

Forecasting Ground Level Ozone

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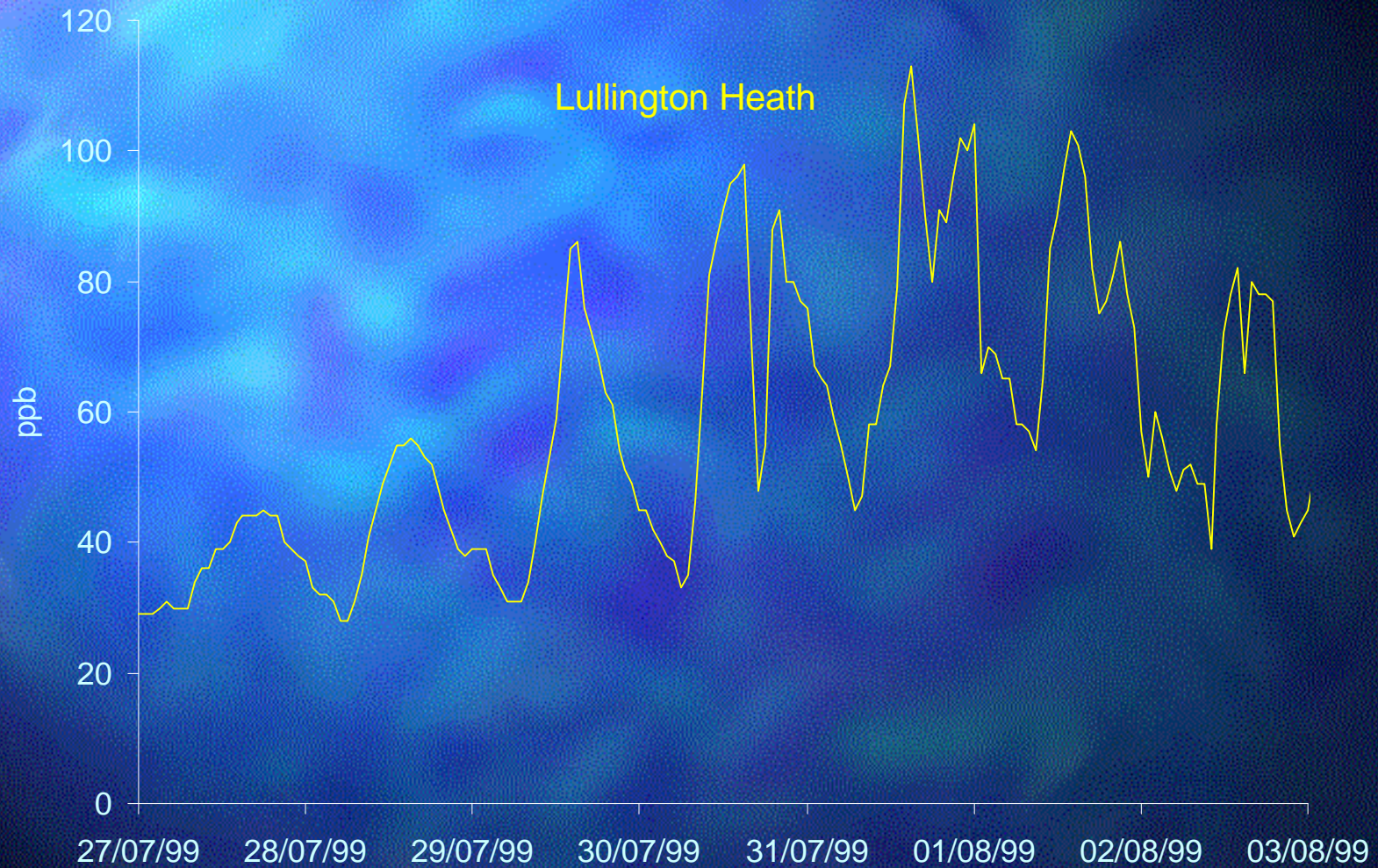
*AEA Technology Environment, National Environmental
Technology Centre*

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Today's Presentation:

- *Ozone episodes: concentrations and chemistry*
- *Forecasting ozone episodes*
- *The Ozone Trajectory Model*
- *Forecasting success rate*
- *Features:*
 - *origins of episodes*
 - *ozone in urban areas*
 - *day of the week*
 - *cloud cover*

Summer Smog: ozone



Summer Smog

Ground level ozone episodes

- *Hot sunny weather*
- *Light winds*
- *Often with transport of air masses from the east*

Ozone episodes

- *Index 4: above 100 $\mu\text{g m}^{-3}$ / 50 ppb (Moderate)*
- *Index 7: above 180 $\mu\text{g m}^{-3}$ / 90 ppb (High)*
- *Index 10: above 360 $\mu\text{g m}^{-3}$ / 180 ppb (Very High)*

Chemistry

Photochemical reactions between oxides of nitrogen and volatile organic compounds



- *no net ozone production*
- *but the photochemical degradation of volatile organic compounds (VOC) provides an alternative route for the oxidation of NO to NO₂*

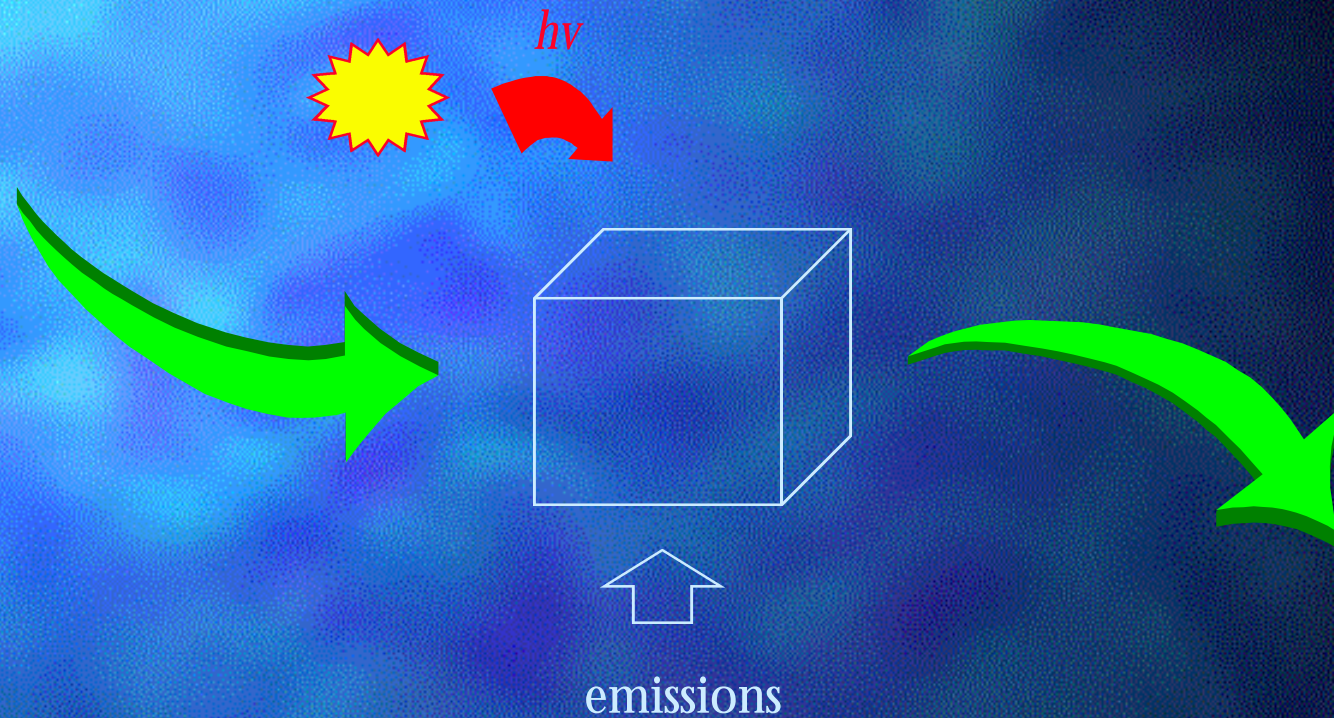
Inputs to the ozone forecast

- *Ozone Trajectory Model results*
- *Current data from UK monitoring networks*
- *Weather forecasts*
- *Data from other European countries*
- *Expert analysis*

Ozone Trajectory Model

- *Ozone formation is complicated:*
 - *Complex models can include over 100 emitted VOCs, 10,000 reactions, and 3,500 species*
 - *But these models can take several days to run*
- *Results from complex models used to develop a forecasting model:*
 - *Ozone formation in the UK is typically 'VOC limited'*
 - *Identify the top 20 VOCs contributing to ozone*
 - *Rate determining step is OH attack on VOC*
 - *Estimate the number of ozone molecules per VOC*

Ozone Trajectory Model

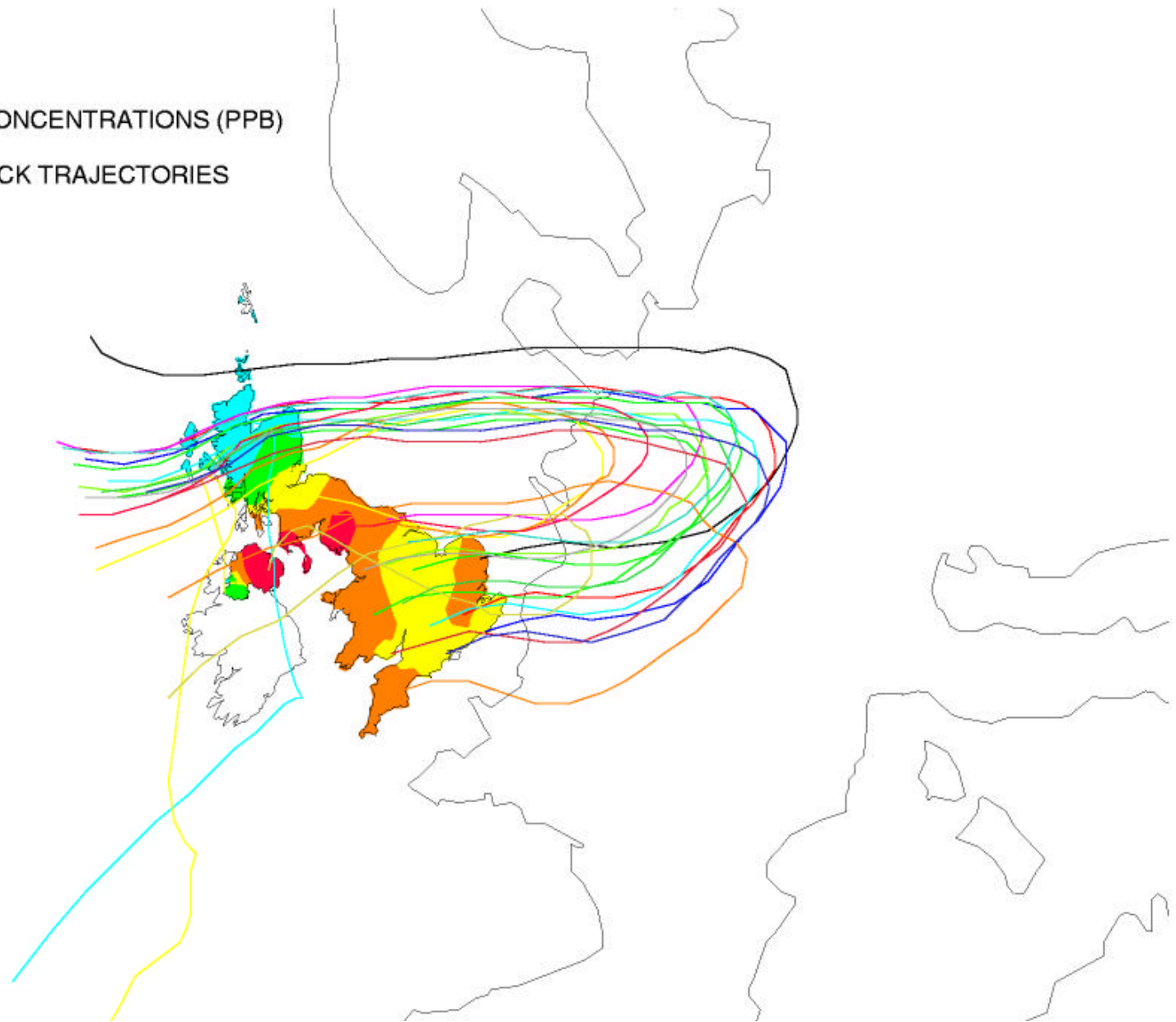
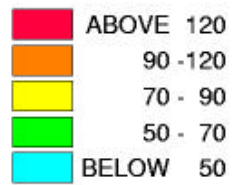


Ozone Trajectory Model

- *Simplified chemistry along a forecast 96 hour trajectory:*
 - *since 1992*
 - *with updates to the VOC emission inventory and chemical scheme*
- *Peak hourly concentration predicted at 20 sites for 1, 2 and 3 days ahead*

FORECAST OZONE CONCENTRATIONS (PPB)
AND ASSOCIATED BACK TRAJECTORIES

04/07/2001 1200

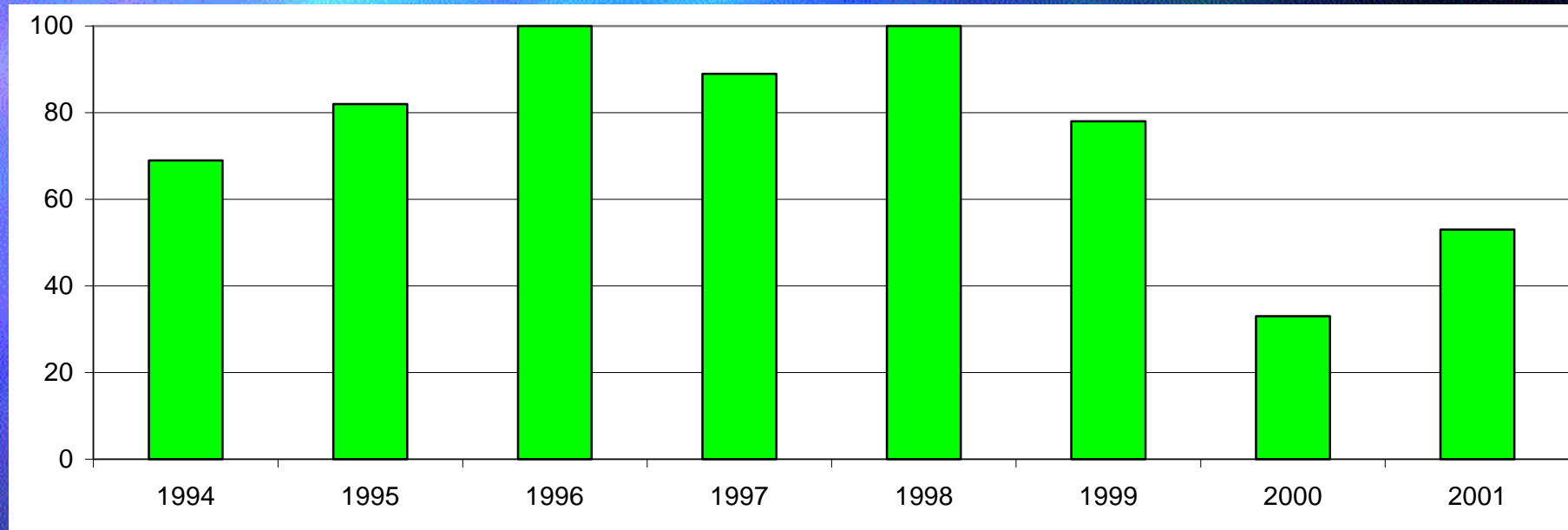


Ozone forecasting success rate

Over 10 regions of the UK: 1998 - 2000

■ <i>High days measured:</i>	<i>49</i>
■ <i>High days forecast:</i>	<i>171</i>
■ <i>Forecast and measured:</i>	<i>39</i>
■ <i>Forecast and not measured:</i>	<i>132</i>
■ <i>Not forecast and measured:</i>	<i>10</i>
■ <i>Overall success rate:</i>	<i>80%</i>

Ozone forecasting success rate



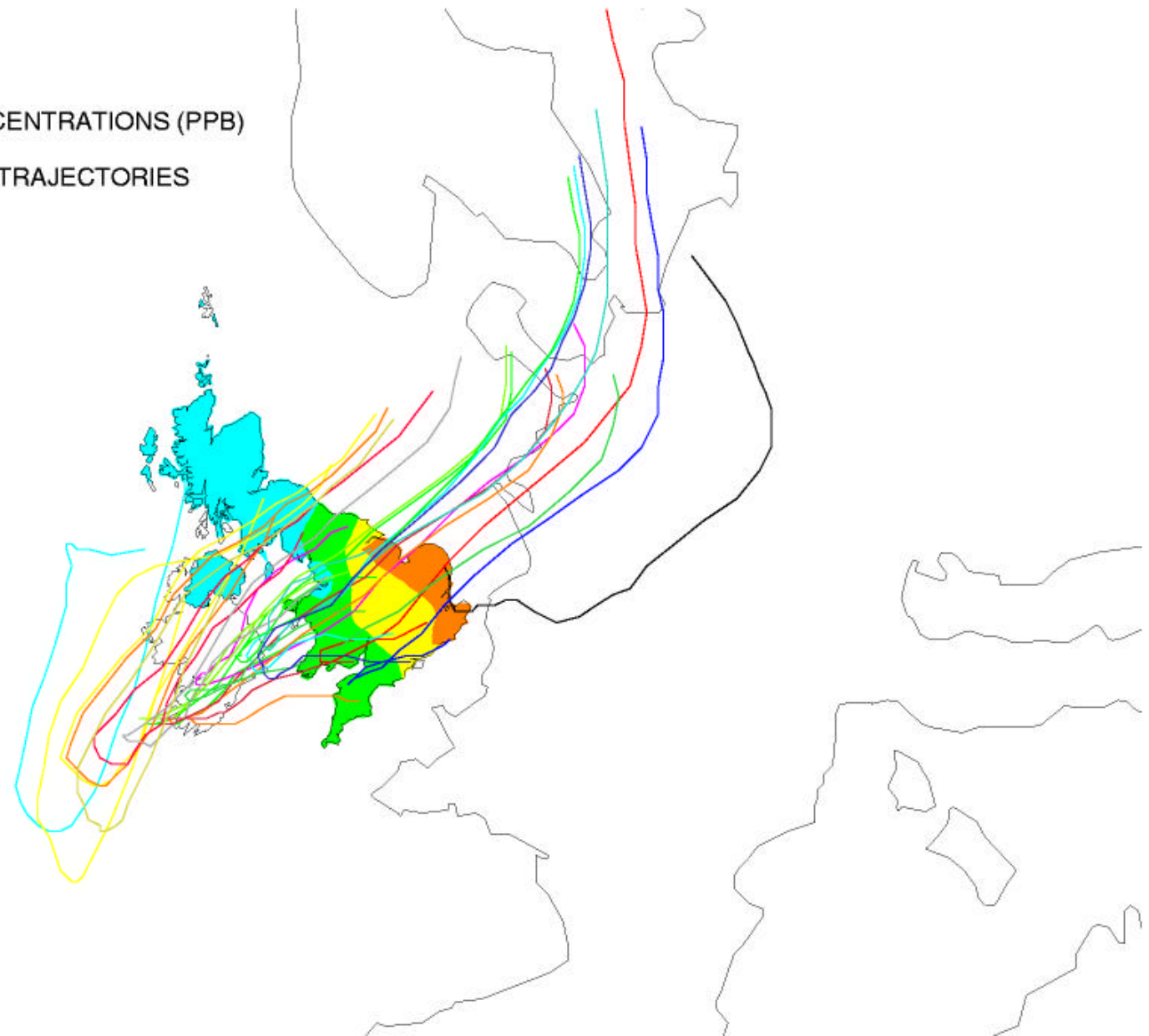
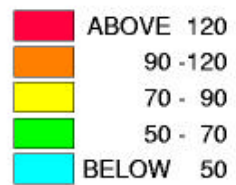
■ *Getting harder to forecast as peak concentrations decline:*

- *57 episodes across 7 regions in 1995*
- *3 episodes across 10 regions in 2000*
- *19 episodes across 10 regions in 2001*

Origins of episodes

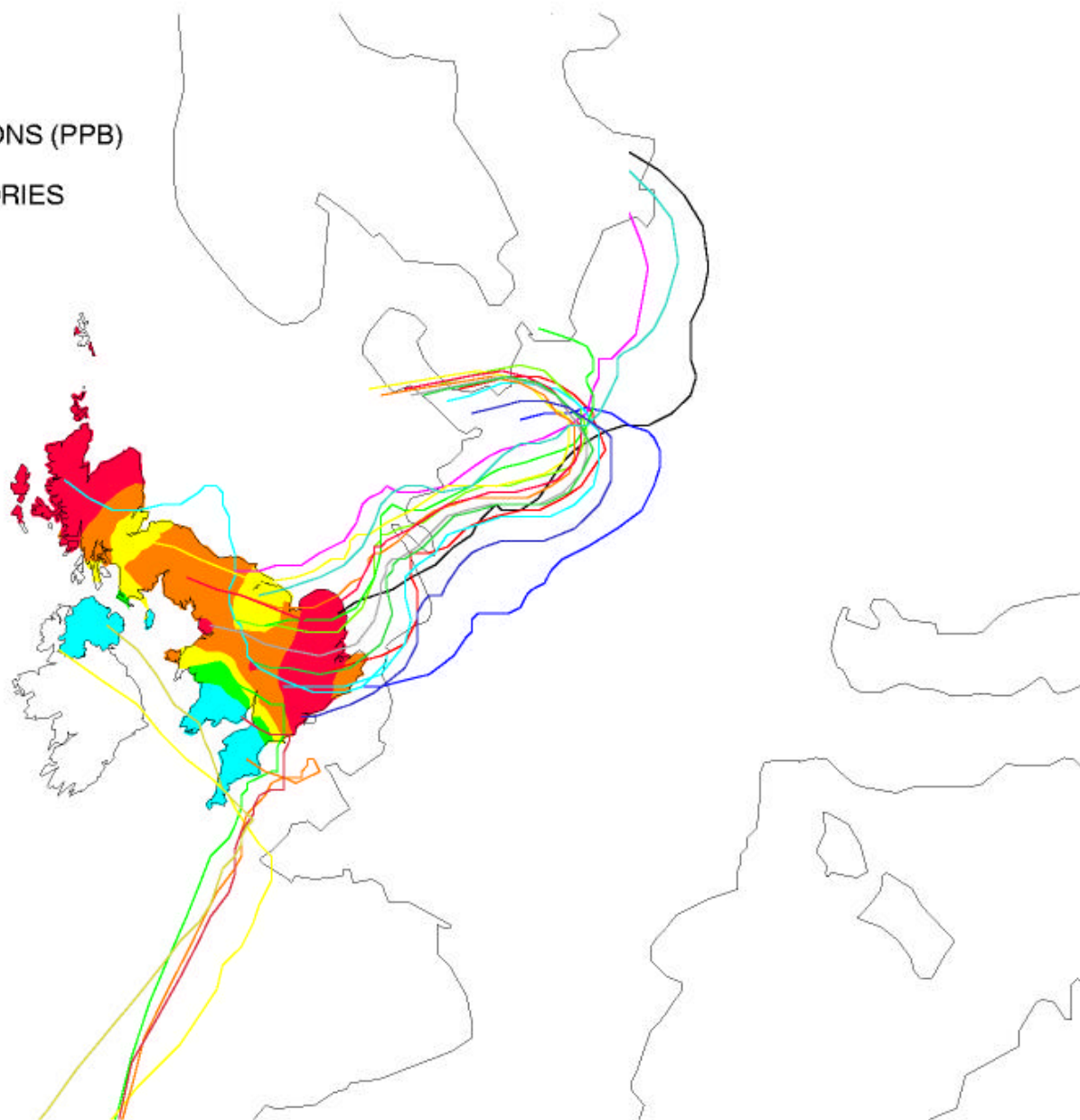
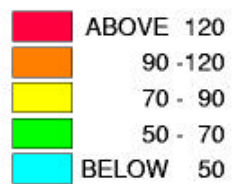
FORECAST OZONE CONCENTRATIONS (PPB)
AND ASSOCIATED BACK TRAJECTORIES

09/08/1997 1200



FORECAST OZONE CONCENTRATIONS (PPB)
AND ASSOCIATED BACK TRAJECTORIES

19/08/1997 1200



Origins of episodes

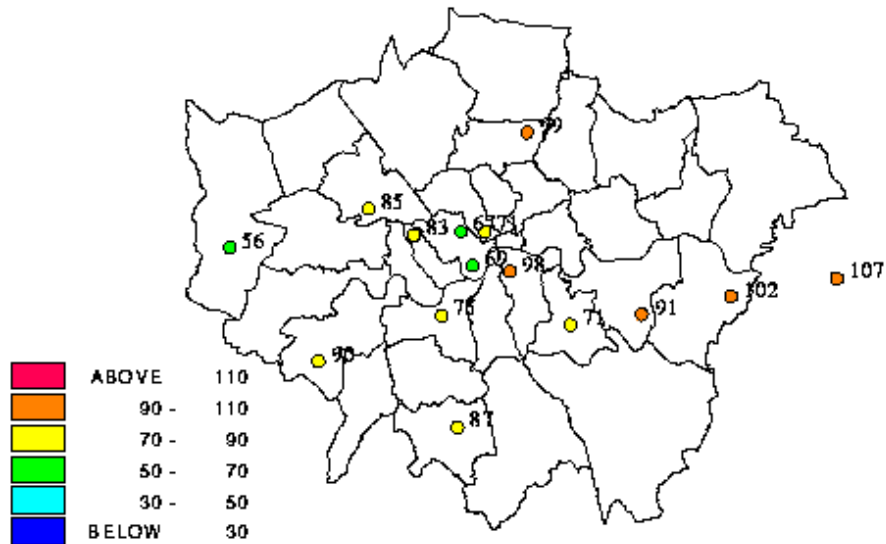
*Contributions to photochemical ozone episodes
estimated using ozone trajectory model (%):*

	<i>UK + Ireland</i>	<i>Europe</i>
<i>9 August 1997</i>	<i>80</i>	<i>20</i>
<i>19 August 1997</i>	<i>25</i>	<i>75</i>

Urban Areas

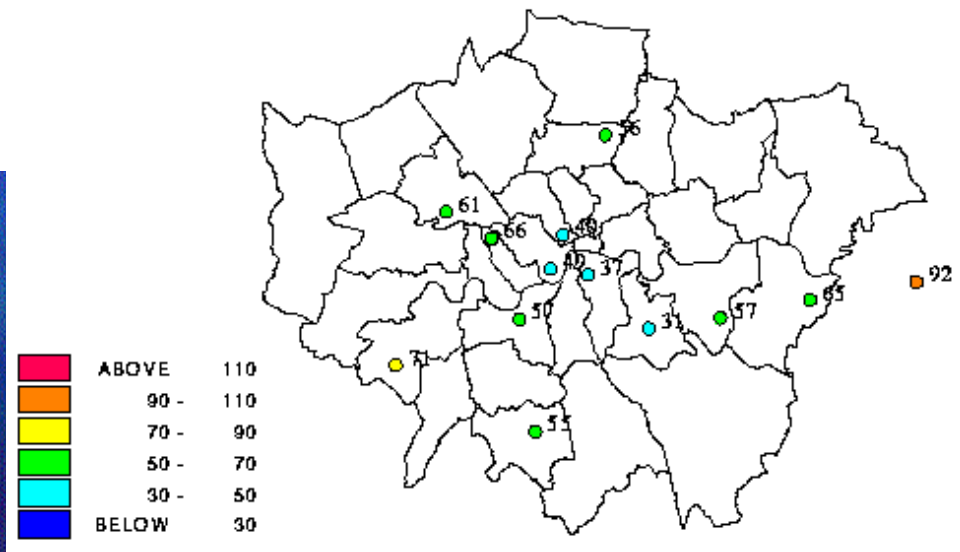
Daily maximum hourly average ozone concentration (ppb)
London, 10/08/97

Sunday

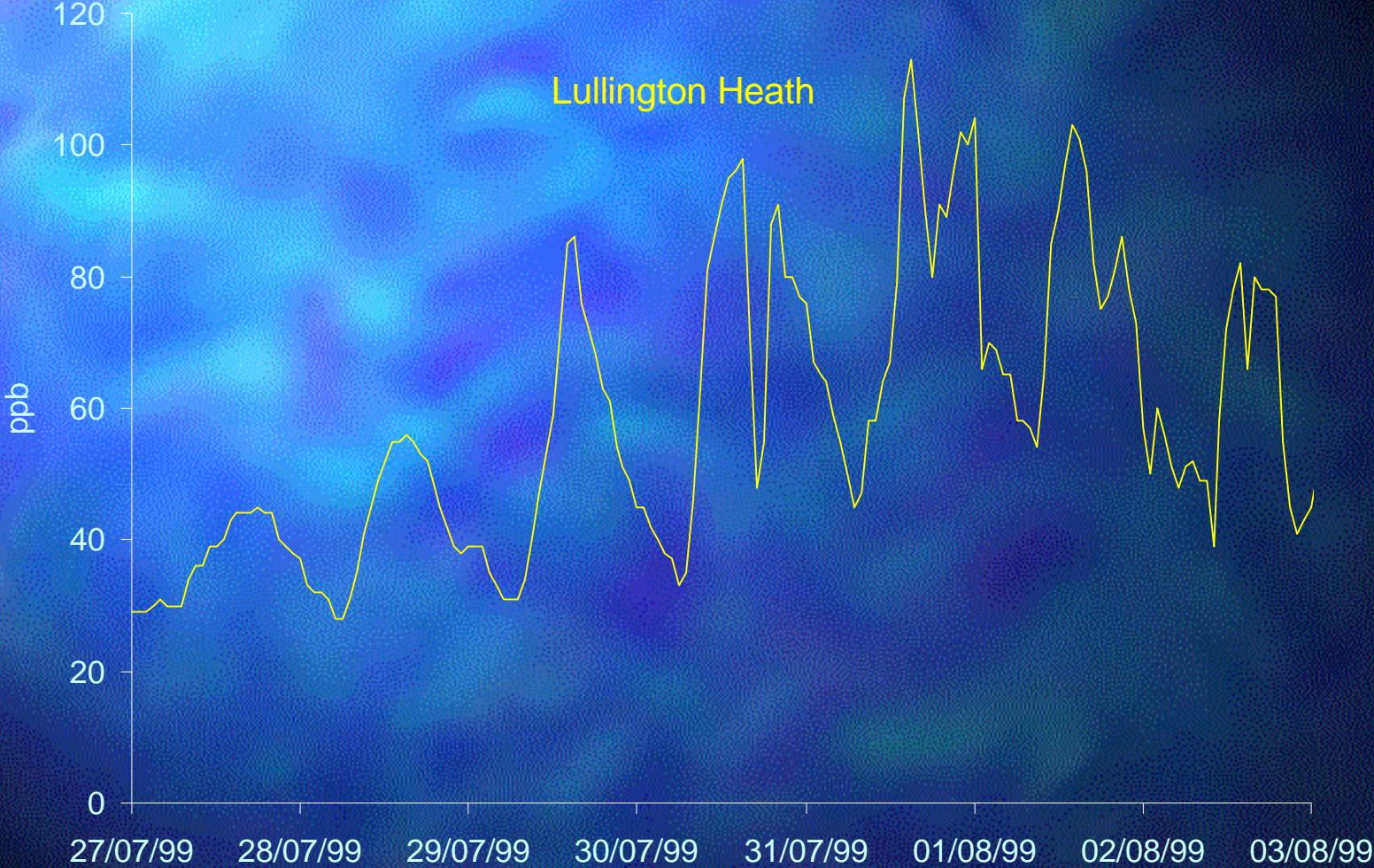


Daily maximum hourly average ozone concentration (ppb)
London, 11/08/97

Monday

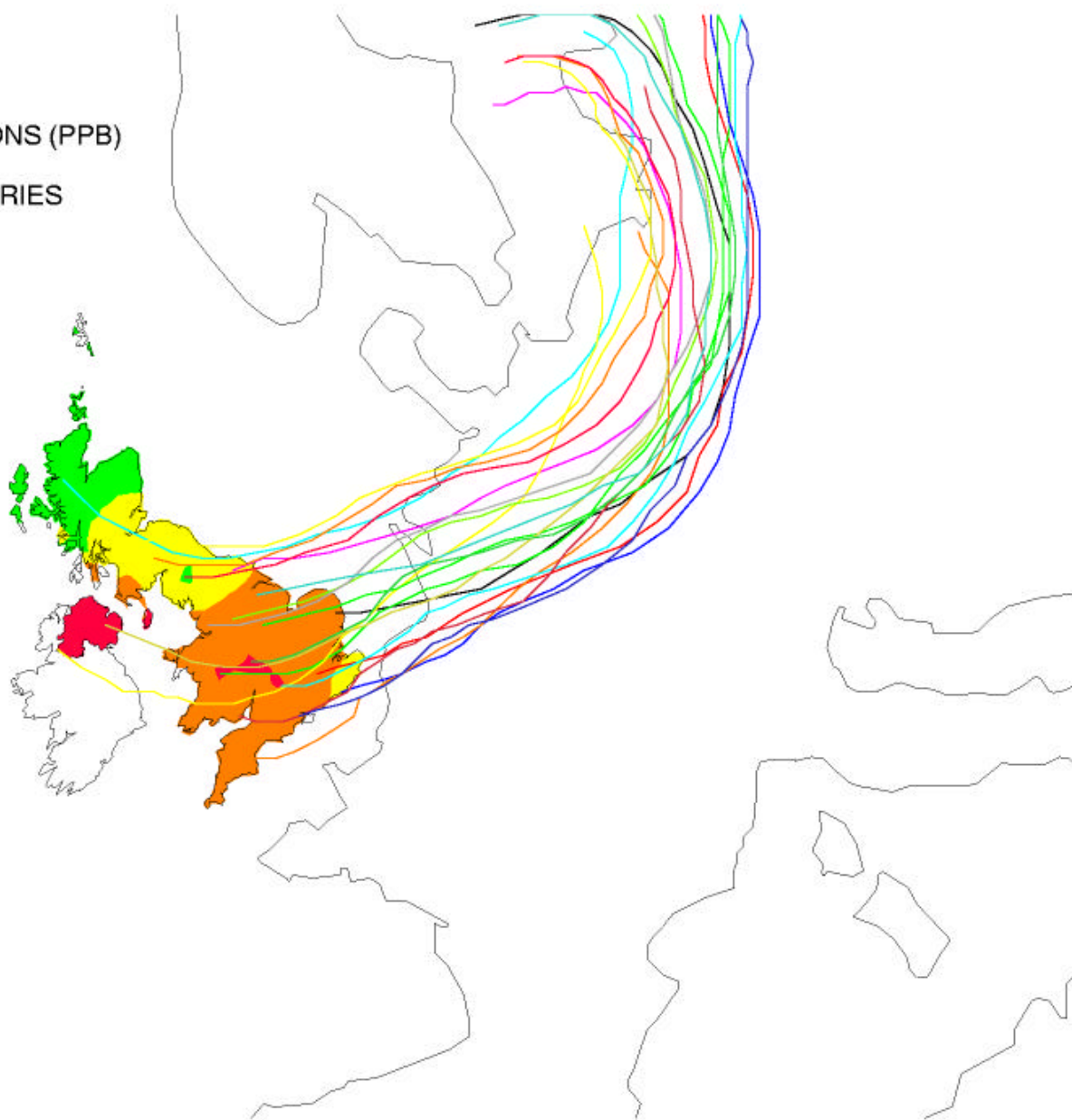
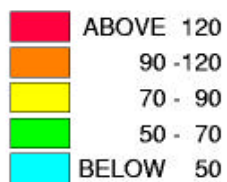


Day of the week



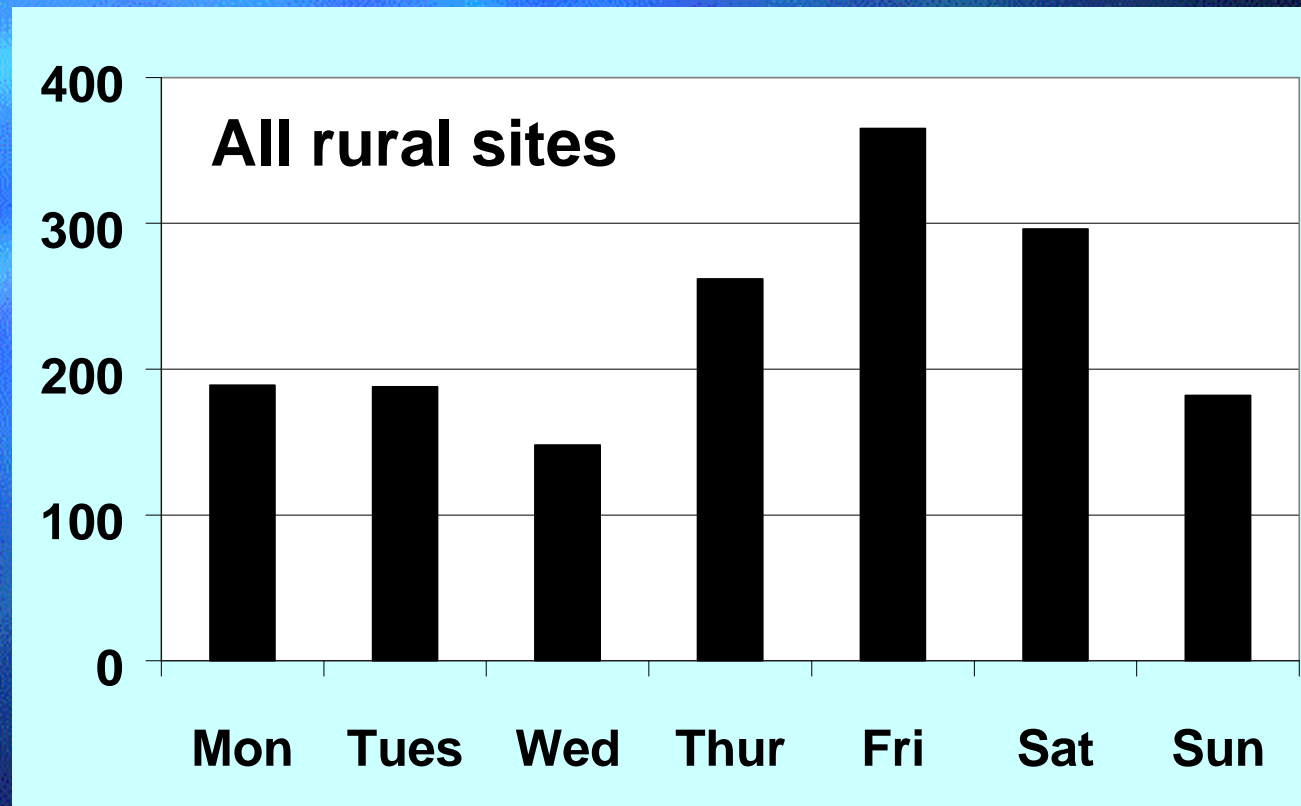
FORECAST OZONE CONCENTRATIONS (PPB)
AND ASSOCIATED BACK TRAJECTORIES

31/07/1999 1200



Day of the week

Number of hours with ozone greater than or equal to $180 \mu\text{g m}^{-3}$ (90 ppb) 1989 - 1999

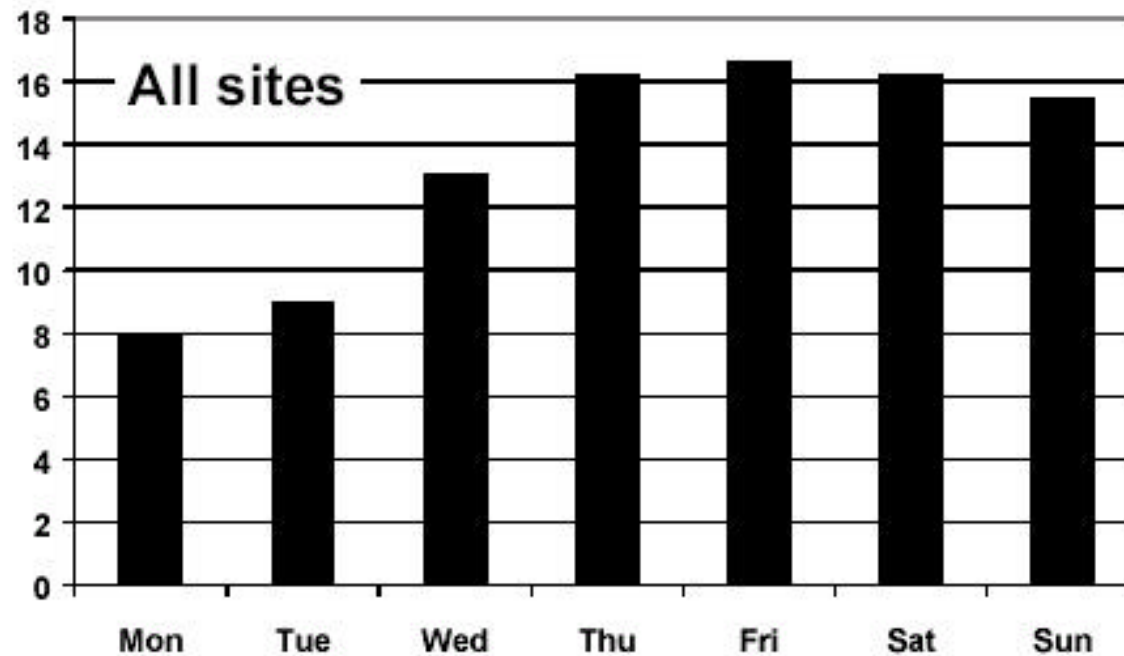


Day of the week

- *Emissions of ozone precursor chemicals from both traffic and industrial sources are reduced at the weekend*
- *Chemistry takes several days as air masses collect emissions and are transported 100s of km*
- *Time lag between weekend minimum of emissions and mid week minimum in peak concentrations ozone*

Day of the week

Variation of number of hours with ozone greater than or equal to 180 mgm^{-3} (90 ppb) calculated using a complex chemistry model for 31/07/1999 for different days of the week with time varying emissions



Cloud cover

- *Model assumes clear skies*
- *Therefore overestimates ozone concentrations when it is cloudy*
- *Currently testing a revision to the model which incorporates the forecast cloud amounts along the trajectory*

Recap

- *Ozone episodes: chemistry*
- *Forecasting ozone episodes*
- *The Ozone Trajectory Model*
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