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Air Quality, Health and Agriculture

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Atmospheric Environment Research (AER) Division
WMO Secretariat

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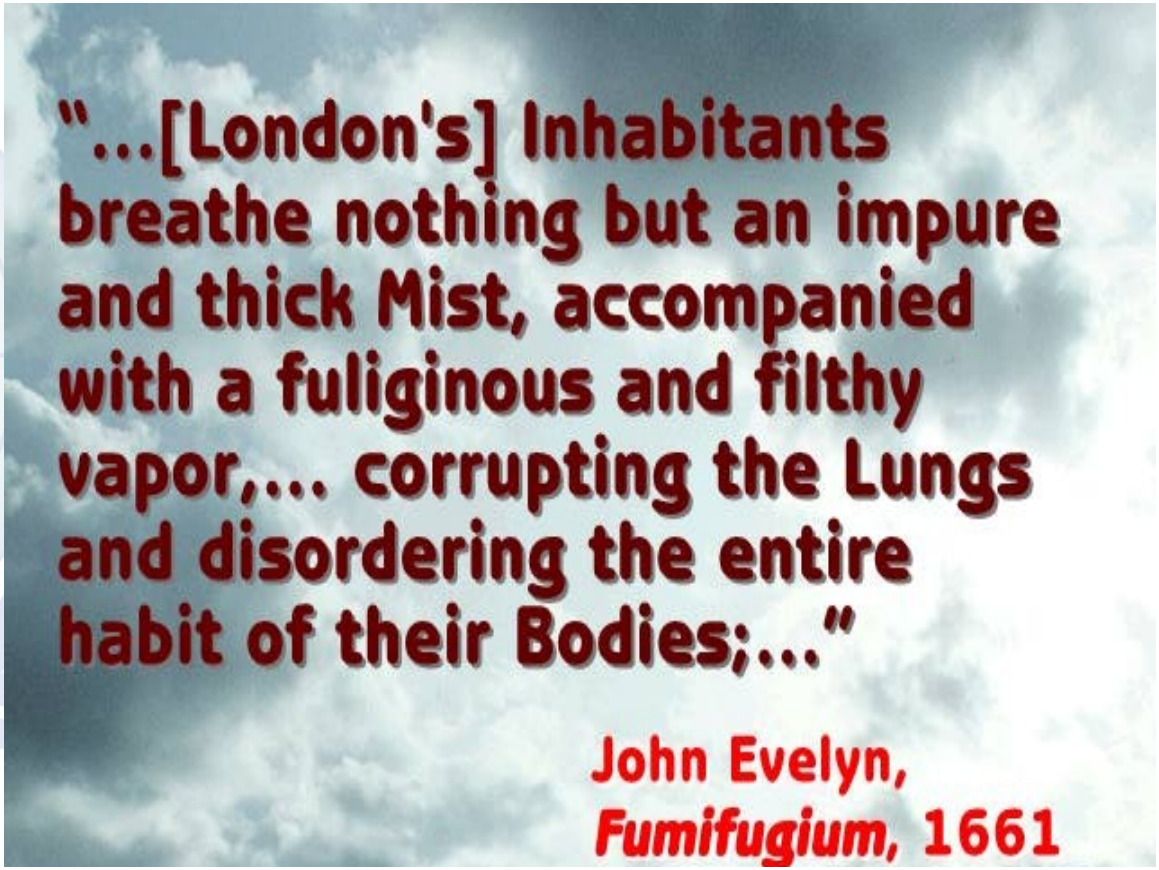
A Brief History of PM



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Air pollution and agriculture

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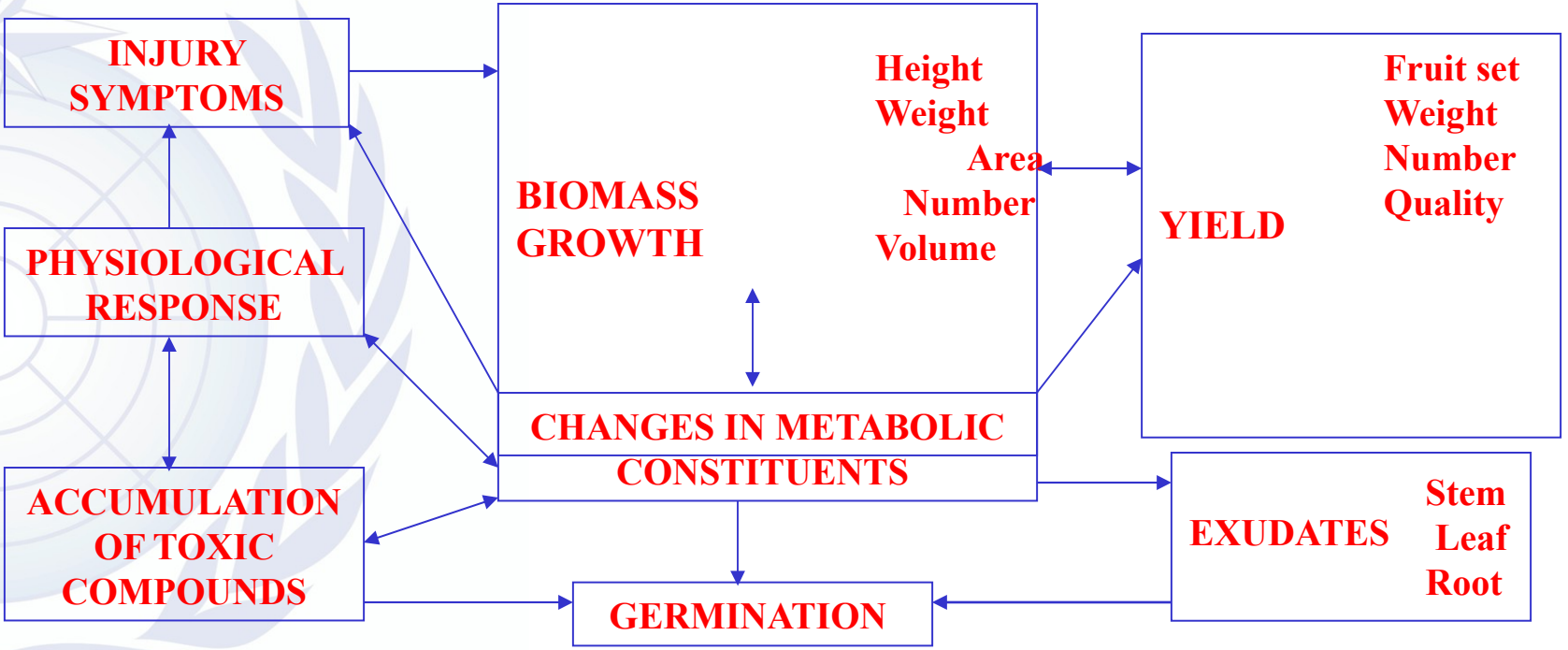
MEASURE OF EFFECTS
HOW THEY INTERRELATE?



AIR POLLUTION EFFECTS ON PLANTS
CONCEPTUAL INTERRELATIONSHIP

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Photosynthesis rate (μ mol $CO_2 m^{-1} s^{-1}$) in selected plants grown (Mean ± 1SE)

S i t e	Mustard	Wheat	Pea	Mung
Reference area	13.75 [a] ± 0.3	20.7 [a] ± 0.31	11.51 [a] ± 0.41	10.03 [a] ± 0.28
Industrial and urban area	7.24 [c] ± 0.35	13.9 [c] ± 0.67	4.56 [d] ± 0.64	5.26 [d] ± 0.26
Periurban area	11.65 [b] ± 0.34	15.2 [c] ± 0.42	5.68 [c] ± 0.38	8.11 [b] ± 0.14
Urban area	10.21 [b] ± 0.49	14.2 [c] ± 0.50	4.96 [d] ± 0.19	7.29 [c] ± 0.32
Rural area	13.55 [a] ± 0.26	18.0 [b] ± 0.52	7.62 [b] ± 0.09	8.34 [b] ± 0.11

Within each plants values not followed by the same letter are significantly different at $p < 0.05$

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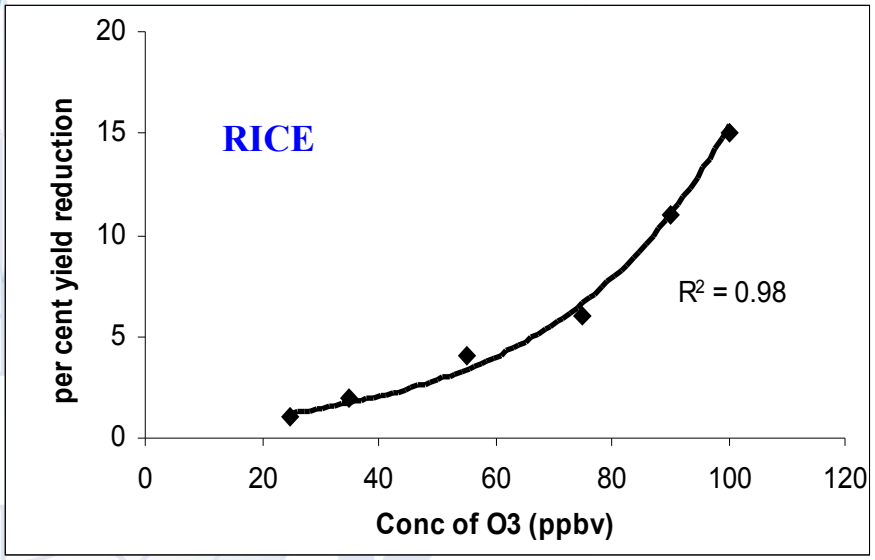
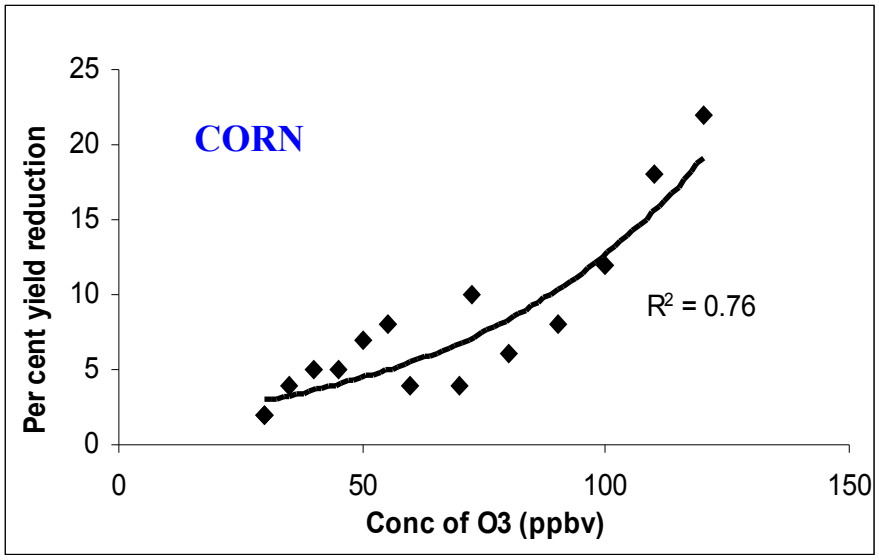
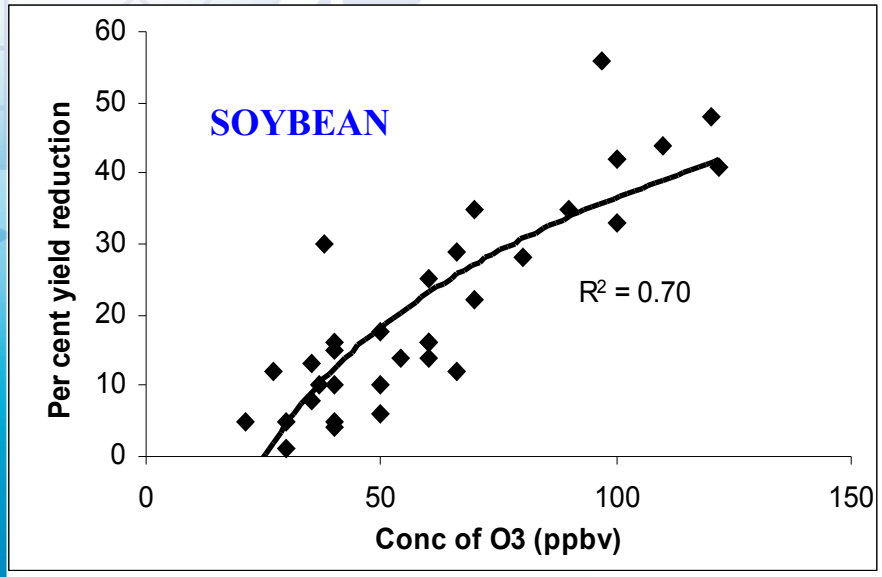
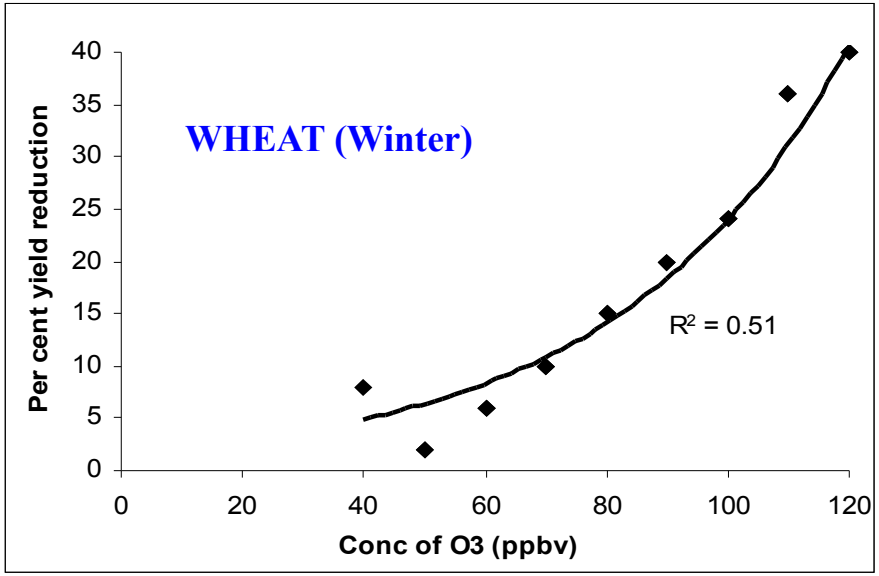
Impact of Ozone Exposure to Crop Yield (Yield Reduction)









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Air pollution and health

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Air Pollution Disasters

1930 Meuse River Valley, Belgium

A three-day episode of severe air pollution makes 6,000 ill and kills 63.

1948 Denora, PA

Oct. 26 to 31: air pollution episode leaves 20 dead out of 14,000 persons.

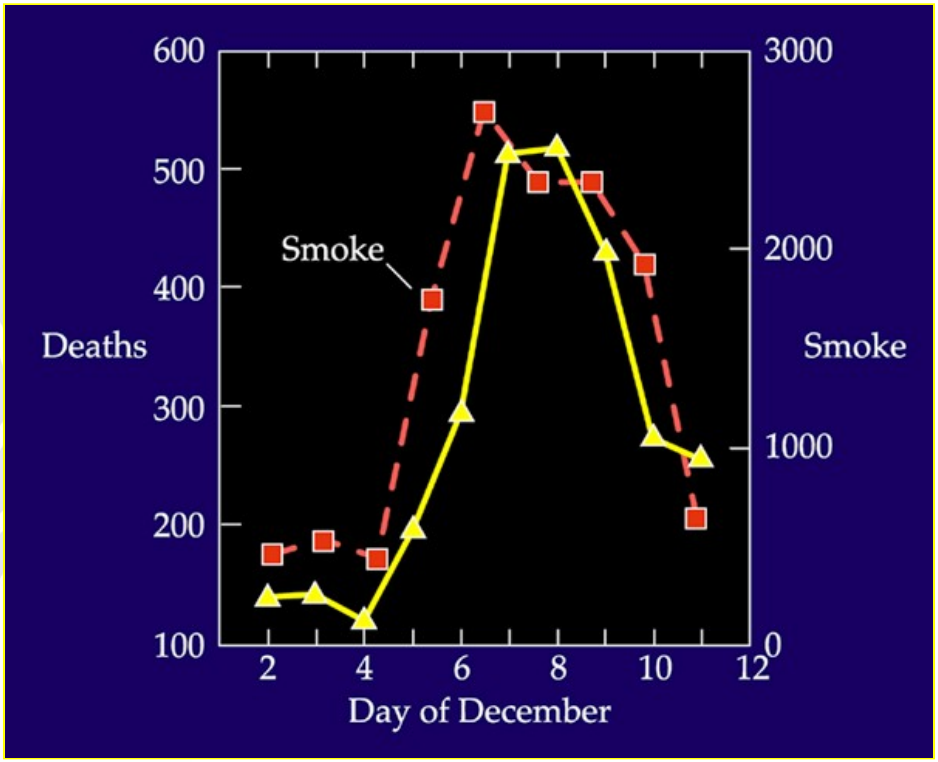
Donora, PA at noon on Oct. 29, 1948

1952 London, England

Dec. 4 to 9: "Killer Fog" leaves three to four thousand people dead.

London buses are escorted by lantern at 10:30 in the morning.

Mortality attributed to London Smog



Schwartz, 1994

1.

Air pollutants and how they affect human health

Pollutants considered

- Particulate matter
  - PM10 (PM < 10 microns)
  - PM2.5 (PM < 2.5 microns)
  - (PM10-PM2.5 = coarse fraction)
- Nitrogen dioxide (NO_2)
- Sulfur dioxide (SO_2)
- Ozone (O_3)

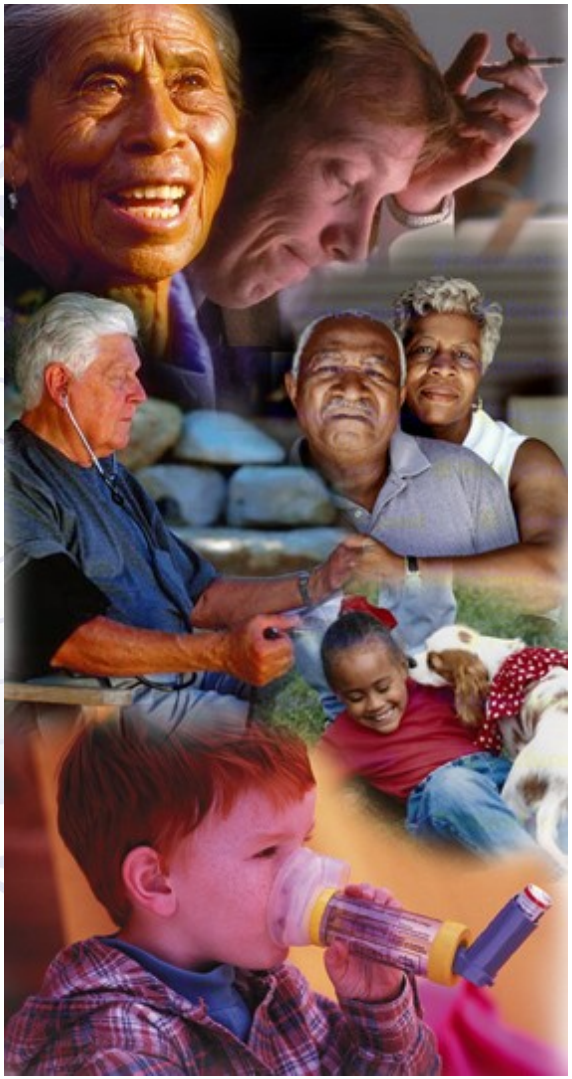
Estimates of the burden of disease attributable to environmental factors vary depending on

- Type of disease
- Vulnerability
- Genetics
- Population group
- Socioeconomic aspects

Large differences between people living e.g. in

- Industrialized/developing countries
- Different sectors of continent/country

Some Groups Are More at Risk



- People with heart or lung disease
  - Greater deposition with chronic obstructive pulmonary disease (COPD)
- Older adults
  - Greater prevalence of heart and lung disease
- Children
  - More likely to be active
  - Breathe more air per kg
  - Bodies still developing

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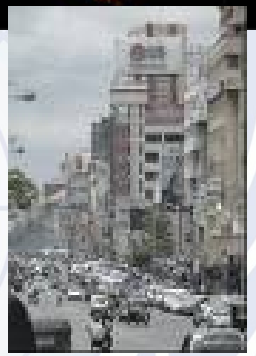
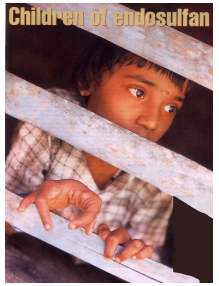
Competing micro-environments (Indoor/Outdoor/Occupational)





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WHO estimates deaths/year:

1.5 mill from indoor air pollution and

800 000 from outdoor air pollution.

These estimates are likely to be too low.

Effects are expressed by

- **Number of deaths** (**mortality** rates)

- **DALY**s:
  An indicator of “burden of disease”,
  “**D**isability-**A**djusted **L**ife **Y**ears”
  Gives an indication how disease can alter the ability of people to live a normal life compared with those with no disease. **Expresses years of lost life.**

- **Morbidity**, such as increased frequency of chronic bronchitis, respiratory hospital admissions, restricted activity days.

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PARTICLES

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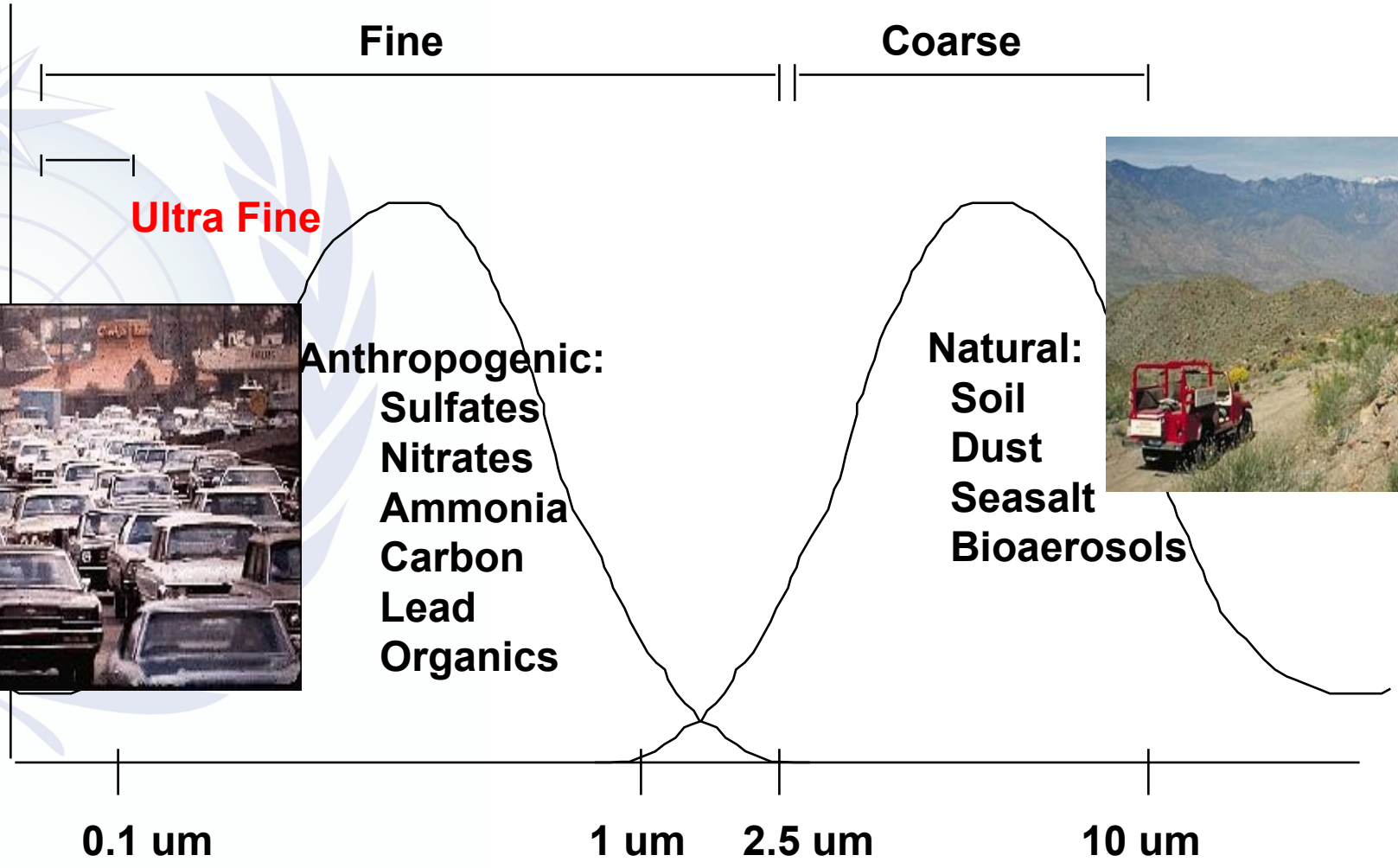
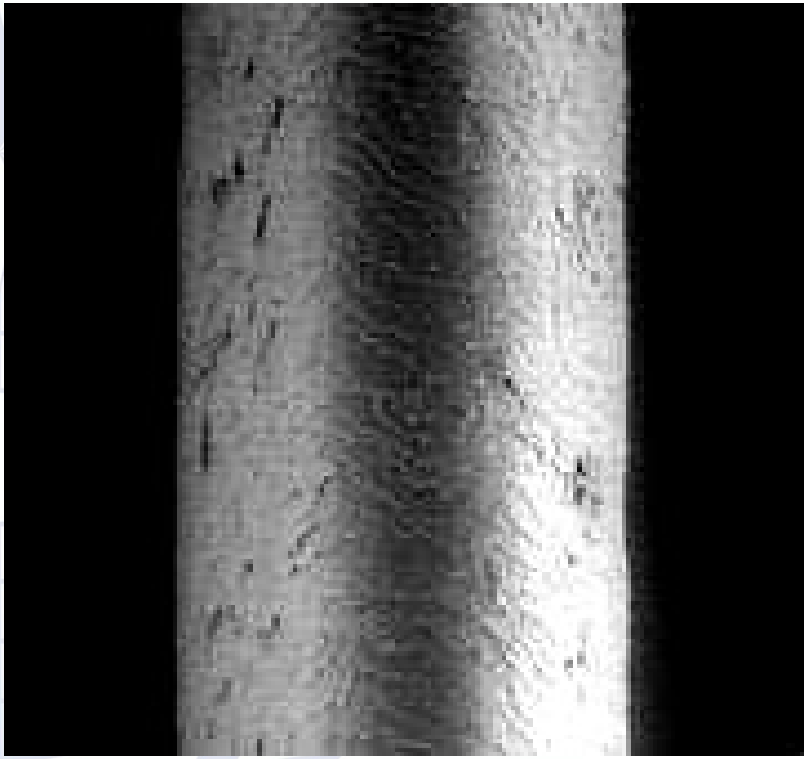
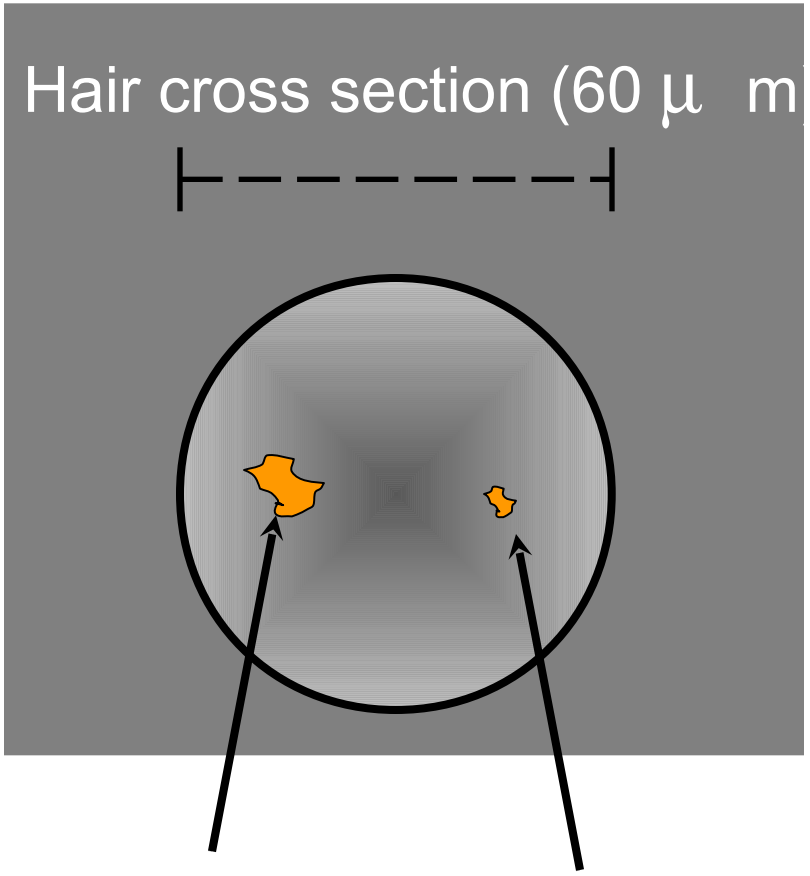
Particulate Matter Sizes and Composition



PM relative to hair cross section



Human Hair



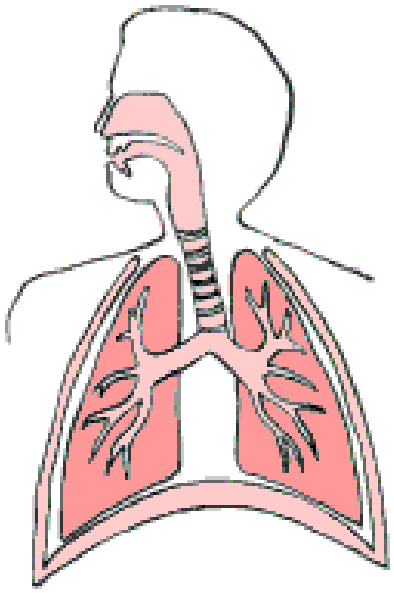
PM10
(10 µ m)

PM2.5
(2.5 µ m)

Particles Affect the Lungs

Respiratory system effects:

- Respiratory symptoms – irritation of airways, cough
- Decreased lung function
- Airway inflammation
- Asthma attacks, bronchitis
- Chronic bronchitis



Public Health Risks Are Significant

Particles are linked to

- Premature death from heart and lung diseases
- Aggravation of heart and lung diseases, with increased
  - Hospital admissions
  - Doctor and ER visits
  - Medication use
  - School and work absences

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Nitrogen dioxide (NO_2) effects

- Strong oxidant and respiratory irritant (forms nitrous and nitric acids in contact with water)
- NO_2 irritates the nose, throat and lungs especially in people with asthma.
- Lowers resistance to respiratory infections such as influenza.
- Contributes to ozone formation (and thus to ozone effects indirectly).

SO_2 Effects

- Usually short-term concentration peaks
- SO_2 reduces lung function:
- Constricts breathing passages, causing wheezing, shortness of breath and coughing, happens quickly.
- Lung function returns to normal about an hour after exposure ends.
- Causes above in healthy subjects and asthmatics; latter are substantially more sensitive

Ozone (O_3)

- Formed through natural processes as well as human activities
- Principal constituent of photochemical smog – not emitted directly
- Highly reactive, but poorly soluble, allowing deep lung penetration
- Acute toxicity is related to dose = Concentration x Ventilation Rate x Time – increased risk from outdoor exertion

Ozone Irritates Airways

Symptoms:

- Cough
- Sore or scratchy throat
- Pain with deep breath, or chest pain
- Fatigue

Rapid onset, but effect is greater 24 h after exposure

Similar symptoms for people with or without asthma

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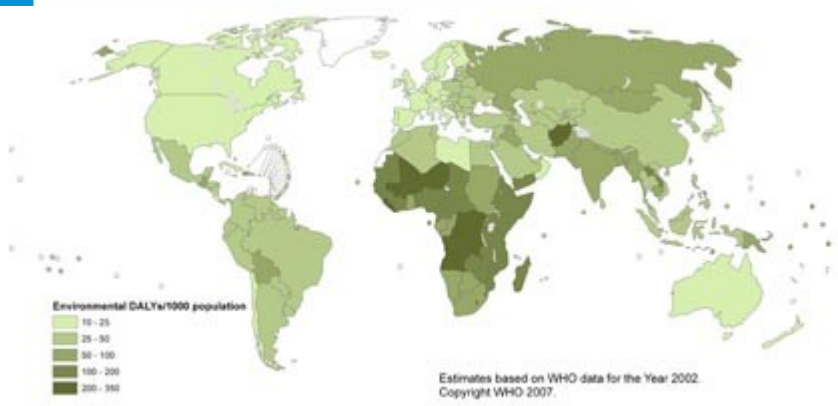
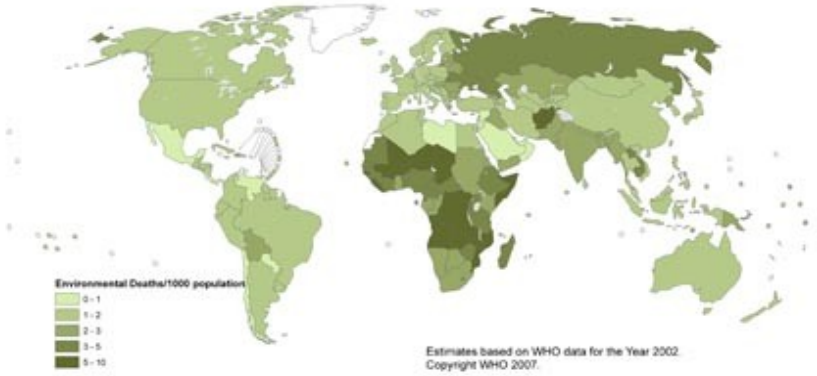
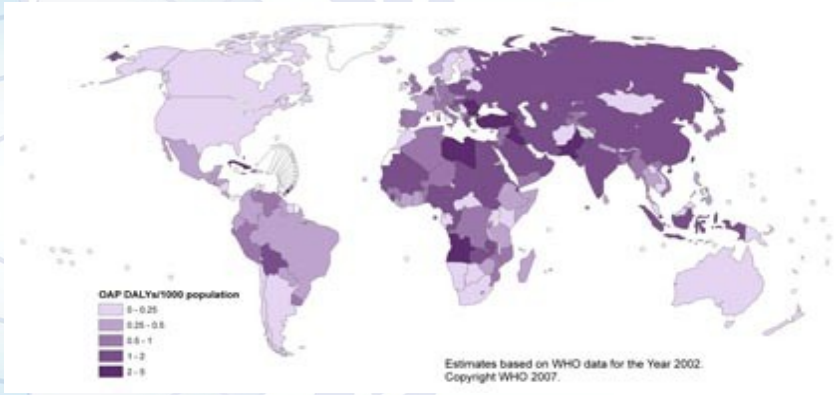
Air pollution level and relation with mortality and morbidity

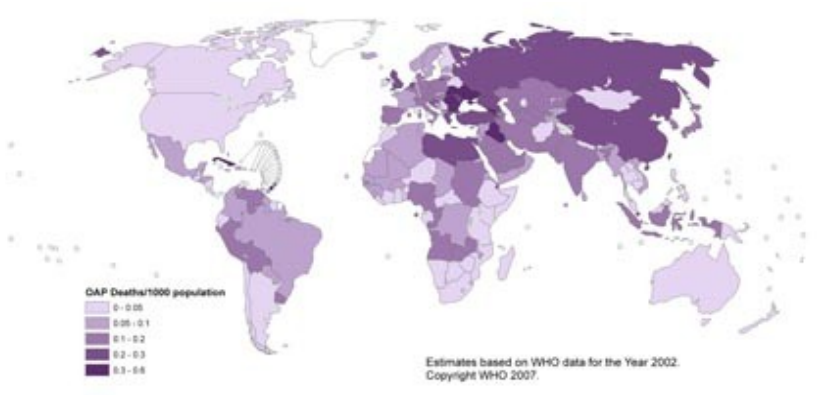
Air pollution is the **environmental factor** with the **greatest health impact** in Europe



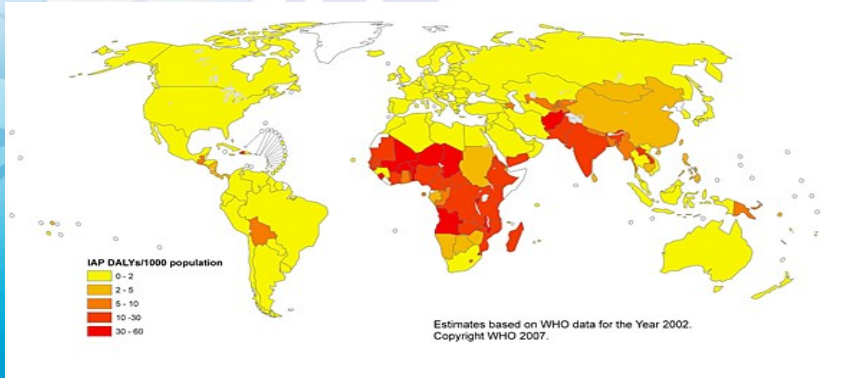


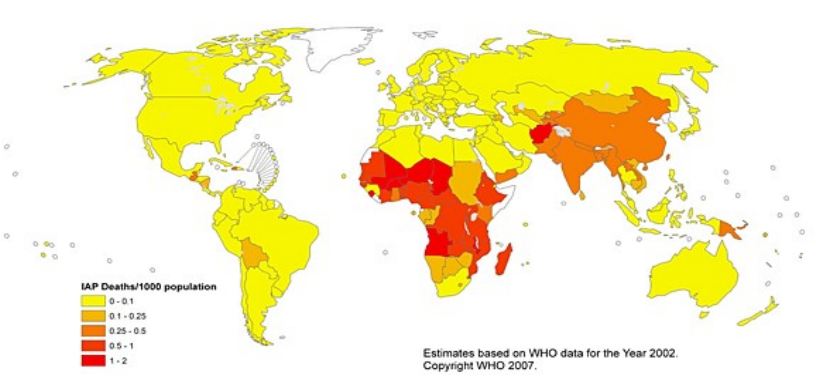
TME





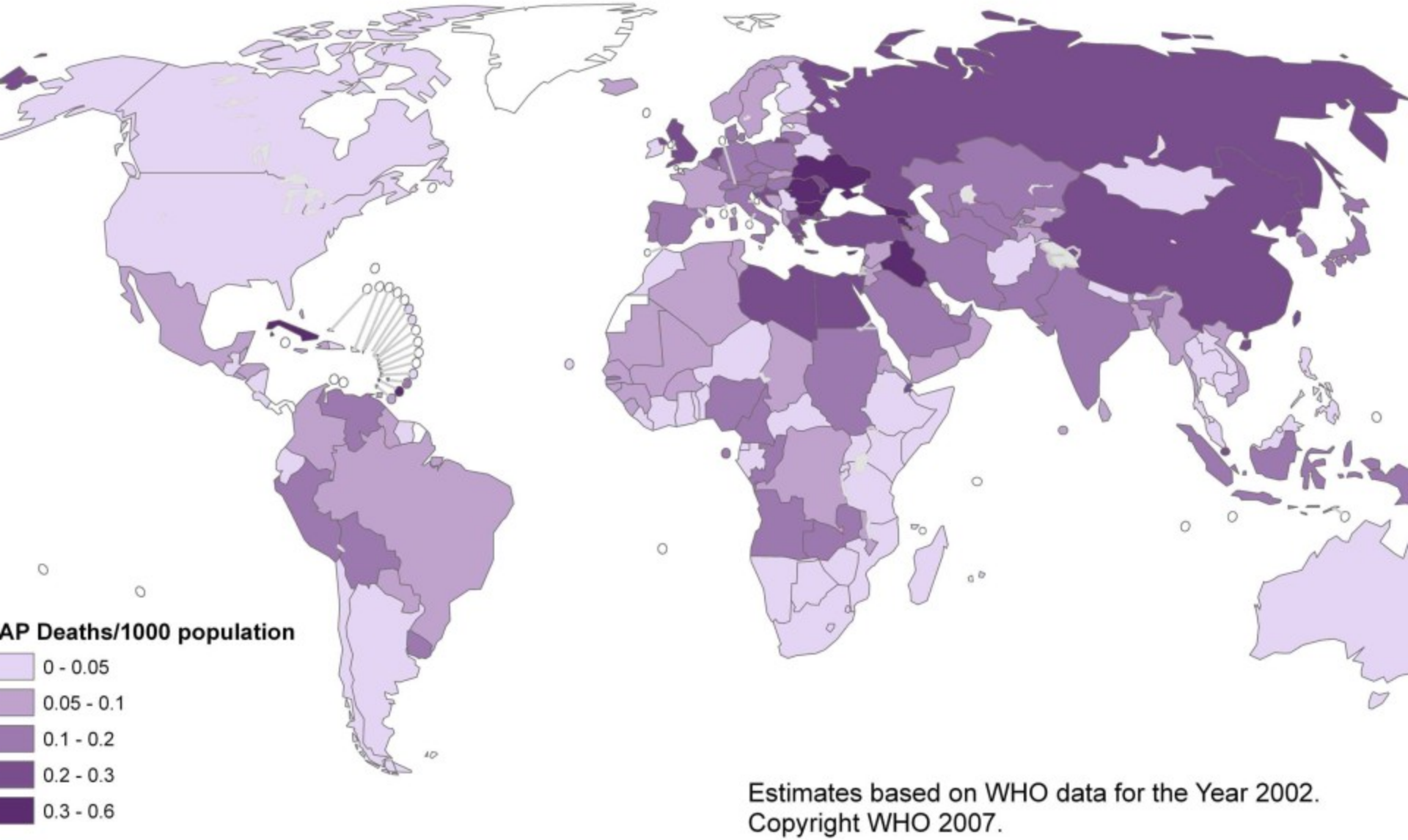
OAP



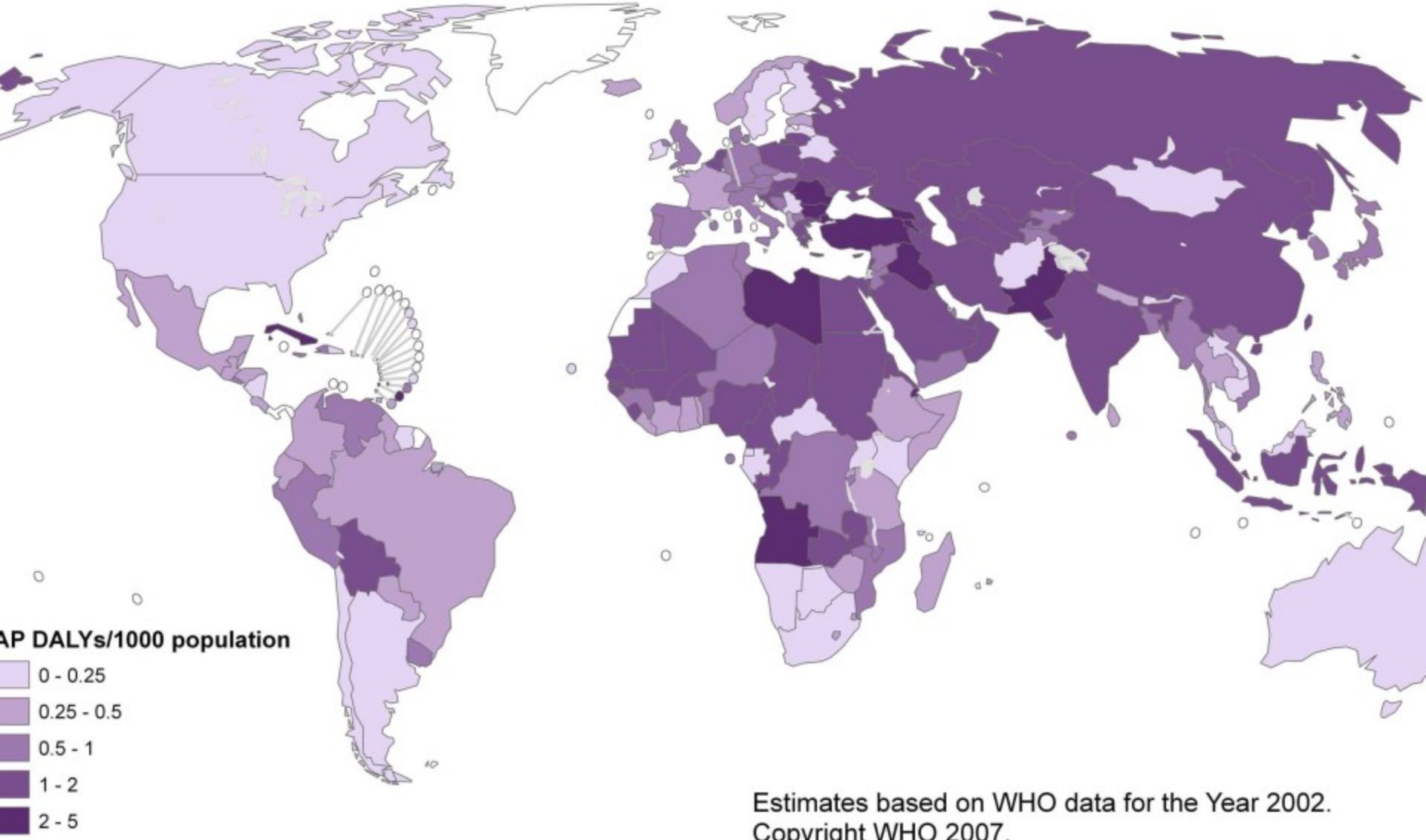


IAp

From "Environmental burden of disease, WHO 2007"



Estimates based on WHO data for the Year 2002.



Estimates based on WHO data for the Year 2002.

WHO AQG: Global update: Particulate matter: 24-h mean

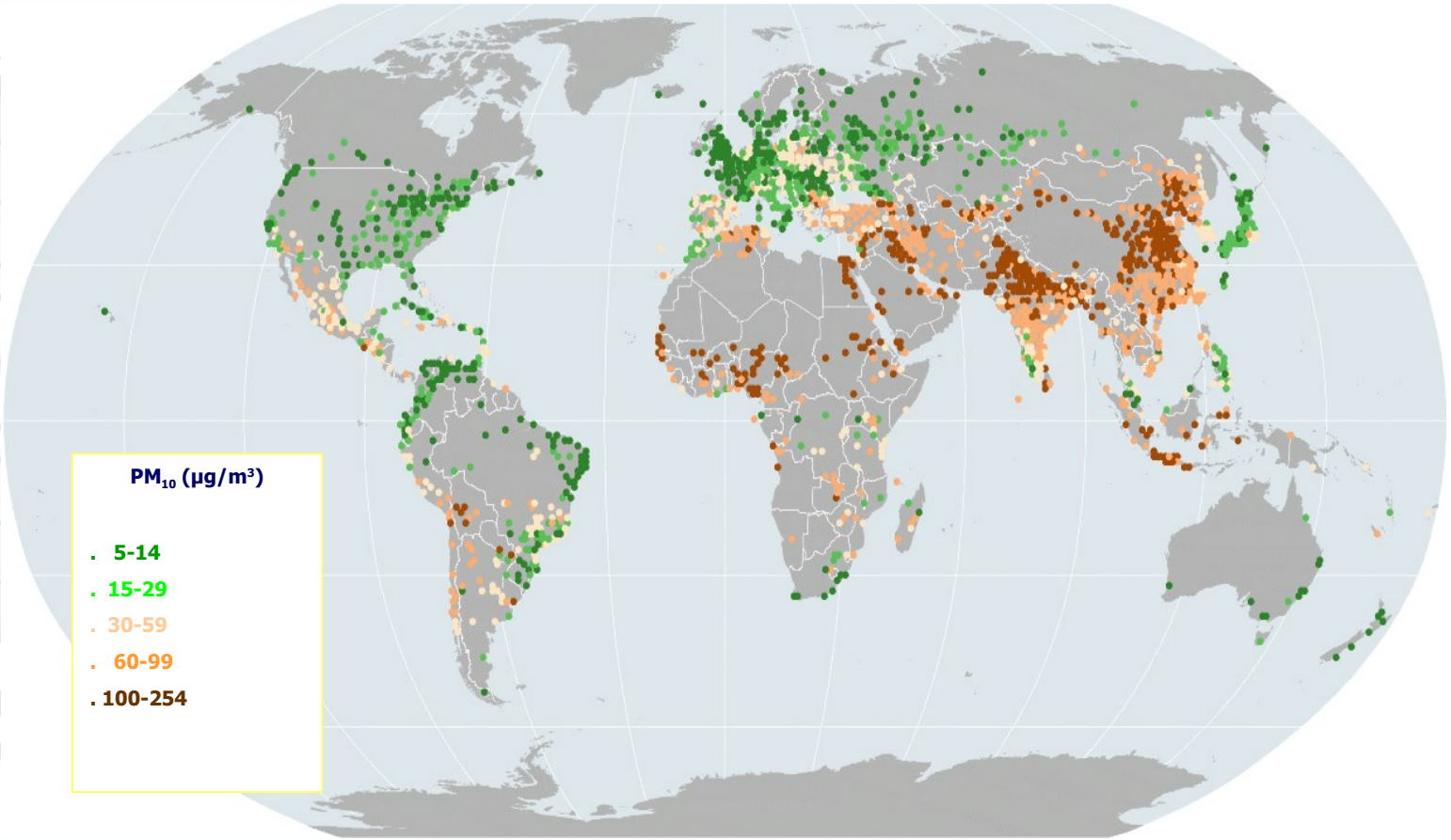
24-hour mean level *)	PM_{10} (µg/m³)	$PM_{2.5}$ (µg/m³)	Basis for the selected level
Interim target-1 (IT-1)	150	75	About 5% increase of short-term mortality over AQG
Interim target-2 (IT-2)	100	50	About 2.5% increase of short-term mortality over AQG
Interim target-3 (IT-3)	75	37.5	About 1.2% increase in short-term mortality over AQG
Air quality guidelines (AQG)	**50**	**25**	Based on relation between 24-hour and annual PM levels

*) 99th percentile (3 days / year)

AQG 2000: no guideline value

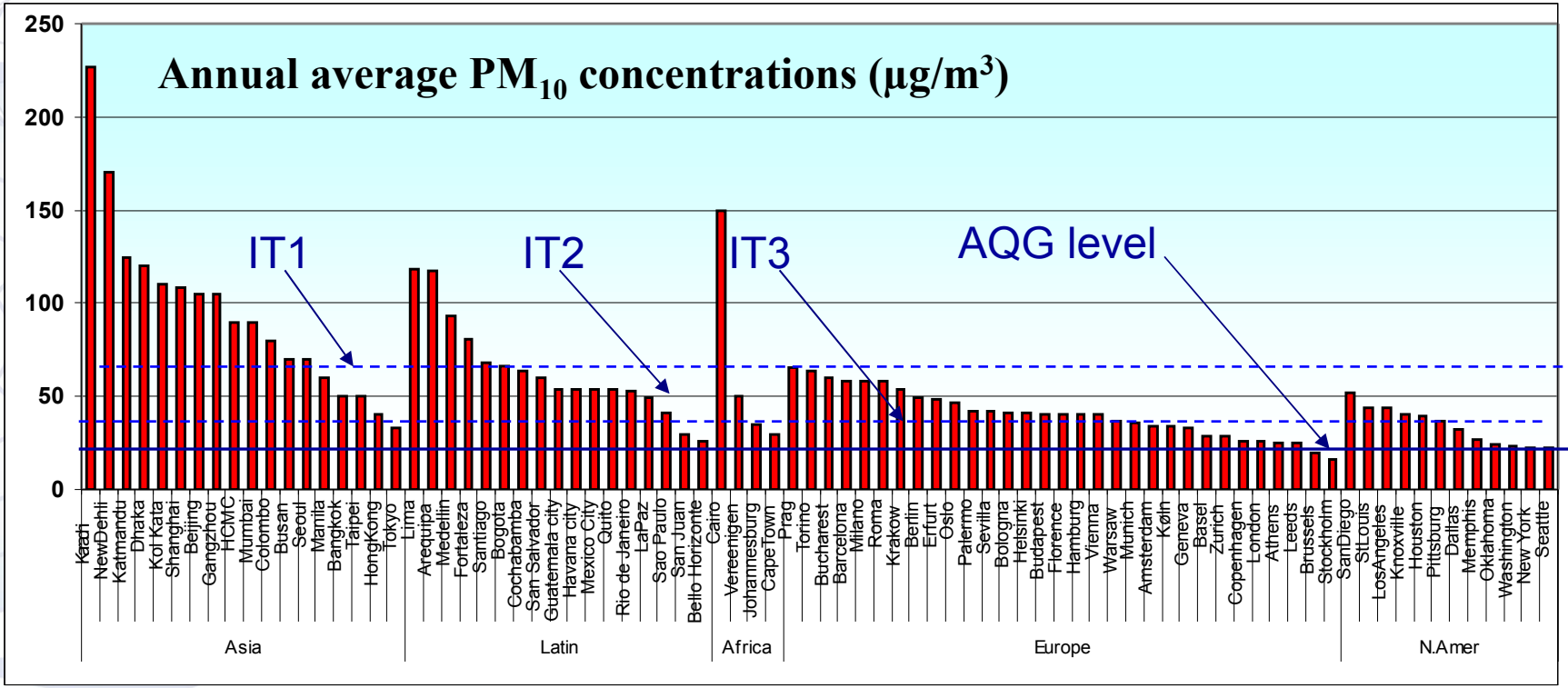
Outdoor Air Pollution

Estimated PM10 Concentration in World Cities (pop >=100,000)



Cohen et al., WHO CRA Report 2002

Annual average PM10 concentrations observed in selected cities worldwide



M Krzyzanowski, H-G. Mucke

WHO AQG: Global update: Ozone: daily maximum 8-h mean

	Daily maximum 8-hour mean	Effects at the selected ozone level
High level	240 µg/m^3	Significant health effects, substantial proportion of vulnerable population affected.
Interim target-1 (IT-1)	160 µg/m^3	Important health effects, an intermediate target for populations with ozone concentrations above this level. Does not provide adequate protection of public health.
Air quality guideline (AQG)	**100 µg/m^3**	This concentration will provide adequate protection of public health, though some health effects may occur below this level.

AQG 2000: 120 µg/m3

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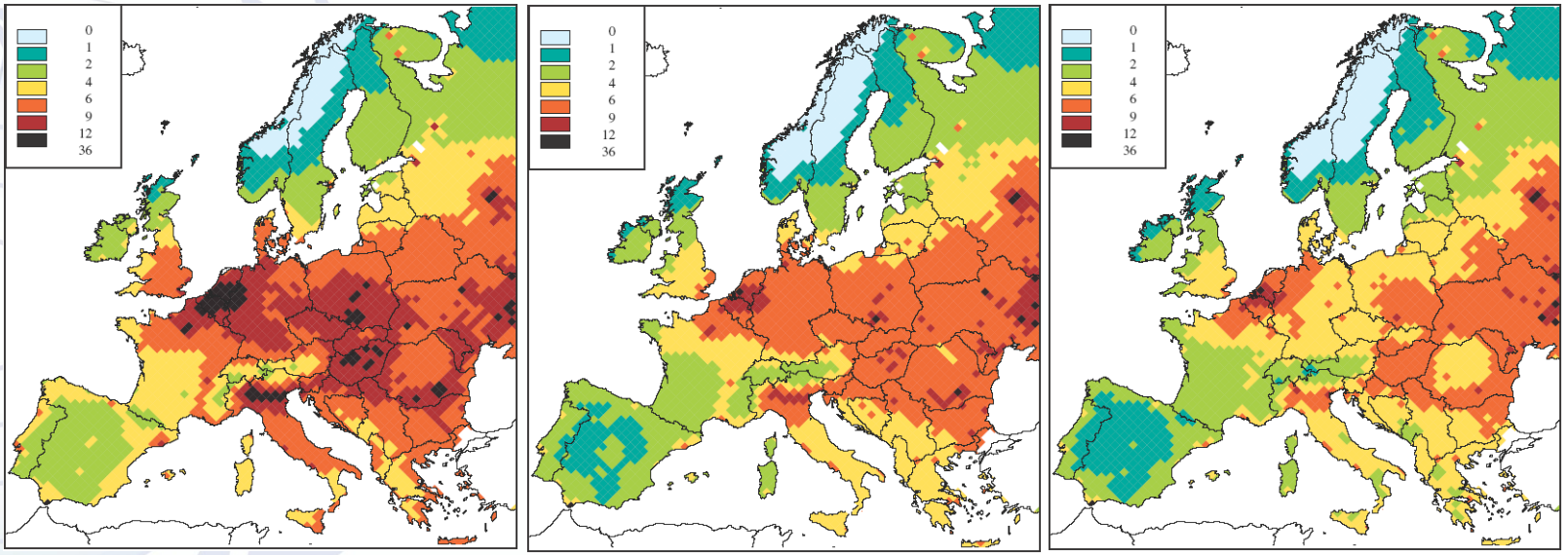
Loss in life expectancy

attributable to anthropogenic PM2.5 [months]



2000 2010 2020

Loss in average statistical life expectancy due to identified anthropogenic PM2.5

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Estimated Risk of first CV event or death associated with an exposure increase of 10 µg/m3 PM2.5

Women Health Initiative (WHI) study of 65,893 postmenopausal women without previous cardiovascular disease recruited in 36 U.S. metropolitan areas from 1994 to 1998, with a median follow-up of 6 years.

	Number of events	%increase in risk per 10 µg/m3 PM2.5 (95%CI)		
		Overall	Between cities	Within cities
Any cardiovascular event	1816	24 (9 – 41)	15 (-1 – 32)	64 (24 – 118)
Death from cardiovascular disease	261	76 (25 – 147)	63 (0 – 140)	128 (10 – 375)

Source: Miller et al. NEJM 2007

3.

Examples and actions

Will It Matter if Air Pollution Decreases?

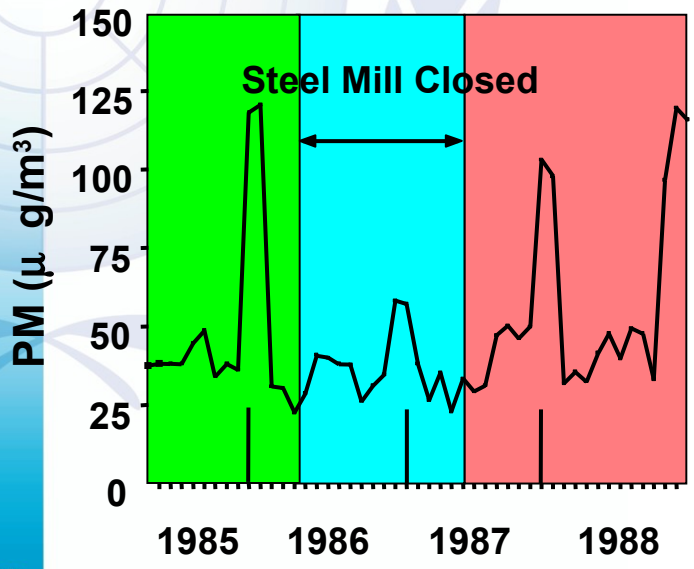
The Dublin Experience

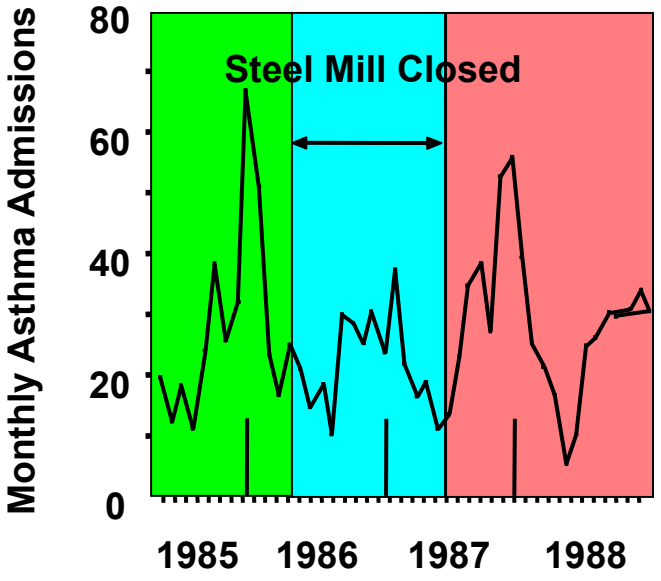
- **Dublin's air quality deteriorated in the 1980s after a switch from oil to cheaper bituminous coal for heating.**
- **In 1990 the Irish Government banned the use of bituminous coal within the city of Dublin, resulting in a reduction in PM concentrations.**

Change in age-standardized total, cause-specific, and age-specific mortality rates for Dublin County Borough for 72 months before and after ban of sale of coal in Dublin: decrease from 4.5 to 15.5 % depending on the specific group.

The Utah Valley

Steel mill closed due to a labor dispute





Example of action

Phasing out leaded gasoline

Mental retardation due to lead exposure was estimated to be nearly 30 times higher in regions where leaded gasoline was still being used compared with regions where leaded gasoline had been completely phased out.

Air Quality Index

Descriptors	Cautionary Statement
Good 0 – 50	No message
Moderate 51 – 100	Unusually sensitive individuals
Unhealthy for Sensitive Groups 101 - 150	Identifiable groups at risk - different groups for different pollutants
Unhealthy 151 - 200	General public at risk; sensitive groups at greater risk
Very Unhealthy 201 - 300	General public at greater risk; sensitive groups at greatest risk

Use AQI to Reduce Risk

Dose = Concentration x Ventilation rate x Time

- Reduce concentration – schedule activities when pollution levels lower
- Reduce ventilation rate by taking it easier
- Reduce time spent in vigorous outdoor activities

Pay attention to symptoms

Heat waves cause excess deaths, large portion due to air pollution

Heat wave in Europe summer 2003:

70 000 extra deaths, about 20 – 38 % due to air pollution

More ozone:

- High T favors production of O_3
- Low RH reduces destruction of O_3
- Less dry removal through vegetation (T, no precipitation)
- Biogenic precursor emissions higher (isoprene)
- Stable meteorological situation with no clouds (containment of pollutants and favorable for photochemistry)

AQ forecasts and Heat Health Early Warnings (HHEW)

Heavy sand storm in Minqin County, northwest of China's Gansu Province.

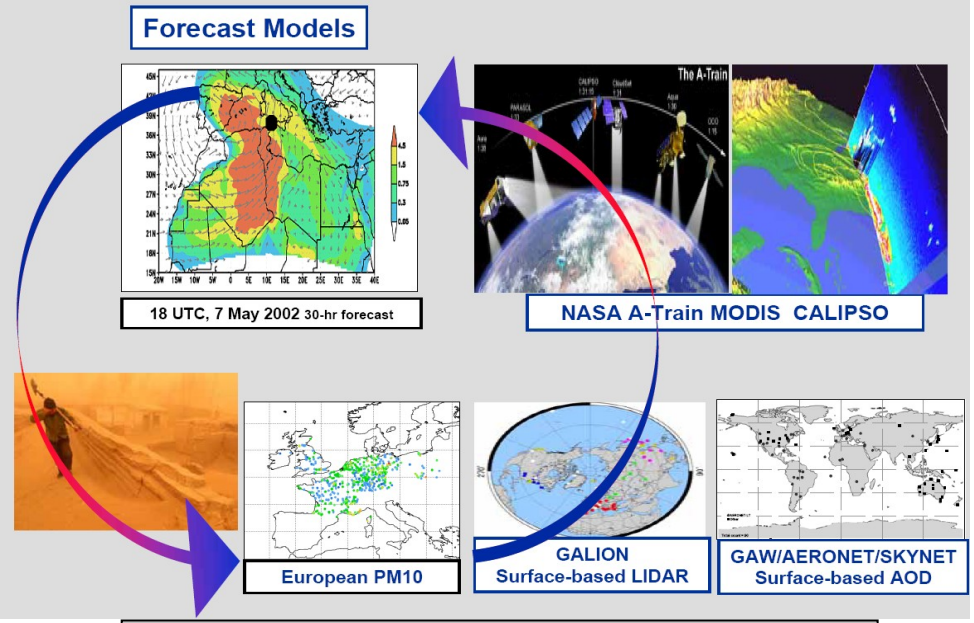
Sand covered about one-eighth of China from April 14 to 18, 2006 and about 330,000 tons of sand fell in Beijing on Sunday night April 10.

The WMO Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS)

- A Global Consortium Helping Society Reduce Risk Through Research, Assessments and Forecasts

SDS-WAS

- 40 WMO Members interested in the initiative
- ~ 15 institutions running research operational dust model forecasts
- 2 SDS-WAS nodes (in China and Spain) established to coordinate regional cooperation



SDS integrates observations, models and delivers products to users

SDS Impacts

- Human Health
  (Asthma, infections, Meningitis in Africa, Valley Fever in the America's)
- Agriculture (negative & positive impacts)
- Marine productivity
- Improved Weather and Seasonal Climate Prediction
- Aviation
- Ground Transportation

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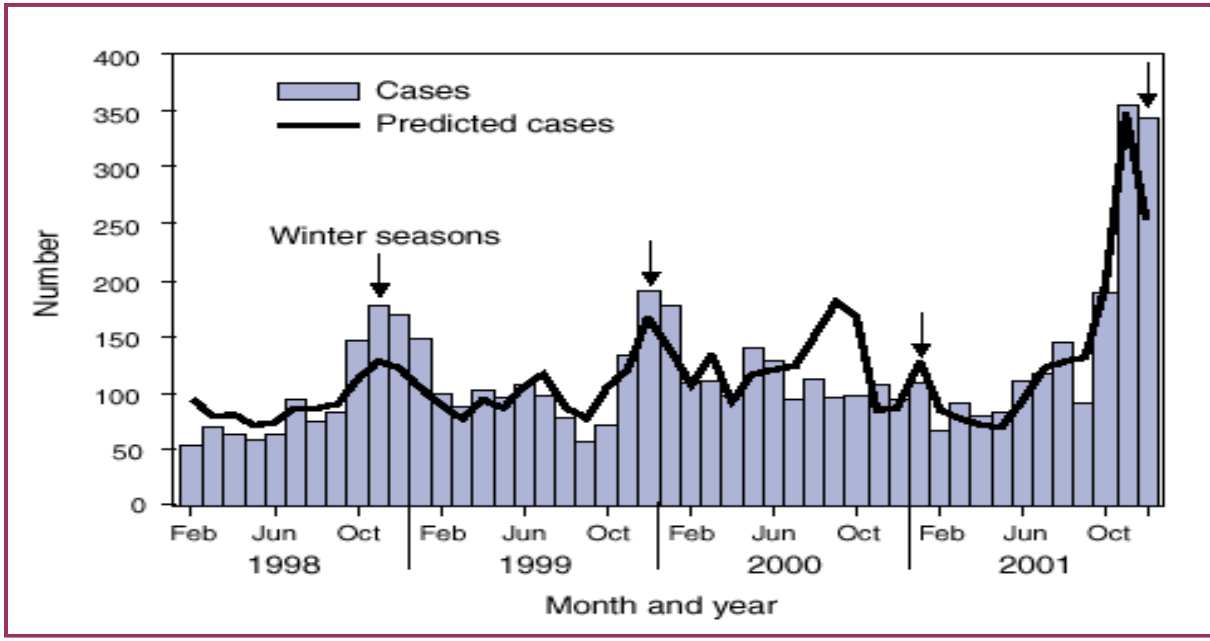
Health Impacts: Valley Fever

Endemic regions:

located mainly in western hemisphere

Source: Hector & Laniado-Laborin, 2002

Valley Fever spores transported by SDS storms



Number of Valley Fever cases in Arizona

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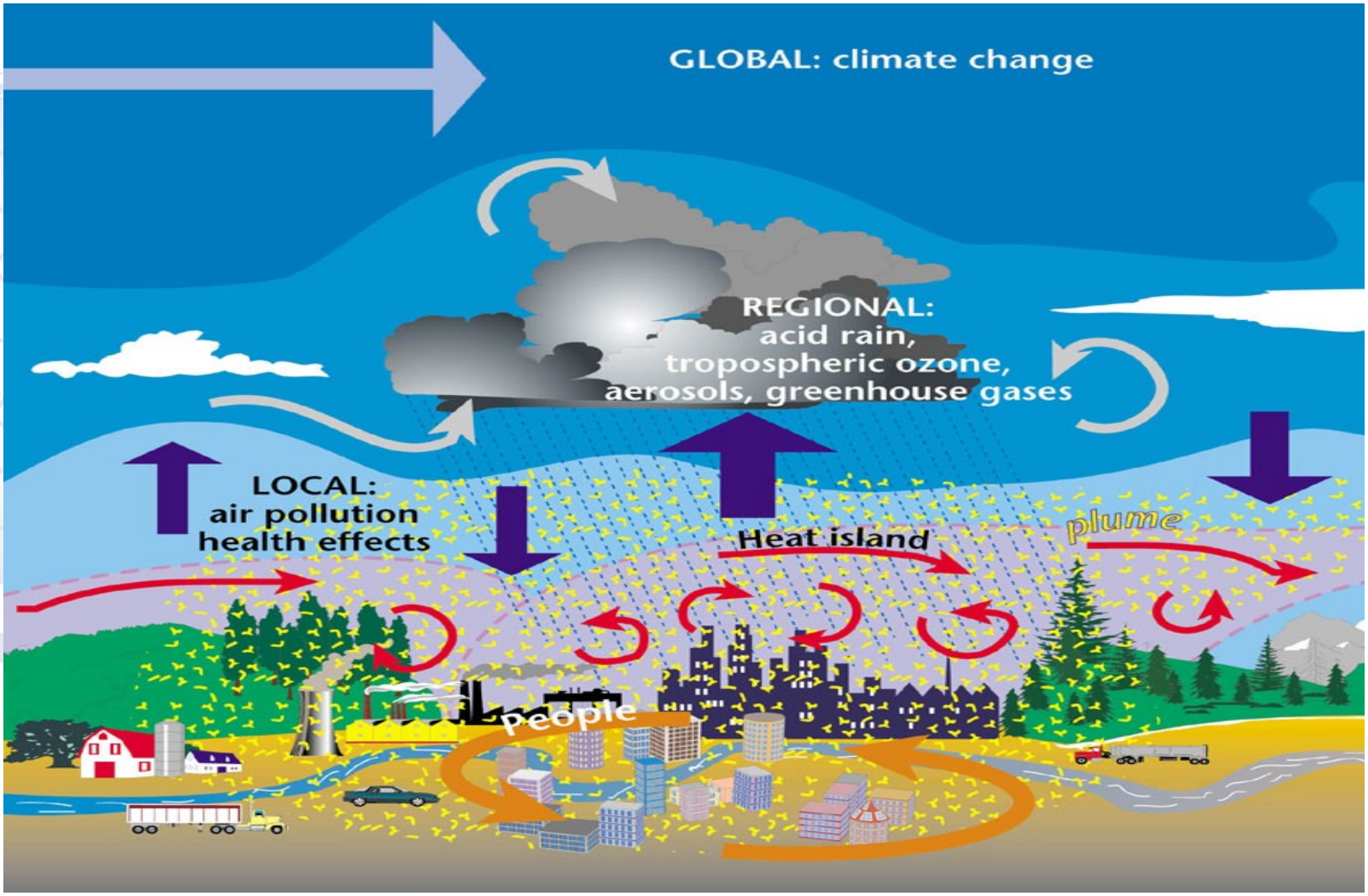
GAW Urban Research Meteorology and Environment
GURME project
Build capacity for air quality modelling and monitoring



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Weather, climate, air and health are inextricably linked

Protecting the global atmosphere, local air quality and health are part of the same agenda

Governments are asking the health sector to work closely with the climate and environmental communities

Thank you!

Extras

The main policy messages

- **Controls on emissions at a global scale are required to control ozone effectively**
- **Shipping and aviation need to be included in any strategy**
- **Implementing existing legislation is vital to prevent the ground level ozone problem becoming worse**
- **Climate change will tend to increase ozone in the polluted regions of the world**
- **Improved integration of sectoral policies is needed to maximise emission reductions across sectors and to reduce ozone impacts. Ozone is not just an air quality issue; it is a human health, environment, climate change, and economic development problem**

WHO AQG: Global update: Summary of updated AQG values

AQG levels recommended to be achieved everywhere in order to significantly reduce the adverse health effects of pollution

Pollutant	Averaging time	AQG value
Particulate matter		
$PM_{2.5}$	1 year	10 µg/m³
	24 hour (99th percentile)	25 µg/m³
PM_{10}	1 year	20 µg/m³
	24 hour (99th percentile)	50 µg/m³
Ozone, O_3	8 hour, daily maximum	100 µg/m³
Nitrogen dioxide, NO_2	1 year	40 µg/m³
	1 hour	200 µg/m³
Sulfur dioxide, SO_2	24 hour	20 µg/m³
	10 minute	500 µg/m³

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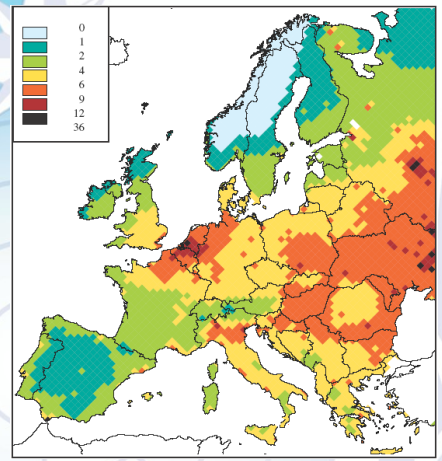
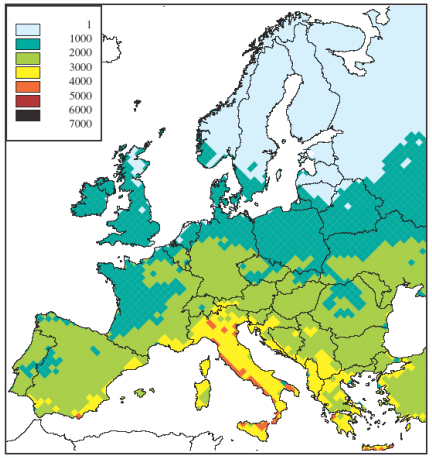
Remaining problem areas in 2020

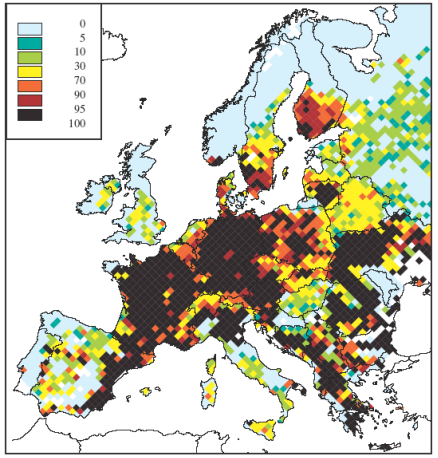
Light blue = no risk



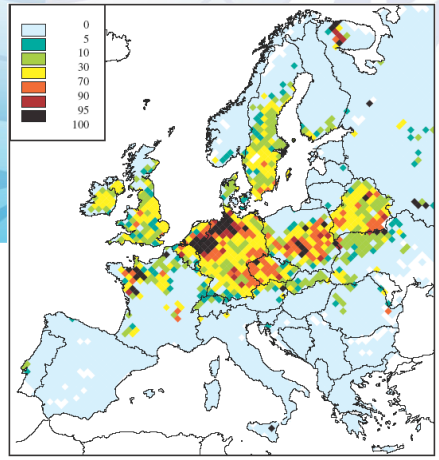
Health - PM



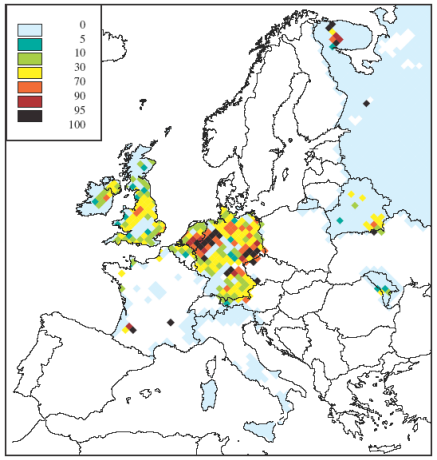
Health+vegetation - ozone



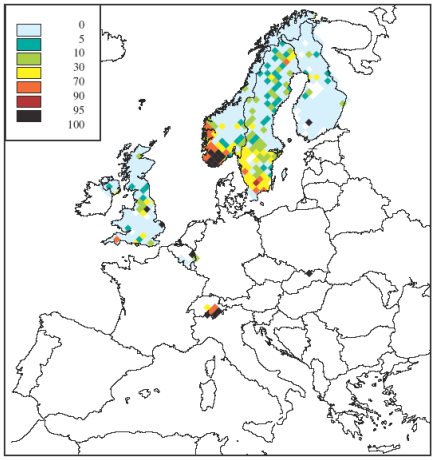
Vegetation – N dep.



Forests – acid dep.



Semi-natural – acid dep.



Freshwater – acid dep.

IIASA, Amann