AEA Energy & Environment
From the AEA group

Modelling the air quality health impact of the 2006 UK heatwave

Andrew Kent
John Stedman
Heather Walton
Susannah Grice
David Green

16th May 2007

Introduction

- An assessment of the number of deaths brought forward as a result of increased air pollution concentrations during the extended heatwave in June-July 2006.
- The study developed methodology used in an analysis of the 2003 heatwave, undertaken by John Stedman.
- Pollutants under investigation were ozone, PM_{10} and SO_2.
- Study conducted on behalf of Defra (Air & Environmental Quality division).
- Collaboration between AEA Energy & Environment, HPA and ERG.

Methodology (1)

- Health impact was measured in terms of ‘deaths brought forward’.
- Dose response functions used to estimate the impact of changing concentrations on health.

	Ozone	PM_{10}*	SO_2
Baseline death rate (per 100 000 people per annum)	989.7	989.7	989.7
Concentration response function	0.6 (COMEAP, 1998) 0.3 (WHO, 2004)	0.75	0.6

* For particle concentrations measured using a Tapered Element Oscillating Microbalance (TEOM) instrument

- Coefficients are expressed as a percentage change in mortality rate for a specified change in pollutant concentration (e.g. 0.6% per 10 µg m^{-3}).

Methodology (2)

- Principle was to apply dose response coefficients to measured concentrations and population data for the heatwave period:

Zone/agglomeration mean * dose response function * baseline mortality rate * population

- Thresholds used for ozone calculations at:

Threshold	Recommendation
0 µg m^{-3} (no threshold)	COMEAP (1998)
70 µg m^{-3}	WHO/UNECE (2004)
100 µg m^{-3}	COMEAP (1998)

- An equivalent period in 2004 was used to provide a non-heatwave baseline to find the excess deaths associated with the heatwave.

Area and time period

- Calculations performed for each of 43 zones and agglomerations (defined under first air quality Daughter Directive).

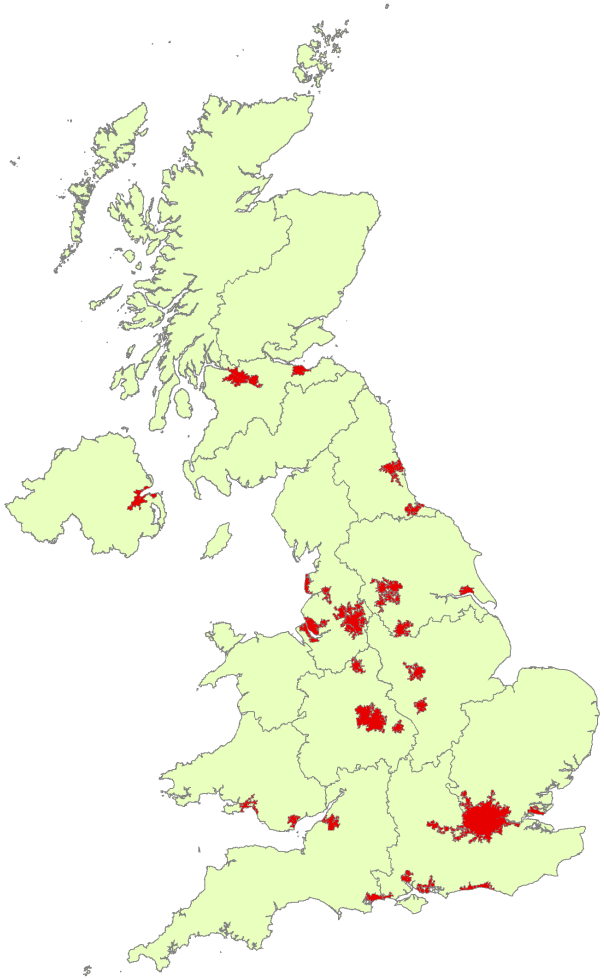
- Calculations at the zone and agglomeration level allowed aggregation into their respective countries using population-weighted means to provide statistics for each Devolved Administration.

- Results were calculated for:
  - the whole of June and July.
  - two episodes (27th June - 7th July and 13th - 23rd July) – defined by concentrations.
  - two ONS 'hot periods' (1st - 7th July and 16th - 28th July) – defined by temperature.

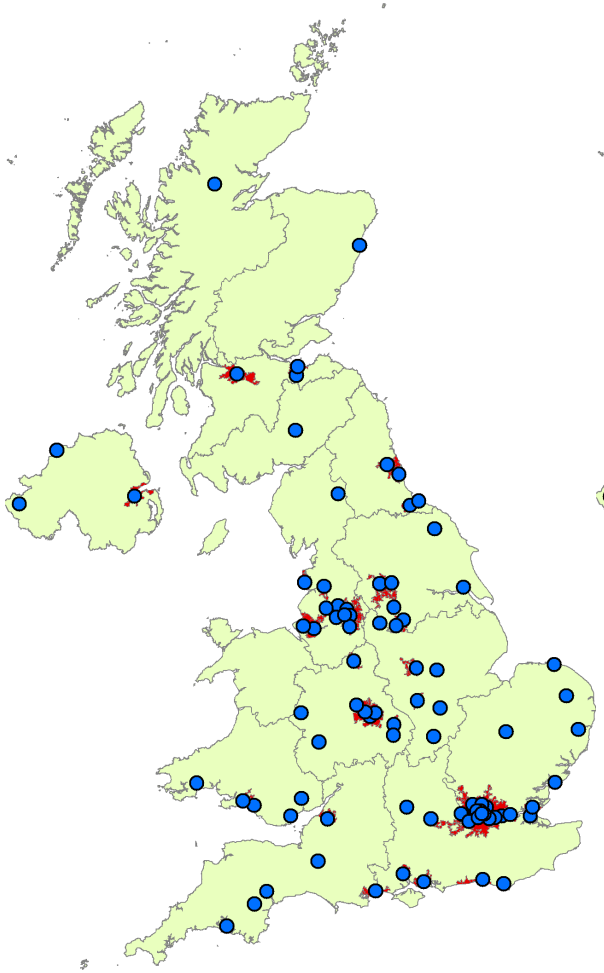
- Focus of this presentation will be the two ONS hot periods.

UK zones, agglomerations and AURN monitoring sites

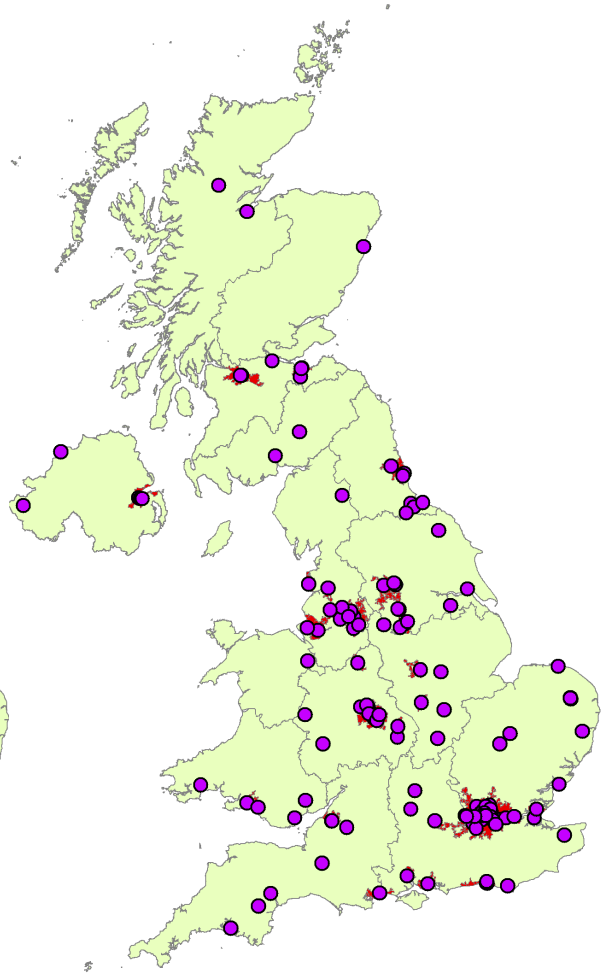
Zones and Agglomerations



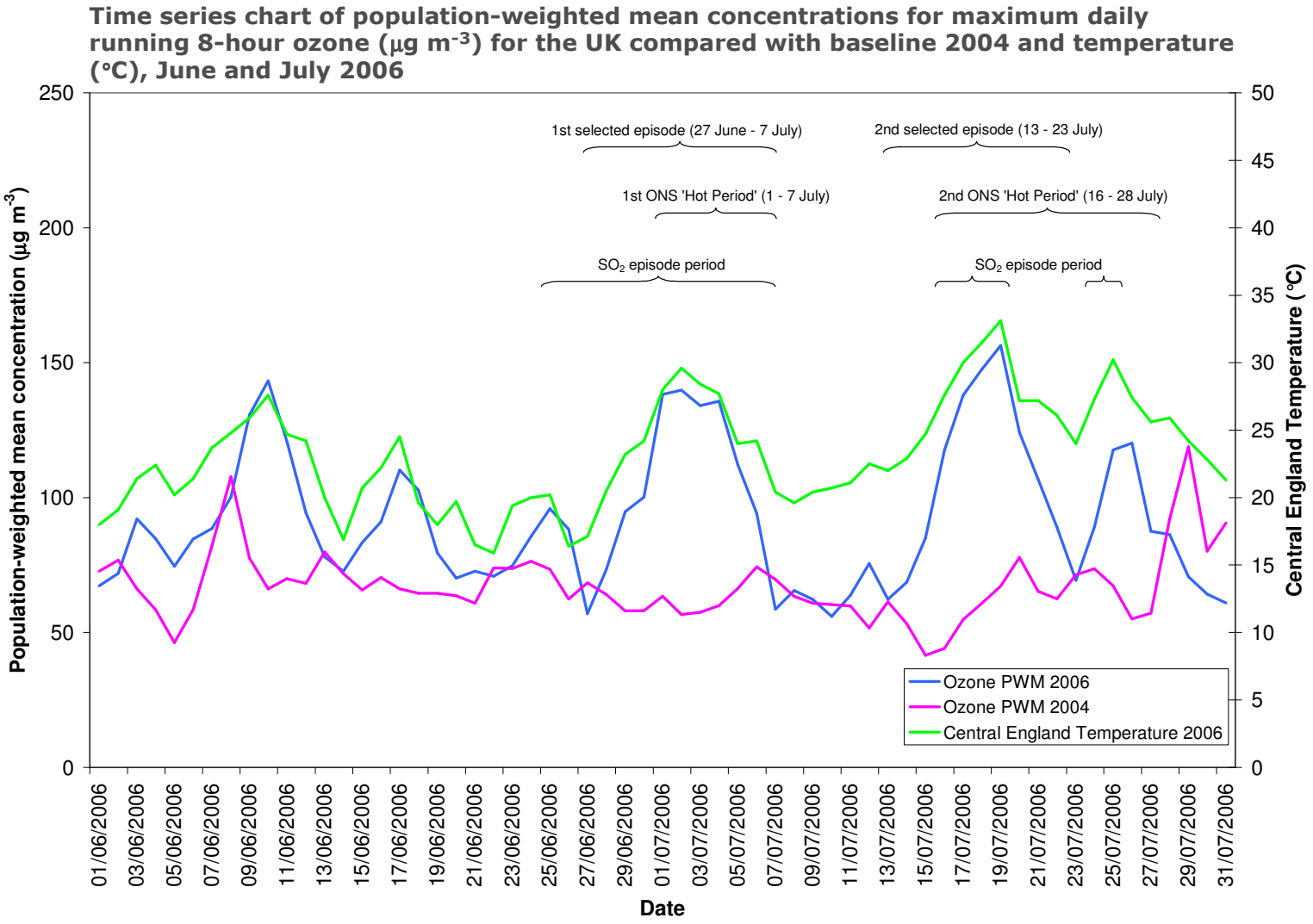
Ozone sites



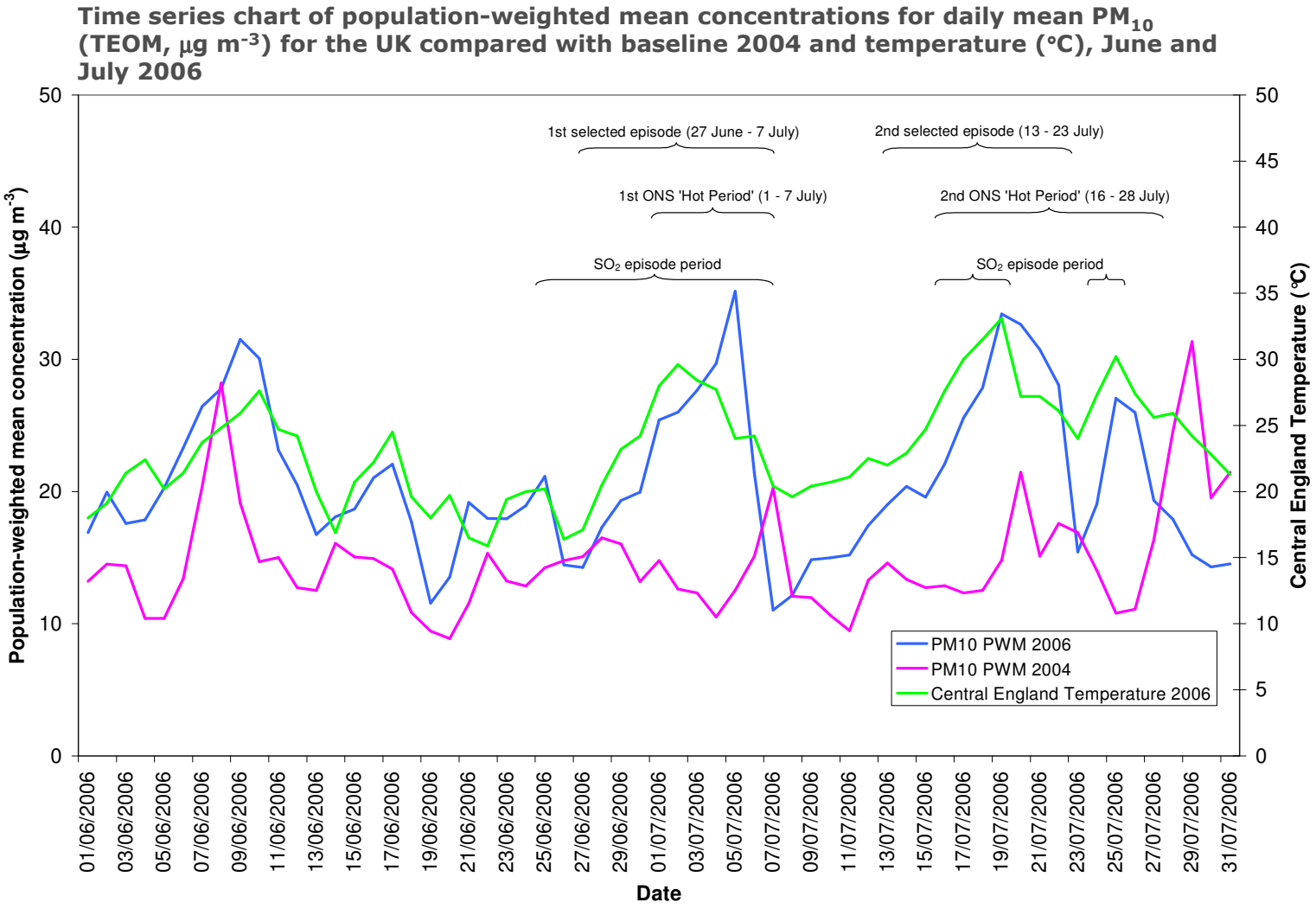
PM_{10} (TEOM) sites



Ozone concentrations over time



PM_{10} concentrations over time



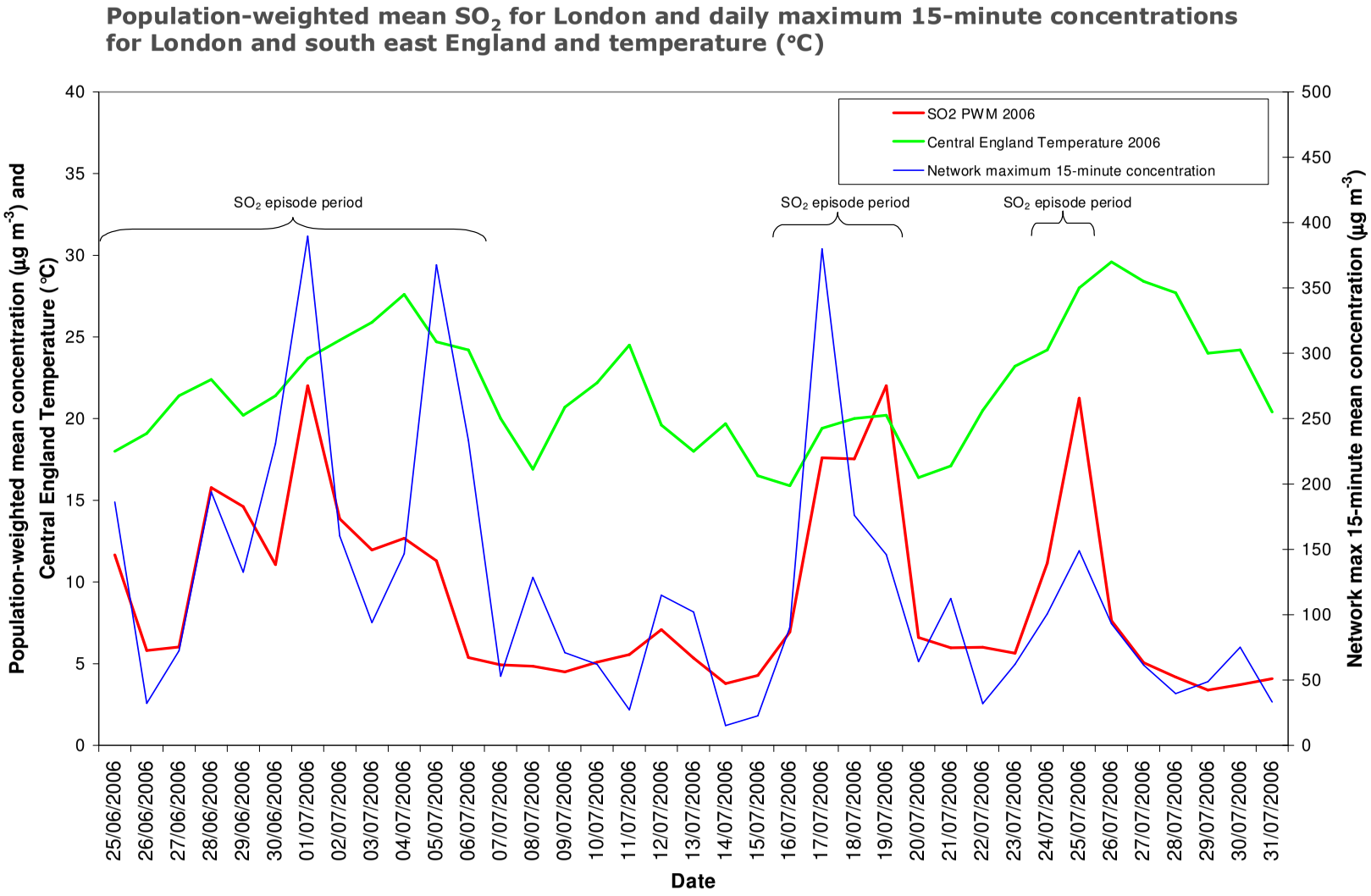
SO_2 methodology (1)

- Elevated SO_2 levels were an unexpected feature of the heatwave and one of the most interesting aspects.
- Area under assessment was limited to Greater London where the elevated concentrations were measured.
- Episode days used in the calculations:
  - 25th June - 6th July
  - 16th - 19th July
  - 24th - 25th July
- Baseline of 5 µg m^{-3} was used to represent the equivalent period without the influence of heatwave conditions.

SO_2 methodology (2)

- The spatial variability of SO_2 concentrations required an alternative method of modelling.
- Concentrations across AURN, LAQN, Kent & Medway, Hertfordshire & Bedfordshire monitoring networks were used.
- Inverse distance weighted interpolation was used to estimate concentrations across the area on a 1km grid which were then calculated as population-weighted means for each grid square.
- Calculations were performed on a 1km grid square basis and aggregated to the Greater London area.

SO_2 concentrations over time



Results – Ozone and PM_{10} (ONS 1st Hot Period)

Predicted number of deaths brought forward due to ozone and PM_{10} concentrations, 1st to 7th July, 1st ONS 'Hot Period' (7 days) (compared with 2004 baseline)

	Deaths brought forward			
	Ozone			**PM_{10}**
	Coefficient 0.3% per 10 μg m^{-3}			
Region	**No threshold**	**70 μg m^{-3} threshold**	**100 μg m^{-3} threshold**	**No threshold**
England and Wales	166	148	86	81

- England and Wales only.
- Most realistic range – ozone using 0.3% coefficient and 70 μg m^{-3} threshold and no threshold plus PM_{10}.
- ONS estimated excess deaths brought forward = 0
- Modelled deaths brought forward = 229-247

Results – Ozone and PM_{10} (ONS 2nd Hot Period)

Predicted number of deaths brought forward due to ozone and PM_{10} concentrations, 16th to 28th July, 2nd ONS 'Hot Period' (13 days) (compared with 2004 baseline)

	Deaths brought forward			
	Ozone			**PM_{10}**
	Coefficient 0.3% per 10 μg m^{-3}			
Region	**No threshold**	**70 μg m^{-3} threshold**	**100 μg m^{-3} threshold**	**No threshold**
England and Wales	272	224	120	130

- ONS estimated excess deaths brought forward = 680
- Modelled deaths brought forward = 354-402 (52-59% of total).
- This is a higher percentage of total estimated excess deaths than was modelled for the 2003 heatwave (21-38% of total excess deaths).

Comparing with ONS daily mortality figures

- The ONS figures are also only estimates and contain their own uncertainties.
- The 1st hot period (1st - 7th July) did show a positive number of excess deaths in the oldest (most sensitive) cohort (75+).
- Uncertainty over an ozone threshold – if the threshold is higher than the 70 µg m^{-3} presented here, then excess deaths would be lower.
- High proportion of our predicted excess deaths due to air pollution compared with ONS total excess deaths:
  - Residual confounding of effects of temperature.
  - Possible impact of Government's Heat Wave Plan (HWP).

Results – SO_2

Predicted number of deaths brought forward due to SO_2 in Greater London relative to ozone and PM_{10} during episode days

	Deaths brought forward		
Region	**SO_2**	**PM_{10}**	**Ozone***
Greater London	17	25	40-53

* based on the range using a 0.3% coefficient and 70 µg m-3 threshold and no threshold

- Total number of deaths brought forward associated with heatwave in London = 82-95.
- Assumes that deaths associated with SO_2 and PM_{10} are additional.

Comparison with 2003 heatwave (1)

- Comparison was made by recalculating the 2006 heatwave using the dose-response coefficients and thresholds for ozone and PM_{10} used in the 2003 assessment.

Comparison of 2003 heatwave episode with the two selected 2006 episode periods

	Deaths brought forward		
	27th June – 7th July 2006	**13th July – 23rd July 2006**	**1st – 14th August 2003**
Number of days in episode	11	11	15
Ozone 0.6% coefficient, 100 $\mu g\ m^{-3}$ threshold	191	208	214
Ozone 0.6% coefficient, no threshold	432	494	580
PM_{10}	108	135	206
Total	299 - 540	343 - 629	420 – 786

Comparison with 2003 heatwave (2)

- The 2006 heatwave was lower intensity, longer duration event than the 2003 heatwave.
- Each of the two episodes in 2006 resulted in fewer predicted deaths brought forward than the 2003 episode but combined they exceeded the 2003 episode.
- Due to the different lengths of episode periods in 2006 and 2003 it is better to compare number of excess deaths per day:
  - similar or higher for ozone in 2006 than in 2003.
  - lower for PM_{10} in 2006 than 2003.

Conclusions

- 2003 ozone and PM_{10} analysis predicted 21-38% of total excess deaths were due to air pollution. In 2006 a similar analysis predicted 52%-59%.
- 2006 analysis resulted in inconsistent results with ONS estimates, predicting a significant number of deaths when ONS estimated zero during the 1st hot period and predicting a high percentage of air pollution related deaths during the 2nd hot period.
- The number of SO_2 and PM_{10} related deaths were similar. Ozone and PM_{10} due to unusual weather conditions but SO_2 levels resulted from unusual weather and unusual emission patterns which themselves due to the heatwave.
- Individual episode periods in 2006 resulted in a lower number of deaths than the 2003 heatwave but the combined event exceeded deaths in 2003 heatwave.
- Future heatwaves - climate change trends $\longrightarrow$ more frequent, longer duration events like 2006?

and finally…

…thank you for your attention.

Any further questions: andrew.kent@aeat.co.uk