Using AIRS observations to forecast Asian pollution and stratospheric intrusion events in western U.S. surface air

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Asian and stratospheric influences on high-O$_3$ events in western U.S. surface air

The policy challenges:
1) An ever-tightening ozone NAAQS
2) Screening of “exceptional events”
3) Developing forecasting tools

Current NAAQS
Future?

Observed
GFDL AM3 model
(~50 km)

O$_3$-Strat
(w/ e90 tropopause, Prather et al., 2011)

Asian

Lin et al., 2012a, JGR
Lin et al., 2012b, JGR

Boulder (~2 km a.s.l.), Colorado

Daily max 8-hr average O$_3$

April to June 2010

55.1±9.7  58.4±8.9  3.3±2.7  19.2±11.3

Lin et al., 2012b, JGR
Space-based indicators of daily-to-yearly variability in background ozone

AIRS CO and O$_3$ products (V5.2):
- Global coverage obtained twice daily ➔ Process studies of chemical evolution
- 2002-present (incl. several ENSO cycles) ➔ Examination of yearly variability

[Aumann et al., 2003; Susskind et al., 2003; Pan et al., 2007; McMillan et al., 2005, 2011; Warner et al., 2007, 2010]

Mean Asian and stratospheric contributions to U.S. surface O$_3$ in spring
Estimated by the GFDL AM3 model at ~50x50 km$^2$ resolution
Trans-Pacific Asian pollution plumes

The view from satellites
(AIRS CO columns, V5.2, Level 3)

→ GFDL AM3 model captures the interleaving structure of stratospheric (2-4 km) and Asian ozone (4-10 km)

→ How important is Asian influence in surface air?

Lin, et al., 2012a, JGR
Asian pollution contribution to high-O$_3$ episodes

Asian influence may confound efforts to attain tighter standards
Developing forecasting tools from AIRS daily CO products?

[Lin et al., 2012a, JGR]
Towards a predictive relationship: Correlations of daily AIRS CO and Asian influence on WUS surface ozone

Correlation of Asian O$_3$ at Grand Canyon NP with AIRS CO columns 2 days prior in May-June 2010

Enhancements in AIRS CO

Advanced warning of Asian impacts on surface O$_3$ episodes in WUS?

An unusually large tropopause fold over Southern California (May 23, 2010)

AIRS O₃ retrievals capture consistent dynamic features with PV, model and lidar measurements [see also Pan et al., 2007; Pittman et al., 2009; Wei et al., 2010]
AIRS $\text{O}_3$ retrievals capture upper dynamics conducive to deep stratospheric intrusions over the western U.S.

Western U.S. is prone to deep intrusions
$\Rightarrow$ Co-varying enhancements in UT/LS, lower trop, and surface $\text{O}_3$

Lin, et al., 2012b, JGR
Towards a predictive relationship: Correlations of daily AIRS UT/LS ozone and surface ozone

Correlation coefficient of AM3 O$_3$S and observed O$_3$ at CHA surface site, respectively, with AIRS 300 hPa O$_3$ at each 1°x1° grid using daily datasets from April-May in 2011.
Forecasting surface destinations of transported $O_3$-strat

Using daily datasets from April-June, 2003-2011

Developing regional indicators for different receptor sites?

Stronger potential for accurate prediction in ~1 day as to where the intrusion will reach the surface

AIRS $O_3$ variability ~5°x5° NW of a receptor site indicates incoming intrusions

Chiricahua NM, AZ

Great Basin NP, NV

Rocky Mtn NP, CO
The spatial pattern of correlations varies interannually: Links to ENSO in day-to-day progression

Correlation coefficient of AM3 surface O$_3$S at Grand Canyon NP with AIRS total O$_3$ at each 1°x1° grid, 0-3 days prior using datasets from April-June


La Niña years (2008, 2011)
Space-based indicators of daily-to-yearly variability in transported “background”

**Insights to processes controlling Western U.S. Air Quality:**

1) AIRS CO over NE Pacific indicates potential for Asian influence
2) AIRS O$_3$ over WUS indicates potential for stratospheric influence

**Potential AQ Applications:**

1) Public health alerts
2) Identify exceptional events
3) Chemical data assimilation

**Moving Forward:**

1) Towards a quantitative relationship, e.g. $\Delta$O$_3$ variability?
2) Exploration of other products, e.g. Aura (OMI/MLS), AIRS V6, IASI?

*Thank you! (Meiyun.Lin@noaa.gov)*
Additional slides for Q&A
For some results presented, see also:


**Correlations of daily OMI ozone and surface ozone**

**Potential AQ Applications:**
- Screening of “exceptional events”...combined with suborbital observations
- Advanced warning of regional high $O_3$-Strat events with a lead time of ~1-3 days (more skill in 1 day)
- Qualitatively promising ...ongoing work for a quantitative relationship ($\triangle O_3$)
- Utility of other Aura ozone products, e.g. MLS and TES?

*For discussion, please contact Meiyun.Lin@noaa.gov*