ATMOSPHERIC PARTICLES
IMPORTANCE, SIZE, CHEMICAL COMPOSITION, SOURCES, SINKS AND EFFECTS

KONSTANTINOS ELEFTHERIADIS

ENVIRONMENTAL RADIOACTIVITY LAB

INRaSTES NCSR 'DEMOKRITOS'

What is an aerosol?

- an assembly of liquid or solid particles suspended in a gaseous medium
- 0.001 μm - 100 μm in diameter
- *Dust:* solid particles formed by mechanical disintegration of a parent material
- *Smoke:* a visible aerosol resulting from incomplete combustion
- *Fog or mist:*liquid particle formed by condensation or atomisation

Dust: It is transported on a planetary scale
Smoke: incomplete combustion of fossil fuel or biomass
Haze: condensation of water vapour on atmospheric nuclei

Smoke Dust& haze by S. Friedlander, 2000, 2nd edition

Atmospheric aerosol concentration displays strong temporal variability

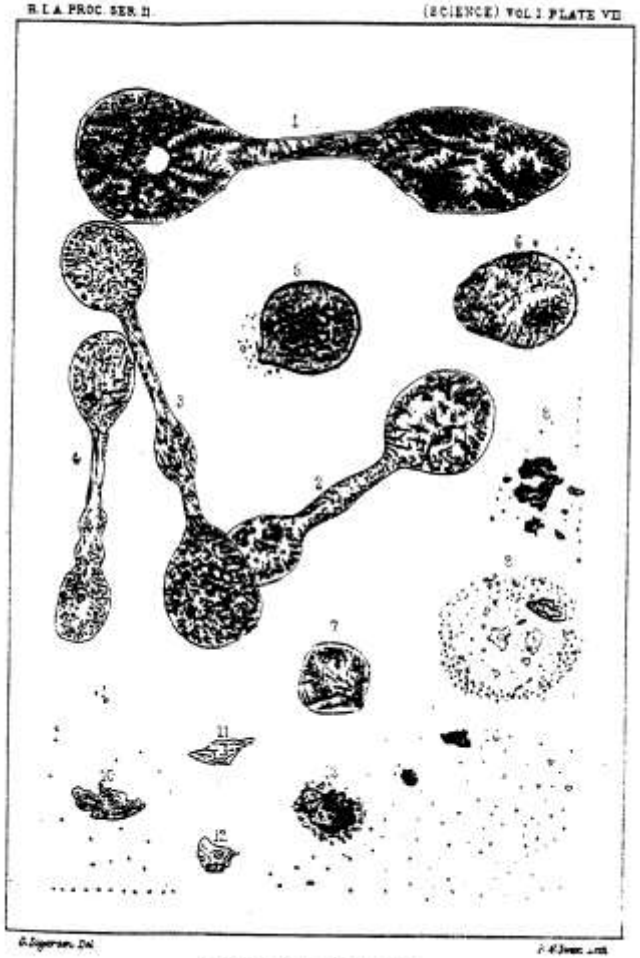
Reasons

- Emission intensity and atmospheric chemistry conditions
- Local meteorological conditions affecting dispersion
- Different Origin of air-masses due to large scale circulation patterns

Sigerson 1870 Proc Roy Irish Acad Sci

CITY AIR

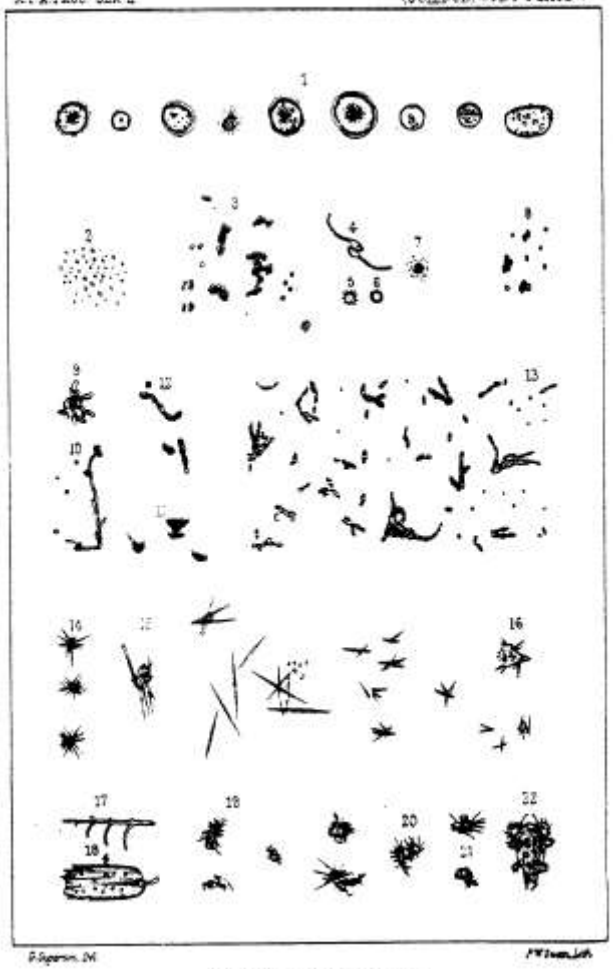
R. I. A. PROC. SER. II. (SCIENCE) VOL. I. PLATE VII.



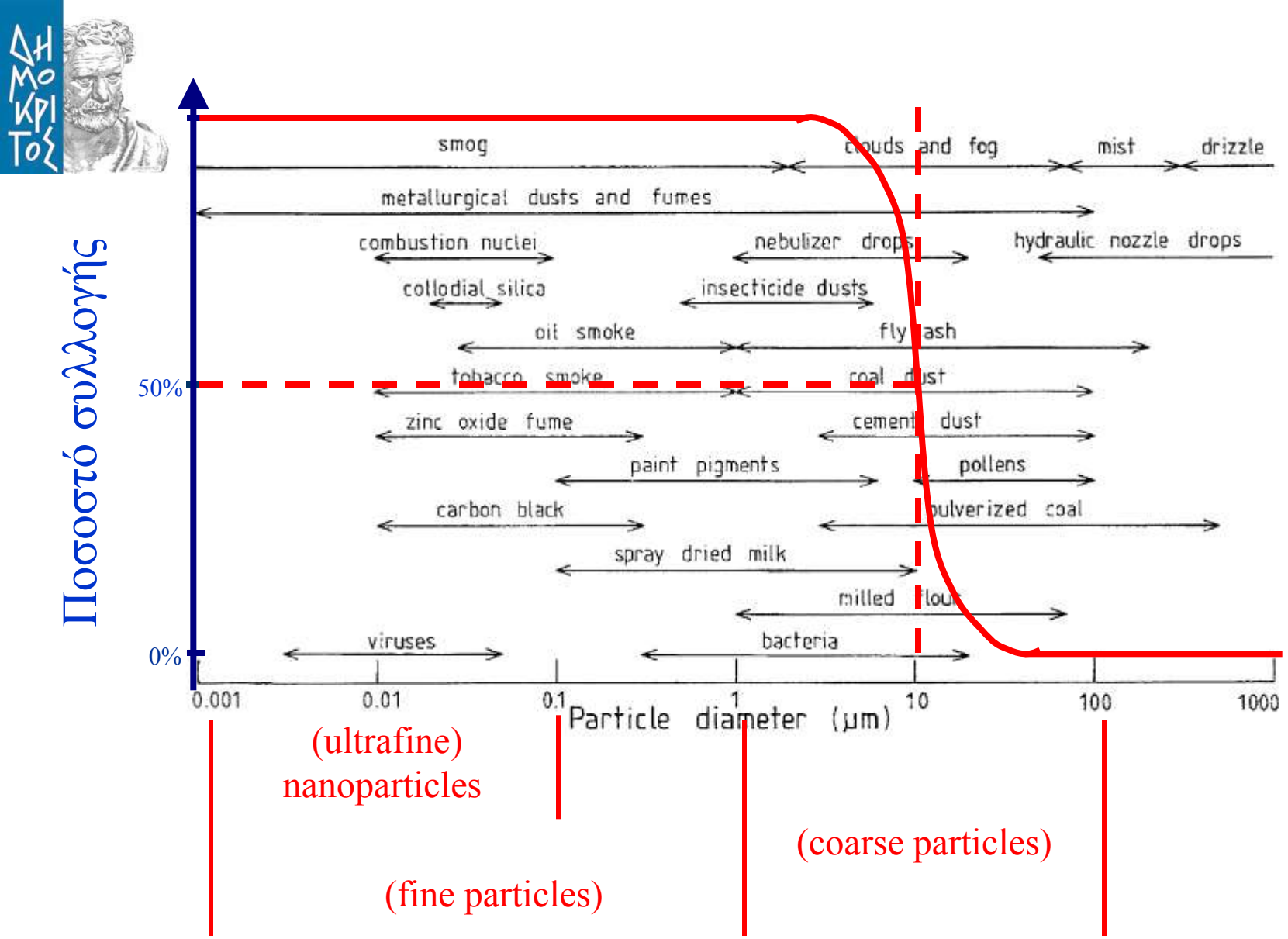
DR. SIGERSON on the Atmosphere.

COUNTRY AIR

R. I. A. PROC. SER. II. (SCIENCE) VOL. I. PLATE V.



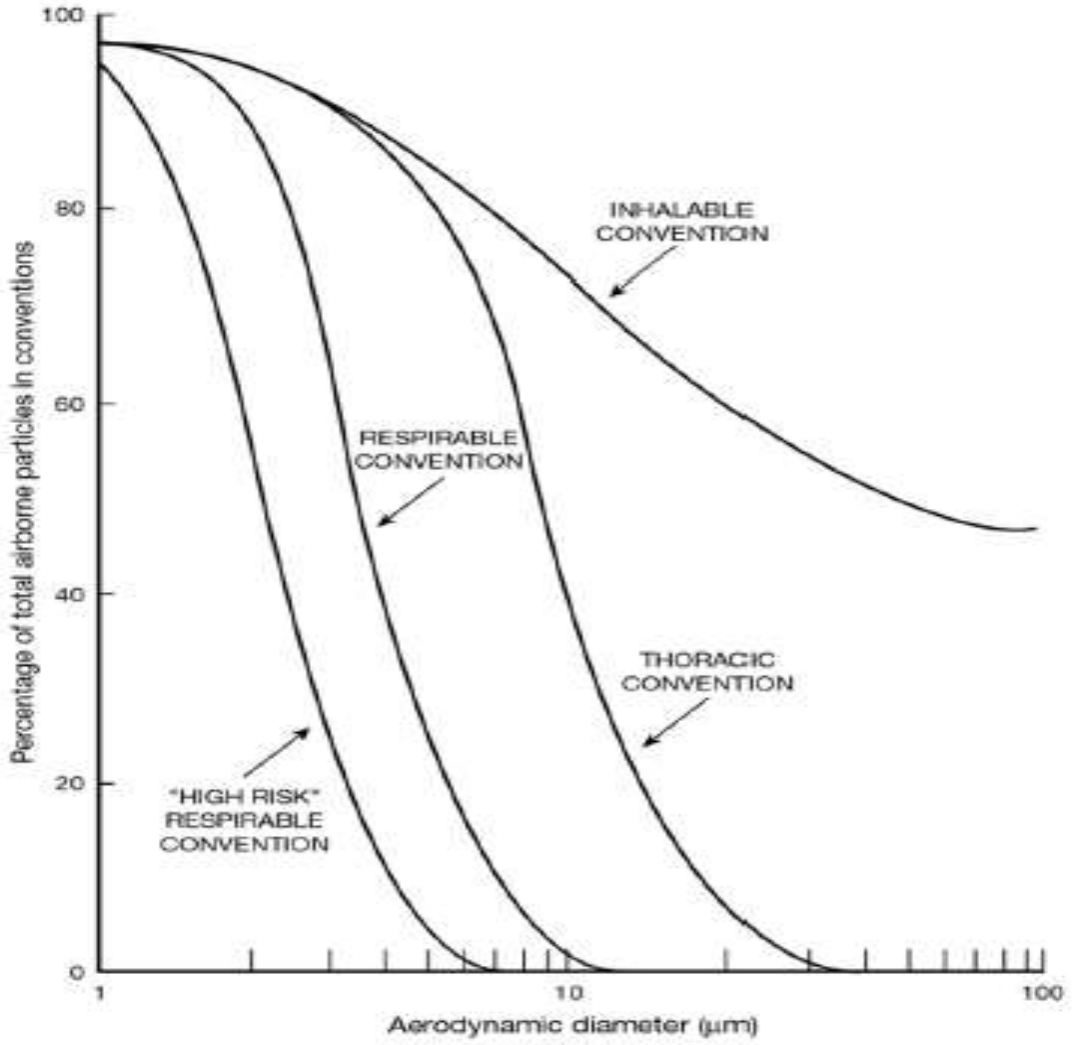
DR. SIGERSON on the Atmosphere.



What is PM-10? And why does it exist?

Sampling convention for PM measurements

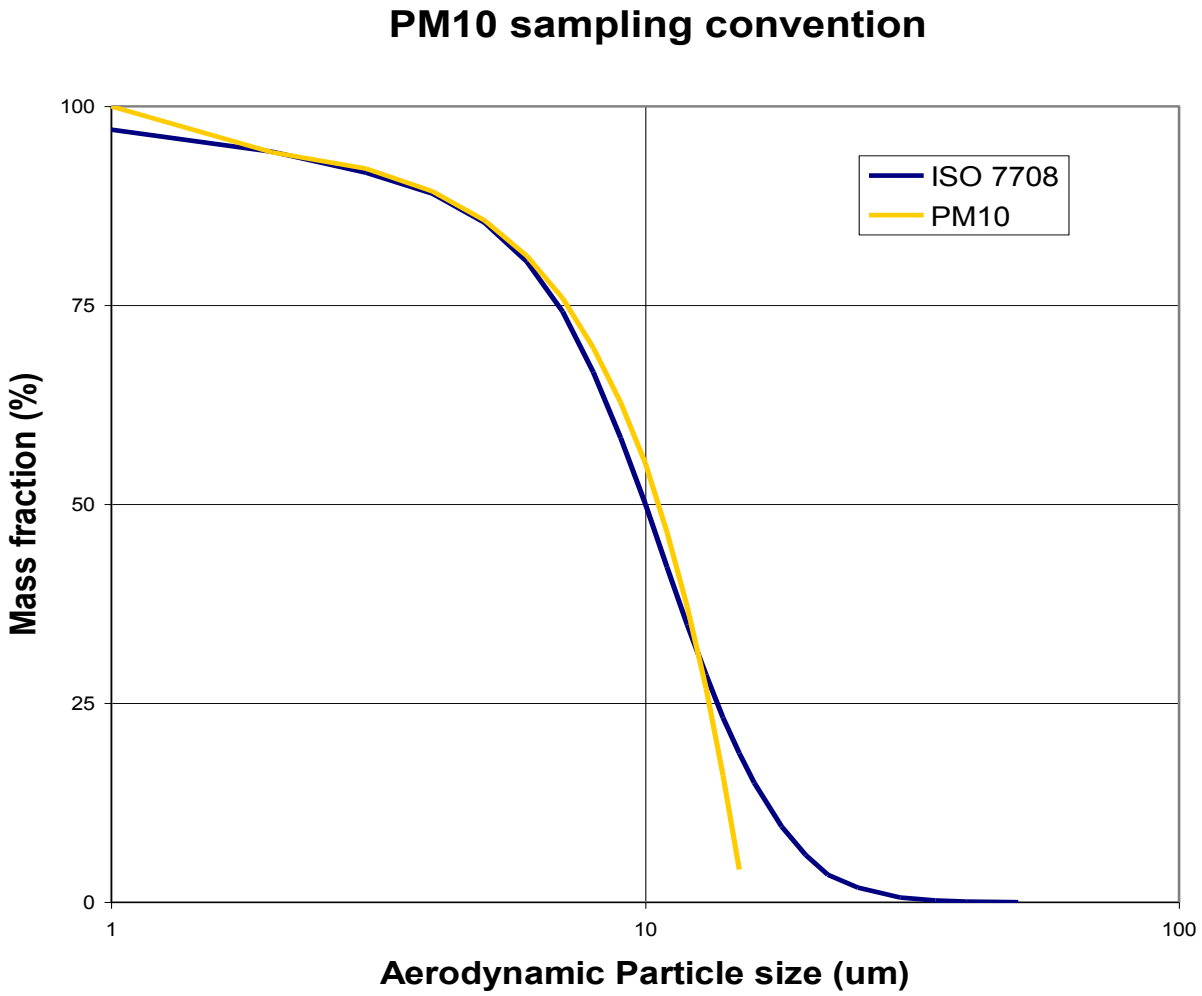
Introduced in order to derive ambient PM concentration relevant to human health effects



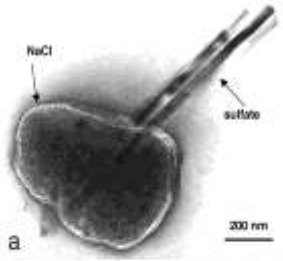
European Standard EN12341

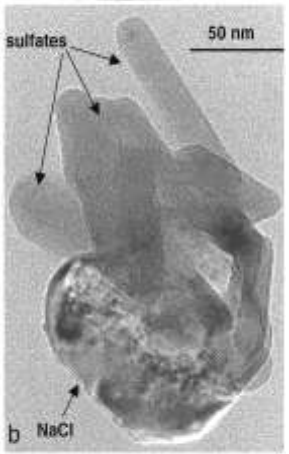
- Reference method for PM_{10} fraction of SPM
- PM_{10}: Instrumental sampling specification to determine thoracic aerosol
- Equivalent definition by ISO through the thoracic convention (ISO 7708)
- thoracic aerosol:

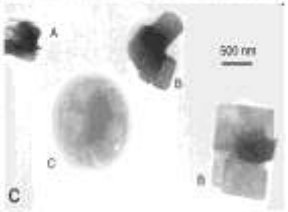
  Particles penetrating beyond the larynx



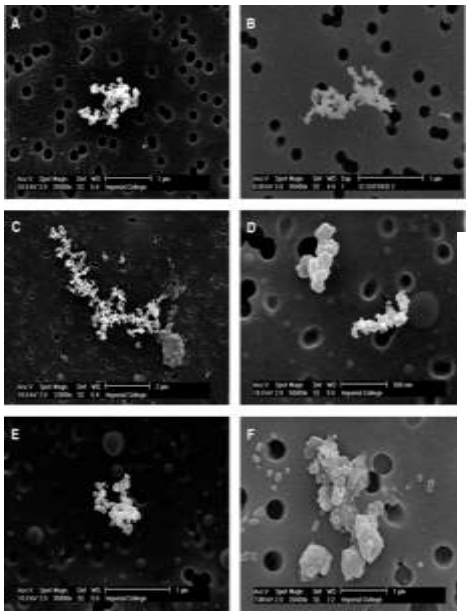
Aerosol particles are a complex mixture of different substances undergoing continuous change in the air

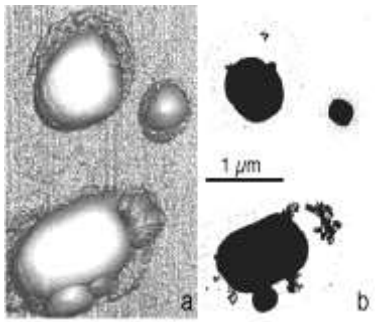






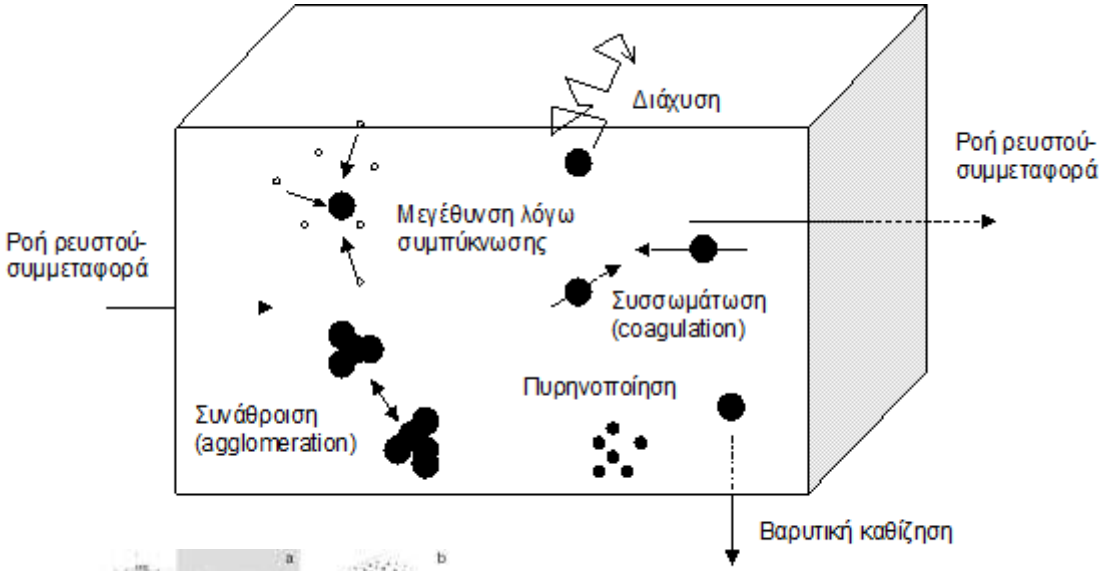
TEM NaCl & (NH4)2SO4

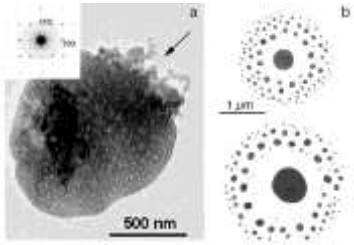




Οργανικά και θειακά σε AFM and TEM

Atmospheric processes contribute further to the variability of their microphysical properties





TEM (NH4)2SO4

Documentation of emissions and source apportionment of observed PM concentration is becoming necessary for controlling adverse effects

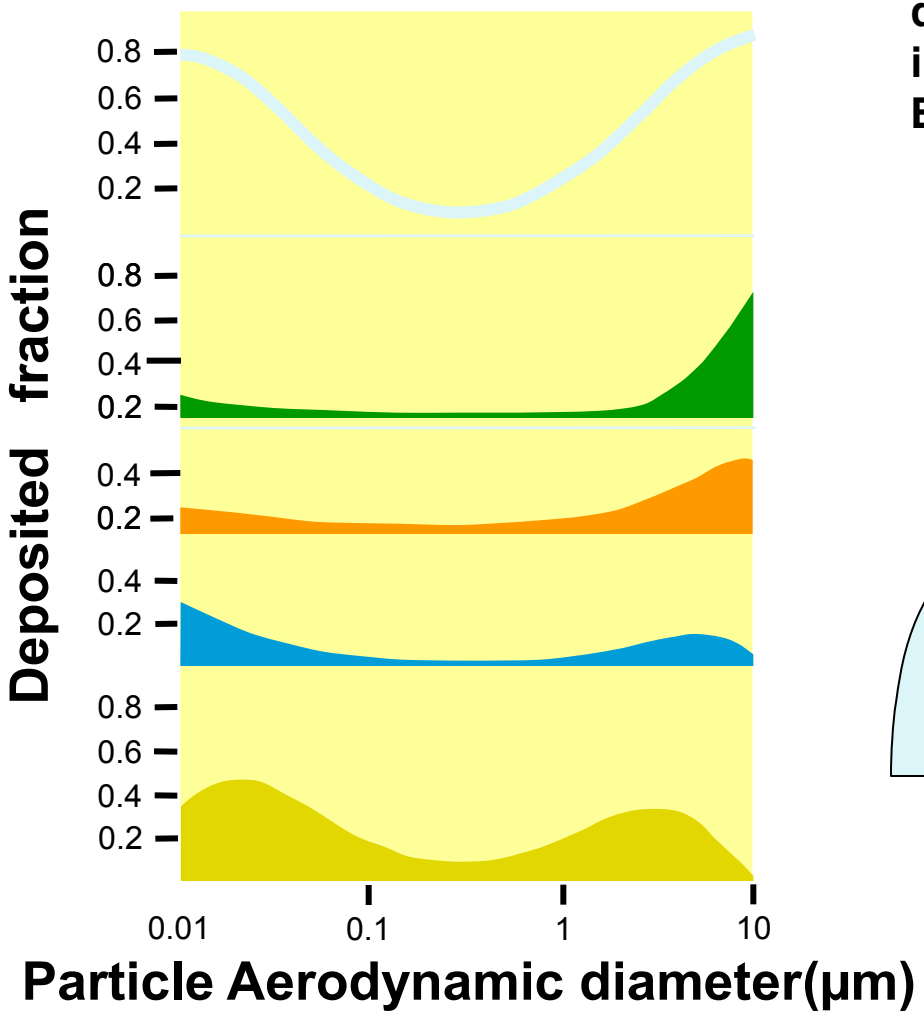
Health effects

Inhalation

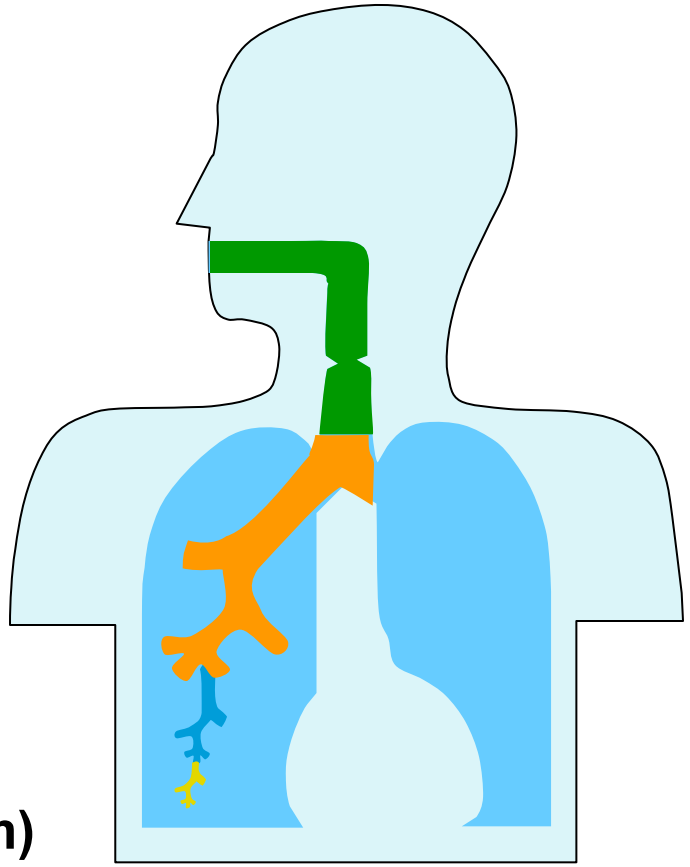
Effects: allergies, emphysema, cardiovascular disease, cancer

- High aerosol mass and number concentrations are observed in industrial areas and large urban agglomerations
- Epidemiological studies have demonstrated that aerosol parameters like mass and number (ultrafine aerosol particles < 100 nm) lead to increase in human mortality and morbidity
- The chemical composition of particles (soot, organic compounds, heavy metals and ionic species) is a factor which is related to the higher or lower impact of health effects.

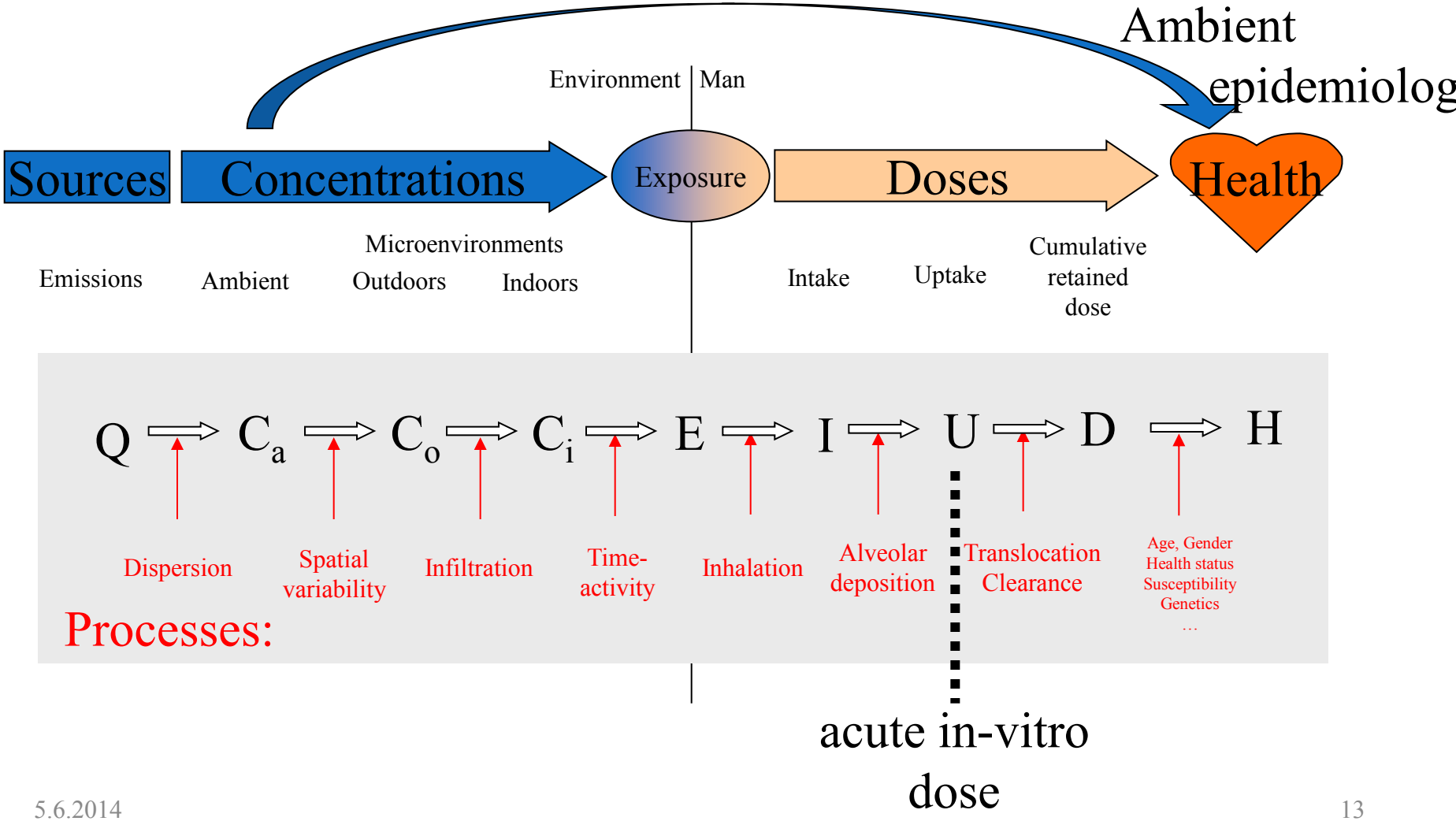
Particle deposition in the human respiratory tract



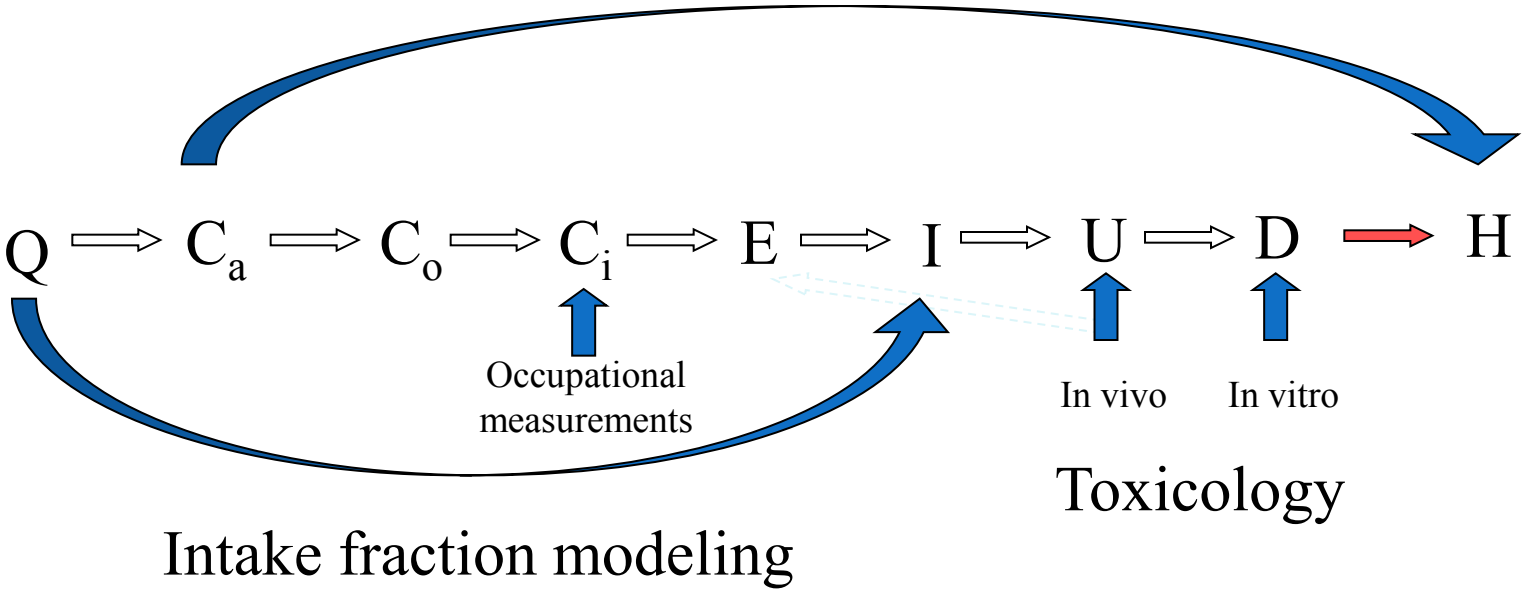
density : 1 g cm^{-3}
inhaled volume: 300 cm^3 s^{-1}
Breathing cycle : 5 s



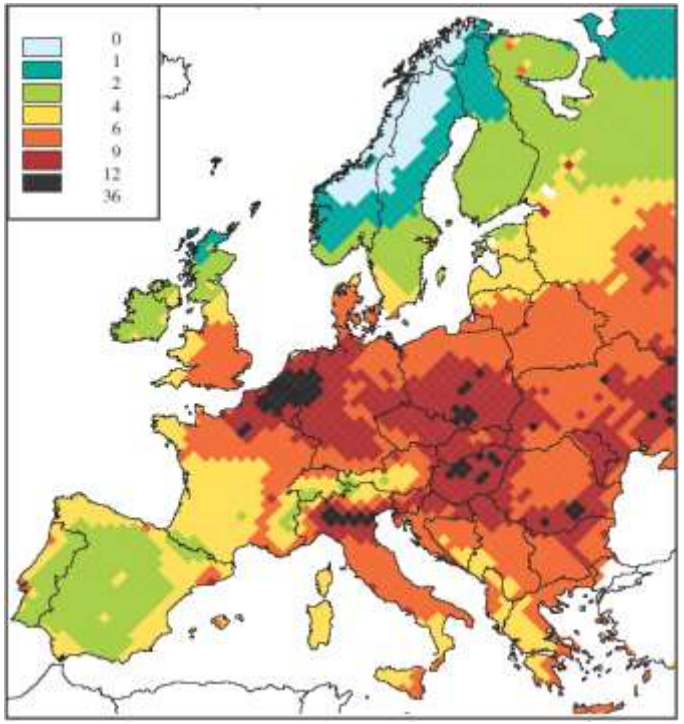
Exposure metrics and processes



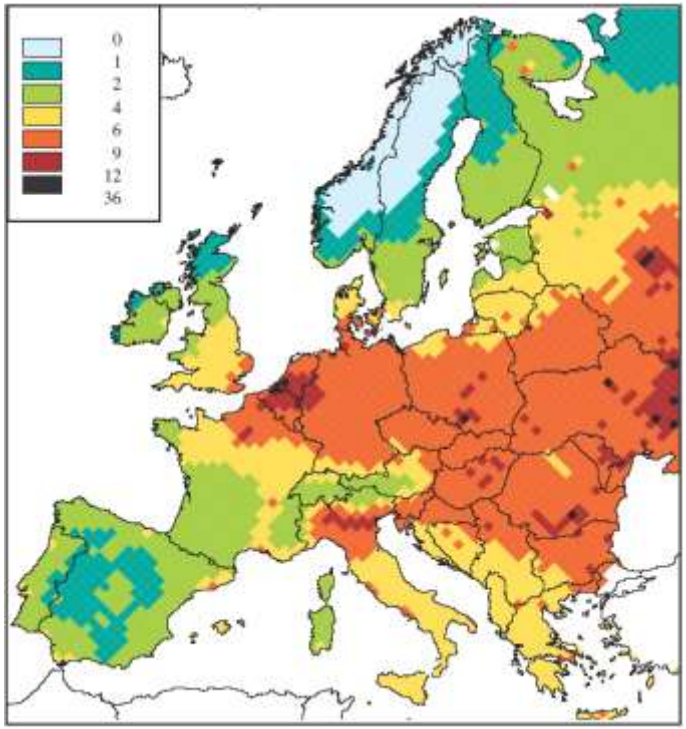
Ambient epidemiology



Loss of life expectancy due to PM2.5 from anthropogenic sources



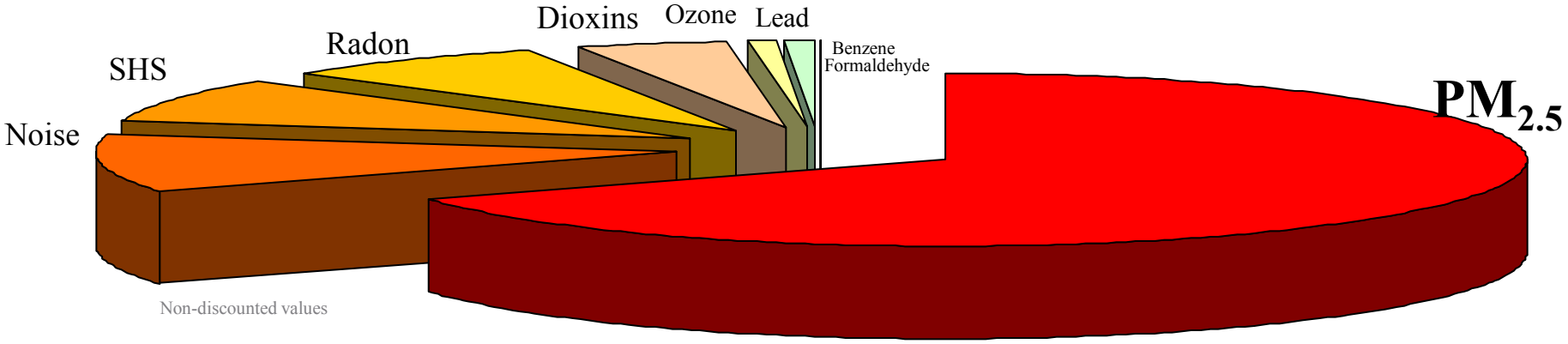
2000



2020

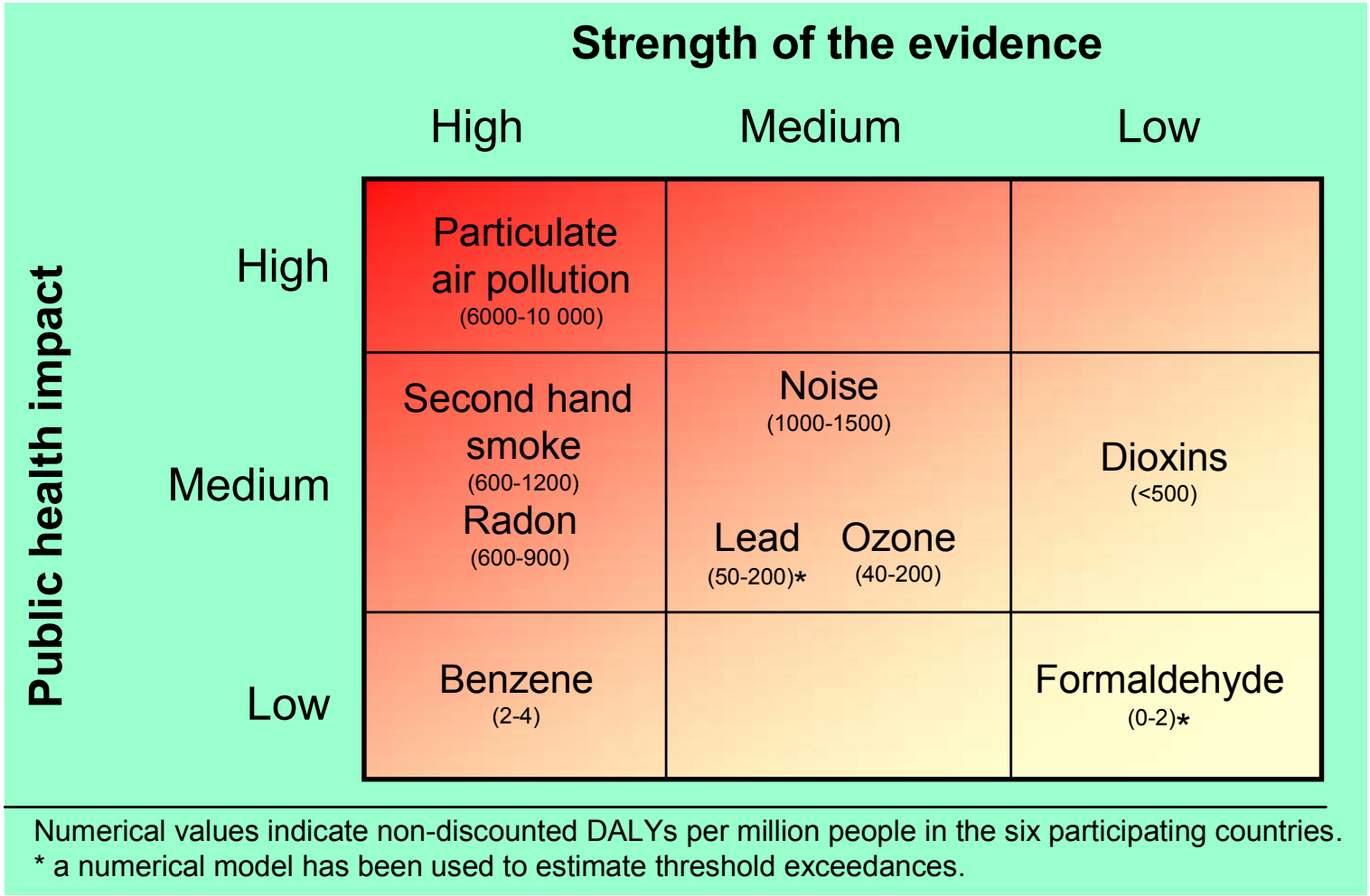
Loss of Life expectancy in months

Few environmental factors are responsible for most of the environmental burden of disease in Europe



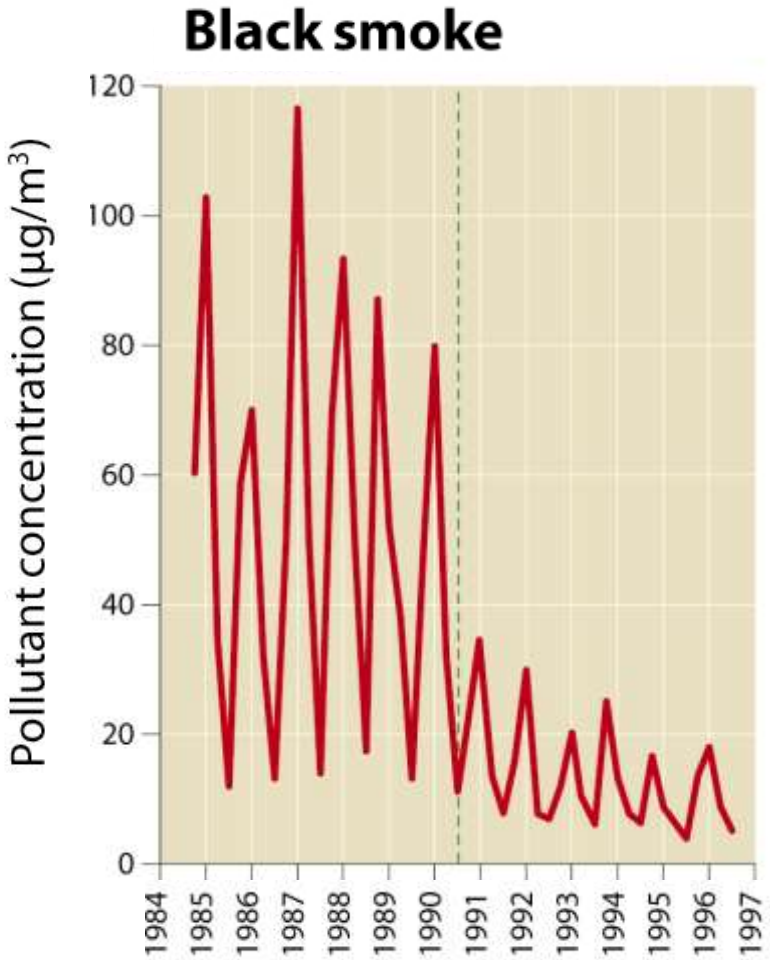
- A small number of key stressors contribute most of the EBoD in Europe
- Only SHS exposures are currently effectively reduced. Dioxin and benzene exposures are also declining. The others are steady or increasing.
- Environmental stressors remain important determinants of health in Europe

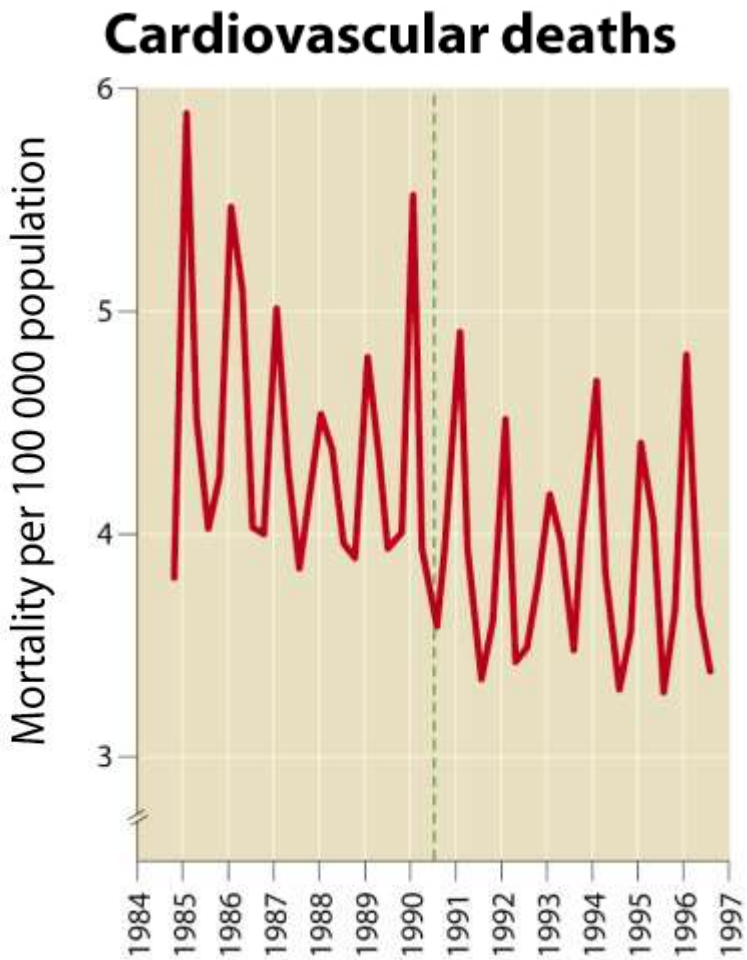
Strength of evidence vs impact



Numerical values indicate non-discounted DALYs per million people in the six participating countries.
* a numerical model has been used to estimate threshold exceedances.

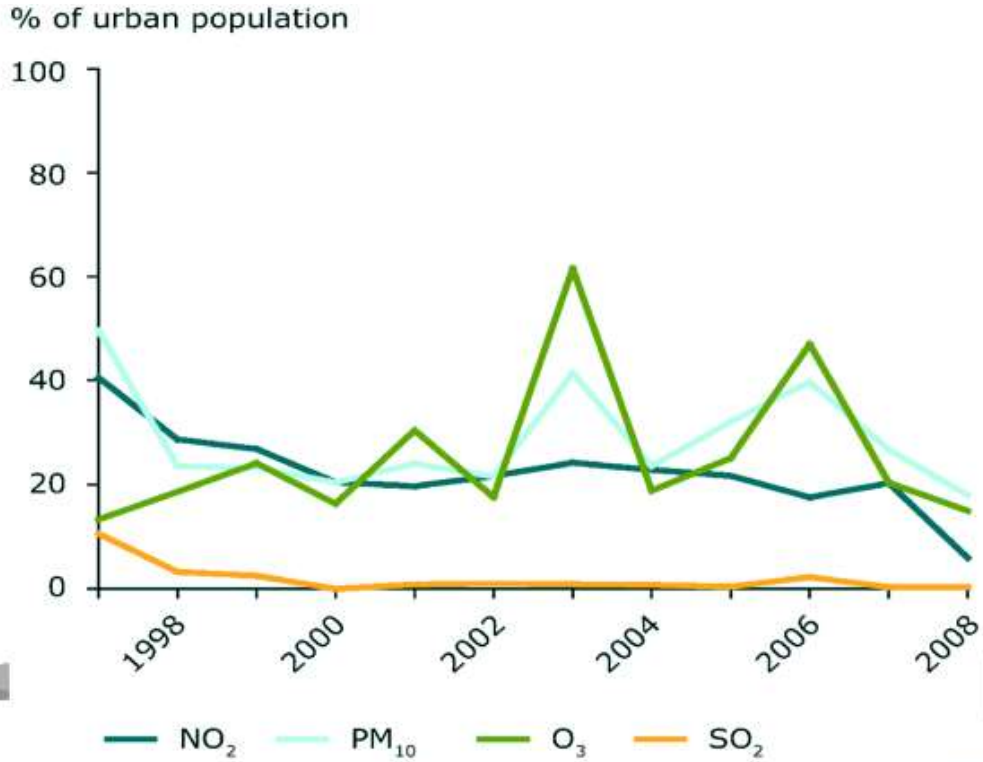
The health benefits of a ban of coal sales in Dublin





WORLD HEALTH ORGANIZATION
EUROPE

Το πρόβλημα της ατμοσφαιρικής ρύπανσης σε Ευρωπαϊκή κλίμακα



Source: Copyright EEA, Copenhagen, 2009
www.eea.europa.eu

Ποσοστό αστικού πληθυσμού που εκτίθεται σε συγκεντρώσεις ρύπων άνω των οριακών τιμών (Πηγή: Ευρωπαϊκός Οργανισμός περιβάλλοντος Έκθεση Νο 12/2011)

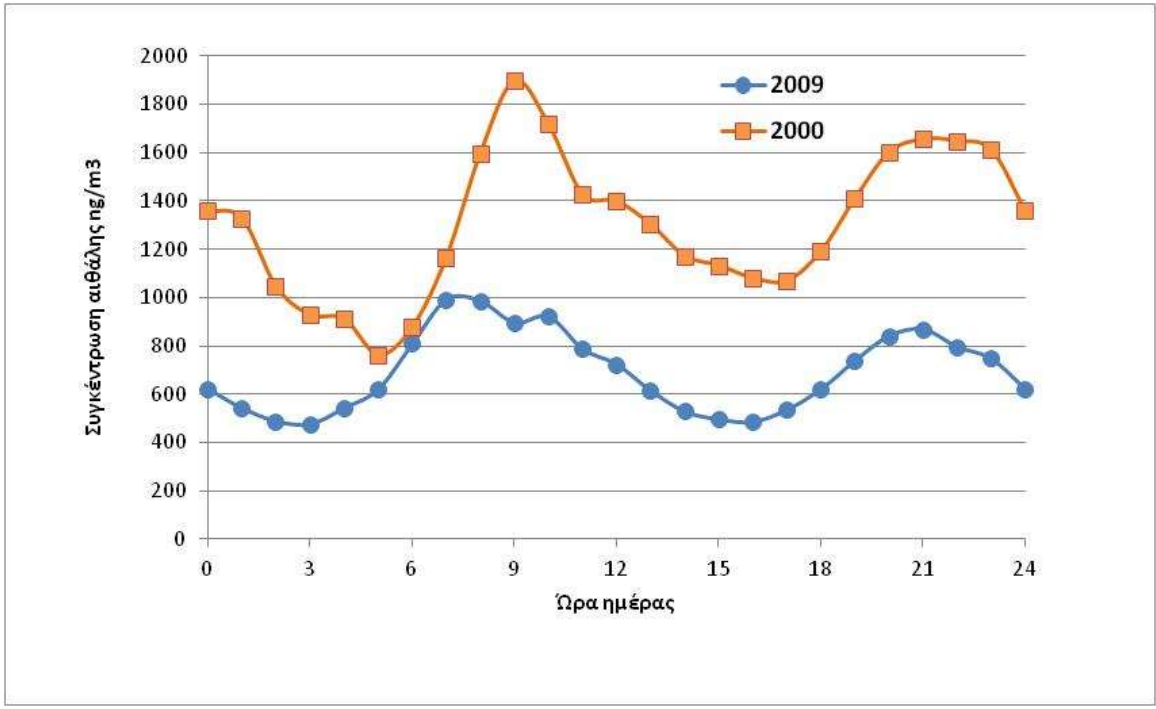
Limit and target values for PM_{10} and $PM_{2.5}$ (Οδηγία 2008/50/ΕΚ)

Table 2.1 Air quality limit and target values for PM_{10} and $PM_{2.5}$ as given in the Air Quality Directive

Size fraction	Averaging period	Value	Comments
PM_{10}, limit value	One day	50 µg/m³	Not to be exceeded on more than 35 days per year. To be met by 1 January 2005
PM_{10}, limit value	Calendar year	40 µg/m³	To be met by 1 January 2005
$PM_{2.5}$, target value	Calendar year	25 µg/m³	To be met by 1 January 2010
$PM_{2.5}$, limit value	Calendar year	25 µg/m³	To be met by 1 January 2015
$PM_{2.5}$, limit value (a)	Calendar year	20 µg/m³	To be met by 1 January 2020
$PM_{2.5}$, exposure concentration obligation (b)		20 µg/m³	2015
$PM_{2.5}$ exposure reduction target (c)	0–20 % reduction in exposure (depending on the average exposure indicator in the reference year) to be met by 2020		

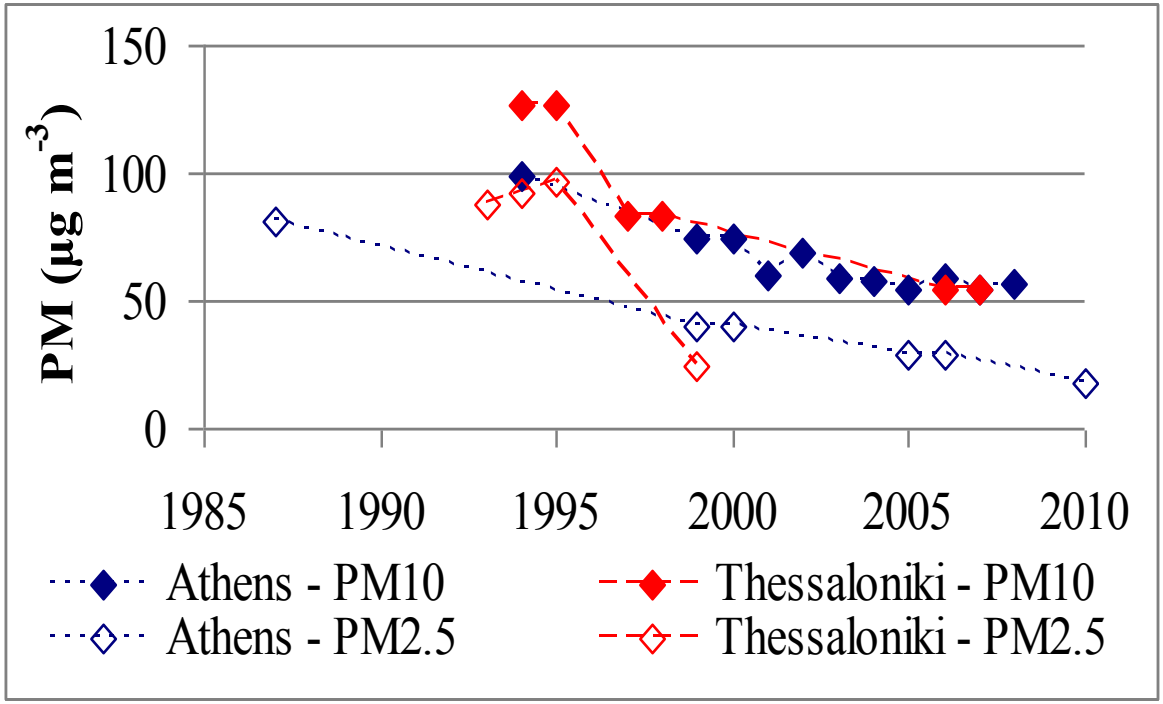
Long term monitoring of aerosol parameters at the Demokritos Urban Background station

Member of the Global Atmosphere Watch Network of W.M.O.

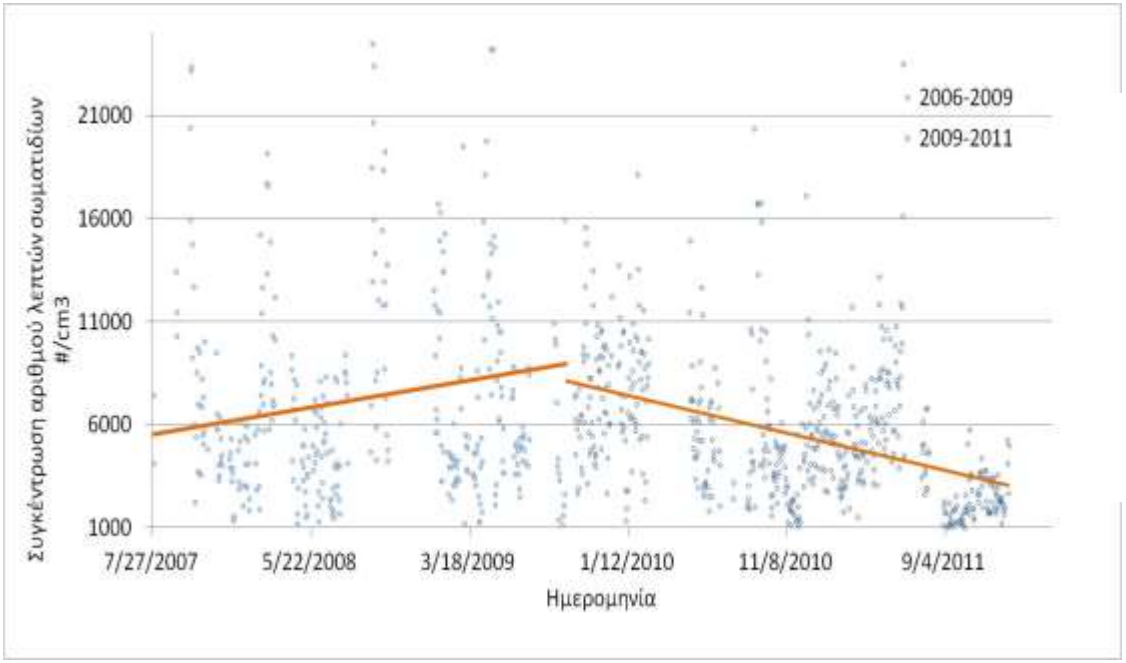


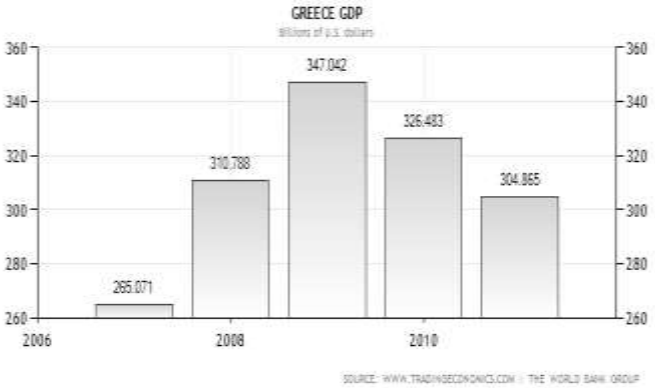
Historical record of concentration trend for PM at large Greek cities

- Gradual decline towards limit values
- The current and future directives demand for lower target values
- There is a need to determine the contribution of natural sources



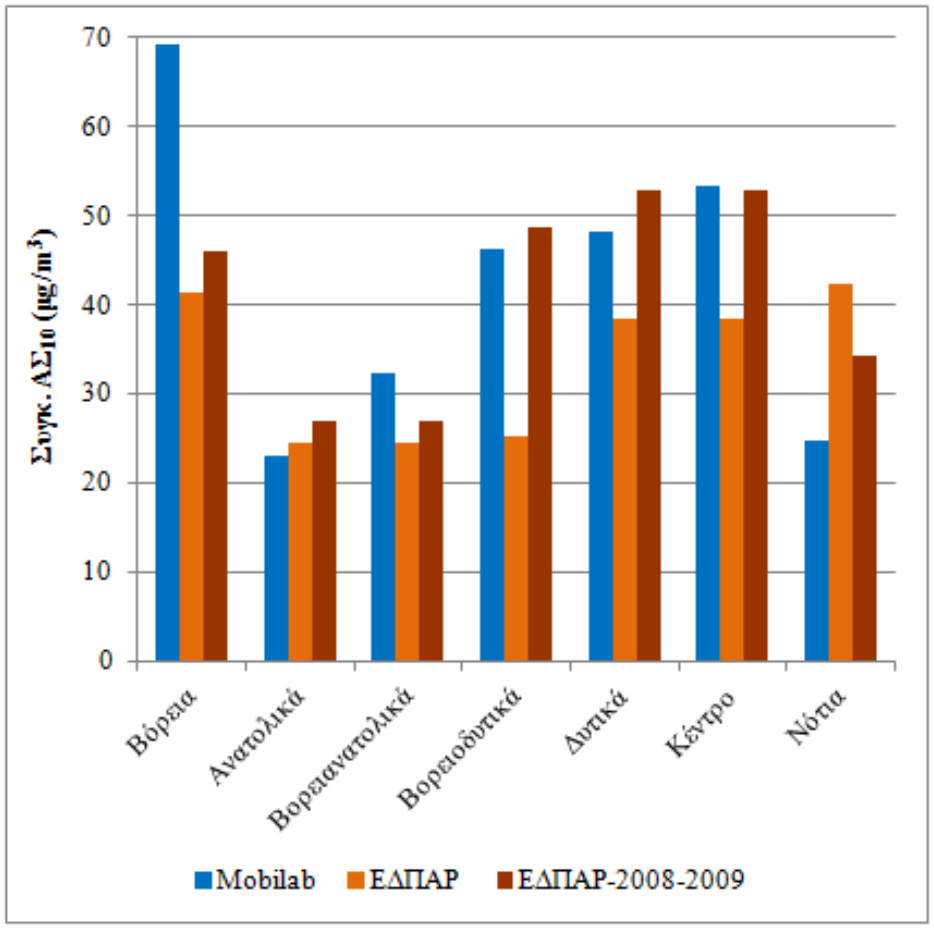
Certain microphysical parameters demonstrate the evolution of air pollution sources and the appearance of new characteristics





GAW Demokritos

Results in Athens showing spatial variability



Area	Time (ώρες)	Monitoring site
North	6,2	Marousi
East	1,9	Ag. Paraskevi
NorthEast	16,2	Ag. Paraskevi
Northwest	1,5	Lykovrisi
West	2,0	Aristotelous
Central	11,4	Aristotelous
South	16,9	Piraeus

Variability in BC (22/9/11)

Source apportionment studies and results

Κύριες πηγές:

- **S1**: Soil/road dust
- **S2**: vehicle emisions
- **S3**: Oil combustion/Industry
- **S4**:Biomass/waste combustion
- **S5**: Marine aerosol,
- **S6**: Secondary/unclassified

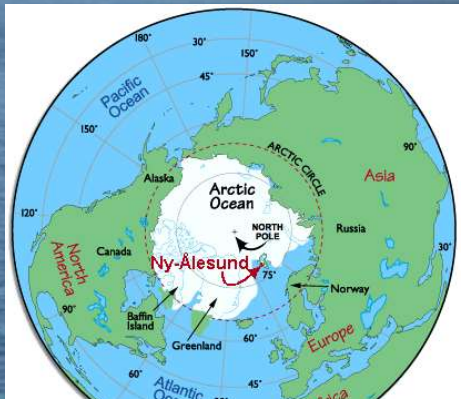
Location(PM) size class	*S1*	*S2*	*S3*	*S4*	*S5*	*S6*	*Model*
Thessaloniki 1994 TSP*	4-9	4-5	21-42			44-70	APCA
Thessaloniki 1994 TSP*	7-11	4-5	25-33			54-66	FA/MR
Thessaloniki 2002 fine fraction	**28**	**38**	**14**			**20**	**APCA**
Thessaloniki 2002 Coarse	**57**	**9**	**26**			**8**	**APCA**
Thessaloniki 2003 PM10*	18-22	45-65	10-35				CMB
Thessaloniki 2007 PM10*	20-25	23-39	20-38	1-4	1	13-15	CMB
Athens 2002+ PM<2	20	27	12	15	19	7	PMF
Athens 2002+ 2<PM<10	**54**	**8**			**16**	**22**	**PMF**
Volos 2001+ 2<PM<10	30		27		20	23	PMF
Volos 2008 PM10*	3-12	28-40	15-39	22-27	1-2	2-9	CMB

Results from AUTH* C. samara &Co

Results from Athens and Volos+ NCSR Demokritos & co

Climate change
Global warming

Ny Ålesund, Svalbard



Kongsfjord, Ny Ålesund, Svalbard

Polar caps are the earth's areas where global change is mostly visible and unprecedented in terms of reduction in ice cover

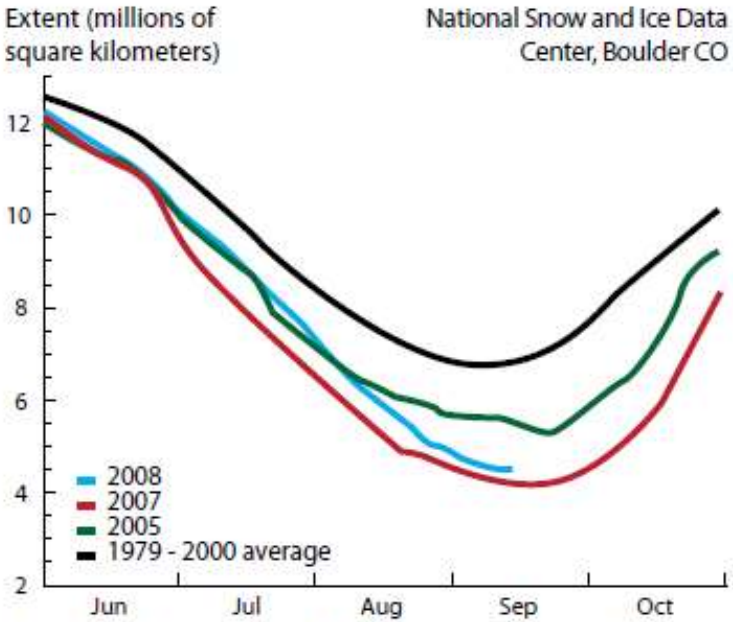
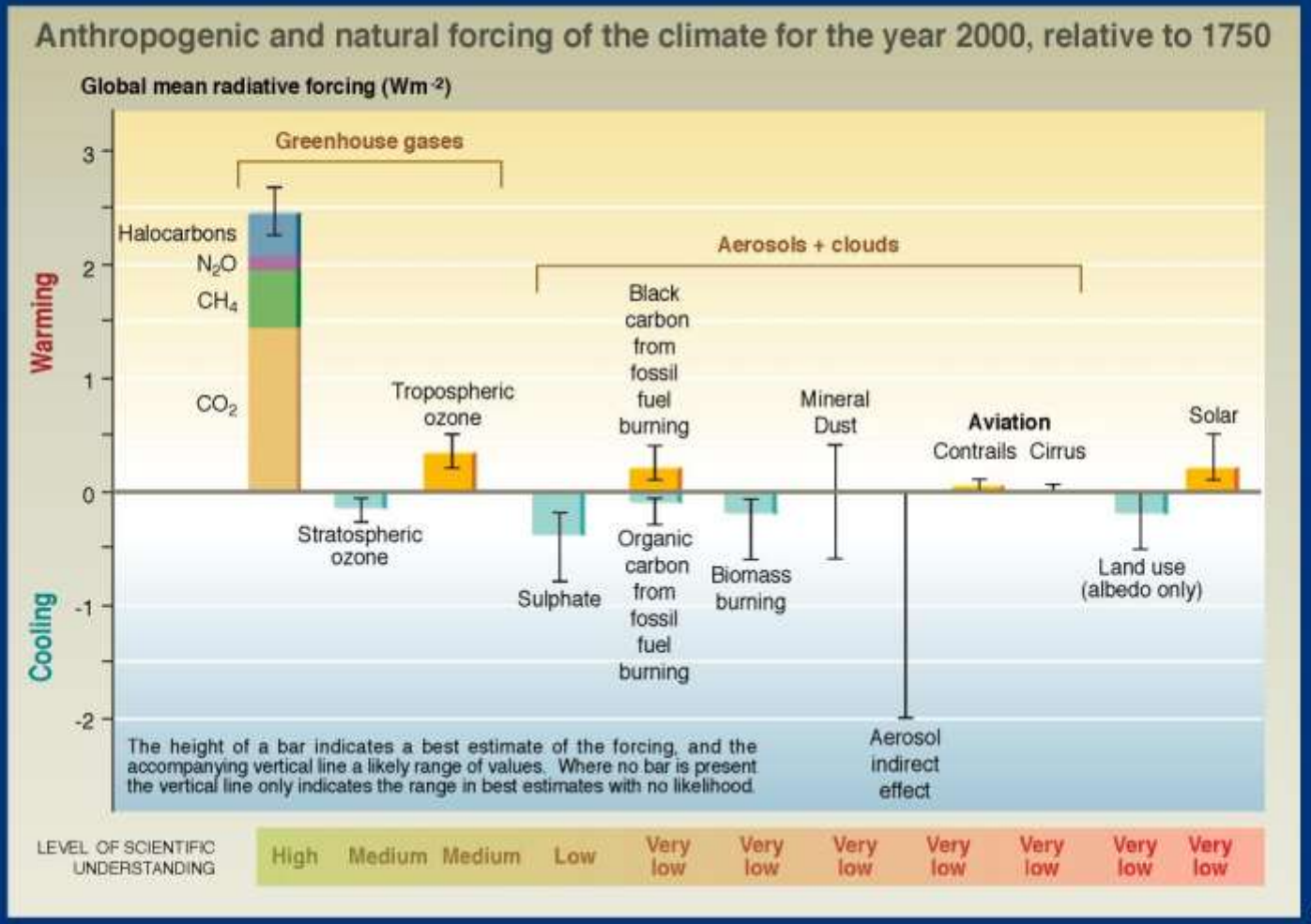


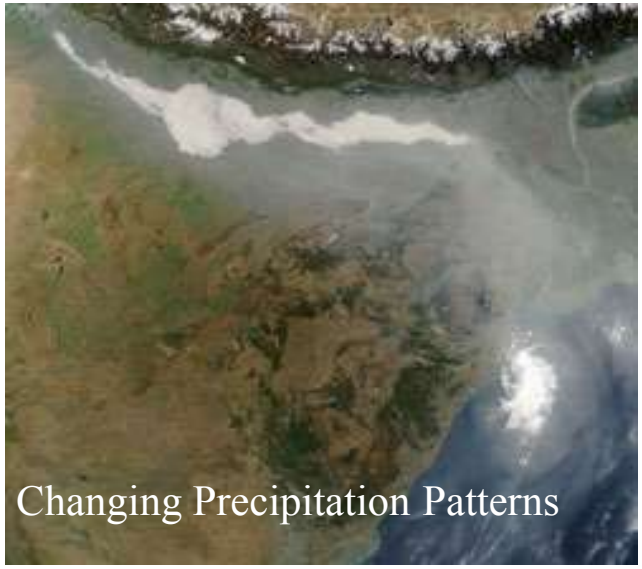
Figure 1. Daily sea ice extent. The blue line indicates 2008 extent, the grey line indicates extent for the average over 1979 to 2000, and the dotted green line shows extent for 2007 (National Snow and Ice Data Center).

Effects of atmospheric aerosol components on climate



SYR - FIGURE 2-2

Climate Impacts of Black Carbon



NASA Goddard Space Flight Center/
Jeff Schmaltz

Image: Glaciers Online
Jurg Alean

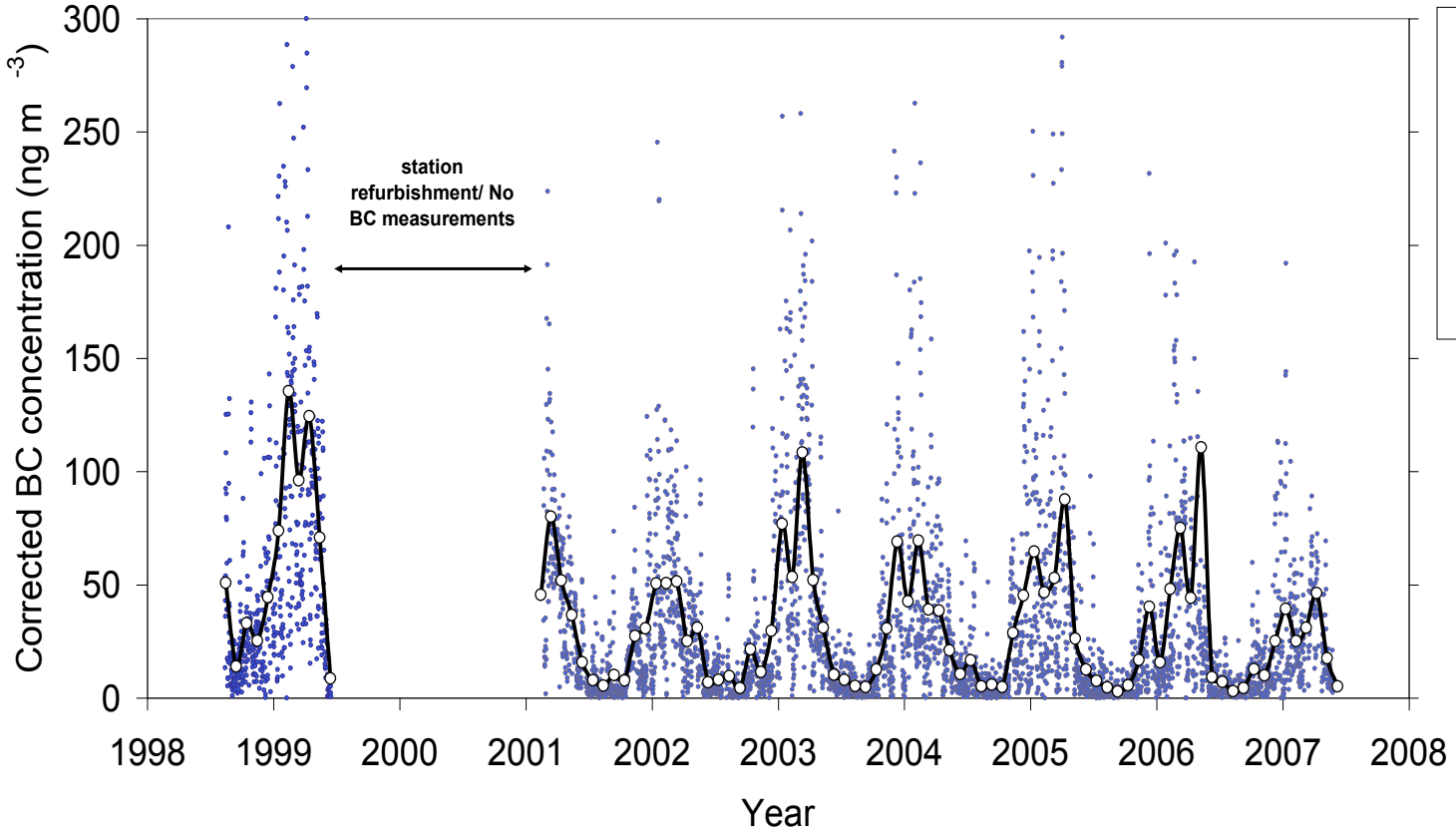
NASA Goddard Space Flight Center

Decreasing Summer Sea Ice

NP/NILU/MISU Zeppelin atmospheric monitoring station

(474 m asl; 78°54'N, 11°53'E)

Time series of "equivalent" BC mass concentration at the GAW Zeppelin station, Ny-Aalesund

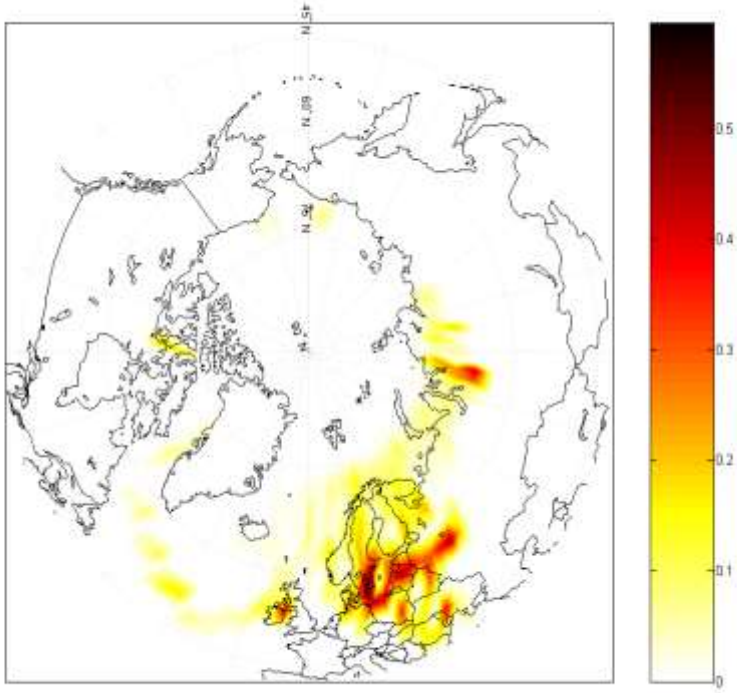


For FEB 2001 to FEB 2007
The 10-year trend line gives a decadal decrease of

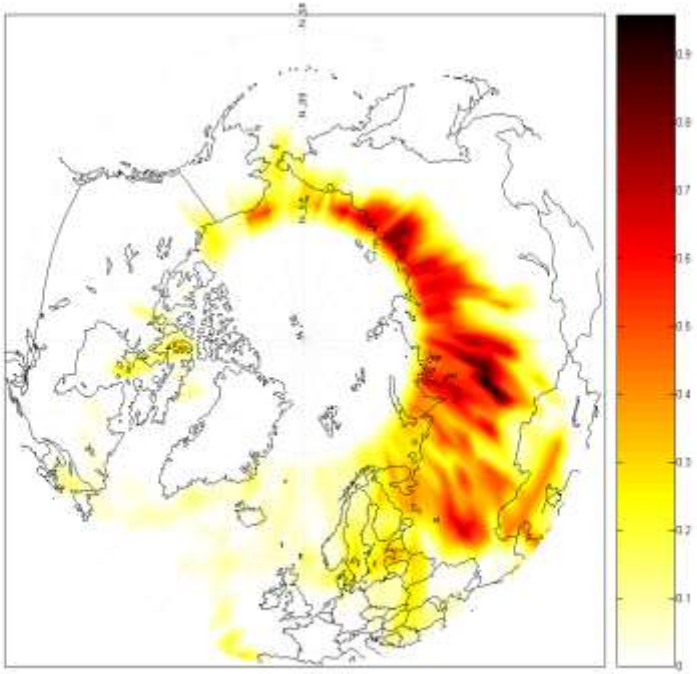
9.5 ng.m^{-3} per decade

Similar to the detection limit

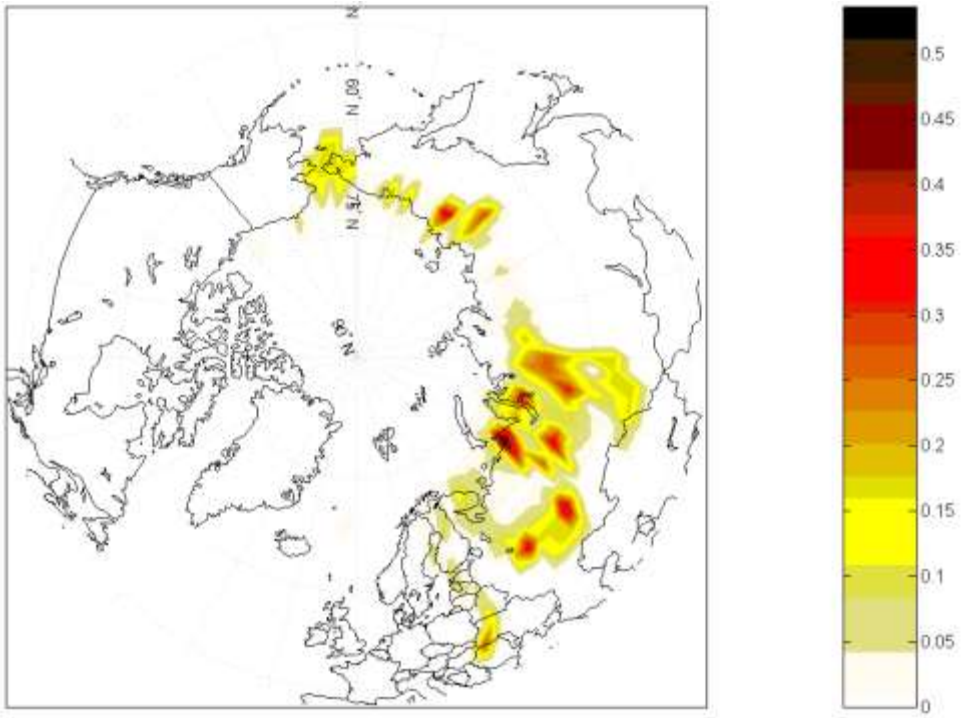
BC source regions determined by a PSCF model, summer months(may to october), 2001-2007



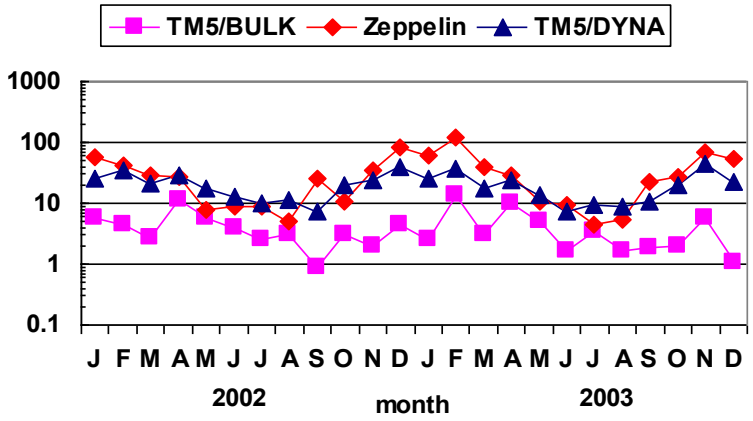
BC source regions determined by a PSCF model, winter months(november to april), 2001-2007



SO_4 source regions determined by a PSCF model, winter months(november to april), 2001-2003



Closure studies between observations and CTM modeling



Comparison of BC surface concentrations modeled with the CTM TM5 and Zeppelin BC observations (Vignati E., personal communication)


Thanks!