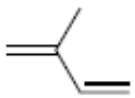
Biogenic VOC:
A Potential Urban Air Pollutant?

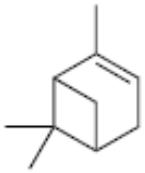
Rainer Steinbrecher

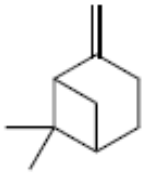
- **Biogenic VOC and Sources**
- **Biogenic VOC and Urban Atmospheres**
- **Plants and Urban Atmospheres**
- **Synopsis: Plants and Urban Climate**

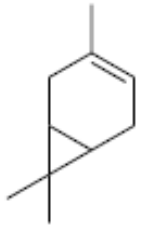
Biogenic VOC and Sources

Isoprenoides

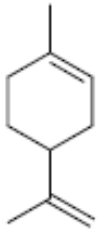

Isoprene

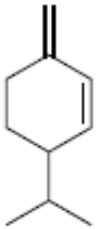

α-Pinene


β-Pinene

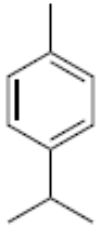

Δ^3–Carene

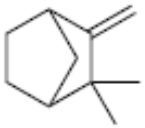

Sabinene

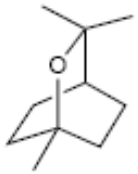

Limonene

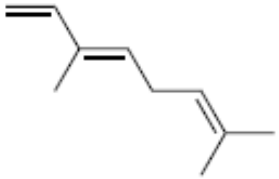

β-Phellandrene

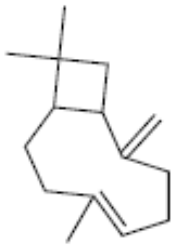

Myrcene


p-Cymene


Camphene


1,8 Cineol

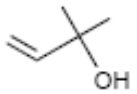

trans-β-Ocimene

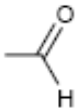

trans-β-Caryophyllene

Oxygen Containing Compounds

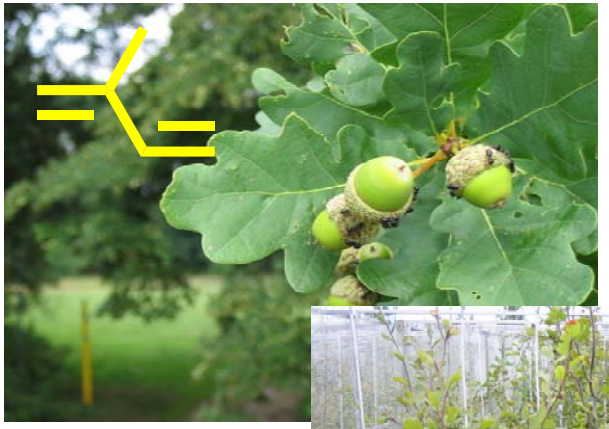

Methanol

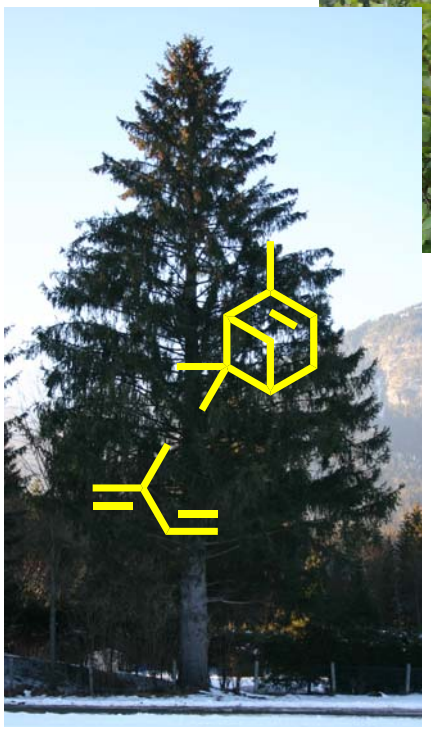

Ethanol


2-Methyl-3-buten-2-ol

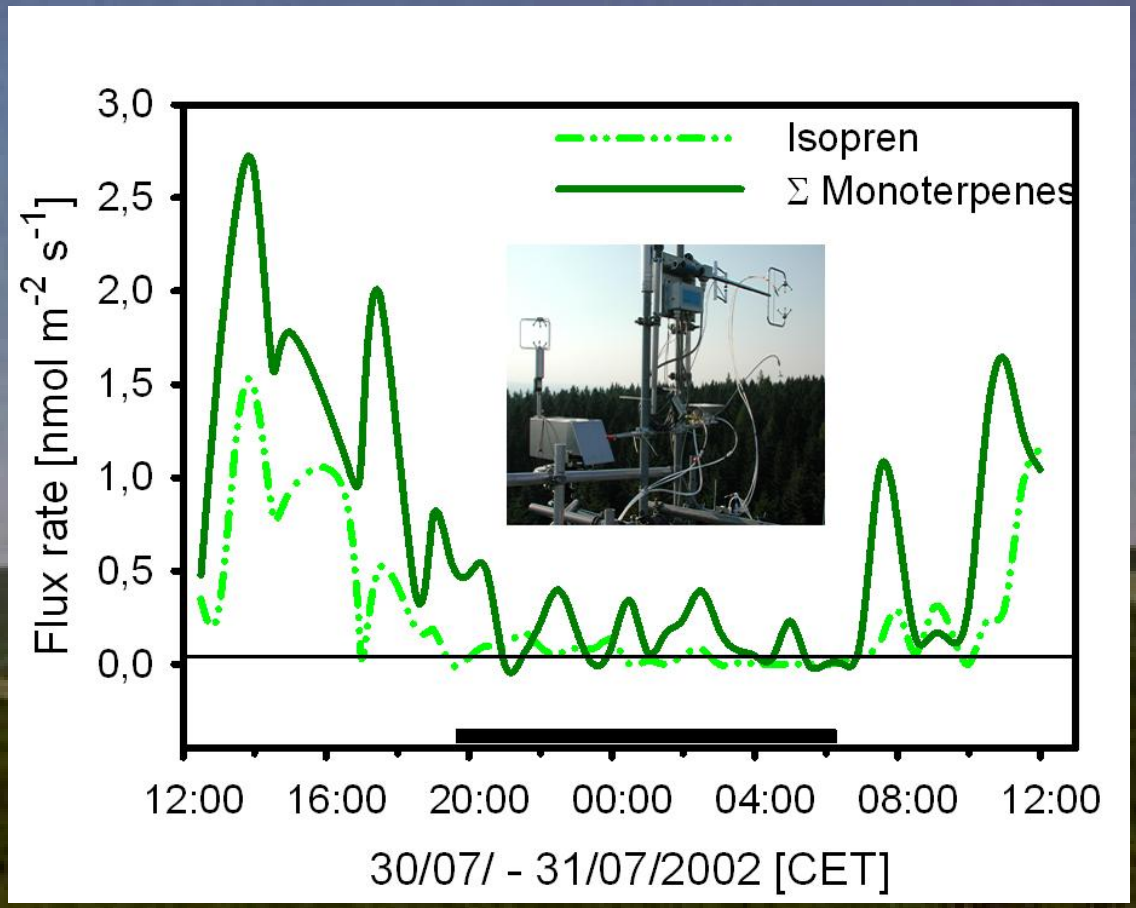

Acetaldehyde


Acetone

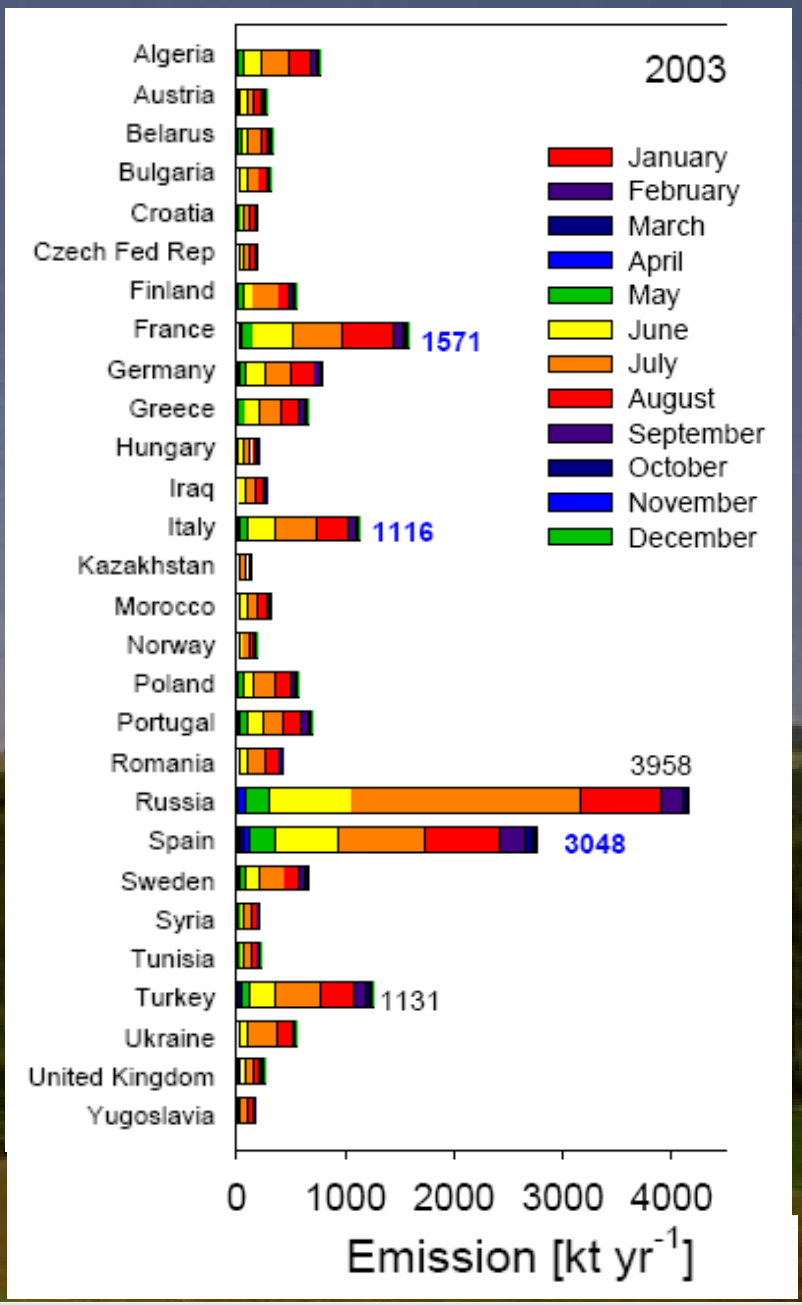




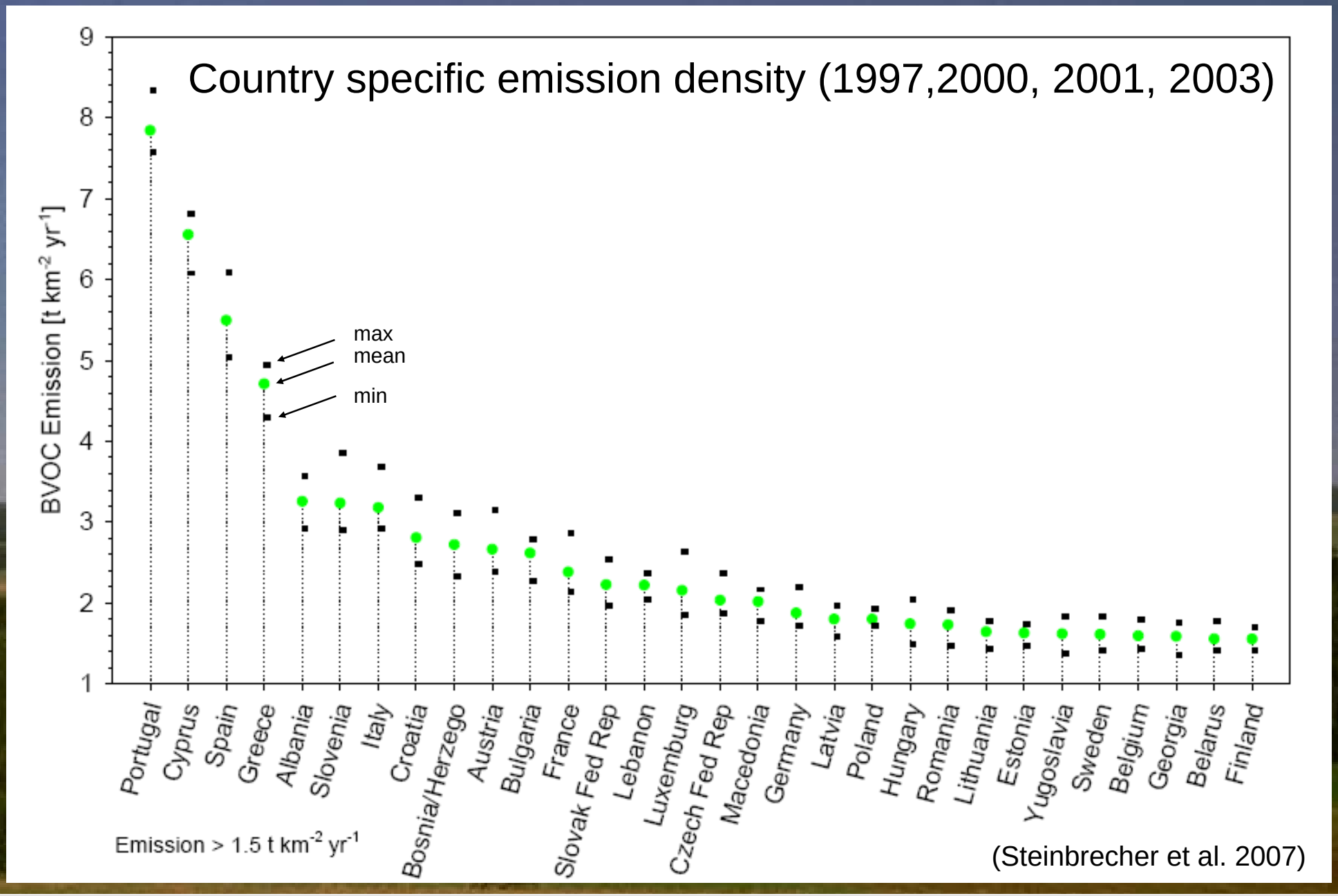
Biogenic VOC and Sources



(Steinbrecher et al. 2007)

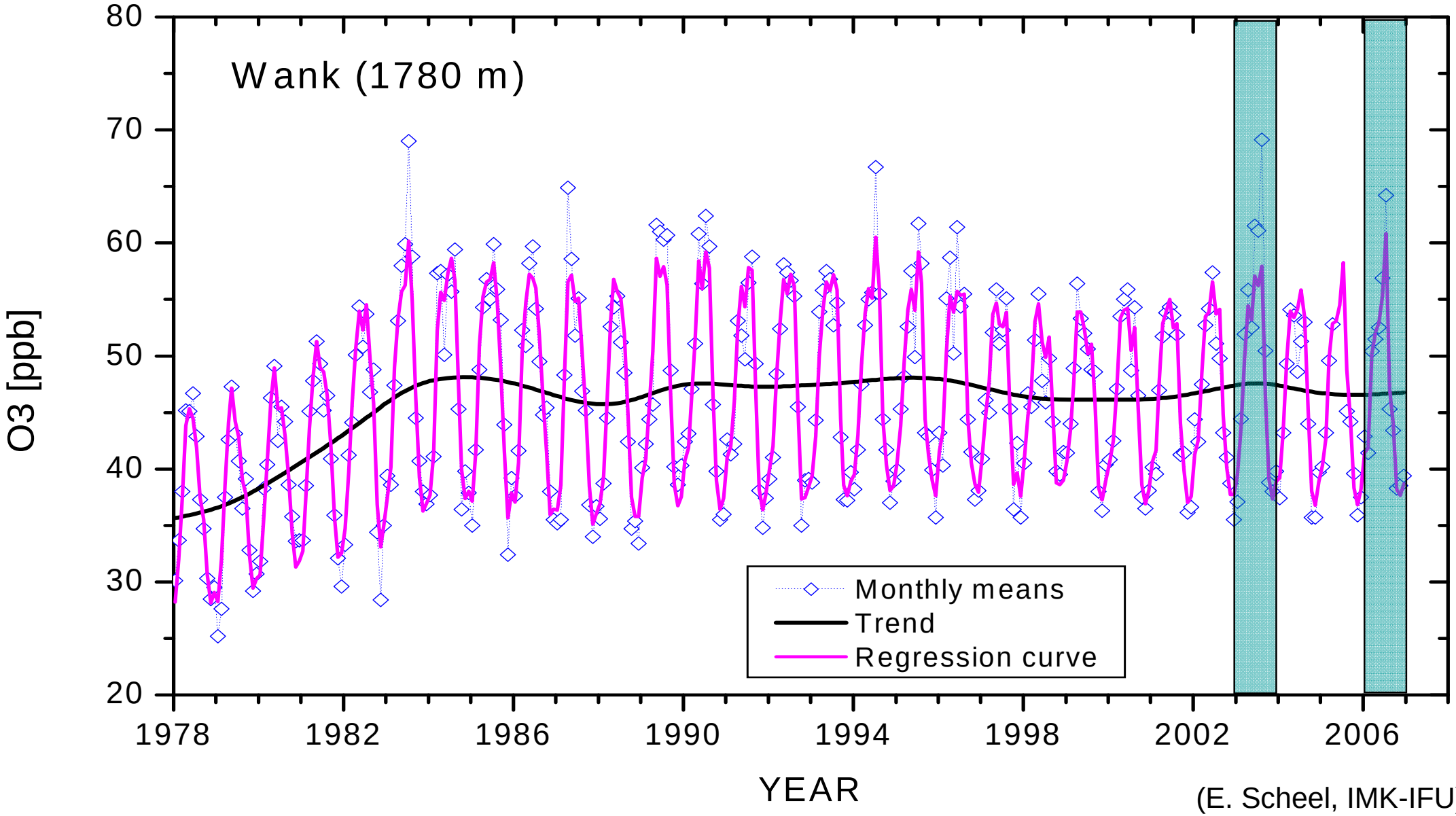


Biogenic VOC and Sources



Biogenic VOC and Urban Atmospheres

Ozone Wank (1780 m asl.), Garmisch-Partenkirchen



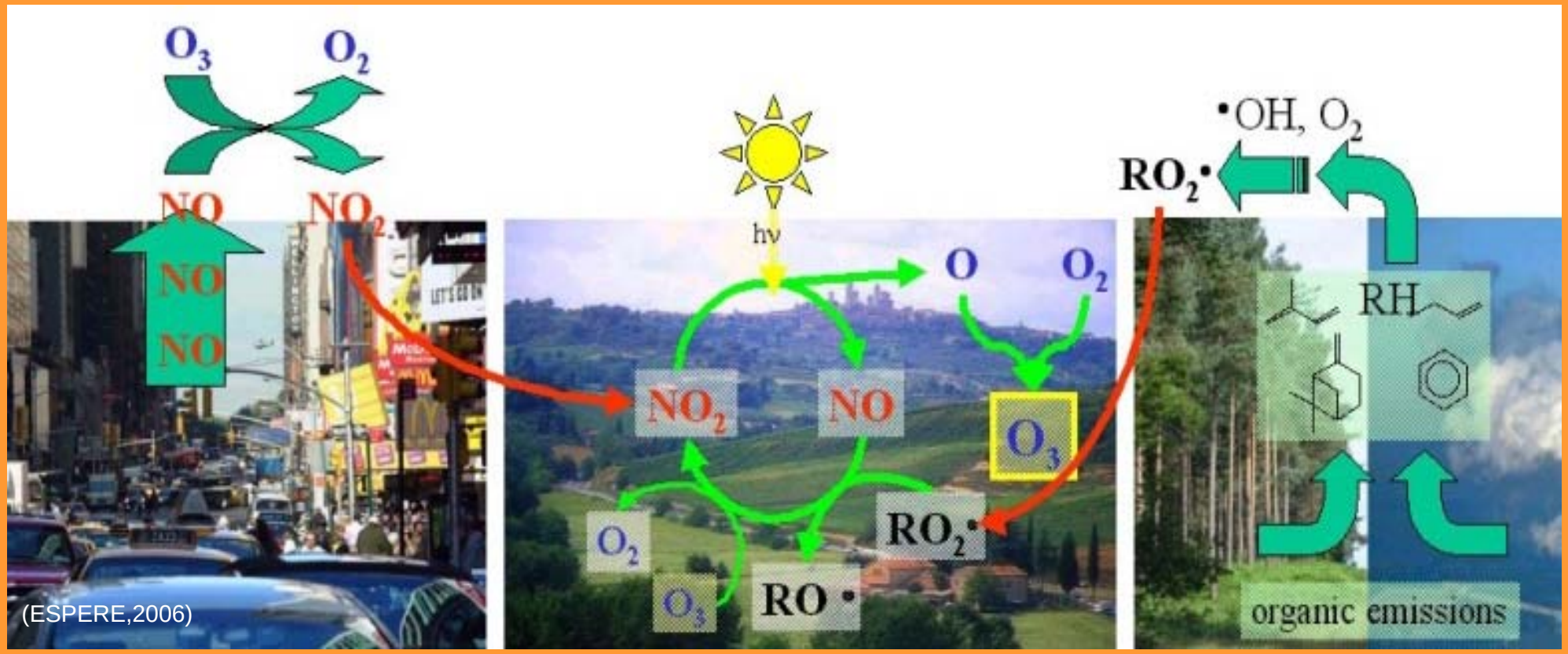
(E. Scheel, IMK-IFU)

Biogenic VOC and Urban Atmospheres

Ozone
NO_X
VOC

Light
Water Vapor

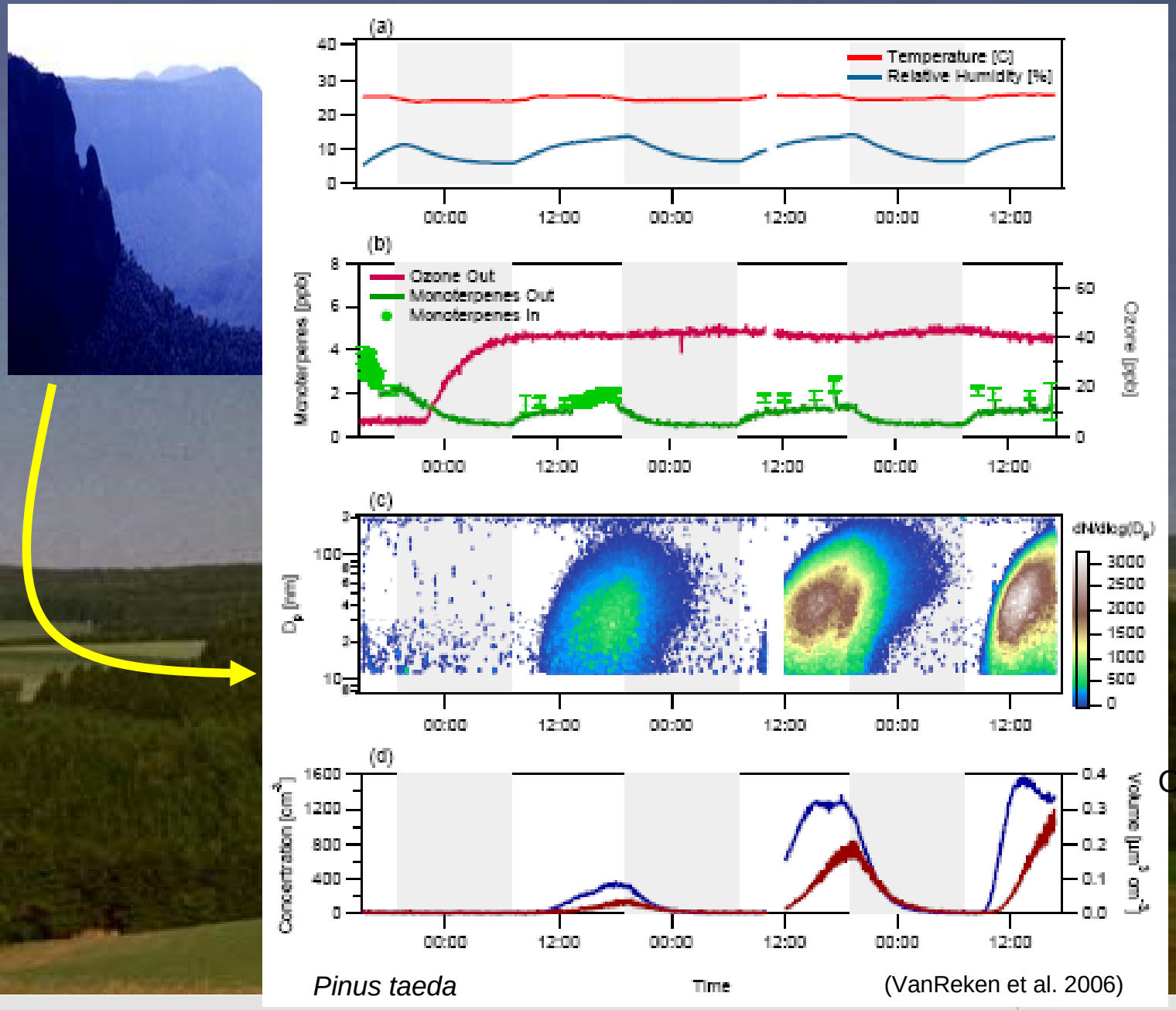
Radicals
(O_3, HO, NO_3, org-R)
PAN
CO, etc



Biogenic VOC and Urban Atmospheres

Ozone

BVOC



Pinus taeda

(VanReken et al. 2006)

O_3 ~ 20 ppb

Biogenic VOC and Urban Atmospheres

Ozone Production

- Box model (CSS with RADM2 + isoprene chemistry)
- O_3, H_2O, NO, CO, speciated hydrocarbons, HCHO, SO_2, H_2O_2, and organic peroxides
- clear sky conditions
- impact of VOC is based on HO reactivity

$$VOC_r = \sum k_i [VOC_i]$$

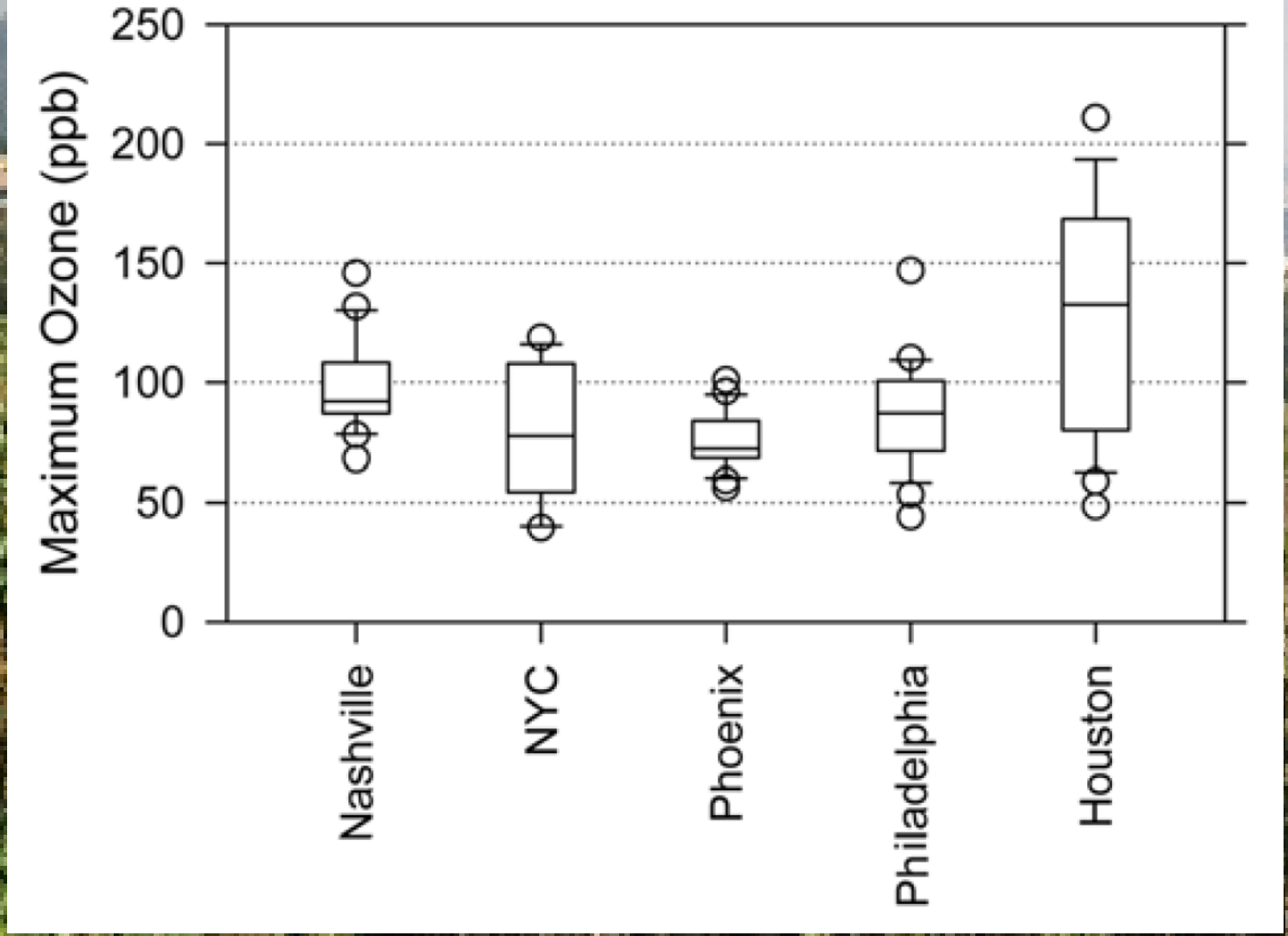
Where k_i is the reaction constant for HO reactivity

HO + VOC → peroxy radicals

(Kleinmann et al. 2005)

Biogenic VOC and Urban Atmospheres

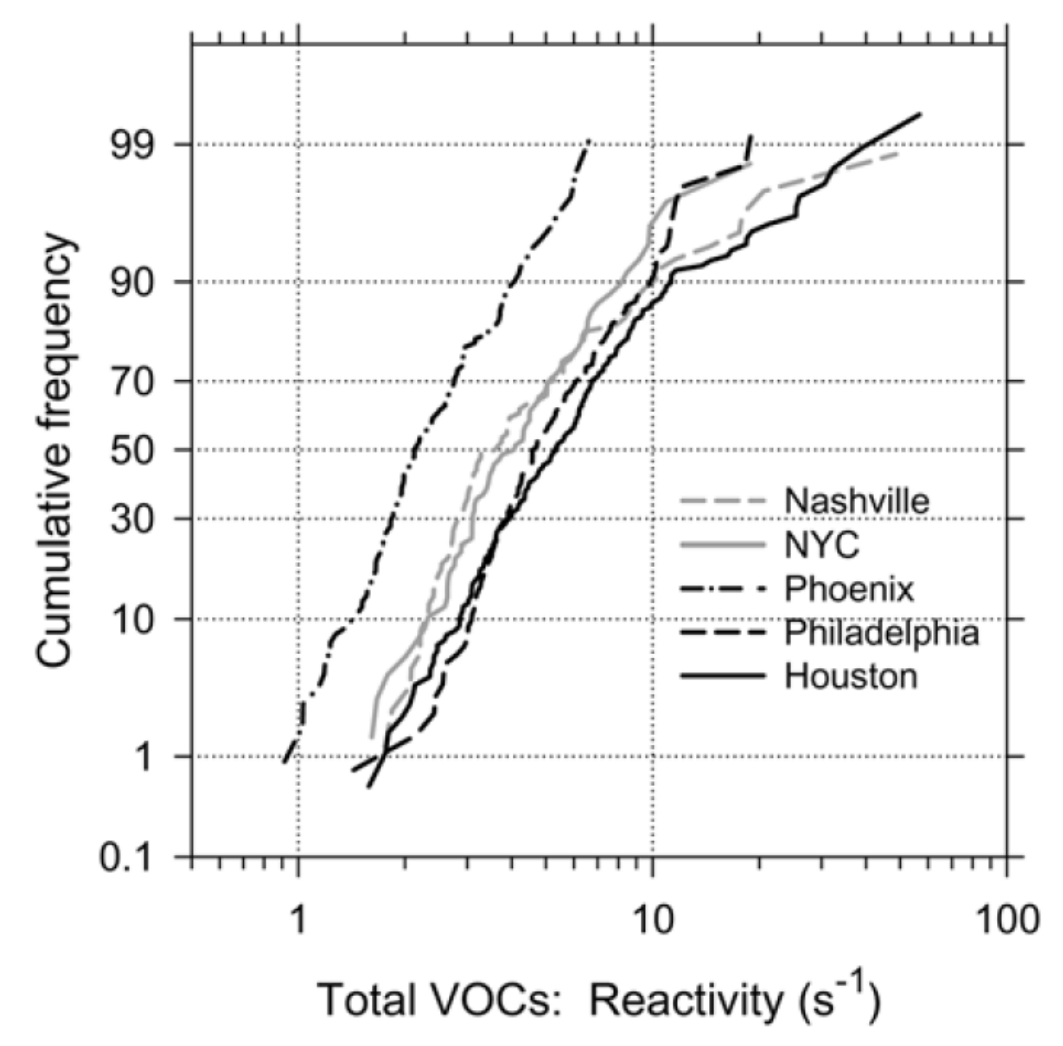
Ozone Production in 5 US Metropolitan Areas

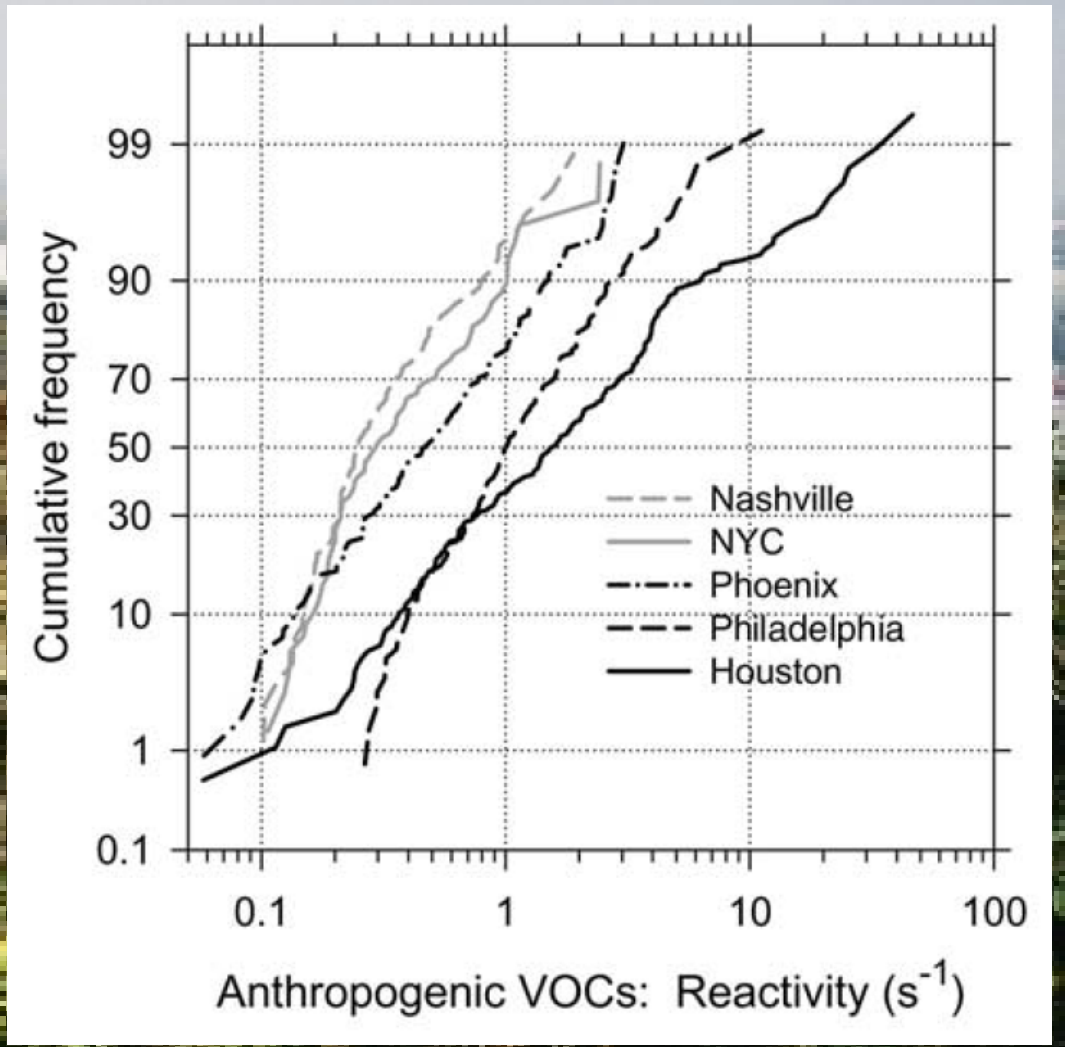


(Kleinmann et al. 2005)

Biogenic VOC and Urban Atmospheres

Ozone Production in 5 US Metropolitan Areas

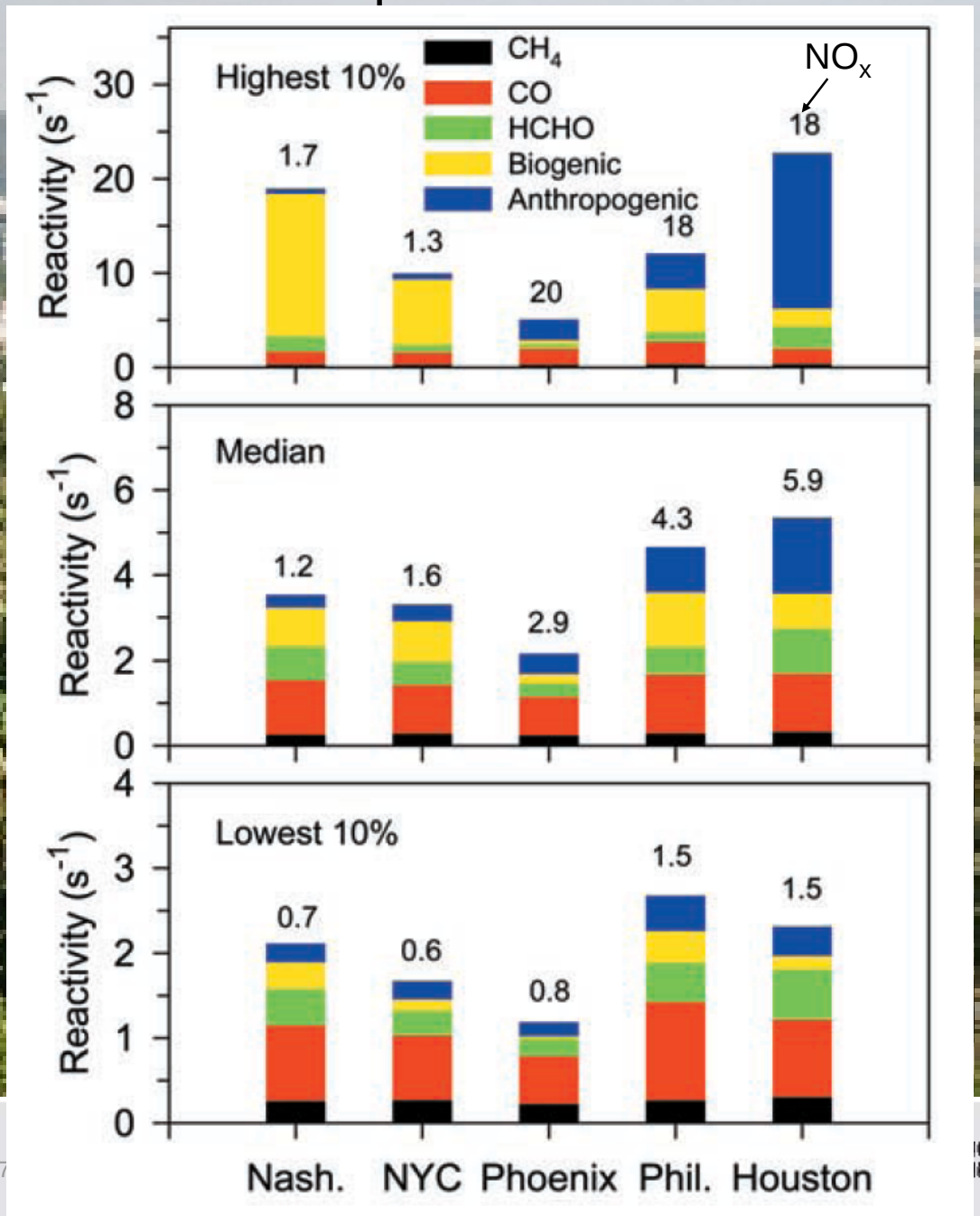




(Kleinmann et al. 2005)

Biogenic VOC and Urban Atmospheres

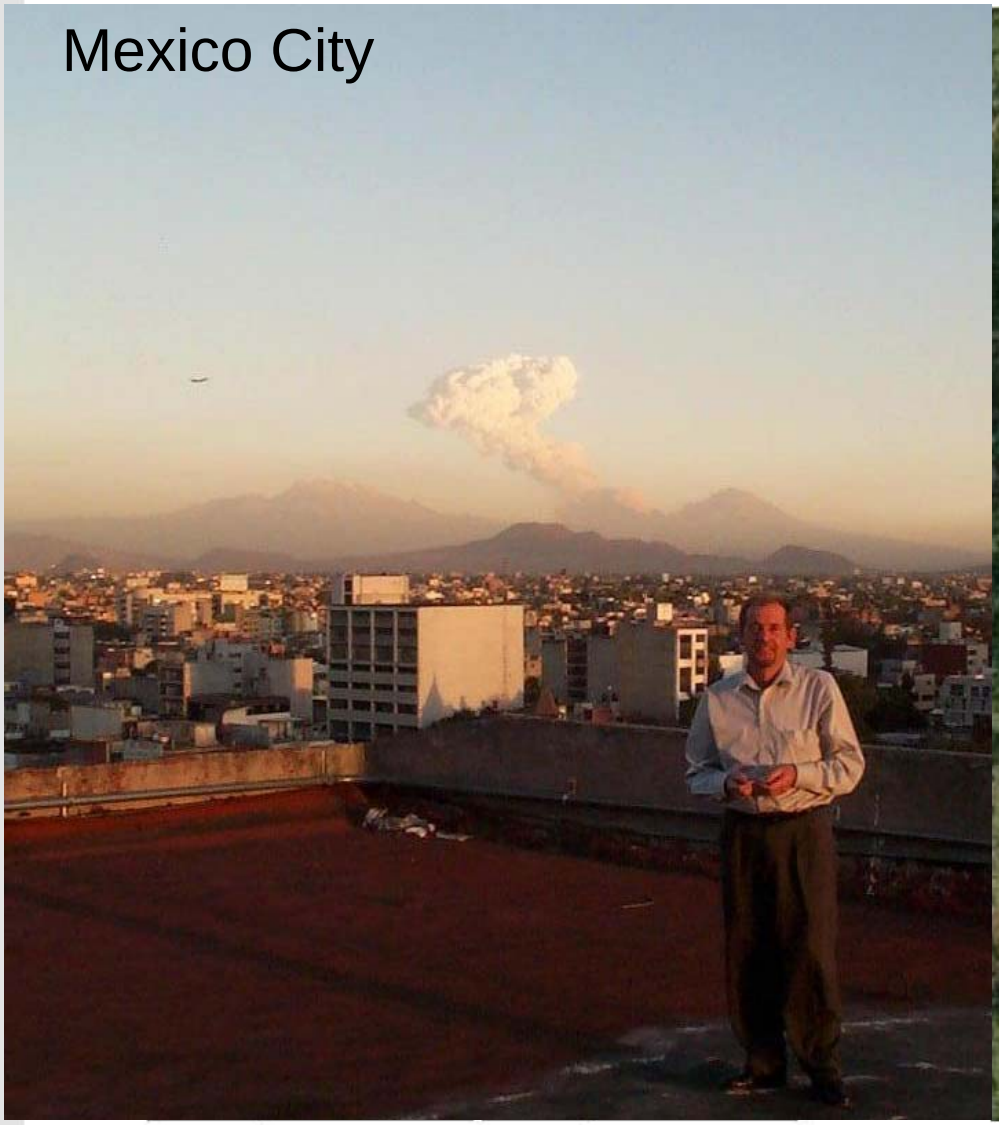
Ozone Production in 5 US Metropolitan Areas



(Kleinmann et al. 2005)

Biogenic VOC and Urban Atmospheres

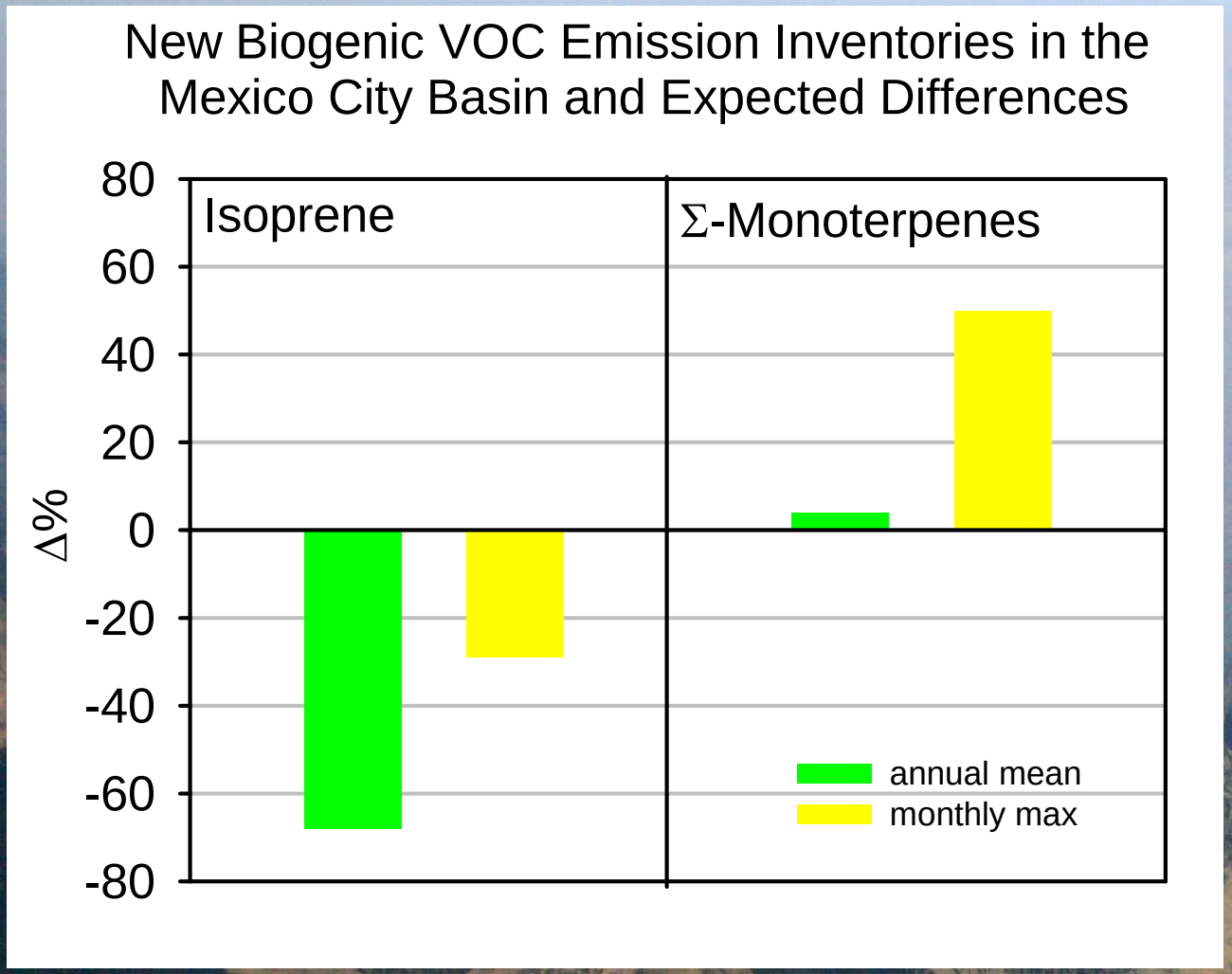
Mexico City



Biogenic VOC and Mexico City

(Dominguez et al. 2006)

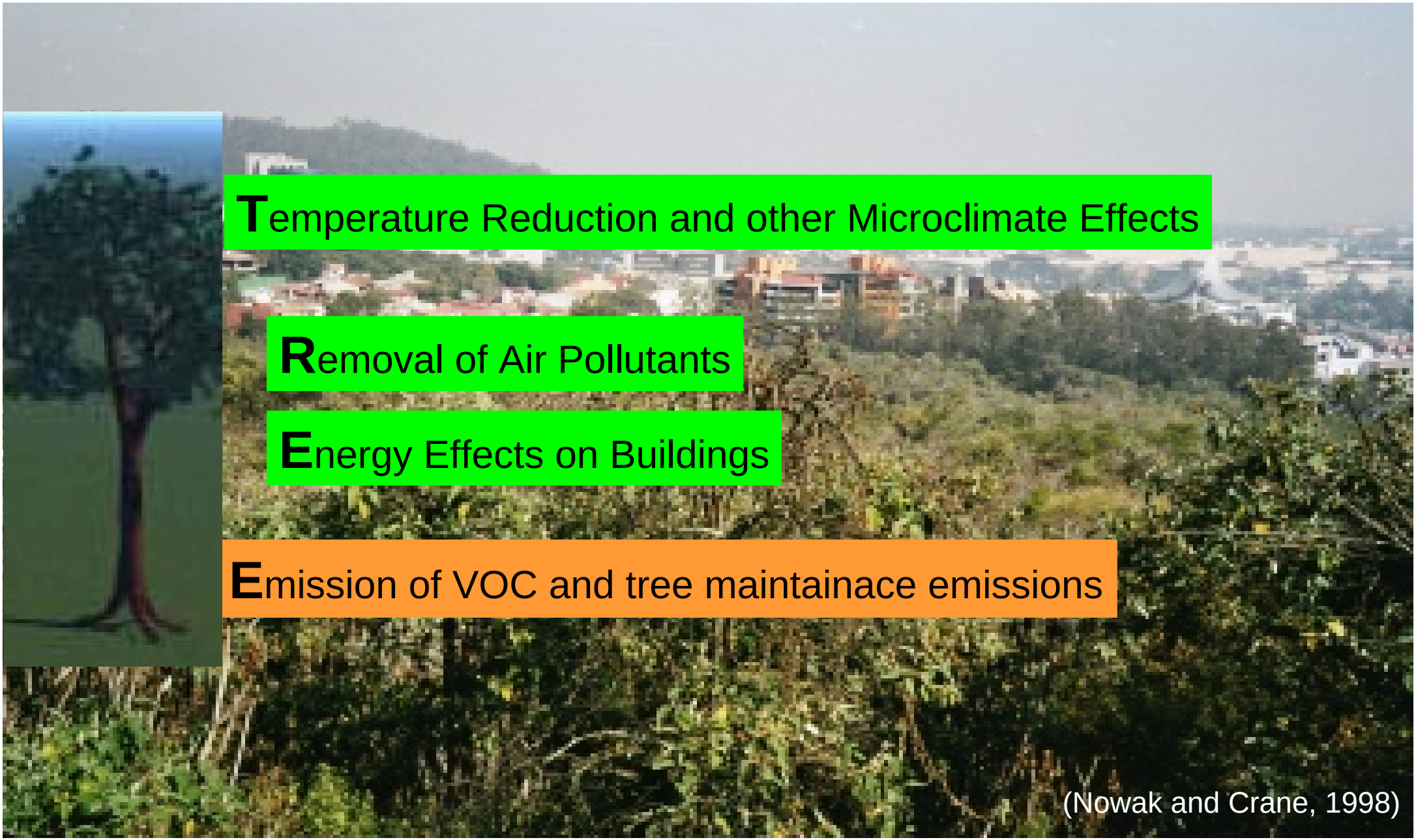
Biogenic VOC and Urban Atmospheres



The new isoprenoid emission factors will correct current biogenic VOC inventories with significant consequences for air quality modeling.

This may partly explain the high fraction of biogenic contribution in OC of particles for this area (Szidat et al., 2007).

Plants and Urban Atmospheres



Plants and Urban Atmospheres

Modular Urban Forest Effects (UFORE) Model

UFORE- A: Anatomy of the Urban Forest – quantifies urban forest structure (species composition, density, tree health, leaf area, leaf and tree biomass).

UFORE-B: Biogenic Volatile Organic Compound (VOC) emissions – quantifies hourly urban forest VOC emissions (isoprene, monoterpenes and other VOC emissions that contribute to ozone formation) and ozone and CO formation based on VOC emission.

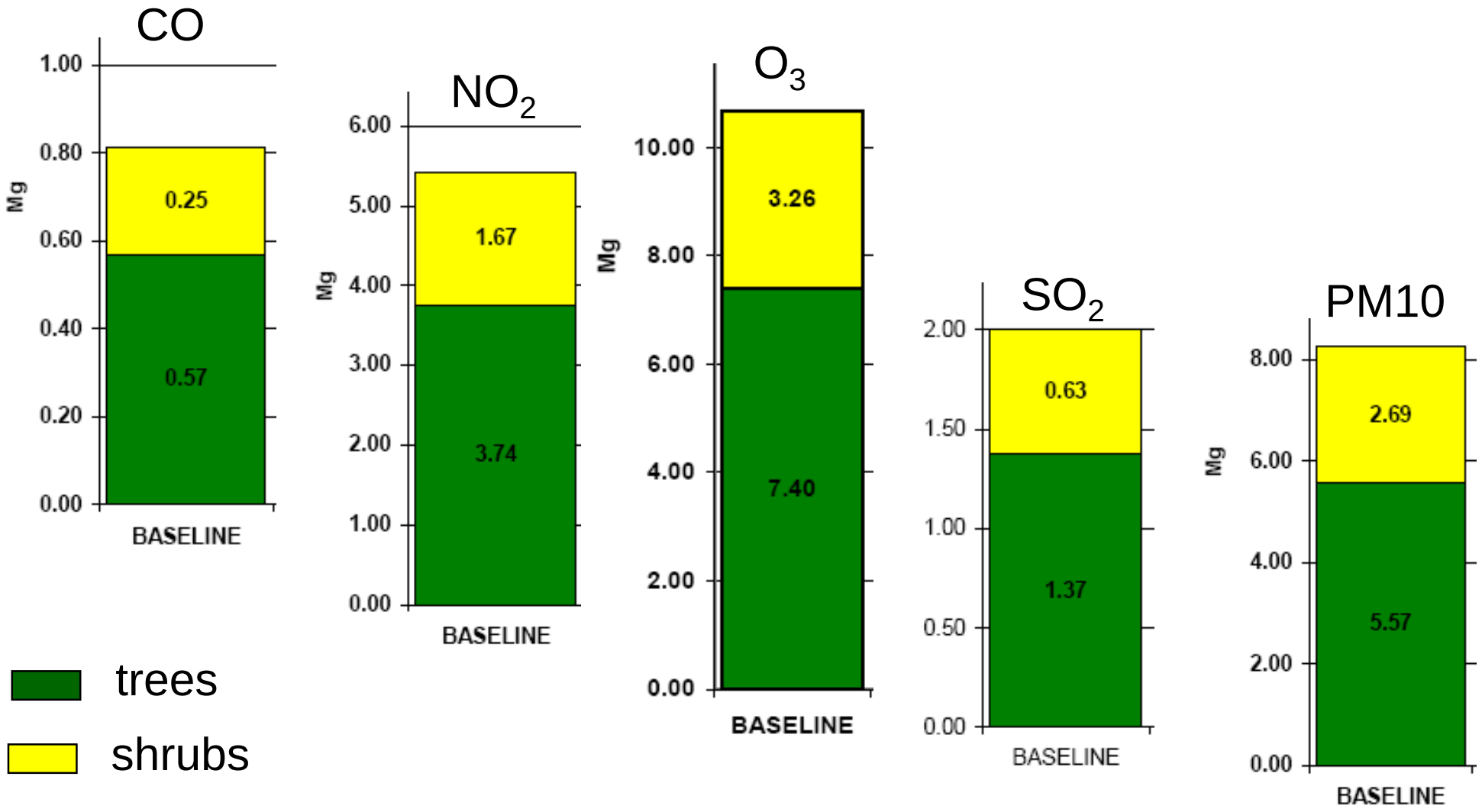
UFORE-C: Carbon Storage and Sequestration – calculates total carbon (C) storage potential and gross and net C sequestered annual by the urban forest based on field data.

UFORE – D: Dry Deposition of Air Pollution – quantifies the hourly amount of pollution removed by the urban vegetation and the associated per cent improvement in air quality through out a year. Pollution removal is calculated for 0_3, $S0_2$, $N0_2$, CO and PM10.

(Nowak and Crane, 1998)

Plants and Urban Atmospheres

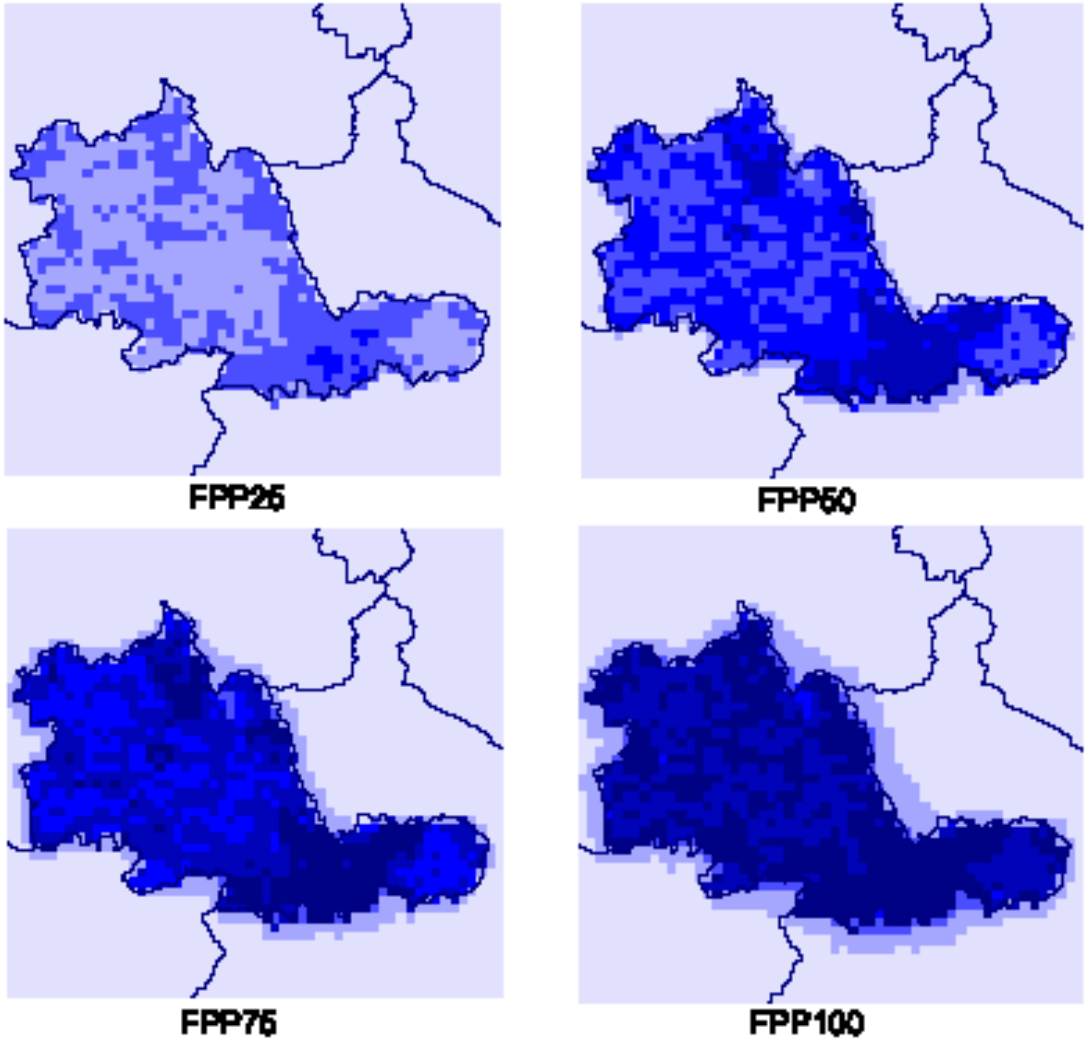
Toronto: Annual Pollutant Deposition with UFORE



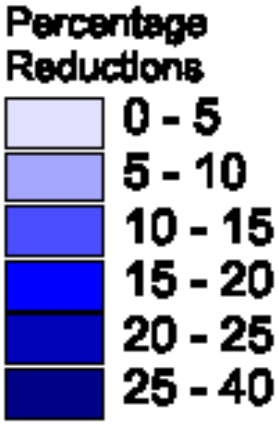
(Curie and Bass; brad.bass@ec.gc.ca)

Plants and Urban Atmospheres

UK Midlands: Particle Deposition with FRAME (Base 1998; PM10)
(Fine Resolution Atmospheric Multi-Pollutant Exchange Model)



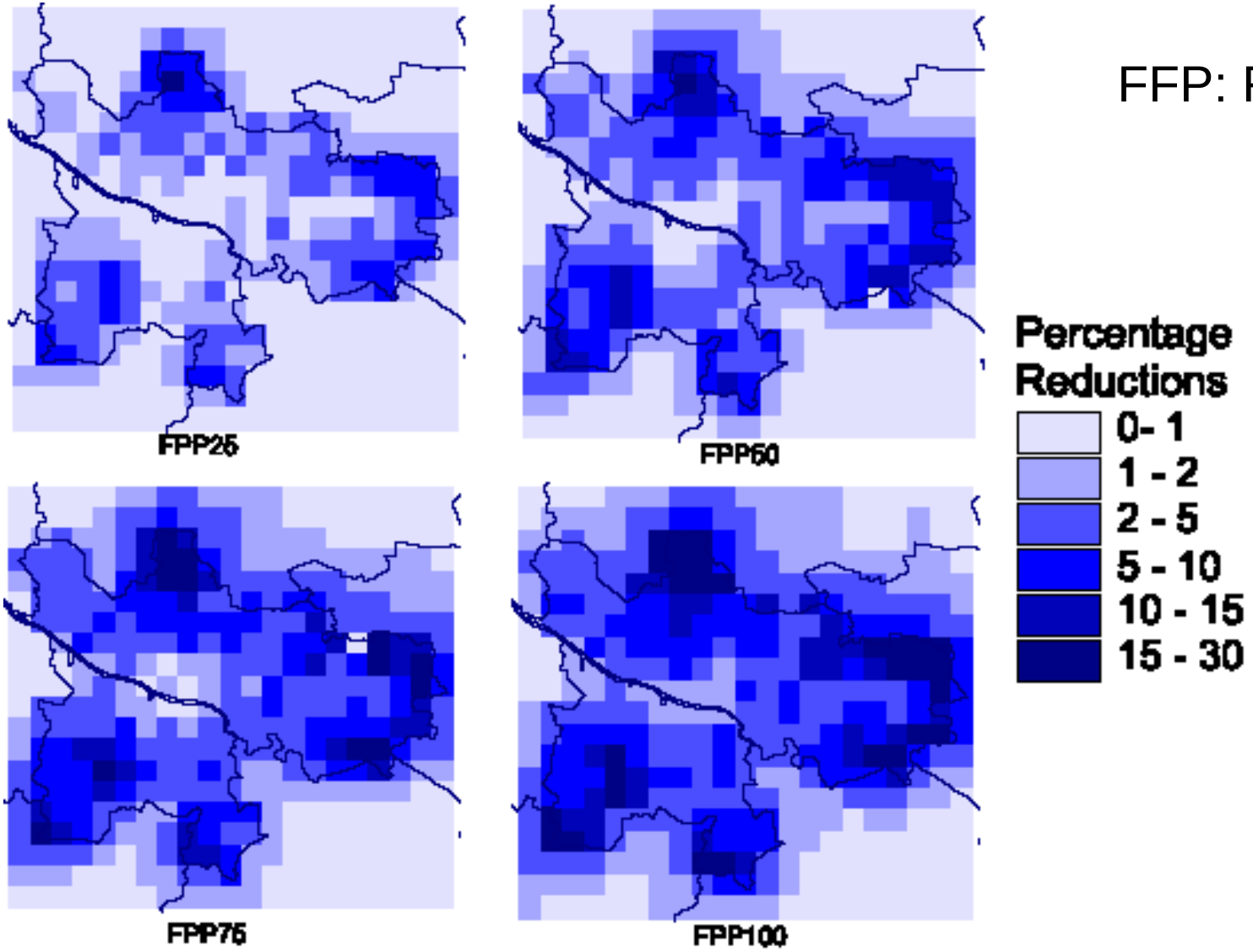
FFP: Future planting Potential



(McDonald et al. 2007)

Plants and Urban Atmospheres

Glasgow: Particle Deposition with FRAME (Base 1998 PM10)
(Fine Resolution Atmospheric Multi-Pollutant Exchange Model)



FFP: Future planting Potential

(McDonald et al. 2007)

Synopsis: Plants and Urban Climate

- Increase the number of trees (increases pollution removal).
- Sustain existing tree cover in particlular large healthy trees (maintains pollution removal levels).
- Maximize use of low VOC emitting trees (reduces ozone and particle formation, increase carbon sink).
- Use long-lived trees (reduces long-term pollutant emissions from planting and removal).
- Use low maintenance trees (reduces pollutants emissions from maintenance activities).
- Reduce fossil fuel use in maintaining vegetation (reduces pollutant emissions).

(modified after Nowak, USDA Forest Service)

Synopsis: Plants and Urban Climate

- Plant trees in energy conserving locations (reduces pollutant emissions from power plants).
- Plant trees to shade parked cars (reduces vehicular VOC emissions).
- Supply ample water to vegetation (enhances pollution removal and temperature reduction).
- Plant low VOC emitting trees in polluted areas or heavily populated areas (maximizes tree air quality benefits).
- Avoid pollutant sensitive species (increases tree health).
- Utilize evergreen trees for particulate matter reduction (year-round removal of particles)

(modified after Nowak, USDA Forest Service)

Synopsis: Plants and Urban Climate

- Moreover

Esthetic Value and Meeting Point

Let's Green the Cities
Reduce CO2
Fight Global Warming