Profiles and Trends of Tropospheric Ozone

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Ozone profile from Houston, Texas in August 2006 obtained with an ozonesonde.

The polluted boundary layer is thin in relationship to the rest of the atmosphere.
What is the relationship between tropospheric ozone and air quality?

- Air quality is usually associated with ground level ozone.
- Ozone measured at a particular site may have contributions from several sources.
  1. Ozone formed photochemically relatively nearby from emitted ozone precursors.
  2. Ozone formed regionally and transported to the site.
  3. **Long-range transport for 1,000s of miles.**
  4. Ozone from higher altitudes from natural sources such as lightning and the stratosphere.
Ozone sources: stratospheric injection, local production, lightning, and long-range transport

- **Narragansett, RI**
  - Stratospheric air, 245 ppb
  - Top of boundary layer

- **Houston, TX**
  - Lightning, 25 ppb

- **Hilo, HI**
  - Transport Layer from S.E. Asia, 115 ppb
  - Local production, 120 ppb

Cooper et al., J.G.R., 2007
illustrating large variability with time and altitude
O$_3$, CO, absorption and scattering showing influence of Biomass burning in SE Asia and transport to Hawaii.

Ozone

Carbon Monoxide

Aerosol Absorption

Aerosol Scattering
What do we know about long term changes in tropospheric ozone and their relation to air quality?

• It is expected that the largest impact on tropospheric ozone changes comes from emission of ozone precursors.

• At some locations this might be from precursors emitted long distances away (e.g. east Asian emissions on the U.S.)

• Ozone measured at a particular site may have contributions from several sources.

• What are some examples of records showing changes in tropospheric ozone?
Changes in **US** ozone and NO$_2$ an important ozone precursor showing a **decline** in NO$_2$ emissions and a small **decline** in high ozone: 1980-2006.

Source - http://www.epa.gov/airtrends/

**NO$_2$ Air Quality, 1980 – 2006**
(Based on Annual Arithmetic Average)
National Trend based on 87 Sites

**Ozone Air Quality, 1980 – 2006**
(Based on Annual 4th Maximum 8-Hour Average)
National Trend based on 287 Sites

**US: 87 Sites, 1980-2006**
1980 to 2006: 41% decrease in National Average

**US: 287 sites, 1980-2006**
1980 to 2006: 21% decrease in National Average
West Coast surface ozone and Trinidad Head ozonesonde profiles

10-day back trajectories to Trinidad Head, CA on days in April 2003 when ozone was ≥50 ppb. Air was generally from off Asia.

Trinidad Head, CA 3-6 km layer ozonesonde data

11 years of data

Yreka, CA surface ozone

27 years of data
Decadal air flow patterns to Hawaii influence ozone.

Trends from long term surface ozone and ozonesonde measurements in the N.H. and S.H.

SIGNIFICANCE: There is no single pattern of change.
Emissions of NO\textsubscript{x} ozone precursors are rising in Asia and are predicted to continue.

Summary

• Long-term tropospheric ozone changes on a global basis show no hemisphere scale patterns.

• A variety of processes contribute to both the geographic distribution and vertical structure of longer-term O$_3$ changes.

• Tropospheric ozone increases may have slowed or reversed at locations where precursor emissions have declined (U.S. and Europe).

• The influence of Asian precursor emissions on tropospheric ozone on the west coast of the U.S. is still not clear.
Thank You For Your Time