

The Weybourne atmospheric observatory- long term composition measurements according to changing air mass origin



Zoë Fleming¹, Paul Monks², Roland Leigh³, Brian Bandy⁴, Alistair Manning⁵

Email contact: z5f@le.ac.uk



- (1) National Centre for Atmospheric Science (NCAS), Chemistry department, University of Leicester, UK
- (2) Chemistry department, University of Leicester, UK
- (3) Earth Observation Science, Space Research Centre, Department of Physics & Astronomy, University of Leicester, UK
- (4) The Met office, Exeter, UK
- (5) National Centre for Atmospheric Science, School of the Environment

Introduction

The UK Met office's NAME atmospheric dispersion model has been used to track the air arriving at several trace gas observatories in order to link air mass origin and emission sources with atmospheric composition measurements. Previous studies have used back trajectories with cluster analysis to compare different transport routes to a site and linked it with the corresponding chemistry at the site but this footprint analysis, using the probability of particles passing over certain areas, displays well sites' regional influences.

NAME footprints

The model output (units of particle conc. s /m³) was captured every 3 hours for a period of 4 years. Examples of the types of 10 day footprints the site receives are shown in Fig. 2. These footprints have been integrated to create monthly footprints (Fig. 3 for 2008). Examples of 20 day footprints are shown in Fig. 4 (a period with Westerly and another with Northerly influences).

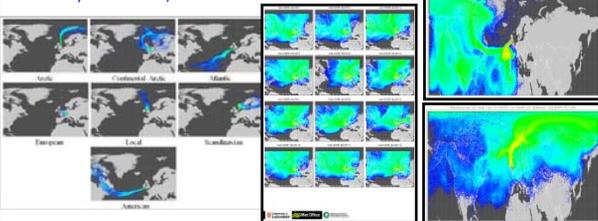


Fig. 2. 3 hourly footprints (main trajectory types) Fig. 3. Monthly 10 day footprints Fig. 4. 20 day footprints (W & N air masses)

Weybourne, Norfolk



Fig. 1. The Weybourne Atmospheric Observatory

The Weybourne Atmospheric Observatory receives air masses from a variety of directions that pass over many differing areas of pollutant loadings. The observatory itself has been sited at this location that is a few hours downwind of the London conurbation to trace the effect of urban pollution on a rural downwind area but also to sample North Sea and Arctic air as well as aged European air masses.

Twenty years of measurements of ozone precursors (NOx and various VOCs), ozone, SO₂ and various meteorological parameters a few years of greenhouse gas measurements can be used in combination with dispersion modelling to investigate how they have varied with air mass direction over the years.

Regional Division of the Domain

The output domain has been divided into regions (Fig. 5) and the % of total particles during each 3 hour release passing over each region is calculated. Each 3 hour period was assigned to one of the 7 trajectory types in Fig. 2. Fig.6 shows the timeseries of trajectory types over 3 years and for a 2 week period.

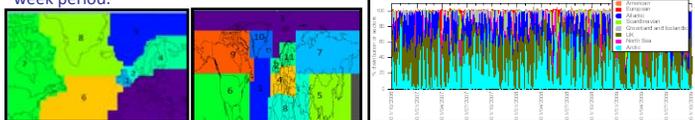


Fig. 5. 10 day and 20 day regional divisions Fig. 6. Timeseries of trajectory types

Chemistry differences between sectors

The classification of air mass origins and pathways helps to explain short-term changes in many trace gases and allows the comparison of air masses of the same type over the years. Long term trends can be extracted from this and changes in the ratios and concentrations of these trace gases can be studied in a consistent manner.

From the 10 day footprints, average species concentrations during each trajectory type were calculated:

- Ozone levels were highest in the Scandinavian air masses but also high in the Arctic air masses (Fig. 8)
- NO₂ varies significantly between years within each trajectory type but was considerably higher in European, local and American air masses. There is some contamination in Atlantic air (Fig. 9)
- European and local air masses had the highest SO₂. High levels in 2009 Arctic continental show how local emissions or a point source can cause unusually high SO₂ levels (Fig. 10)
- Condensation Nuclei levels were highest in the local (strong UK influence) air masses and lowest in the Arctic and Scandinavian air masses, the trajectory types that had the highest ozone (Fig. 11)

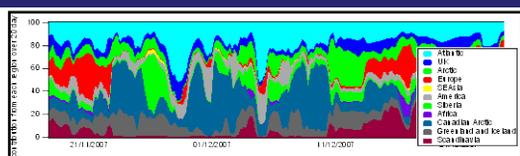


Fig. 7. 20 day trajectory types and isolating Asian and Arctic air

For 20 day back runs, the aim is to isolate all the periods when the air passed over Asia (see Fig. 4 lower plot) and find average O₃, NO_x, CN and VOCs and check how levels have changed over the last few years. Fig. 7 shows how rarely South East Asian air masses arrive at Weybourne within 20 days so Siberian/Arctic air masses may contain aged Asian emissions.

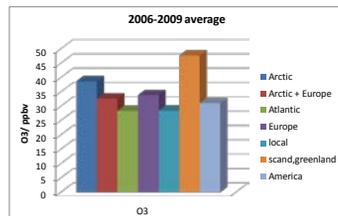


Fig. 8. Average O₃ levels over 4 years

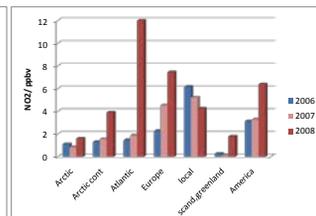


Fig. 9. Average NO₂ levels in 3 years

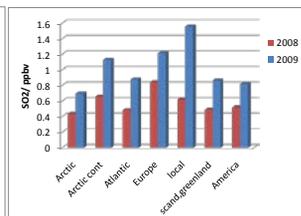


Fig. 10. Average SO₂ levels in 2 years

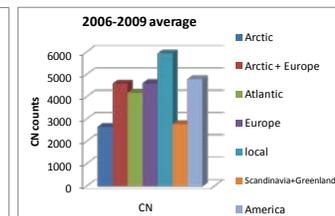


Fig. 11. Average Condensation Nuclei

Conclusions and Future work

- Analysis has been carried out on 4 years of chemical and meteorological measurements taken at the Weybourne Observatory to compare the chemistry with the origin and passageway of the air arriving at the station
- Many species have been shown to have different levels according to which areas they have passed over; clean Arctic air, old polluted processed air from America, clean Atlantic air or polluted British isles and European air masses
- This technique has proved to be very useful for this north European site experiencing a variety of air mass types and origins to explain pollution episodes
- This method can help us to understand source-receptor relationships and the role of long range transport to this coastal boundary layer site
- This station and the dispersion analysis helps us to understand northern European pollution transport
- We will calculate many years of 20 day or longer footprints to detect trends in ozone and its precursors between seasons and years and follow the long range influence of rising Asian emissions in the clean Arctic air masses