HIPPO-5

ACO2 (ppm)

LATITUDE (deg)

LATITUDE (deg)
Plans for Future Development

• Operationalize V6 mid-trop PGE and Release
  – Top priority is to reduce execution time using SARTA V6
    • V6 execution time
      – ~ 5 minutes/granule using SARTA V107 and SARTA V108 (same as V5 execution time)
      – ~2.5 hours/granule using SARTA V6
        » Due to reinterpolation of all coefficients for 2378 channels for each call to SARTA
    – Test V6 SARTA operation against V108 SARTA operation
      • Seasonal analysis over globe (Jan/Apr/Jul/Aug)
      • Validate against collocated HIPPO measurements
  – Document and release to operational team

• Optimal channel selection for sensitivity lower in troposphere
  – Select channel sets based on Jacobians (for T,q,O3, CO2)
  – Test and refine selection to quantify/minimize impact of surface temperature bias

• Test retrievals lower in the troposphere
  – Validate against collocated HIPPO/CARIBIC measurements
    • Extend in situ profiles with MACC-II model data
  – Quantify impact of biased CO2 prior
  – Adjust channel sets and QA as found necessary
V6 vs V6R107 and V6R108 CO2
1 January 2007

- V6R107 RTA coefficients are fixed “at launch” set, valid before the 29 Oct 2003 Coronal Mass Ejection forced Aqua shutdown
- V6R108 RTA coefficients are the fixed post-CME set, valid after instrument temperature stabilized
- V6R108 is more consistent with the full V6 results, but does not include Doppler and orbital variations of coefficients
Profile Analysis Tool

Input:
- Standard models
- AIRS L2 profiles

Output for all AIRS channels:
- Weighting Functions
- Contribution Functions
- Jacobians
- Fractions of TOA radiances
  - From surface
  - From troposphere
  - From stratosphere
Summary-1

• V5 AIRS-Only CO2 product is current public release
  – Retrieved CO2 differences from V5 AIRS/AMSU small except at the highest northern latitudes
  – Yields differences small except in areas where extensive low stratus cloud cover is present

• V6 code
  – Code designed for rapid conversion to PGE
    • Execution options set via environmental variables
      – Channel lists, priors, SARTA version, QA filtering rules and thresholds
  – Capable of ingesting V5 and V6 AIRS L2 products
  – Capable of using three RTA versions (V107, V108 or V6)
  – Supports multiple channel sets for separate partial column retrievals
  – Plan to operationalize V6.0 Retrieval when V6 RTA speedup task and final tests are completed
    • Seasonal analysis of global yield and retrieval (Jan/Apr/Jul/Oct)
    • Validation against HIPPO
    • Document and release
• **V6 retrieval testing**
  – V6 execution in V5 mode (ingest V5 L2 and RTA V107) yields identical result as the V5 Operational PGE
    • End-to-end validation of V6 interim processing code
  – **V6 execution time**
    • ~ 5 minutes/granule if using SARTA V107 and SARTA V108 (same as V5 execution time)
    • ~2.5 hours/granule if using SARTA V6
      – Due to necessary reinterpolation of large coefficient arrays for all 2378 channels for each call to SARTA
        » Currently testing methods to bring execution time down to that for SARTA V108
  – V6 externalized near surface partial layer temperature profile tweak due to intrusion of topography
    • Yields result identical to that leaving it active in RTA for current channel set
    • Required for iterative solution using channels sensitive lower in the atmospheric column
  – V6 retrievals using same channel set and RTA V108 are consistent with V5 for |lat| < 50°
    • V6 does not require V5 radiance bias correction
  – **V6 Yield**
    • Enhanced over V5 everywhere and for all seasons except in tropics
      – Possibly due to V5 AIRS-Only yield being artificially high in areas where low stratus predominates
    • Daytime yield enhancement usually larger than that at nighttime everywhere and for all seasons
    • Land scene yield enhancement generally larger than ocean scene enhancement, everywhere and for all seasons
  – **V6 Retrieved CO2 diurnal variation**
    • Over ocean is smaller than V5; constant to within 0.5 ppm over latitude range |lat| < 60°
    • Over land shows more variation than V5 with latitude, changing with season
      – Greatest amplitudes are in the mid-lat of the summer hemisphere
        » Convection, or RTA108 (i.e., w/o Doppler and variable module offsets in RTA V6) effect?
    • Nighttime land/ contrast lower than V5
    • Daytime land/ocean contrast higher than V5 and shows variation with latitude
Summary-3

• V6 retrieval testing (continued)
  – Validating against in situ measured profiles
    • HIPPO Profiles
      – Initial validation completed
      – Future extension of profiles with MACC-II model forecast
    • CARABIC Profiles
      – Data in hand
      – Create readers to allow use with current analysis codes
  • Plan is to have a standard set of in situ measurements for test and validation of incremental changes to V6 CO2 retrieval
    – Quantify impact of biased CO2 prior