Recent increases in Asian emissions and consequences for transpacific ozone pollution in the United States: Aura and INTEX-B observations

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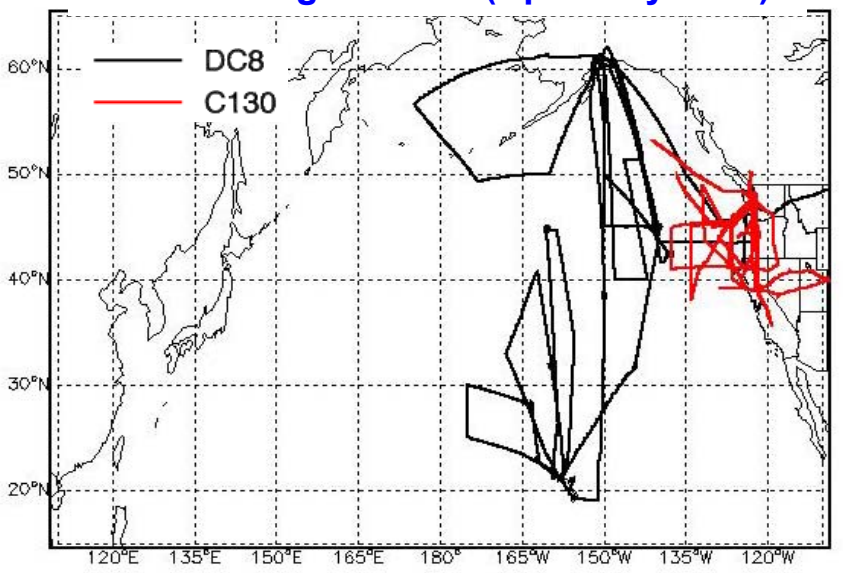
Aura Science Team Meeting
(Oct 4, 2007)

INTEX-B flight tracks (April-May 2006)

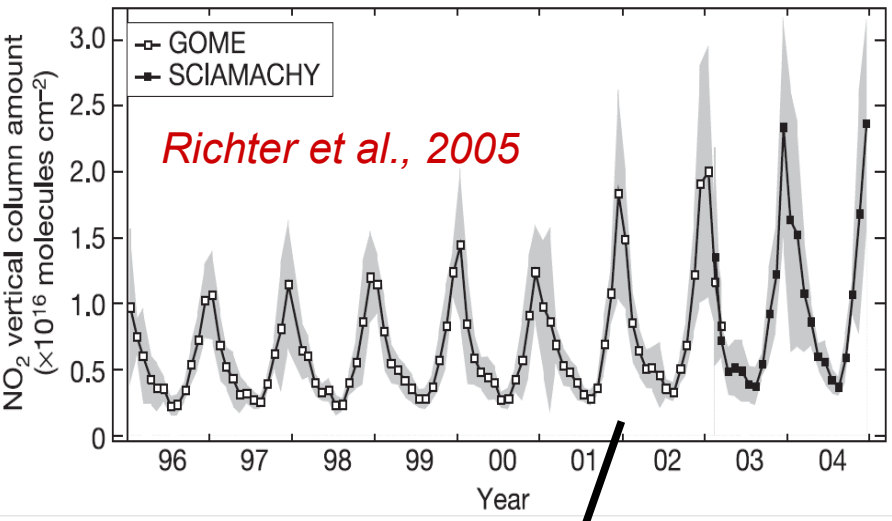


HARVARD UNIVERSITY
ATMOSPHERIC CHEMISTRY MODELING GROUP

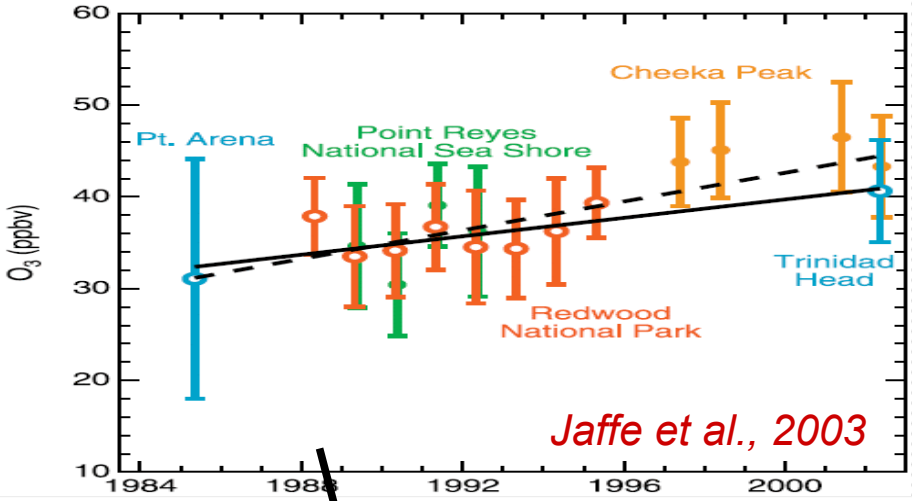
tes

Objective

NO_2 tropospheric columns over East China

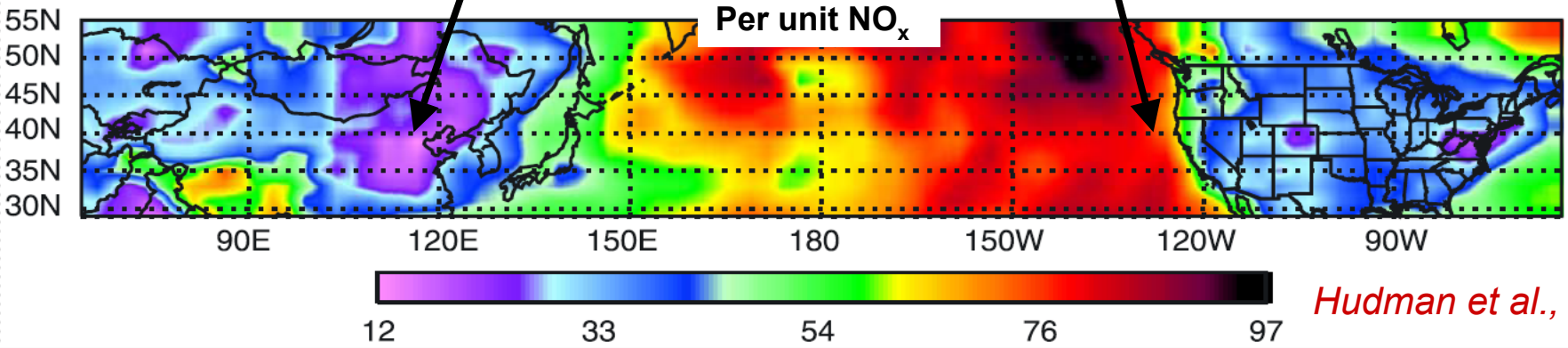


Spring background O_3 levels at MBL sites



Ozone Production Efficiency May 2002 (2-4 km mean)

Per unit NO_x



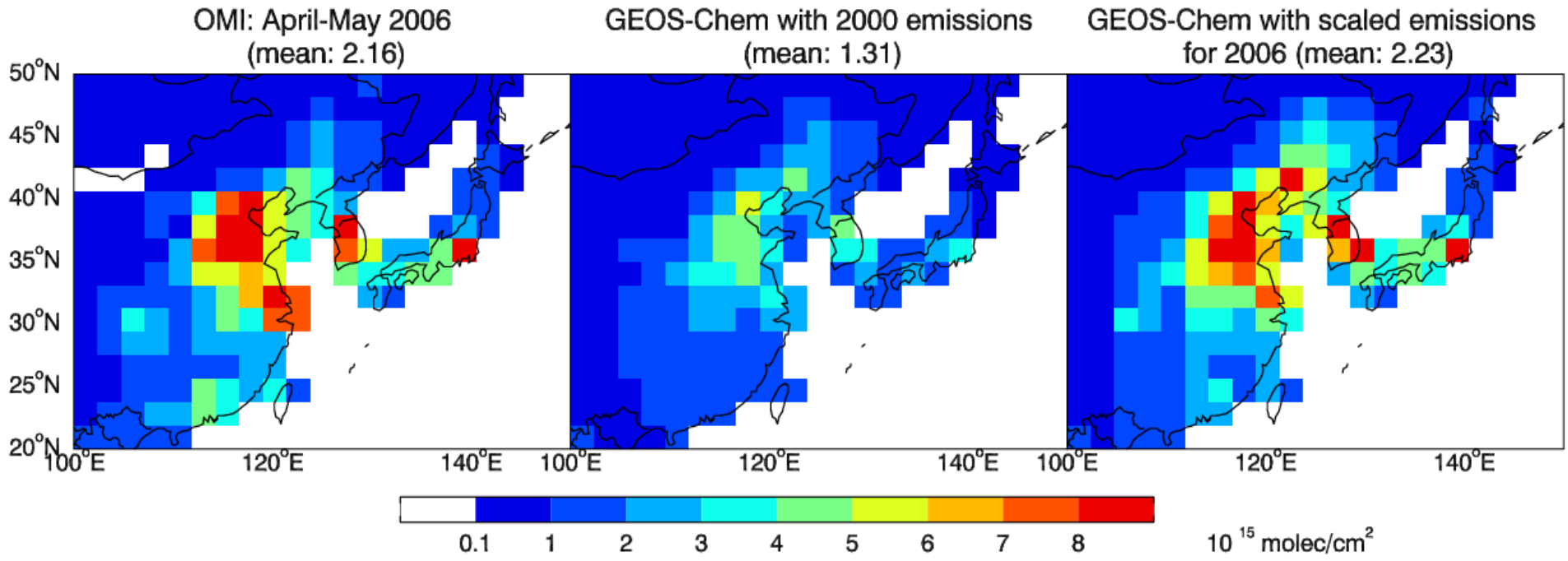
- Use observations from INTEX-B campaign for better understanding transport and chemical evolution of Asian plumes
- Assess the impact of rising Asian emissions on the U.S. surface ozone air quality

OMI NO_2 Tropospheric Column Compared with GEOS-Chem

Data from KNMI

Asian NO_x anthropogenic emissions for the year 2000 from Streets et al. [2003]

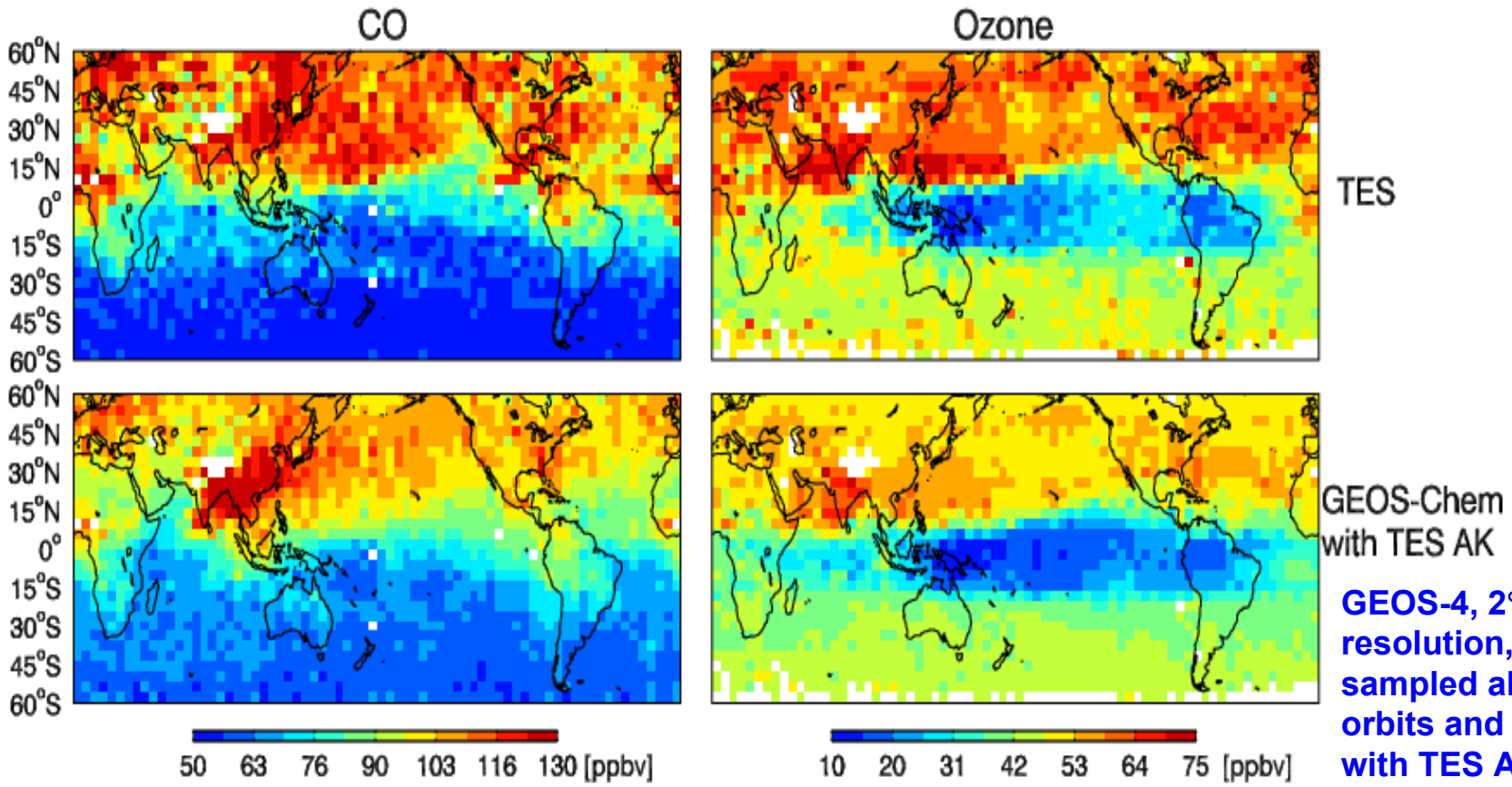
2 x 2000 Asian NO_x emissions



OMI NO_2 tropospheric column observations show a factor of 2 increase of Asian anthropogenic NO_x emissions from 2000 to 2006.

Mean ozone and CO concentrations at 618 hPa

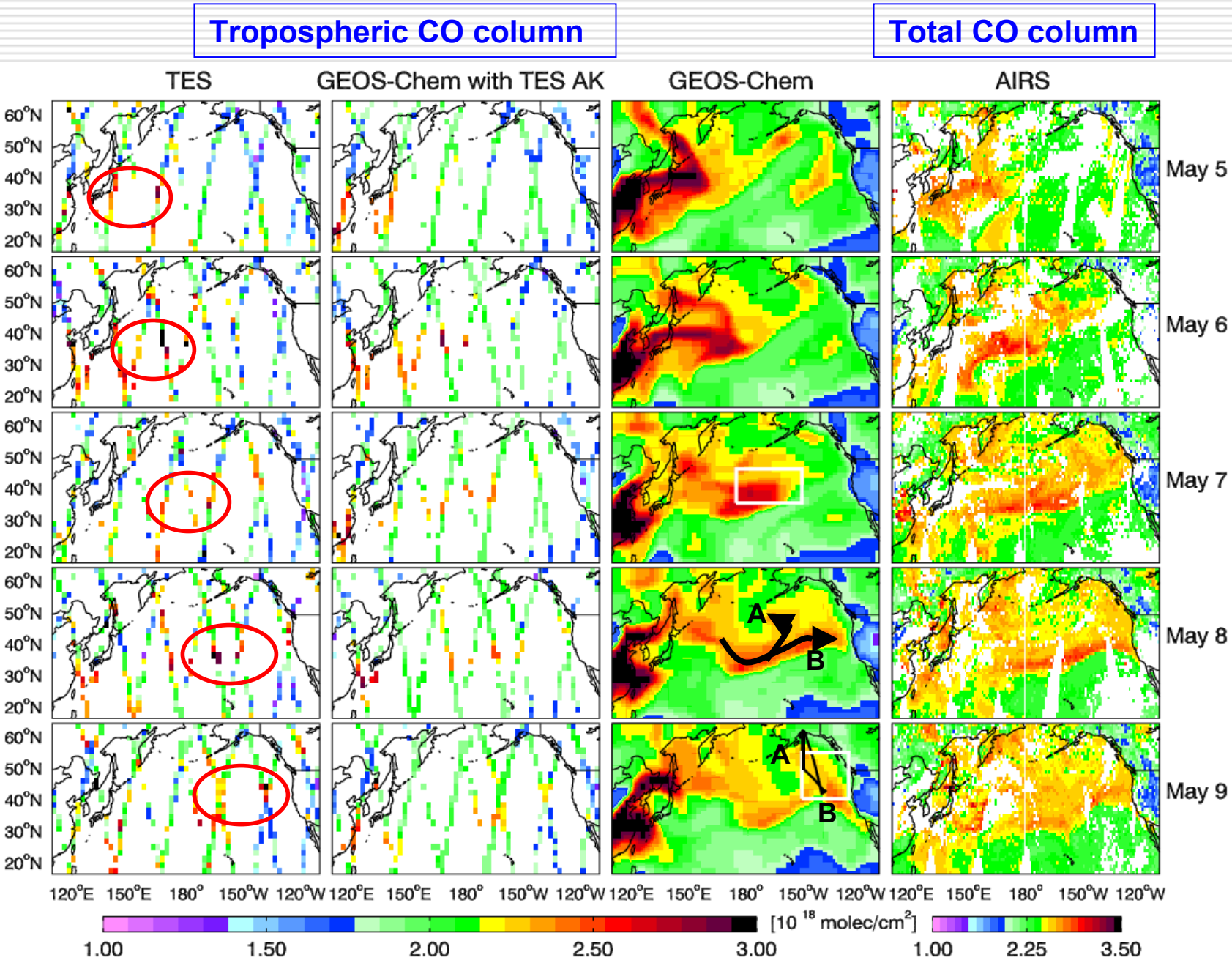
During INTEX-B (Apr 16 – May 15 2006), averaged in 4x5 grid cells



GEOS-4, 2° x2.5° resolution, sampled along TES orbits and applied with TES AK

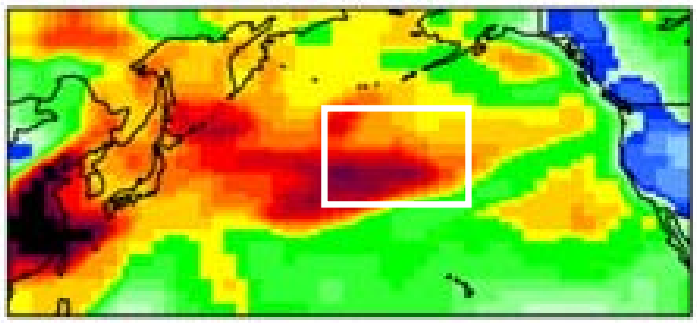
- TES
  CO: within 5% at 618 hPa (Luo et al. [2007])
  Ozone: 3-10 ppbv positive bias compared with sondes (Nassar et al. [2007])
- GEOS-Chem
  CO: 10% lower than INTEX-B DC-8 and C-130 measurements
  Ozone: agrees well with DC-8, but 5 ppbv lower than C-130 measurements

TES and AIRS Observations of a Transpacific Plume

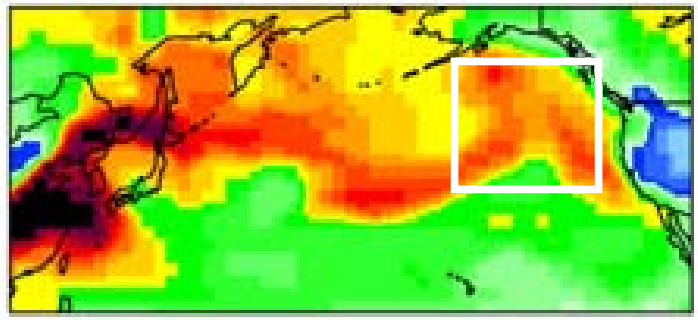


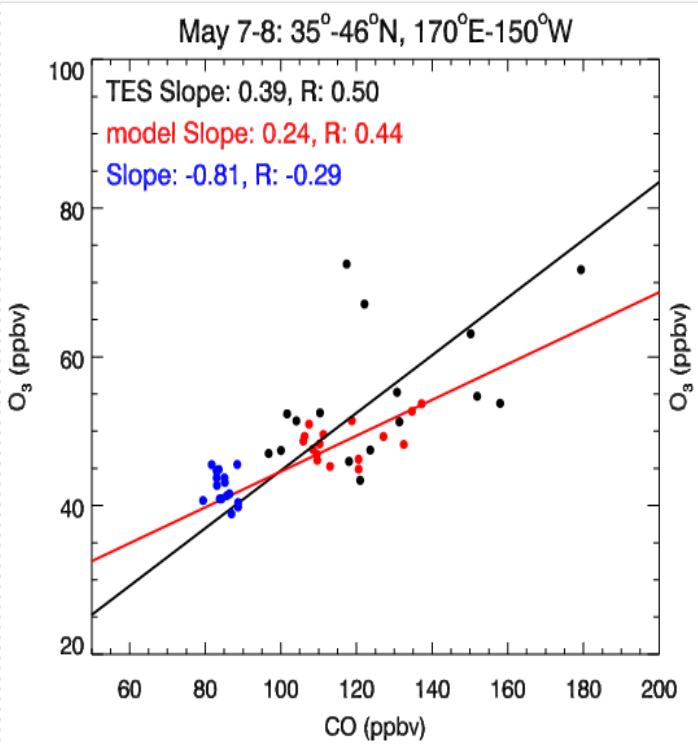
TES Observed O_3-CO Correlations at 680 hPa

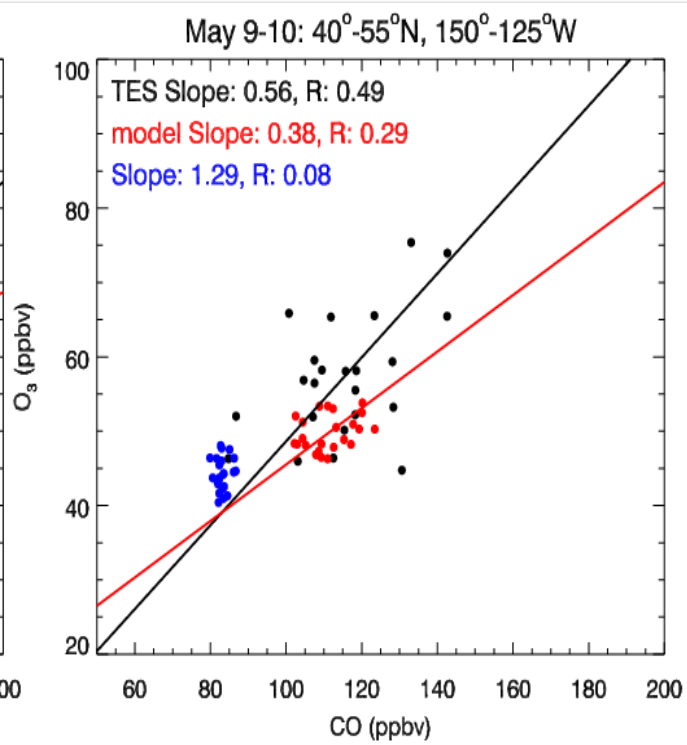
May 7

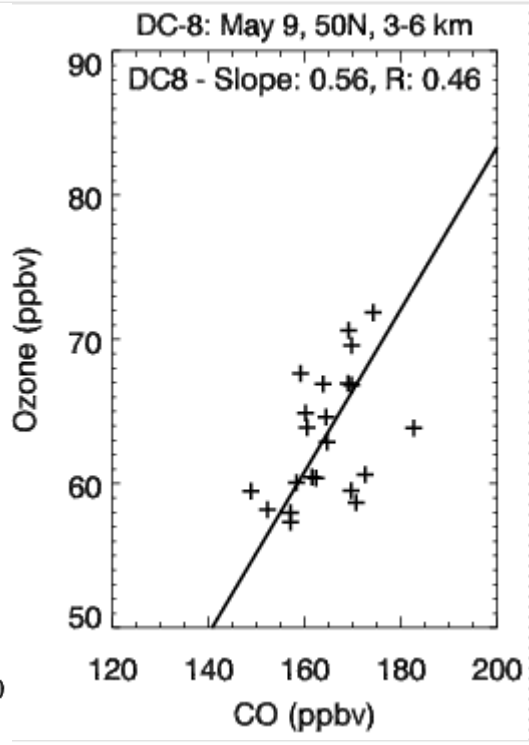


May 9









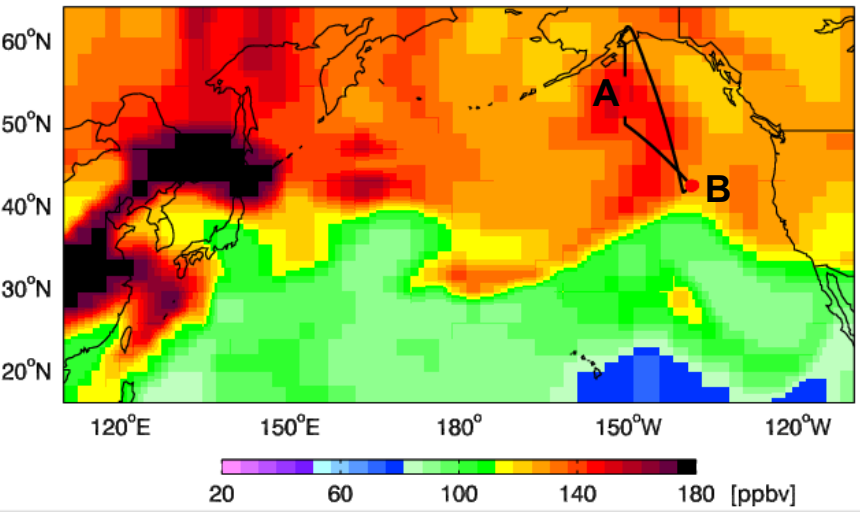
Observations

Model

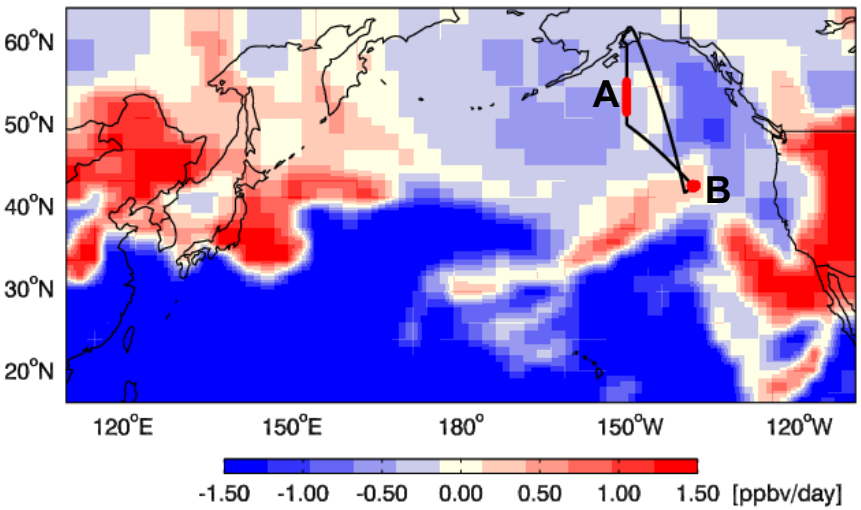
Model without Asian emissions

Aircraft Measured Transpacific Plume on May 9th

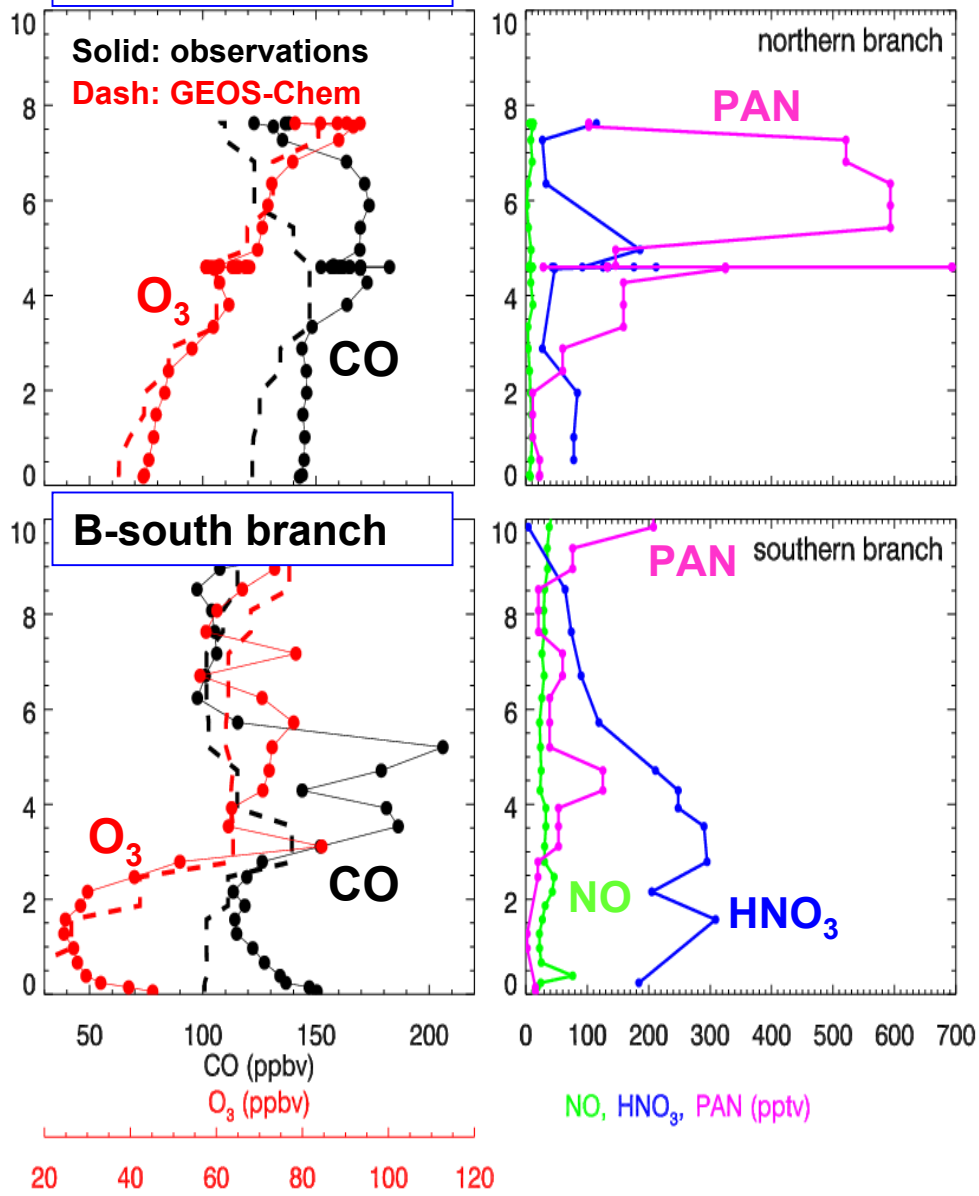
GEOS-Chem CO at 680 hPa on May 9



Simulated net ozone production at 680 hPa

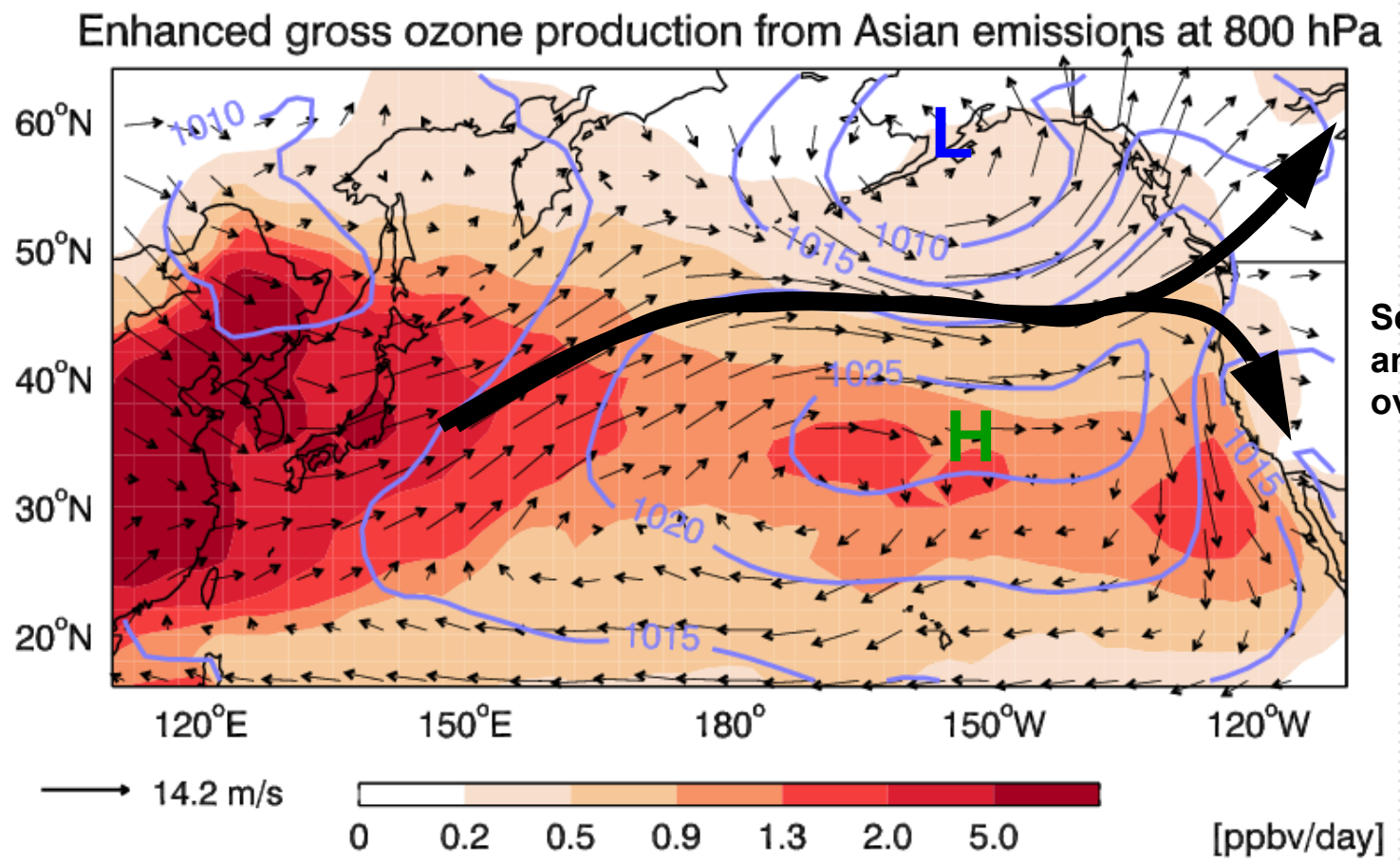


A-north branch



Ozone Production in Transpacific Plumes

Mean for the INTEX-B period (April 17-May 15, 2006)

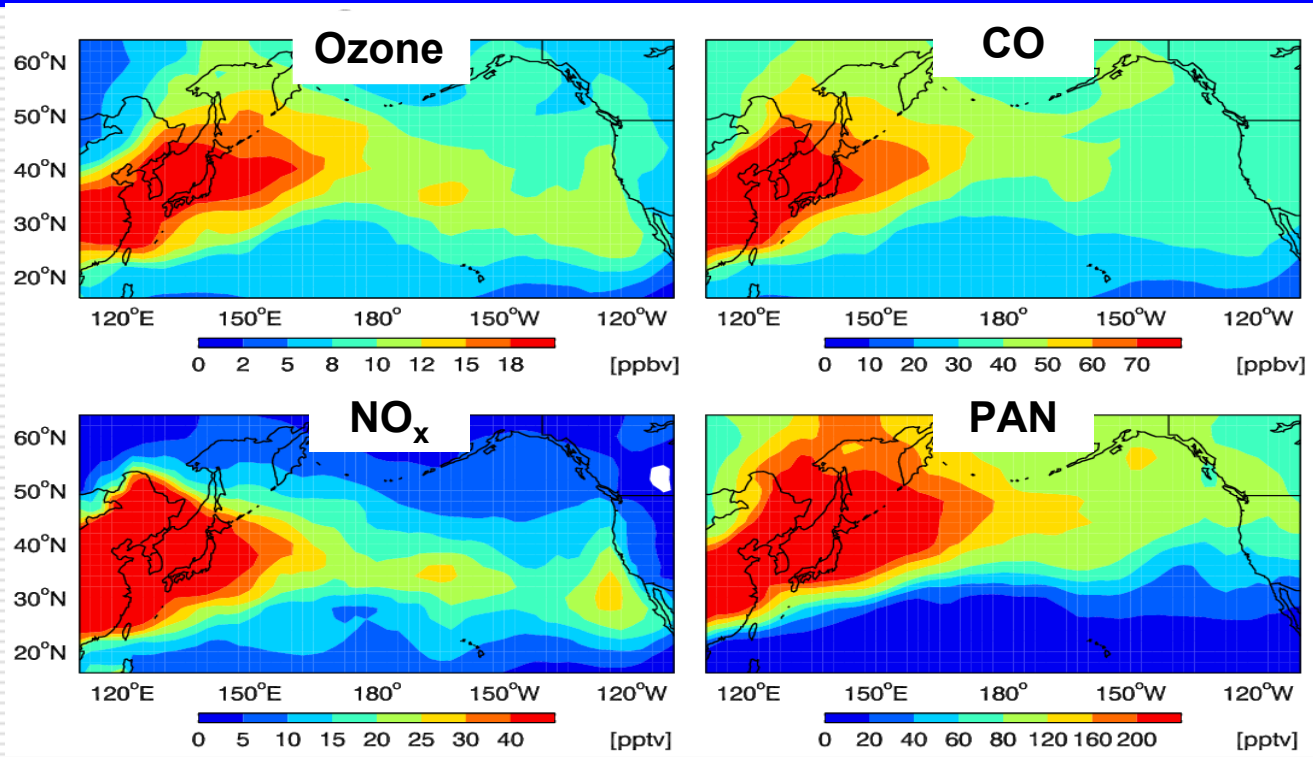


Sea level pressure and 800 hPa winds overplotted

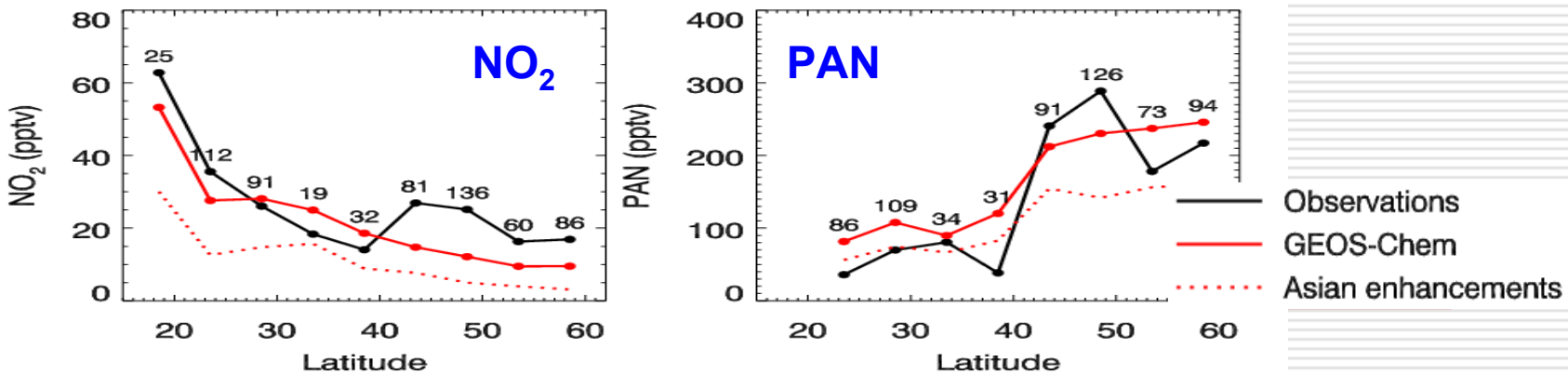
- Direct transport of Asian ozone produced in the boundary layer and continuous ozone formation over the Pacific
- Splitting of transpacific plumes over the northeast Pacific

Transport of Asian Ozone and its Precursors

The mean Asian ozone, CO, NOx, and PAN enhancements at 800 hPa for INTEX-B



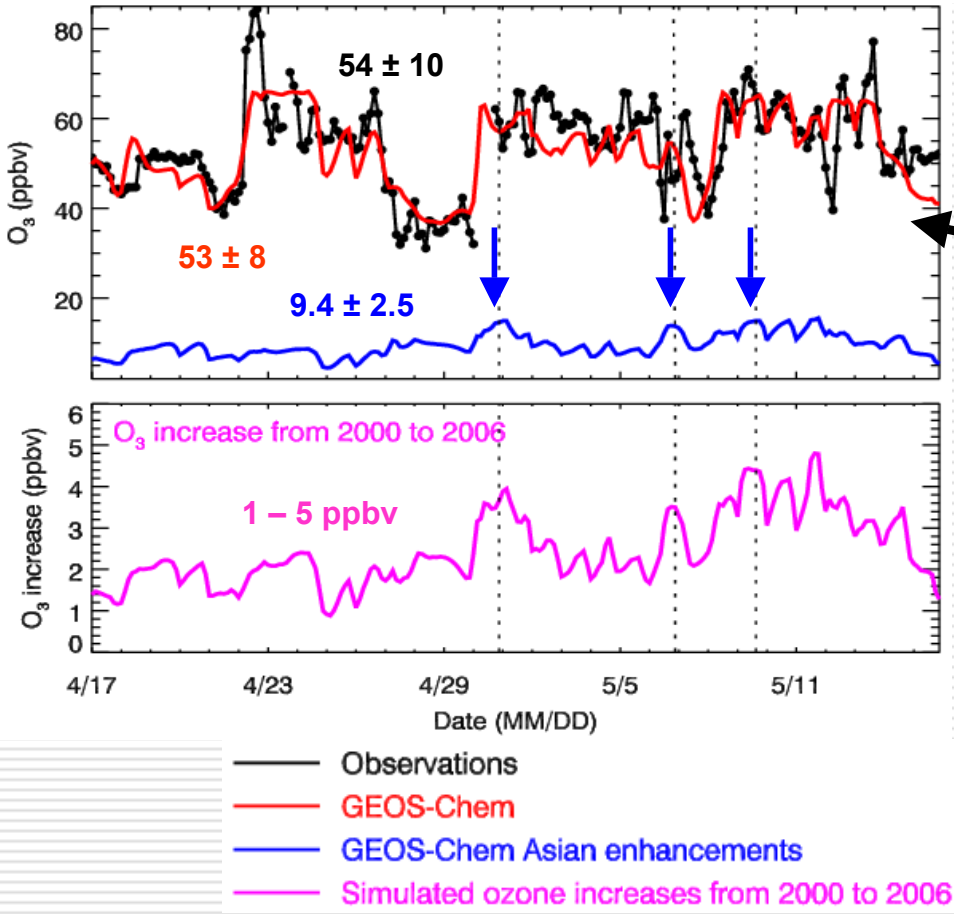
Latitudinal distribution of NO_2 and PAN at 1.5 -5 km



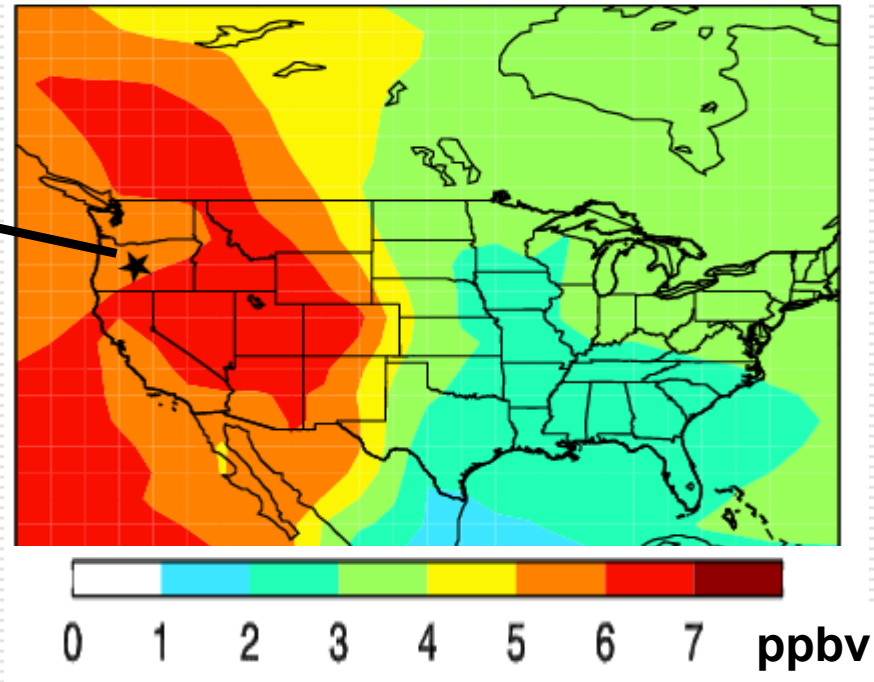
Impact of Rising Asian Emissions on Surface Ozone

Data from Dan Jaffe

O_3 measurements at Mt. Bachelor (44N, 122W, 2.7 km, in central Oregon)



Simulated mean Asian surface O_3 enhancement for INTEX-B



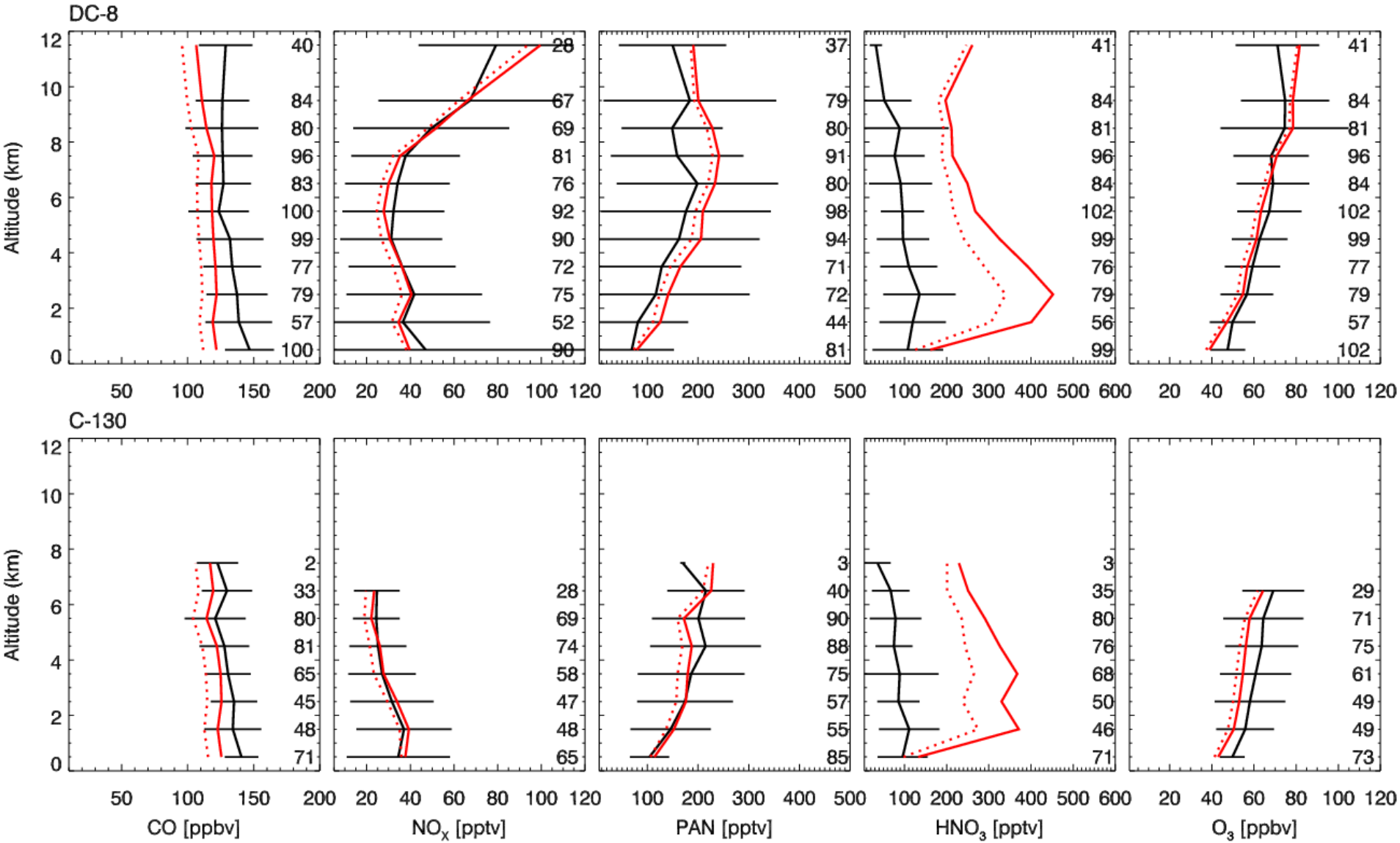
2000-2006 rise in Asian emissions has increased U.S. surface ozone by 1-2 ppbv in the West.

Summary

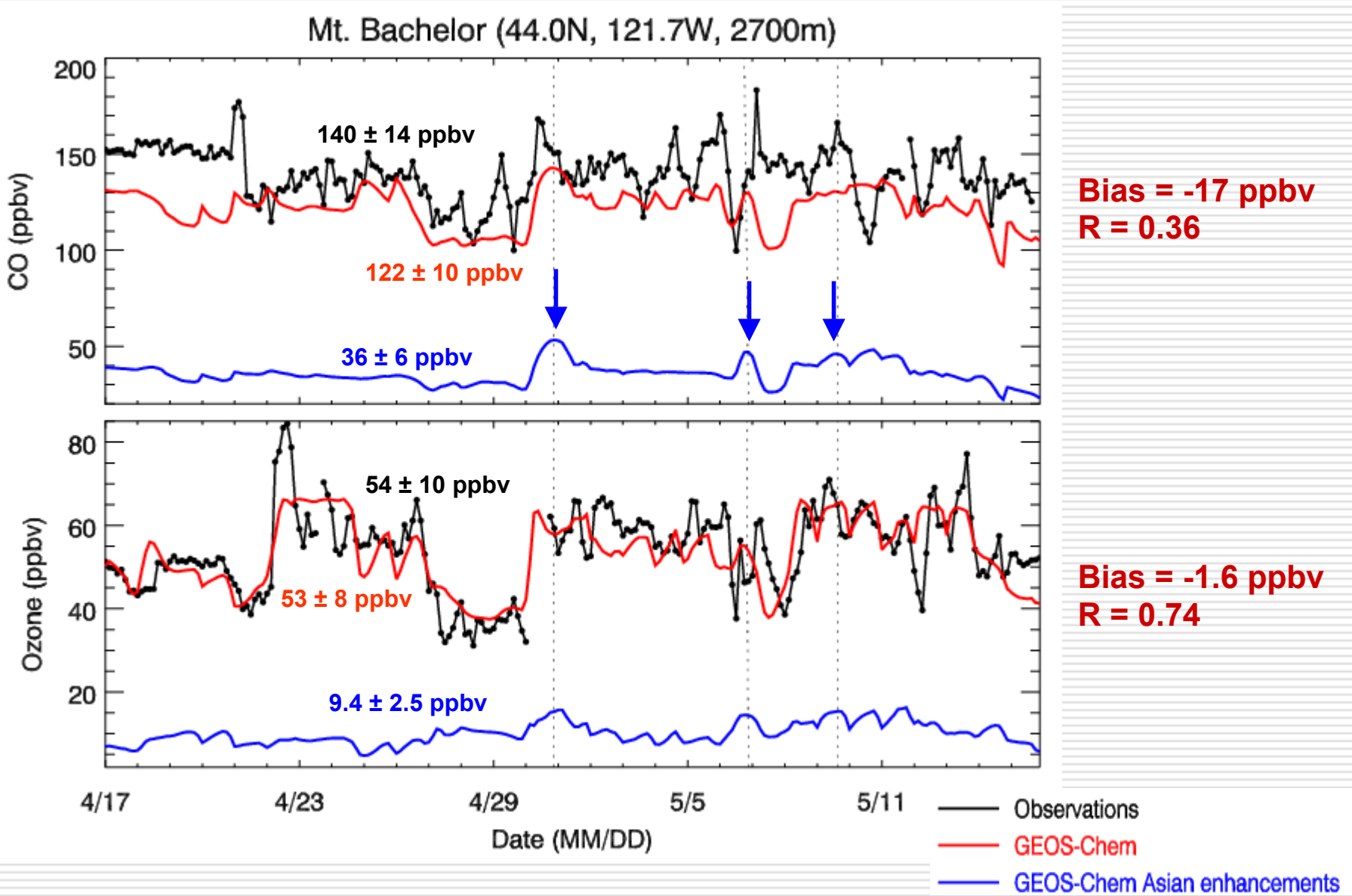
- OMI Tropospheric NO_2 column measurements show a factor of 2 increase in NO_x anthropogenic emissions over eastern Asia from 2000 to 2006.
- TES and aircraft are consistent in observing transpacific Asian plumes. TES allows visualization of the progression of plumes and tracking ozone pollution.
- Splitting of transpacific plumes often takes place over the northeast Pacific. Ozone production was observed in the southern branch driven by PAN decomposition.
- The doubling of Asian anthropogenic NO_x emissions from 2000 to 2006 increased surface ozone by 1-2 ppbv in the western United States. Rising Asian emissions increases the possibility to detect Asian ozone plumes at mountain sites such as MBO.

Extra

Comparisons of Mean Vertical Profiles for INTEX-B



Measurements at Mt. Bachelor (2.7 km)

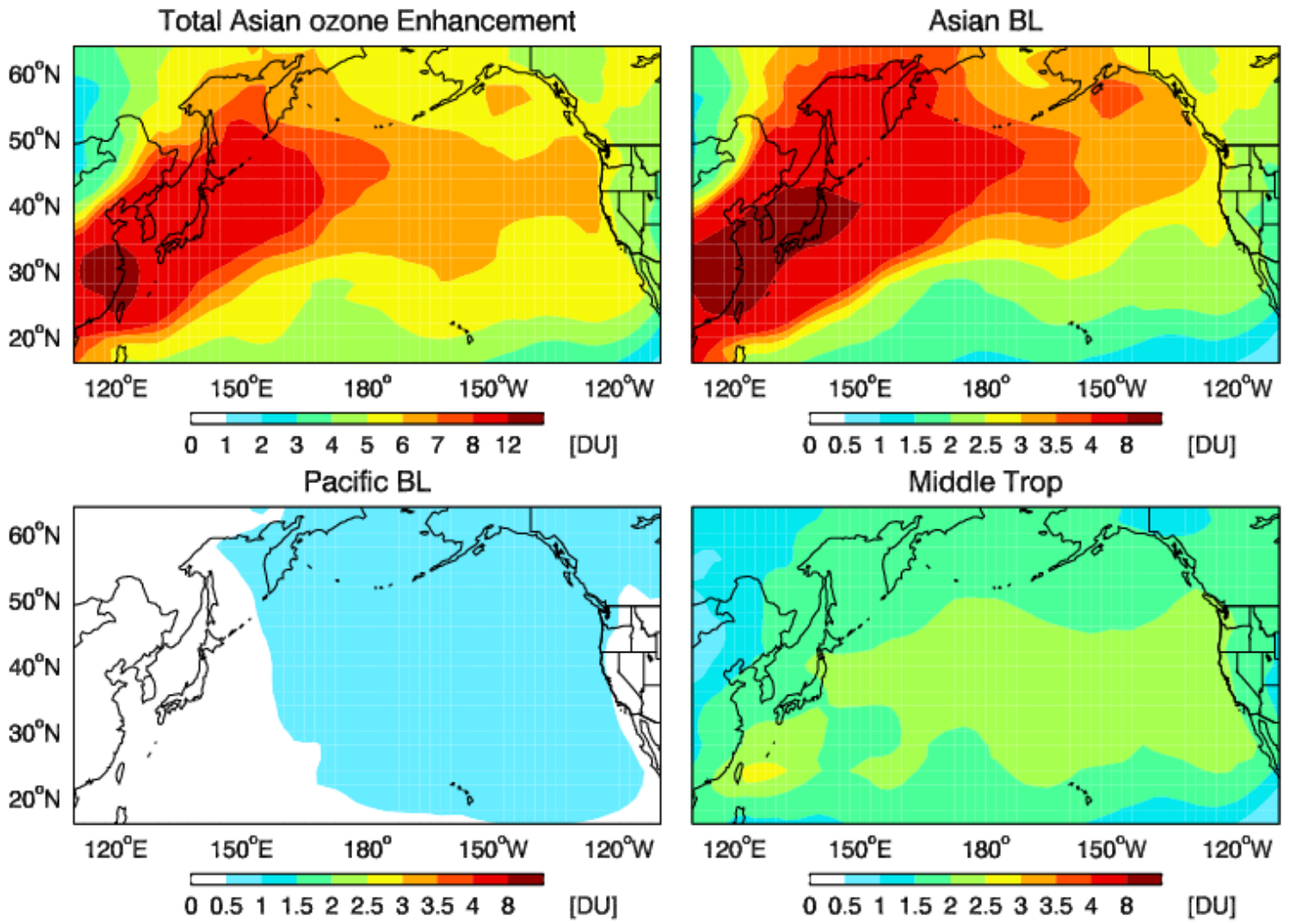


Bias = -17 ppbv
R = 0.36

Bias = -1.6 ppbv
R = 0.74

Model Simulated Asian Ozone Column Enhancement

for INTEX-B (Apr 16 – May 15 2006)



Asian emissions contribute 4- 7 DU ozone over the eastern Pacific and North America with 2- 3.5 DU produced in the Asian boundary layer and 1.5-2.5 DU in the middle troposphere.