AIRS V6 CO2 Retrieval Development

Edward Olsen, Luke Chen, Steve Licata

AIRS Science Team Meeting, April 24-27, 2012
Activities – AIRS V6 CO2 Development

• V6 PGE-compatible multi-layer CO2 Retrieval Code
  Objective is to have a single post-processing CO2 retrieval PGE stripped of development and test code fragments capable of processing either V5 or V6 data to retrieve CO2 at one or more levels of the atmosphere independently.

• Channel selection
  Objective is to optimize channel subsets by analyzing their contribution functions over the globe using AIRS L2 retrievals for Jan/Apr/Jul/Oct of 2003/2007/2011 to better constrain the partial columns of the atmosphere which they represent.

• V6 Testing
  Initial test using V5 implementation
  Currently implementing V6 RTA to support full V6 testing using V6.0.2 L2 data sets
AIRS V6 CO2 PGE Development

- V6 CO2 retrieval post-processing PGE reorganized for maintainability
  - Combines four separate research codes into one PGE
  - Legacy research code fragments and stubs removed
  - Code modularized and heavily commented
  - Implements both mid-trop and mid-strat capability
    - Common code modules
    - Switch between mid-trop and mid-strat by environmental variable controlling:
      - Channel lists
      - QA filtering rules
      - Priors
    - Validated that execution mode results in the same output as earlier runs of the four separate research codes
  - Allows easy addition of lower-trop capability
  - Supports choice of V5 or V6 RTA
    - Allows processing of V5 data as well as V6 data
    - Implements V6 Doppler/orbital/seasonal spectral shifts (new)
    - We learned a lot about V6 RTA while developing the Weighting Function and Contribution Function Tools
Expected V6 Spectral Shift Range and Offset of V5 from V6 Nominal Shift for VPD Mid-Trop Tair and CO2 Channels

Note:
Maximum spectral shift on the focal plane is expected to be ± 1 µm after adding up contributions of Doppler, orbital, seasonal and long-term contributions (1 µm ≈ 8.4 ppmf)
WgtFnc/CntFnc Tool Flow Diagram
For Channel Selection Analysis

Definitions:
TOA: Top of Atmosphere
SARTA: Standalone AIRS Rapid-Transmittance Algorithm

One of several tools developed as wrappers for V5 and V6 RTAs
### Example Report for AIRS L2 Arctic Footprint

**Output profiles encompass all 100 layers**

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<thead>
<tr>
<th>Channel</th>
<th>Number Det</th>
<th>lat/lon, deg</th>
<th>lower pressure, layers</th>
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### Footprint Information

- **Channel Number**: 01-17
- **Profile Data**: All 100 layers
- **Spatial Coverage**: All channels
- **Accuracy**: All channels
- **Version**: 2.1
- **Reference**: AIRS L2 Arctic Footprint
- **Source**: NASA JPL
- **Data Format**: ASCII
- **Date Range**: 2004-2005

### Additional Information

- **Output Profiles**: All 100 layers
- **Standard Deviation of Peak Pressure**: All channels
- **Peak Pressure of the Overhead Average of All Channels**: 12.47

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**NOTES**

- **Data Quality**: High
- **Data Availability**: Continuous
- **Data Access**: Public

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**References**

- National Aeronautics and Space Administration
- Jet Propulsion Laboratory
- California Institute of Technology
- Pasadena, California
Contribution Functions/Temperature Profiles
V5 VPD $T_{\text{air}}$ Auxiliary Groups using V6 RTA

Mid-Trop channel set at high latitude likely requires optimization
Contribution Functions/Temperature Profiles
V5 VPD CO2 Groups using V6 RTA

Mid-Trop/Upper-Trop channel sets at high latitude likely require optimization
Contribution Functions
Initial CO2 Mid-Strat Channel Set using V6 RTA

AIRS Level 2 Footprint Tropical Pacific Atmospheric Profiles
1 Jan 2007; Granule 231; FP01; SC02
Lat: 00.46S  Lon: 149.29W
CO2 profile assumed: 381 ppm throughout

Averages Contribution Function, $B(T)\Delta T/\Delta \ln(p)$
Contribution Functions
Initial CO2 Mid-Trop Channel Set using V6 RTA

AIRS Level 2 Footprint Tropical Pacific Atmospheric Profiles
1 Jan 2007; Granule 231; FP01; SC02
Lat: 00.46S  Lon: 149.29W
CO2 profile assumed: 381 ppm throughout

AIRS Level 2 Footprint Frozen Arctic Ocean Atmospheric Profiles
1 Jan 2007; Granule 202; FP01; SC02
Lat: 74.86N  Lon: 178.39W
CO2 profile assumed: 381 ppm throughout

\[ \text{Average Contribution Function, } B(T) \times \Delta T / \Delta \ln(p) \]
Contribution Functions
Initial Tair Lower-Trop Channel Set using V6 RTA

AIRS Level 2 Footprint Tropical Pacific Atmospheric Profiles
1 Jan 2007; Granule 231; FP01; SC02
Lat: 00.46S  Lon: 149.29W
CO2 profile assumed: 381 ppm throughout

AIRS Level 2 Footprint Frozen Arctic Ocean Atmospheric Profiles
1 Jan 2007; Granule 202; FP01; SC02
Lat: 74.86N  Lon: 178.39W
CO2 profile assumed: 381 ppm throughout

Average Contribution Function, B(T)xΔτ/Δln(p)
Contribution Functions
Initial CO2 Near-Surf Channel Set using V6 RTA

AIRS Level 2 Footprint Tropical Pacific Atmospheric Profiles
1 Jan 2007; Granule 231; FP01; SC02
Lat: 00.46S Lon: 149.29W
CO2 profile assumed: 381 ppm throughout

AIRS Level 2 Footprint Frozen Arctic Ocean Atmospheric Profiles
1 Jan 2007; Granule 202; FP01; SC02
Lat: 74.86N Lon: 178.39W
CO2 profile assumed: 381 ppm throughout
Interannual and Seasonal Variations
Retrieved Mid-Trop CO2
Early V6 L2 Data; Unoptimized V5 Operational VPD

interannual variation is reasonable

expected 8 ppm interannual variation at 2 ppm/yr

CO2 values over Antarctica now reasonable using V6 L2 data

high NH latitude variation may be impacted by suboptimal channels (too great a contribution from low stratosphere)
Zonal Average of Retrieved Mid-Trop CO2 Early V6 L2 Data; Unoptimized V5 Operational VPD Compared to Matsueda In Situ Measurements and Zonal Average of V5 Operational Retrieval
V6/V5 Diurnal Variation Comparison

January:
V6 diurnal about 1 ppm smaller than V5

April:
V6 diurnal 0.5 - 1 ppm smaller than V5

July:
V5/V6 diurnal about the same

October:
V6 diurnal 0.5 – 1 ppm smaller than V5
# Atmospheric Infrared Sounder

## Schedule

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<th>Sep-11</th>
<th>Oct-11</th>
<th>Nov-11</th>
<th>Dec-11</th>
<th>Jan-12</th>
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<th>Jun-12</th>
<th>Jul-12</th>
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<td>Compare V6 mid-trop retrievals to in situ measurements, Optimize V6 QA Filters (Olsen)</td>
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Summary – AIRS V6 CO2 Development

- **V6 CO2 retrieval post-processing PGE reorganized for maintainability**
  - Legacy research code segments/stubs removed
  - Code modularized and heavily commented
  - Implements both mid-trop and mid-strat capability
    - Choice: channel lists, priors and QA filtering rules; code modules are common
    - Allows easy addition of lower-trop capability
    - Choice of V5 or V6 RTA to allow V5 or V6 data processing
      - Implements V6 Doppler/orbital/seasonal spectral shifts

- **Revisiting channel selection – tools developed**
  - Analyzing channel sensitivity over globe using V5 and V6 L2 & RTA
  - Identifying sub-optimal channels
  - Optimizing selection criteria and QA filters for V6

- **Early V6 results (V5.9.12 ZBT)**
    - Interannual variation consistent with global growth of CO2
    - Diurnal variation is small fraction of 1 ppm
    - Lower NH high latitude winter mid-trop CO2 in V6 may be due to sub-optimal channel contribution tails extending into lower stratosphere
    - Reasonable mid-trop CO2 over Antarctica likely due to better temperature profiles over that continent
AIRS V6 CO2 Development

Thank You!