Chapter 4. Particle Size Statistics

Read:

- Chapter 4
- Handouts

Background:

- Monodisperse (or quasi-monodisperse) size distributions ($D_p \approx$ const.)
  - o useful theoretical construct
  - o applicable to certain synthetic aerosol samples, e.g., latex beads
  - o few natural aerosols, except clouds, perhaps
- Polydisperse size distribution
  - o represents most natural aerosols
  - o often a long tail shows up in distribution, i.e., D_p is not normally distributed around a mean D_p.
- Aerosols often assumed to be spherical; corrections can be made for non-spherical particles, e.g., fibers, cubic crystals.
- Wide range in D_p and in number conc. requires statistical description, e.g., water dimer (2 molecules) 10^{-3} µm to rain drop 10^3 µm (see Fig 1.6, 1.7).
- Simple presentation of "mers" in histogram intellectually appealing, accounting for all matter discretely but it is impractical:
  - o enormous count
  - o impossible to verify by measurement
  - o continually evolving
- Instead, represent amount of matter by D_p range on x-axis. On y-axis use a number concentration to yield an aerosol number distribution where near-infinite # of "mers" is reduced to just 11 bins in the example (Table 4.1; Fig 4:1).
- •Deal with unequal bin widths (often caused by real measurement techniques) by normalizing number concentration for D_p–range, i.e., n (#/cm^3/µm) = ΔN (#/cm^3)/ΔD_p (µm).
- Fig 4.2; note Hinds calls #/cm^3 as "frequency" – not everyone else does.
- As a step to further distilling the information in the size distribution we prepare ourselves for a continuous aerosol number distribution by reducing the bin width from ΔD_p to dD_p. Then an important definition emerges naturally (Seinfeld and Pandis handout):

  dn = # particles/cm^3 in size range D_p to $D_p + dD_p$

  or dn = dN/dD_p (see above)
- Finally, advance from 11 points on n vs. D_p graph to a continuous function that approximates a best fit through some or all of the points using just 2 parameters. In practice, for natural aerosols experience shows two useful functions can be used to represent entire distribution using first two constants.
  1. Junge distribution, also called the power law distribution
  2. $\log_e$ – normal distribution
- Junge distribution

  $n = dN/d(\log D_p) = C/D_p^{\alpha}$ (eq 4.6.2) where C, α = constants to be experimentally determined, e.g., log/log plot yields a st. line with slope $-\alpha$; and C got from value of n at D_p = 1 μm

- Valid only for small D_p – range e.g. 1 = order magnitude.
- Small deviations of straight line approximation from true number distribution greatly magnified when n_N converted to n_S, n_V or n_M. (Wallace & Hobbs, Seinfeld & Pandis handouts)

- Log – normal distribution
  - Assumes that (ln D_p) is normally distributed. Note subtle, but important distinction between a distribution of (ln D_p)'s and a distribution of D_p's plotted on a ln-axis. (see Hinds e.g. 4.41, 4.42)
  - log – normal distribution represented by two constants, σ_g and mean D_p, both of which are obtained easily from a straight line log-probability plot (Fig 4.12; e.g., 4.49 – 4.46)
- Hatch – Choate Equations
  - Often need to convert from number distribution to mass distribution: easily done if it's log–normal. Use Hatch – Choate .eq. 4.47 and Table 4.2

    e.g. mass $\propto D_p^3$, i.e., moment, b = 3

    so, MMD = CMD exp (3 $\ln^2 \sigma_g$)

    CMD = count medium diameter, i.e., D_p where 50% number conc. distribution is above/below.

    MMD = mass median diam., i.e., D_p where 50% of mass conc. distribution is above/below

    σ_g = geometric std. deviation (doesn't change)

    (See Fig 4.15; see worked examples Q 4.1, 4.5