10. Los Angeles Smog

- History of LA Smog
- Main components of LA Smog
- London vs. LA Smog
- Emissions of primary pollutants
- Smog chemistry
- Particles / Visibility
- Environmental and Health Effects
- Politics / the future

History of LA Smog

1943: First recognized smog episode called "gas-attack"
Visibility ~ 3 Blocks
people suffer from discomfort, nausea, vomiting

1945: LA begins air pollution control program

1950: Public electric transit systems are replaced with buses

1952: Dr. Arie Haagen-Smit discovers the causes of photochemical (LA) smog

History of LA Smog

1956: Highway act starts increased highway construction

1963: First federal clean air act defines "air quality"

1965: Reliable ozone measurements in LA start
max. 1-hour average ozone m.r.: 580 ppbv

1966: Auto tailpipe emission standards for CO and hydrocarbons are adopted in CA

1968: California Air Resources Board (CARB) funded

1970: US Environmental Protection Agency (EPA) funded

History of LA smog

1971: Air quality standards defined (O_3: 120ppbv)
LA had 580 ppbv ozone!

1975: Two way catalytic converters come in use
LA exceeds Stage 1 smog alerts (O_3 above 200 ppbv), 118 days per year!

1984: California Smog check program starts

1985: Ozone maximum in LA: 390ppbv
LA exceeds Stage 1 smog alerts 118 days per year!

1995: Ozone maximum in LA: 0.26ppbv
LA exceeds Stage 1 smog alerts 14 days per year!

Main Components of LA Smog

Primary Pollutants: (pollutants that are directly emitted)

NO (and NO_2): emitted by combustion sources
i.e. cars, power plants

CO: emitted by combustion sources

Hydrocarbons (HC, VOC) or
Reactive Hydrocarbons (RH, ROG):
emitted by industry, cars, plants

Main Components of LA Smog

Secondary Pollutants: (pollutants that are formed chemically)

Ozone and Particles:
VOC + NO + sunlight
$\rightarrow\ldots\rightarrow$ ozone + NO_2
$\rightarrow\ldots\rightarrow$ particles

Health Effects of O_3

ppmv

0.02 Odor threshold (acrid/sweet smell)

0.10 Nose/throat irritation in sensitive people

0.30 Nose/throat irritation in most people

1.0 Airway resistance; headache; sleep difficulties

Los Angeles vs. London Smog

	London	LA
Primary Pollutant	SO_2, soot particles	CO, HC, NO_x
Secondary Poll.	H_2SO_4, acid droplets	O_3,particles
Temp.	cool	warm
Inversion	radiation	subsidence, marine
Time of pollutant peak	morning	afternoon

Carbon Monoxide (CO)

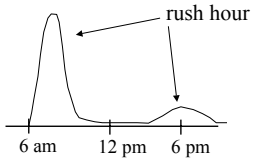
Emitted by combustion engines under oxygen poor condition (fat burning)

Catalytic converter reduces CO emissions

Fate of CO: $CO + OH \rightarrow CO_2 + H$

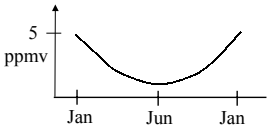
residence time: days - weeks

CO Concentration Pattern



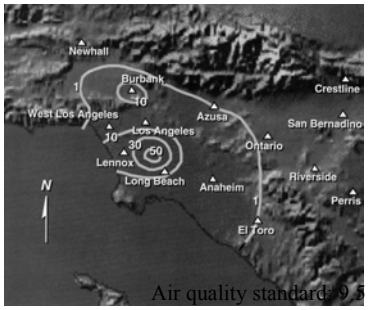
inversion lower in the morning

wind stronger in the evening



inversions lower in winter

CO Distribution (ppmv)



Air quality standard: 9.5 ppmv

Nitrogen Oxides: NO and NO_2

$N_2 + O_2 + \text{heat} \rightarrow NO + NO$

very hot temperatures are needed as, for example, found in engines

$NO + O_3 \rightarrow NO_2 + O_2$

NO (nitric oxide): natural m.r. ~ 25pptv

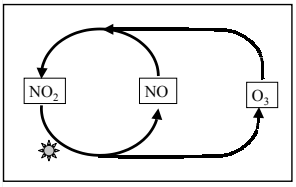
NO_2 (nitrogen dioxide): natural m.r. ~ 25pptv

NO/NO_2 Chemistry

$NO_2 + h\nu\ (UV) \rightarrow O + NO$

$O_2 + O \rightarrow O_3$ (very fast)

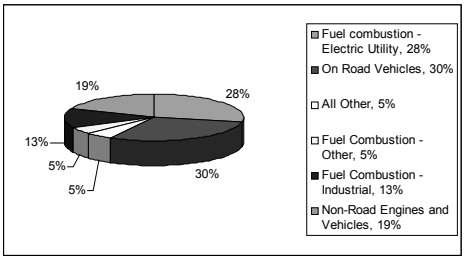
Net : $NO_2 + O_2 + h\nu \rightarrow O_3 + NO$



NO, NO_2, and O_3 get converted into each other continuously during the day. Length of time for conversion is around 1 minute

$NO_x = NO + NO_2$

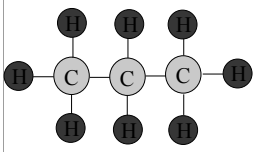
NO_x emissions



NOx in LA

Turco figure 6.6

Hydrocarbons (HC)

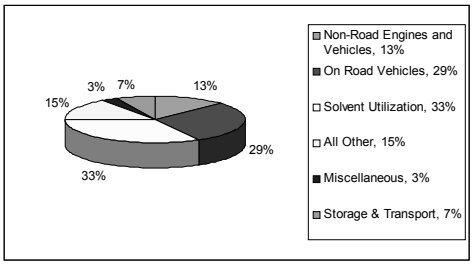


Gases that mainly consist of carbon and hydrogen atoms

There are thousands of different HC in the atmosphere

Sources: Plants (i.e. pine smell),
Sovents (i.e. acetone),
Fuel fumes (i.e. benzene)
unburned fuel

Anthropogenic HC Emissions



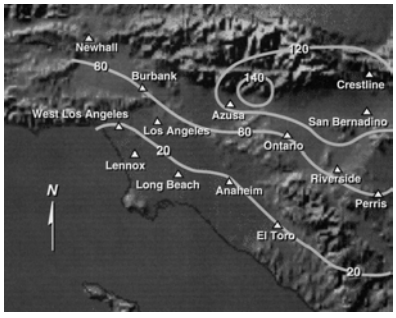
Ozone

Ozone in the troposphere: (do not confuse with stratospheric ozone!)

Natural levels of O_3 on the ground:

Paris in 1870:	10 - 20 ppbv
Today in remote location:	30 - 40ppbv
LA 1970's :	up to 600 ppbv
LA today:	up to 150 ppbv

Ozone Distribution



Diurnal Pollutant Variations