Dynamical Variability of Ozone near the Tropopause from AIRS Data

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AIRS Ozone Data

- Continue to show impressive consistency with dynamics of the UTLS – case 5

- Validation study continues –
  - Using ozonesonde data
  - Using aircraft data (MOZIAC)

- Dynamical variability – Preferred locations of Stratosphere to troposphere transport (STT) of ozone
Case 5: Stratospheric Intrusion during a Dust Storm

In collaboration with Mel Shapiro and Hsiao-ming Hsu
Rossby Wave-Train Ray Path — — →

50 N.

EQUATOR
PV from NCAR WRF/ARW model and AIRS Ozone, March 4th, 2004
Ozone from AIRS on NASA Aqua Satellite

AIRS Ozone March 4, 2004 Longitude=5E
PV from NCAR WRF model and AIRS Ozone cross section
3D ozone structure near the tropopause from AIRS – if validated, it will provide unprecedented opportunities for quantitative studies of STE

We need to understand where the retrieval information is from
More Validation Studies

- For our own validation studies, we have compared AIRS ozone with ozonesondes and aircraft data (HIAPER and MOZAIC).

- The comparisons shown here use AIRS v4 retrievals, gridded to daily grids with 1x1 degree resolution.

- Ozonesondes profiles are taken from the WOUDC archive.

- MOZAIC comparisons are in an early stage (preliminary results here).
There are examples of excellence agreement between AIRS ozone profiles and ozonesondes.

(200hPa ozone, using 442 soundings during 2003-2005)

Payerne, Switzerland (47N)
AIRS – ozonesonde correlations at 9 stations:

<table>
<thead>
<tr>
<th>Station</th>
<th>#</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boulder</td>
<td>122</td>
</tr>
<tr>
<td>Payerne</td>
<td>442</td>
</tr>
<tr>
<td>Sapporo</td>
<td>128</td>
</tr>
<tr>
<td>Tateno</td>
<td>149</td>
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<tr>
<td>Edmonton</td>
<td>104</td>
</tr>
<tr>
<td>Goosebay</td>
<td>84</td>
</tr>
<tr>
<td>Churchill</td>
<td>75</td>
</tr>
<tr>
<td>Resolute</td>
<td>46</td>
</tr>
<tr>
<td>Lauder</td>
<td>135</td>
</tr>
</tbody>
</table>

High correlations at each station over ~100 – 300 hPa
AIRS – ozonesonde correlations and biases
(9 stations, 2003-2005)

small AIRS low bias

significant AIRS high bias below ~ 250 hPa
Beijing Ozonesonde comparisons [Bian et al., 2006]
We have found an asymmetry between NH and SH retrievals – there is a larger (high) bias in SH tropospheric ozone values. The reason for this bias is likely associated with the bias in ECMWF A Priori
MOZAIC flight map (05/2003)
160 flights this month
AIRS $O_3$ vs. MOZAIC flights for one day

AIRS $O_3$ at 250hPa (MAY/02/2003)
AIRS vs. MOZAIC $O_3$ profiles

1. Interpolated $O_3$, 20030502013 (fmt)

2. Points along flight track
   - AIRS (+++), MOZAIC (oooom)
   - Interpolated $O_3$, 20030502022 (fmt)
Time vs. altitude sections

MOZAIC measurements

curtain from AIRS
Overall comparisons suggest that AIRS v4 ozone is quite reasonable for levels ~300-100 hPa.

We anticipate using AIRS ozone to study space-time variability of the tropopause and UTLS transport.
Lagrangian Models – preferred locations

ERA15 climatology: STT

Winter vs. summer

Sprenger and Wernli 2003 (JGR)
HIAPER Progressive Science Mission

Stratosphere–Troposphere Analyses of Regional Transport (START) Experiment

(December 2005)
The yellow surface represents dynamical tropopause (2 PVU) from NCEP GFS analyses. HIAPER flight track is colored by *in situ* ozone values.
Separation of the Thermal and Dynamical Tropopause and Mixing
Origins and the fate of the airmass inside the intrusion

(3 days backward and forward trajectories of the air parcels in the fold)

First HIAPER Research Flight (502rf01): 2005-12-01

Kenneth P. Bowman
Texas A&M University
Preferred STE location in NH by AIRS, May 1–9, 2005
Preferred STE location in NH by AIRS, monthly mean May 2005

Dynamical Tropopause (2PVU)  Ozone tropopause (oztp=120 ppbv)
Summary

- AIRS v4 ozone show significant correlation with sondes between 300–50 hPa range, with the best accuracy near the extratropical tropopause.

- Significant high bias in the mid troposphere and a small low bias in the lower stratosphere.

- Current ozone data is very valuable for characterizing the dynamical variability of the ozone in the extratropical UTLS, including stratosphere troposphere exchange.

- How well the data can be used to study deep stratospheric intrusion into troposphere and transport in the troposphere is uncertain.

- An improved characterization of retrieval information content is highly desirable.
Thank You!
Tropospheric tracer

Stratospheric tracer

Stratosphere

“depth”

Troposphere

Lower boundary of the mixing

Tropospheric tracer