Ozone production in transpacific Asian pollution plumes and implications for ozone air quality in California


Western Pacific AGU
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Intercontinental Transport and Chemical Transformation (ITCT-2K2) and Pacific Exploration of Asian Continental Emissions (PEACE-B): Overview

1) PEACE-B and ITCT-2K2 aircraft campaigns: April - May 2002

2) GEOS-CHEM, global 3-D model of tropospheric chemistry
3) MOPITT CO to track pollution across the Pacific

Our motivation: Examine the ozone production in transpacific Asian pollution plumes, and the implications for ozone air quality in California
**GEOS-CHEM vs. PEACE-B:**

*Comparison along the flight tracks*

**LEGEND**

- Data > 30 N
- Observations are averaged over model grid

- Observed: Solid
- Simulated: Dashed Red
- Asian FF: Dashed Green
- Asian BB: Dashed Blue

**CO:** Strong BL outflow
Secondary buldge above 5 km (WCB)

**NOy:** Strong BL outflow
No secondary buldge (HNO3 scavenged)

Prior estimates suggest 10 - 15% NOx exported as NOy, of which ~50% is exported as PAN
[Koike et al, 2003; Miyazaki et al., 2003]
NOAA ITCT-2K2: April-May 2002, Monterey Bay, CA

*Major Asian pollution plumes*

Primarily anthropogenic
Very different transport pathways

**MAY 5**

- CO
- PAN

**MAY 17**

- O3
- HNO3

May 5th
5-8 km
High CO,
Moderate ozone enhancement
High PAN

May 17th
2-4 km
High CO, Large Ozone enhancement
PAN → NOx → HNO3

Observational Estimate: 17 ppbv ozone produced from 320 pptv PAN
Ozone production efficiency per unit NOx consumed (OPE) ~50
PAN driven ozone production in subsiding transpacific pollution plumes

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

Stratospheric downwelling

Warm Conveyor Belt
10-15% NOx exported as NOy

PAN, moderate ozone enhancement

Subsidence

PAN → NOx → HNO3

OPE ~ 60–80

strong ozone enh. into dry region with strong insolation

NOx → HNO3

OPE ~ 5

PAN

Asia

U.S.
Asian contribution to Trinidad Head timeseries = 6 +/- 2 ppbv of total Ozone.

Why no plumes?

Analogy to dust: Aircraft and surface observations show an order of magnitude dilution between surface and free troposphere.

20 ppbv enhancement aloft is only a 2 ppbv enhancement at the surface
California mountain sites are particularly sensitive to Asian Ozone pollution:

*Observed 8-h ozone at Sequoia National Park (1800 m) in May 2002 vs. corresponding simulated (GEOS-CHEM) Asian pollution ozone enhancement.*

May 17 obs. Asian plume event in red

Asian enhancements are 6-10 ppbv during NAAQS exceedances; unlike at surface sites, Asian pollution influence is not minimum under high-ozone conditions!