



KING'S
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LONDON

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The Policy-Science Interface

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Workshop on current issues regarding nitrogen dioxide
Health Protection Agency 2-3 March 2011

Outline of talk

- **The nitrogen dioxide problem is an exercise in managing uncertainty – some general thoughts**
- **Talk will highlight regulatory gaps/deficiencies**
- **Reasons to control NO₂**
- **Emission controls**
- **Ambient levels and the Limit Values**

Uncertainty in the policy process

- Three areas of uncertainty of importance for the policy process
 - ***Uncertainty in the basic science*** – often regarding cause and effect; is there a real problem? Is it something we can control?
 - ***Uncertainty over the size of the effect*** – even the sign of the effect; how vigorous does the policy response need to be?
precautionary principle
 - ***Uncertainty in the policy evaluation/analysis*** – numerical uncertainty in models and projections; Cost-benefit analysis

Scale of importance

Basic science/ Cause and effect	∞ 0 or 1
Size of effect	10^n
Policy evaluation	+/- factor of 2 ?

Uncertainty over cause and effect

Are the associations between PM and health causal?

- UK Department of Health COMEAP report on Non-biological Particles and Health, 1995:
 -it would be *imprudent not* to regard the associations as causal...'

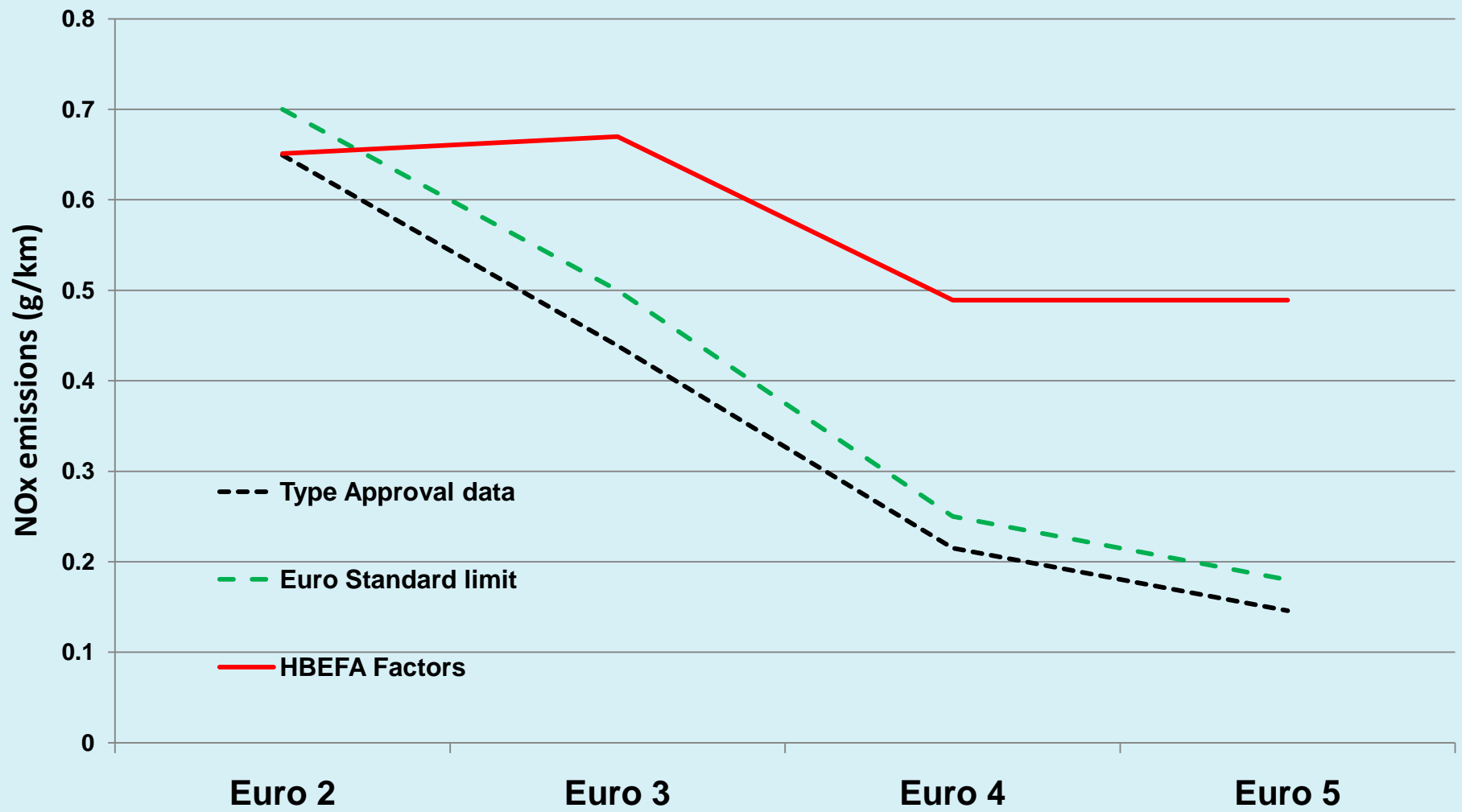
Is the changing climate related to the increase in greenhouse gas concentrations?

- **IPCC AR4 Summary for policy makers:**
 - *is very likely (more than 90%) due to the observed increase in anthropogenic greenhouse gases*

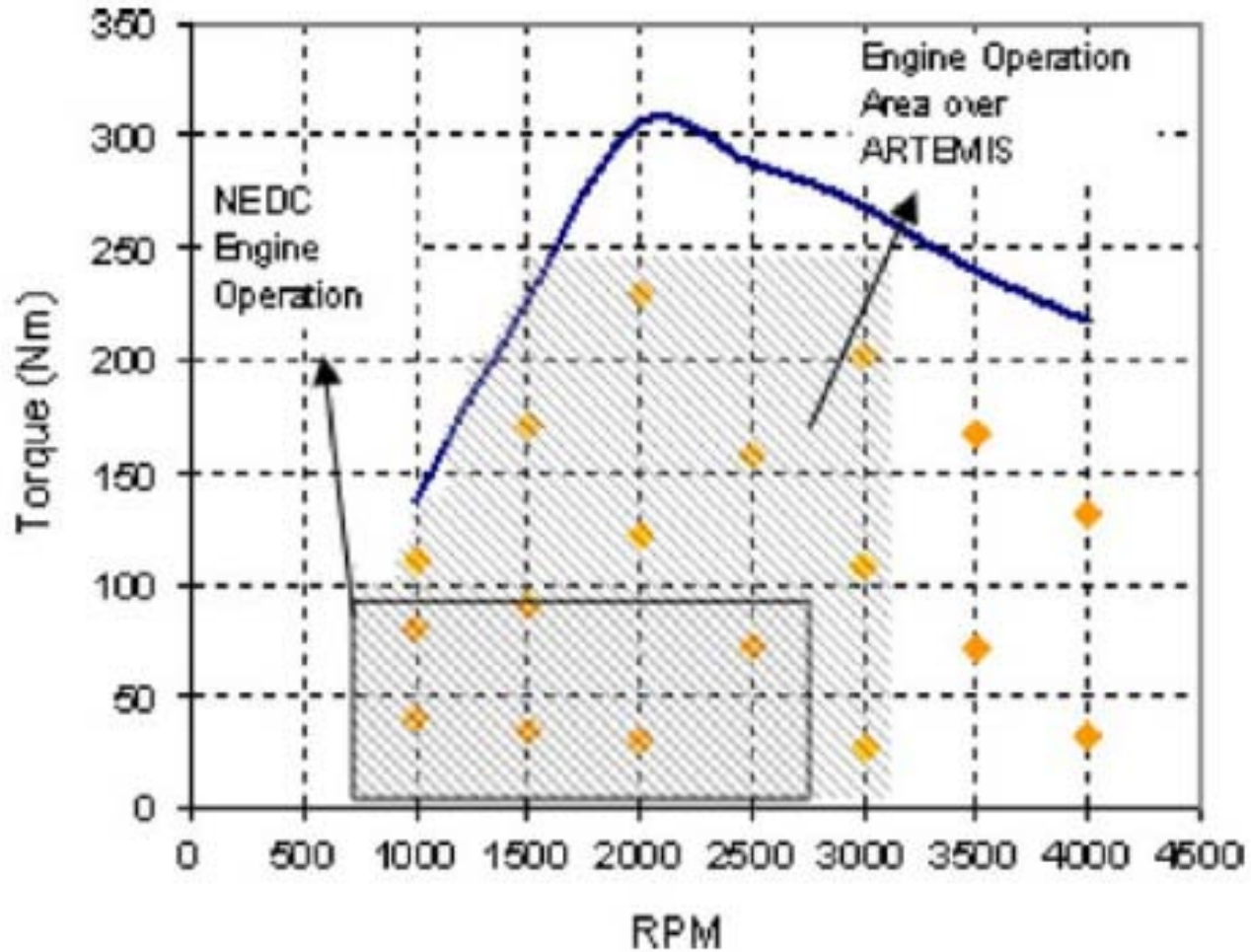
Reasons to control NO_x and NO_2

- There are good reasons to control NO_x & NO_2 in ambient air
 - Toxic
 - Precursor of ozone
 - Precursor of PM_x
 - Acidifying agent
 - Eutrophying agent

NO_x Emissions from diesel cars (g/km)



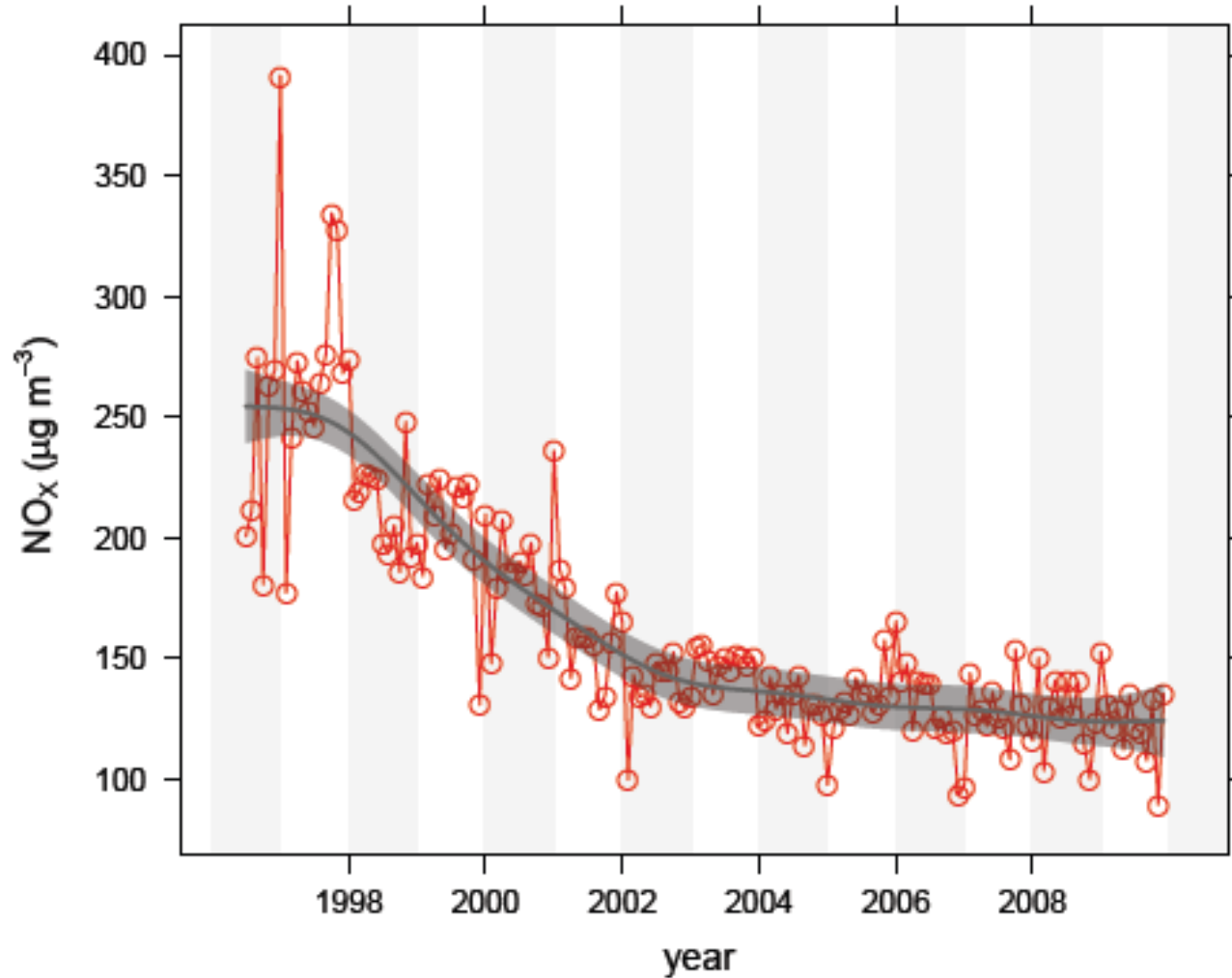
Why has this happened?



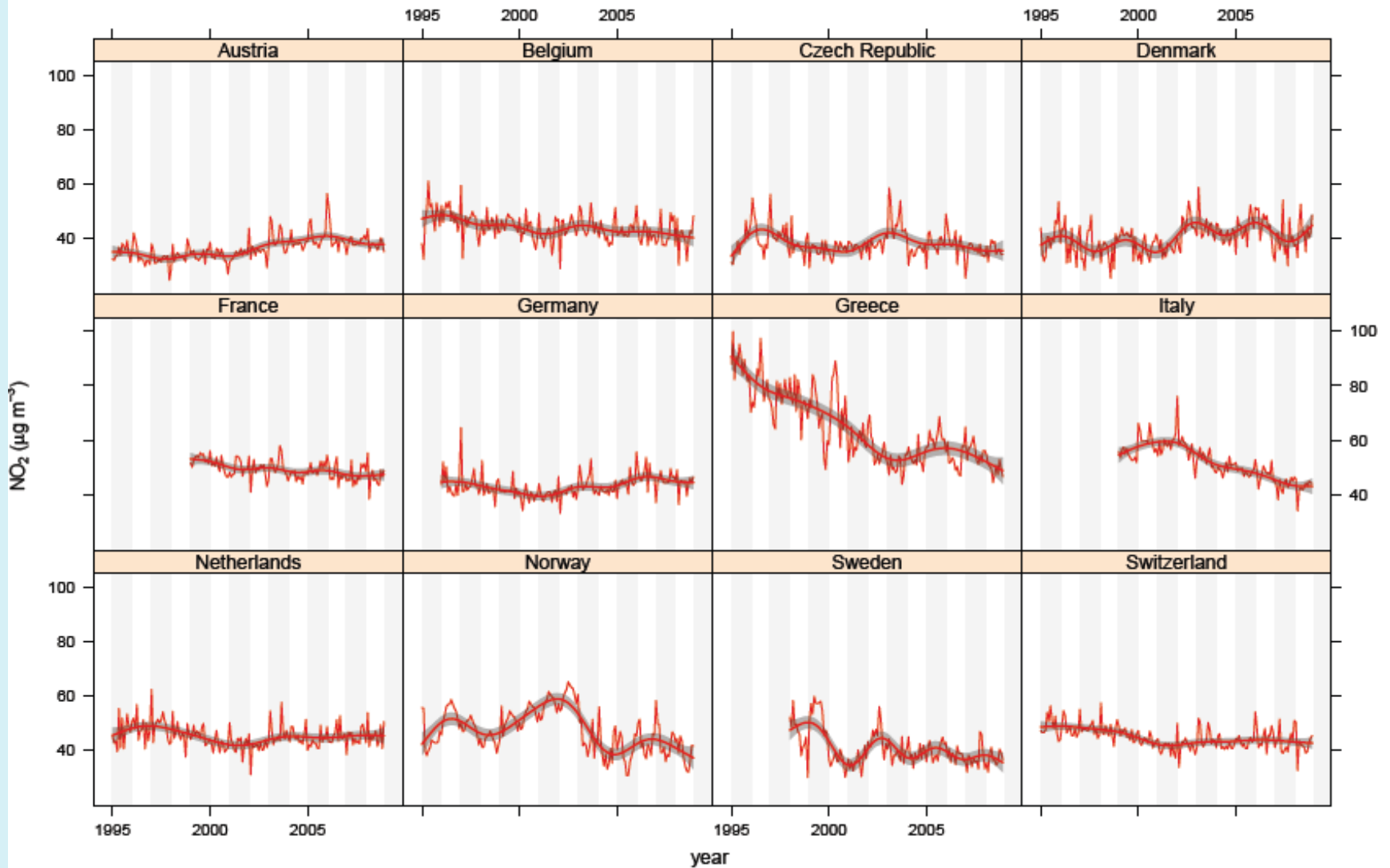
Policy message

- **The Euro standard regulatory test cycle is not adequate to reduce real world emissions of NO_x from diesel cars**
- **The revision currently taking place needs to be better**

Trend in NO_x at 12 long-running UK roadside sites



An EU-wide problem

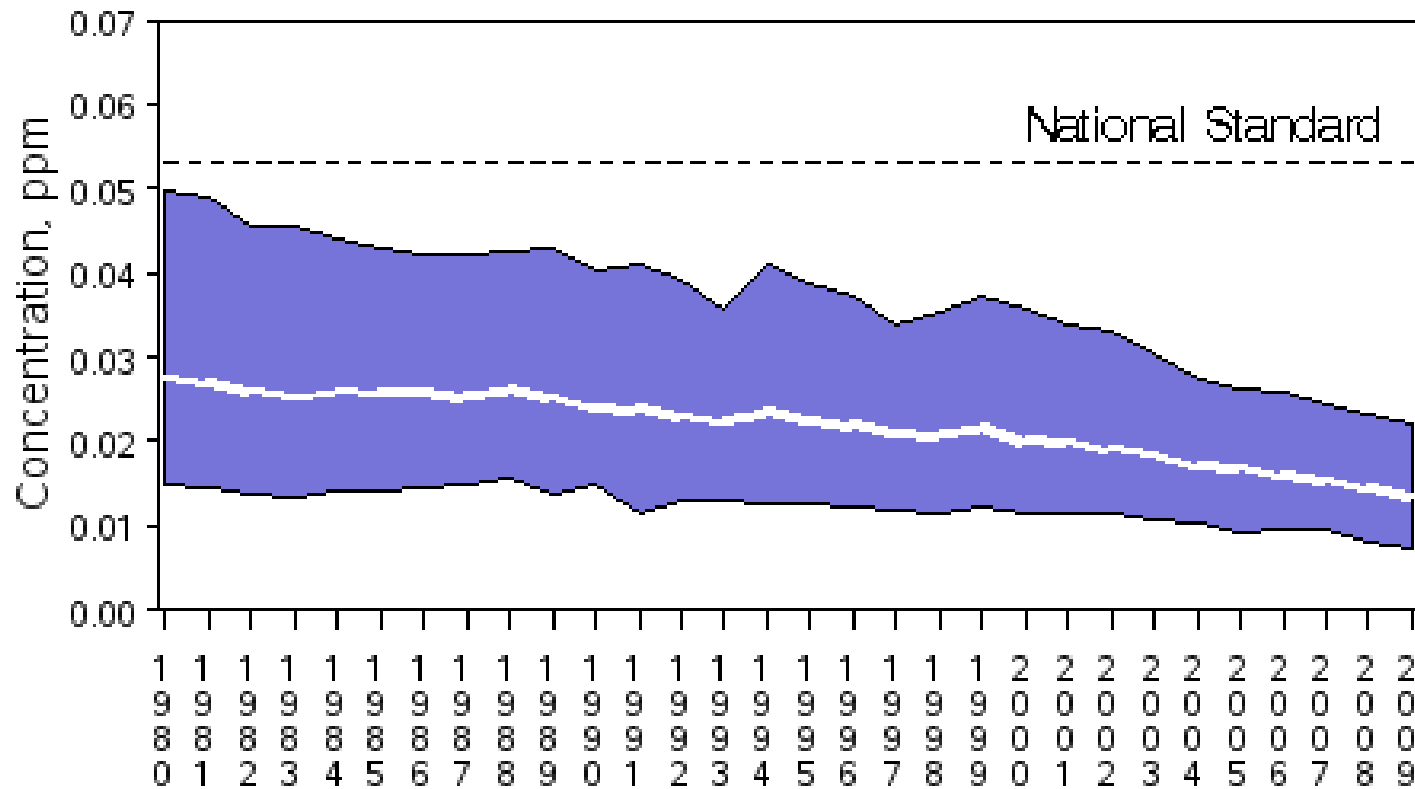


Trends are clearer in the USA

NO2 Air Quality, 1980 - 2009

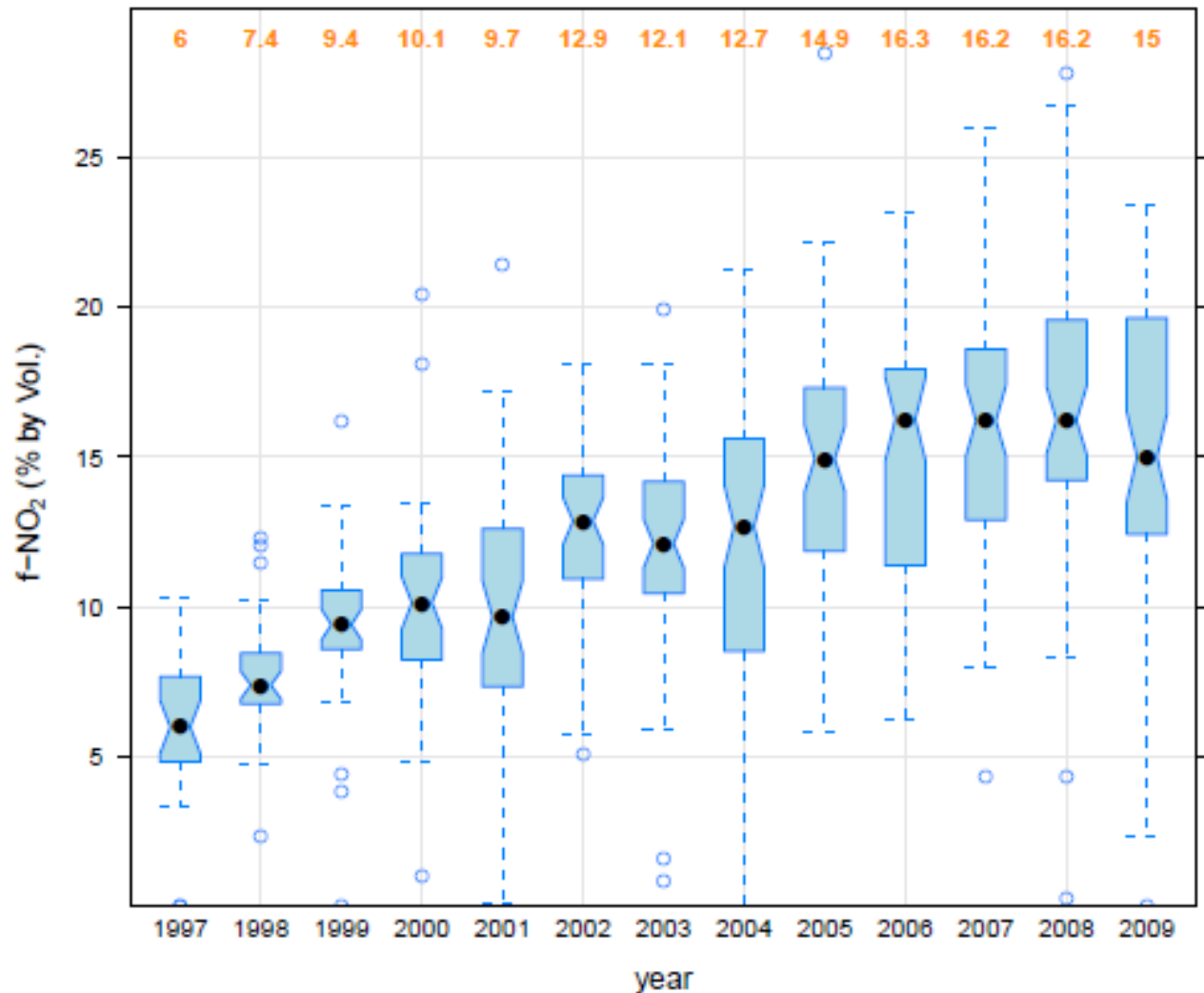
(Based on Annual Arithmetic Average)

National Trend based on 81 Sites



1980 to 2009 : 48% decrease in National Average

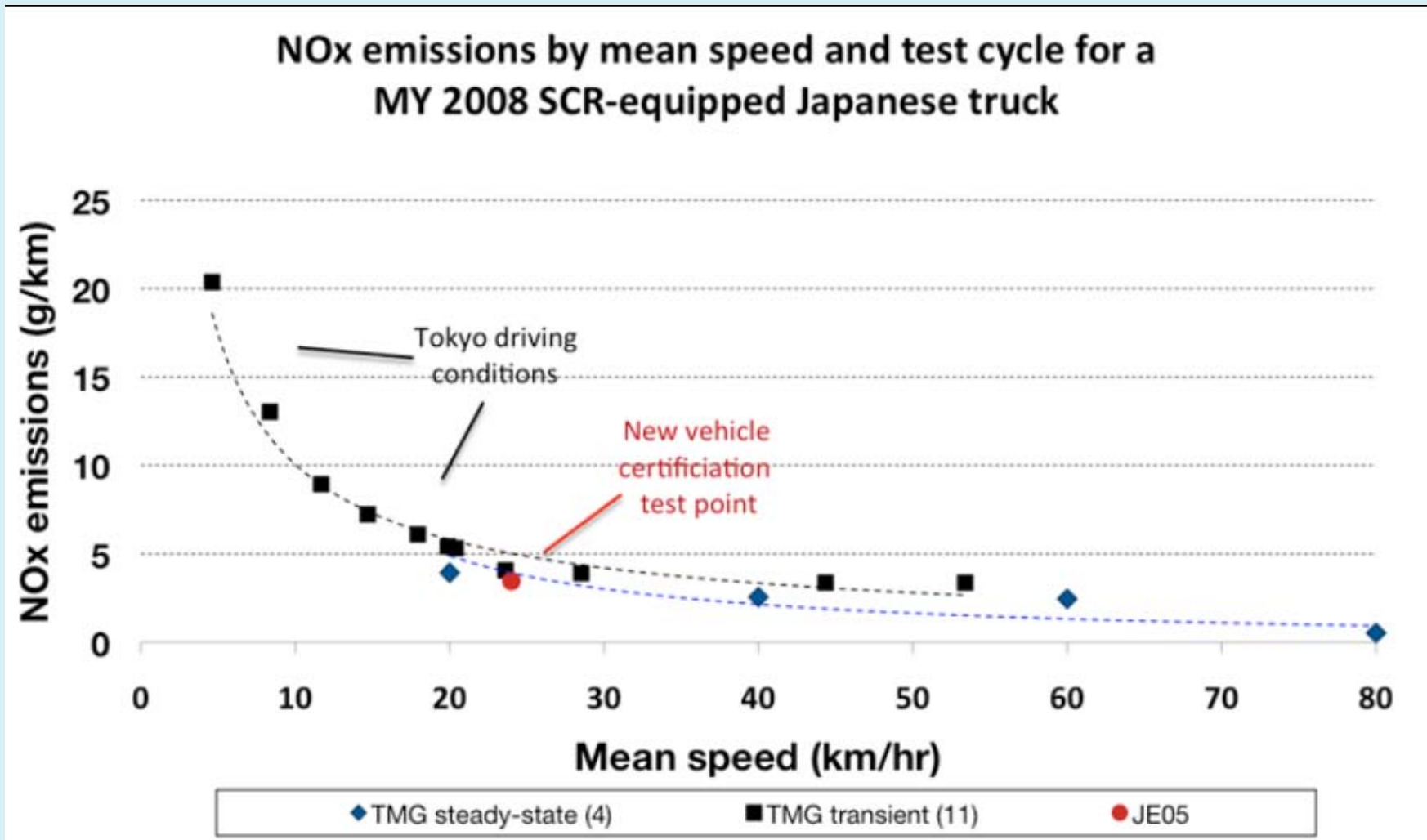
Primary emissions of NO₂ have increased



Policy message

- **Primary NO₂ emissions are not regulated in Europe; they are in California**, after an earlier standard was slackened.
- Comments from CARB:
- ‘..the maximum amount by which a **retrofit** may increase..NO₂ from a diesel engine will be 30%of the total baseline NO_x emissions.’
- ‘The new limits will result in higher NO₂ emissions from diesel engines than the current..limit.....Staff believes the benefits of avoiding hundreds of premature deaths due to continuing use of PM control devices that reduce PM emissions by up to 85% clearly outweigh the adverse impact of a relatively small increase in **ozone**’.

We have techniques to reduce NO_x & NO₂ but.....



NO₂, health and the Limit Values

- Annual LV based on WHO Guideline (2000)
- WHO Guideline used IPCS Environmental Health Criteria report (1997)
- Based on meta-analysis of 9 indoor studies
- 4 studies measured NO₂ by Palmes tubes
- 5 studies used ‘gas or electric stoves?’ as the only exposure measure
- “On the basis of a background level of 15 µg/m³ and the fact that significant adverse health effects occur with an additional level of 28.2 µg/m³ or more, an annual guideline of 40 µg/m³ is proposed.”

WHO, AQ Guidelines 2000

Although there is no particular study or set of studies that clearly support selection of a specific numerical value for an annual average guideline, the database nevertheless indicates a need to protect the public from chronic nitrogen dioxide exposure. For example, indoor air studies with a strong nitrogen dioxide source, such as gas stoves, suggest that an increment of about $30 \mu\text{g}/\text{m}^3$ (2-week average) is associated with a 20% increase in lower respiratory illness in children aged 5–12 years. However, the affected children had a pattern of indoor exposure that included peak exposures higher than those typically encountered outdoors. Thus the results cannot be readily extrapolated quantitatively to the outdoor situation. Outdoor epi-

WHO AQ Guidelines 2000 (2)

ide be established. Selecting a well supported value based on the studies reviewed has not been possible, but it has been noted that a prior review conducted for the Environmental Health Criteria document on nitrogen oxides recommended an annual value of $40 \mu\text{g}/\text{m}^3$ (5). In the absence of support for an alternative value, this figure is recognized as an air quality guideline.

Secretary of State for Transport statement to the House, 20 November 2001 following Inquiry report Heathrow Terminal 5

The inspector weighs all the benefits and costs very carefully. He says, and I use his words, that he has come to the clear conclusion that the benefits of terminal 5 would substantially outweigh the environmental impact, as long as its effects are properly controlled. I agree with him that terminal 5 should go ahead, but subject to conditions. I shall outline the key conditions to the House.

- If Terminal 5 is built the Inspector concluded that it would exacerbate the difficulties in meeting the objectives of the strategy which provide for minimum standards of air quality and could make them virtually impossible to achieve, although air quality would improve compared to the current position. This would count against Terminal 5.
- The Secretary of State generally accepted the Inspector's conclusions but considered he placed too little weight on the Government's obligation to comply with an EU Directive requiring improvements in air quality. He notes that even if Terminal 5 were not built measures will probably be necessary to meet the Directive's requirements around Heathrow and Terminal 5 would change that necessity only as a matter of degree.
- The Secretary of State reaffirmed the Government's intention to meet the requirements of the Directive and considered the Directive reinforces the case for a condition proposed by the Inspector requiring BAA to produce and keep under review an action plan showing how they intend to minimise emissions attributable to Heathrow.

The EU CAFE process asked WHO ‘What is the basis for maintaining the WHO annual specific guideline for NO₂?’

- **WHO response :**

- “Uncertainty remains over the significance of NO₂ as a pollutant with a direct impact on human health at current ambient air concentrations in the European Union, and there is *still no firm basis for selecting a particular concentration as a long-term guideline for NO₂.*”
- “In recent studies....NO₂ has been associated with adverse effects even when the annual mean is within a range that includes 40µg/m³. However we are unable to establish an alternative AQG from these studies. We therefore recommend that the WHO AQG should be retained or lowered.”

- WHO further response:
 - “We have been asked to comment on our confidence in this guideline. Our reply is that it remains ***difficult to provide solid scientific support for the numerical value of the guideline. There still is no robust basis for setting an annual average guideline value for NO₂*** through any direct toxic effect.”

WHO Global Update 2005

- “In population studies, NO₂ has been associated with adverse health effects even when the annual average concentration complied with the WHO annual average guideline of 40 µg/m³.”
- “These results (with indoor studies) suggest a lowering of the annual average guideline.”
- “However since NO₂ is...highly correlated with other primary and secondary combustion products, it is unclear to what extent the health effects observed in epi studies are attributable to NO₂ itself or to other correlated pollutants.”

The US Federal Approach to NO₂

- The Primary National Ambient Air Quality Standard was first **set in 1971** as an annual average
- In two subsequent reviews it has **not been changed**
- It is considerably less stringent than the EU/WHO value at 101 µg/m³ (in US law it is 0.053ppm; conversion at 20C)
- On 22 January 2010 the EPA introduced an hourly standard of 100ppb assessed as the 3-year average of the 98th %ile of hourly values
- Numerically the same as the EU/WHO hourly LV but less stringent (EU LV allows 18 hours exceedence – a 98th %ile of hours allows 175 exceedences)
- **But** US now require roadside monitoring to assess compliance.

US Integrated Science Assessment view on health evidence

- Strongest evidence from epi studies of respiratory symptoms, ED visits and hospital admissions
- Evidence supports direct effect of **short-term** NO₂ exposure on respiratory morbidity
- Evidence inadequate to infer presence or absence of causal relationship between morbidity & mortality effects from **long-term** NO₂ exposure
- Difficult to determine the extent to which NO₂ is independently associated with respiratory effects or if NO₂ is a marker

California

- California air quality is regulated at state level by the California Air Resources Board
- There is an **annual mean** standard of 0.03ppm or at 20C, **57 $\mu\text{g}/\text{m}^3$**
- There is an **hourly** standard of 0.18ppm or **343 $\mu\text{g}/\text{m}^3$**
(as an absolute standard, no percentiles)

So where are we now?

- Consensus over short-term effects. The policy process decides the percentiles
- We have an annual **guideline** framed with the appropriate scientific uncertainties – causality, indoor vs outdoor, size of effect, specificity
- While there is a broad consensus on standards for other pollutants (PM, O₃), there are wide discrepancies in standards for NO₂
- The policies we relied on to achieve NO_x reductions in urban areas have been inadequate
- We have no credible concentration-response relationships for most health outcomes

What can we do?

- Has the *regulatory/policy process* reflected this uncertainty adequately?
- How does it help the policy process to simply say that NO₂ is a marker for traffic pollution when we have a molecule-specific legal limit?
- Can we do better? How?
 - Spatial percentiles ? (analogous to temporal %iles?)
 - Different compliance date?
 - What more research? – to address the causality issue?

There are good reasons to control NO_x and NO_2

- **The question is, by how much and by when?!**