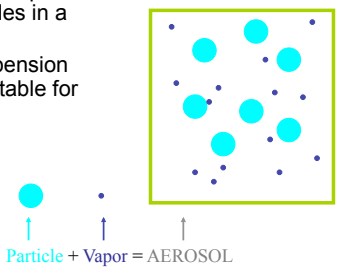
Particle Size and Deposition

- Review
  - Pollution Impacts (depends on size)
  - Particle Sources (depends on size)
  - Chemical Composition (depends on size)
- Sizes
  - Particle Size Distributions (defining "size")
- Microphysics
  - Deposition Velocity (depends on size)

What is an Aerosol?

- Suspension of liquid or solid particles in a vapor phase
- Colloidal suspension that may be stable for <1 s or > 1 yr



What are aerosol particles?

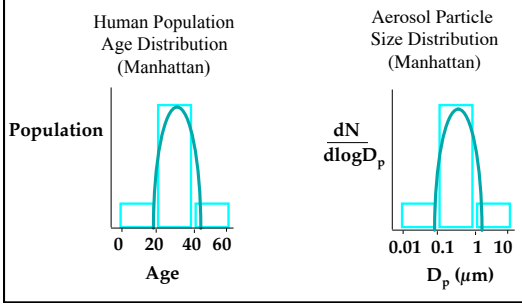
- Particle Sources (depends on size)
- Chemical Composition (depends on size)
- Sizes
  - Particle Size Distributions

Air Pollution: What is it?

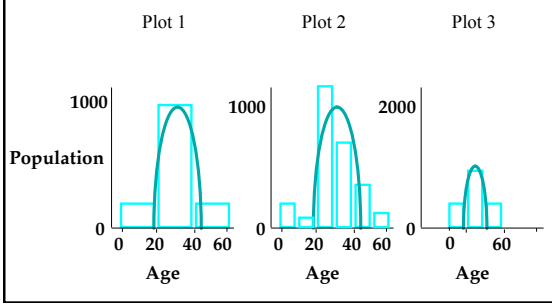
Any atmospheric condition in which *substances* are present at concentrations higher than their normal levels to produce a *measurable* effect on humans, animals, vegetation, or materials.

1.2

Number Distributions vs. Population Distributions

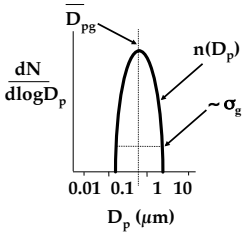


Plotting a Distribution



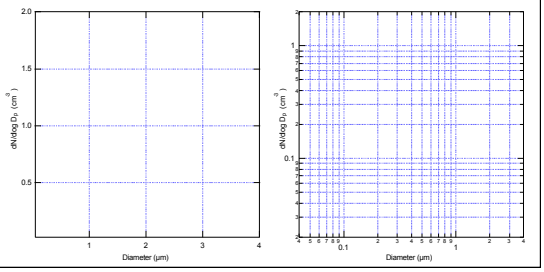
Particle Size Distributions

- Number concentration
  - Total number N
  - Differential number n
- Mean size
  - Geometric
  - Arithmetic
  - Number-based
  - Mass-based
- Size variability
  - Standard deviation σ
  - Geometric standard deviation σ_g



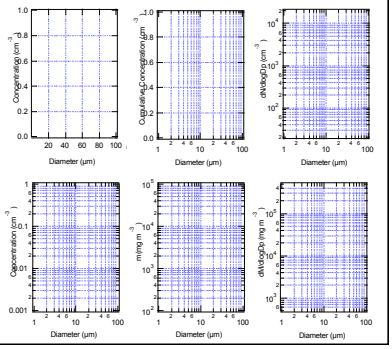
Linear vs. Log Plots

- Works for small range
- Needs equal decades!



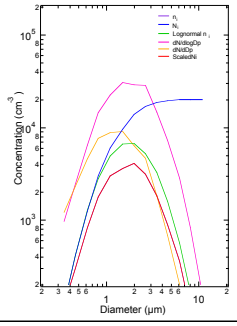
Number and Mass Distributions

- Differential
  - shows small changes with size
- Cumulative
  - emphasizes total properties
- Number
  - most are small
- Mass
  - most are large



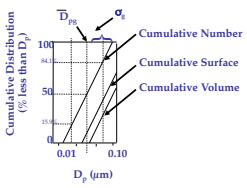
Size Characterization of Particles

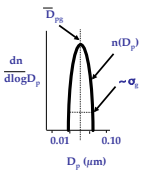
- clusters of molecules
- starting at 100 molecules/cluster
- growth by condensation of molecules is nearly continuous
- multiple ways to graph same distribution



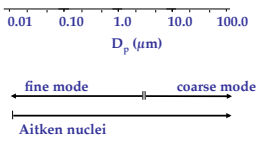
Log-Normal Number Distributions

- Cumulative
- Differential





Particle Sizes



- range of particle sizes is approximately from 1 nm to 1 mm in diameter
- range of approximately 6 orders of magnitude
- concentrations at each of these sizes also vary

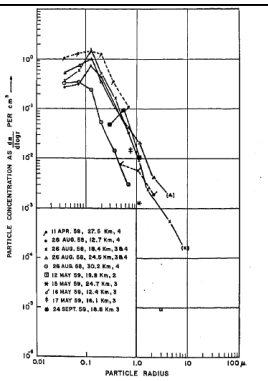


FIG. 22. Compilation of all size-distribution data determined from samples collected as indicated. The numbers given after the altitude refer to the stage of the Casella impactor on which the sample was collected.

Junge et al., 1961

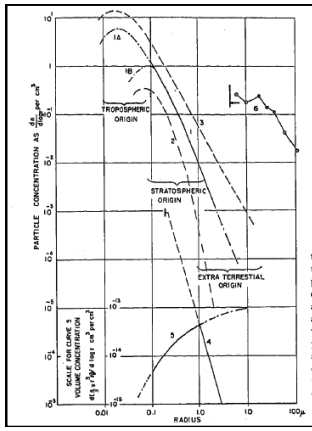


FIG. 23. Average-size-distribution curve of stratospheric aerosols with indication of their most likely origin. Curve 1 = average curve taken from fig. 22. Curve 1A = estimated average curve below 0.1 μ for the lower stratosphere. Curve 1B = the same as curve 1A for altitudes above 20 km. Curves 2 and 3 = estimated confidence limits of size distributions. Curve 4 = size distributions of micrometeoritic dust calculated for 20 km altitude and sedimentation equilibrium from Öpik's (1956) estimates of particle influx into the atmosphere. Curve 5 = volume-distribution curve corresponding to curve 1. Curve 6 = relative-size distribution of spherules according to Laevastu and Mellis (1955).

The second of our three components, comprising those particles with radii between 0.1 and 1.0 μ, was the one which we could investigate best. These particles are distributed with a maximum in concentration at approximately 20 km, are hygroscopic and definitely contain sulfur. Their concentration and size distribution appear to be notably constant with time. Our observations so far suggest that these particles are formed within the layer where they appear. We propose a primary process of oxidation of H_2S and SO_2 introduced by diffusion through the tropopause, followed by growth by coagulation and equilibrium with diffusion and sedimentation.

Junge et al., 1961

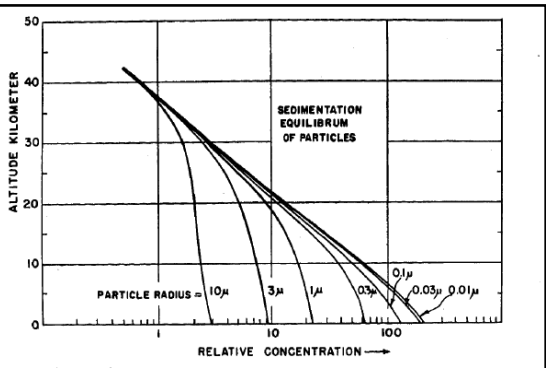


FIG. 3. Relative particle concentration for sedimentation equilibrium in a non-turbulent atmosphere as a function of altitude for various particle radii. A constant concentration at 40 km is assumed.

Junge et al., 1961

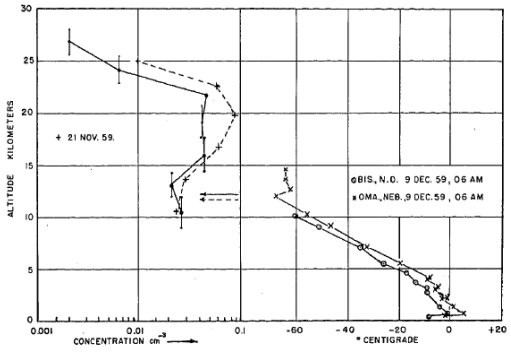


FIG. 18. Vertical profile of particles collected with the General Mills impactors on 9 December 1959, and the available temperature soundings closest in time and space. The vertical bars indicate the altitude interval over which the sample was collected. Profile of fig. 17 is plotted for comparison.

Junge et al., 1961

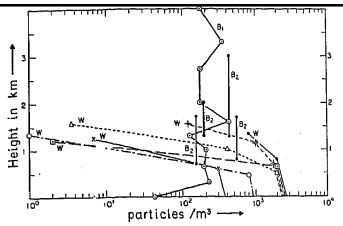


Fig. 4. Vertical distribution of the number of sea salt particles having a dry radius $\geq 3\mu$ (equivalent to a radius of 7 μ at 80 per cent relative humidity and a mass of 5×10^{-10} gr). The curves marked W were measured by Woodcock (1953) in regions of trade winds; the portion of the curve between the ocean surface and the measured values around 0.5 km is assumed. The values show a rapid decrease at the level of the trade wind inversion. The curves marked B are given by Byers (1955). B_1 is an average of three soundings made in Illinois. B_2 are average concentrations for four overland flights southward from Chicago. The length of the bar indicates the altitude range during the flight.

Junge et al., 1961

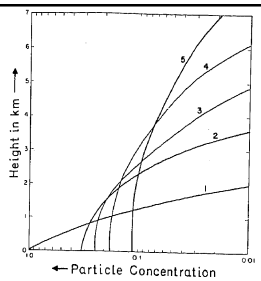


Fig. 6. The change of the vertical distribution of particles by mixing. Curve 1 gives the distribution over the Gulf at time zero. Curves 2 to 5 are calculated distributions at later times under the assumption of a constant eddy diffusion coefficient with height D. The time in hours which corresponds to these curves depends on the assumed value of D:

curve =	1	2	3	4	5	
$D = 8 \times 10^5$ cm²/sec	$t =$ 0	3	6	12	24	hours
$D = 4 \times 10^5$ »	$t =$ 0	6	12	24	48	»
$D = 2 \times 10^5$ »	$t =$ 0	12	24	48	96	»

Junge and Gustaffson, 1957