URBAN AIR QUALITY

GEOG/ENST 3331 – Lecture 13

A&B: Chapter 14; Turco: Chapter 6

Opportunity: Climate Panel

February 23: The Ecofiscal Commission will hold a live-stream event “to dig into the challenges and solutions of coordinating federal and provincial government climate policies”

Moderator: Chris Ragan: Chair of Canada's Ecofiscal Commission and McGill University, Department of Economics

Expert Panel Members

- Paul Boothe: Director, Lawrence National Centre for Policy & Management, Western University
- Stewart Elgie: Professor of law and economics, University of Ottawa, and director of the interdisciplinary Environment Institute
- Kathryn Harrison: Professor of Political Science, UBC
- Jennifer Winter: Associate Director, Energy and Environmental Policy, Asst. Professor, The School of Public Policy, University of Calgary

Federal and provincial ministers will be meeting on March 3rd to discuss how best to move forward with coherent climate policies.

Urban air quality

- Acid smog
- Photochemical smog
- Particulate matter
- Mitigation

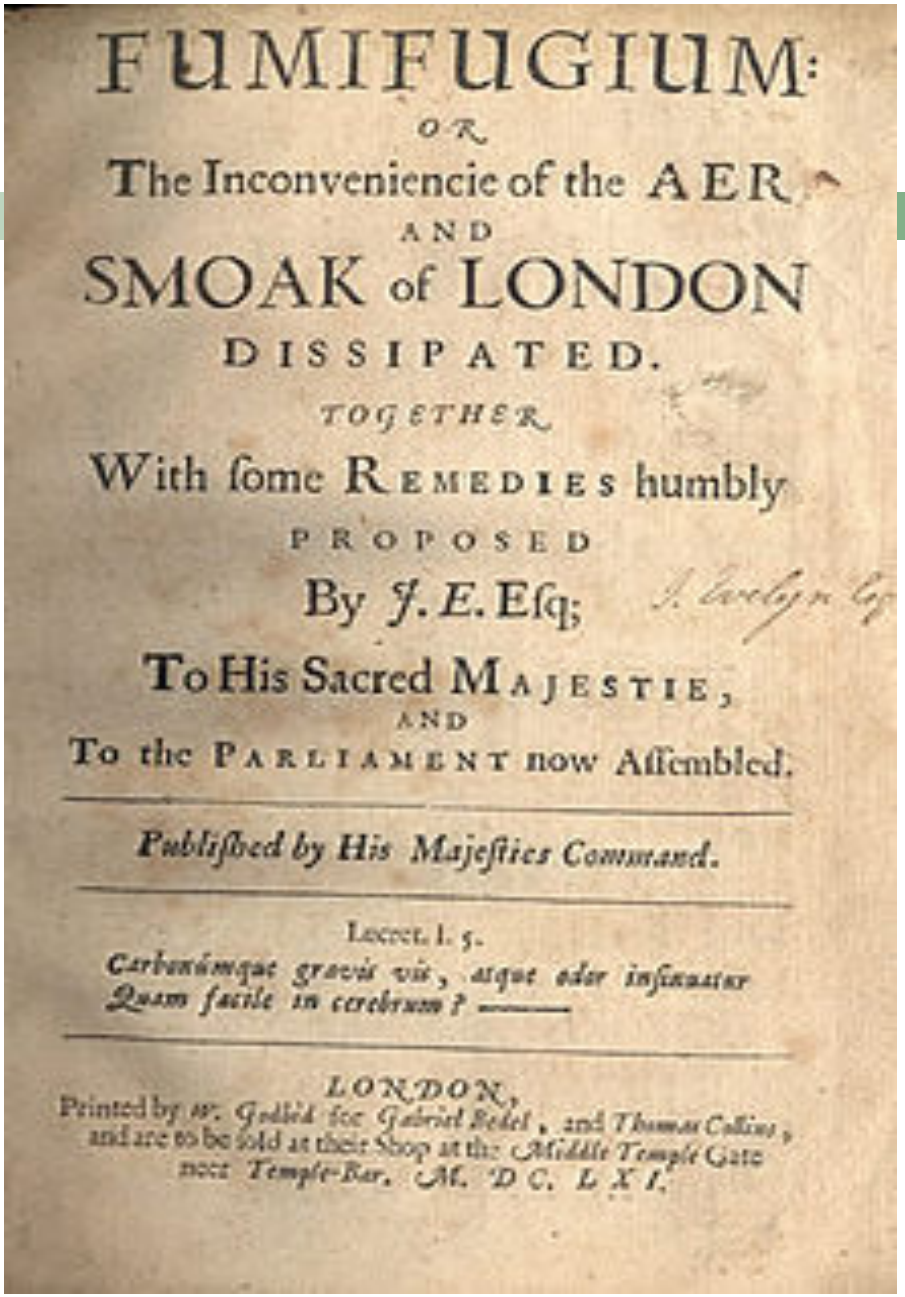
Smog

Ahrens: Fig. 18.17

Smog

- What is it?
  - Originally the joining of the words smoke and fog

- Two kinds:
  - London Smog
  - Los Angeles Smog



FUMIFUGIUM:
OR
The Inconveniencie of the AER
AND
SMOAK of LONDON
DISSIPATED.
TOGETHER
With some REMEDIES humbly
PROPOSED
By J. E. Esq;
To His Sacred MAJESTIE,
AND
To the PARLIAMENT now Assembled.

Published by His Majesties Command.

Lucret. l. 5.
Carbonúmque gravis vis, atque odor insinuatur
Quam facile in cerebrum? ——

LONDON,
Printed by *W. Godbid* for *Gabriel Bedel*, and *Thomas Collins*,
and are to be sold at their Shop at the *Middle Temple* Gate
neer *Temple-Bar*. *M. DC. LXI.*

John Evelyn, 1661
Fumifugium, or, The inconveniencie of the aer and smoak of London dissipated together

London Smog

- Sulfur dioxide in smoke from coal burning
- Mixed with fog (water droplets) – sulfuric acid produced
  - Corrosive
- Featured in English literature (Conan Doyle; Dickens)
  - Percy Shelley:

    "Hell is a city much like London –

    a populous and smoky city."

Poetry of the Time: Ballad of Gresham College 1663

Stanza 23 in modern English) describes how Evelyn [...] shows that 'tis the sea-coal smoke

That always London does environ,
Which does our lungs and spirits choke,
Our hanging spoil, and rust our iron.
Let none at Fumifuge be scoffing
Who heard at Church our Sunday's coughing.

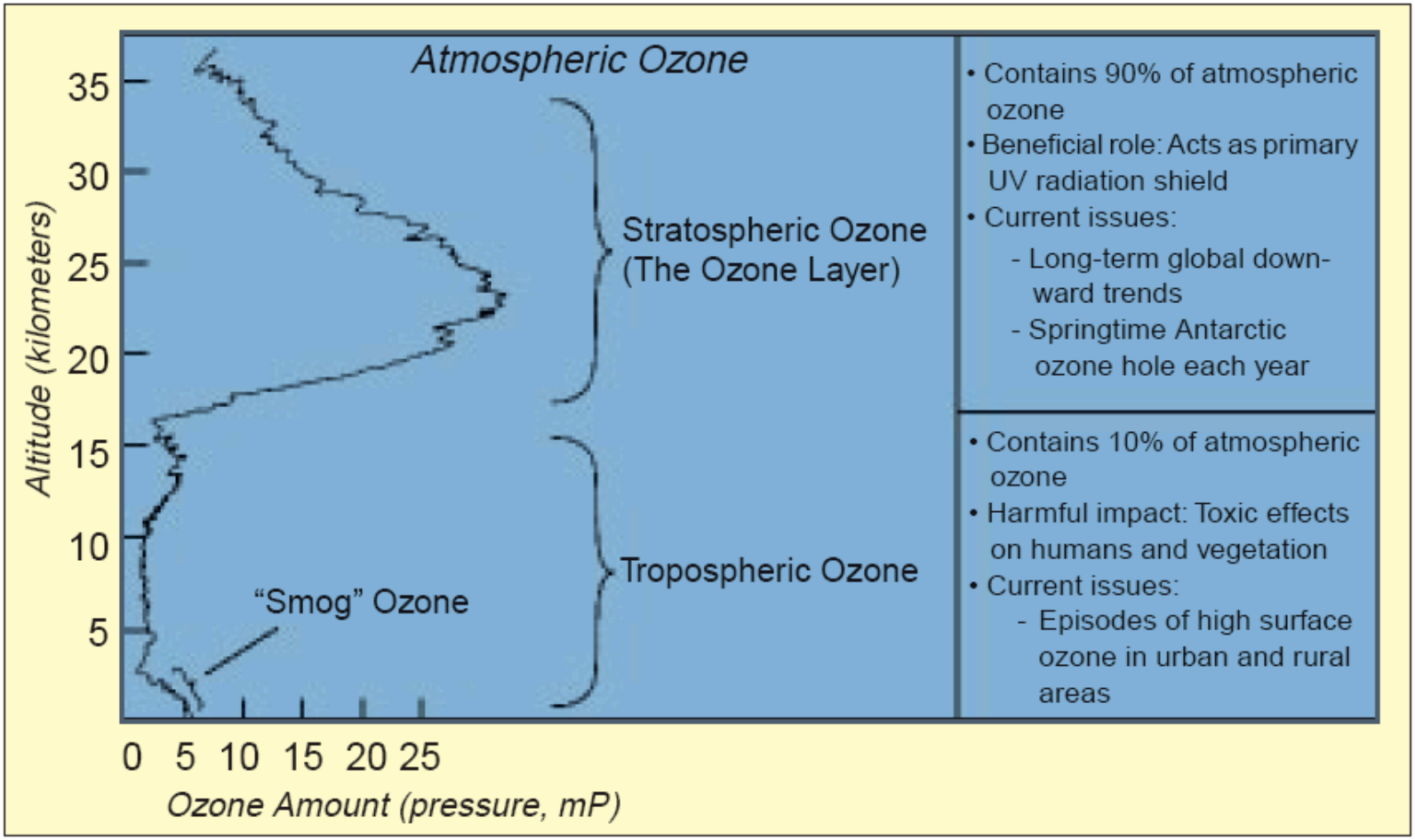
Photochemical smog

- "Los Angeles" smog
  - Less of a fog, but visibility is affected by the scattering of visible light
- Result of pollutants mixing in the atmosphere
  - Chemical reactions driven by solar radiation
- Secondary pollutants
  - Ozone

Ozone

- O_3
  - Invisible gas
  - Distinctive smell – 'clean clothes'
- 'Normal' surface concentration:
  - 10 ppbv
  - 40 is the new 'normal'
- Heavily polluted air:
  - 100-200 ppbv

Ozone



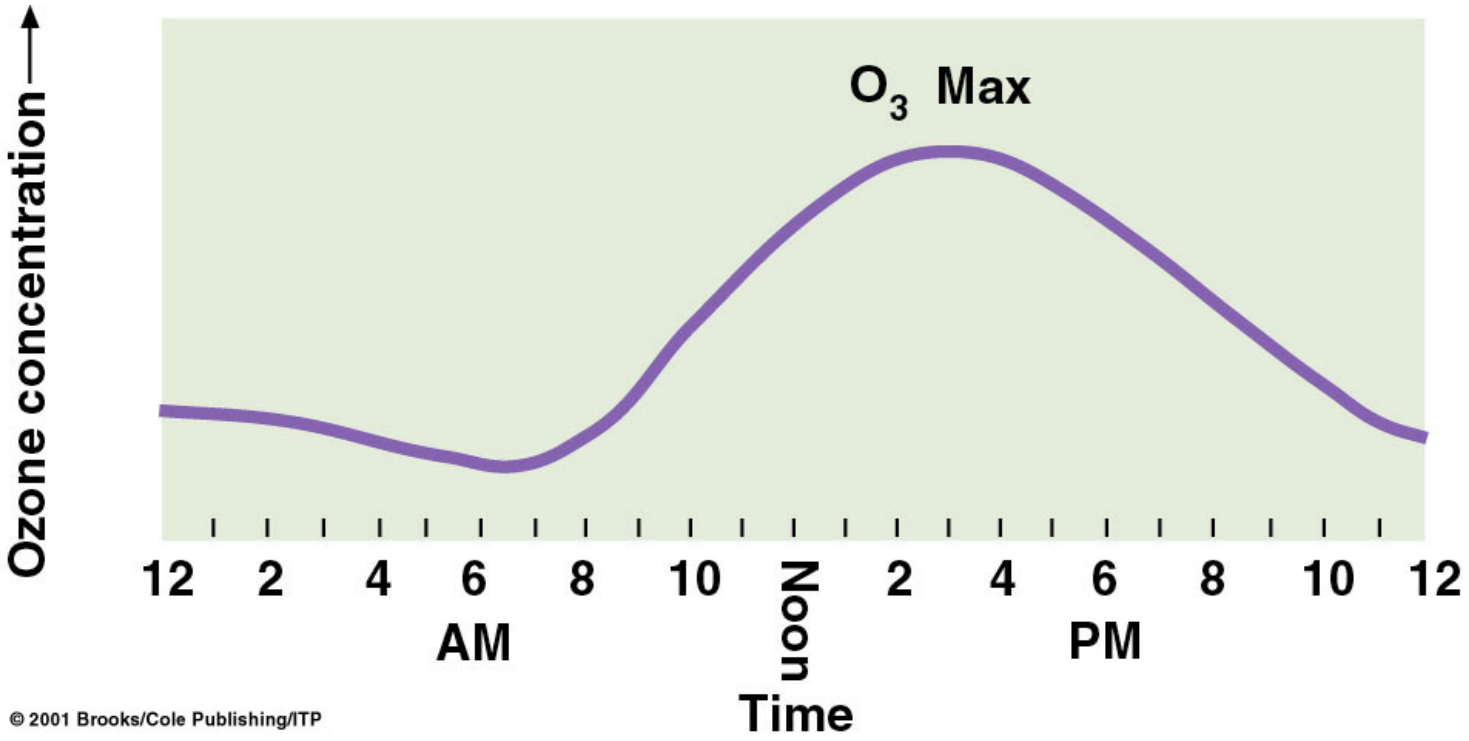
Earth Observing System Science Plan, Fig. 7.1

Ozone in the troposphere

- Main component of photochemical (Los Angeles) smog
- Noxious substance that irritates eyes and lungs
  - Asthma, bronchitis
- Also harmful to trees, crops
  - US: several billion USD per year in crop damage

Diurnal Variation of Ozone

- Ozone formation is dependent on sunlight and peaks in the afternoon.



A mix of culprits

$NO_2 + h\nu \rightarrow NO + O$

$O + O_2 \rightarrow O_3$

$NO + O_3 \rightarrow NO_2 + O_2$

Three reactions illustrate the creation of ozone from NO_2 and the destruction of ozone by NO

VOCs contribute to net ozone creation through reactions that convert NO to NO_2

In the absence of sunlight, NO will deplete O_3

Ingredients

- Intense sunlight
- Temperature inversions
- Internal combustion engines
  - High temperatures
    - N_2 and O_2 react to form NO_x
  - Gasoline combustion
    - Perfectly tuned engines produce CO_2 and H_2O
    - Untuned engines also produce VOCs and CO

Smog susceptibility

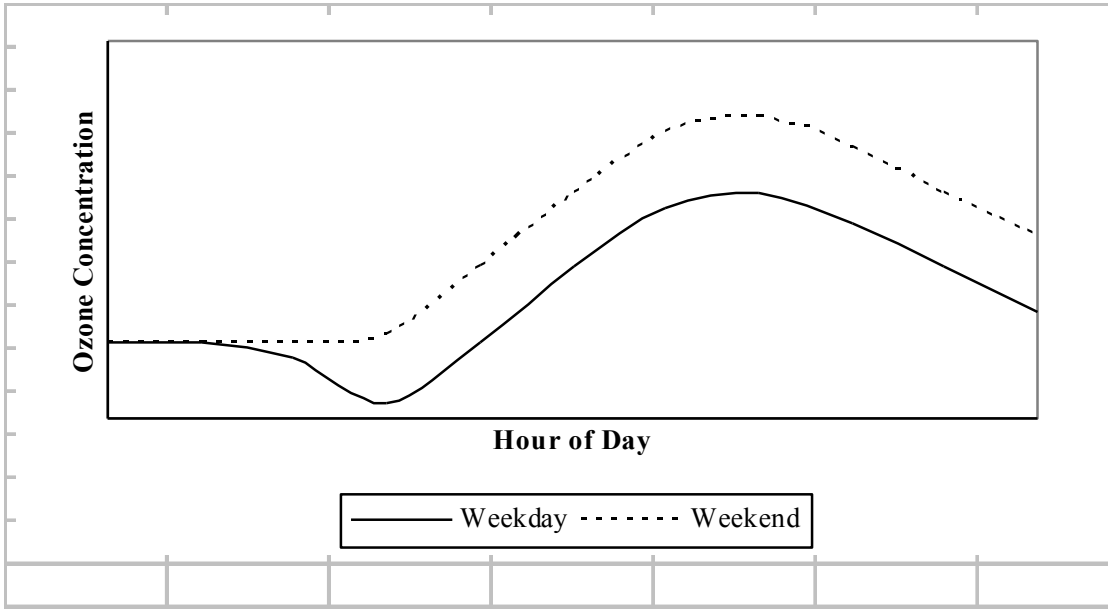
- Climatology:
  - Prevailing clear skies
  - Warm temperatures
  - Temperature inversions
- Topography:
  - Mountains can block winds and create subsidence inversions
  - Sea breezes also create inversions and can return pollutants to shore

Smog susceptibility

- Sources of pollutants
  - High vehicle traffic
  - Dense traffic area
  - Poorly maintained vehicles
- Timing
  - Morning emissions are more effective at creating ozone
  - Summers are warmer and feature more intense radiation

Weekday/weekend effect

- Intuitively ozone levels should decrease on the weekend
- However the opposite has been observed. Why?



Some ozone chemistry

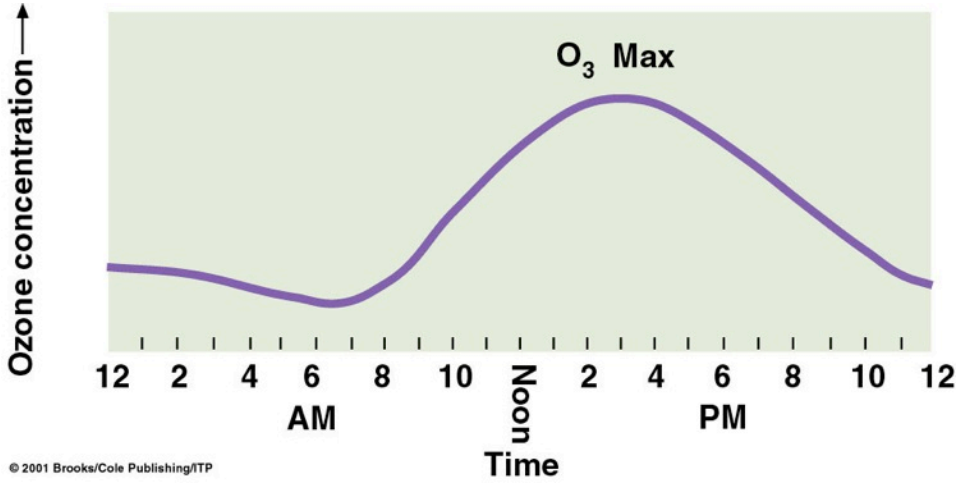
Recall:

$NO_2 + h\nu \rightarrow NO + O$

$O + O_2 \rightarrow O_3$

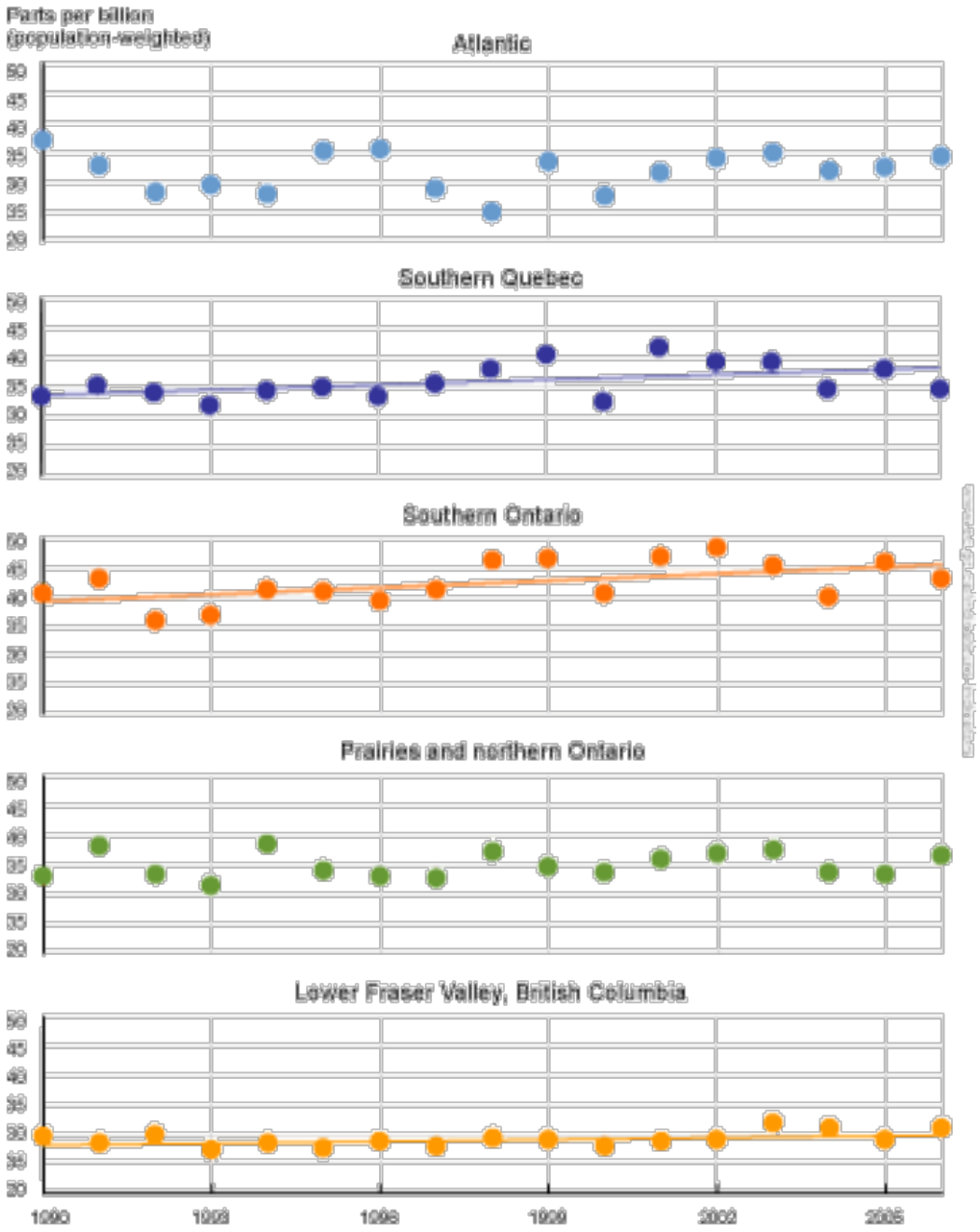
$NO + O_3 \rightarrow NO_2 + O_2$

- On weekends there is no e*arly* morning rush hour
- Morning NO scavenging of previous day's ozone does not take place, leading to higher levels of ozone on the weekend



Air quality monitoring

- Environment Canada monitors ozone and particulate matter levels across Canada

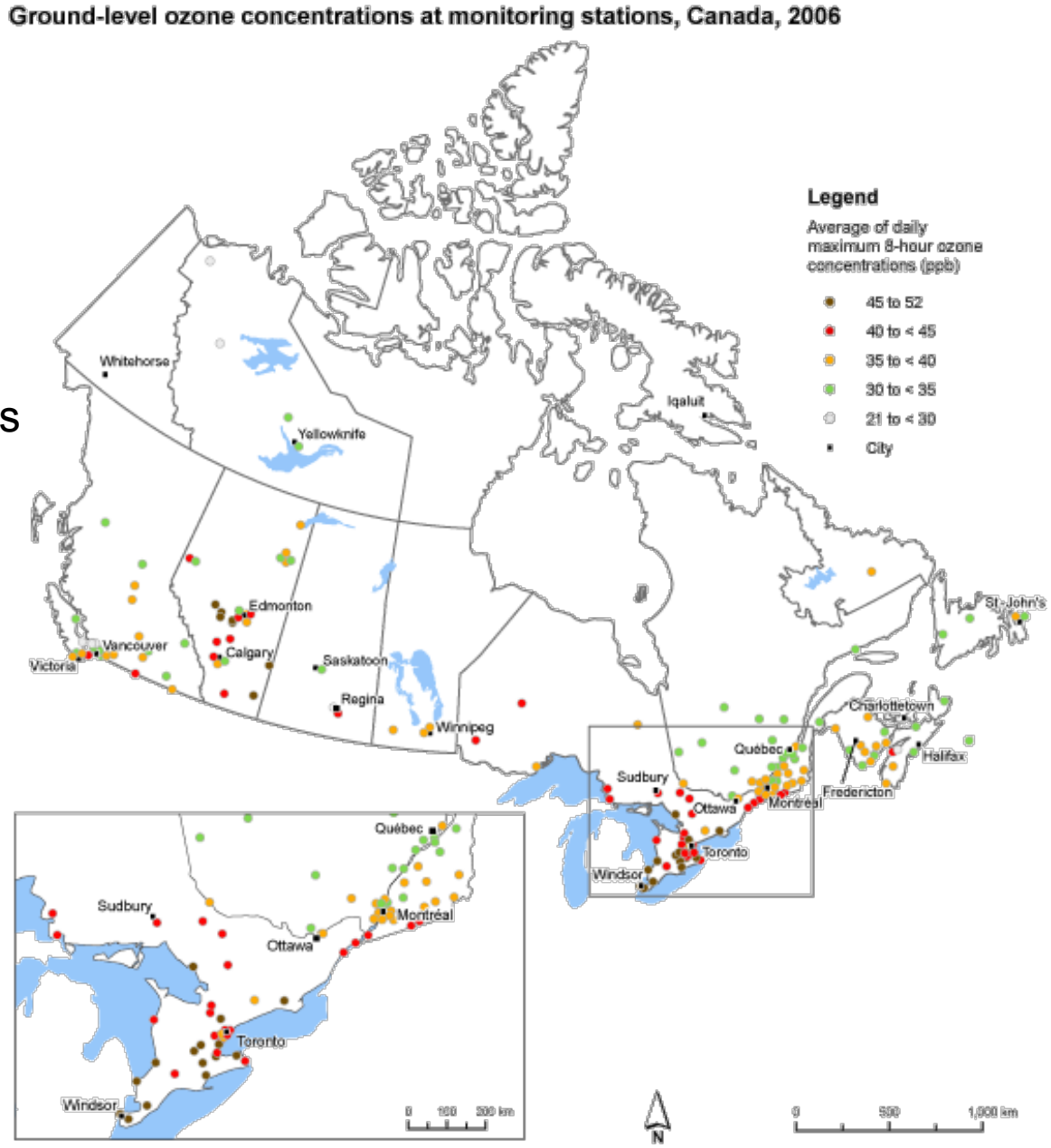


Ozone monitoring by Environment Canada

No trend in Northern Ontario

Canada Wide Standard:
<65 ppbv ozone for 8 hours
<82 ppbv ozone for 1 hour

Thunder Bay, 2006:
39 ppbv ozone

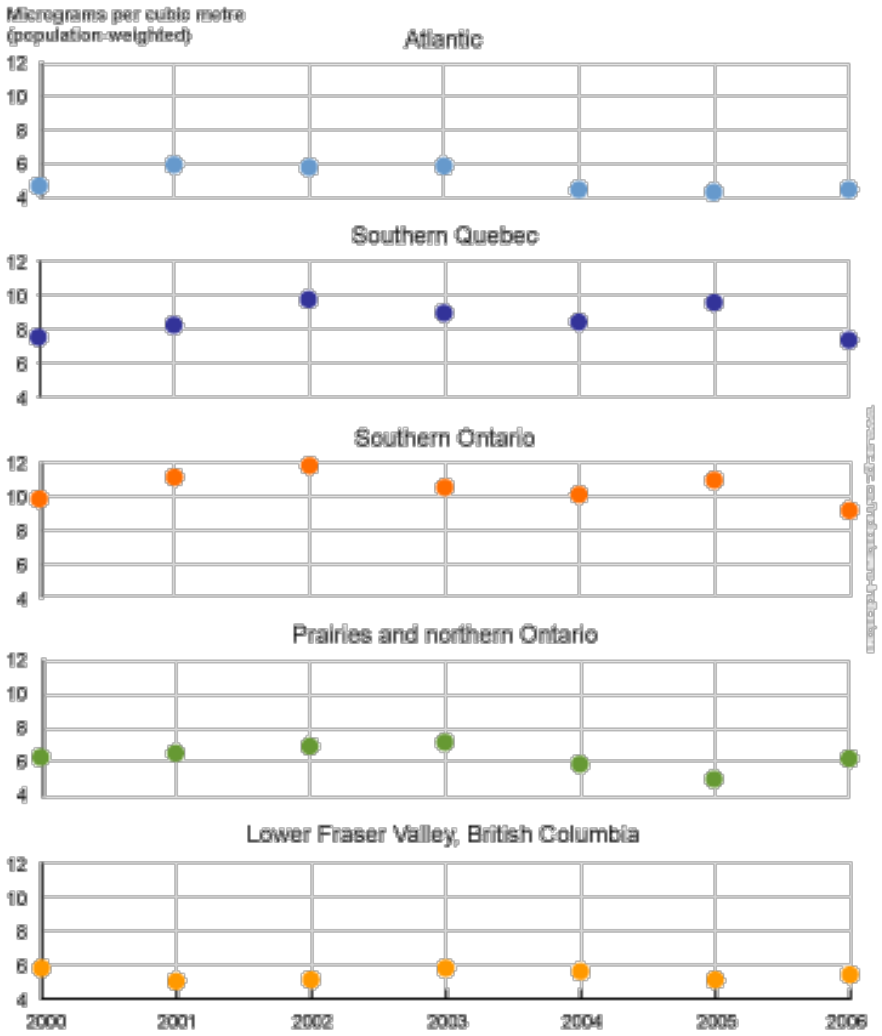


Note: Data were collected from 189 monitoring stations. Ozone concentrations are not weighted by population.

Source: The National Air Pollution Surveillance (NAPS) Network and the Canadian Air and Precipitation Monitoring Network (CAPMoN).

Air quality monitoring: $PM_{2.5}$

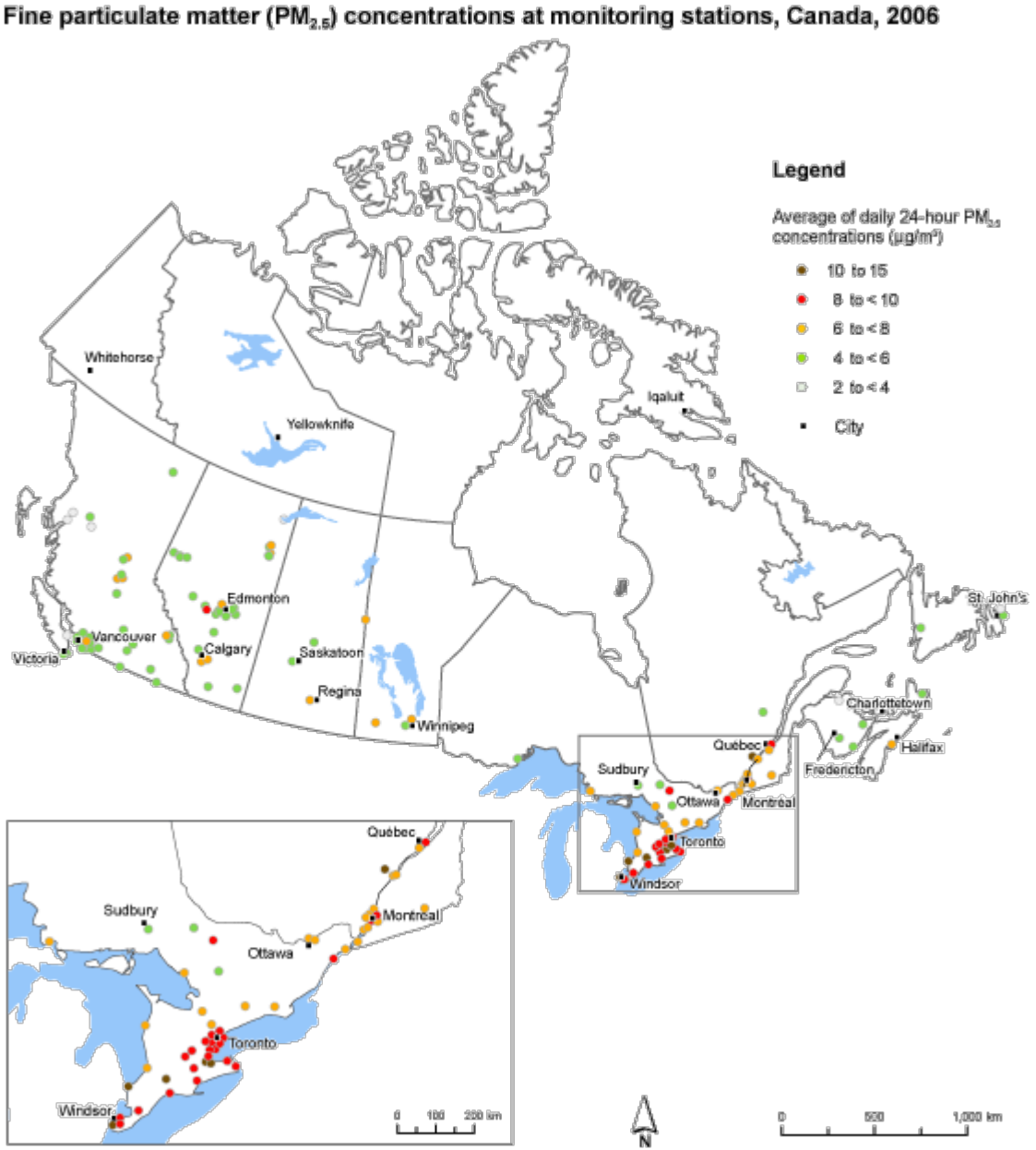
- No trends in particulates
- Canada Wide Standard:
  - 30 $\mu g/m^3$



Canada Wide Standard:
<30 μg/m^3 $PM_{2.5}$

Thunder Bay, 2006:
5.5 μg/m^3 $PM_{2.5}$

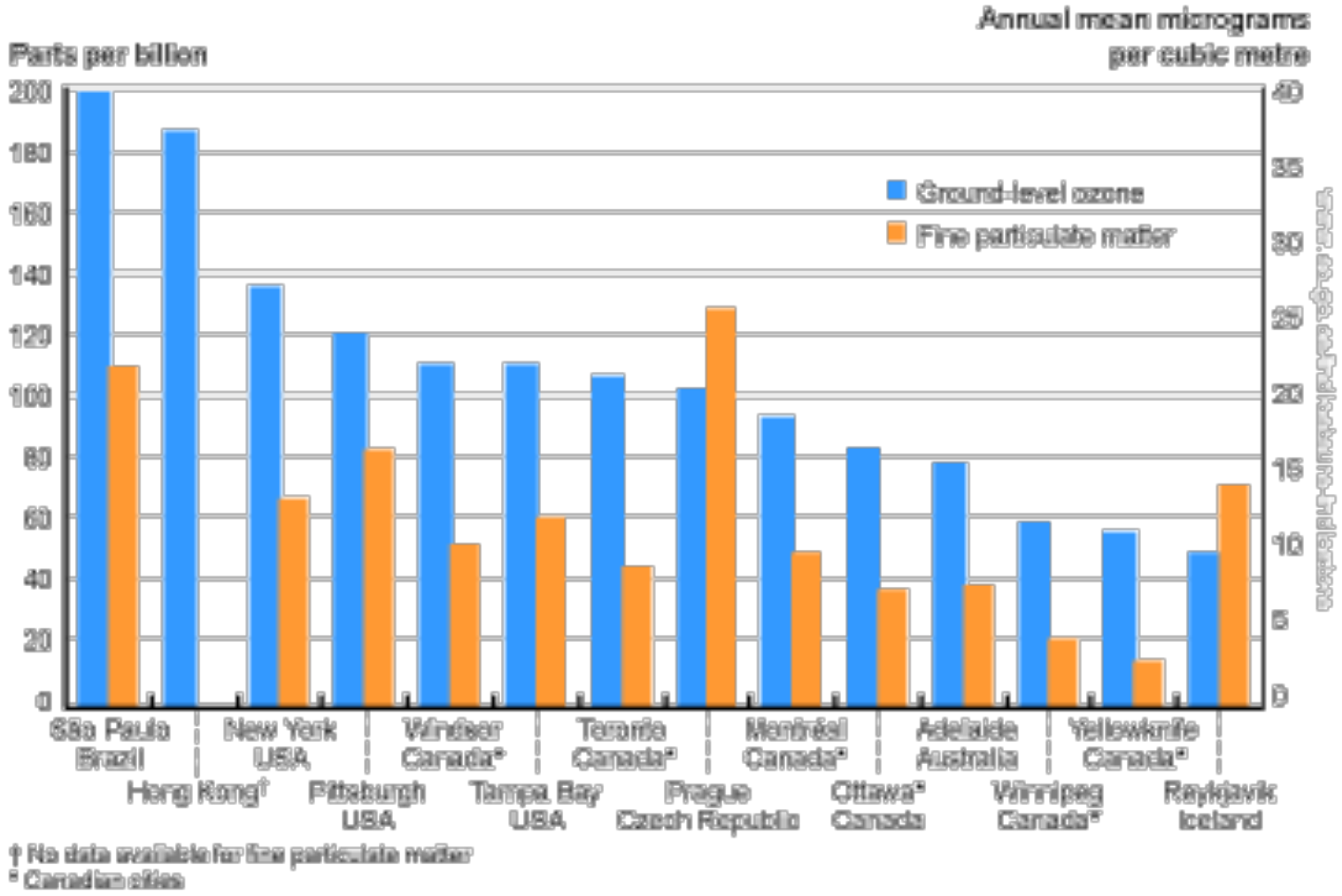
(24-hour numbers)



Note: Data were collected from 142 monitoring stations. Concentrations of PM2.5 are not weighted by population.

Source: The National Air Pollution Surveillance (NAPS) Network.

2005 City Comparison



Automobile emission controls

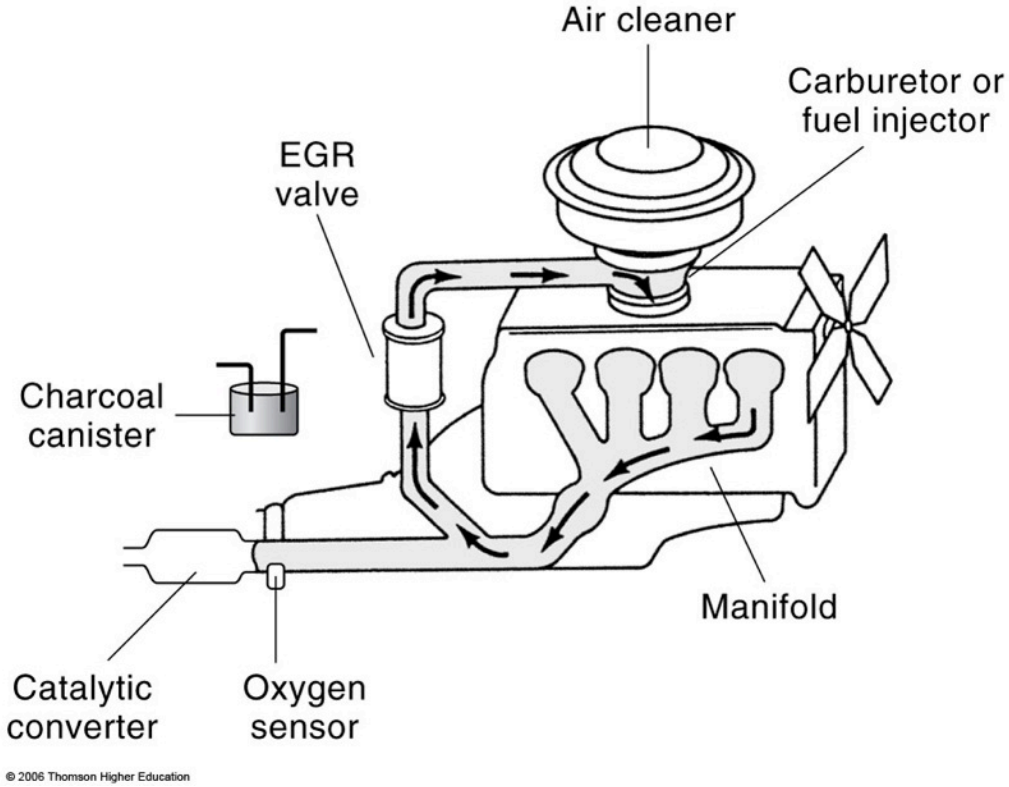
- CO and VOC emissions come from unburned or incomplete combustion of gasoline
- This can be reduced by increasing engine temperature and air-to-fuel ratio

- NO_x increases!

Automobile emission controls

- Reduce NO_x emissions by delaying the timing and reducing the compression ratio
- Lowers fuel efficiency

1975: Catalytic Converter



H&K: Figure 8.14

Wikipedia: Redburn

Gasoline alternatives

Table 8.4 GASOLINE ALTERNATIVES			
Fuel	Source	Benefits	Drawbacks
Methanol	Coal, wood, gas	Less hydrocarbons and CO_2 High octane	Less energy content
Ethanol	Corn, sugar	Less pollutants High octane	Less energy content High fuel cost
Compressed gas	Natural gas	Inexpensive Less hydrocarbons and CO_2	Expensive vehicle conversion
Electricity	Fossil, nuclear, solar	No car emissions Power plant emissions easy to control	Limited range Battery cost

H&K: Table 8.4

What about indoors

- Shutting the windows can shut out the pollution
- But…

Tobacco smoke

- Addictive stimulant (nicotine)
- Toxins
  - CO, formaldehyde
- Carcinogens
  - PAHs, tar
- Nicotine
  - Cumulative heart damage

Second-hand smoke

- Harmful to others
  - Smoker gets the worst of it
- Has led to banning in public places

Formaldehyde

- Embalming fluid
- VOC
- Soluble: absorbed by respiratory tract
  - Eye, nose, throat irritation
  - Dizziness, nausea, loss of concentration
  - Recurring respiratory infections
  - Low birth weights and pregnancy complications

Sources of formaldehyde

- Fibreglass insulation
- Particle board
- Plywood
- Imitation wood
- Clothing

Asbestos

- Natural mineral
- Once very commonly used as flame retardant and insulator
- Banned in Canada
  - Still the world's fourth-largest producer

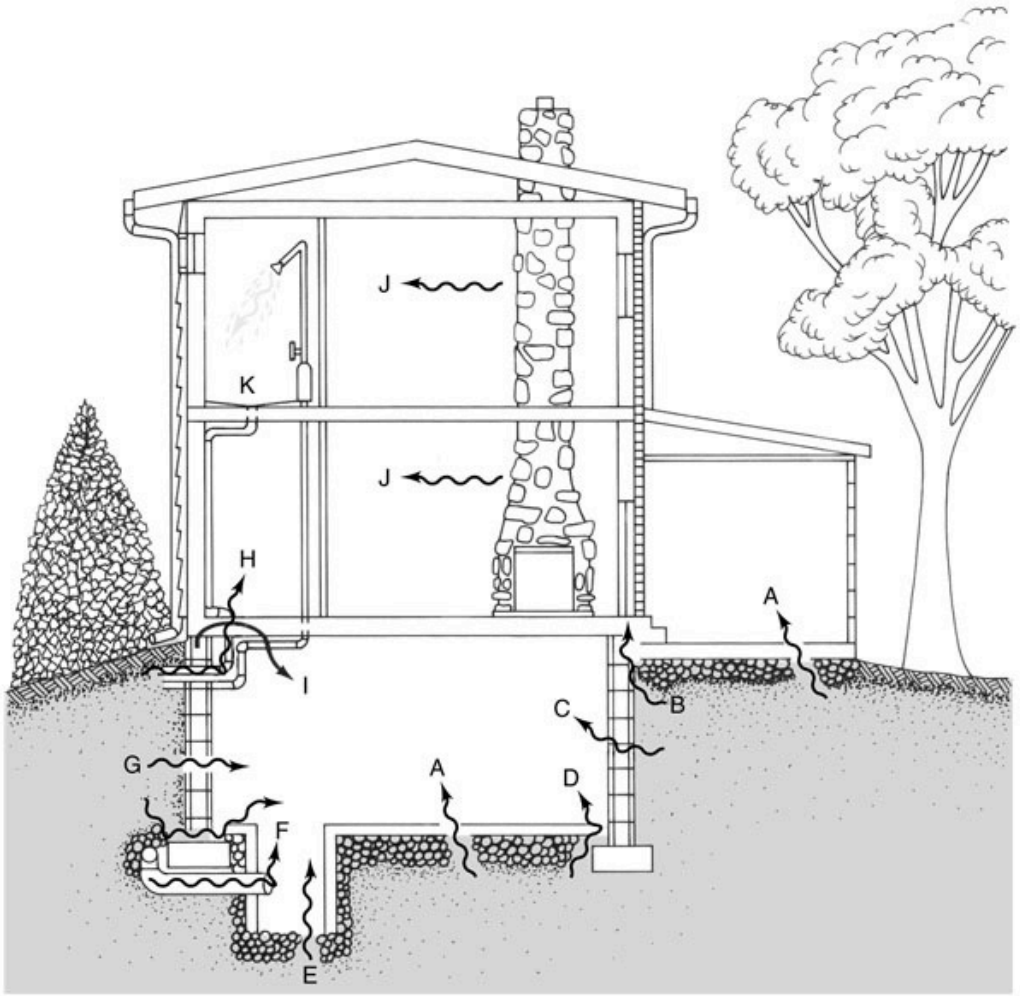
Radon in the home

Hinrichs & Kleinbach: Figure 15.7

Average natural radiation dose:
30-60 mrem/year

Average US dose from radon:
200 mrem/year

See also Turco: Figure 8.2



A. Cracks in concrete slabs
B. Spaces behind brick veneer walls that rest on uncapped hollow-block foundation
C. Pores and cracks in concrete blocks
D. Floor–wall joints
E. Exposed soil, as in a sump
F. Weeping (drain) tile, if drained to open sump
G. Mortar joints
H. Loose-fitting pipe penetrations
I. Open tops of block walls
J. Building materials, such as some rock
K. Water (from some wells)

Indoor air safety

- Outdoor pollutants can accumulate
  - Ventilation through windows and doors increases contamination
- Indoor pollutants can accumulate
  - Well-sealed buildings can have high levels of radon and formaldehyde
- Balance
  - Air circulation, ventilation and filtration

Coming up

- Acid Rain