# New developments to the NAME modelling system

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## Government Meteorological Research

# Introduction

- NAME model and current uses

- Infrastructure Improvements to NAQF system

- Improving the Physics underpinning NAME

- Upgrading the Chemistry scheme in NAME

- New feature for describing airmass origin

# The NAME dispersion model

- Lagrangian particle model

    - Air concentrations

    - 1–10000km, hours–days

    - 3D met data from
      Unified Model

    - 3D Chemistry

    - Deposition: Wet and Dry



Particle Height (m)
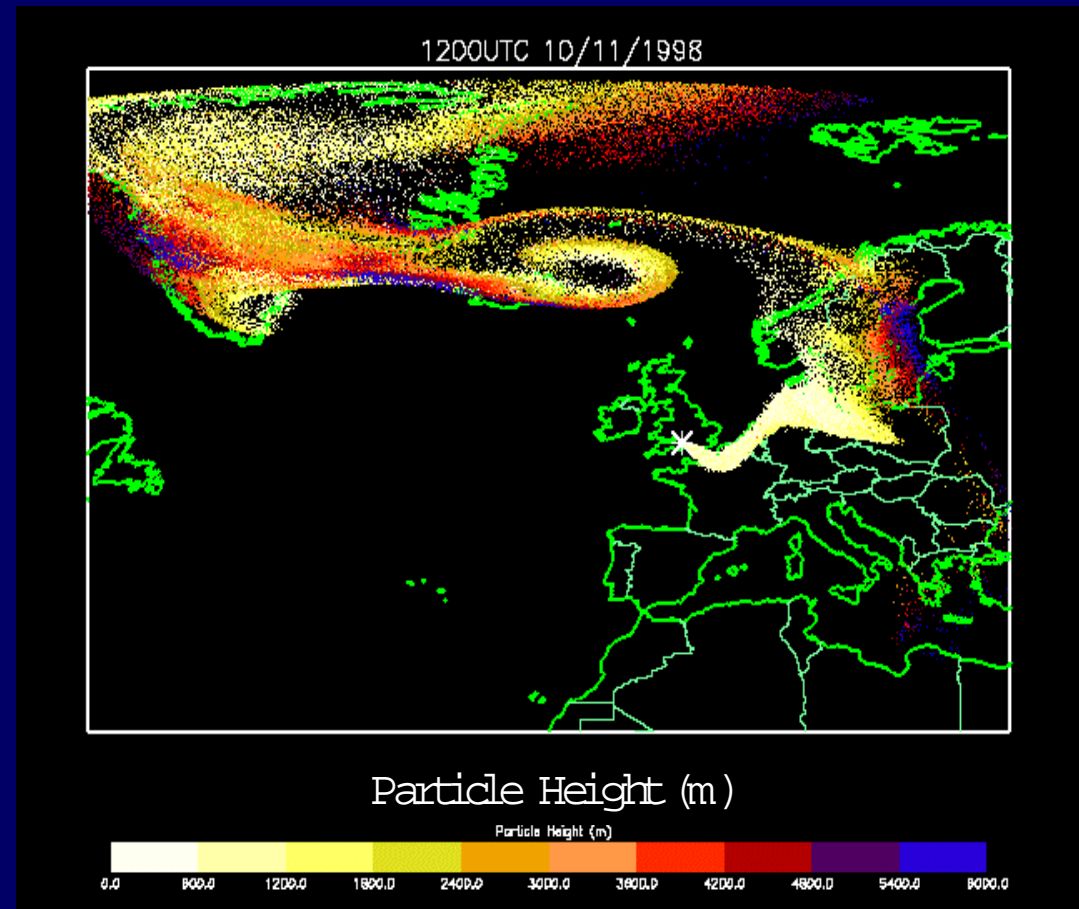
# Applications

- Emergency response
  - nuclear
  - chemical
  - volcanoes
  - foot and mouth disease
  - fires

- Air Pollution
  - air quality forecasts
  - episode studies

- Identify and quantify emission sources
  - verify inventories of ozone-depleting and greenhouse gases
  - Saharan dust
  - Forest fires

# Upgrading the Infrastructure for the National Air Quality Forecasting System

- Current HP system has been replaced by Linux PC dual system

- Approximate 5x increase in speed

  - Increase Model Resolution

  - Extend Model Domain Size

    » Greater European Impact

  - Reduced Statistical Noise

} Increased Modelling Skill

- Additional system for development work

# Improvements to the Physics underpinning NAME

- **Urban Effects**

  - Increased Heat Flux

    » Reduced Stability and Increased Mixing

  - Changes to wind speed and direction

    » Improving resolution of the Meteorology
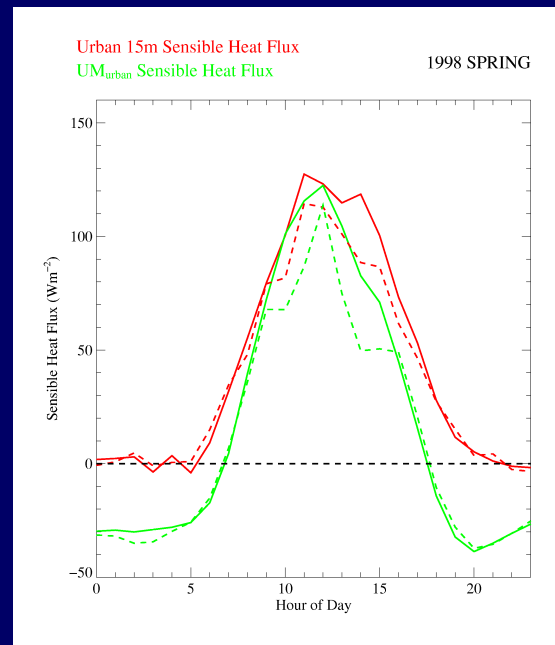
- **New Boundary Layer Turbulence Scheme**
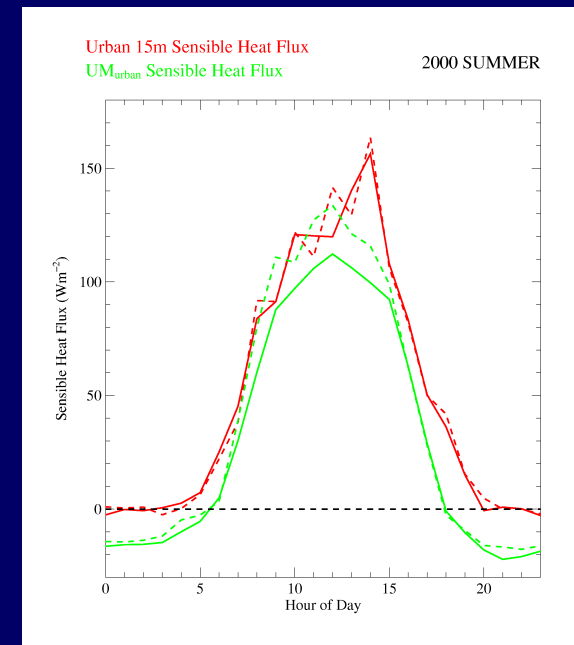
# Problem: Urban Sensible Heat Flux

## Measurements (red) v Meteorological Model (green)
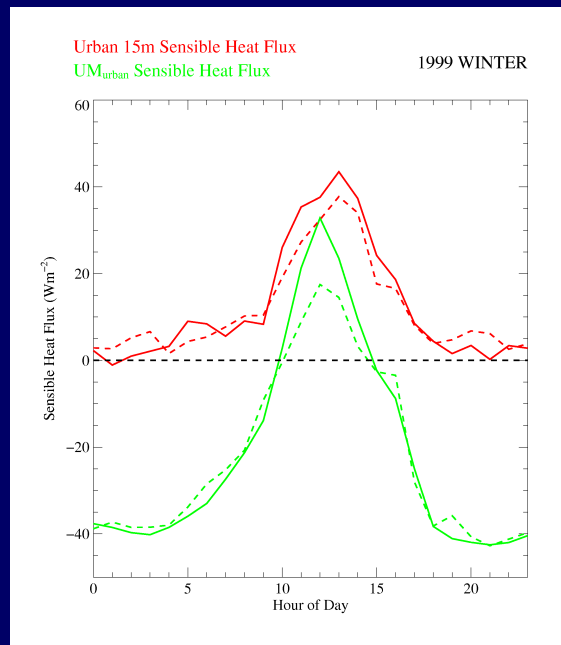


Winter      Spring      Summer

# New Physics

- Urban areas modelled using high resolution land-use map
  - Limit Monin-Obukhov length in urban areas to 10000
  - Compare with $NO_2$ obs.

| Location | Correlation Before | Correlation After | % Change |
|---|---|---|---|
| London N.Kensington | 0.66 | 0.72 | +9 |
| Sheffield | 0.59 | 0.63 | +7 |
| London Bloomsbury | 0.56 | 0.60 | +7 |
| Glasgow | 0.61 | 0.64 | +5 |
| Leeds | 0.50 | 0.49 | -2 |

- New Turbulence Scheme
  - Remove discontinuity
    - Stable – Unstable
  - Compare with Observations

| Parameter | Correlation Before | Correlation After | % Change |
|---|---|---|---|
| $\sigma_u$ | 0.74 | 0.77 | +3 |
| $\sigma_v$ | 0.73 | 0.75 | +3 |
| $\sigma_w$ | 0.77 | 0.78 | +2 |

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# Improved chemistry scheme

- Represents 37 species and over a hundred reactions in both gas and aqueous phase to generate:
    - secondary aerosols:
        - » sulphate, ammonium sulphate, nitrate & ammonium nitrate
    - oxidants (e.g. ozone, hydrogen peroxide)
    - free radicals (e.g. hydroxyl (OH), hydroperoxy ($HO_2$))
- 23 species are carried on particles, including direct emissions of:
    - sulphur dioxide, nitric oxide, ammonia, carbon monoxide, nitrous acid, primary $PM_{10}$ and 7 VOCs (Volatile Organic Carbons)
- 7 VOCs modelled scaled to represent the full (500+) VOC inventory
- Oxidants and free radicals modelled as static 3-D fields
- Aerosol species are carried on model particles

# Sulphate Aerosol

## PUMA urban measurement campaigns in Birmingham
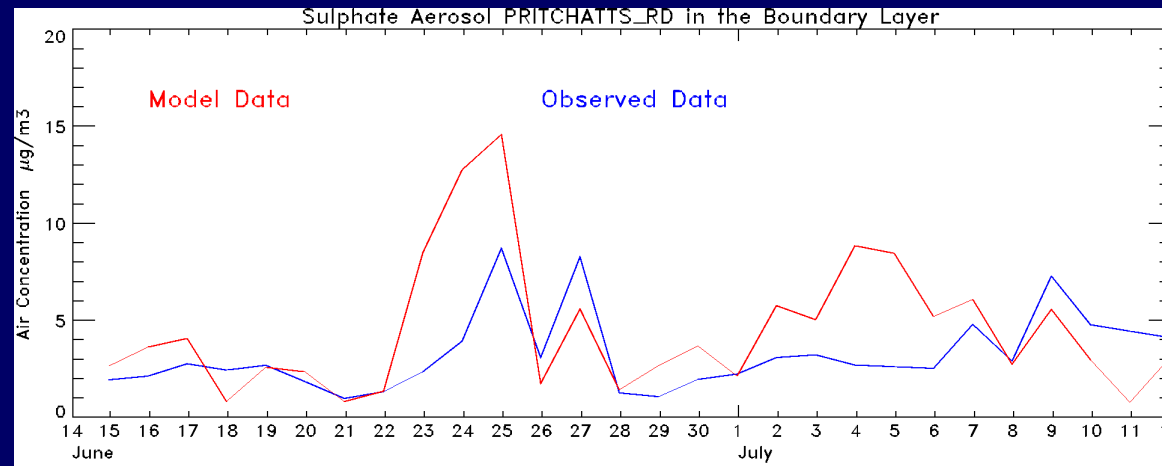


Summer 2000

r = 0.51
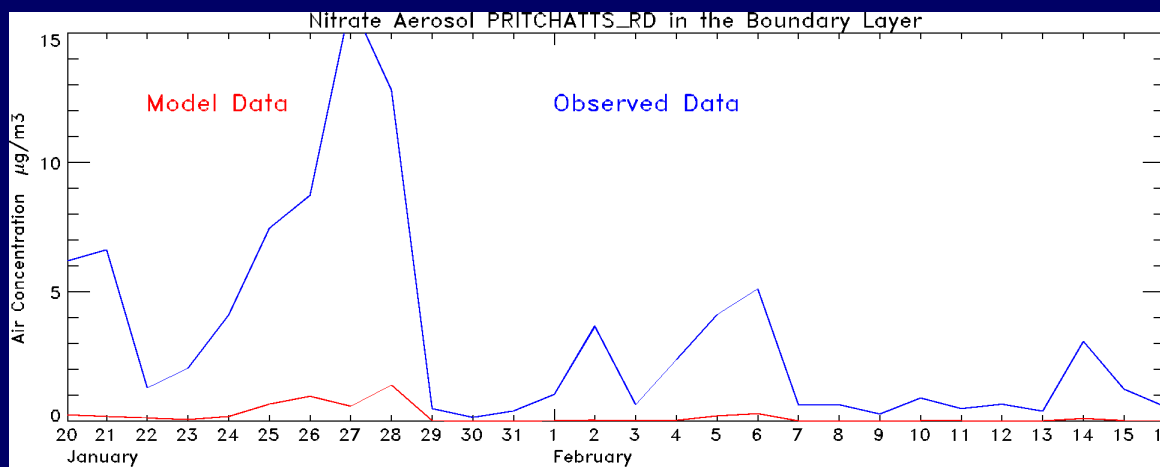
Winter 2001
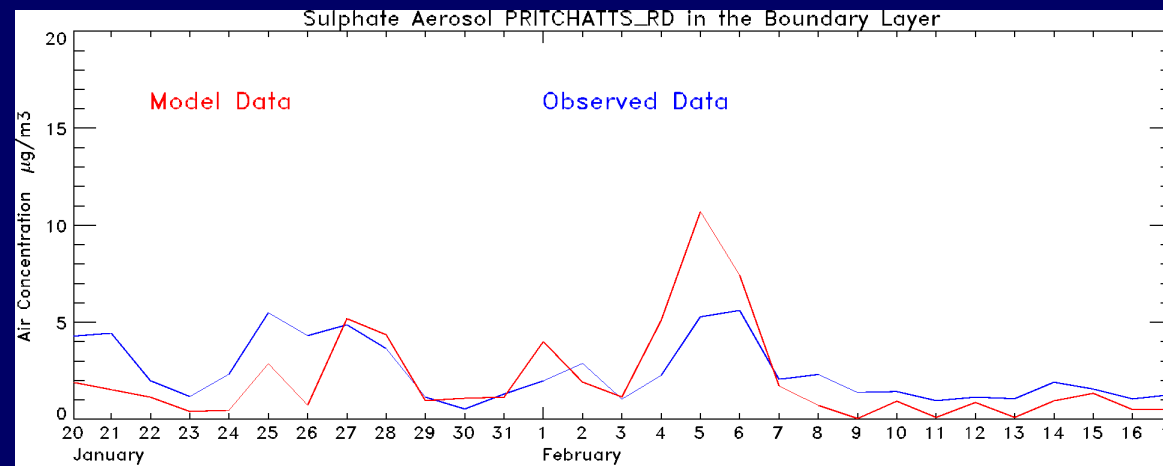
r = 0.68

# Nitrate Aerosol

## PUMA urban measurement campaigns in Birmingham
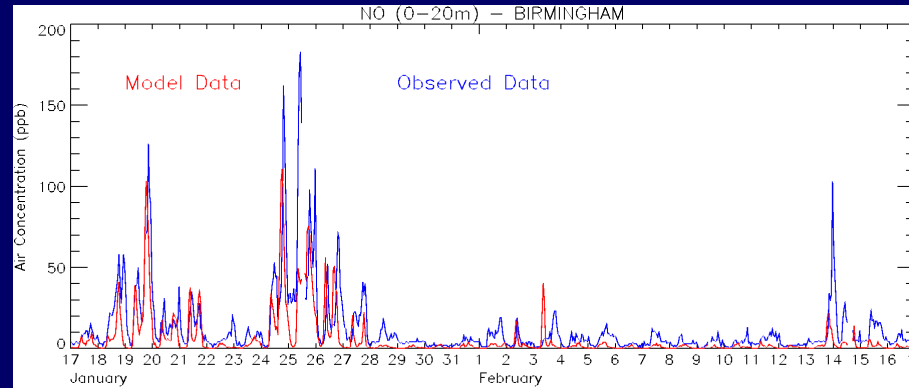


Summer 2000
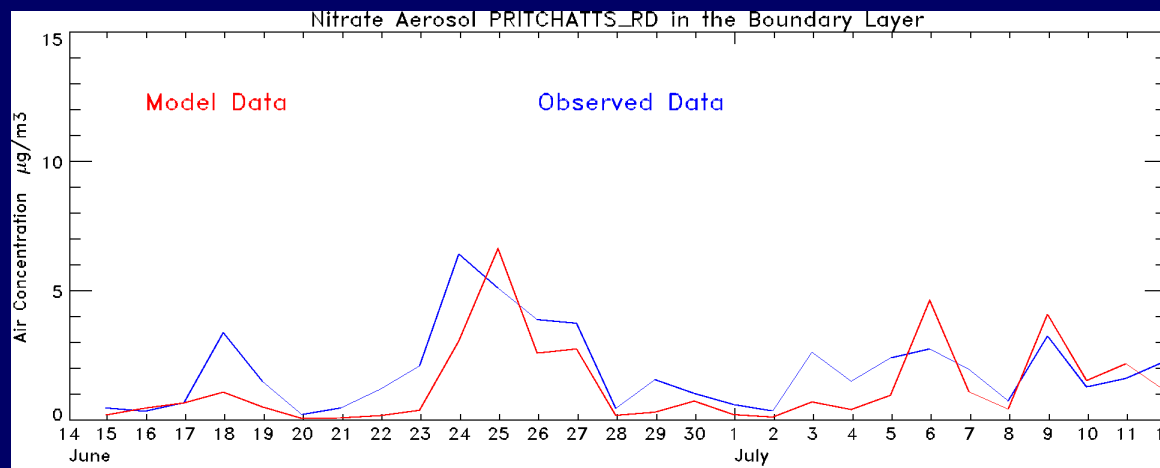
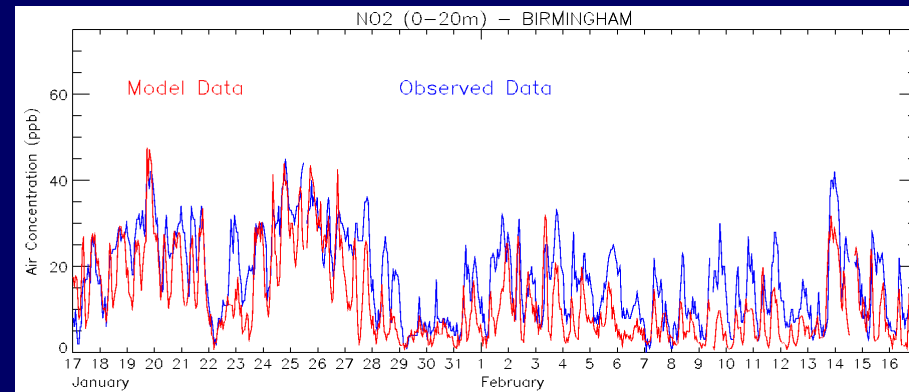r = 0.76

Winter 2001

r = 0.84

# $NO_2$ modelled directly

## PUMA: urban winter measurement campaign in Birmingham

NO



$r = 0.68$

$NO_2$



$r = 0.78$

# $PM_{10}$

Model Vs. measured
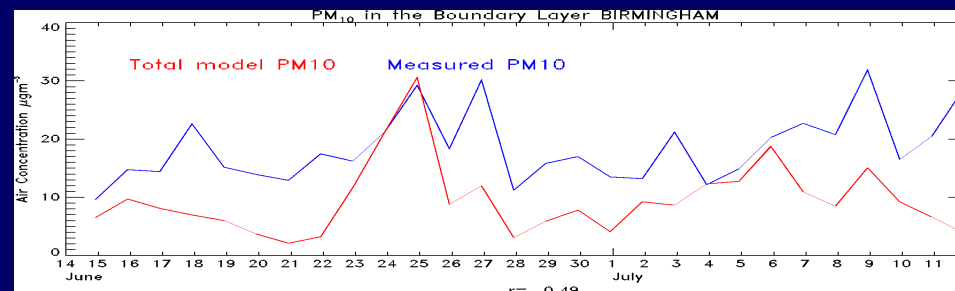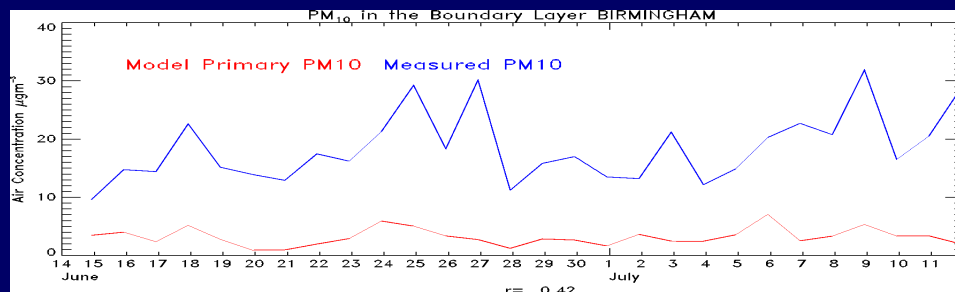**sulphate aerosol**
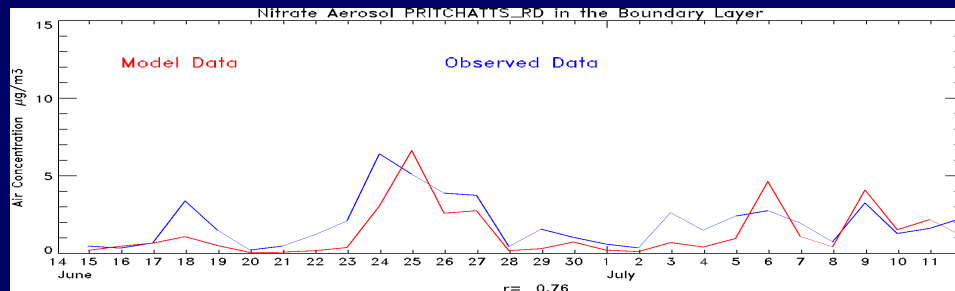
**+**

Model Vs. measured
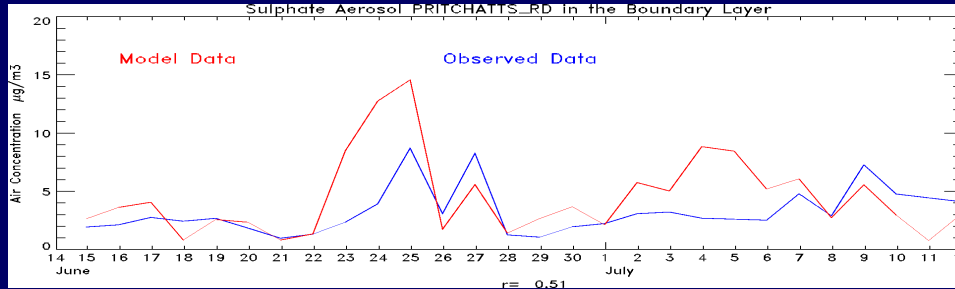**nitrate aerosol**

**+**

Model **primary $PM_{10}$** Vs.
total measured $PM_{10}$

**=**

**Total $PM_{10}$**

model Vs. measured



Modelled Emissions do **not** include:

Natural (Dust, Saharan sand, Forest Fire Smoke etc.) or Re-suspended components

# Future Chemistry Development

- Advection of oxidant fields would allow modelling of regional ozone concentrations

- Inclusion of biogenic VOC emissions

- Modelling of additional anthropogenic VOCs

- Improved representation of nitrate aerosol: natural dust could play a key role in the heterogenous formation of nitrate aerosol in the atmosphere

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# New Feature

- Running NAME backwards

- Uses:

  - Understanding Episodes and Identifying sources

    » e.g. Saharan Dust, Smoke from Forest Fires

  - Replacing Basic Trajectories to Forecast Air Origin
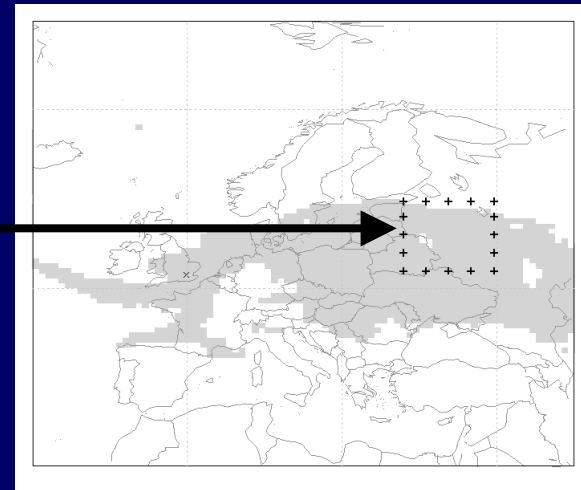
- Run operationally for several UK sites



Midday 9th March 2003

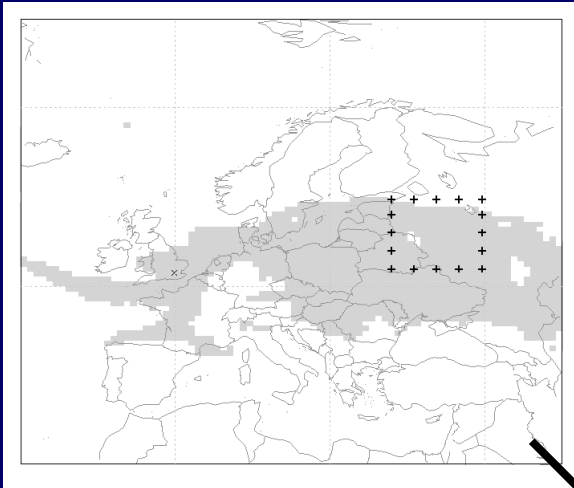Basic Trajectory



9th March 2003
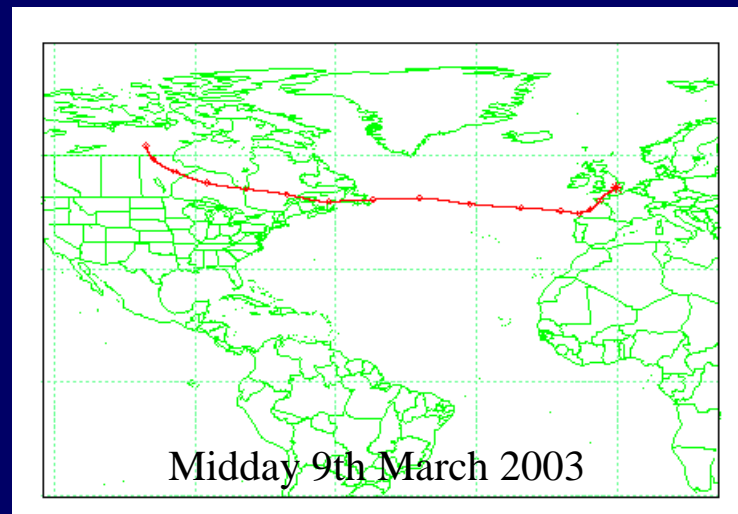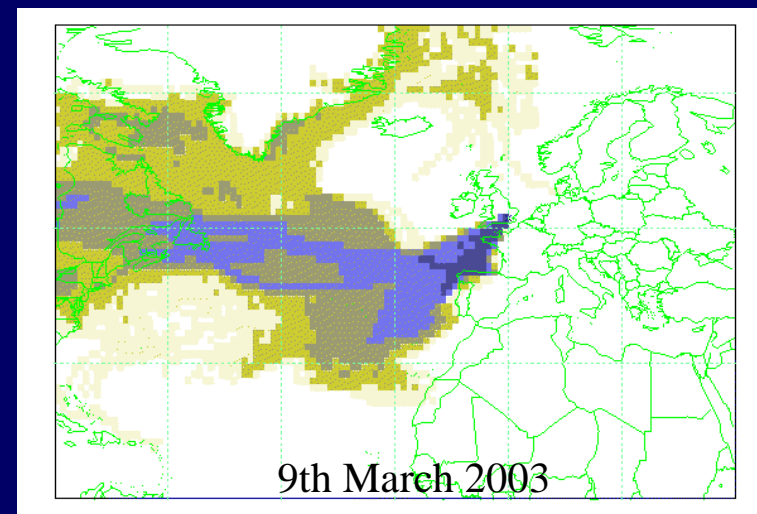
24hr Air Origin Map

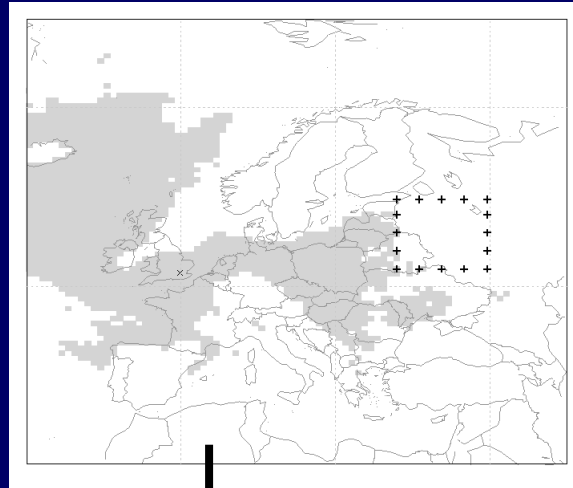# Satellite image of western Russia from MODIS for the 4th Sept 2002
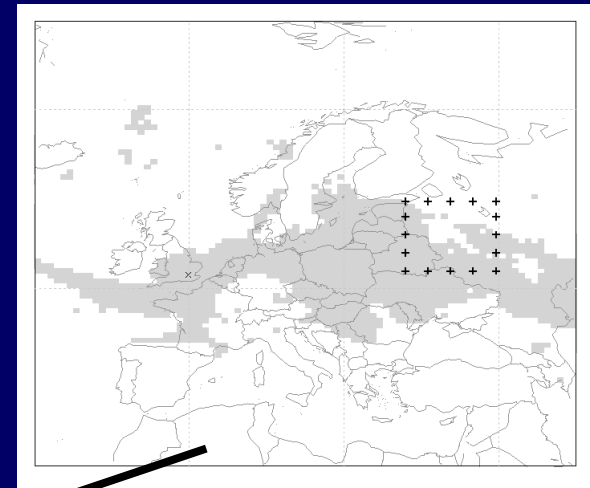
# 10-day Back-attribution maps for London

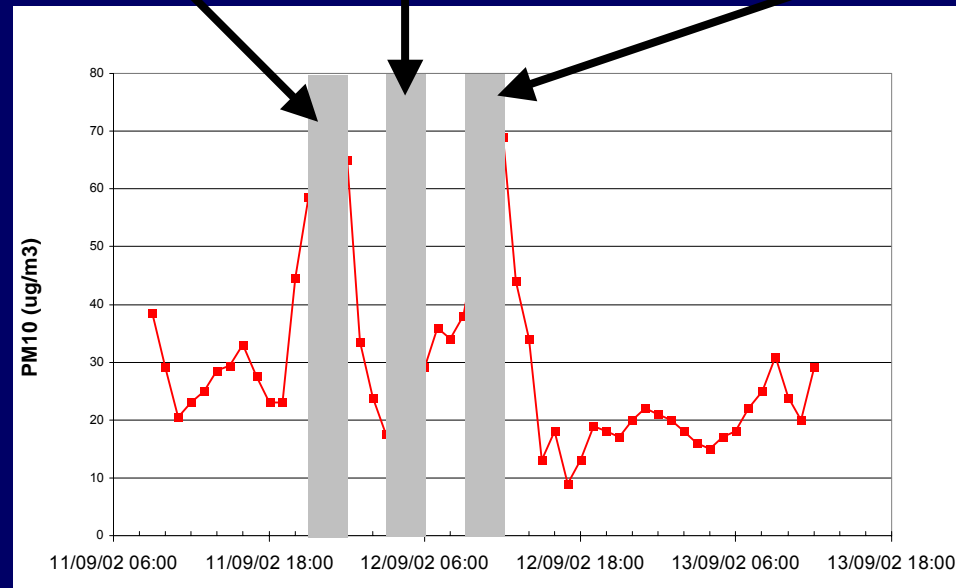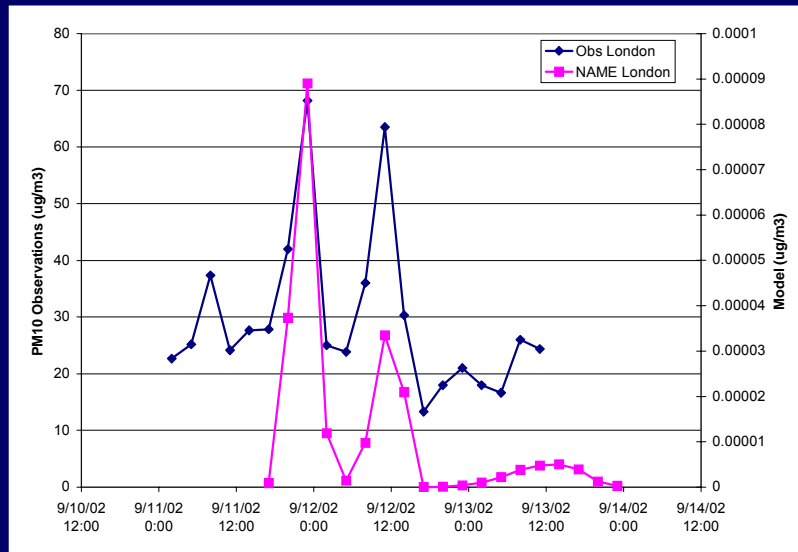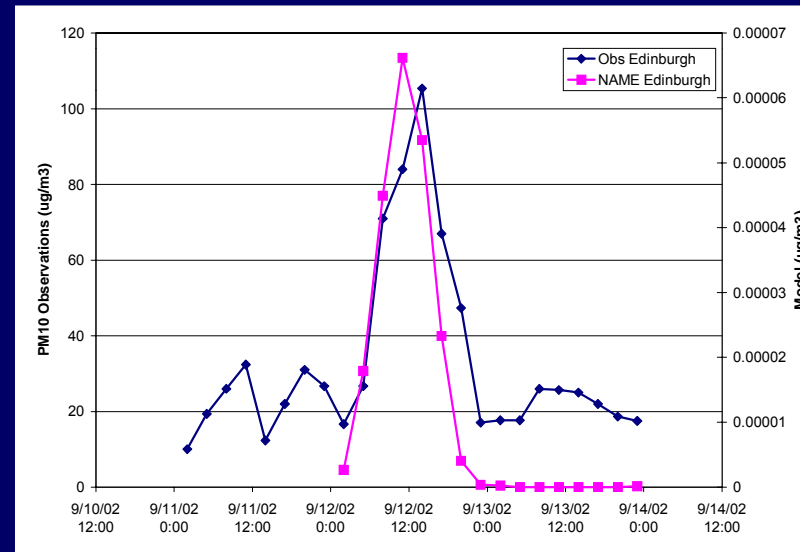3hr ending 00Z 12/09/02    3hr ending 06Z 12/09/02    3hr ending 12Z 12/09/02



London PM$_{10}$ Measurements

# Time-series of observed background PM$_{10}$ and modelled air concentration from the estimated area on fire in Western Russia



London



Edinburgh

# Summary

- Incorporating the impacts of urban areas

  - Reduce model stability over urban areas

- Improved turbulence scheme

- Chemistry (37 species & more than 100 reactions)

  - $NO_2$ modelled directly

  - Nitrate aerosol chemistry included

  - Ozone and Hydrocarbon modelling under development

- New Feature: Running NAME backwards

  - Improved air origin maps

  - Episode and source origin analysis

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