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:

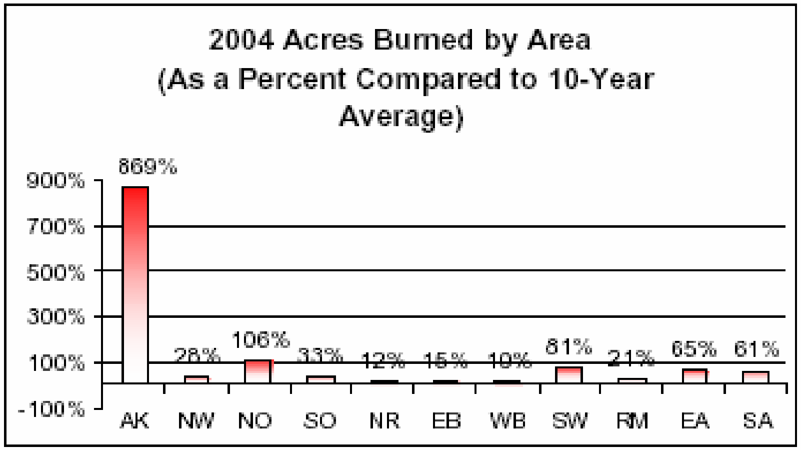
http://coco.atmos.washington.edu/cgi-bin/ion-p?page=geos_intexa.ion

Bottom-up inventory of the biomass burning emissions in North America during the summer 2004

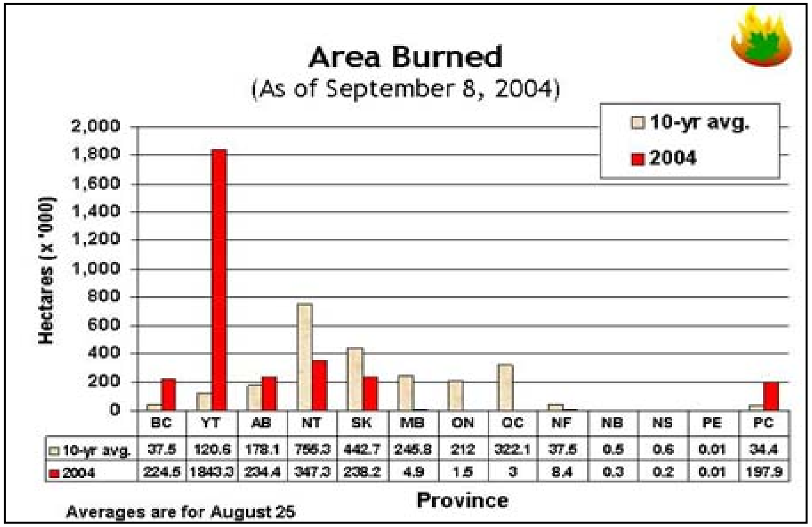
S. Turquety, D. J. Jacob, R. C. Hudman, J. A. Logan, R. M. Yevich, F. Y. Leung, R. M. Yantosca,
L. K. Emmons, D. P. Edwards, INTEX Science Team

- **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**

US National Interagency Coordination Center (NICC)

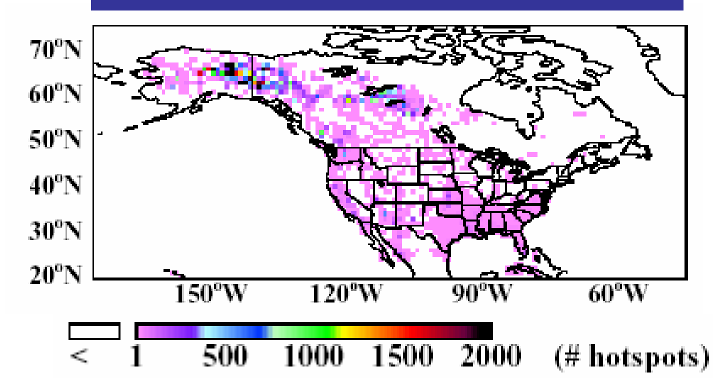


Canadian Interagency Forest Fire Center (CIFFC)



Bottom-up inventory of the biomass burning emissions in North America during the summer 2004

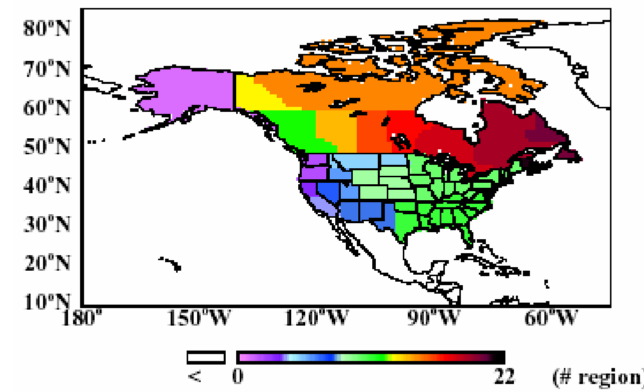
MODIS hotspots



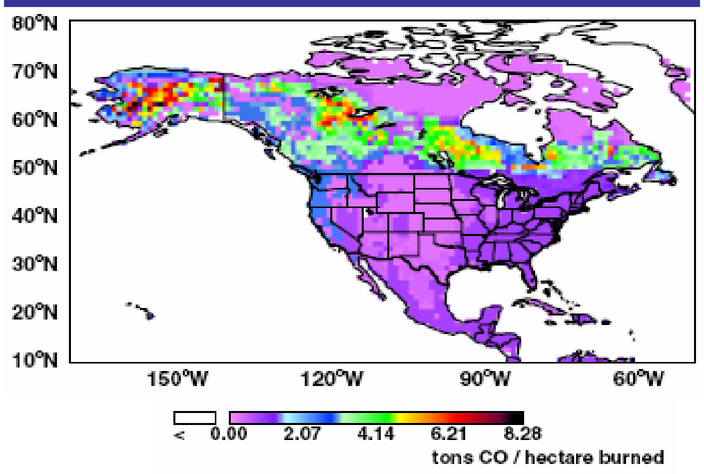
Daily reports of the area burned from the NIFC

A x 60%

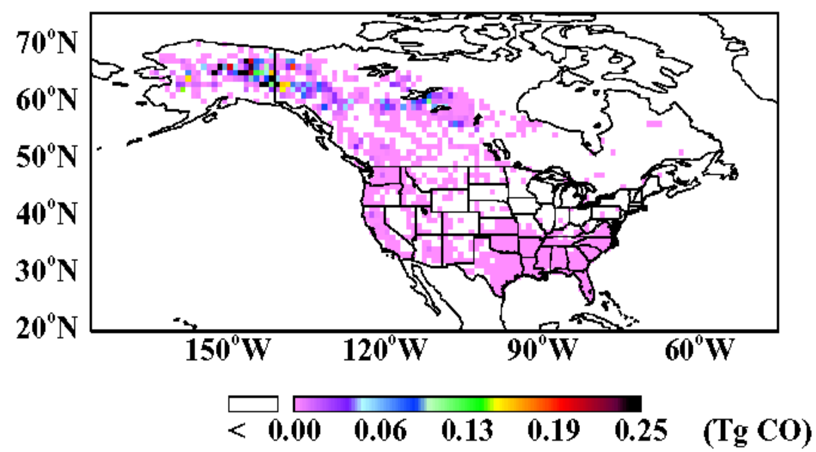
[W.M. Hao, FSL, Personal comm.]



Emissions / unit area

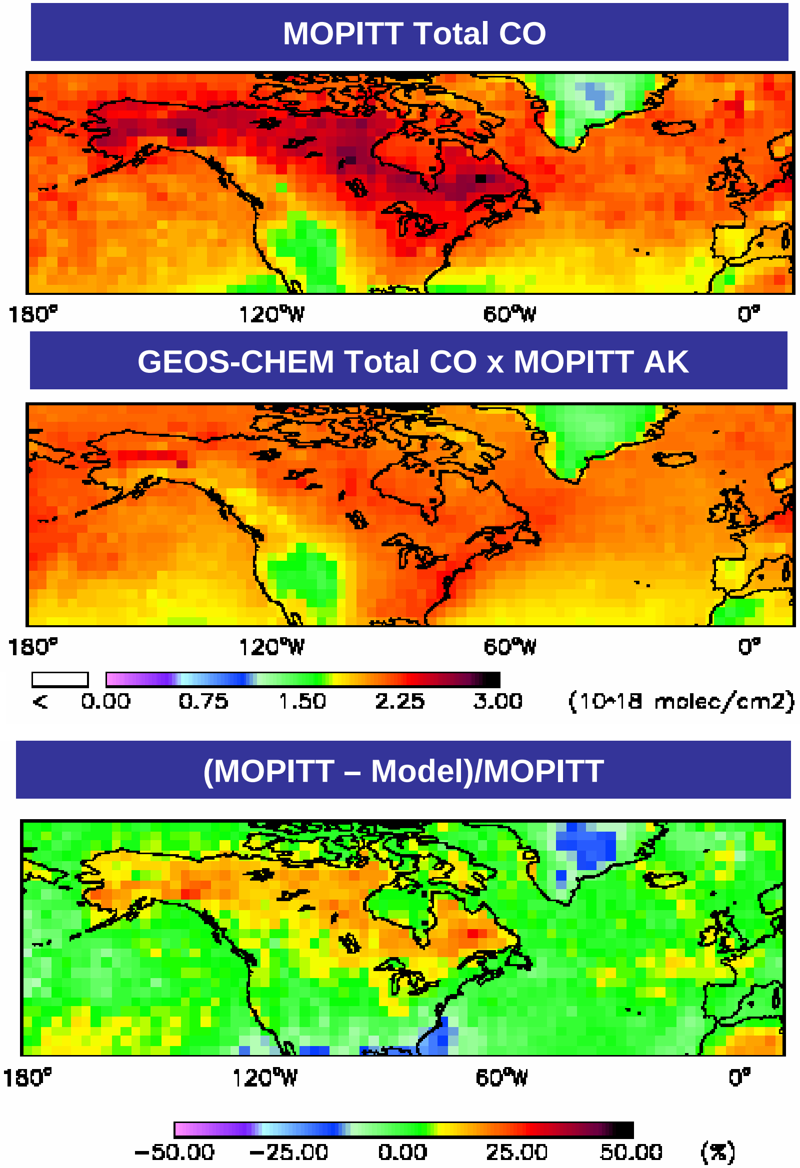


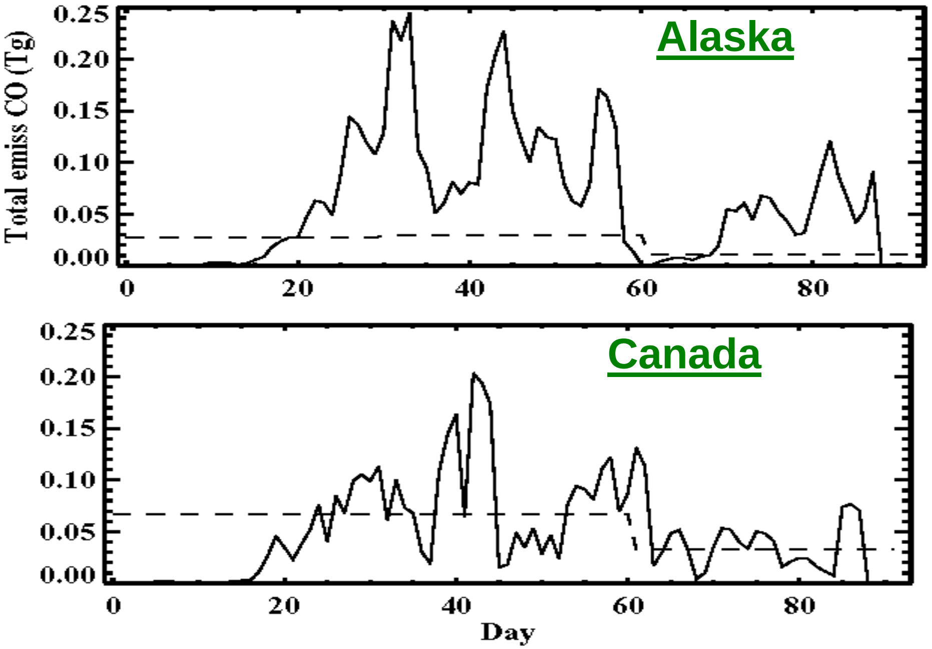
Emissions CO 2004



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.

Bottom-up inventory of the biomass burning emissions in North America during the summer 2004





Total emissions North America

June 1st – August 31st = <u>10.3 Tg CO</u>

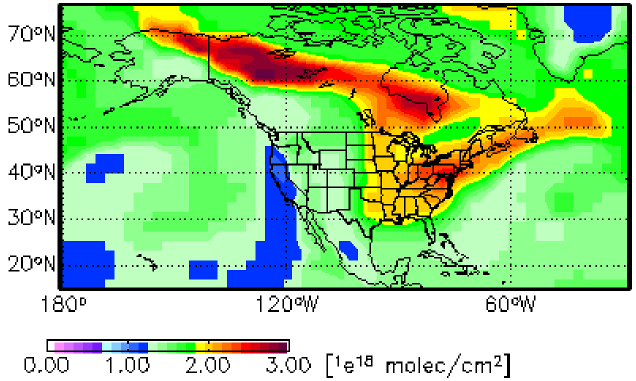
- **Alaska : 5.7 Tg CO ≈ 3 x climatology *Yevich et Logan***
- **Canada: 4.5 Tg CO ≈ 0.9 x climatology**
  Yukon territory: 2.3 Tg CO ≈ 4.4 x climatology

→ **Underestimate emissions by ~ 25% on average**

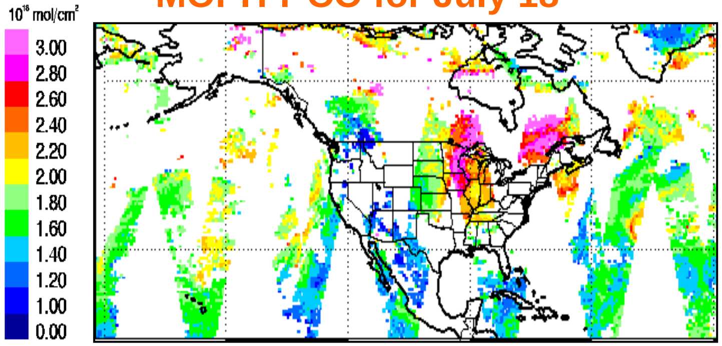
Ongoing and future work

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

GEOS-CHEM NRT July 18



MOPITT CO for July 18



GEOS-CHEM

A priori sources

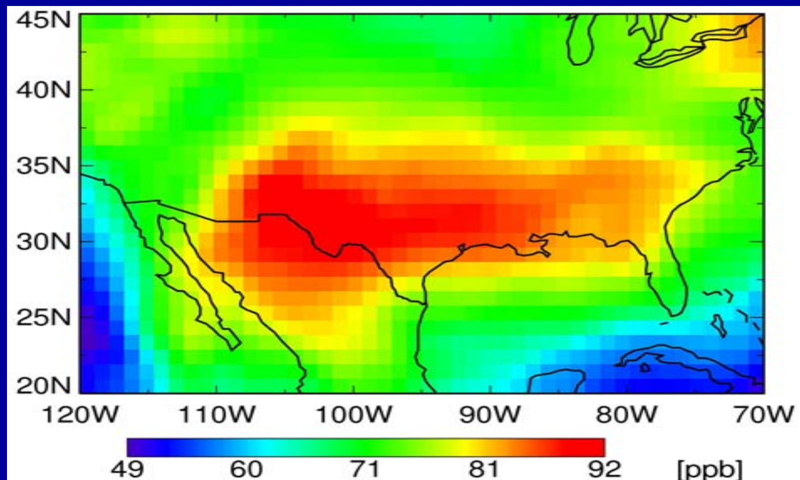
Inversion

A posteriori sources

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

A Summertime Ozone Maximum in the UT over the Southern U.S.: Trapping of Convective Pollution by the Upper-level Anticyclone

GEOS-CHEM Ozone 300 hPa, July 2000



Qinbin Li[1]
Daniel Jacob[2], Rokjin J. Park[2]
Yuxuan Wang[2], Rynda Hudman[2]
Robert M. Yantosca[2]
Randall V. Martin[3], Mathew Evans[4]

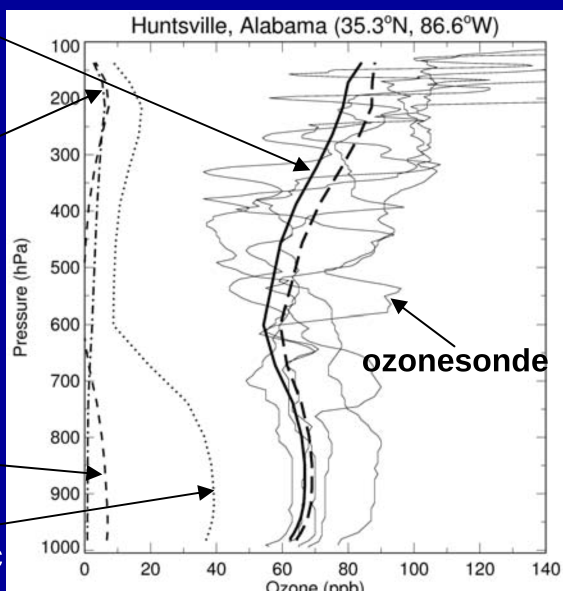
[1]JPL [2]Harvard University
[3]Dalhousie University [4]University of Leeds

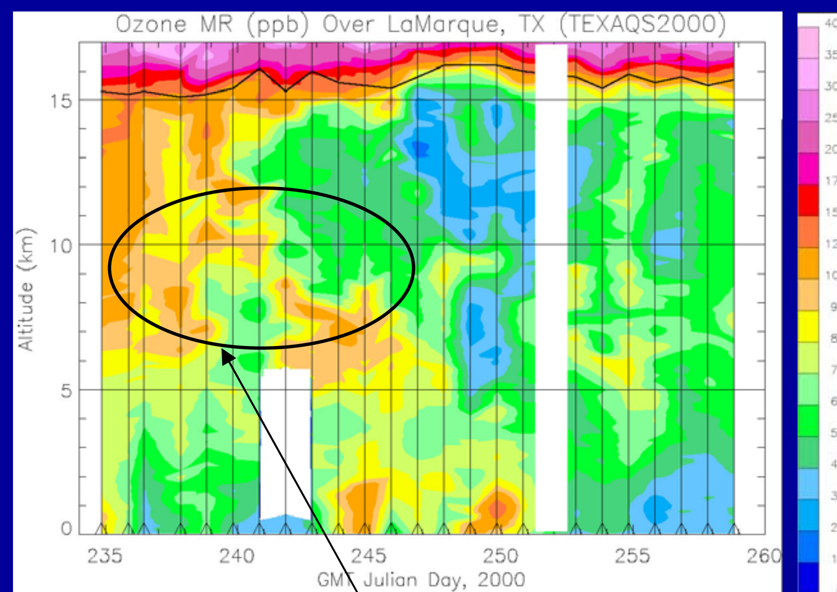
GEOS-CHEM

Lightning

Biogenic

Anthropogenic



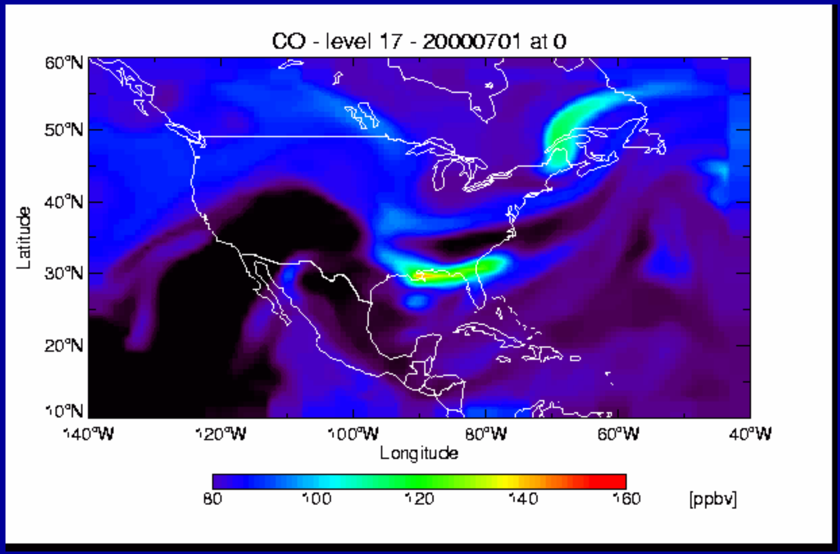


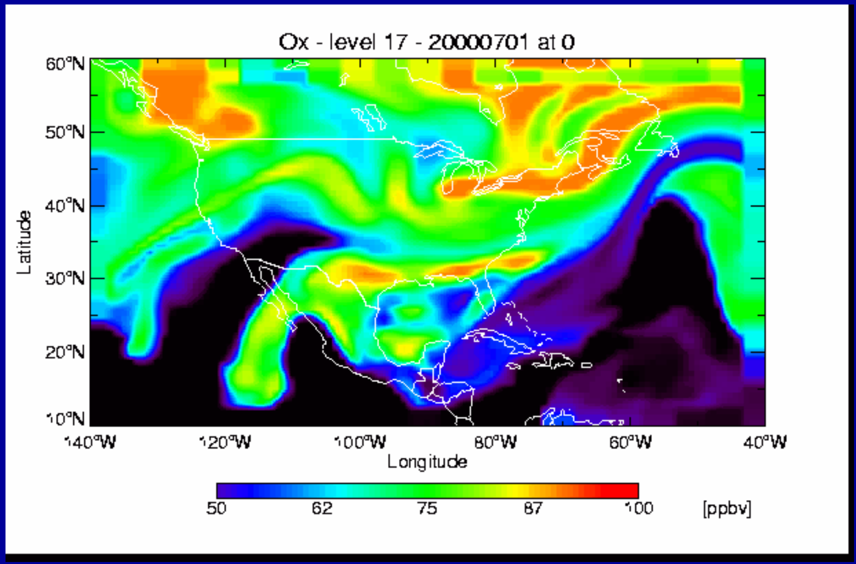
Ozonesonde data from *NewChurch et al.* [2003]

Ozone > 90 ppb

Convective Outflow Trapped by the Upper-level Anticyclone

GEOS-CHEM CO and Ozone at 300 hPa

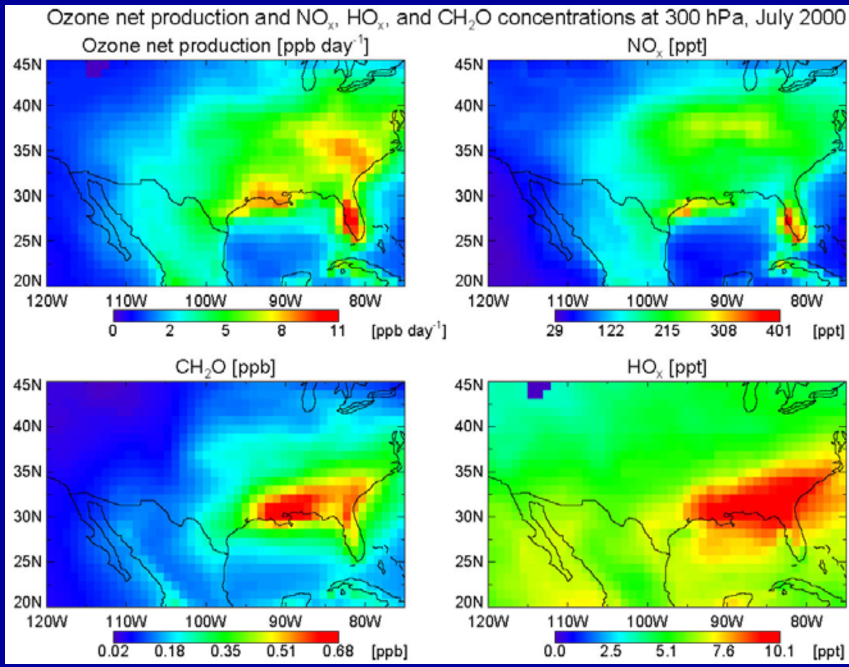




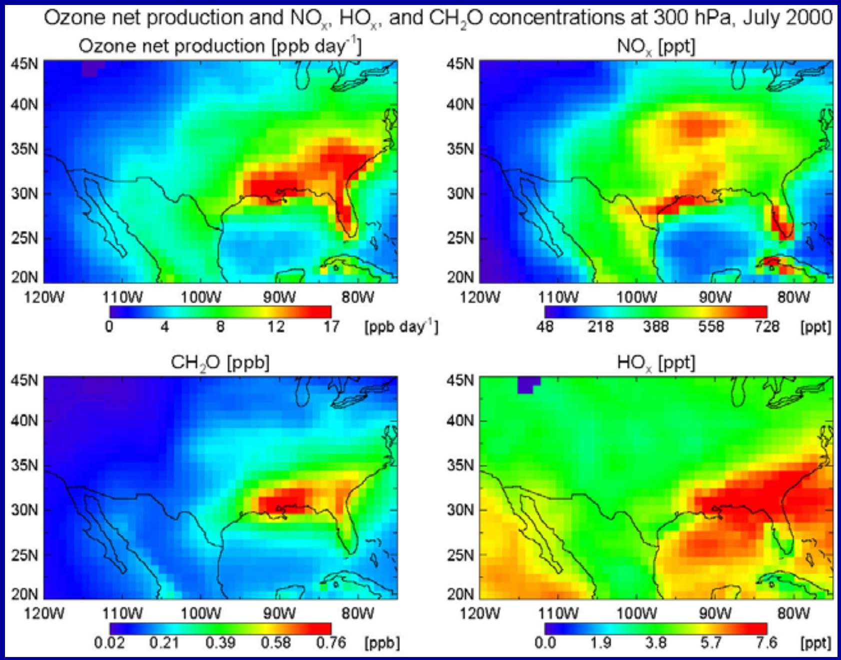
Deep convection over the central and southeast U.S. lifts surface emissions to the upper troposphere. Some of the pollution can be trapped by the upper-level anticyclone before eventual export to the North Atlantic.

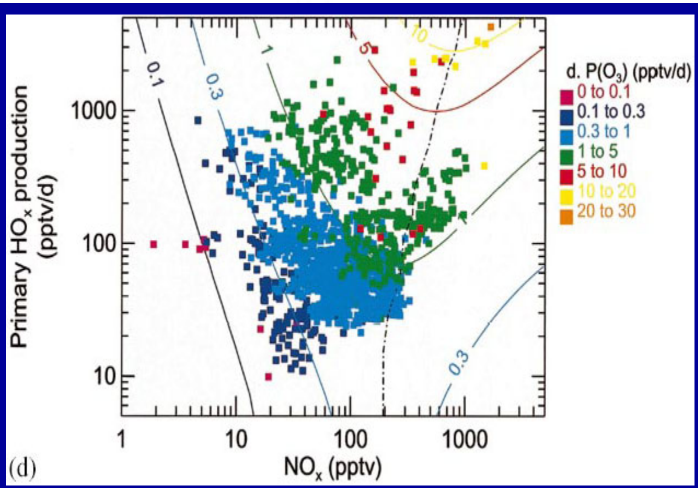
Ozone production & concentrations of NOx, CH_2O, and HOx at 300 hPa

Standard Simulation



Lightning NOx x 4

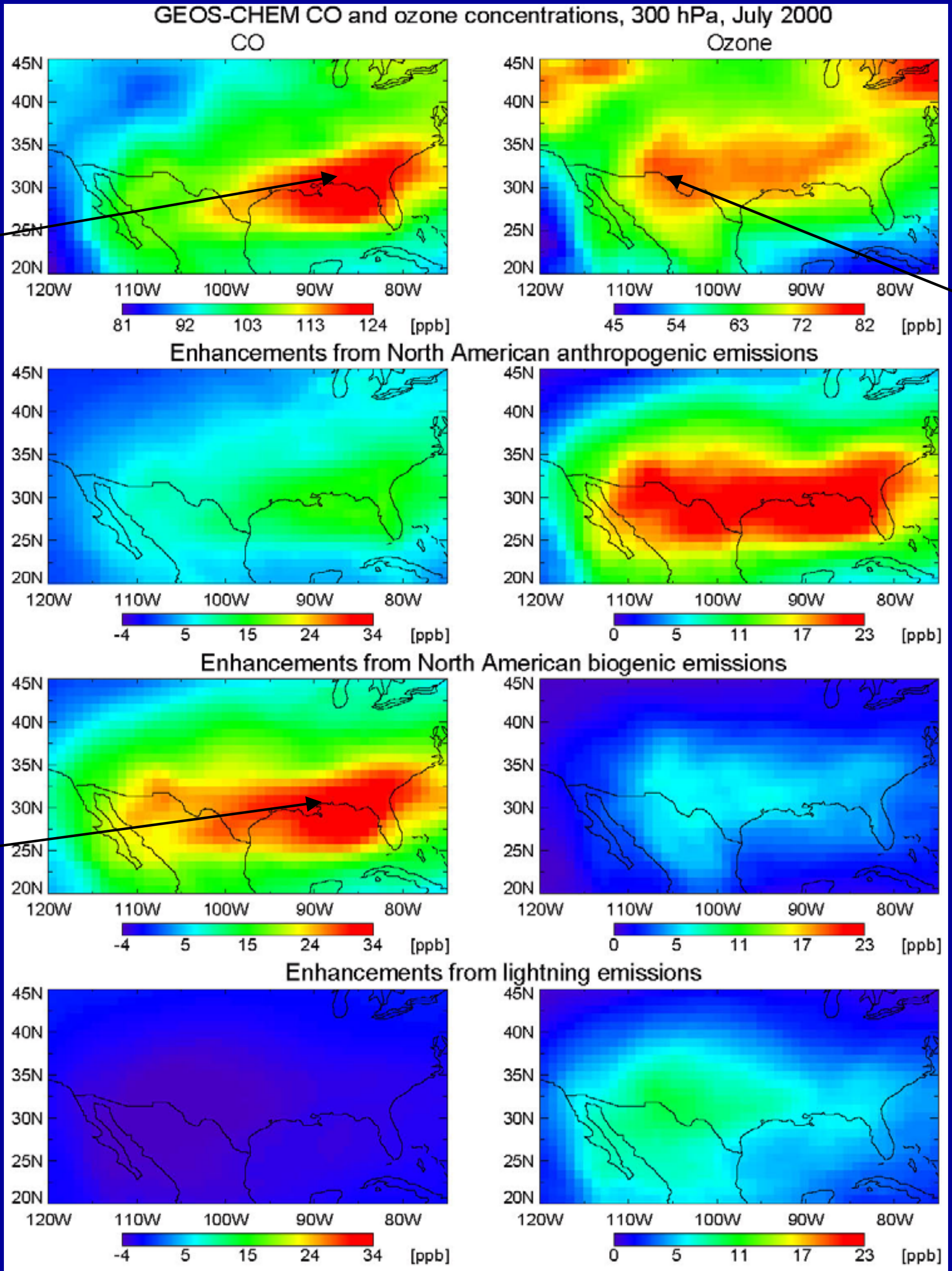




Jaegle et al. [2001]

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_2O from biogenic isoprene convectively lifted to the upper troposphere.

Source Attributions by Sensitivity Simulations



Strong deep convection region

Ozone production during circulation

Anthropogenic

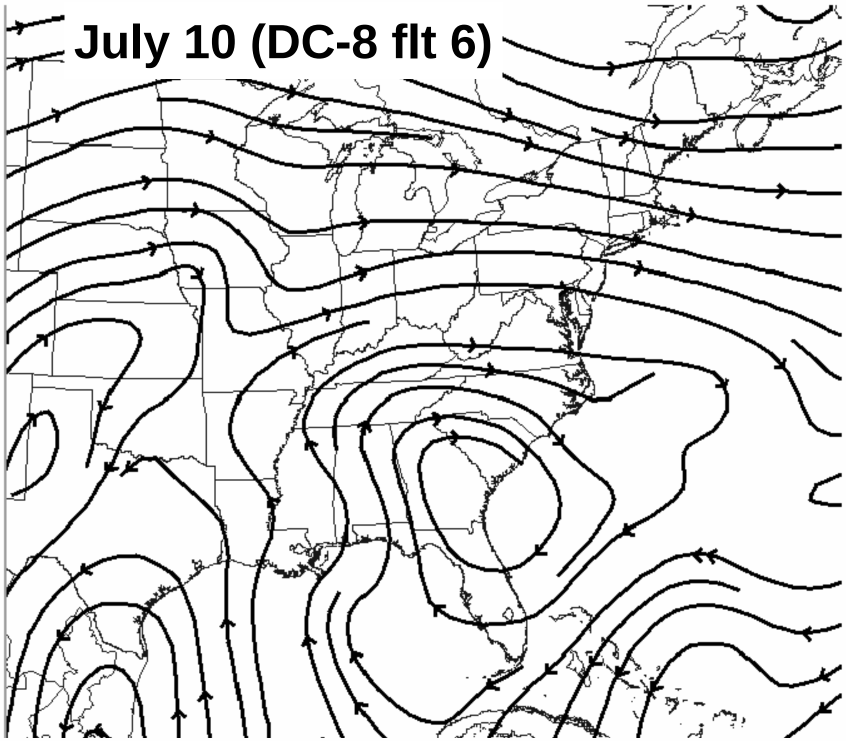
Biogenic

Dominated by high biogenic isoprene emissions

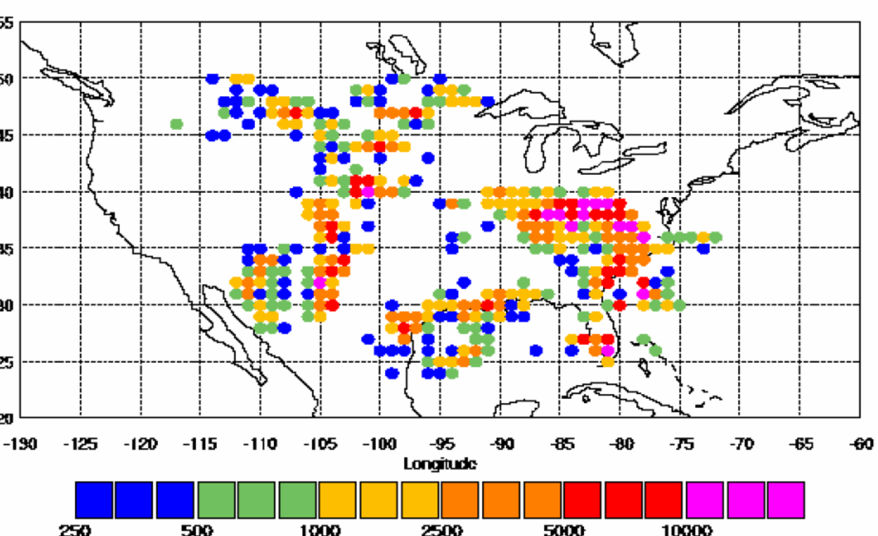
Lightning

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

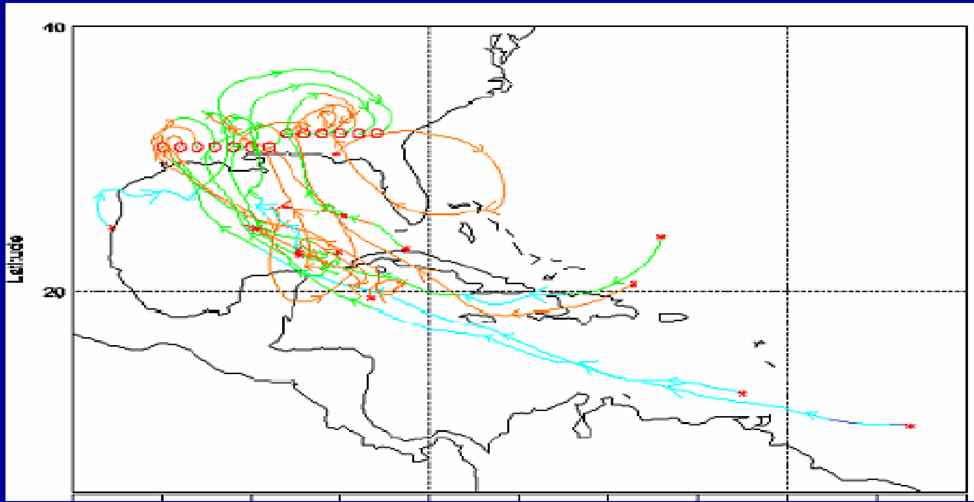
300 mb Winds



Lightning Intensity (strokes)
For 24 Hour Interval Centered on
2004 JUL 10 18 Z

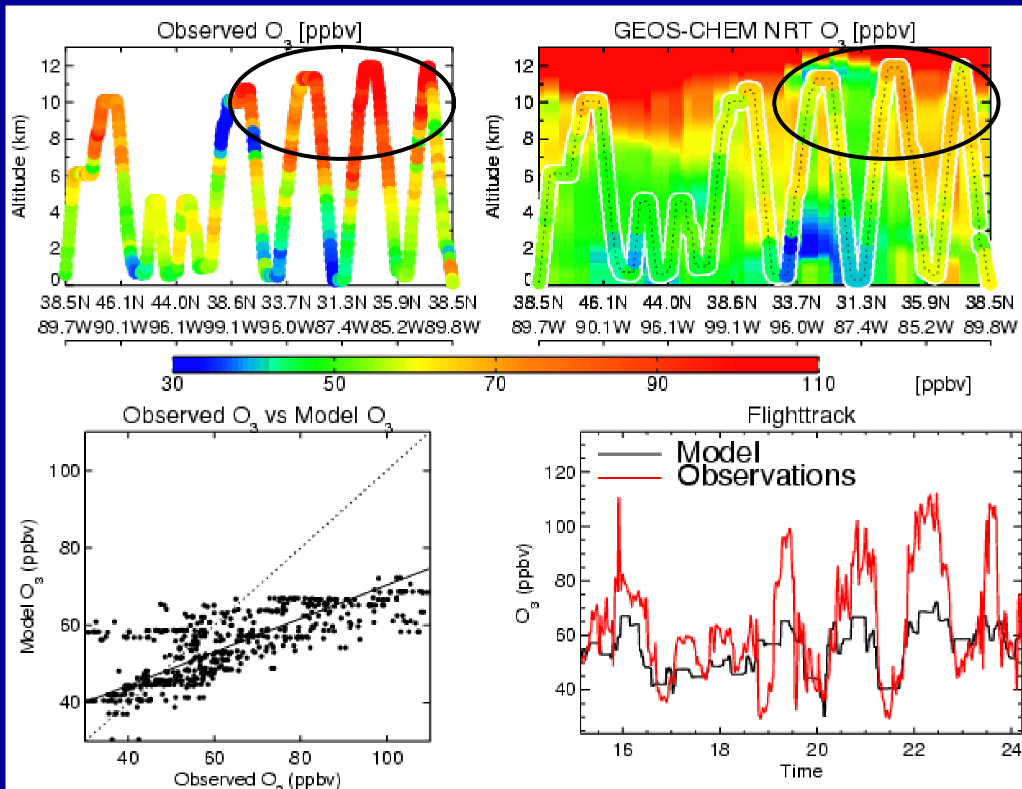


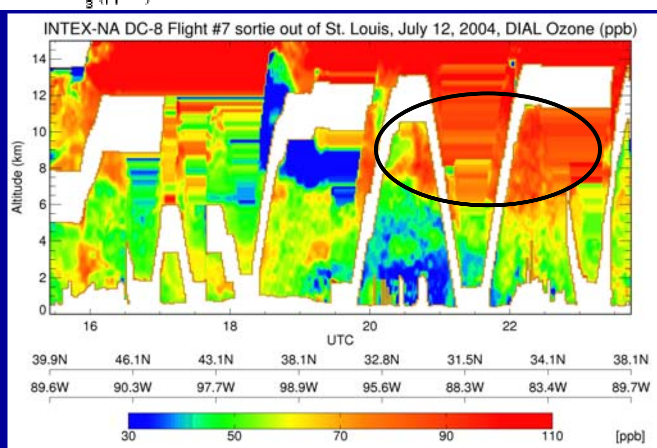
300 hPa 7-day back-trajectories,
July 12 flight track (DC-8 flt 7)



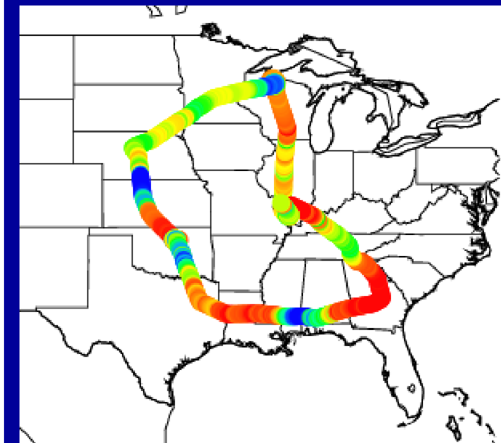
DC-8 July 12 flight: 80-110 ppb O_3 observed at 6-10 km over SE U.S.

model too low by 20-30 ppbv

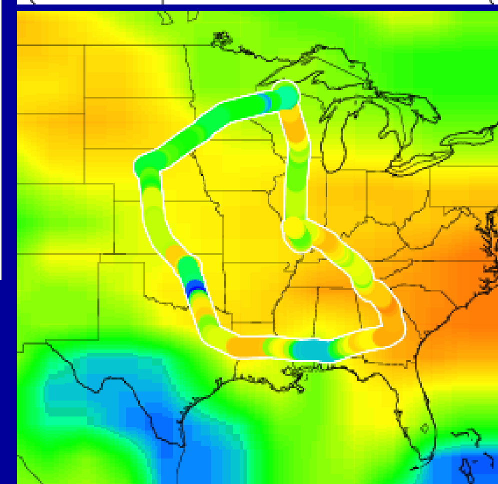




DIAL O3



DC8



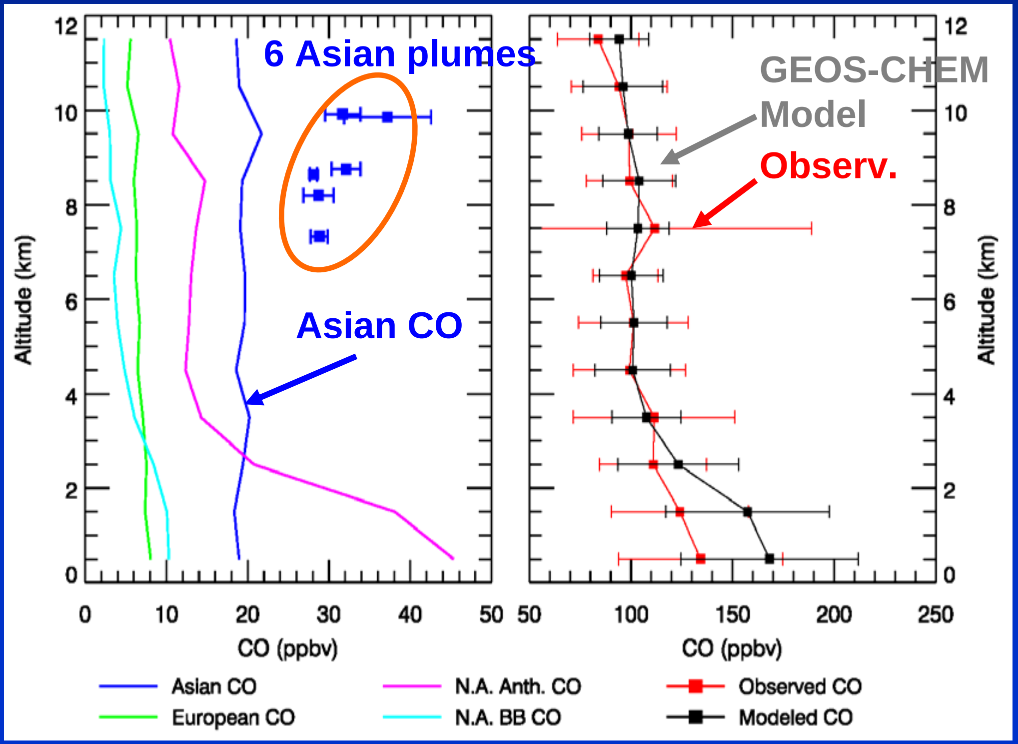
Model

(300 hPa)

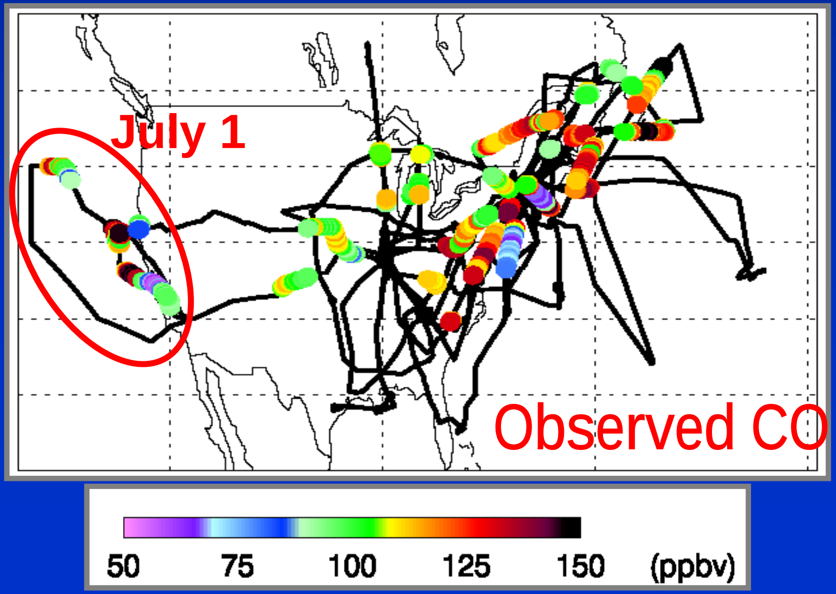
Summertime influence of Asian pollution in the middle and upper troposphere during INTEX-A

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

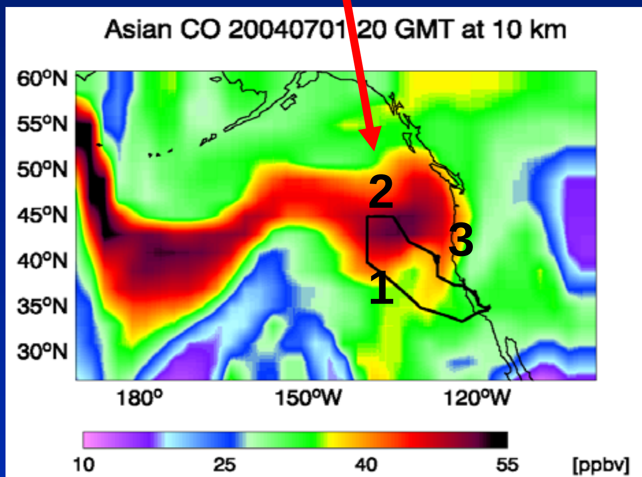


Asian plumes sampled during INTEX-A
(Modeled Asian CO > 25-30 ppbv)

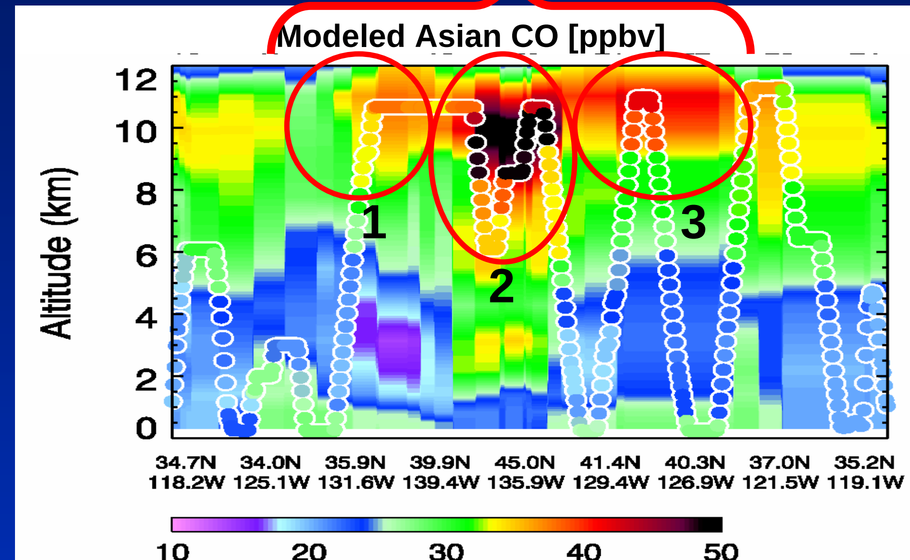


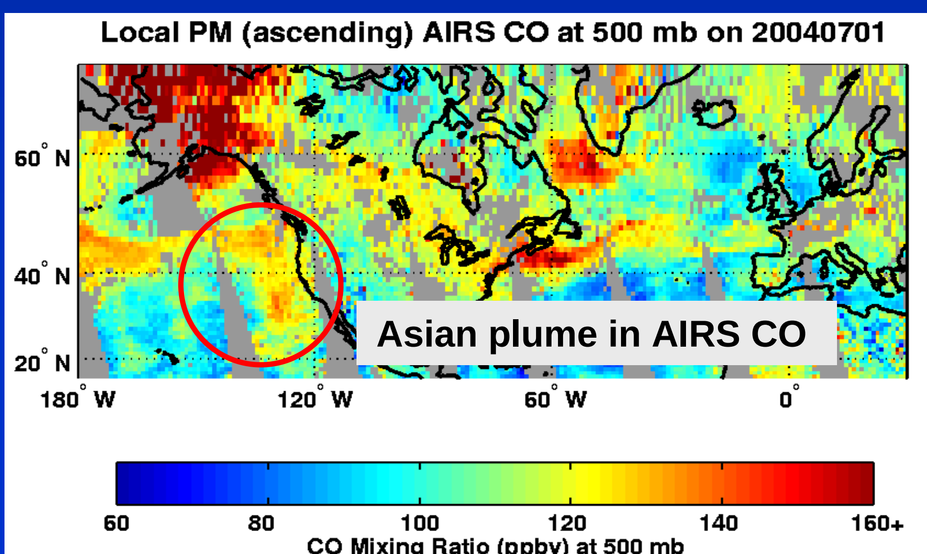
July 1, 2004: Rapid trans-Pacific transport in 3-5 days!

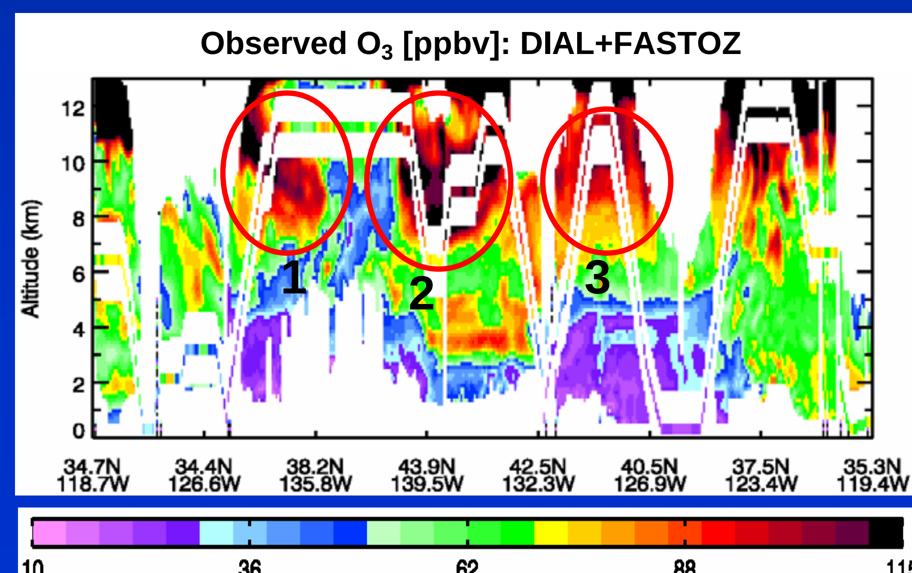
Asian plume intercepted 3 times



Asian Plume





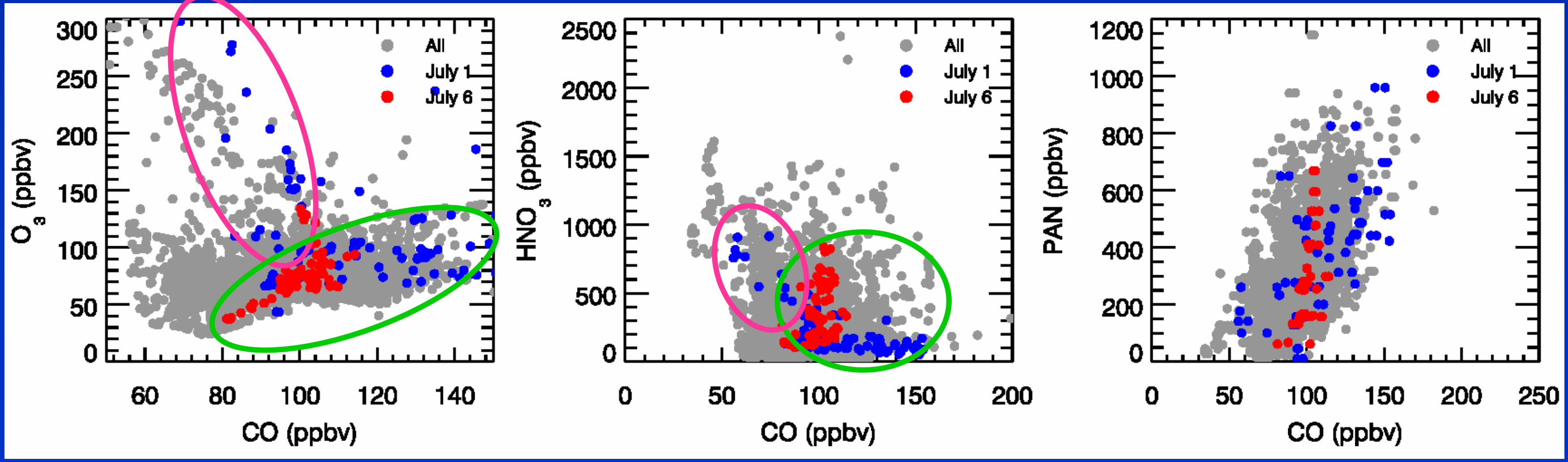


Chemical Composition of Asian Plumes

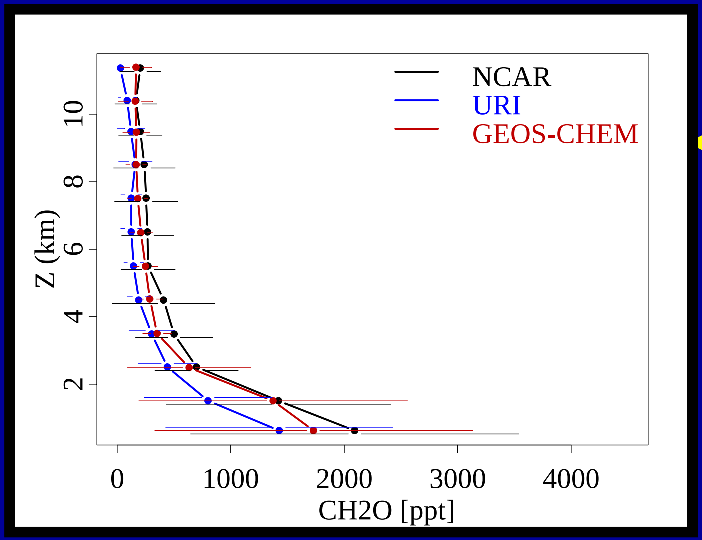
- **Asian Plumes** -- Model Asian CO > 25~30 ppbv
- **Background air** – Eliminate fresh convection, lightning, stratosphere, Alaskan fires

	Background	Asian Plumes	Observed Δ	Model Δ	July 1	July 1 Δ
CO, ppbv	94	113	+19	+6	108	+14
O_3, ppbv	69	92	+23	+13	101	+32
HNO_3, pptv	241	233	-8	+20	188	-53
PAN, pptv	302	399	+97	+4	316	+14
Acetylene, pptv	78	125	+47		129	+51
$SO_4^=$, pptv	86	86	0		119	+33

CO – O_3 CO – HNO_3 CO – PAN

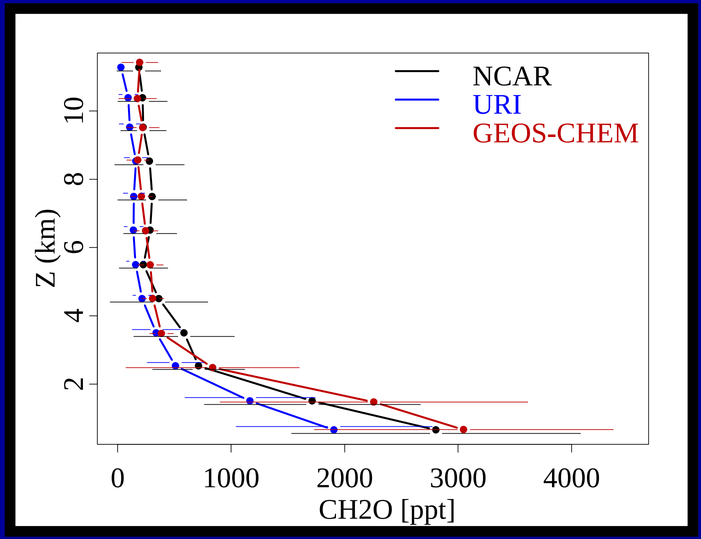


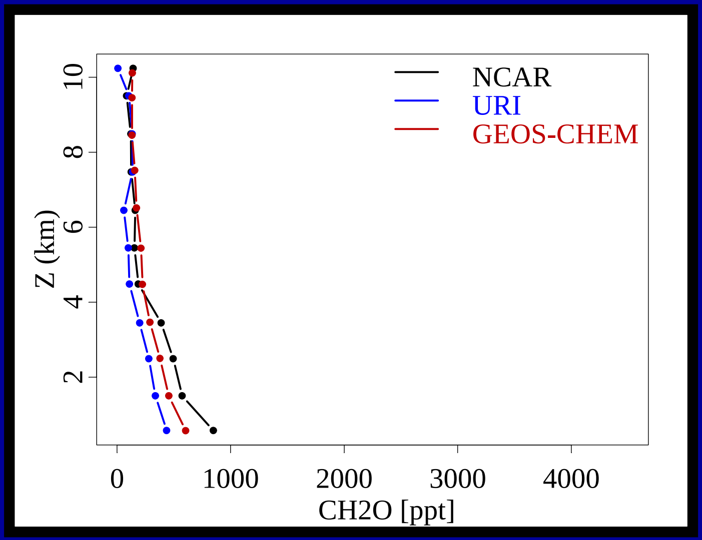
HCHO during ICARTT: implications for GOME/OMI



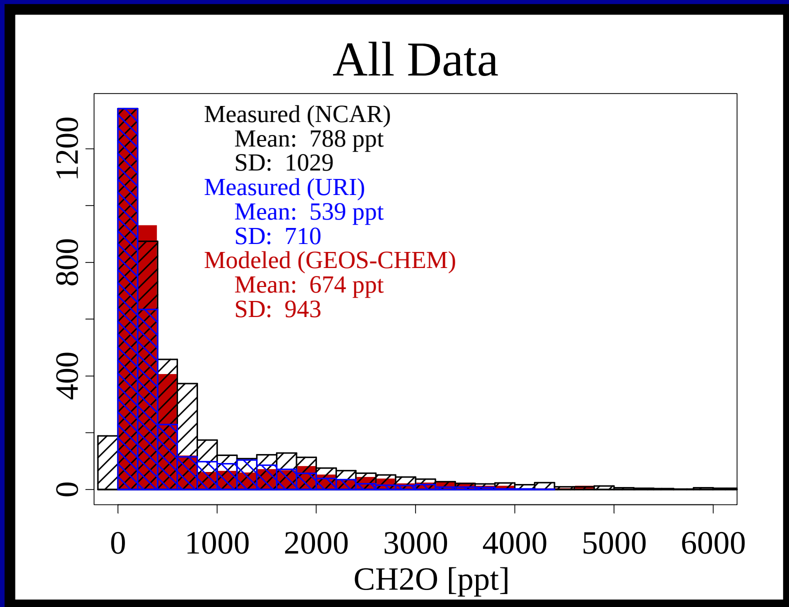
All profiles

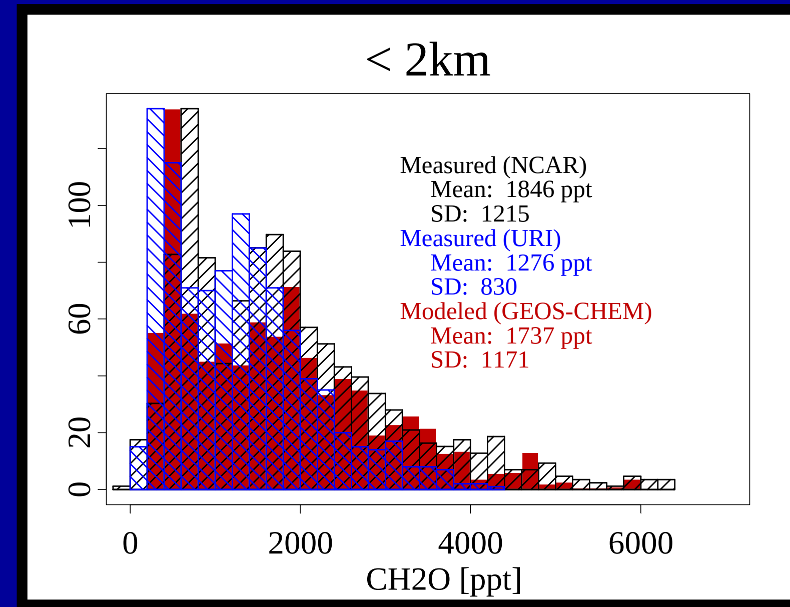
E. U.S.

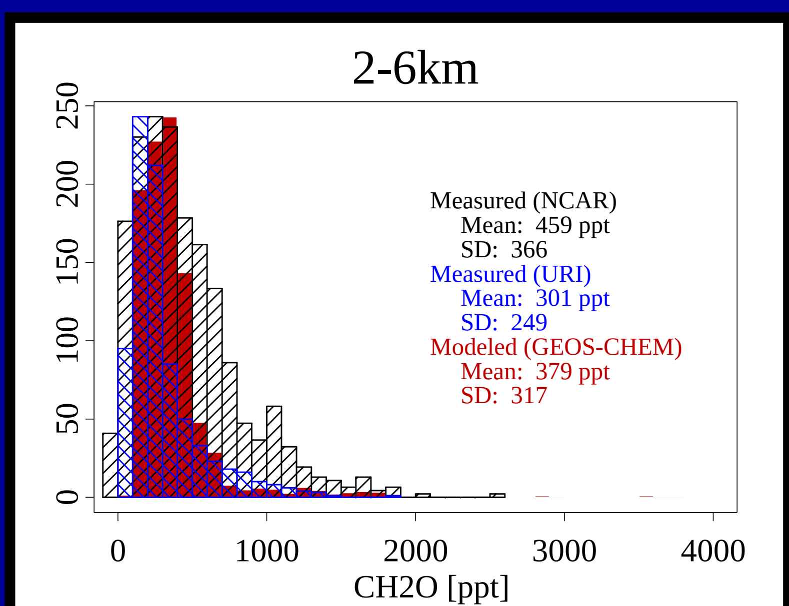


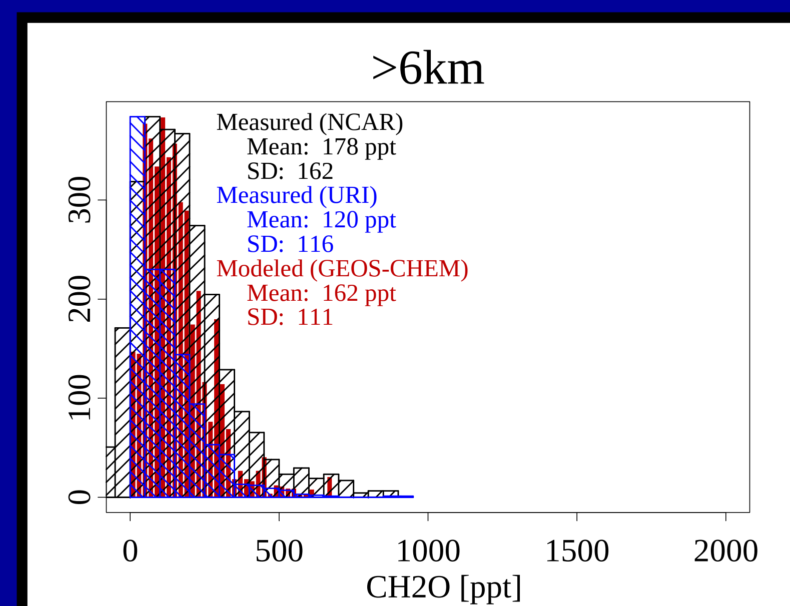


Atlantic


All Data
Measured (NCAR)
Mean: 788 ppt
SD: 1029
Measured (URI)
Mean: 539 ppt
SD: 710
Modeled (GEOS-CHEM)
Mean: 674 ppt
SD: 943
0
400
800
1200
0
1000
2000
3000
4000
5000
6000
CH2O [ppt]


< 2km
Measured (NCAR)
Mean: 1846 ppt
SD: 1215
Measured (URI)
Mean: 1276 ppt
SD: 830
Modeled (GEOS-CHEM)
Mean: 1737 ppt
SD: 1171
0
20
60
100
0
2000
4000
6000
CH2O [ppt]

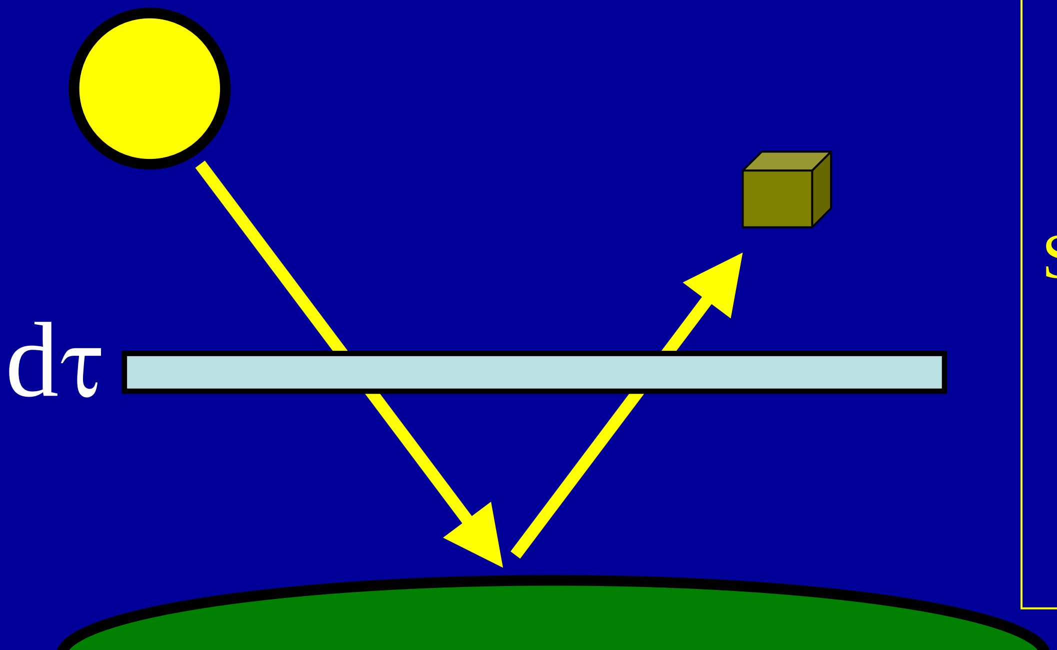

2-6km
Measured (NCAR)
Mean: 459 ppt
SD: 366
Measured (URI)
Mean: 301 ppt
SD: 249
Modeled (GEOS-CHEM)
Mean: 379 ppt
SD: 317
0
50
100
150
200
250
0
1000
2000
3000
4000
CH2O [ppt]


>6km
Measured (NCAR)
Mean: 178 ppt
SD: 162
Measured (URI)
Mean: 120 ppt
SD: 116
Modeled (GEOS-CHEM)
Mean: 162 ppt
SD: 111
0
100
200
300
0
500
1000
1500
2000
CH2O [ppt]

HCHO during ICARTT: implications for GOME/OMI

$$AMF = AMF_G \int_1^0 w(\sigma) S(\sigma) d\sigma$$

AMF: Slant column / vertical column



AMF_G: Geometric factor

$w(\sigma)$: Scattering weights

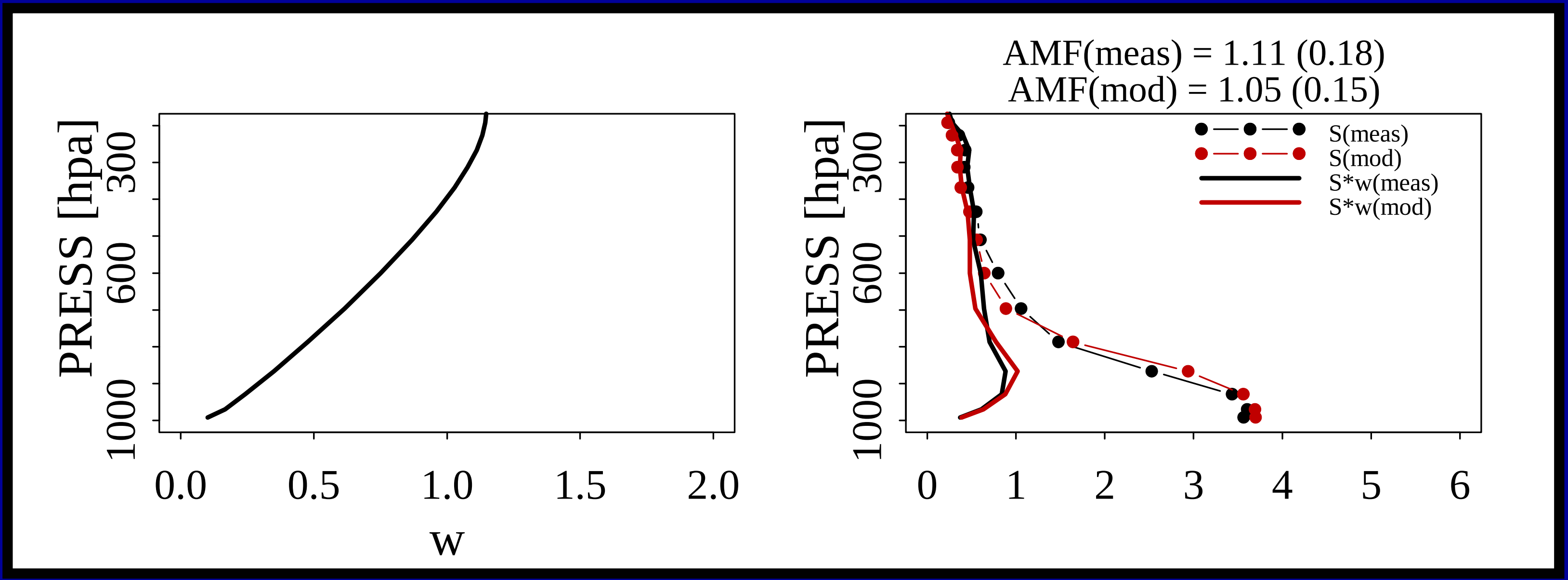
$\sim -\partial(\ln I_B) / \partial \tau$

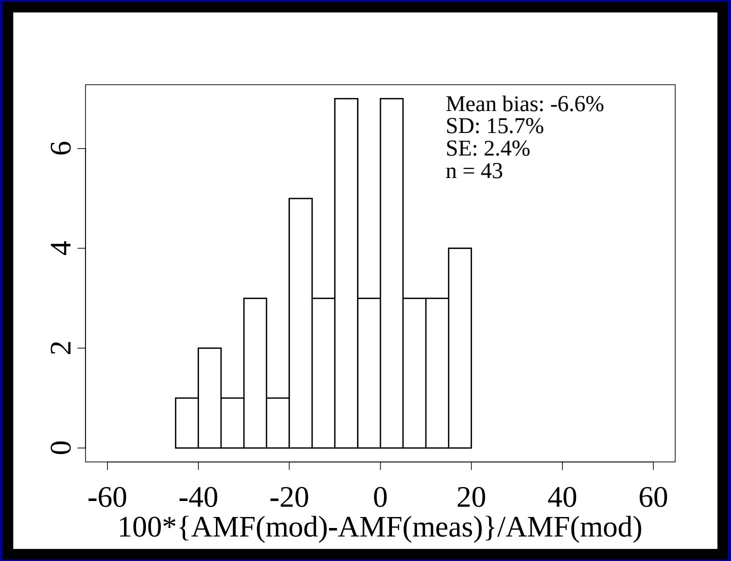
$S(\sigma)$: Shape factor

Normalized vertical distribution

From model

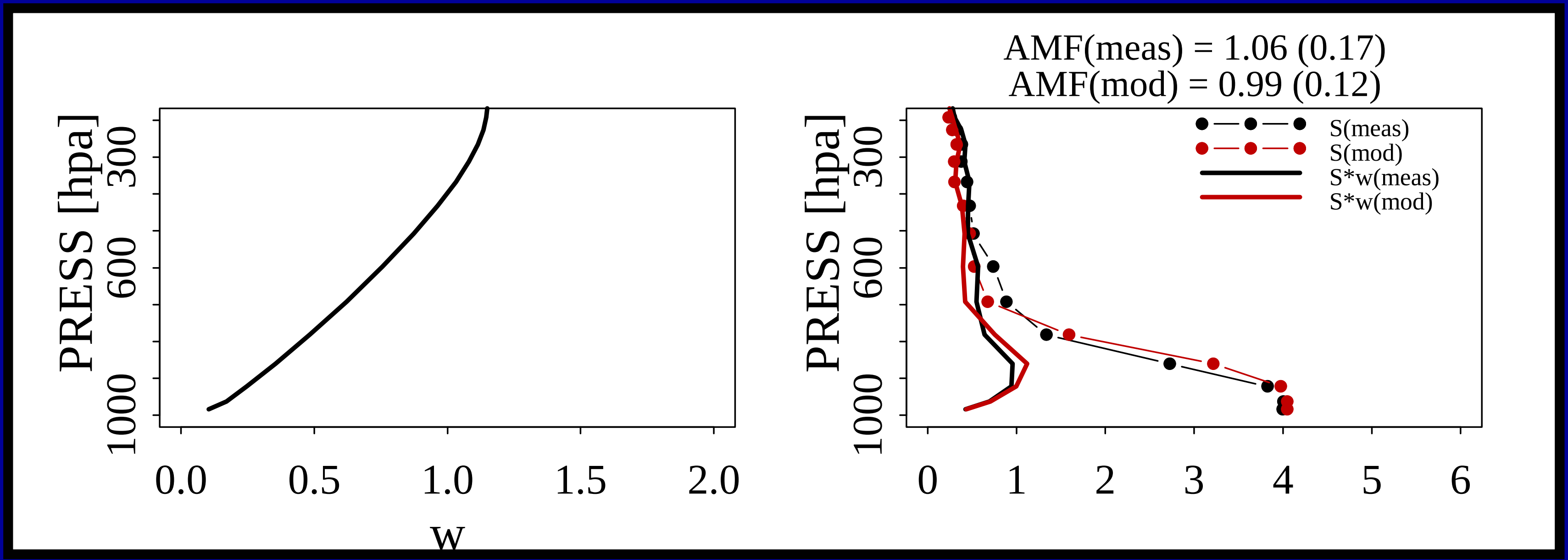
Clear Sky AMF Comparison
- all profiles -





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

Continental profiles:



Oceanic profiles: