Atmospheric Aerosols

Lecture 9

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AEROSOL CHEMICAL COMPOSITION

METALS

Man made sources : incorporated in the particle in early stage of particle formation from combustion process

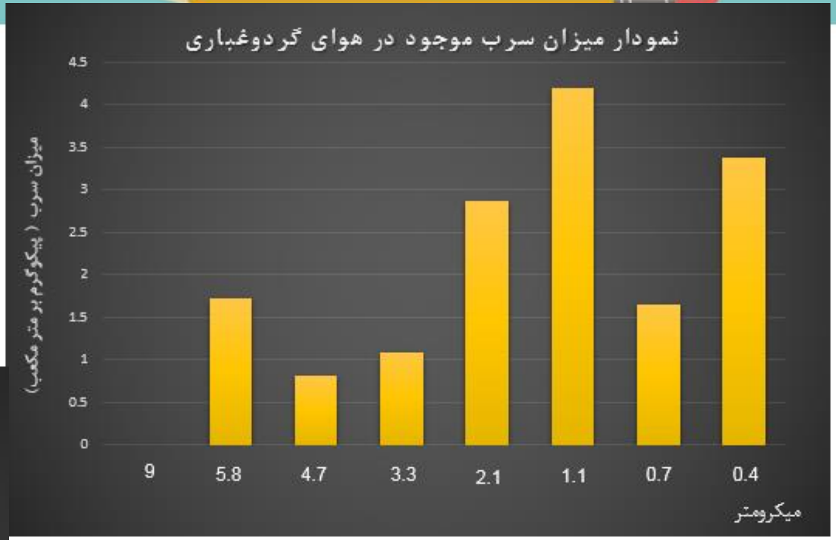
Natural sources: volcanoes + soil erosion

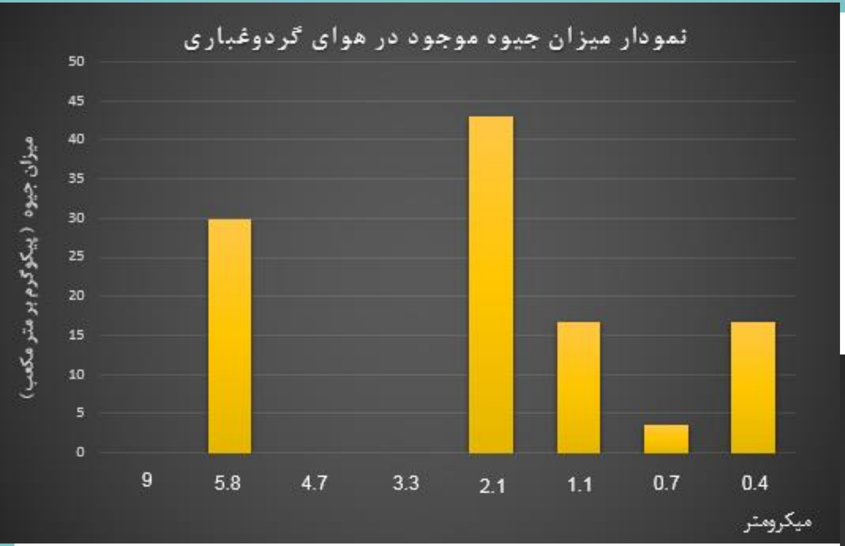
Fine mode : Pb, Zn, Fe, Cd, As…

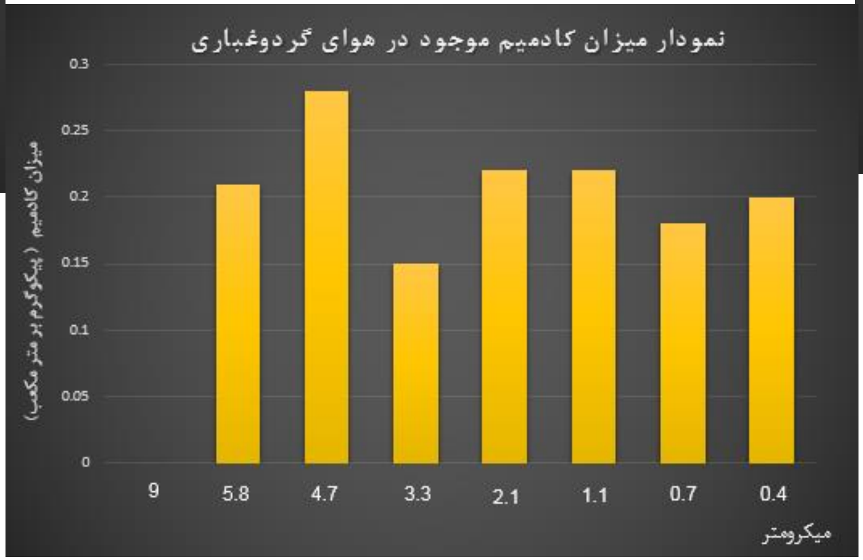
Coarse mode : Ca, Mg, Al, Ti,

Fine & Coarse mode: Na, K, Fe, V, Cr, Co, Ni, Mn, Cu

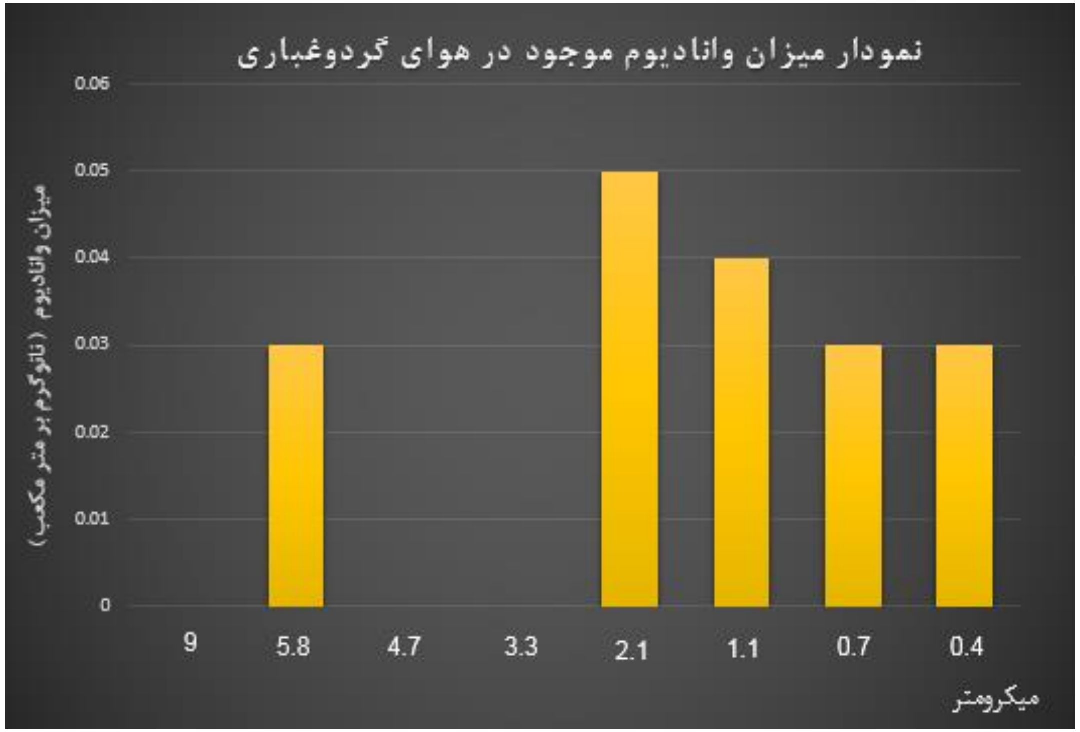
تعیین ترکیبات شیمیایی ذرات گردوغبار

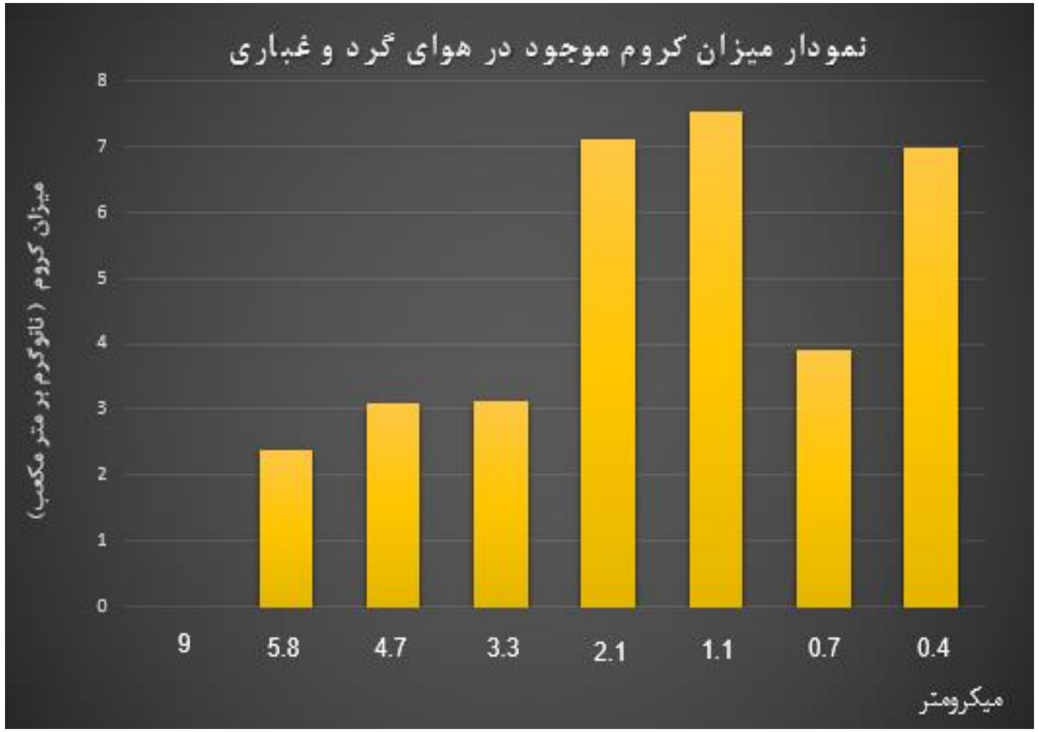




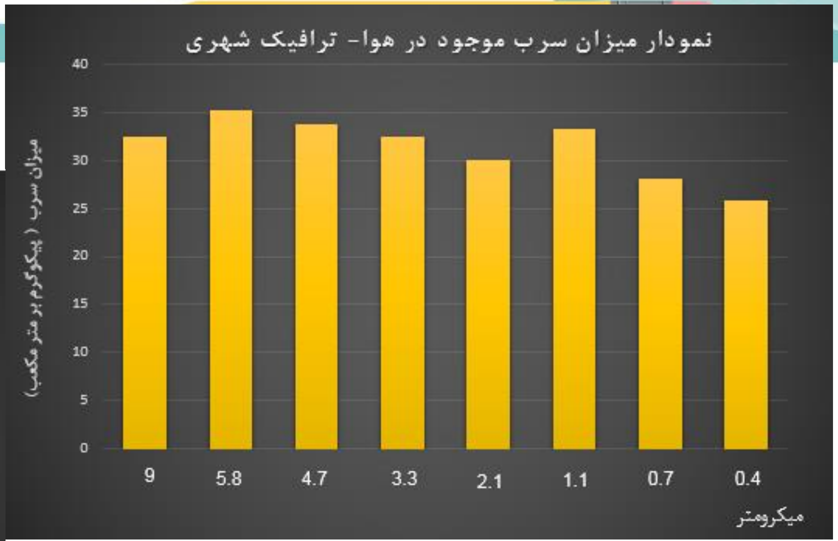


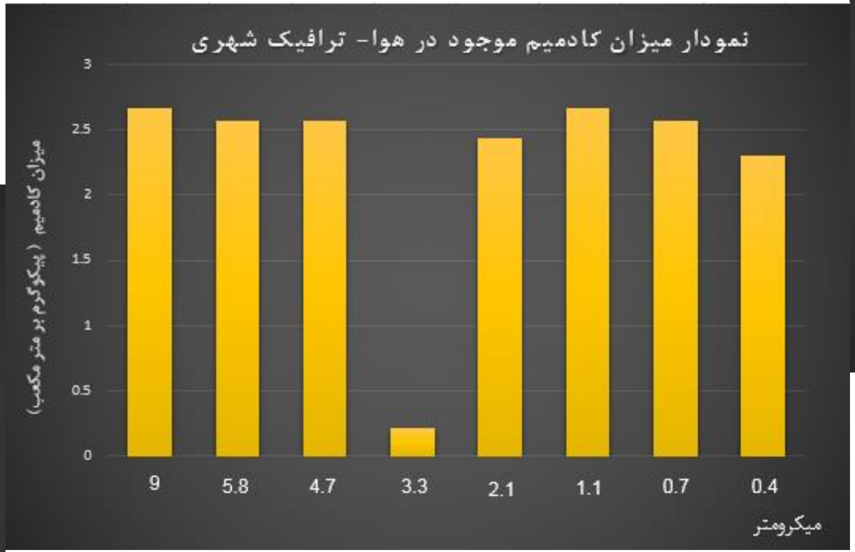
تعیین ترکیبات شیمیایی ذرات گردوغبار

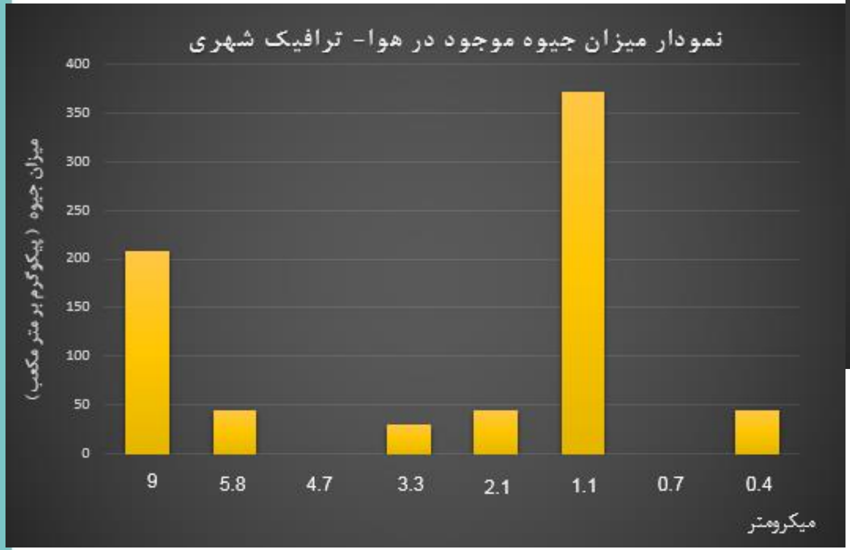




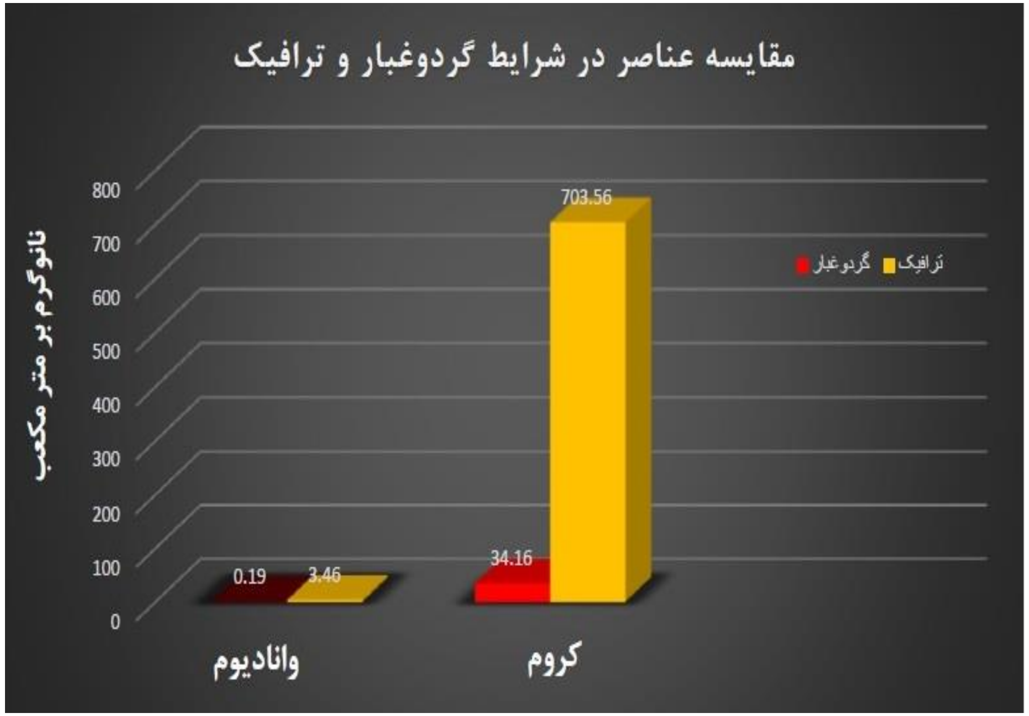
تعیین ترکیبات شیمیایی ذرات آلاینده در ترافیک شهری

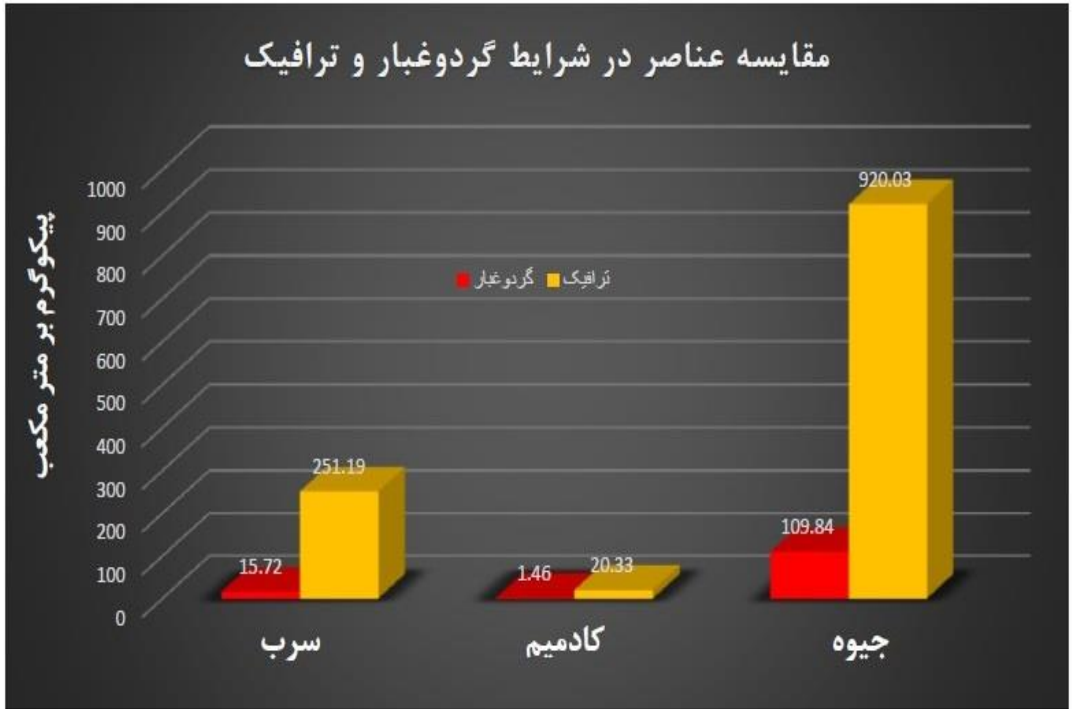






مقایسه ترکیبات شیمیایی ذرات آلاینده در شرایط گردوغبار و ترافیک شهری





VERTICAL VARIATION

The vertical distribution of aerosol mass concentration typically shows an exponential decrease with altitude up to a height H_p and a rather constant profile above that altitude (Gras1991).

The aerosol mass concentration as a function of height can then be expressed as

$$M(z) = M(0)\exp\left(-\frac{z}{H_p}\right)$$

where M(0) is the surface concentration and H_p the scale height. Jaenicke (1993) proposed values of

H_p =900 m marine,
H_p=730 m remote continental
H_p=2000 m desert
H_p=30,000 m polar

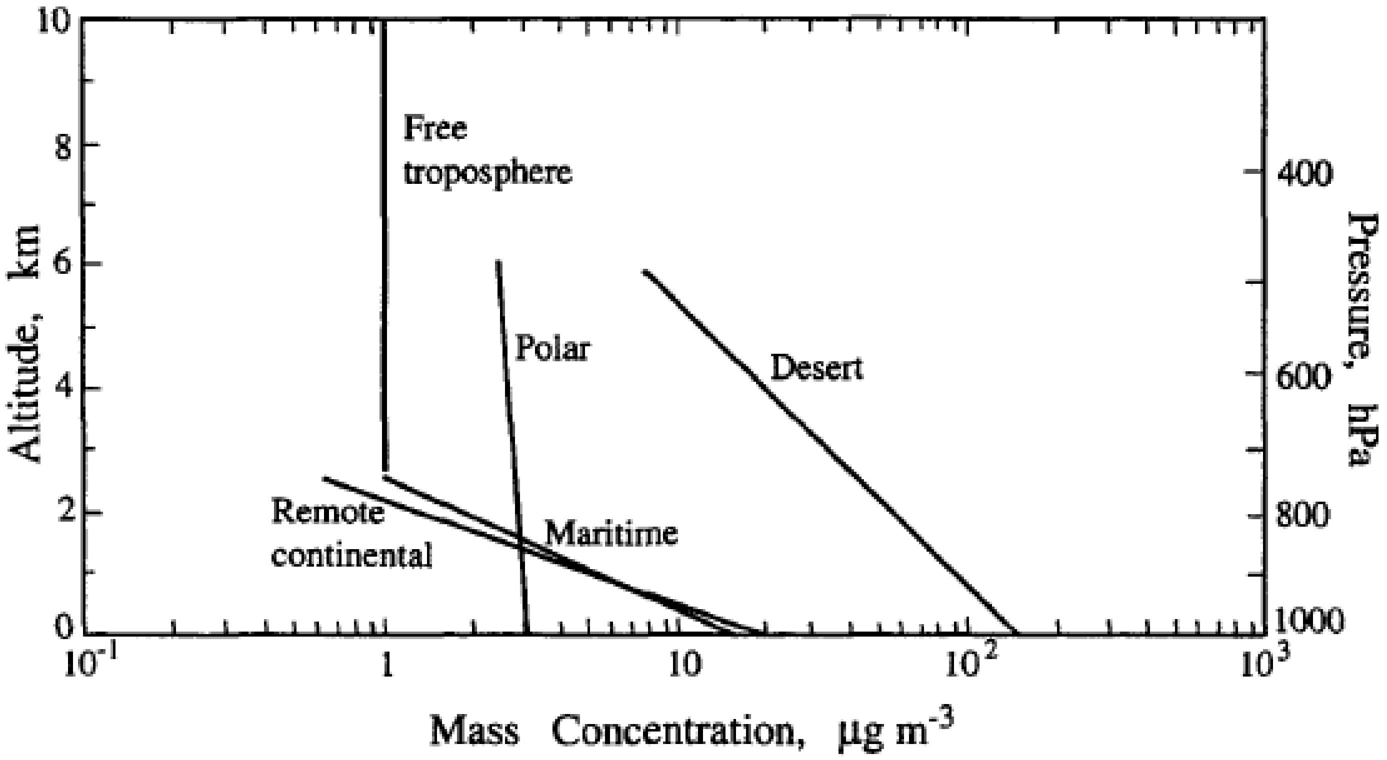
The corresponding vertical aerosol mass concentration profiles are shown in Figure.

H_p =900 m marine,

H_p=730 m remote continental

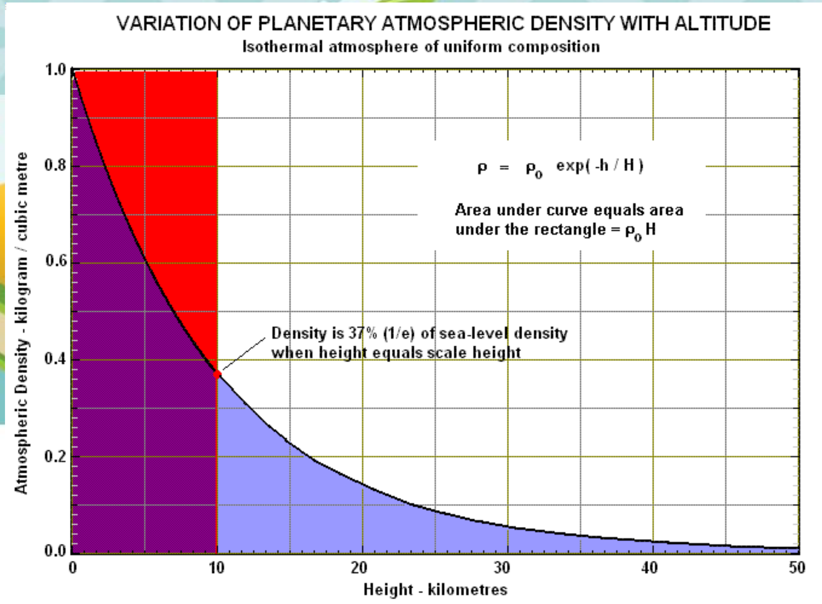
H_p=2000 m desert

H_p=30,000 m polar



Representative vertical distribution of aerosol mass concentration (Jaenicke 1993).

SCALE HEIGHT



Elevation	Density
0	ρ_0
H	$(1/e)\rho_0 = 0.368\rho_0$
2H	$(1/e^2)\rho_0 = 0.135\rho_0$
3H	$(1/e^3)\rho_0 = 0.050\rho_0$
4H	$(1/e^4)\rho_0 = 0.018\rho_0$

Scale height is a general way to describe how a value fades away and it is commonly used to describe the atmosphere of a planet.

It is the vertical distance over which the density and pressure fall by a factor of 1/e.

These values fall by an additional factor of 1/e for each additional scale height H.

Thus, it describes the degree to which the atmosphere “hugs” the planet.

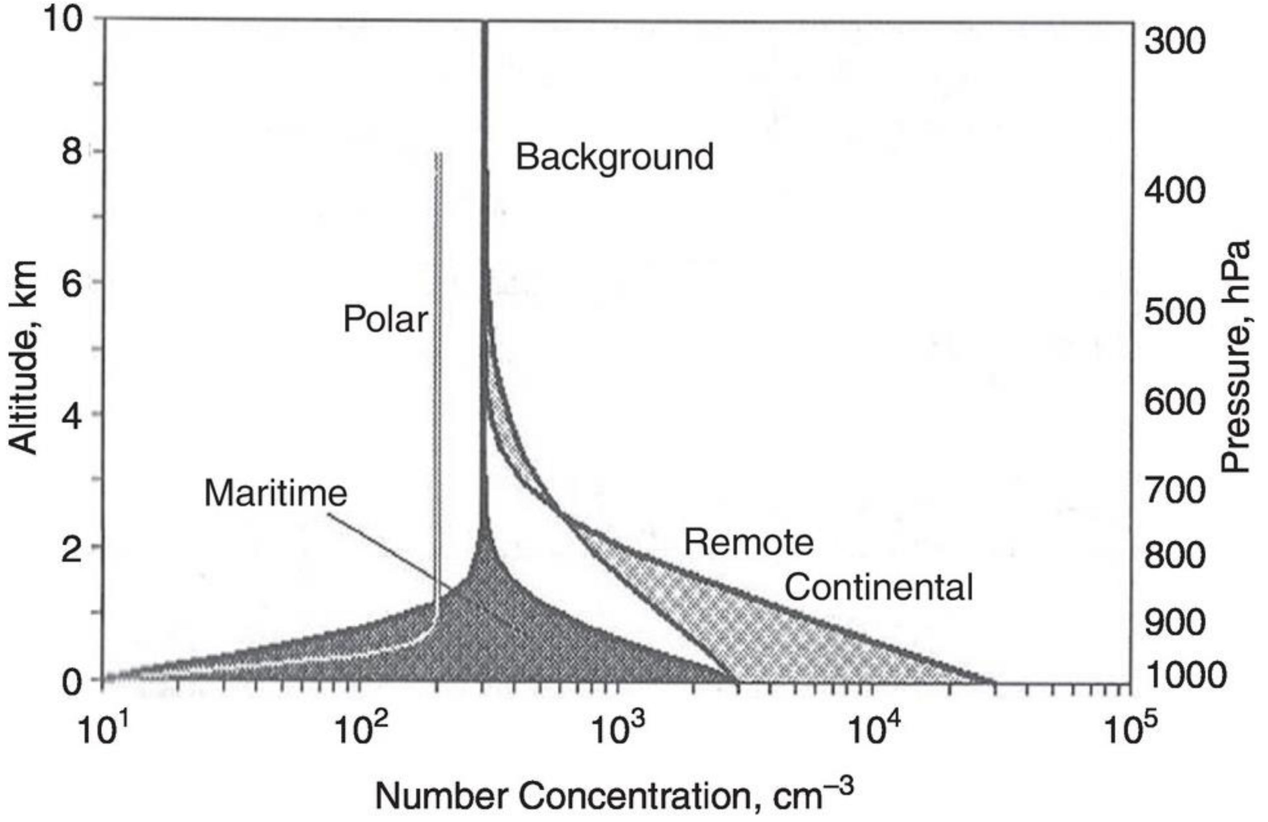
Model vertical number concentration profiles are known in figure

Representative vertical distribution of aerosol number concentration.

A range of concentration is shown for marine and remote continental aerosols.

These vertical profiles are rough representations of long-term averages.

Significants variability is observed in aerosol concentration in anthropogenic plumes, areas influenced by local sources, or during nucleation events in the free troposphere.



Dynamics of Single Aerosol Particles

In this chapter, we focus on the processes involving a single aerosol particle in a suspending fluid and the interaction of the particle with the suspending fluid itself.

We begin by considering how to characterize the size of the particle in an appropriate way in order to describe transport processes involving momentum, mass, and energy.

CONTINUUM AND NONCONTINUUM DYNAMICS:

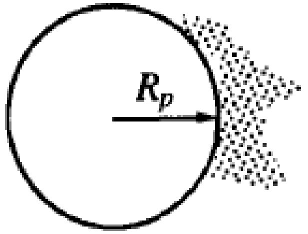
As we begin our study of the dynamics of aerosols in a fluid (e.g., air), we would like to determine, from the perspective of transport processes, how the fluid "views" the particle or equivalently how the particle "views" the fluid that surrounds it.

Mean Free Path

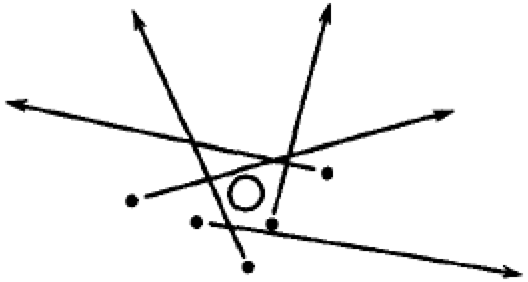
The average distance traveled by a molecule between collisions with other molecules is defined as its mean free path.

If particle siz >> mean free path → gas behaves, as a continuous fluid

If particle size << mean free path → a small particle and gas molecule moving discretely around it



continuum regime



free molecule (kinetic) regime

Transition regime

The Knudsen Number

The key dimensionless group that defines the nature of the suspending fluid relative to the particle is the Knudsen number (Kn)

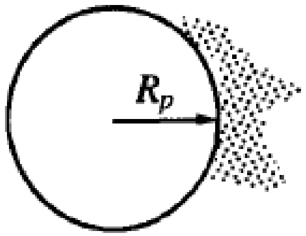
$$\mathrm{Kn} = \frac{2\lambda}{D_p} = \frac{\lambda}{R_p}$$

where λ is the mean free path of the fluid,

D_p the particle diameter,

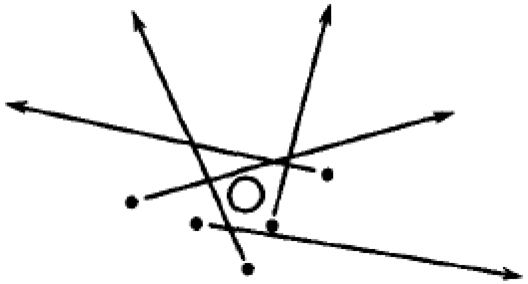
R_p the particle radius

Thus the Knudsen number is the ratio of two lengthscales, a length characterizing the "graininess" of the fluid with respect to the transport of momentum, mass, or heat, and a length scale characterizing the particle size, its radius.



continuum regime

(Kn → 0)



free molecule (kinetic) regime

(Kn → ∞)

Transition regime

(Kn ~1)