Emergency Response and Plume Modelling at the Met Office

Helen Webster

Outline of Presentation

Meteorology and dispersion

Emergency-response activities

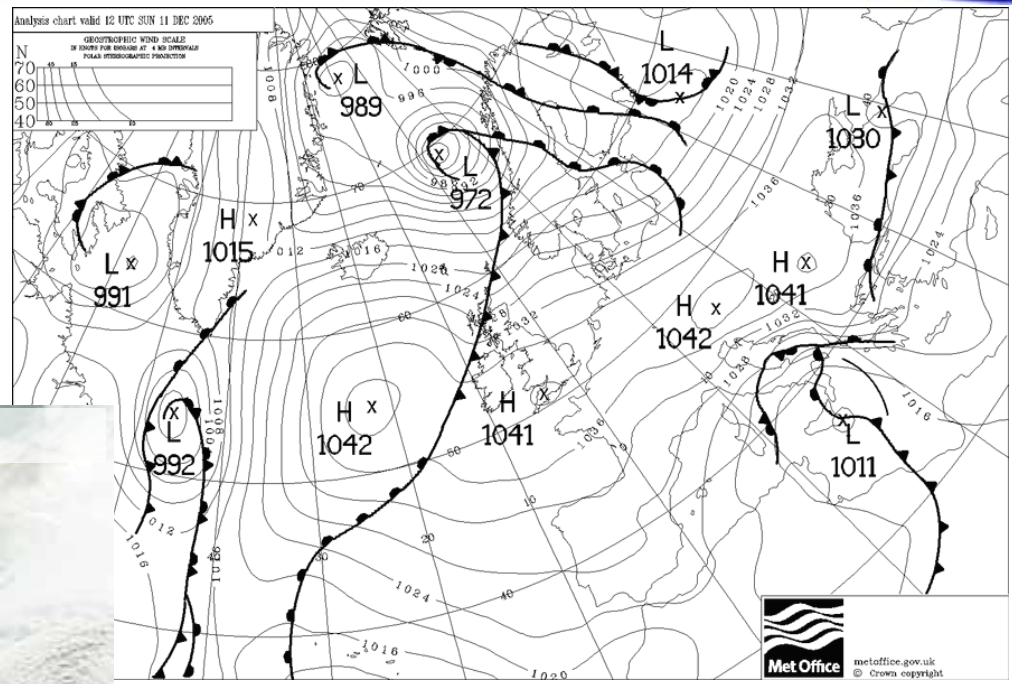
Post-event analysis

Conclusions

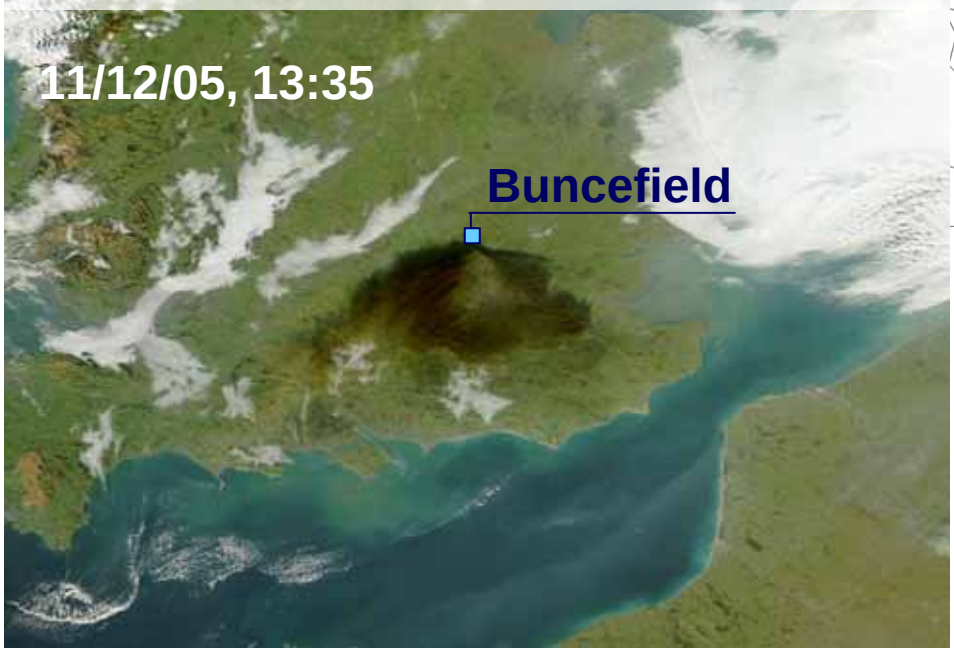
Meteorology and Dispersion

Meteorological situation – 12:00 11/12/05

- Winter anticyclonic conditions
- Light winds
- Stable atmosphere



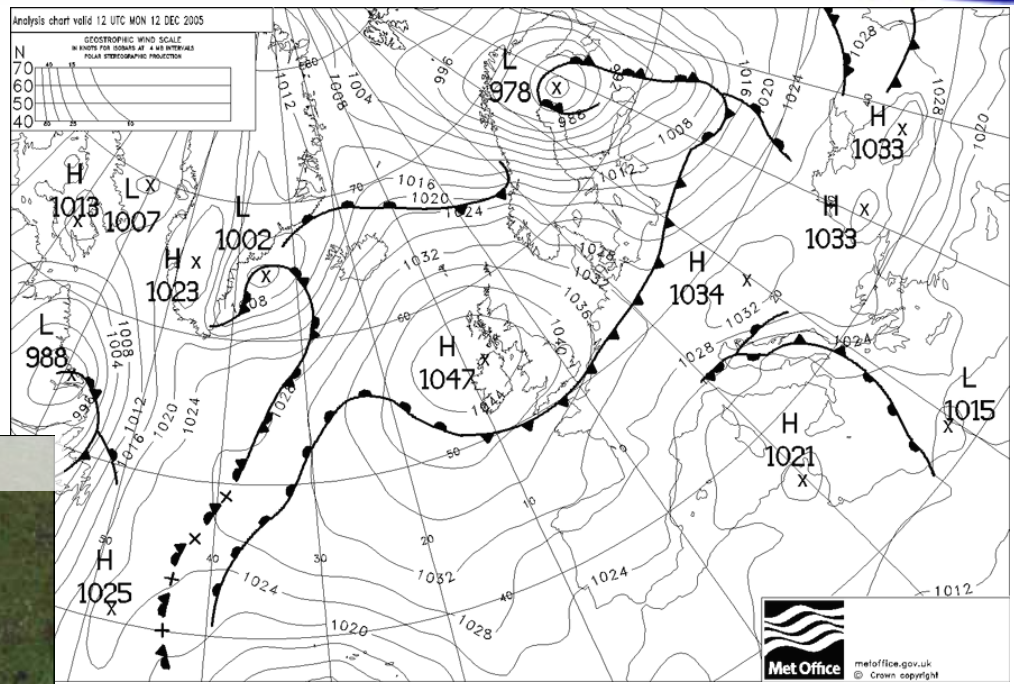
Imagery from MODIS instrument on the NASA AQUA platform



- Plume rises to ~ 3km
- Significant vertical wind shear
  → fan-like plume

Meteorological situation – 12:00 12/12/05

- High pressure continuing to dominate
- Weak front passed through
- Then a north-easterly wind at all levels



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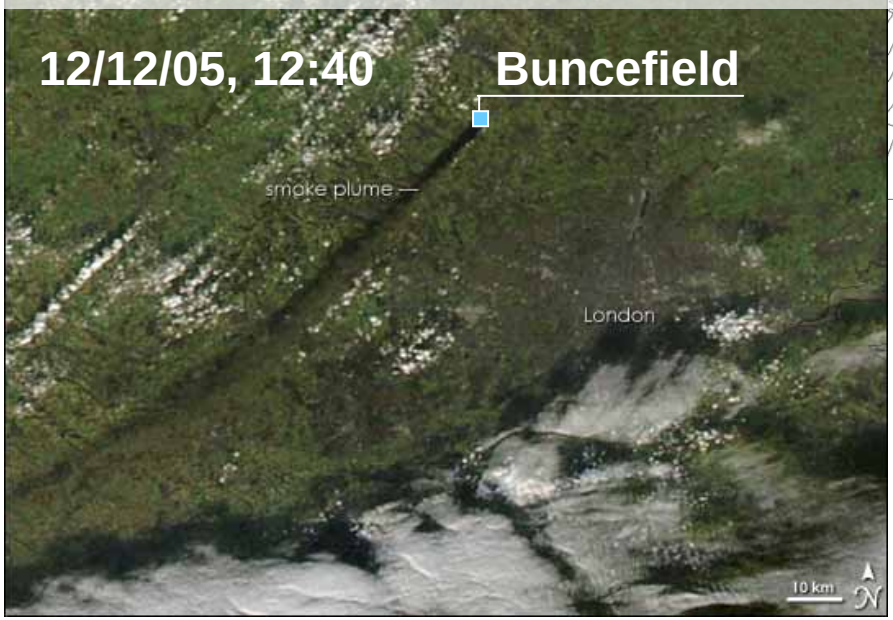
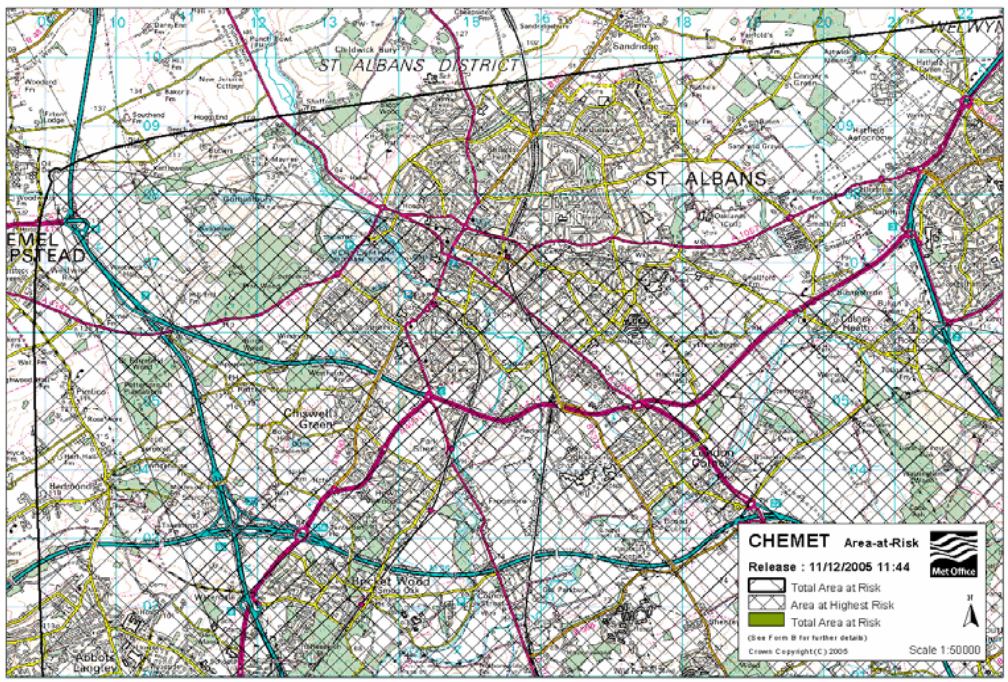


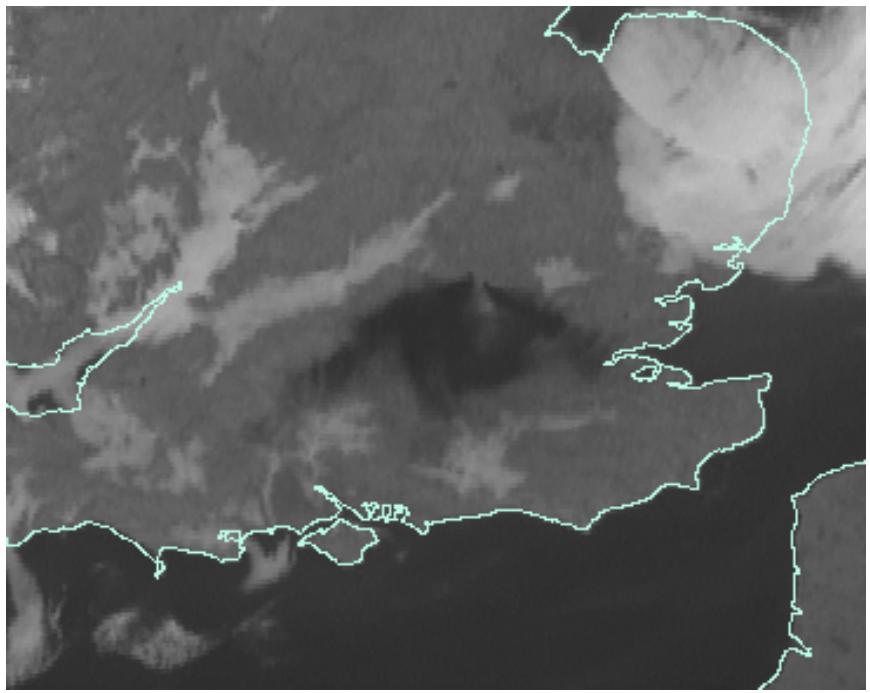
- Narrow plume transported south-westwards towards Southampton and Weymouth

Emergency-Response Activities

EMARC response

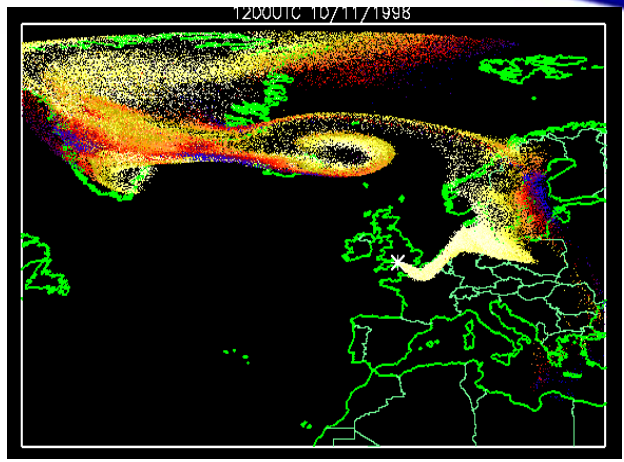
- EMARC informed 07:30UTC Sunday 11 Dec
- Initial response:
  - CHEMET “Area-at-Risk” to east and south
- During incident issued:
  - CHEMETs
  - NAME products
  - Weather briefings
  - Satellite imagery

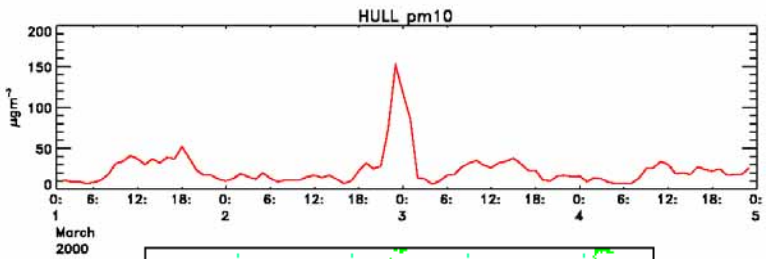


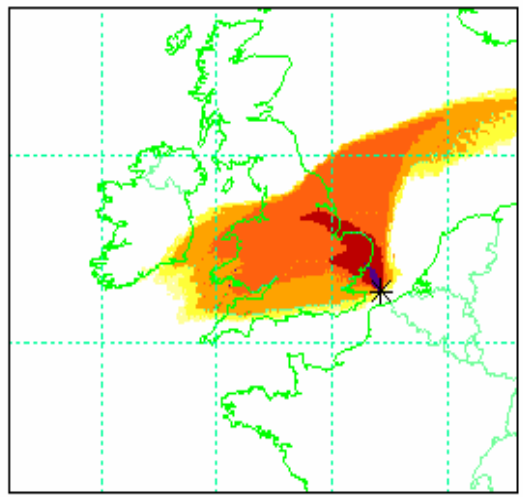


Met Office dispersion model NAME

- Lagrangian particle model
- Driven by 3-D met fields from the Met Office operational NWP model (12km UK mesoscale version)
- Predicts air concentration, dosage, surface deposition
- For ranges from 1km to global
- Latest version (NAME III) has puff scheme for short-range applications



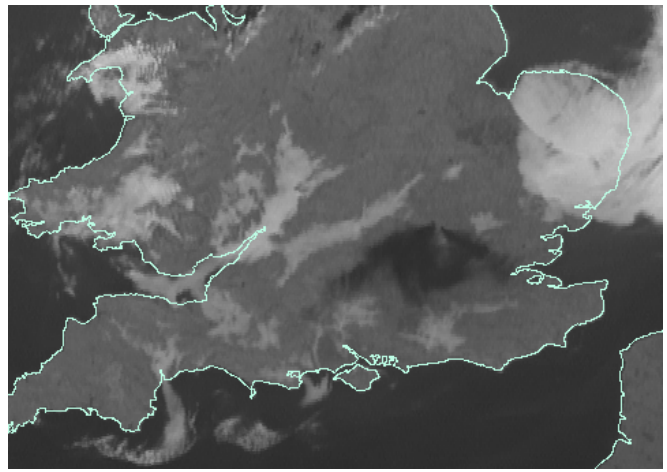




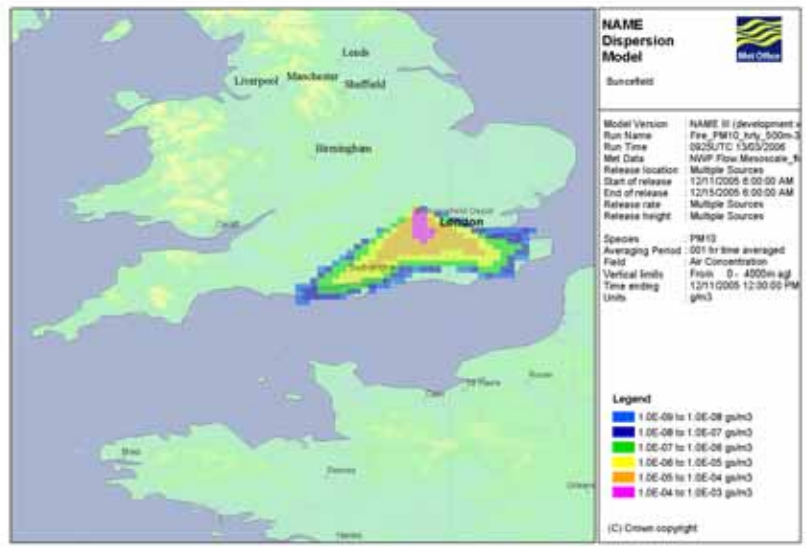
NAME modelling

- Uncertainties
  - Source / release details
    - Composition
    - Quantity of material
    - Plume rise
- Initial modelling
  - Unit release of tracer
  - Utilising pilot report and satellite imagery to best estimate plume height
  - Simple elevated source

MSG 12:00UTC 11 Dec



NAME 12:00UTC 11 Dec



Post-Event Analysis

Further NAME modelling

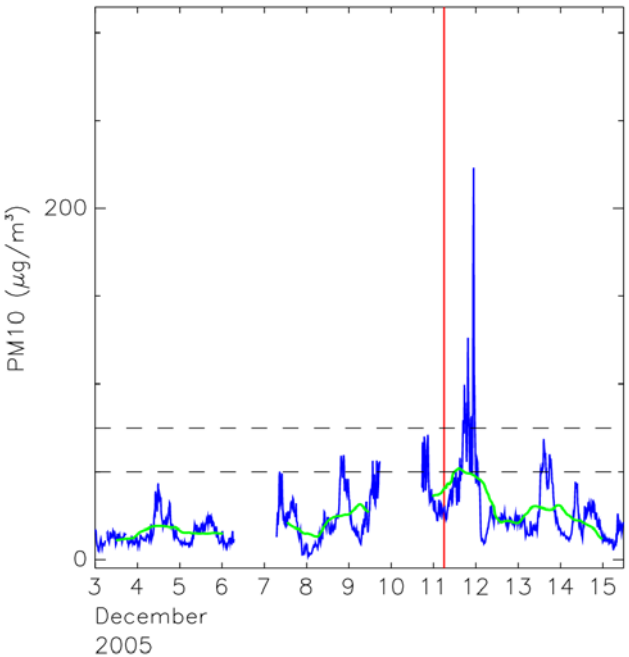
Refined NAME modelling has incorporated

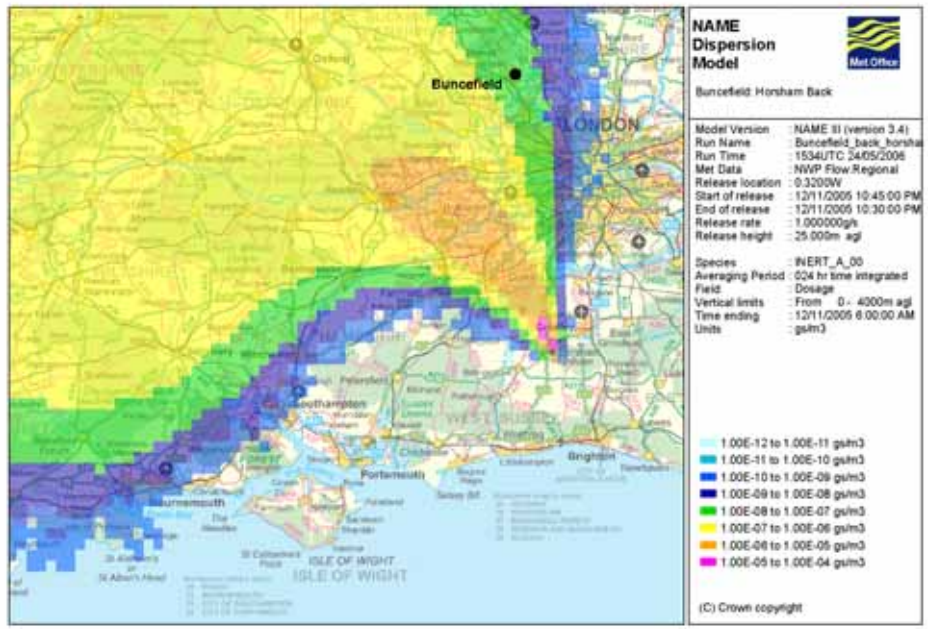
- Plume observations
- Emission estimates
  - Rates (~50 kg/s PM_{10}?)
  - Pollutants
  - Time variation
- Air quality measurements
- Plume rise
  - Plume temperature
  - Heat flux

Understanding observations - Air history maps

PM_{10} measurements at Horsham

Courtesy of King's Environmental Research Group





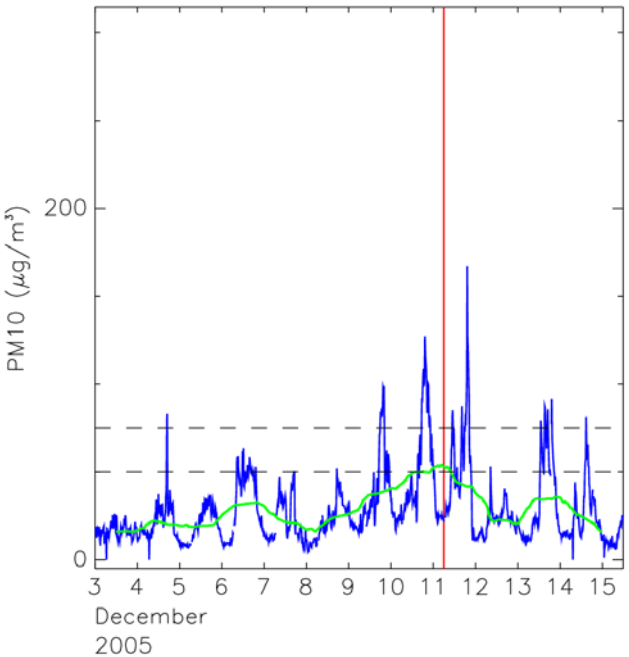
15-minute mean PM_{10} concentrations

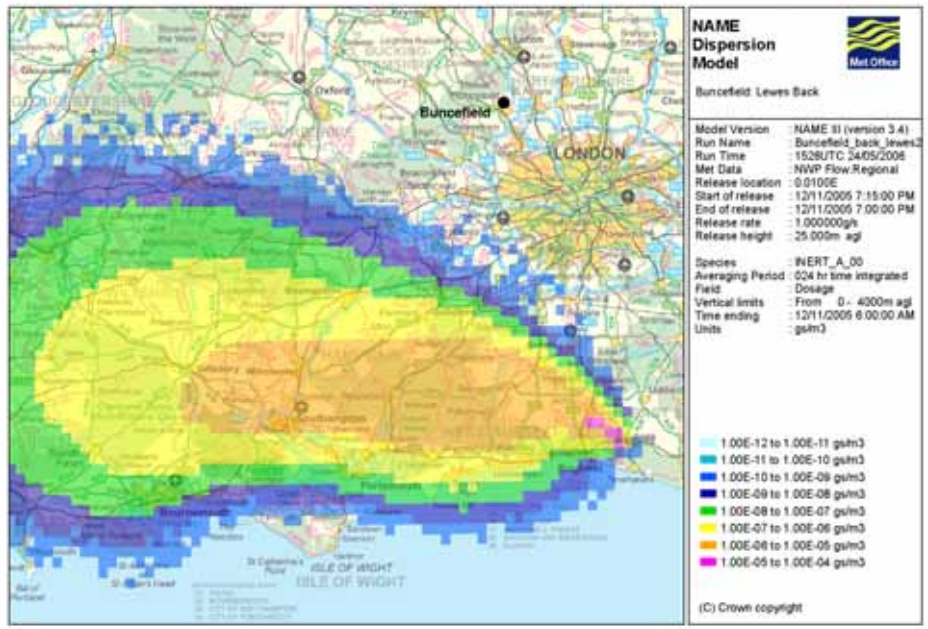
24-hourly mean PM_{10} concentrations

Understanding observations – Air history maps

PM_{10} measurements at Lewes

Courtesy of King's Environmental Research Group





15-minute mean PM_{10} concentrations

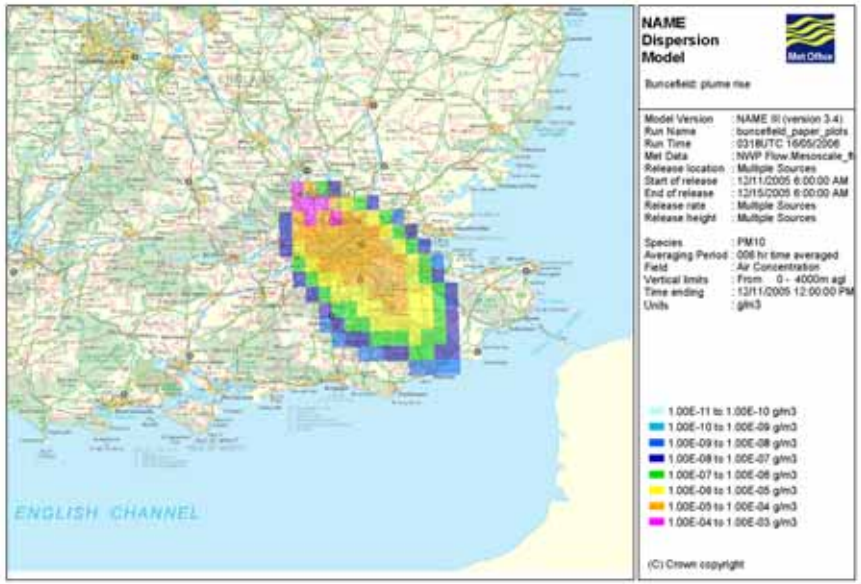
24-hourly mean PM_{10} concentrations

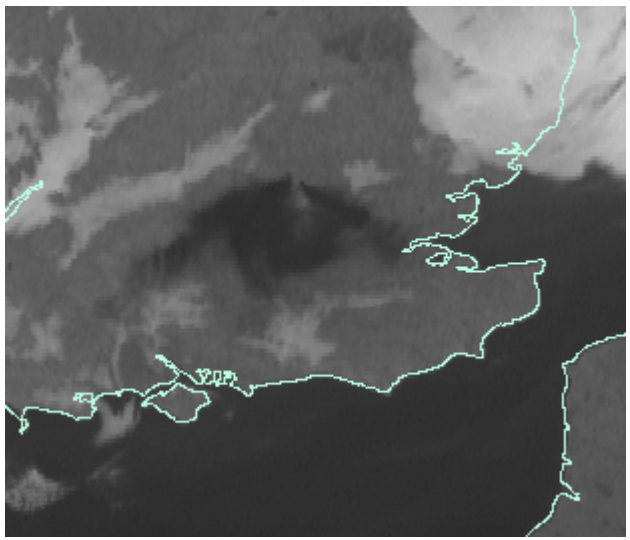
“What if?” scenarios

We were very lucky!

- Meteorological conditions affect
  - Height plume rises to
  - Mixing of plume with ambient air
  - Ground level concentrations
  - Pooling of flammable material prior to explosion
- To model the Buncefield incident in different meteorological conditions
  - Plume rise scheme
    - Heat flux estimates
    - Plume radius, emission temperature and velocity

Plume rise modelling



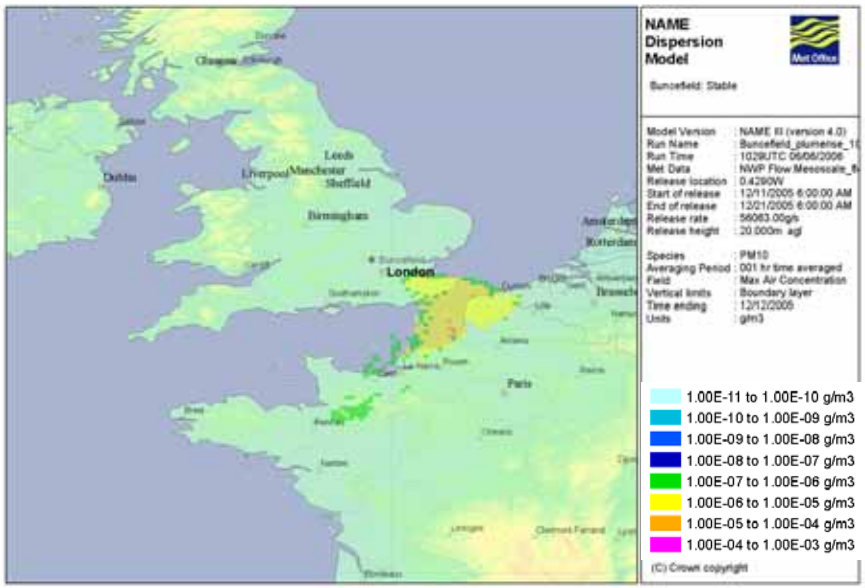


- Maximum height of the plume too low
- Insufficient vertical spread of the plume

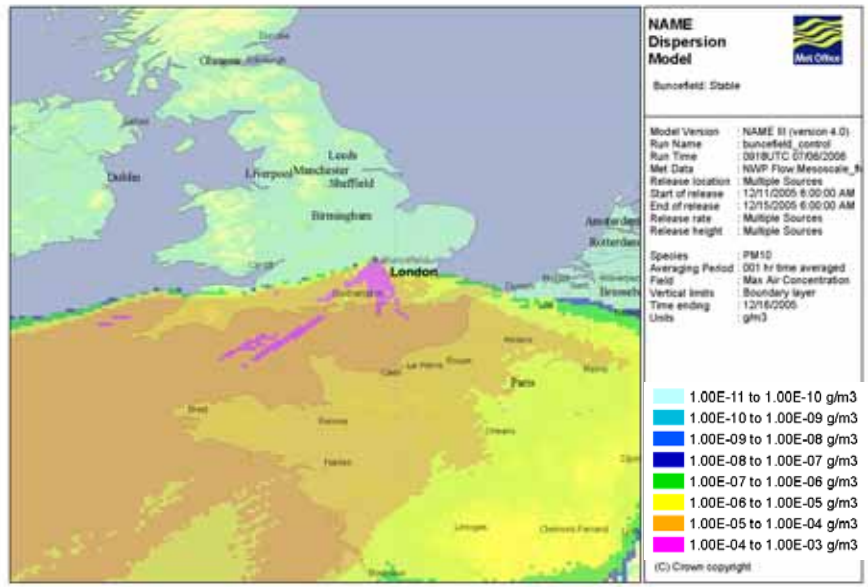
- Why?
  - Release of latent heat
  - Lofting of the plume
  - Complex source
  - Inaccurate meteorological representation

Favourable conditions on Sunday

Sunday 11th December



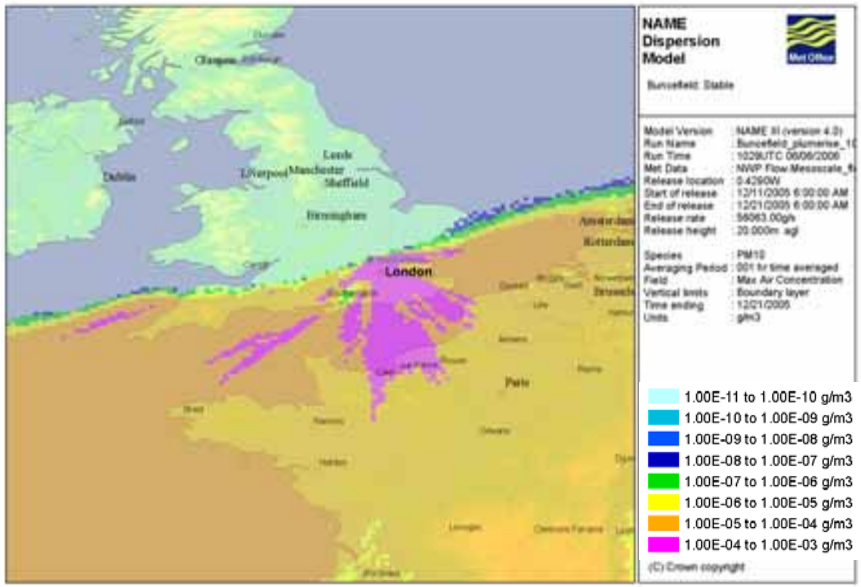
During event



Maximum hourly averaged PM_{10} concentrations

Let it burn?

Burning uncontrolled for 7 – 10 days



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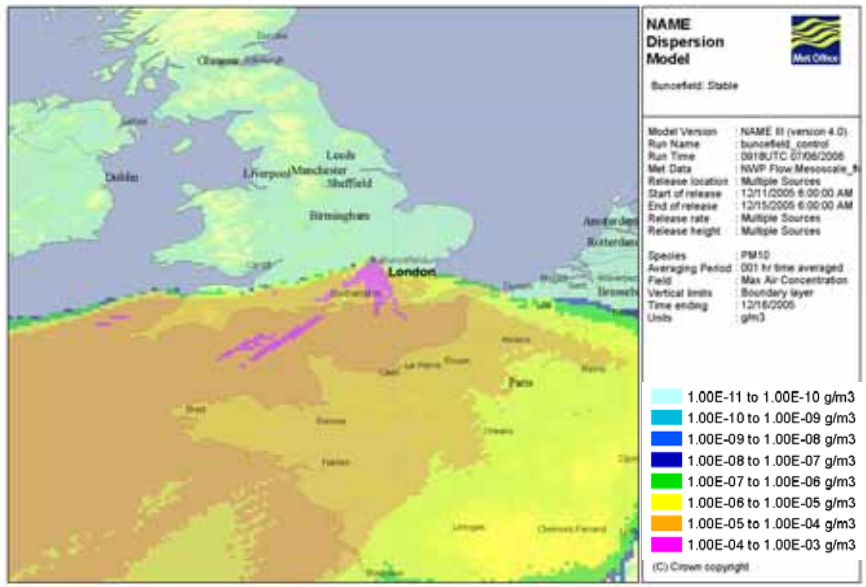
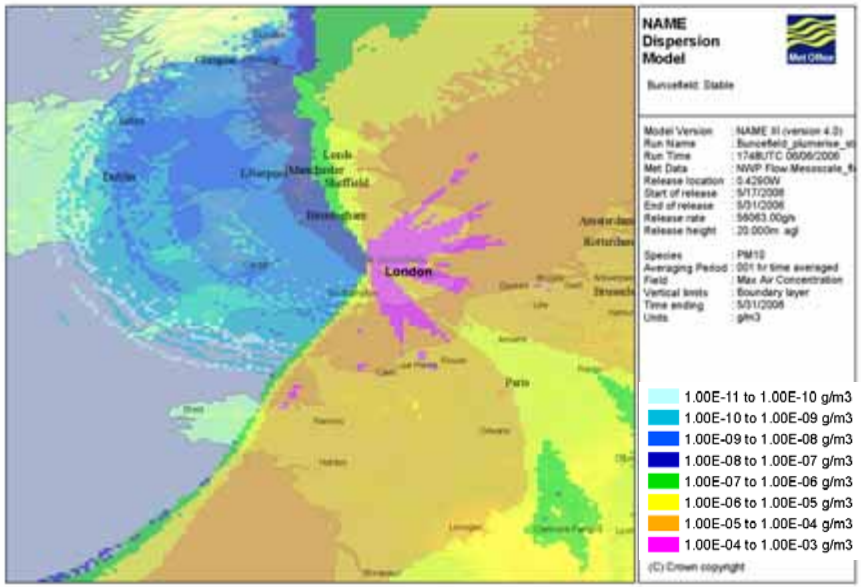


Maximum hourly averaged PM_{10} concentrations

Strong winds

Windy conditions



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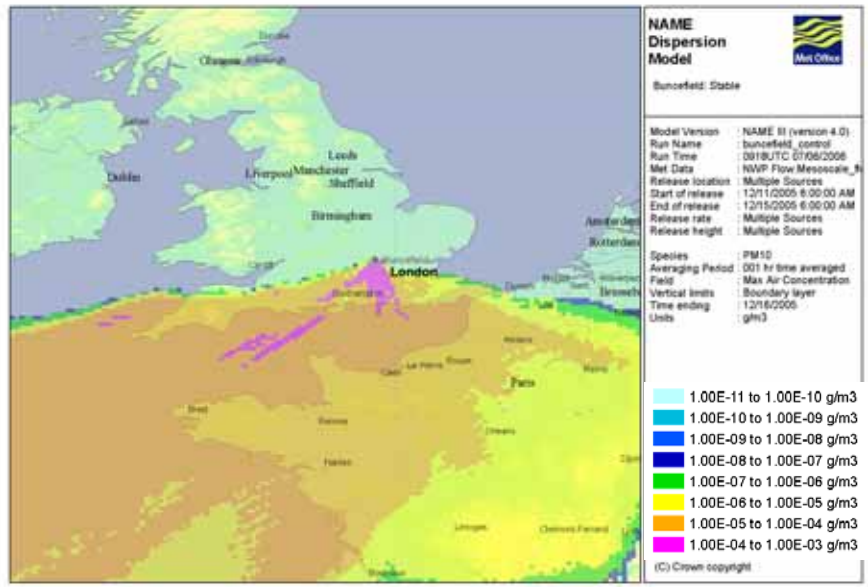
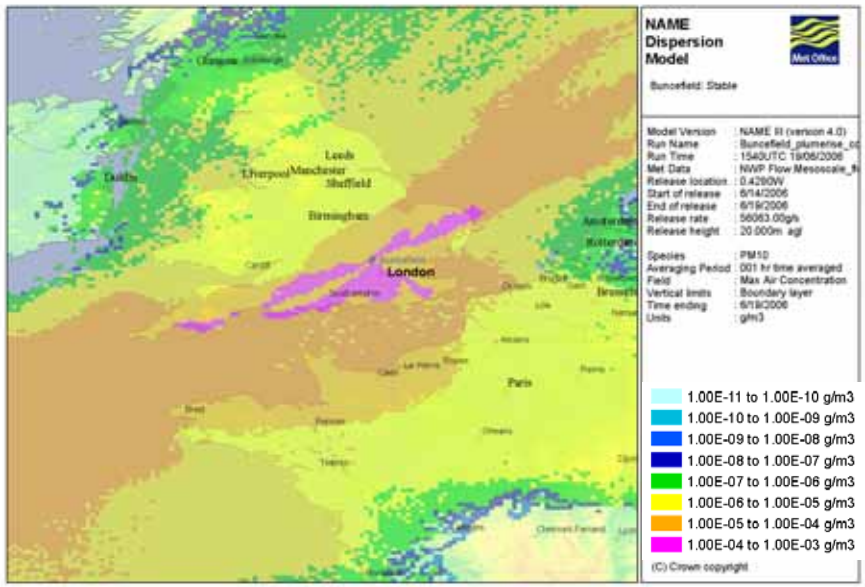


Maximum hourly averaged PM_{10} concentrations

Summer convective conditions

Convective conditions



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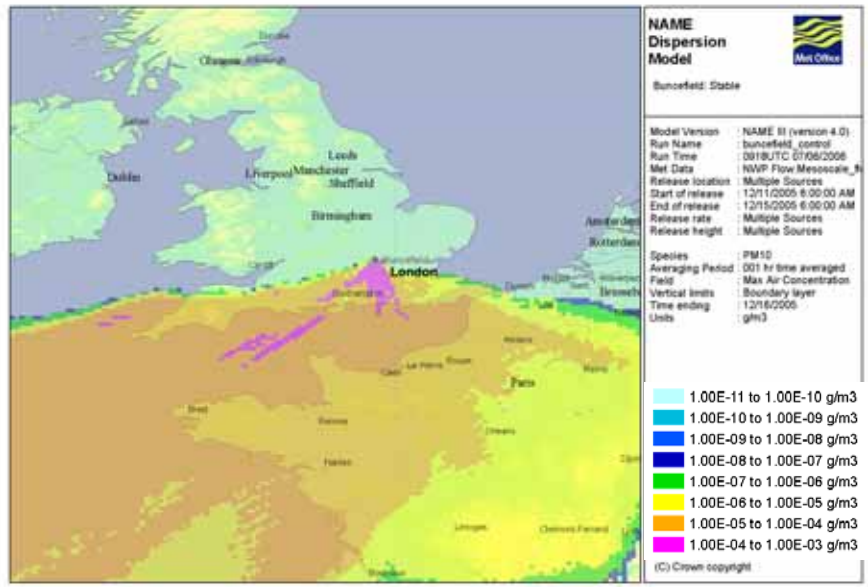

Maximum hourly averaged PM_{10} concentrations

Conclusions

Conclusions

- 3-D dispersion modelling was essential in this event
- Supporting observations (satellite imagery, aircraft measurements, etc.) also very important
- Accurate modelling requires good input information
  - Emissions data
- Fortunate weather conditions minimized surface impacts on Sunday
- Potential plume grounding at Horsham and St Albans