Modelling road tunnels using ADMS-Urban: implementation and validation

Christina Hood

UK-US meeting on Air-Quality Modelling and Exposure Science

29th September 2016

Kings College London

Contents

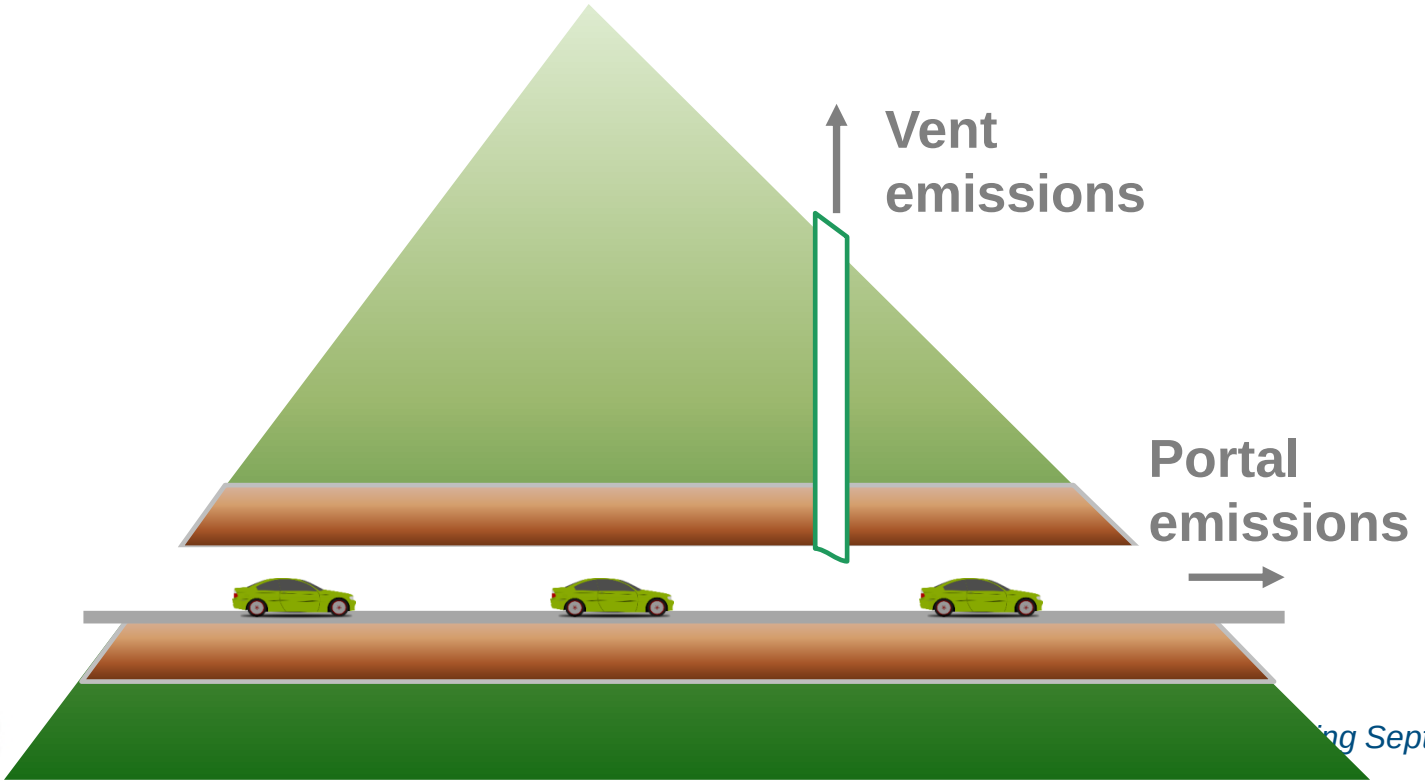
- Background to road tunnel modelling
- Modelling concept
- Model implementation
  - Tunnel portals
  - Tunnel vents
  - Limitations
  - Sample run
- Validation
  - Bell Common (M25)
- Summary

Background to road tunnel modelling

- Road tunnels are used for:
  - Reducing traffic congestion
  - Crossing difficult terrain (mountains, rivers)
  - Moving air pollution and noise from traffic away from sensitive areas

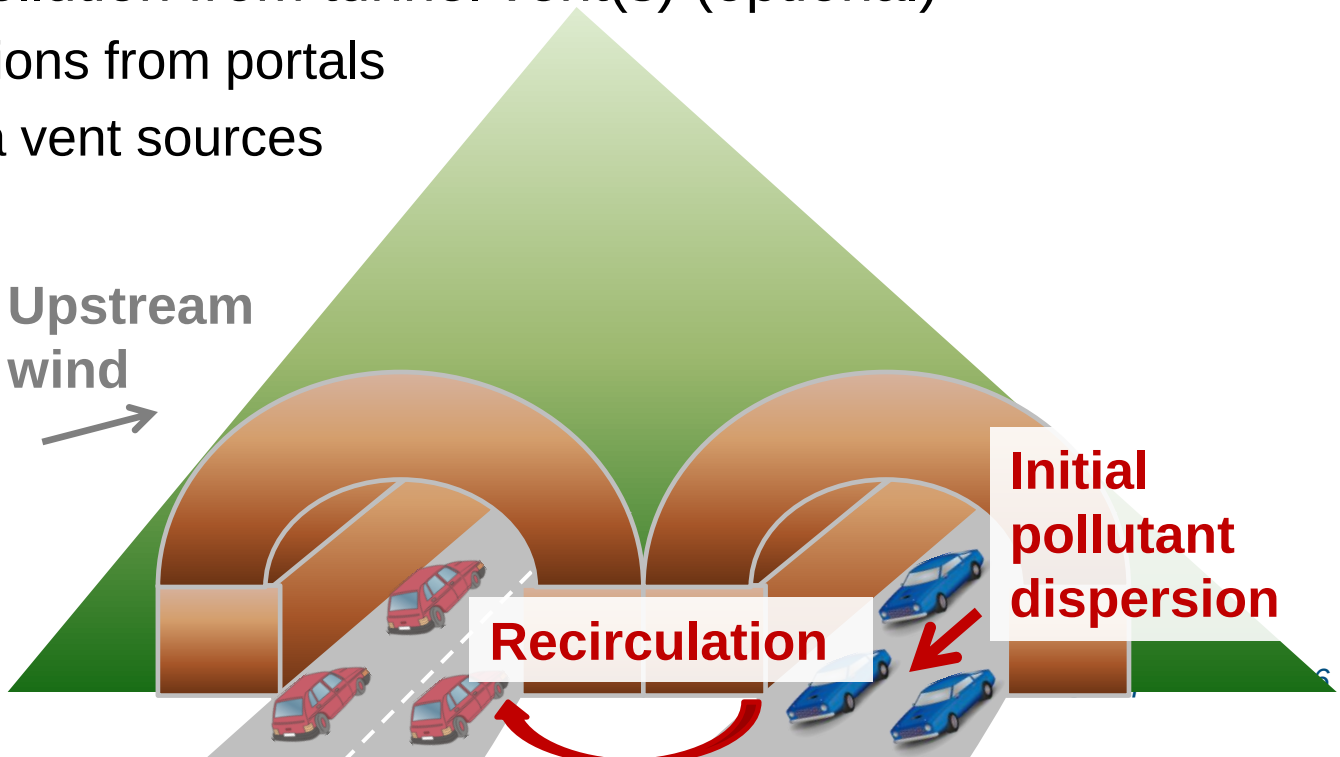
Background to road tunnel modelling

- Air quality implications of road tunnels include:
  - Poor air quality within the tunnel
  - Poor air quality near tunnel portals
  - Good air quality above the tunnel
- Additional tunnel ventilation may reduce negative effects



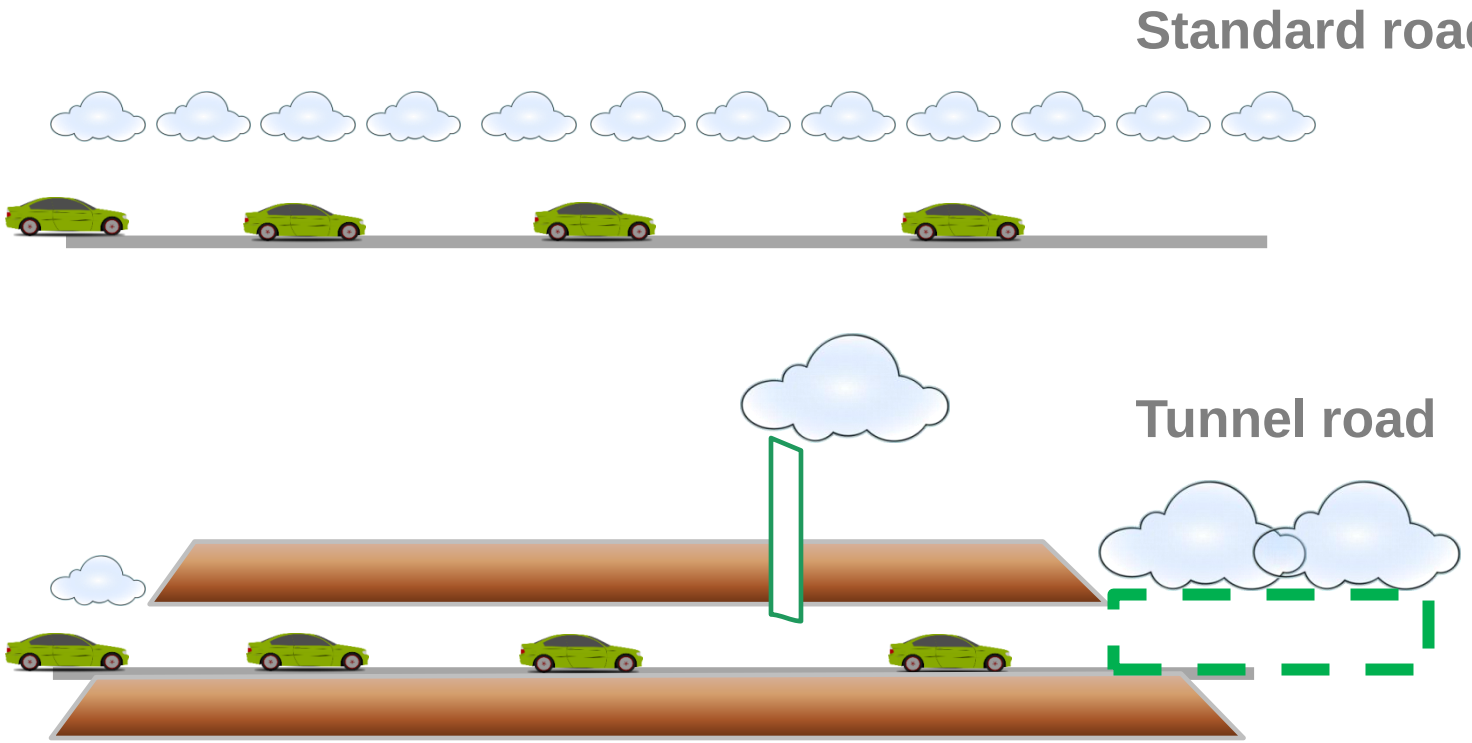
Modelling concept

- Model the effects of the tunnel on the surrounding area, **not** the air quality within the tunnel
- Emission of pollution from the tunnel portal(s)
  - in the direction of traffic flow
  - following traffic along an outflow road
- Emission of pollution from tunnel vent(s) (optional)
  - divert emissions from portals
  - point or area vent sources



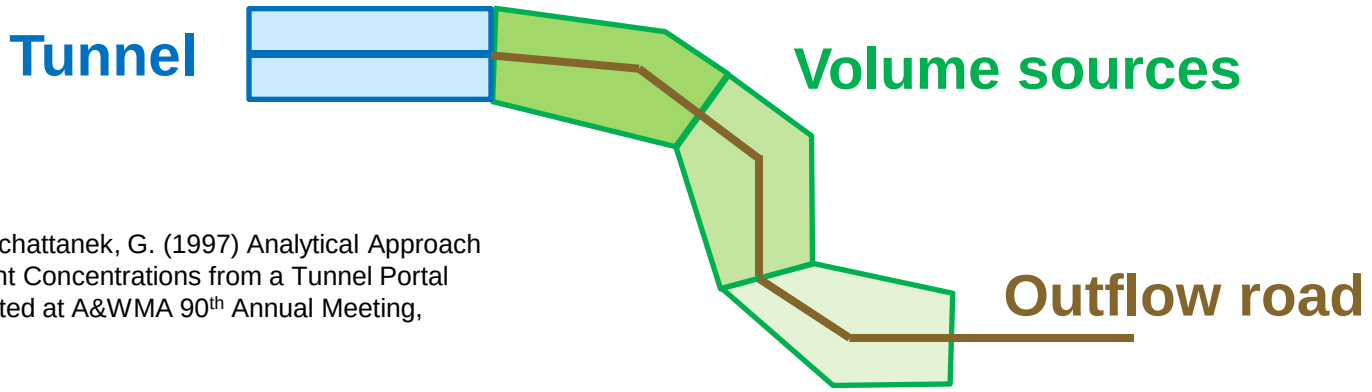
Modelling concept

- Replace a tunnel road source with volume source(s) at outflow end(s), plus vent(s)



Model implementation - tunnel portals

- Based on Ginzburg and Schattanek (1997) approach
  - 3 volume sources per outflow end
  - Volume source lengths based on wind speed, traffic speed and portal geometry (range 30 – 250 m)
  - Reduced emission weighting moving away from the portal
- Volume source geometry follows outflow road
- Allow for portals and outflow roads below or above ground level
- Also applicable to rail tunnels, modelled as elevated roads



Ginzburg, H. and Schattanek, G. (1997) Analytical Approach to Estimate Pollutant Concentrations from a Tunnel Portal Exit Plume. Presented at A&WMA 90th Annual Meeting, Toronto, Canada.

Model implementation - tunnel vents

- Same vent can extract from multiple tunnels
- One tunnel can emit via multiple vents
- Point or area source properties defined by source geometry and efflux parameters
- Specified fraction of emissions from road tunnel assigned to each vent
- Fraction of emissions extracted by vent can be altered with time-varying factors applied to vent

Model implementation - limitations

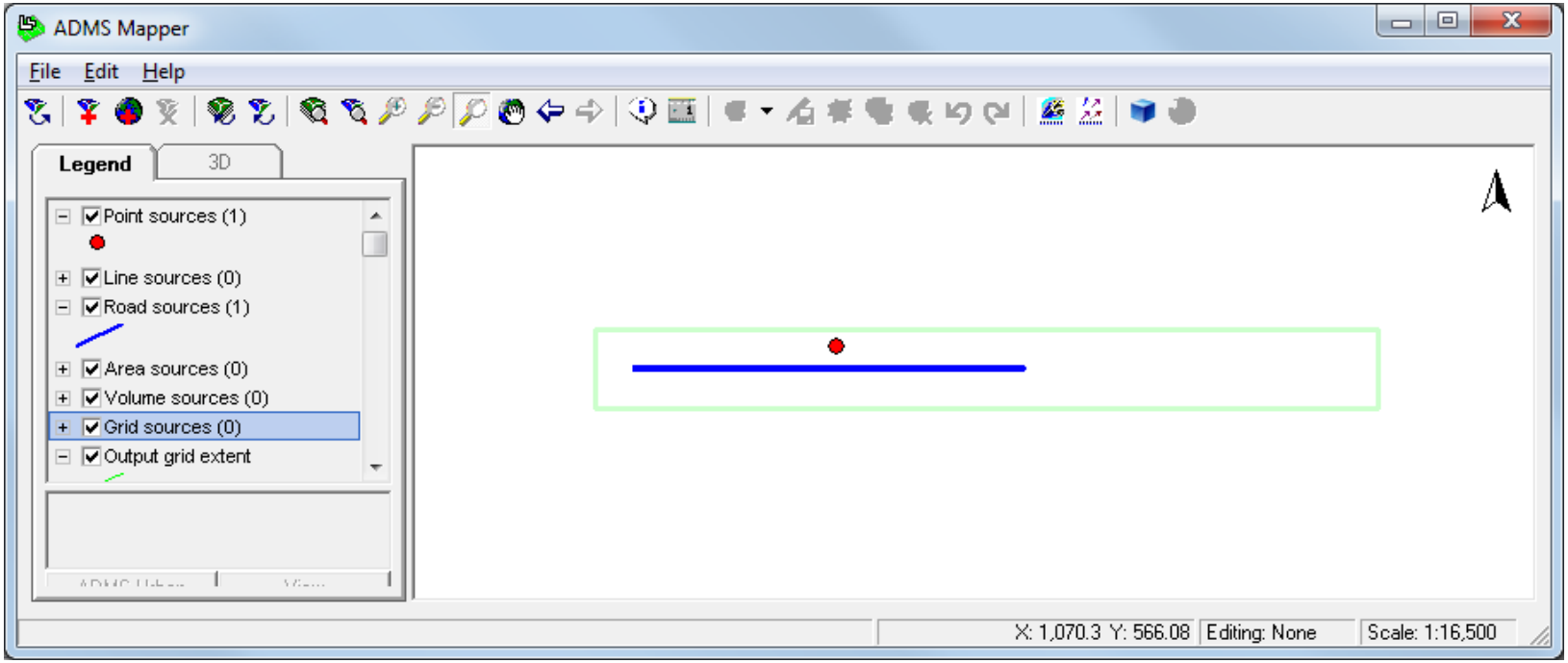
- No deposition or chemistry within tunnel
- No explicit treatment of recirculation between bores
- No allowance for removal of pollutants prior to venting eg. filtration

  Adjust tunnel emissions if these effects are known to be significant

- Ambient temperature assumed for tunnel portal emissions

Tunnels: implementation - sample run

- Simple illustrative example
  - One “tunnel” road, no outflow road
  - One vent source near ground level
  - Identical met conditions, varying vent fraction



Tunnels: implementation - sample results

- NOx concentration contours with varying vent fraction

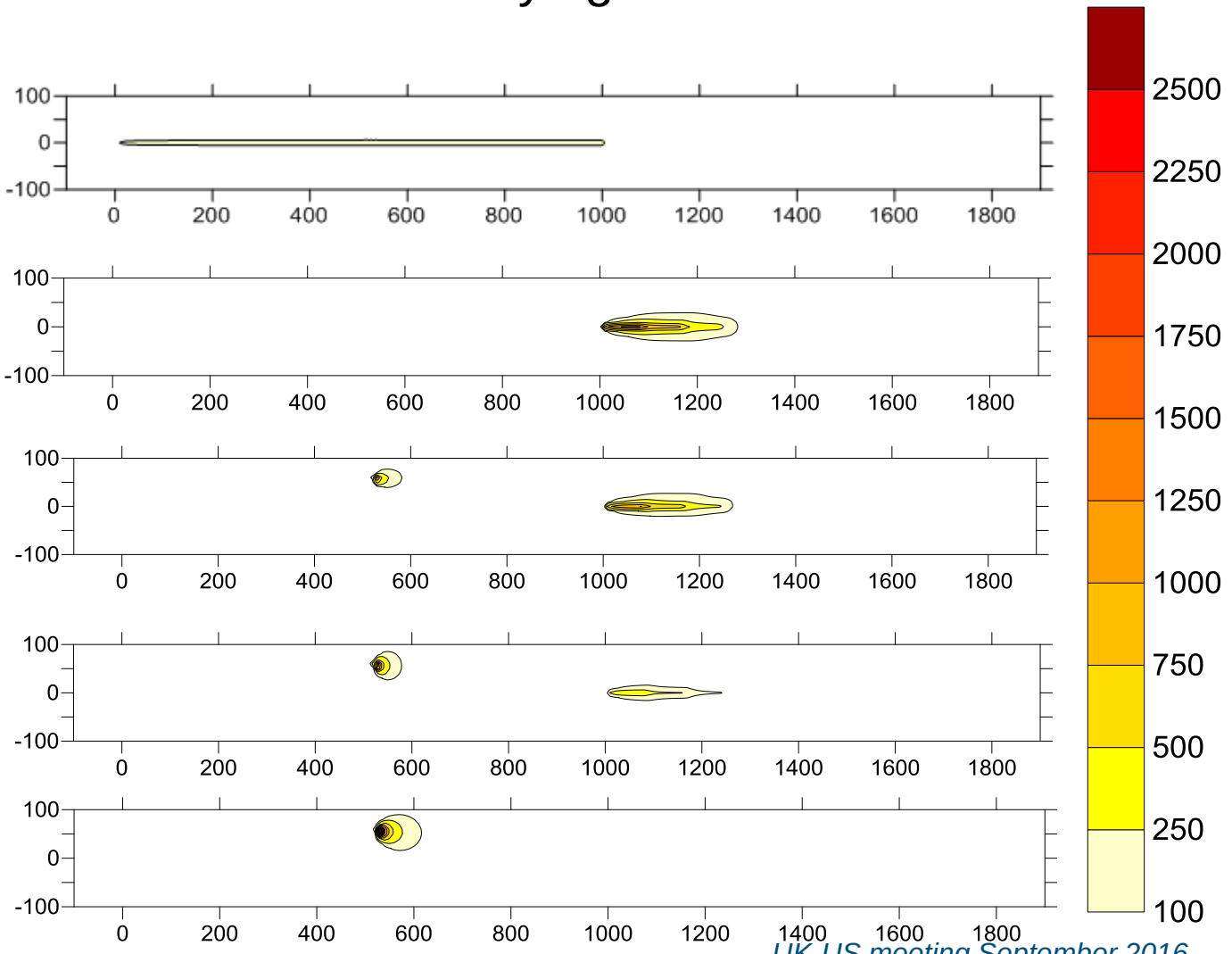
No tunnel or vent

Tunnel
Vent fraction 0.0

Vent fraction 0.25

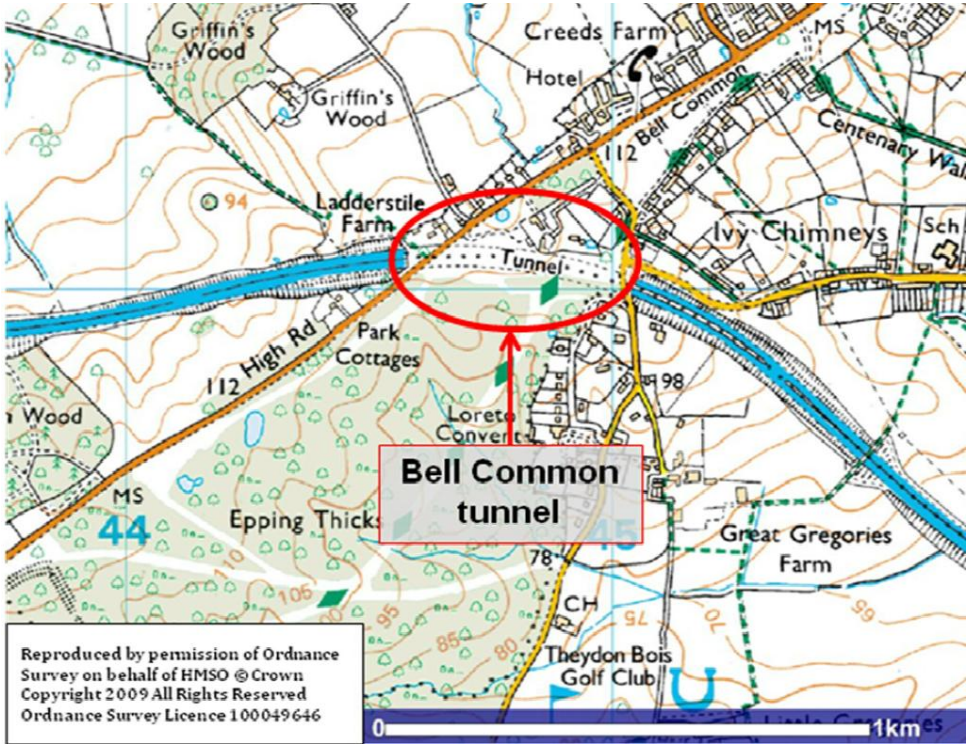
Vent fraction 0.5

Vent fraction 1.0



Tunnels: validation

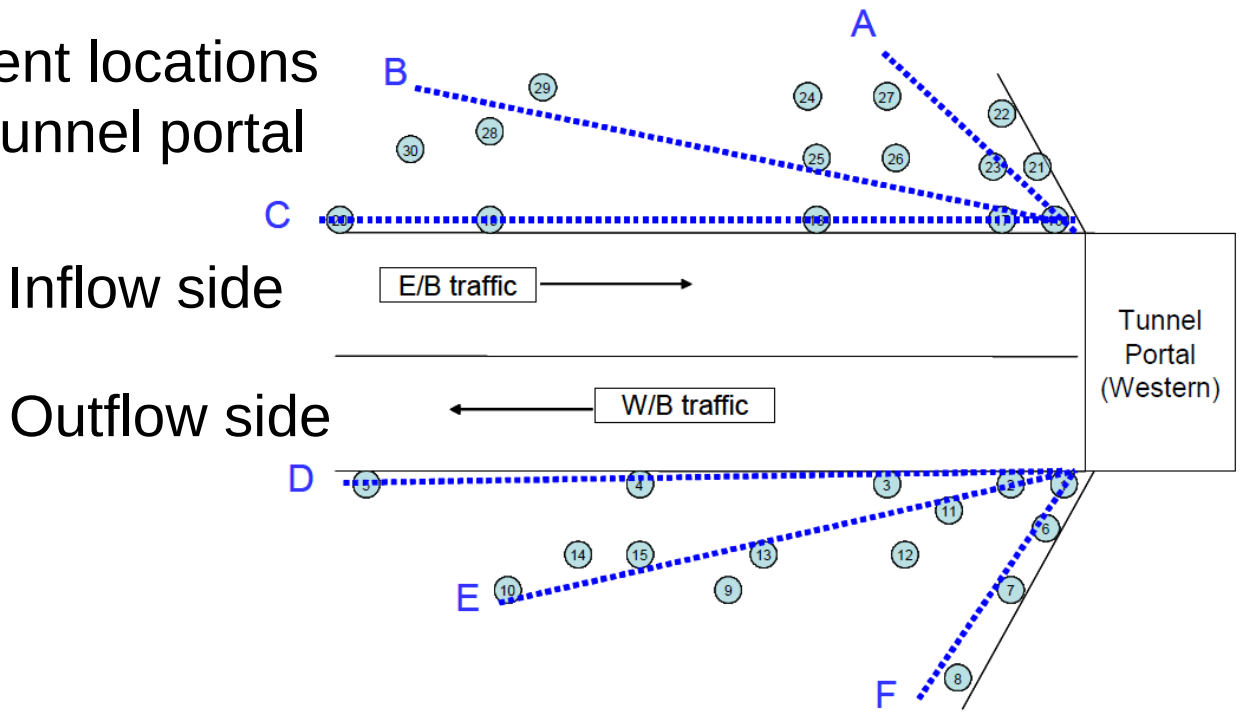
- Detailed measurement datasets for one Austrian and one UK road tunnel currently available for model testing/validation
- Focus on UK tunnel results: Bell Common (M25)
- Glasgow city centre modelling study – complex urban site



Validation – Bell Common measurements

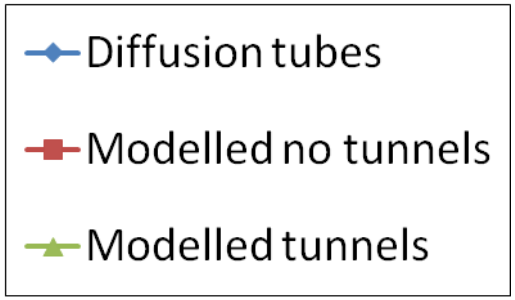
- Study by TRL for Highways Agency, report PPR449
- Measurements using passive samplers at 30 locations over 12 weeks in summer 2006
- Focus on NO_2 measurements from diffusion tubes

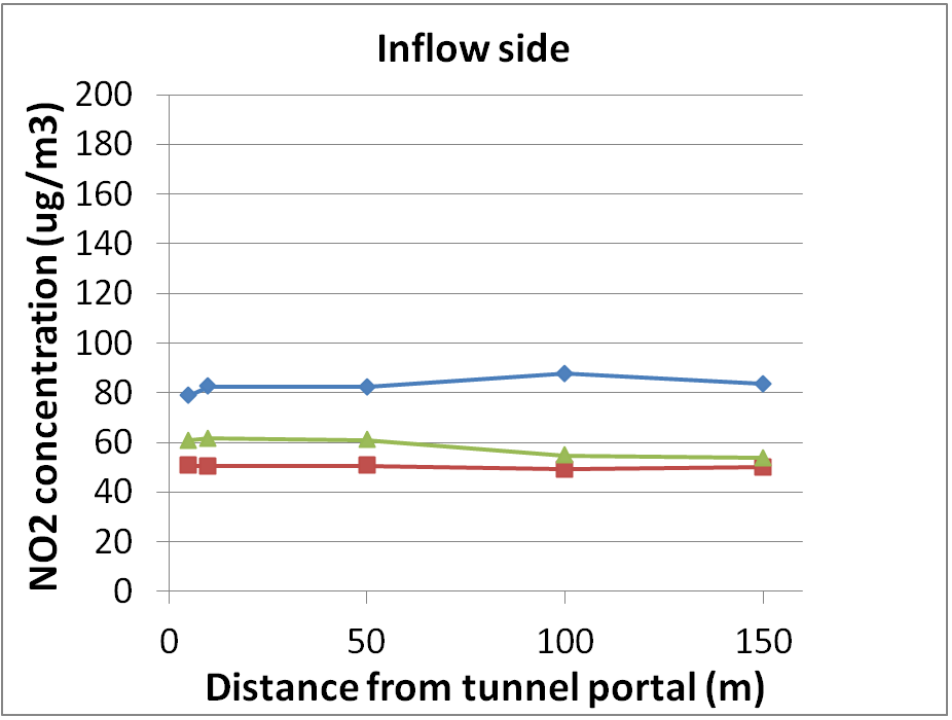
Measurement locations relative to tunnel portal

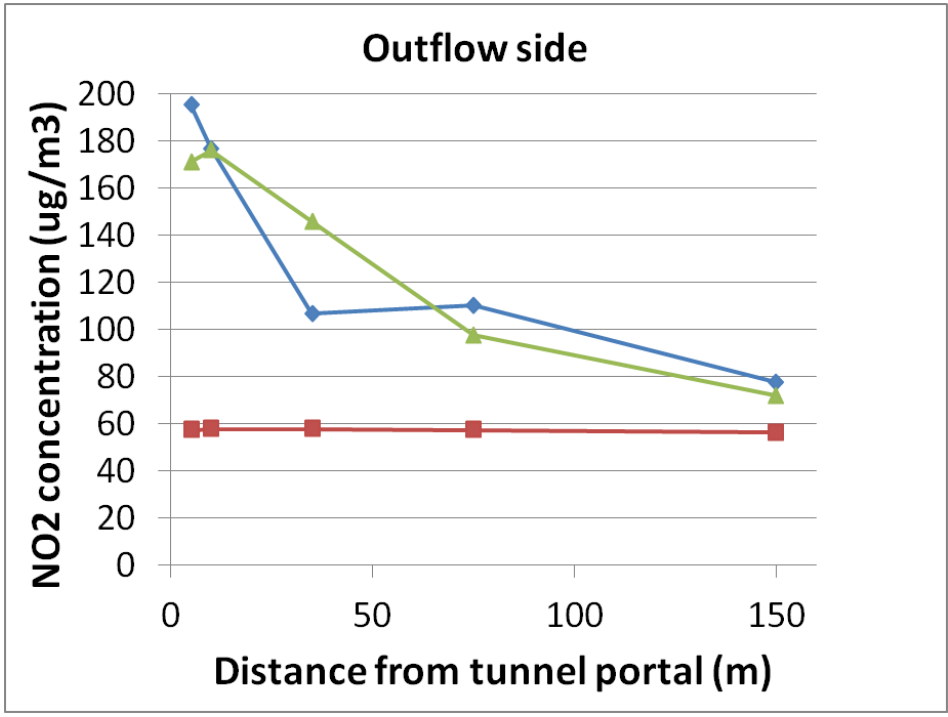


Validation – Bell Common model results

- Along-verge concentrations
- Averages over full measurement period (3 months)

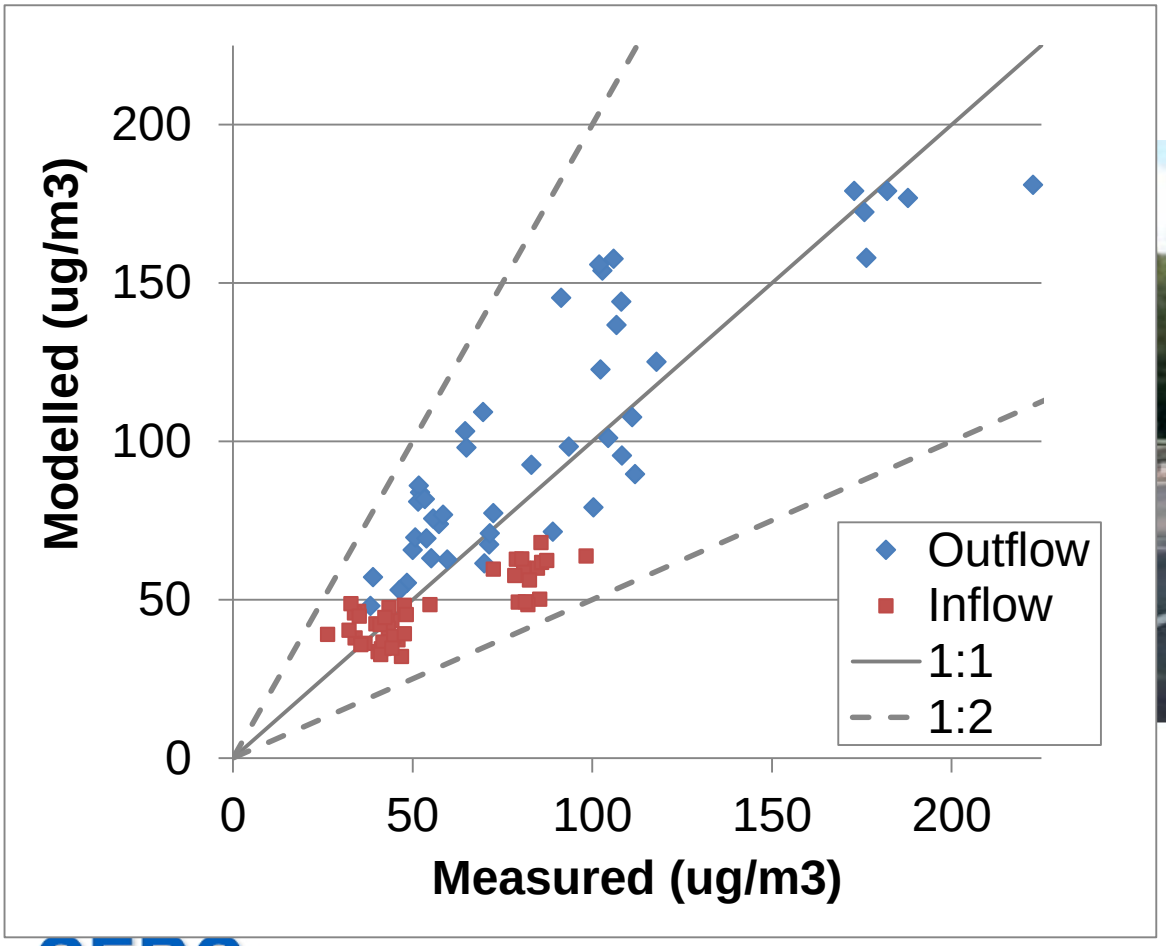






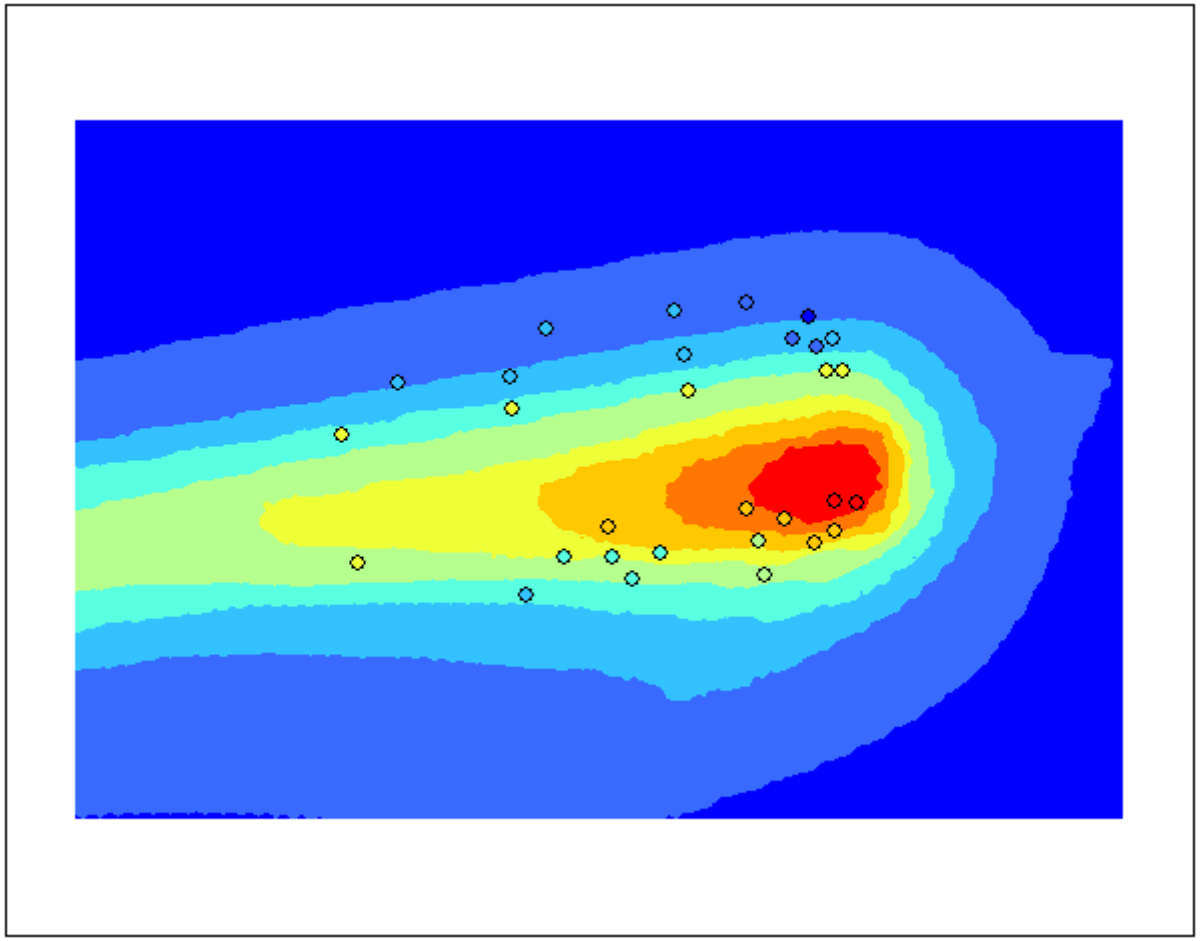
Validation – Bell Comon model results

- NO2 concentrations for all diffusion tube measurement sites
- 4 week averages



Validation – Bell Common model results

- Contours of modelled concentration and measurement points showing spatial matching



Summary

- New module for automatic modelling of road tunnels in ADMS-Urban and ADMS-Roads 4
- Validation carried out for tunnels in UK and Austria
- Local urban modelling can involve complex multiple effects

- More details in ADMS-Urban User Guide (available online) and Technical Specification (available on request from CERC)

Questions