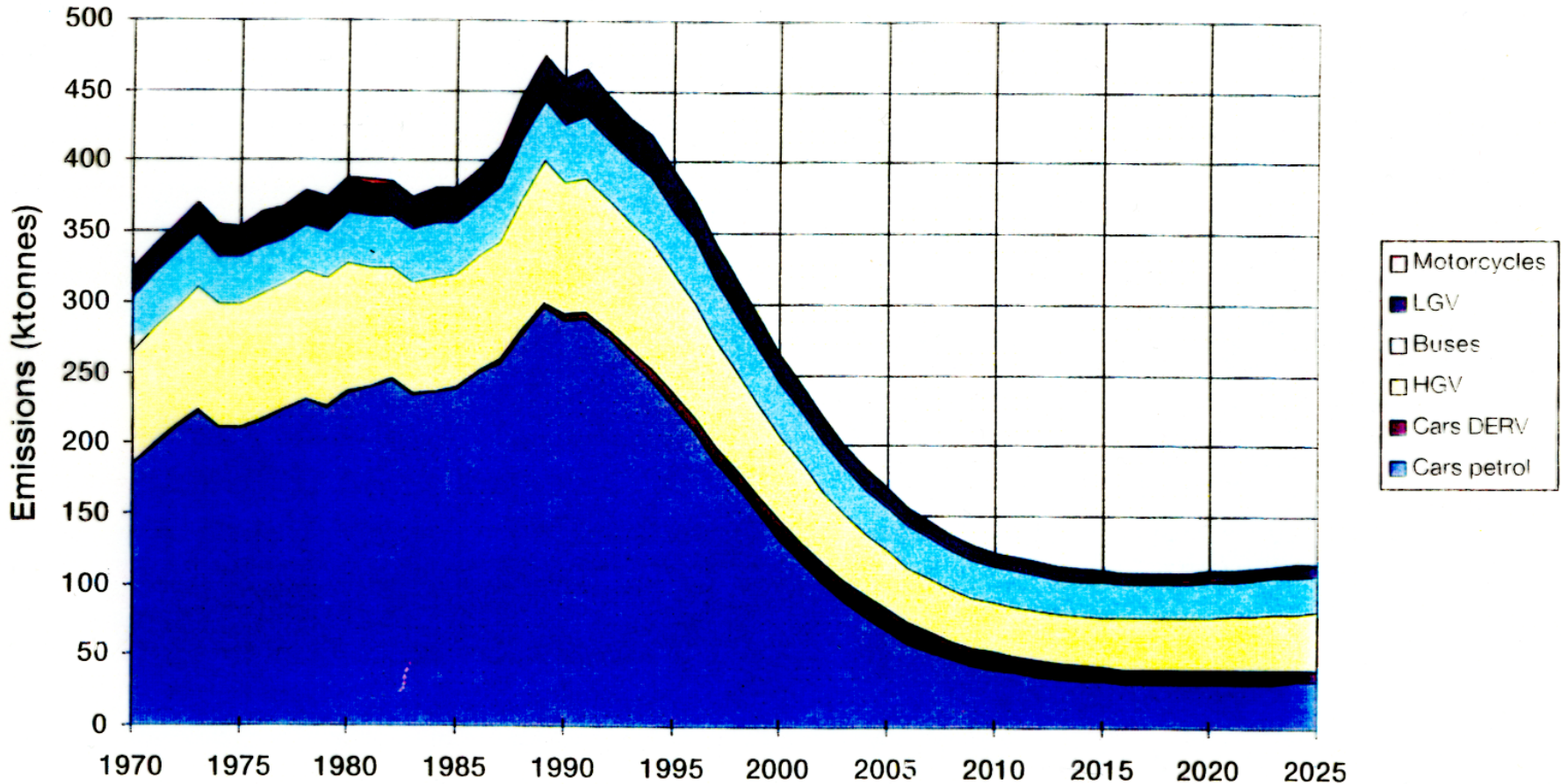


LOCAL AIR QUALITY MANAGEMENT

- **Nitrogen dioxide**
 - **in urban areas arises mainly from vehicle exhaust**
 - **secondary pollutant, not linearly related to NO_x emissions**
 - **annual mean objective is major problem for air quality management**
 - **changes in background ozone affect NO₂ concentrations**

UK ANNUAL URBAN ROAD TRANSPORT EMISSIONS OF NO_x, 1970-2025 (ktonnes)



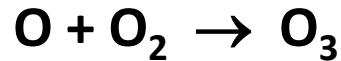
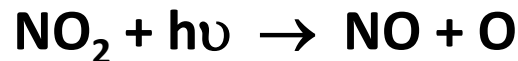
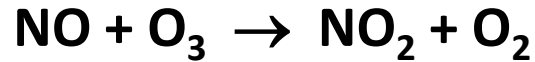
20% diesel car sales; Central 1997 NRTF; Assumes Euro III emission reductions for all new vehicles in 2001, EURO IV reductions for cars, LGVs only in 2006; Fuel standards reduce emissions in 2000 & 2006 for all vehicles

THE PROBLEM WITH NITROGEN DIOXIDE

- Nitrogen dioxide is a secondary pollutant and will not reduce as rapidly as precursor emissions of NO_x decline.
- Emissions of primary NO_2 appear to be increasing and secondary NO_2 is formed by reaction of primary NO_x emissions with ozone.
- Increases in the background ozone concentration will lead to production of more nitrogen dioxide, so concentrations may not decline at all.
- The National Air Quality Strategy objective for nitrogen dioxide of $40\mu\text{g m}^{-3}$ is widely exceeded at heavily trafficked locations currently.

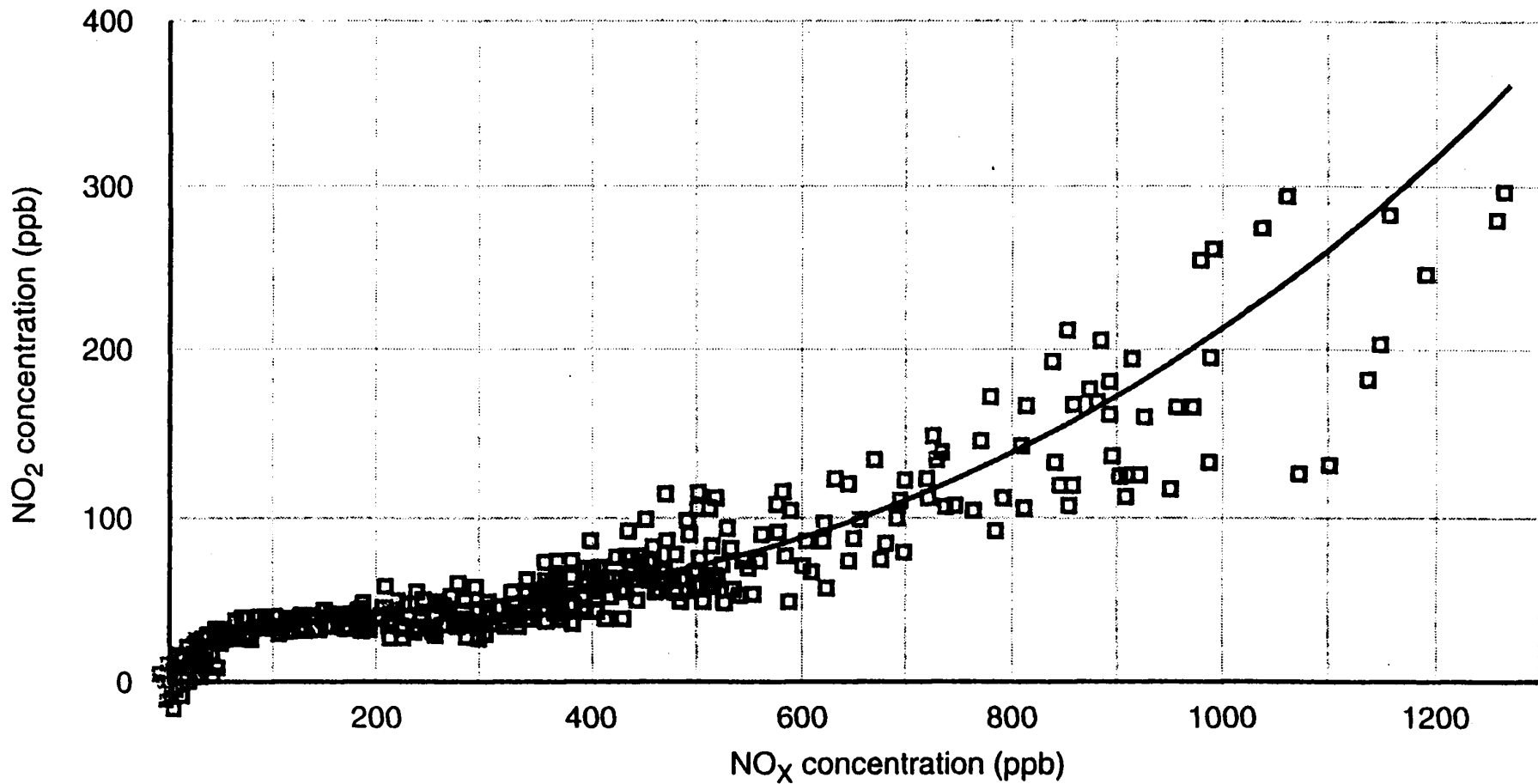
A SHORT TUTORIAL IN NO_x-OZONE CHEMISTRY

- Emissions of NO_x from combustion sources are typically 95% NO and 5% NO₂ (the more harmful substance)
- Conversion of NO to NO₂ occurs primarily by reaction with ozone, although this is partially reversible in sunlight



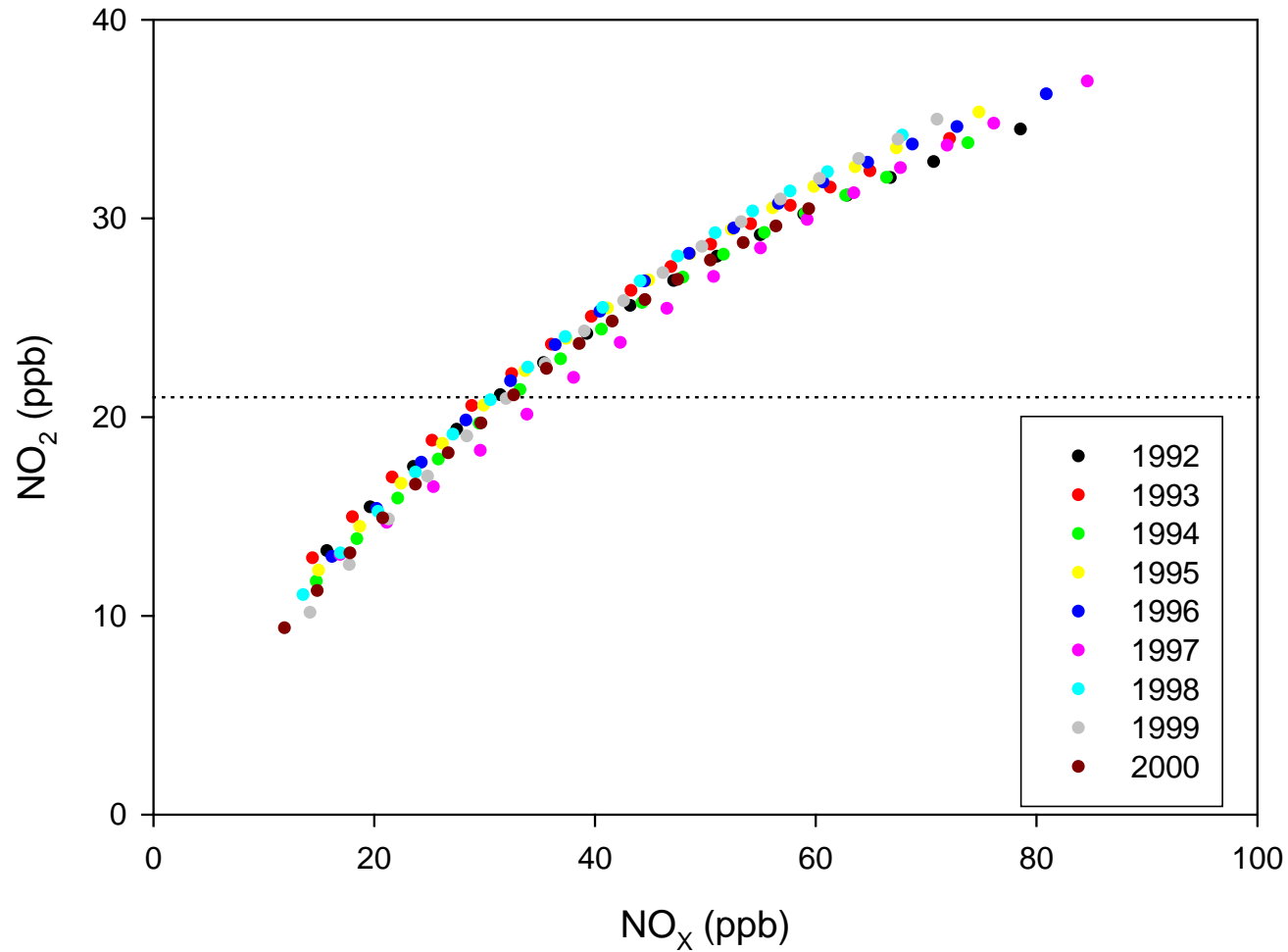
- Urban concentrations of NO_x can far exceed those of ozone in the background air, and the process of NO₂ production is then oxidant-limited
- An increase in the 5% of primary emitted NO₂ will lead to increased NO₂ in air
- Cutting NO_x emissions when NO₂ formation is oxidant-limited will have little effect on NO₂ concentrations

Relationship between Hourly Mean NO_2 and NO_x Concentrations



Note: Measurements taken 20th May 1991- 30th June 1992 in Exhibition Road, London.

ANNUAL MEAN NO_x VS. NO_2 (1992-2000) DERIVED USING THE ERG APPROACH



SOURCE: ENVIRONMENTAL RESEARCH GROUP, KINGS COLLEGE, LONDON

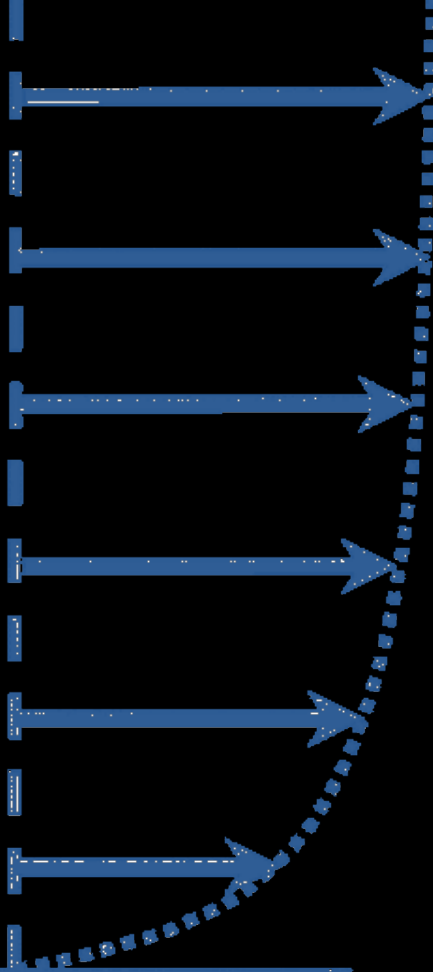
NITROGEN DIOXIDE

Abatement measures:

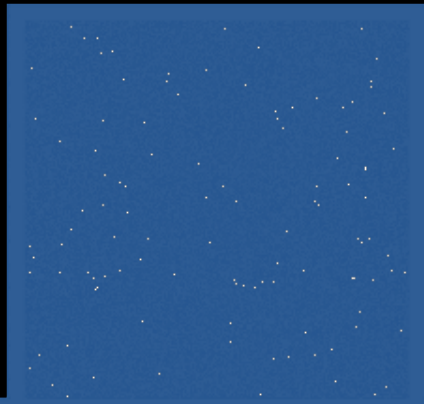
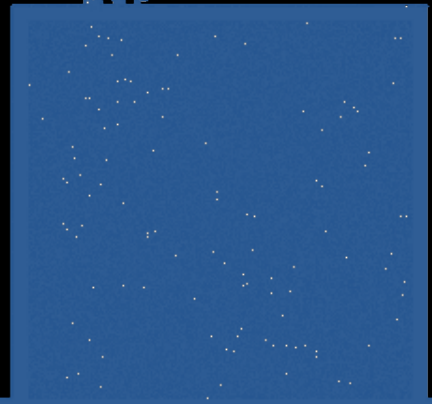
1. Reduce all NO_x emissions
2. Reduce NO_2/NO_x ratio in primary emissions
3. Reduce background ozone

Where is the NO_2 problem worst?

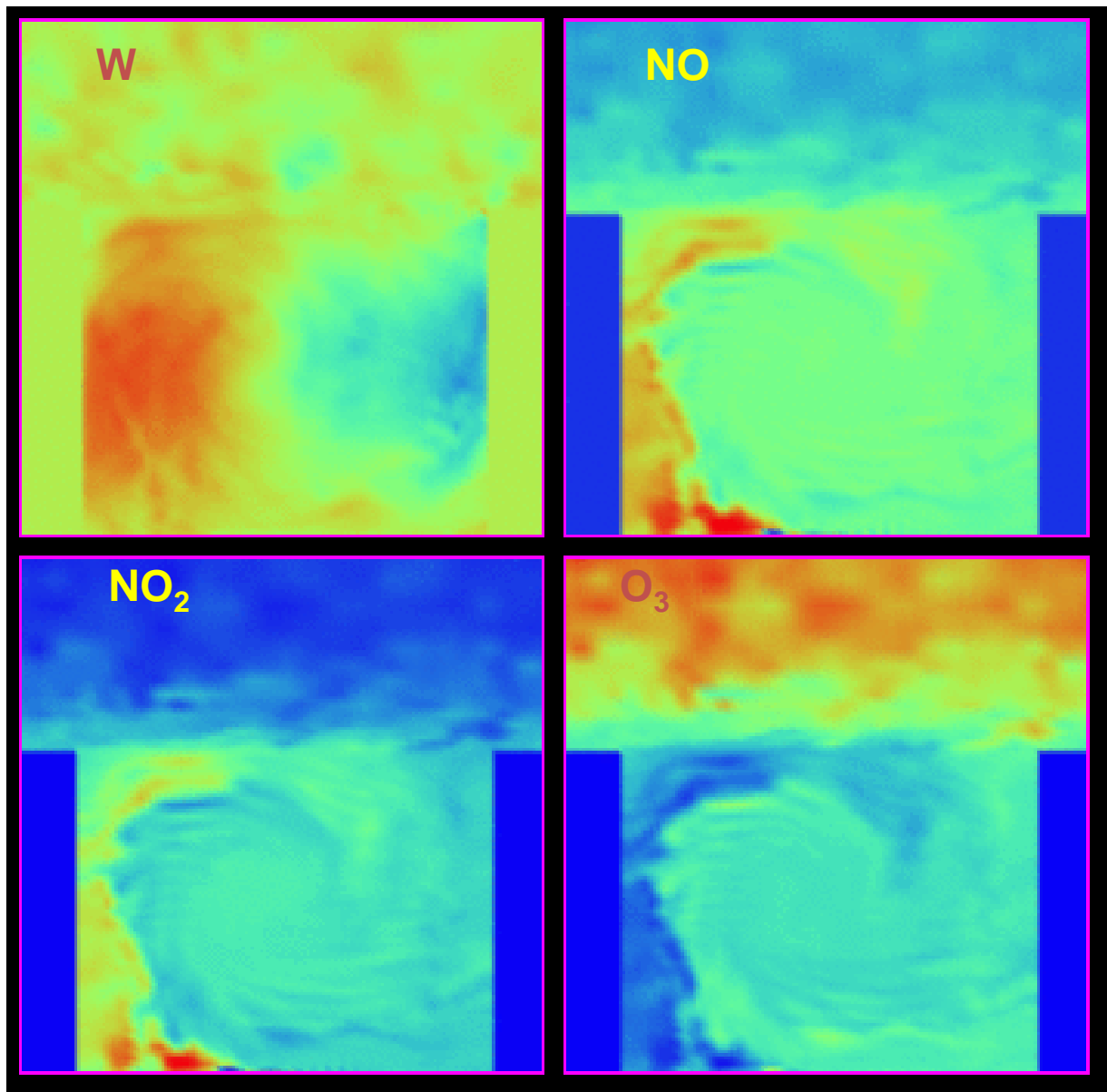
- In street canyons

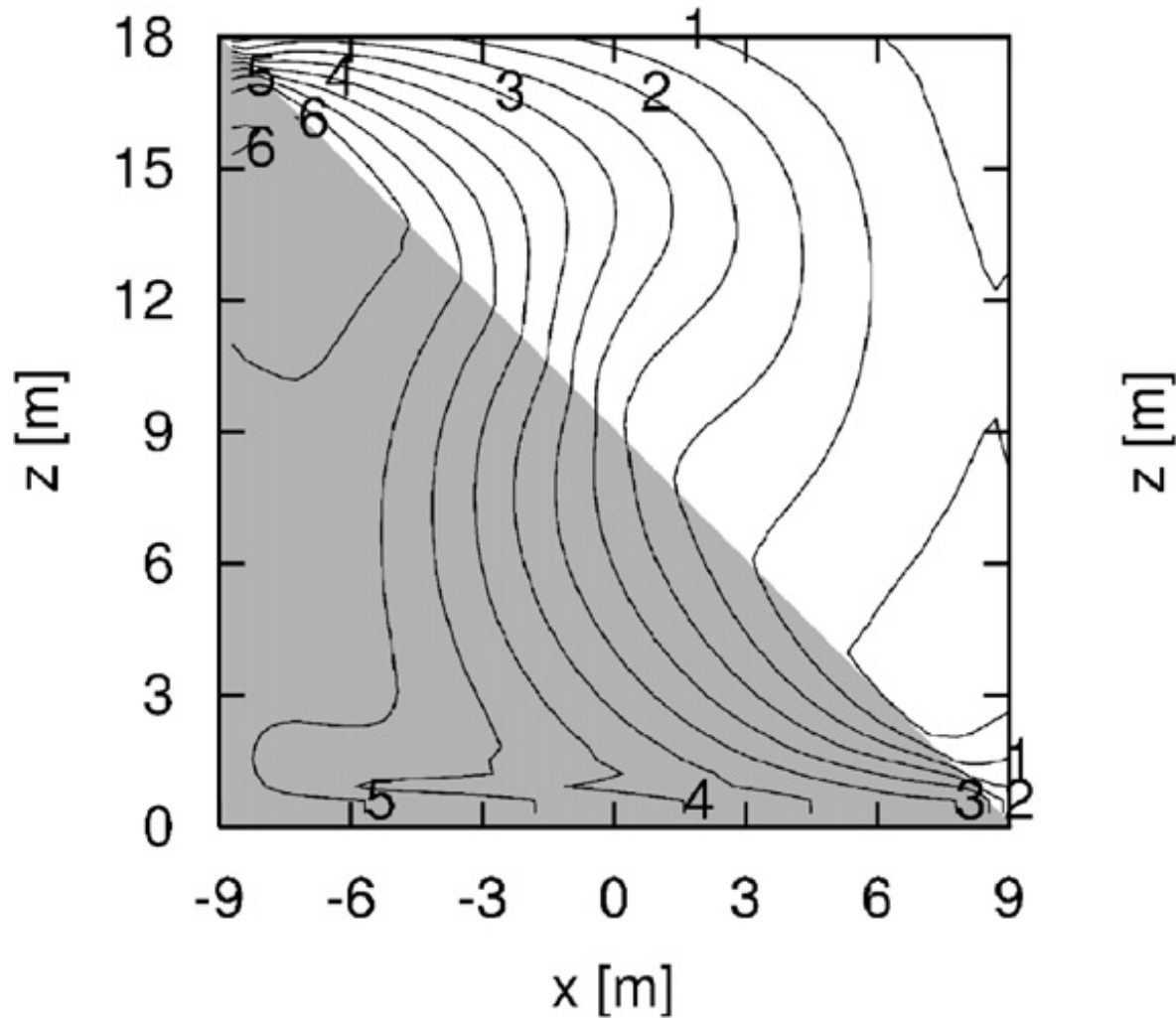


$H=W=18\text{m}$
 $dx=dz=0.3\text{m}, dy=1\text{m}$
 $dz(\text{max})=5\text{m}$
 $Lx=36\text{m}, Ly=40\text{m}$
 $Lz=90\text{m}$



LES of NO_x - O_3 in a street canyon





Influence of shading of street canyon upon nitrogen dioxide concentrations (isopleths in ppb).

From: D. Grawe, X.-M. Cai and R.M. Harrison, *Atmos. Environ.*, 41, 7304-7313 (2007).