Gaussian Plume Model and Dispersion Coefficients

Author: John M. Cimbala, Penn State University
Latest revision: 17 February 2020

Procedure to calculate the dispersion coefficients $\sigma_y$ and $\sigma_z$:

1. Determine the Stability Classification of the atmosphere, A, B, ... using Table 1.
2. Determine constants $a, b, ..., f$ using Table 2.
3. Calculate $\sigma_y = ax^2$ and $\sigma_z = cx^2 + f$, with $x$ in units of km and $\sigma_y$ and $\sigma_z$ in units of m.

Gaussian plume model to estimate mass concentration of air pollutant at location $(x, y, z)$:

With ground absorption:

$$c_j = \frac{m_{js}}{2\pi U \sigma_y \sigma_z} \exp \left\{ -\left[ \frac{1}{2} \left( \frac{y}{\sigma_y} \right)^2 + \left( \frac{z-H}{\sigma_z} \right)^2 \right] \right\}$$

where $H = h_s + \delta h$ = effective stack height, $h_s$ is the actual stack height, and $\delta h$ is the additional plume elevation due to buoyancy of the plume.

With ground reflection:

$$c_j = \frac{m_{js}}{2\pi U \sigma_y \sigma_z} \exp \left\{ -\left[ \frac{1}{2} \left( \frac{y}{\sigma_y} \right)^2 + \left( \frac{z-H}{\sigma_z} \right)^2 \right] \right\} + \exp \left\{ -\left[ \frac{1}{2} \left( \frac{y}{\sigma_y} \right)^2 + \left( \frac{z+H}{\sigma_z} \right)^2 \right] \right\}$$