Transport of CO and $O_3$ into the TexAQS II Study Area as Observed by the Atmospheric InfraRed Sounder (AIRS)

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Thanks to the P-3 and AIRS Teams

TexAQS II Workshop  http://physics.umbc.edu/~mcmillan  5/31/07
AIRS:
daily satellite BIG view

Questions G and H:
Distant sources and transport impacts
Local AP (day+night) AIRS CO at 500 mb from DAAC on 20060820

AIRS daily overview product  v4.0.9.0

CO Mixing Ratio (ppbv) at 500 mb

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Local AP (day+night) AIRS CO at 500 mb from DAAC on 20060821

CO Mixing Ratio (ppbv) at 500 mb
Local AP (day+night) AIRS CO at 500 mb from DAAC on 20060822

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Local AP (day+night) AIRS CO at 500 mb from DAAC on 20060824
Local AP (day+night) AIRS CO at 500 mb from DAAC on 20060825

CO Mixing Ratio (ppbv) at 500 mb
Local AP (day+night) AIRS CO at 500 mb from DAAC on 20060827
Local AP (day+night) AIRS CO at 500 mb from DAAC on 20060828

CO Mixing Ratio (ppbv) at 500 mb
Local AP (day+night) AIRS CO at 500 mb from DAAC on 20060829

CO Mixing Ratio (ppbv) at 500 mb
Local AP (day+night) AIRS CO at 500 mb from DAAC on 20060831

CO Mixing Ratio (pptv) at 500 mb

80  70  60  50  40  30  20  10  0  10  20
N    N    N    N    N    N    N    N    N    N

0°  60°  120°  180°  120°  60°  0°
E    E    E    E    E    E    E

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Local AP (day+night) AIRS CO at 500 mb from DAAC on 20060901

CO Mixing Ratio (ppbv) at 500 mb
Local AP (day+night) AIRS CO at 500 mb from DAAC on 20060902
Local AP (day+night) AIRS CO at 500 mb from DAAC on 20060903
Local AP (day+night) AIRS CO at 500 mb from DAAC on 20060904

CO Mixing Ratio (ppbv) at 500 mb

80  100  120  140  160+

http://physics.umbc.edu/~mcmillan
Local AP (day+night) AIRS CO at 500 mb from DAAC on 20060905

CO Mixing Ratio (ppbv) at 500 mb
Local AP (day+night) AIRS CO at 500 mb from DAAC on 20060906

CO Mixing Ratio (ppbv) at 500 mb

80
70
60
50
40
30
20
10
0

80 100 120 140 160+

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Local AP (day+night) AIRS CO at 500 mb from DAAC on 20060907

CO Mixing Ratio (ppbv) at 500 mb
Local AP (day+night) AIRS CO at 500 mb from DAAC on 20060909

CO Mixing Ratio (ppbv) at 500 mb
Local AP (day+night) AIRS CO at 500 mb from DAAC on 20060910
Local AP (day+night) AIRS CO at 500 mb from DAAC on 20060911
Local AP (day+night) AIRS CO at 500 mb from DAAC on 20060912

CO Mixing Ratio (ppbv) at 500 mb
Local AP (day+night) AIRS CO at 500 mb from DAAC on 20060913
Local AP (day+night) AIRS CO at 500 mb from DAAC on 20060914
Local AP (day+night) AIRS CO at 500 mb from DAAC on 20060915

CO Mixing Ratio (ppbv) at 500 mb
Local AP (day+night) AIRS CO at 500 mb from DAAC on 20060917

CO Mixing Ratio (ppbv) at 500 mb

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Local AP (day+night) AIRS CO at 500 mb from DAAC on 20060918
Local AP (day+night) AIRS CO at 500 mb from DAAC on 20060919
Local AP (day+night) AIRS CO at 500 mb from DAAC on 20060920
Launched May 4, 2002, onboard Aqua
• 13.5 km nadir IR FOV 1650 km swath
• 45 km nadir μwave FOV (AMSU)
• 324,000 AIRS retrievals per day
• 2378 channels
AIRS Spectrum on 9/5/2002 @ 1830 UTC

Wavelength (μm)

Brightness Temperature (K)

Wavenumber (cm⁻¹)

CO₂, O₃, CH₄, H₂O, CO, CO₂, N₂O

Surface
## AIRS/AMSU/HSB DATA PRODUCTS

<table>
<thead>
<tr>
<th>Radiance Products (Level 1B)</th>
<th>RMS Uncertainty*</th>
<th>Horizontal Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIRS IR Radiance</td>
<td>3%</td>
<td>15 x 15 km</td>
</tr>
<tr>
<td>AIRS VIS/NIR Radiance</td>
<td>20%</td>
<td>2.3 x 2.3 km</td>
</tr>
<tr>
<td>AMSU Radiance</td>
<td>0.25-1.2 K</td>
<td>45 x 45 km</td>
</tr>
<tr>
<td>HSB Radiance</td>
<td>1.0-1.2 K</td>
<td>15 x 15 km</td>
</tr>
</tbody>
</table>

### Standard Core Products (Level 2)

<table>
<thead>
<tr>
<th>Product</th>
<th>Uncertainty</th>
<th>Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cloud Cleared IR Radiance</td>
<td>1.0K</td>
<td>45 x 45 km</td>
</tr>
<tr>
<td>Sea Surface Temperature</td>
<td>0.5K</td>
<td>45 x 45 km</td>
</tr>
<tr>
<td>Land Surface Temperature</td>
<td>1.0K</td>
<td>45 x 45 km</td>
</tr>
<tr>
<td>Temperature Profile</td>
<td>1K</td>
<td>45 x 45 km</td>
</tr>
<tr>
<td>Humidity Profile</td>
<td>15%</td>
<td>45 x 45 km</td>
</tr>
<tr>
<td>Total Precipitable Water</td>
<td>5%</td>
<td>45 x 45 km</td>
</tr>
<tr>
<td>Fractional Cloud Cover</td>
<td>5%</td>
<td>45 x 45 km</td>
</tr>
<tr>
<td>Cloud Top Height</td>
<td>0.5 km</td>
<td>45 x 45 km</td>
</tr>
<tr>
<td>Cloud Top Temperature</td>
<td>1.0 K</td>
<td>45 x 45 km</td>
</tr>
</tbody>
</table>

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1 km below 700 mb
2 km 700-30 mb
2 km in troposphere
### New Standard Products

<table>
<thead>
<tr>
<th>Product</th>
<th>Desired RMS Uncertainty</th>
<th>Expected Footprint</th>
</tr>
</thead>
<tbody>
<tr>
<td>O$_3$</td>
<td>&lt; 10% total column</td>
<td>45 km x 45 km</td>
</tr>
<tr>
<td>O$_3$</td>
<td>mid-upper tropospheric</td>
<td>45 km x 45 km</td>
</tr>
<tr>
<td>CO</td>
<td>&lt; 15% for column</td>
<td>45 km x 45 km</td>
</tr>
<tr>
<td>SO$_2$</td>
<td>volcanic eruption detector</td>
<td>45 km x 45 km</td>
</tr>
<tr>
<td>CH$_4$</td>
<td>1-5% for column</td>
<td>135 km x 135 km</td>
</tr>
</tbody>
</table>

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SUMMARY: AIRS

• Simultaneous retrieval for all products
  – 45 km horizontal resolution
  – Temperature (2 km vertical resolution)
  – Water vapor (3 km vertical resolution)
• Map 70-80% of the planet every day!
• CO (UMBC) operational next month
  – Total column + changes in vertical sensitivity
• O₃ (JPL) operational next month
• Data reprocessing underway
• See poster 37
Regional Influences During Aug 30 - Sep 02, 2006
Houston Ozone AQ event – from REALTIME forecasts

Synthesis of EPA AIRNOW, NOAA P3, NASA AIRS measurements and RAQMS chemical analyses

24hr averaged ozone shows 30ppbv enhancement during the period that could be due to regional transport

Brad Pierce (NOAA)
From 9/15/06 RSS talk
Houston surface (red) and 850mb (blue) 5-day back trajectories

On-shore to Northeasterly transition

Brad Pierce (NOAA)
5-day Lagrangian mean ozone mixing ratio, altitude, and pbl height
Houston AIRNOW sites 09/01/06

Daily ozone production along back trajectories results in Lagrangian mean ozone increase of nearly 30ppbv during previous 4 days

Trajectories remain within boundary layer during the previous 5 days

Brad Pierce (NOAA)
Local AP (day+night) AIRS CO at 500 mb from DAAC on 20060826

V4.0.9.0

CO Mixing Ratio (ppbv) at 500 mb

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Local AP (day+night) AIRS CO at 500 mb from DAAC on 20060826

CO Mixing Ratio (ppbv) at 500 mb

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Tes Observations - Aug 30, 2006

- TES Global Survey
- High ozone in the troposphere over the Gulf of Mexico seen in Trop Column
- Lower values over East TX

- Enhancement in ozone in middle troposphere over TX, OK, KA
- Low ozone in lower troposphere over East Texas, Central Oklahoma
- High ozone in lower troposphere over the Gulf (still under investigation)

Greg Osterman (JPL)
CO enhancement in lower troposphere
CO vertical sensitivity profiles
AIRS CO Column Averaging Kernels

AIRS CO Verticality on 20060830 PM along TES track

- upwind (40N)
- enhancement (35N)
- Houston (30N)
- offshore (26N)
CO enhancement in lower troposphere
August 30, 2006

CO enhancement in lower troposphere

Stratospheric intrusion
CO enhancement in lower troposphere

Stratospheric intrusion

AIRS cannot see O3 near surface

August 30, 2006
CO enhancement

August 31, 2006
Stratospheric intrusion

August 31, 2006

CO enhancement
P-3 In Situ O3 vs. AIRS Retrieved O3 at P-3 Pressure: 20060831

- AIRS 1835 Z
- AIRS 2014 Z

O3 Mixing Ratio (ppbv)

UTC (hours)

P-3 Static Pressure (mb)
AIRS cannot see near surface O3
AIRS cannot see near surface O3

AIRS can see mid-tropospheric O3
SUMMARY: AIRS

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