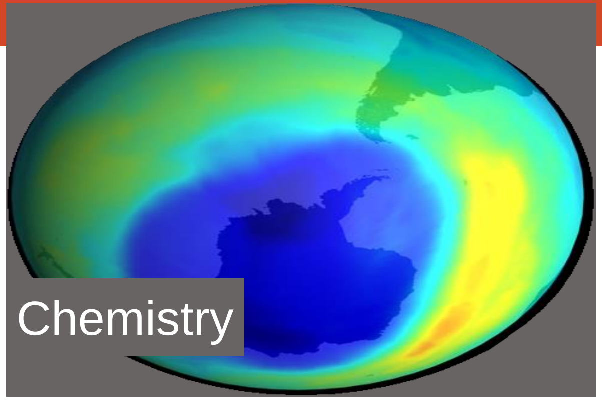
Aerossois

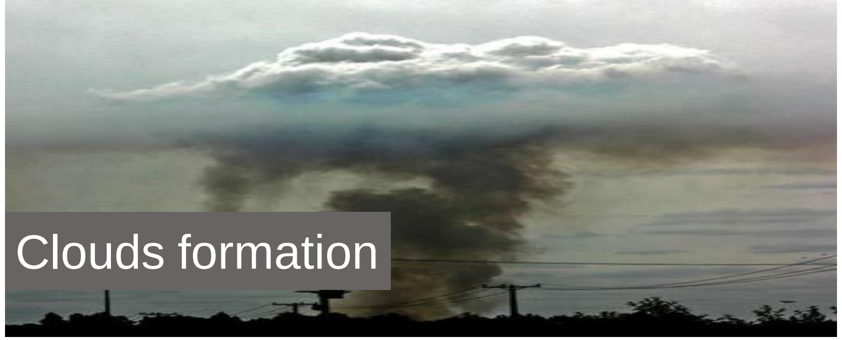
- Introducao
- Composição
- Fontes

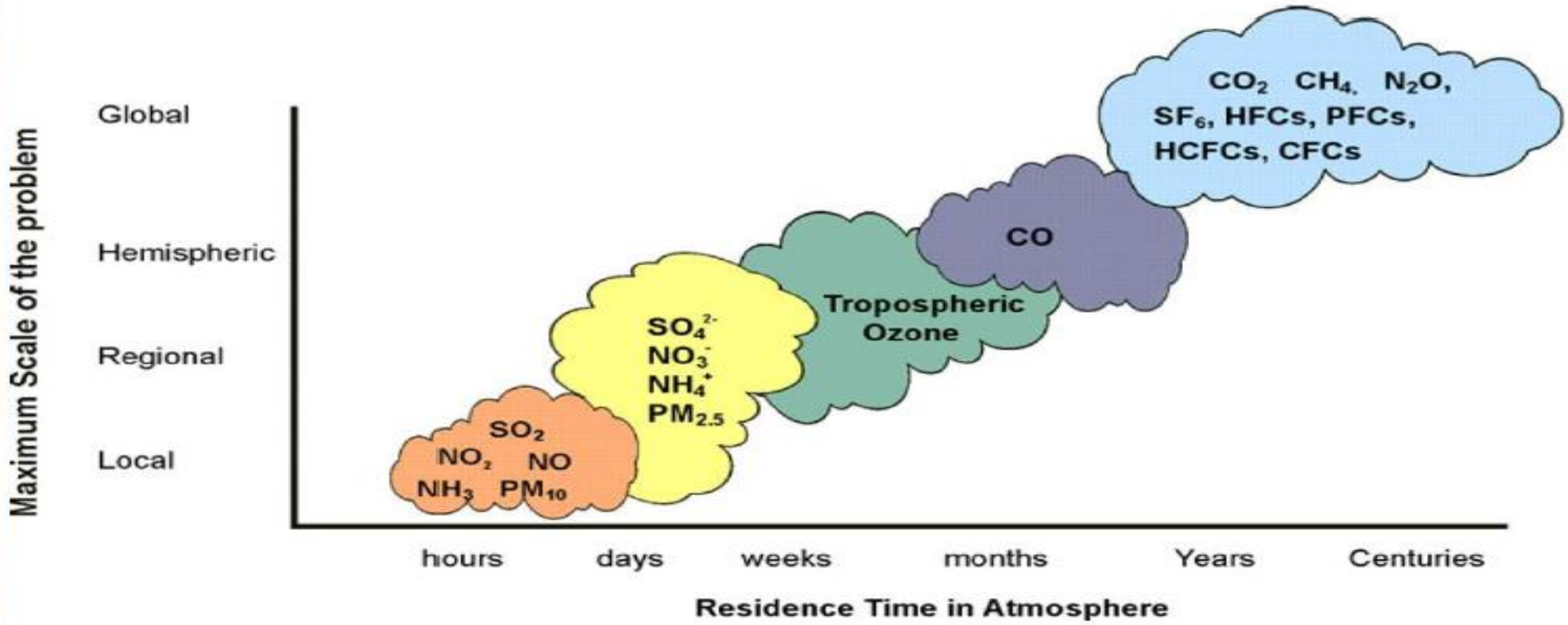
Questões do artigo:

1) Definição do aerossol atmosférico
2) Processos de formação
3) Classificação por tamanho

Por que os aerossóis são tão importantes?

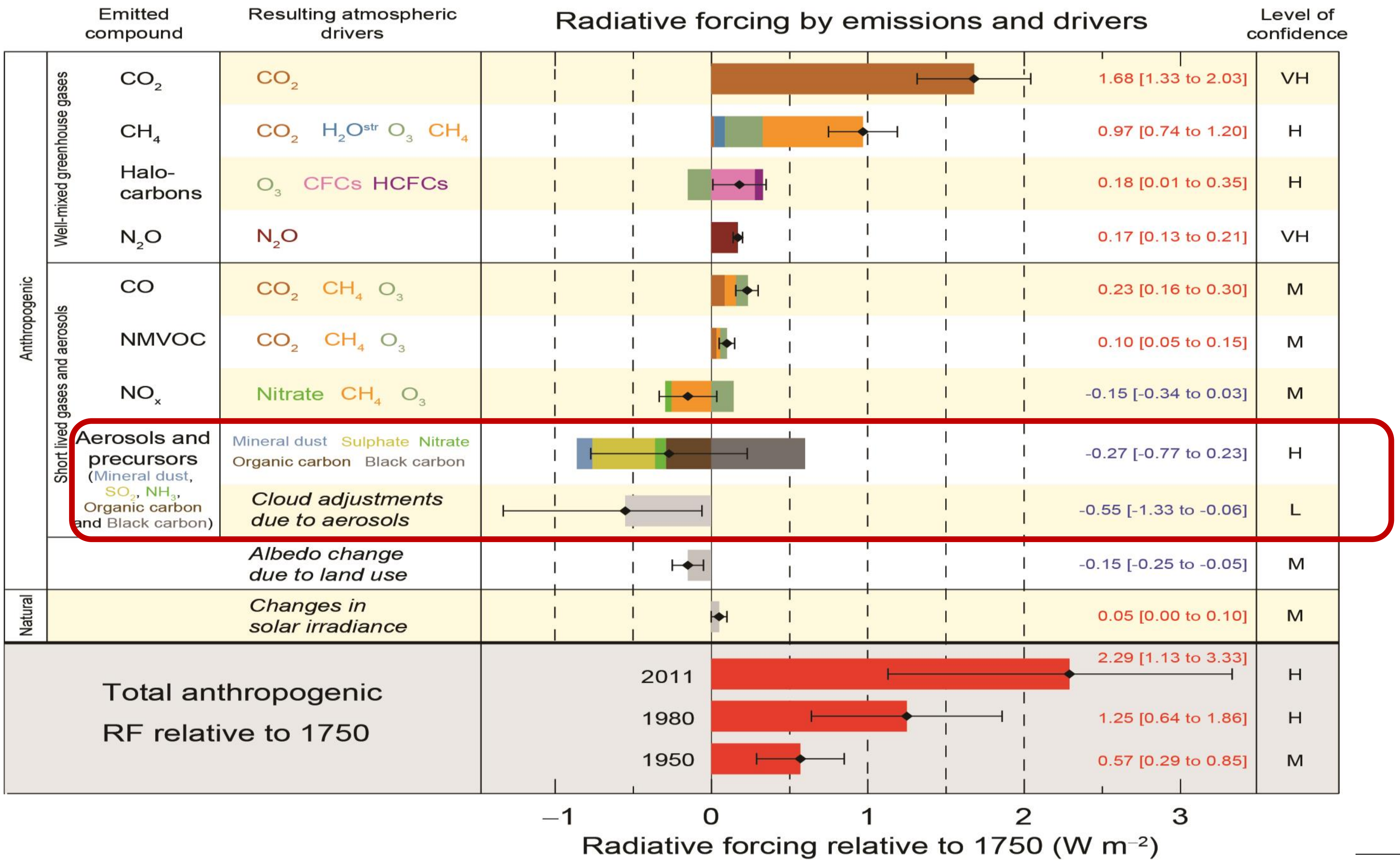





Maximum Scale of the problem
Global
Hemispheric
Regional
Local
CO_2 CH_4, N_2O, SF_6, HFCs, PFCs, HCFCs, CFCs
CO
Tropospheric Ozone
SO_4^{2-}
NO_3^-
NH_4^+
$PM_{2.5}$
SO_2
NO_2 NO
NH_3 PM_{10}
hours
days
weeks
months
Years
Centuries
Residence Time in Atmosphere

Forçamento Radiativo em 2011 relativo a 1750 e suas incertezas associadas aos compostos relacionados com as mudanças climáticas.

Radiative Forcing – IPCC, AR5



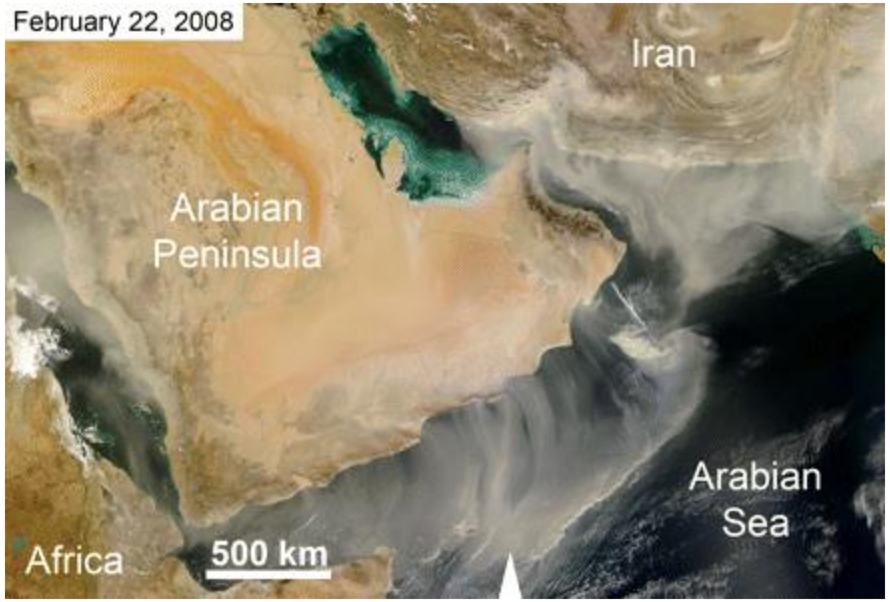
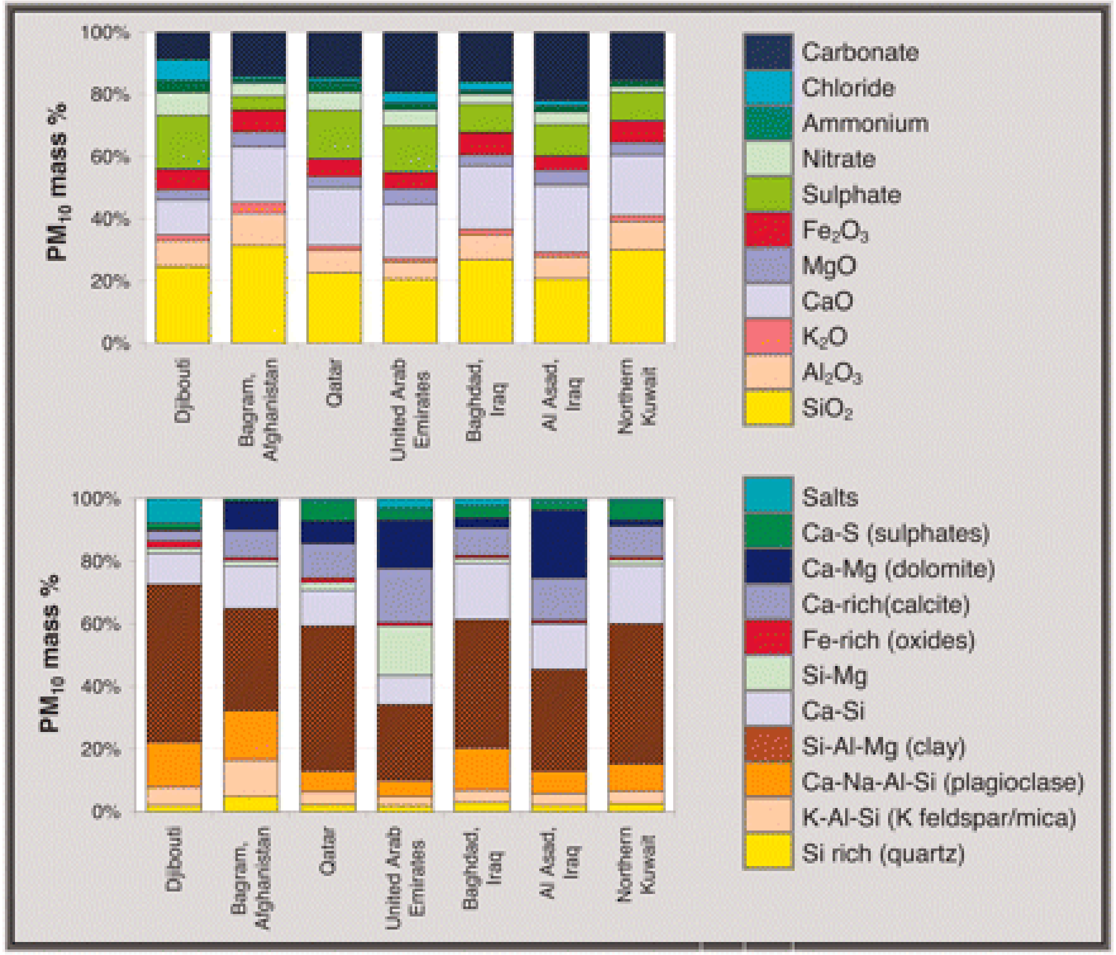


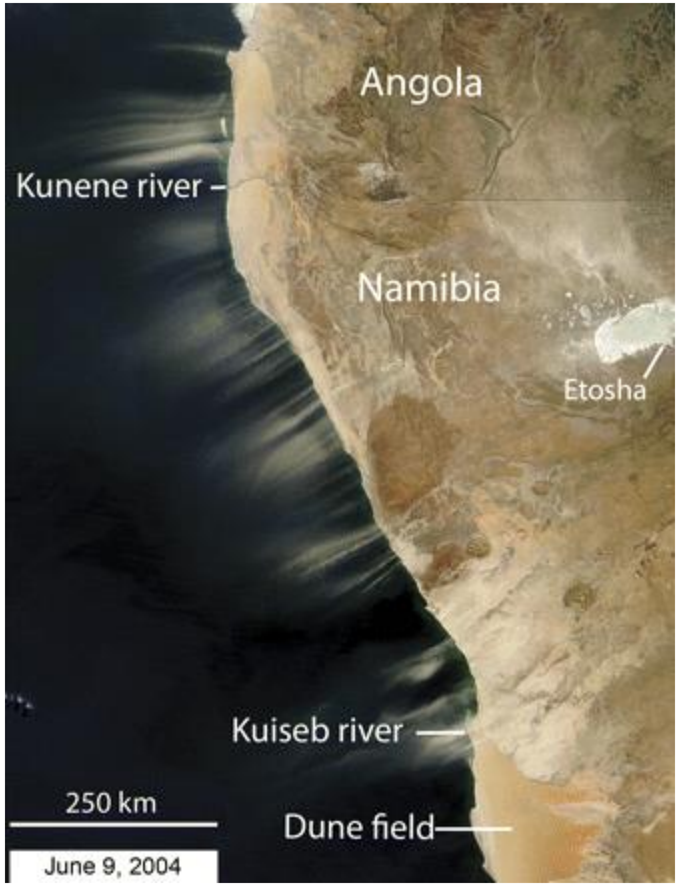
Imagem de satélite de uma tempestade de areia, gerada por ventos de noroeste, extendendo-se desde a Africa até a India.

Nuvens de poeira visíveis da Peninsula Arabica, assim como do Irã e Paquistão. As trajetórias se extendem sobre as águas do Mar vermelho (esquerda), Golfo da Persia (centro) e Mar Arabe.

Satellite image courtesy of NASA



Chemical and electron microscope analyses for Middle East PM10 dust sample. Concentrations (in mass %) of oxides, sulphate (in gypsum), chloride (in salt), nitrate, ammonium, and carbonates. (Bottom) Elemental compositions obtained by single-particle electron microscopy. Clay (Si–Al–Mg) minerals, generally occurring as coatings on other silicates, form the largest fraction of particles when analyzed by this method (Engelbrecht et al. 2009a). Engelbrecht, J., *et al September 02, 2010 (Elements)*



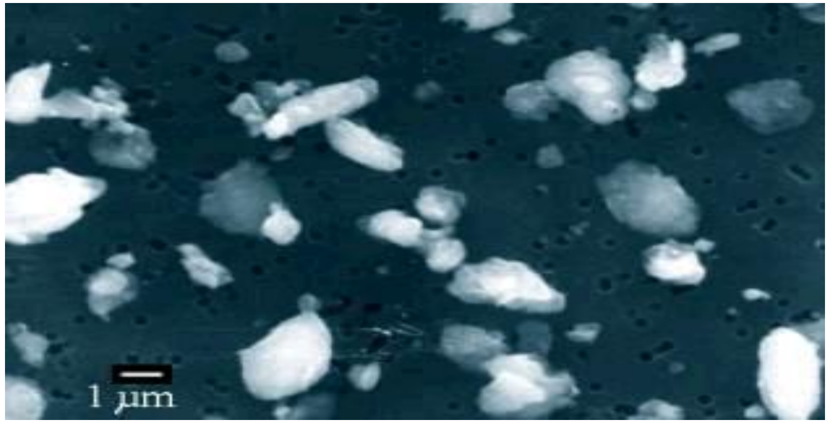
Satellite image of dust plumes streaming westward off the coast of Angola and Namibia.

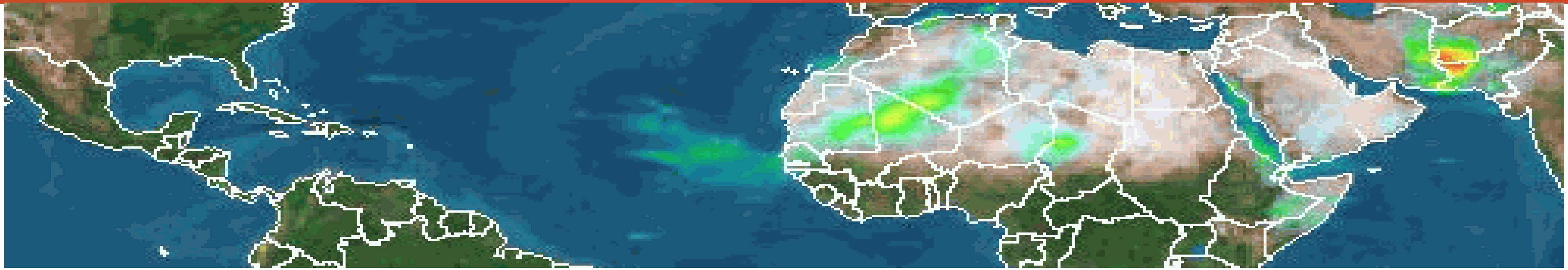
Note that, due to the coarse nature of sand grains, no dust is coming off the dune field along the southern coastline. Satellite image courtesy of NASA

Dust (mineral aerosols)

- **diameter size: 2-300 μm**
- **main material: sand, silt, clay**
- **includes essential trace metals such as Fe, Si, Al, Mg**
- **consists of insoluble and soluble fractions**

Engelbrecht, J., *et al September 02, 2010 (Elements)*





TOMS animation from June 13 to 21, 2001, showing the african plume crossing the Atlantic Ocean and bringing soil particles from the Sahara dust to Atlantic over the Caribean.

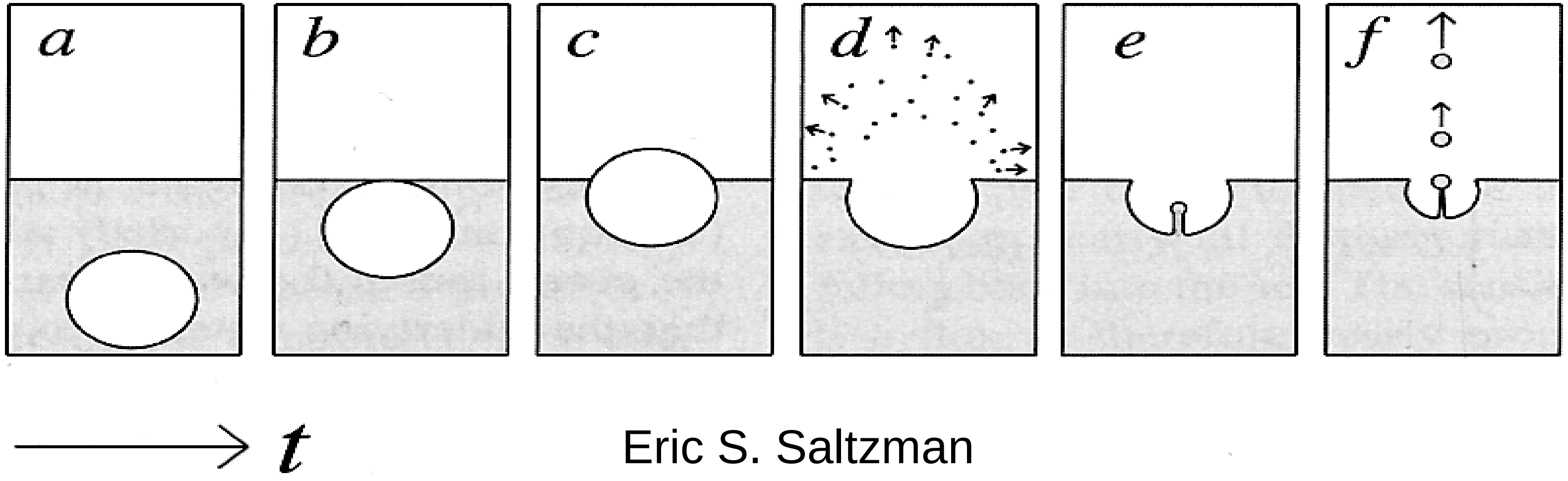
The dust particles bring phosphorus and iron to enrich the ocean

http://science.nasa.gov/headlines/y2001/ast26jun_1.htm

Seasalt aerosols…

seasalt production via bubble bursting…

- film drops (many, small, organics)
- jet drops (fewer, larger)



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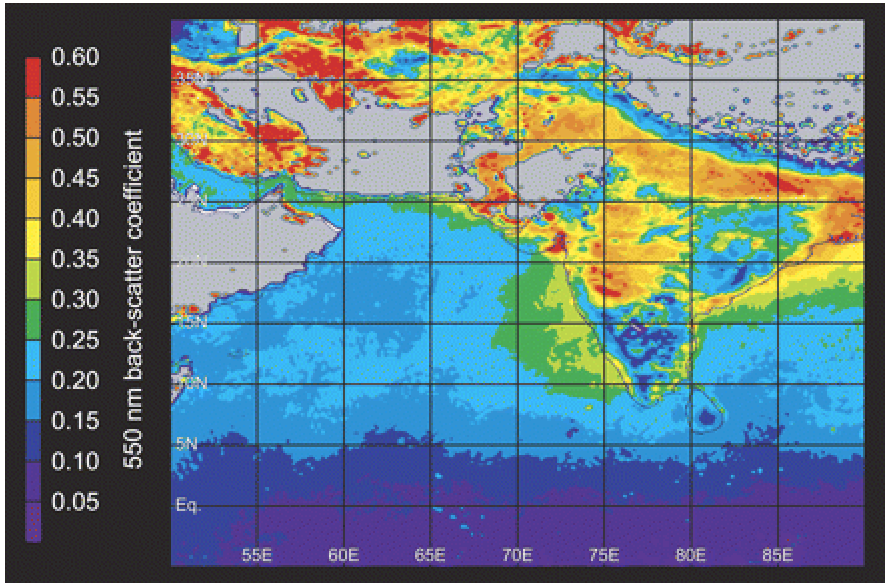
Atmospheric Brown Cloud

Direct Effect of Aerosol

Atmospheric Brown Carbon ABC



Guenter Engling and András Gelencsér

1811-5209/10/0006-0223$2.50 DOI: 10.2113/gselements.6.4.223

MODIS image (NASA's Terra satellite), shows the extent of an atmospheric brown cloud over northern India and Bangladesh. It covers a land area more than 2000 km by 500 km in size.
Image courtesy of Jacques Descloitres,
MODIS Land Rapid Response Team, NASA/GSFC

Mean aerosol optical depth (AOD) at visible wavelengths from December 2001 to May 2002 showing both the spatial extent and intensity of the **Atmospheric Brown Carbon** over the Indian subcontinent.
The data were obtained using the MODIS instrument onboard NASA's Terra satellite.

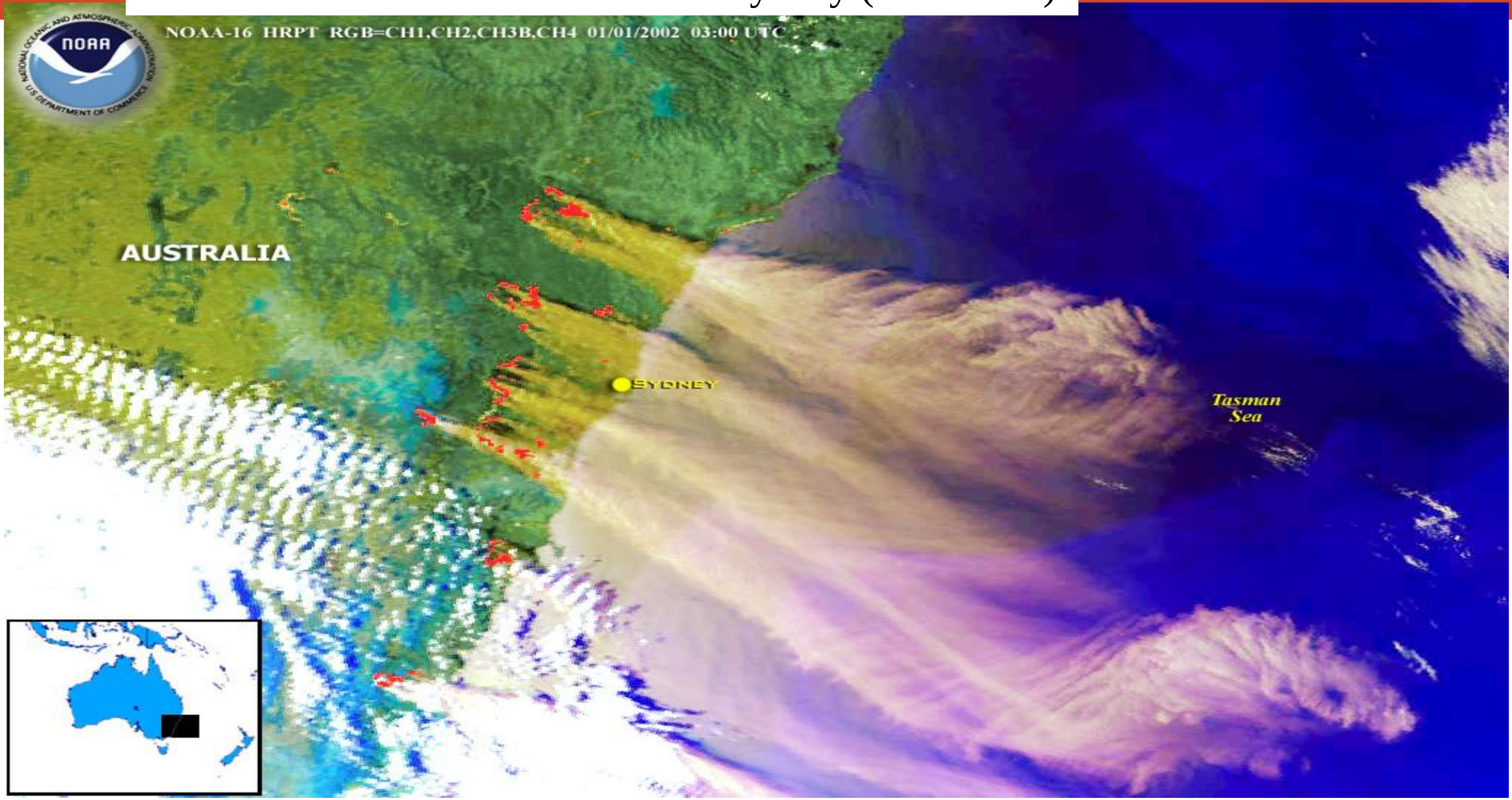
AOD = 1 corresponds to the case when incoming solar irradiation is attenuated to the e−1 fraction (36.8%) of its top-of-the-atmosphere (almost clear-sky) intensity.

An AOD of 0.6, as seen in wide areas of India, signifies very high levels of visible air pollution, levels that are typical during episodes of massive urban smog. The orange-red areas in Iran, Pakistan, and Afghanistan represent desert dust.

Image courtesy of NASA's Earth Observing System (EOS) project

Direct Observations of Aerosols

Smoke Clouds from wild fires near Sydney (Dec. 2001)



Atmospheric Aerosols

According to Seinfeld & Pandis (2008)

Atmospheric aerosols consist of particles ranging in size from a few tens of angstroms (A) to several hundred micrometers. Particles less than 2.5 μm in diameter are generally referred to as "fine" and those greater than 2.5 μm diameter as "coarse."

The fine and coarse particle modes, in general, originate separately, are transformed separately, are removed from the atmosphere by different mechanisms, require different techniques for their removal from sources, have different chemical composition, have different optical properties, and differ significantly in their deposition patterns in the respiratory tract. Therefore the distinction between fine and coarse particles is a fundamental one in any discussion of the physics, chemistry, measurement, or health effects of aerosols.

Aerosol System:

- sedimentation velocity of the particles is low

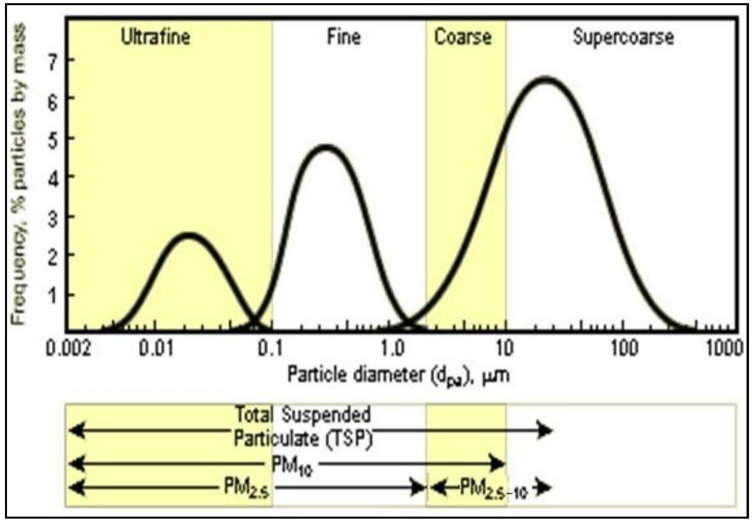
- Inertial Effects during the movement of particles can be neglected (ratio between inertial forces to viscous forces are small)

-Reynolds Number = $(\rho v r)/\mu < 1$

-The Brownian movement of particles due to the thermal agitation of molecules is important

Aerodynamic Diameter:

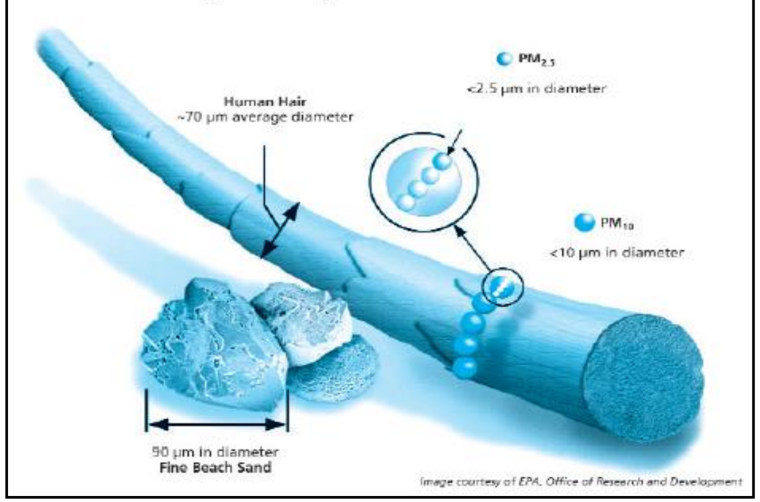
It is the diameter of the sphere with unitary density that has the same sedimentation velocity of the particle.



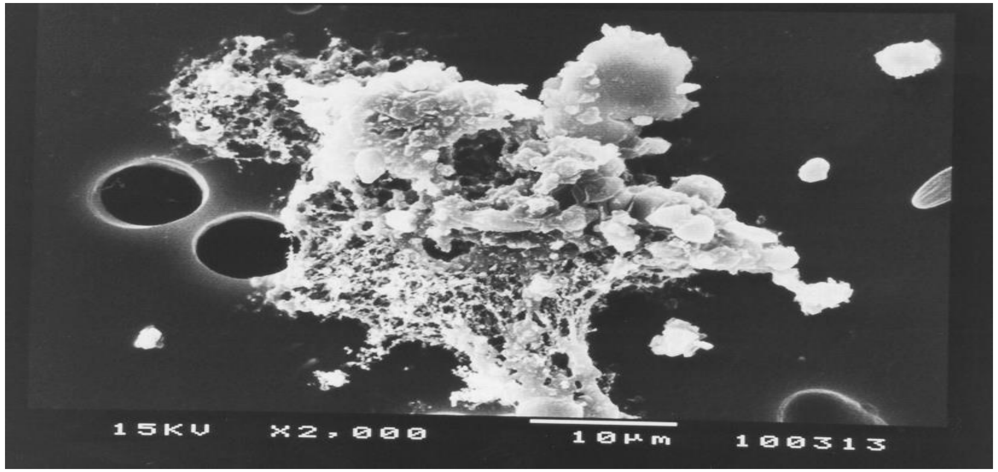
Stokes Diameter:

It is the diameter of the sphere with the same density and sedimentation velocity of the particles

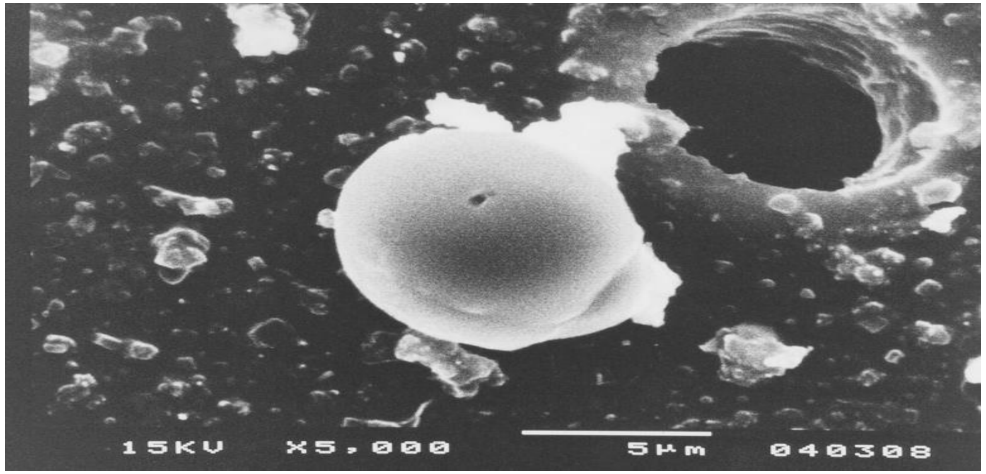
Figure 1. Comparison of PM sizes.



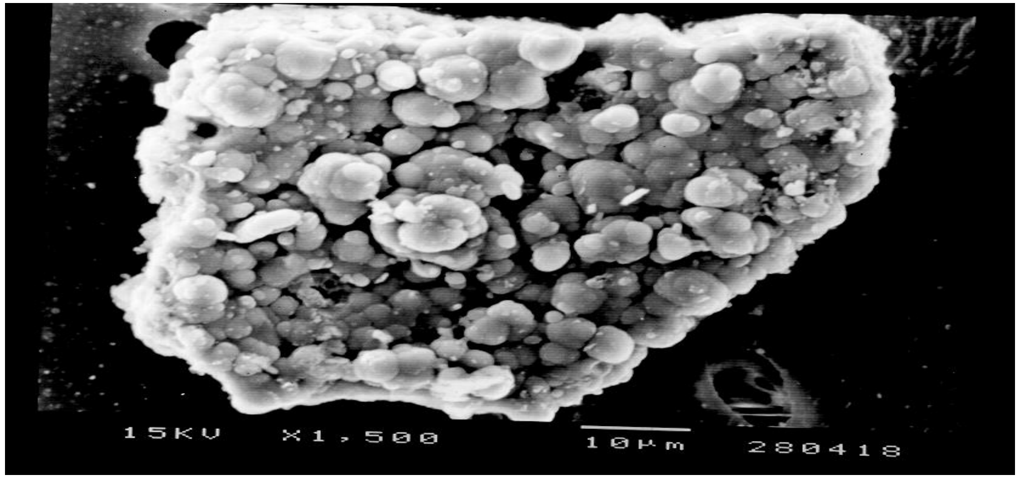
Individual Particles analyzed by Scanning Eletron Microscopy



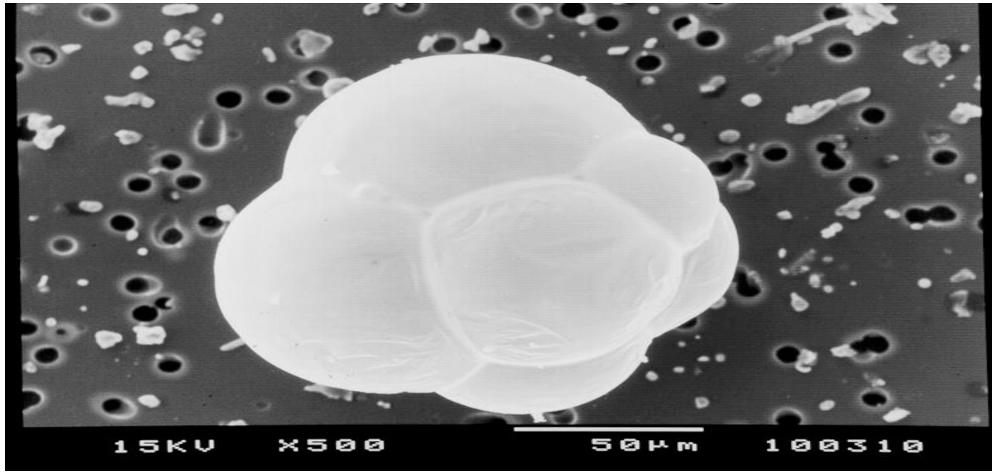
Aluminosilicate



Sulfate

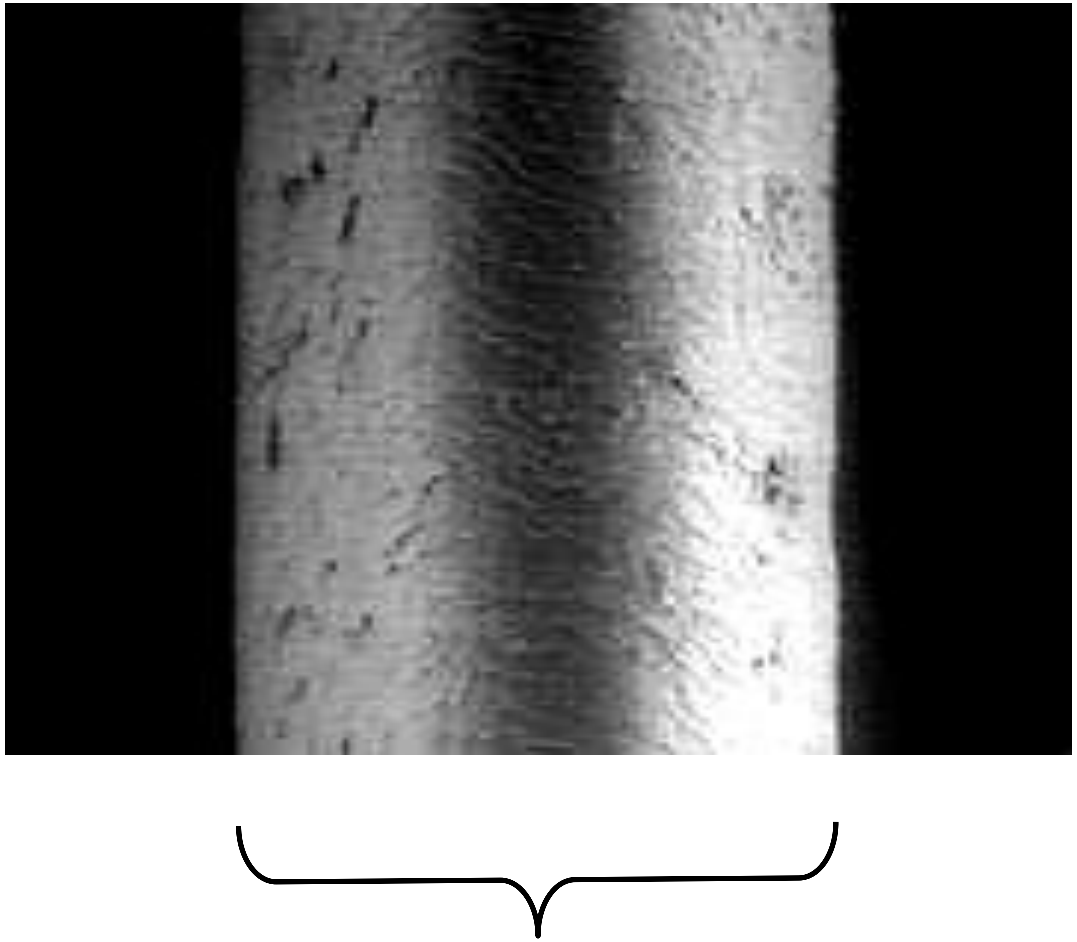


Clorate

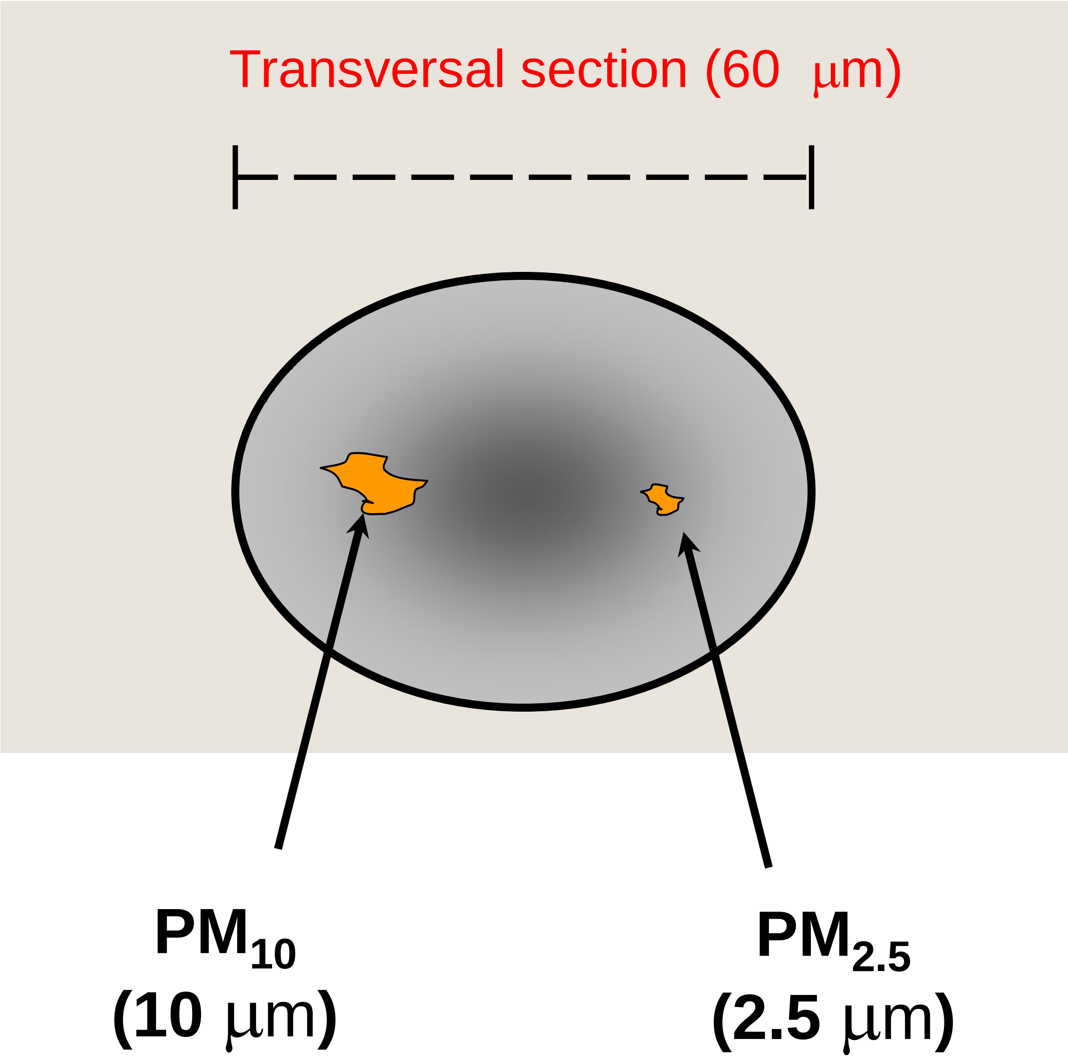


Biogenic

Particulate Matter comparison with a Human Hair



Human hair



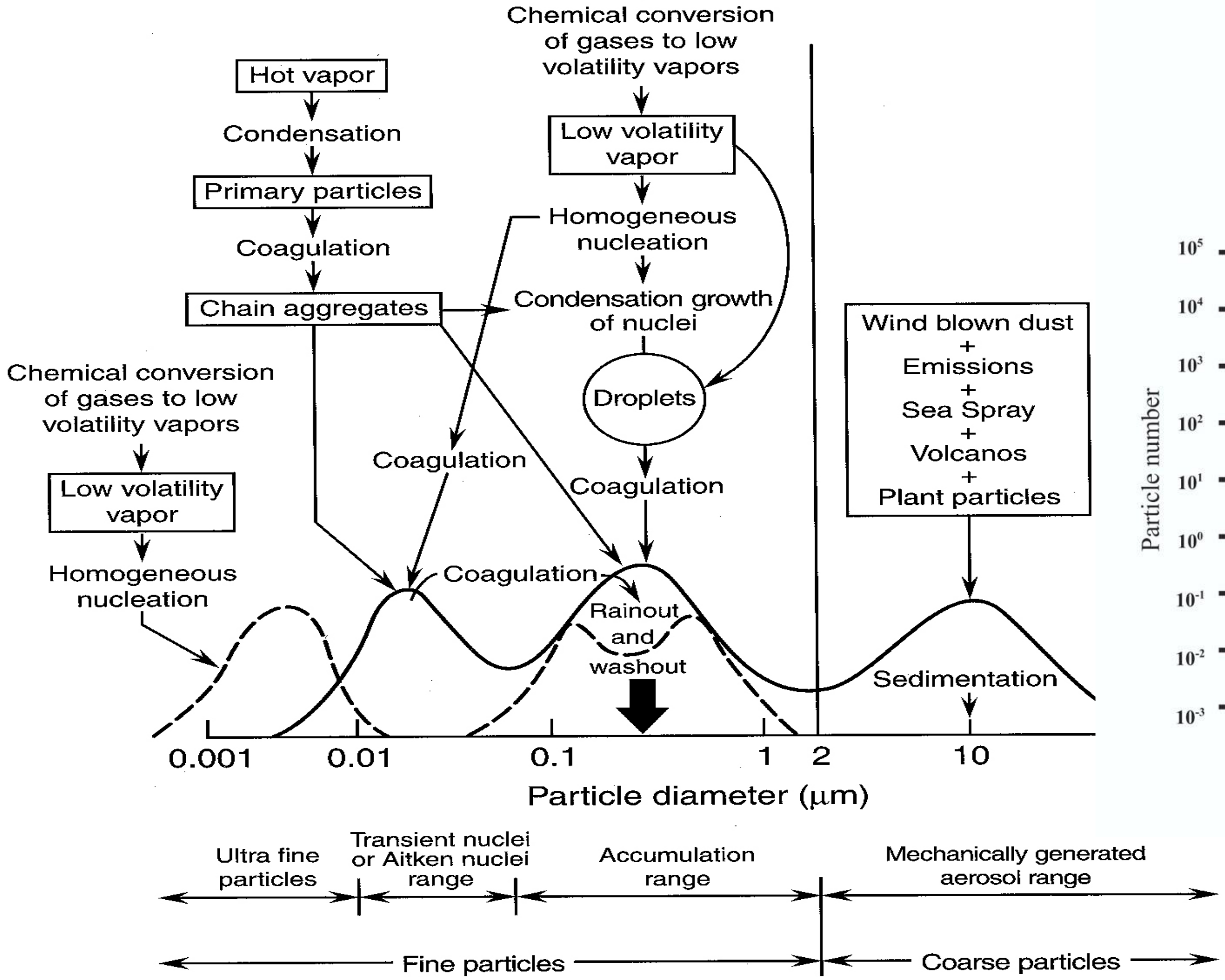
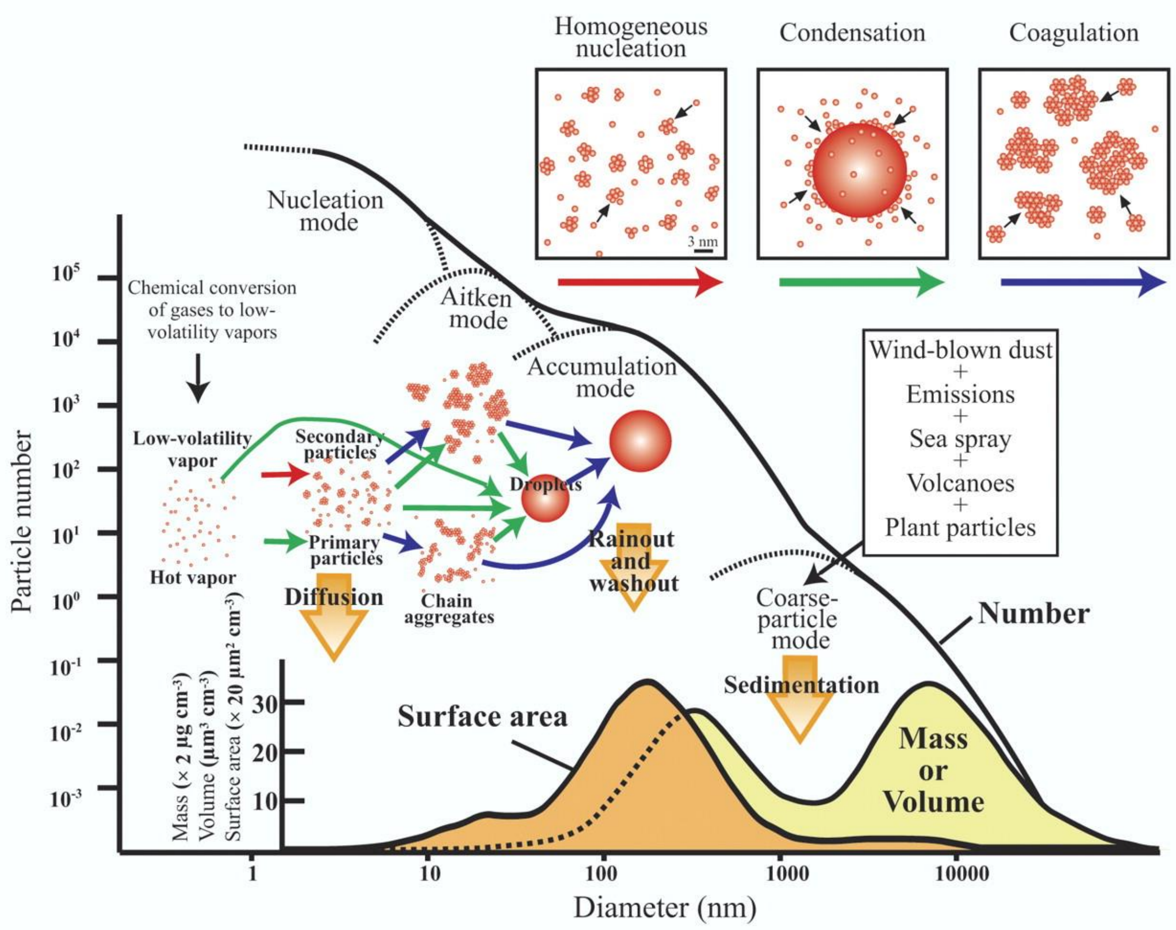


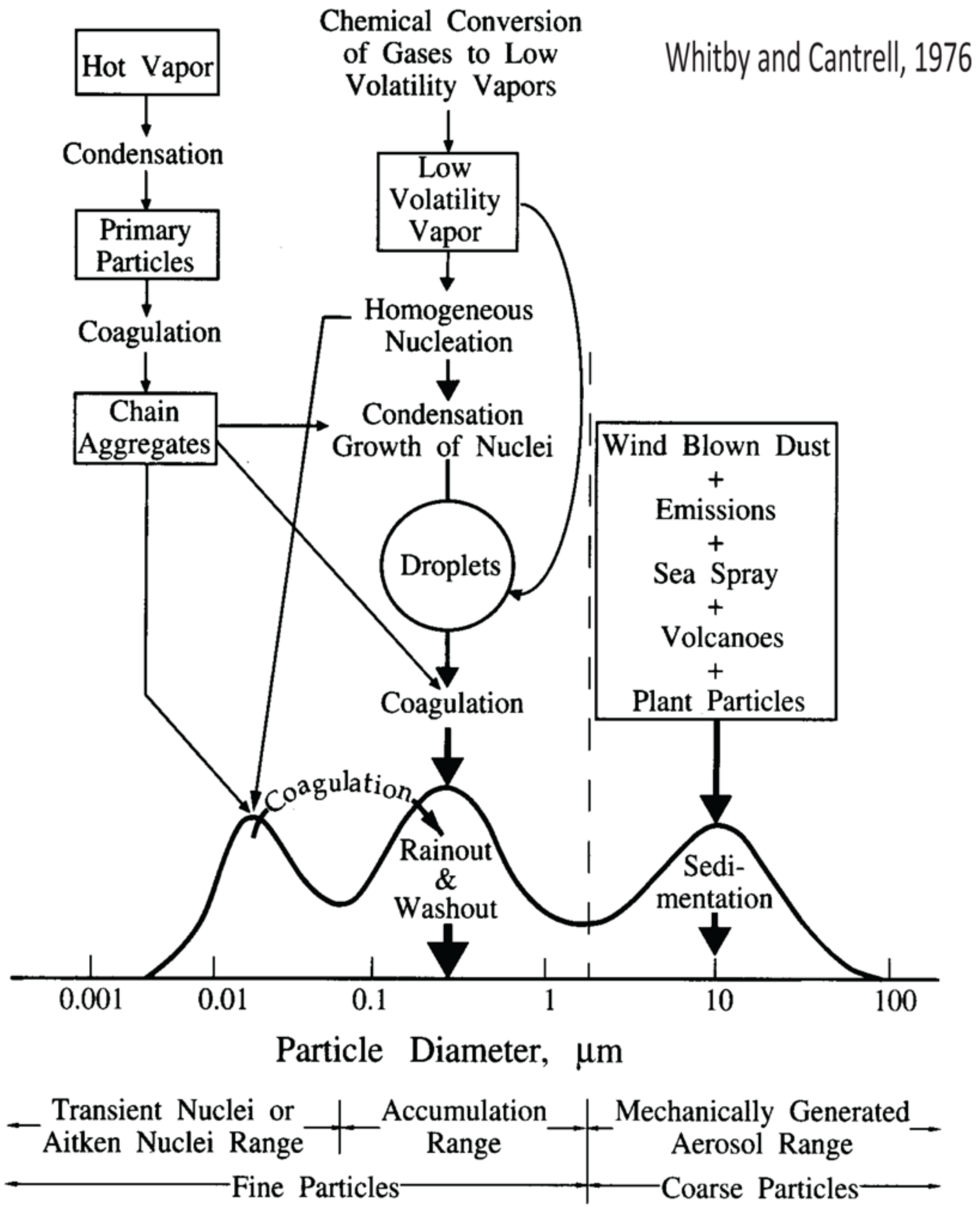
FIGURE 9.7 Schematic of an atmospheric aerosol size distribution showing four modes. The original hypothesis of Whitby and co-workers is shown by the solid, trimodal curves, and the fourth, ultrafine particle mode, as well as the two peaks sometimes observed in the accumulation mode are shown by the dashed lines (adapted from Whitby and Sverdrup, 1980).



elements.geoscienceworld.org

Finlayson_Pitts & Pitts, 2000

The physical characteristics of sulfur aerosols
Whitby & Cantrell, 1976



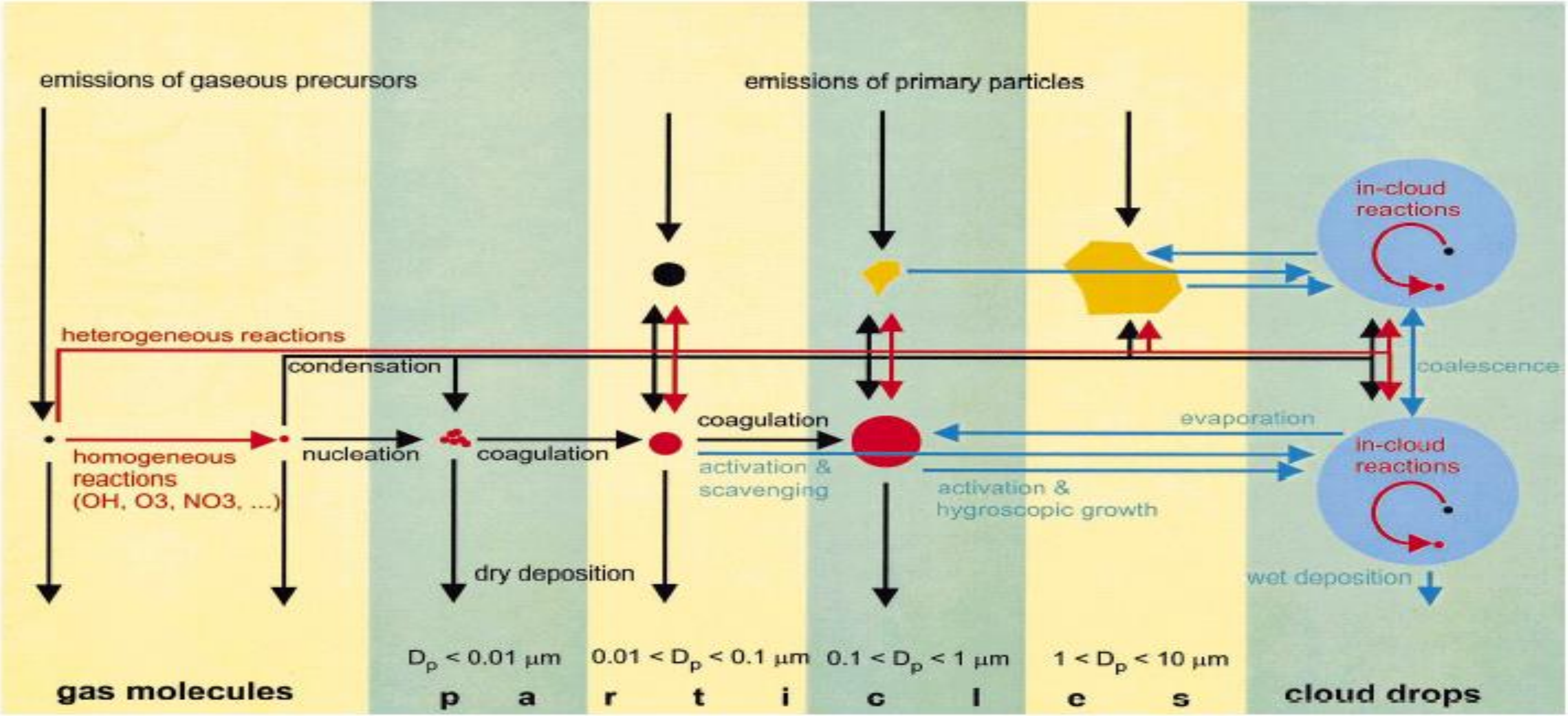


Fig. 1. Scheme of the microphysical processes that influence the size distribution and chemical composition of the atmospheric aerosol. The scheme highlights the large range of sizes that are involved in the formation and evolution of aerosol particles, and how aerosols participate in atmospheric chemical processes through homogeneous, heterogeneous and in-cloud reactions.

Atmospheric Environment 34 (2000) 4215–4240

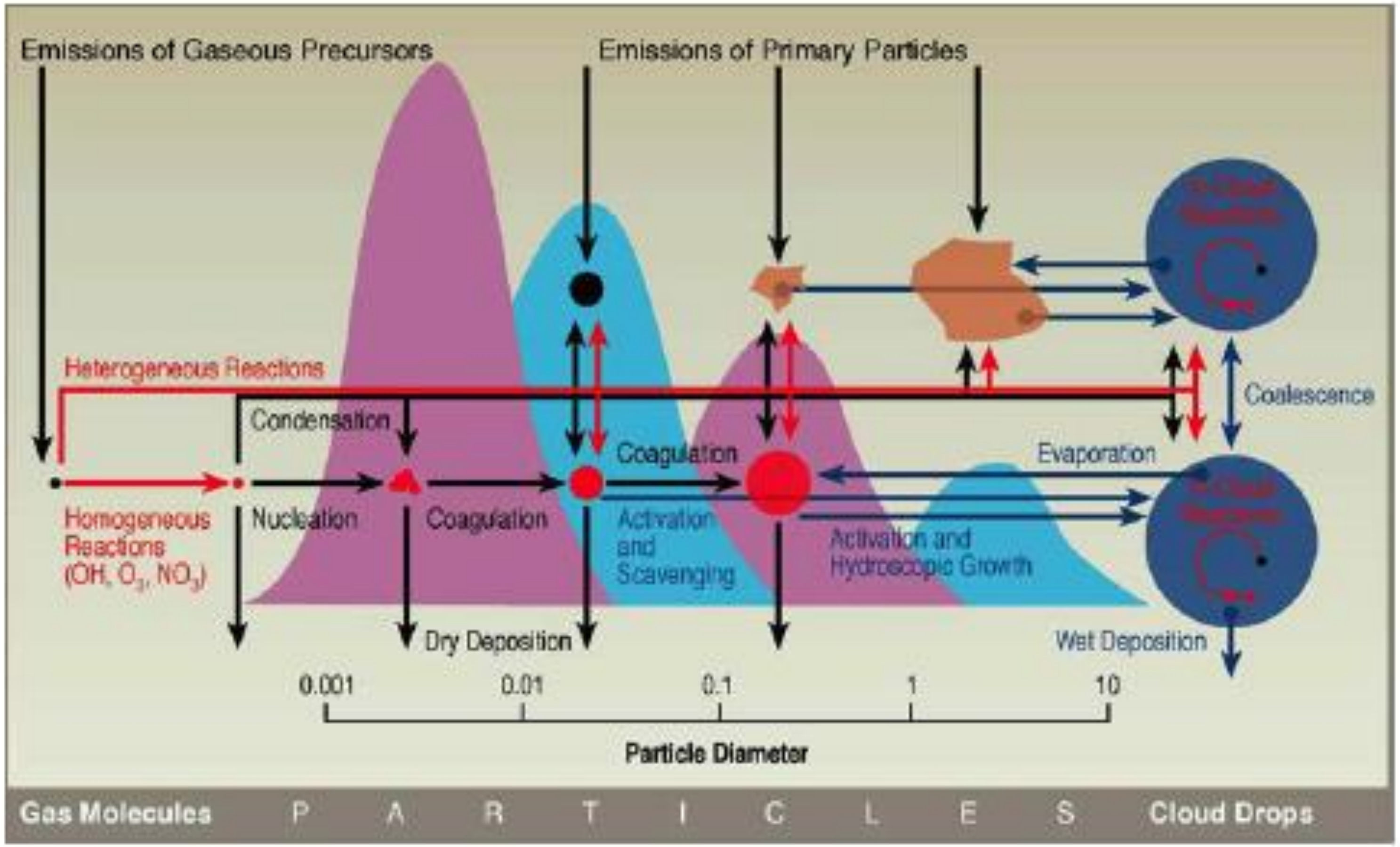


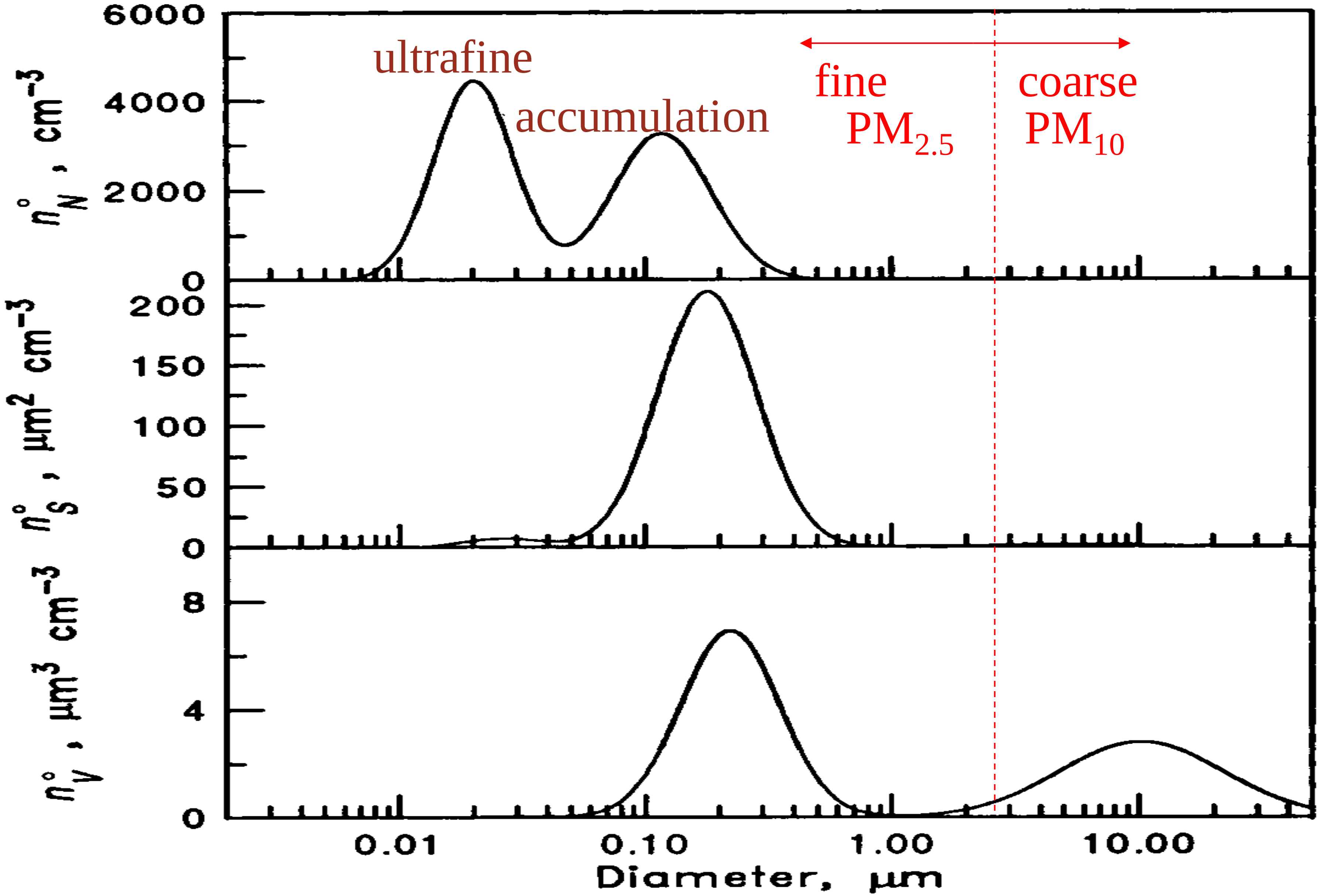
Figure 5.16. Schematic representation of the microphysical processes that determine the evolution of aerosol particles from their formation through nucleation to their activation and conversion into cloud droplets. Particle diameter is in units of µm. Major aerosol modes are highlighted including (in order of increasing size) the nucleation, Aitken, accumulation, and coarse modes. Adapted from Heintzenberg, J., F. Raes, and S.E. Schwartz, 2003: Tropospheric aerosols. In: *Atmospheric Chemistry in a Changing World: An Integration and Synthesis of a Decade of Tropospheric Chemistry Research* [Brasseur, G.P., R.G. Prinn, and A.A.P. Pszenny(eds)].

Table 5.6. Dominant Sources and Components of Nucleation, Accumulation, and Coarse Mode Particles

Nucleation Mode	Accumulation Mode	Coarse Mode
Nucleation $H_2O(aq)$, SO_4^{2-}, NH_4^+	Fossil-fuel emissions BC, OM, SO_4^{2-}, Fe, Zn	Sea-spray emissions H_2O, Na^+, Ca^{2+}, Mg^{2+}, K^+, Cl^-, SO_4^{2-}, Br^-, OM
Fossil-fuel emissions BC, OM, SO_4^{2-}, Fe, Zn	Biomass-burning emissions BC, OM, K^+, Na^+, Ca^{2+}, Mg^{2+}, SO_4^{2-}, NO_3^-, Cl^-, Fe, Mn, Zn, Pb, V, Cd, Cu, Co, Sb, As, Ni, Cr	Soil-dust emissions Si, Al, Fe, Ti, P, Mn, Co, Ni, Cr, Na^+, Ca^{2+}, Mg^{2+}, K^+, SO_4^{2-}, Cl^-, CO_3^{2-}, OM
Biomass-burning emissions BC, OM, K^+, Na^+, Ca^{2+}, Mg^{2+}, SO_4^{2-}, NO_3^-, Cl^-, Fe, Mn, Zn, Pb, V, Cd, Cu, Co, Sb, As, Ni, Cr	Industrial emission BC, OM, Fe, Al, S, P, Mn, Zn, Pb, Ba, Sr, V, Cd, Cu, Co, Hg, Sb, As, Sn, Ni, Cr, H_2O, NH_4^+, Na^+, Ca^{2+}, K^+, SO_4^{2-}, NO_3^-, Cl^-, CO_3^{2-}	Biomass burning ash, industrial fly-ash, tire-particle emissions
Condensation/dissolution $H_2O(aq)$, SO_4^{2-}, NH_4^+, OM	Condensation/dissolution $H_2O(aq)$, SO_4^{2-}, NH_4^+, OM Coagulation of all components from nucleation mode	Condensation/dissolution $H_2O(aq)$, NO_3^- Coagulation of all components from smaller modes

Atmospheric Pollution, History, Science and Regulation. M. Jacobson, 2002.

Size Distribution



Seinfeld & Pandis, 2008

Global Particle Production (Table 2.19 from Seinfeld and Pandis)

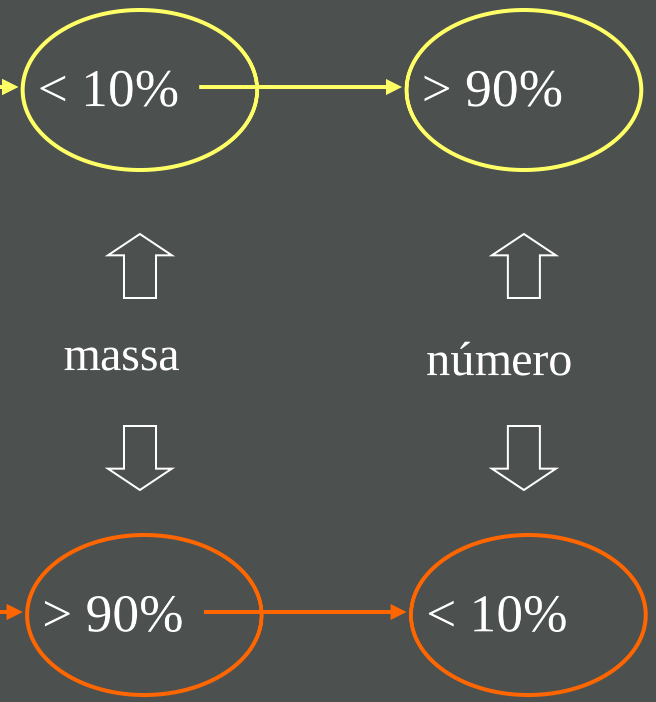
90% mass
10% number

10% mass
90% number

Source	Estimate Flux (Tg/yr)	Particle Size Category
Primary		
Soil dust (mineral aerosol)	1000-3000	Mainly coarse
Sea salt	1000-10000	Coarse
Volcanic dust	2-10000	Coarse
Biological debris	26-80	Coarse
Secondary		
Sulfates from biogenic gases	80-150	Fine
Sulfates from volcanic SO2	5-60	Fine
Organic matter from biogenic VOC	40-200	Fine
Nitrates from NOx	15-50	Fine and coarse
Total Natural	**2200-23500**	**Best estimate 3100**
Anthropogenic		
Primary		
Industrial dust etc. (except soot)	40-130	Fine and coarse
Soot	5-20	Mainly fine
Secondary		
Sulfates from SO2	170-250	Fine
Biomass burning	60-150	Fine
Nitrates from NOx	25-65	Mainly coarse
Organics from anthropogenic VOC	5-25	Fine
Total anthropogenic	**300-650**	**Best estimate 450**
Total	**2500-24000**	**Best estimate 3600**

Processos de formação das partículas

Tipo	Emissão estimada *
Sulfato	
Industria	65,0-92,4
Oceano	10,7-23,7
Aviação	0,04
Queima de biomassa	2,0-3,0
Carbono orgânico	
Combustível fóssil	10-20
Biomassa	30-45
Carbono elementar	
Combustível fóssil	5,8-6,6
Biomassa	6,0-17,2
Nitrato	
Combustível fóssil	0,3
Biomassa	5,7
Outros (homem, solo, animal, agricultura)	74,5
Sal Marinho	
<2 μm	82
>2 μm	2583
Poeira de solo	
<2 μm	243
>2 μm	4859



* Menon (2004), valores em $Tg.ano^{-1}$