GEOS-CHEM INTEX-A modeling and analysis

- Bottom-up inventory of the biomass burning emissions in North America during the summer 2004, S. Turquety, Harvard University;
- A Summertime Ozone Maximum in the UT over the Southern U.S.: Trapping of Convective Pollution by the Upper-level Anticyclone, Qinbin Li, JPL;
- Summertime influence of Asian pollution in the middle and upper troposphere during INTEX-A, Qing Liang, University of Washington;
- HCHO during ICARTT: implications for GOME/OMI, Dylan Millet, Harvard University;
- A multi-platform analysis of the North American reactive nitrogen budget during the ICARTT summer intensive, Rynda Hudman, Harvard University

ICARTT forecasts and NRT:
http://coco.atmos.washington.edu/cgi-bin/ion-p?page=geos_intexa.ion
Bottom-up inventory of the biomass burning emissions in North America during the summer 2004


**US National Interagency Coordination Center (NICC)**

**Canadian Interagency Forest Fire Center (CIFFC)**

- **Alaska:**
  - > 2.6 million hectares burned
  - > 8 x 10-year average

- **Canada:**
  - 15 x average area burned in Yukon Territory (60% of national total)
  - 6 x average in British Columbia
Bottom-up inventory of the biomass burning emissions in North America during the summer 2004

MODIS hotspots

Emissions / unit area

Daily reports of the area burned from the NIFC

Emissions CO 2004

Derive emissions for 10 species, with 1x1 horizontal resolution: NOx, CO, lumped >= C4 alkanes, lumped >= C3 alkenes, acetone, methyl ethyl ketone, acetaldehyde, propane, formaldehyde, and ethane.

A x 60%
[W.M. Hao, FSL, Personal comm.]
Bottom-up inventory of the biomass burning emissions in North America during the summer 2004

Alaska:
- Total CO emissions: 5.7 Tg CO
- Emissions are approximately 3 times climatology (Yevich et Logan)

Canada:
- Total CO emissions: 4.5 Tg CO
- Emissions are approximately 0.9 times climatology

Yukon territory:
- Total CO emissions: 2.3 Tg CO
- Emissions are approximately 4.4 times climatology

Underestimate emissions by ~ 25% on average

Total emissions North America
June 1st – August 31st = 10.3 Tg CO
Ongoing and future work

1. Using satellite observations to constrain the daily North American biomass burning emissions during the summer 2004
   - Magnitude?
   - Injection height?

2. Inverse modeling of North American anthropogenic emissions of CO using aircraft and satellite measurements

Solène Turquety – INTEX Data Meeting
March 30, 2005
A Summertime Ozone Maximum in the UT over the Southern U.S.: Trapping of Convective Pollution by the Upper-level Anticyclone

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Ozonesonde data from NewChurch et al. [2003]  Ozone > 90 ppb
Deep convection over the central and southeast U.S. lifts surface emissions to the upper troposphere. Some of the pollution can be trapped by the upper-level anticyclone before eventual export to the North Atlantic.
Ozone production & concentrations of NOx, CH$_2$O, and HOx at 300 hPa

**Standard Simulation**

Ozone production rates of up to 10 ppb/day over deep convective regions. NOx are 150-300 ppt over much of the eastern US (50-100 ppt from lightning). High HOx (~10 ppt) reflects photolysis of CH$_2$O from biogenic isoprene convectively lifted to the upper troposphere.

**Lightning NOx x 4**

Jaegle et al. [2001]
Source Attributions by Sensitivity Simulations

Strong deep convection region

Dominated by high biogenic isoprene emissions

Ozone production during circulation

Anthropogenic

Biogenic

Lightning
UT recirculation over SE U.S. during July 10-12 (H. Fuelberg)

300 hPa 7-day back-trajectories, July 12 flight track (DC-8 flt 7)
DC-8 July 12 flight: 80-110 ppb O₃ observed at 6-10 km over SE U.S. model too low by 20-30 ppbv

**Observed O₃ vs Model O₃**

**DIAL O₃**

**GEOS-CHEM NRT O₃ [ppbv]**

**Flighttrack**

**Model (300 hPa)**

**DC8**
Summertime influence of Asian pollution in the middle and upper troposphere during INTEX-A

Qing Liang and Lyatt Jaeglé, University of Washington and INTEX Science Team

What was the extent of Asian influence over the U.S. during INTEX-A?

Use GEOS-CHEM to identify Asian plumes in observations, characterize their composition, and elucidate their chemical evolution and transport mechanisms.

Asian plumes sampled during INTEX-A (Modeled Asian CO > 25-30 ppbv)

July 1.

Observed CO
July 1, 2004: Rapid trans-Pacific transport in 3-5 days!

Asian plume intercepted 3 times

Modeled Asian CO [ppbv]

Observed O₃ [ppbv]: DIAL+FASTOZ
Chemical Composition of Asian Plumes

- **Asian Plumes**
  - Model Asian CO > 25~30 ppbv

- **Background air**
  - Eliminate fresh convection, lightning, stratosphere, Alaskan fires

### Table: Chemical Composition

<table>
<thead>
<tr>
<th></th>
<th>Background</th>
<th>Asian Plumes</th>
<th>Observed</th>
<th>Model</th>
<th>July 1</th>
<th>July 1 Δ</th>
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<tbody>
<tr>
<td>CO, ppbv</td>
<td>94</td>
<td>113</td>
<td>+19</td>
<td>+6</td>
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<td>O₃, ppbv</td>
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<td>+23</td>
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<td>HNO₃, pptv</td>
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<td>SO₄²⁻, pptv</td>
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<td>0</td>
<td></td>
<td>119</td>
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</tr>
</tbody>
</table>

### Graphs:

- **CO – O₃**
- **CO – HNO₃**
- **CO – PAN**
HCHO during ICARTT: implications for GOME/OMI

All profiles

E. U.S.

Atlantic
All Data

CH2O [ppt]

Measured (NCAR)
Mean: 788 ppt
SD: 1029

Measured (URI)
Mean: 539 ppt
SD: 710

Modeled (GEOS-CHEM)
Mean: 674 ppt
SD: 943

< 2km

CH2O [ppt]

Measured (NCAR)
Mean: 1846 ppt
SD: 1215

Measured (URI)
Mean: 1276 ppt
SD: 830

Modeled (GEOS-CHEM)
Mean: 1737 ppt
SD: 1171

2-6km

CH2O [ppt]

Measured (NCAR)
Mean: 459 ppt
SD: 366

Measured (URI)
Mean: 301 ppt
SD: 249

Modeled (GEOS-CHEM)
Mean: 379 ppt
SD: 317

>6km

CH2O [ppt]

Measured (NCAR)
Mean: 178 ppt
SD: 162

Measured (URI)
Mean: 120 ppt
SD: 116

Modeled (GEOS-CHEM)
Mean: 162 ppt
SD: 111
HCHO during ICARTT: implications for GOME/OMI

\[ AMF = AMF_G \int_0^1 w(\sigma)S(\sigma) d\sigma \]

**AMF**: Slant column / vertical column

**AMF\(_G\)**: Geometric factor

\( w(\sigma) \): Scattering weights

\[ \sim -\frac{\partial (\ln I_B)}{\partial \tau} \]

\( S(\sigma) \): Shape factor

Normalized vertical distribution

From model
Clear Sky AMF Comparison
- all profiles -

Small negative bias (-7%) in modeled clear sky AMF
Continental profiles:

AMF(meas) = 1.06 (0.17)
AMF(mod) = 0.99 (0.12)

Oceanic profiles:

AMF(meas) = 1.17 (0.04)
AMF(mod) = 1.23 (0.13)