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Eidgenössisches Departement des Innern EDI
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Bundesamt für Meteorologie und Klimatologie MeteoSchweiz
Office fédéral de météorologie et de climatologie MétéoSuisse
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Pollen grain settling velocity

Pollen grain (or aerosol) with diameter D, density ρ_{pollen}.

For typical settling velocities $\sim 1 cm/s$ we have $Re = \frac{\rho_{air} V D}{\mu} \ll 1$.

In this limit, inertial forces are small compared to viscous forces.

We can thus assume the following relation for the drag exerted on the pollen grain: $F_d = f(D, \mu, V)$

Relevant physical quantities F_d, D, μ, V $\quad n = 4$

$[F_d] = ML/T^2$ $\quad [D] = L$ $\quad [\mu] = M/(LT)$ $\quad [V] = L/T$ $\quad K = 3$

$n - K = 1$ dimensionless quantity.

$$\begin{array}{c} \\ L \\ M \\ T \end{array} \overbrace{\begin{array}{cccc} F_d & D & \mu & V \\ 1 & 1 & -1 & 1 \\ 1 & 0 & 1 & 0 \\ -2 & 0 & -1 & -1 \end{array}}^{A} \cdot \overbrace{\begin{pmatrix} V_1 \\ V_2 \\ V_3 \\ V_4 \end{pmatrix}}^{\vec{V}} = 0$$

$$\vec{V} \propto \begin{pmatrix} 1 \\ -1 \\ -1 \\ -1 \end{pmatrix} \qquad \Pi_1 = \frac{F_d}{\mu V D} = Cste$$

For the settling terminal velocity we have $F_{gravity} = F_d$

$$\Rightarrow (\rho_{pollen} - \rho_{air}) \frac{4}{3} \pi R^3 g = Cste \cdot \mu \cdot V_s \cdot D \quad \text{with } R = \frac{D}{2}$$

$$\Rightarrow V_s = \left(\frac{\pi}{6\, Cste}\right) \frac{D^2 g (\rho_{pollen} - \rho_{air})}{\mu} \Rightarrow V_s \propto \frac{g D^2 (\rho_{pollen} - \rho_{air})}{\mu}$$