Atmospheric Dispersion Modelling for Odour Impact: Practices, Issues & Recommendations

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Odour Dispersion Modelling

1. Objectives of dispersion modelling
2. Types of air models
3. Conventions and considerations
4. Limitations
5. Conclusions and Recommendations
1. Objectives of Air Dispersion Modelling
On structure: More dispersion and descent
Off structure: Less dispersion, little descent
Air Dispersion Modelling: Definition & Objective

Objective: to predict how odour sources impact the surrounding environment

- Practical
- Cost-effective
- Repeatable
- Accurate!
When Do We Use Air Models?

- Regulatory - compliance with contaminant criteria
- Engineering - viable control and mitigation
- Health - risk estimates
- Ecological - effects on soils & vegetation
2. Types of Air Models
Air Modelling Hierarchy

1. Look-up tables / Monitored Values
2. Gaussian Screening Models
3. Refined Gaussian Models ✓
4. Refined Numerical / Lagrangian Models
Air Modelling Workhorses

> SCREEN3, AERSCREEN (Gaussian)

> AERMOD (Refined Gaussian) ✓

> CALPUFF (Lagrangian Puff Model)
AERMOD

- Preferred model by US-EPA
  - Frequently updated
- Public domain
- Variety of complex inputs
  - Building physics, meteorology, terrain, receptor grids
- Used throughout North America
- Supported by many regulatory authorities
  - Preprocessed MET data for AERMOD sometimes provided
  - Guidance documents
AERMOD inputs

- Building dimensions/stack locations
- Terrain data
- Receptor locations
- Source locations
  - Upper air observations
  - NWS surface data
  - Site-specific surface data (if applicable)

**BPIPRIME**
- Projected building dimensions
- Receptor locations with elevations
- Source locations with elevations

**AERMAP**

**AERMOD**
- Background concentrations
- Emissions
- Design values and/or appropriate metrics to determine compliance

**AERMET**
- Profile and surface files
- Surface characteristics
- Hourly averaged winds

**AERSURFACE**
- 1992 National Land Cover data

**AERMINUTE**
- 1-minute ASOS data

* AERMOD Implementation Guide recommends plant survey results for source elevations

03/14/2012
U.S. Environmental Protection Agency
Concentration Isopleths
Gaussian Dispersion Equation

Ambient concentration is a function of emissions, downwind, lateral, and relative vertical distance from the source, cross-wise distance from the flow direction, wind speed, and PGT stability class.

\[
C = \frac{Q}{2\pi u \sigma_y \sigma_z} \exp\left(-\frac{1}{2} \frac{y}{\sigma_y}\right) \exp\left(-\frac{1}{2} \frac{z-H}{\sigma_z}\right) + \exp\left(-\frac{1}{2} \frac{z+H}{\sigma_z}\right)
\]

x-axis - Alongwind; y-axis - Crosswind; z-axis - Vertical

Parameters:

- \( C \) = Concentration (\( \mu g/m^3 \))
- \( Q \) = Emission Rate (g/s)
- \( u \) = Stack-top wind speed (m/s)
- \( \sigma_y \) = Crosswind dispersion coefficient (m)
- \( \sigma_z \) = Vertical dispersion coeff.(m)
- \( y \) = Crosswind distance (m)
- \( z \) = Above-ground height (m)
- \( H \) = Effective plume height (m)
Gaussian Modelling Coordinate System
3. Conventions and Considerations for Odour
Model Inputs

1. Scaled site plan: sources, structures, and property boundary
2. Modelling domain and receptor locations
3. Characteristics of direct and fugitive sources
4. Building data
5. Representative processed meteorological data
6. Processed terrain data
Source Characterization

- Point
- Area
- Volume
Protocols Specific to Odour

- Distinct odors are modelled separately since distinct odors are not additive

- Odour Units (OU)- treated as OU/m³ by convention for the model

- Time average should reflect short-term acute impacts (e.g. 5-min, 10-min)

- Scaling factor must be adjusted to 1
  - default set to 1,000,000 (g/s $\rightarrow$ ug/m³)
Time Averaging Period

> Ontario prescribes:

\[ C_1 = C_0 \times \left( \frac{t_0}{t_1} \right)^n \]

where \( n = 0.28 \)

Ex: 10 \( \mu g/ m^3 \) 1-hr converted to 30-mins:

\[ C_1 = 10 \times \left( \frac{1}{0.5} \right)^{0.28} \]

\[ C_1 = 12.14 \ \mu g/m^3 \]
Sample Wind Rose
Maximum Odour Concentrations

Maximum impact occurs on Jan 26, hour 8; WS = 0.57 m/s (1.3 mph) just before the morning inversion broke.
4. Limitations
AERMOD Problems with Low Wind Speed

> AERMOD algorithm currently over-predicts concentrations under low wind conditions

> US-EPA has proposed LowWind3 option to be incorporated in regulatory version
  ❖ “non-Default” BETA option

> LowWind3 increases minimum value of sigma-v from 0.2 to 0.3 m/s and uses ‘effective’ sigma-y value
Steady State Assumptions

- AERMOD relies on 1-hour averaged data
  - assumes steady state (no change) over each 1-hour period

- Odour can fluctuate within this period

- No accounting for degradation in the presence of light and oxygen
MET Data & Surface Characteristics
Input Data Limitations

- The model output relies heavily on the source data input and knowledge of the exhaust parameters
- Odour emission factors are limited to non-existent
- Source testing and panel evaluation is the best option
5. Conclusions and Recommendations
Conclusions & Recommendations

- AERMOD recommended for North American odour studies
- Frequency analysis
- Consider using BETA options for non-regulatory study
- Obtain source data from quality stack testing programs and odour panel evaluation
- Reduce time average periods accordingly
Modelling Resources

> U.S. EPA Support Center for Regulatory Air Models (SCRAM)
  www.epa.gov/ttn/scram/
  ❖ Modeling Guidelines
  ❖ Model Codes and User’s Guides
  ❖ Conference Proceedings & Technical Reports

> Ontario: Guideline A-11 Air Dispersion Modelling Guideline for Ontario
Questions?

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