Modelling odours in ADMS 5

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Introduction

- We can recognise/distinguish thousands of different smells (around 10,000)
- But we're not very good at describing them
  - Don't have names for different smells (cf. colours)
- We tend to prefer scents that we can identify correctly
- We have around 5 million olfactory receptor neurons
  - Rabbits have around 100 million
  - Dogs have around 220 million
- Our olfactory receptors are directly connected to the most ancient and primitive part of the brain
  - Linked to emotions, memories
- We can respond to odour over a 1 to 5 second interval (a single breath)

Odour Guidance - general

- IAQM – Guidance on the assessment of odour for planning (2014)
  - Not intended for regulatory purposes
- Environment Agency – H4 guidance (2011)
  - For permitting purposes
- SEPA – Odour guidance (2010)
  - Note: this is labelled as internal guidance
- Defra – Odour guidance for Local Authorities (2010)
  - designed primarily for use by Environmental Health Practitioners
  - should also be useful to other local authority professionals, regulators and industry professionals who are engaged in any of the following: preventing, investigating and managing odours

Odour guidance: Specific sectors

- Good Practice and Regulatory Guidance on Composting and Odour Control for Local Authorities (2009)
- Code of Practice on Odour Nuisance from Sewage Treatment Works (2006)
- Defra - Guidance on the control of odour and noise from commercial kitchen exhaust systems (2005)

Factors that affect the impact of odours: FIDOL

- A framework for assessing the impact of odours

- **F**requency
- **I**ntensity
- **D**uration
- **O**dour unpleasantness / **O**ffensiveness
- **L**ocation

(Sometimes FIDOR, where R = receptor sensitivity)

- These are important concepts to bear in mind when modelling odour and interpreting the results of odour modelling
- Will go through each of these in turn...

FIDOL: Frequency

- "Frequency of detection" - H4 guidance
- "How often an individual is exposed to odour" – IAQM guidance
- Olfactory fatigue / adaptation:
  - An individual can get 'used to' the odour - unable to detect the odour after a certain period
  - But if odour has an on/off/on pattern, this is disrupted
- Modelling/assessment implications:
  - Averaging time, peak-to-mean concentrations
  - Fluctuations module in ADMS could be used to investigate this
  - But the UK modelling criterion for odour assessments is prescribed:
    - 98th percentile of hourly average concentrations
      - 2% of the hours in a year (175 hours) can exceed the threshold in question

FIDOL: Intensity

- The strength of the odour
- More specifically, the *perception* of the strength of the odour
  - The relationship between a stimulus and the perceived strength is not necessarily linear (smell, noise, brightness, etc), e.g. Steven's power law
  - "The intensity of an odour is a logarithmic function of its concentration." - H4 guidance

- Modelling / assessment implications:
  - The magnitude of the emission rates is key
  - Output concentrations
  - Contour plots

FIDOL: Duration

- Exposure duration
  - Hourly / daily / seasonal patterns of exposure
  - Length of particular odour ‘episode’

- Modelling/assessment implications:
  - Related to ‘frequency’
  - Hours of operation of process
  - Use of time-varying files in ADMS
    - Vary emission rates only (.fac file)
    - Vary emission parameters and emission rates (.var file)

FIDOL: Offensiveness / Odour unpleasantness

- Mixture of the character and the hedonic tone
- The character is the description, e.g. ‘fishy’, ‘sweet’
- The hedonic tone is the ‘acceptability’
  - Is it pleasant or unpleasant?
  - Landfill *vs* baking bread

- Modelling/assessment implications:
  - What thresholds to compare model output against?
- H4 Benchmark levels:
  - 1.5 ou_E for most offensive odours
  - 3 ou_E for moderately offensive odours
  - 6 ou_E for less offensive odours

Which bracket does my source come under?

FIDOL: Offensiveness / Odour unpleasantness

- H4 guidance:
  - Most offensive
    - processes involving decaying animal or fish remains
    - processes involving septic effluent or sludge
    - biological landfill odours
  - Moderately offensive
    - intensive livestock rearing
    - fat frying (food processing)
    - sugar beet processing
    - well-aerated green waste composting
  - Less offensive
    - brewery
    - confectionery
    - coffee roasting
    - bakery

H4: *"Most odours from the processes we regulate fall into [the 'moderately offensive'] category"*

FIDOL: Location

- The nature of the surrounding area and sensitivity of nearby receptors
- Sensitivity of individuals: people have different detection thresholds
  - "Statutory nuisance uses the concept of the response of the average, reasonable person" – Defra guidance
- What is the land use of the surrounding area?
  - Residential *vs* industrial
  - Urban *vs* rural
- Modelling implications:
  - Careful selection of sensitive receptors
  - Contour plots

FIDOL: Location

- IAQM guidance (summary of table 2):

Receptor sensitivity	Surrounding land where:	Examples
High	Users can expect enjoyment of a high level of amenity Users present continuously/regularly for extended periods	Residential Hospitals Schools Tourism
Medium	Users can expect reasonable enjoyment of a high level of amenity Users not present continuously/regularly for extended periods	Workplaces Commercial/retail Playing fields
Low	The enjoyment of amenity not reasonably expected Transient exposure	Industrial Farms Footpaths Roads

Combining FIDOL factors

- Example - IAQM guidance (summary of table 2):

Location

Table 6: Proposed odour effect descriptors for impacts predicted by modelling

Odour Exposure Level C_{98}, ou_E/m^3	Receptor Sensitivity		
	Low	Medium	High
≥10	Moderate	Substantial	Substantial
5-<10	Moderate	Moderate	Substantial
3-<5	Slight	Moderate	Moderate
1.5-<3	Negligible	Slight	Moderate
0.5-<1.5	Negligible	Negligible	Slight
<0.5	Negligible	Negligible	Negligible

When compiling this table, it has been assumed, on a conservative basis that the odour in question is at the offensive end of the spectrum.

Frequency

Duration

Intensity

Offensiveness

Complicating factors - odour

- Often complex mixtures of compounds
  - Difficult to measure
  - Synergistic effects – impact greater than the sum of its parts
  - Masking effects - impact less than the sum of its parts

- Subjective - what constitutes a ‘nuisance’?

- Sources are often complex
  - Different types of sources
  - Often fugitive
  - Often transient

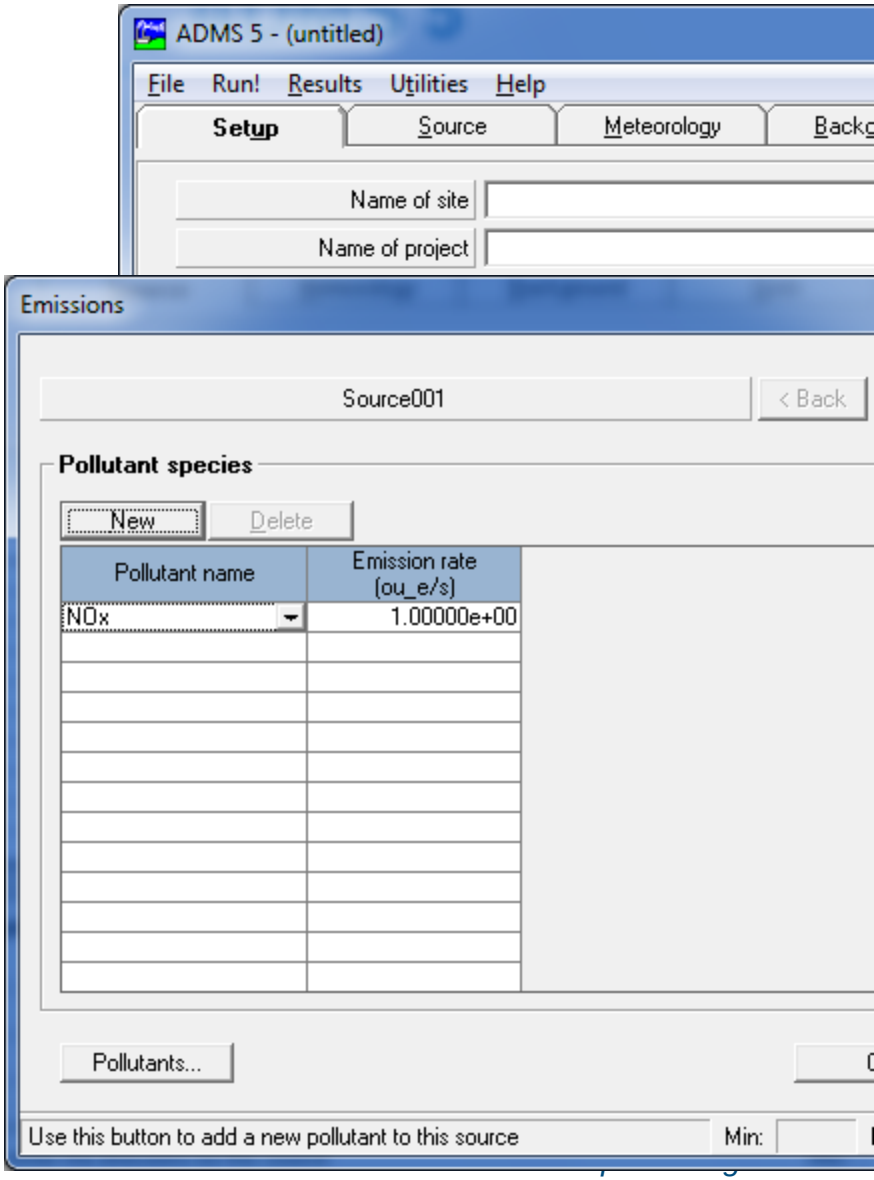
- Can be challenging to model...

Why use dispersion modelling?

- Ambient odours are difficult to measure
  - Human nose is highly effective at measuring odour
  - Sensitive, fast and can distinguish a wide range of compounds
  - Olfactometry is an important tool in odour assessment
    - Air samples ‘measured’ by a panel of selected human assessors
  - But olfactometry is used for determining odour emissions, not ambient concentrations
  - Direct measurements cannot usually be made at receptor locations – concentrations too low
  - ‘Electronic noses’ – improving technology but still not widely used
- Useful at the planning and permitting stage of potentially odourous processes - the source is not yet present
- Can investigate possible mitigation measures – abatement, etc

Modelling odours

- Simply switch on ‘Odours’ under Model Options
- Changes the units used throughout the model interface



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Modelling odours

- In ADMS, there are two options for units when the Odours module is used: ‘ou_e’ and ‘ou’
- The ‘ou_e’ is the CEN Standard European Odour Unit, ou_E
  - mass based
  - commonly used
- ou_E is simply a mass unit
- Could carry out the same model run using g/s as input and g/m^3 as output

- (The other option in ADMS, ‘ou’, is an older, volume based, type of unit, now rarely used)

Modelling odours

- Not all odour modelling is about complex mixtures and ou_E values
- Some processes involve a single (or a single dominant) compound, so ou_E not required, e.g:
  - Industrial processes
  - Paint spraying
  - Hydrogen sulphide as a marker compound for Waste Water Treatment processes
- Usually simply use g/s and g/m^3 in these situations
- Specific compounds will have specific odour detection threshold values

Modelling challenges and uncertainties

- Defining source terms can be challenging:
  - Emission rates and parameters
    - Are they representative?
    - Do they represent a ‘snapshot’?
  - Temporal profiles
    - Are these predictable?
    - e.g. site only operational during the day
- Can have many sources of odour on a site, with different characteristics
- e.g. waste water treatment plants:
  - Point / area / volume sources
  - Different emission rate
- Sensitivity tests

Meteorological data

- Met data – run several years to cover variability
- “At least three, preferably five” – H4 guidance
- IAQM guidance recommends five

- Much discussion of the occurrence of odour episodes during periods of low wind speeds - calm conditions
  - In ADMS 5, hours with wind speed (at 10m) less than 0.75m/s are not modelled
  - The .log file tells you how many hours represent calm conditions:

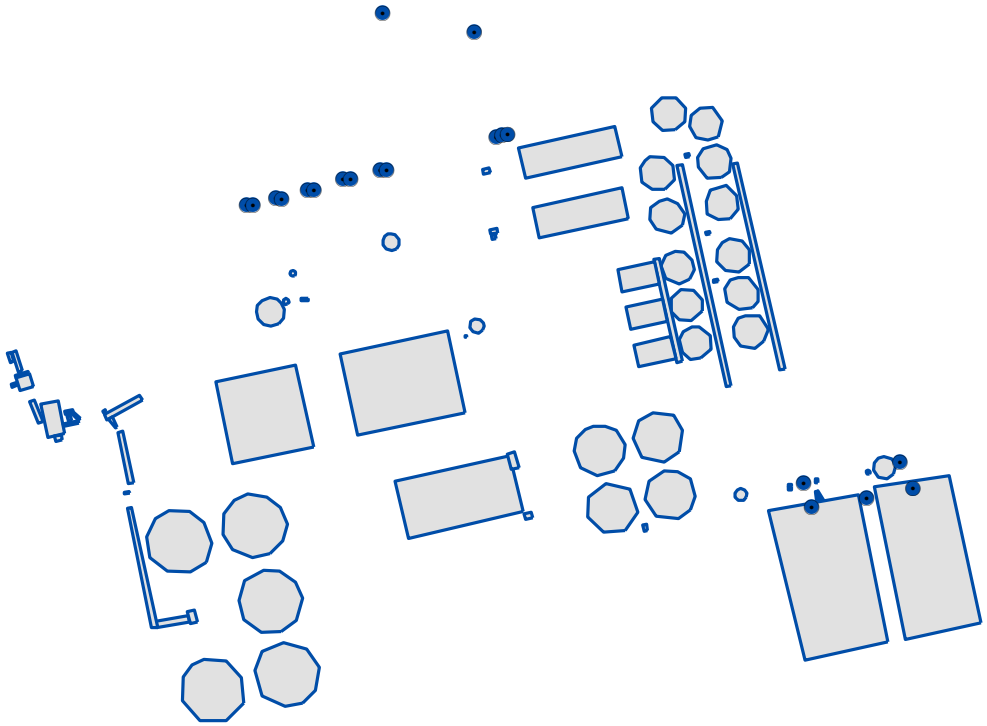
```
SUMMARY OF MET DATA:

INFO   : Number of met lines used =  8695
INFO   : Number of met lines with calm conditions =    15
INFO   : Number of met lines with inadequate data =    50
```

  - Consider using the ‘calms’ option in ADMS
  - Accounts for the variable wind direction during calm conditions

Modelling odour: source types

- Point sources
  - Stacks
  - Vents
- Area sources
  - Settlement tanks
  - Sludge storage areas
  - Landfill sites
- Volume sources
  - Fugitive emissions from buildings
    - Through building fabric or through several vents/windows/doors



Tips: Modelling area sources with buildings

- Modelling area sources without building effects is fine
- You can't model the effect of buildings on area sources
- If the sources are on the building itself, consider using a volume source
- If you want to consider the effect of nearby buildings on an area source:
  - Model the area source as an array of point sources
  - There is a Helpdesk note on this
  - There are two competing factors to consider when determining the best representation of the area source:
    a) Near source configuration, and concentration distribution
    b) Plume rise behaviour
  - Generally, for passive or low plume rise cases, focus on (a)
  - For high plume rise cases, focus on (b)

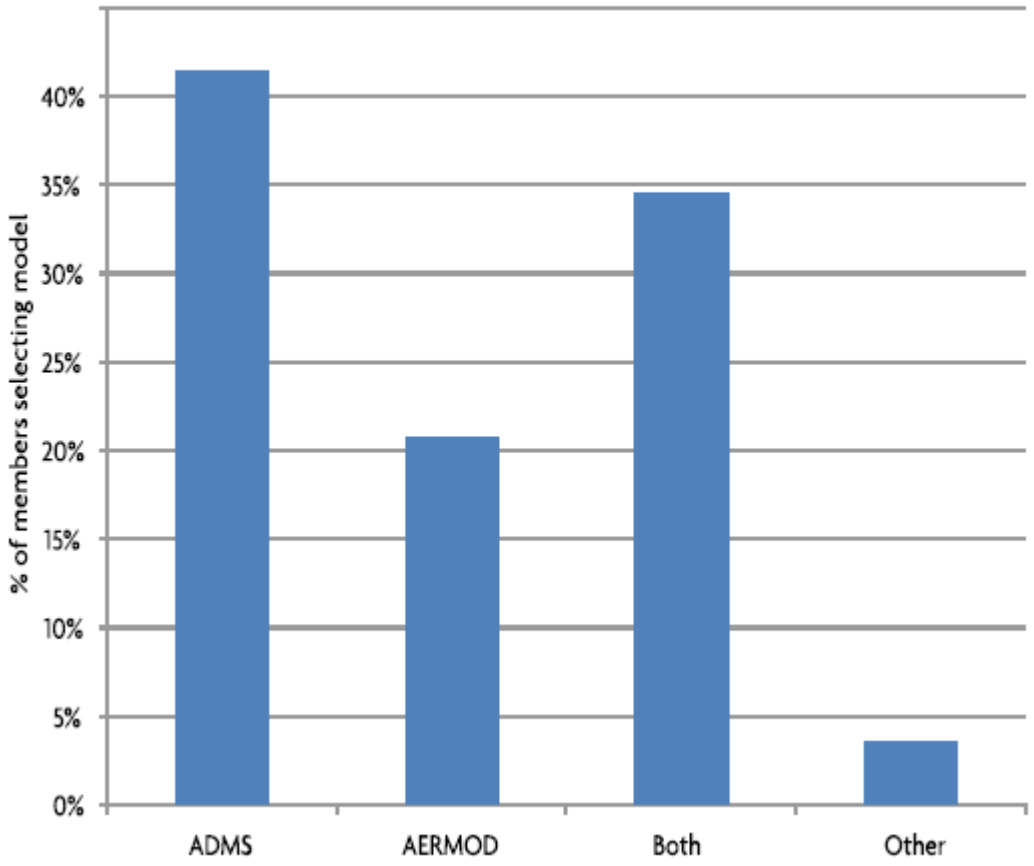
Tips: Modelling low velocity releases

- Many sources of odour have very low efflux rates
- Low velocity / volume flow rate
- Fugitive emissions, emission from tanks etc
- To ensure that buoyancy effects are taken into account, make sure that the velocity is not set to zero
- Use a very small value instead, e.g. 0.2m/s
- If the release is at ambient conditions, set the temperature to be ‘ambient’ in the source table
  - Will pick up the temperature values from the .met file

Tips: Modelling odour with AERMOD code

- IAQM guidance:
- “In a recent survey in preparation for this guidance, members were asked which model they would select for an odour assessment”
- “Odour assessments are almost exclusively undertaken in the UK using the AERMOD or ADMS models”

Figure 3: Percentage of IAQM members selecting each dispersion model option.



Tips: Modelling odour with AERMOD code

- Can't use odour units when running AERMOD in ADMS
- As mentioned previously, ou_E are just mass units, so can simply use g/s as input and g/m^3 as output ('odours' module switched off)

- AERMOD has prescriptive limits on emission rate values
  - Values measured in OU_E are often very large
  - Sometimes values of odour units can be outside the AERMOD permitted range
  - ADMS will give an error message: "ConvertAERMODOutput: Problem reading AERMOD Period file."
  - A solution is to divide the emission rates by a certain factor such as 1000 (and remember to convert the output concentrations back!)

Thank you for listening

Any questions?