Supplemental Material

Plume detection modeling of a drone-based natural gas leak detection system

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List of Contents:

Gaussian plume model concentration enhancement calculation

We use the Gaussian plume model concentration enhancement (C) as a detection predictor where

$$C = \frac{Q_s}{u\sigma_z\sigma_y 2\pi} e^{-y_s^2/2\sigma_y^2}\left(e^{-(z_s-H_s)^2/2\sigma_z^2} + e^{-(z_s+H_s)^2/2\sigma_z^2}\right) \quad (1)$$

where Q_s is the emissions rate of the source (g s^{-1}), u is the wind speed at source (m s^{-1}), σ_z and σ_z are the standard deviations of expected plume diffusion in the z and y dimensions, and H_s is the source elevation. Note that the concentration returned for a source if the $x_s < 0$ (the receptor is upwind of the source location) is defined as 0.0. For the purposes here, we consider the terrain flat, which is simpler than modeling the airflow in 3D. This is a reasonable assumption for our study site, which is flat. Similarly, we assume that the leak location is at ground level and not subject to any lofting. The standard deviation of crossplume dispersion is modeled with the Briggs scheme for rural terrain where

$$\sigma_y = \frac{0.08x_s}{\sqrt{1+0.0001x_s}} \quad (2a)$$

$$\sigma_z = \frac{0.06x_s}{\sqrt{1+0.0015x_s}} \quad (2b)$$

where the constants are defined for the stability class D. All our experiments here were in conditions with stability class D. The Gaussian plume model concentration enhancement at the maximum concentration anomaly in each discretized plume is reported. The Gaussian plume model concentration enhancement is used here not as an estimate of concentration enhancement, but rather as a detection predictor for the location and conditions - we do not expect concentration enhancements to match these predictions.