

ADMS-Urban: Developments in modelling dispersion from the city scale to the local scale

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Cambridge Environmental Research Consultants
Environmental Software and Services

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Motivation

- Why nest a local model within a regional model?

Model feature	Model	
	Regional (eg grid based)	Local (eg Gaussian plume)
Domain extent	Country (few 1000 km)	City (50km)
Meteorology	Spatially and temporally varying from meso scale models	Usually spatially homogeneous
Dispersion in low wind speed conditions	Models stagnated flows correctly	Limited modelling of stagnated flows
Deposition and chemical processes	Reactions over large spatial and temporal scales	Simplified reactions over short-time scales
Source resolution	Low	High
Validity	Background receptors	Background, roadside and kerbside receptors

Motivation

- Why nest a local model within a regional model?
- What are the advantages of a **nested model**?

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CMAQ/ADMS-Urban nesting system

- **Aim:** to nest local model in regional model without double counting emissions i.e.:

$$\text{Concentration within nested domain} = \text{Regional modelling of emissions} - \text{Gridded locally modelled emissions } (\Delta T) + \text{Explicit locally modelled emissions } (\Delta T)$$

ΔT is the time taken to mix the explicitly defined emissions to produce a concentration field that varies spatially on the same scale as the regional model

ΔT varies with meteorology

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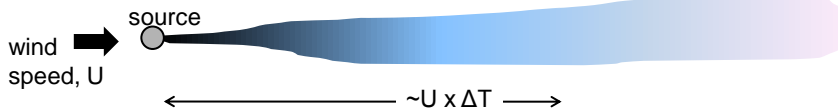
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- ADMS-Urban steady-state Gaussian plume model allows plumes to disperse for times > 1 hour, whilst limiting calculations to 1 hour i.e.:



- Assumption valid if variation in meteorology and emissions relatively slow from hour to hour.

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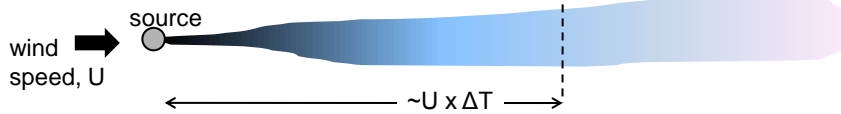
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- ADMS-Urban steady-state Gaussian plume model allows plumes to disperse for times > 1 hour, whilst limiting calculations to 1 hour i.e.:



- Assumption valid if variation in meteorology and emissions relatively slow from hour to hour.
- When nesting ADMS-Urban in CMAQ, ensure that the locally modelled emissions (gridded and explicit) are **truncated** (- - -) at the correct time.

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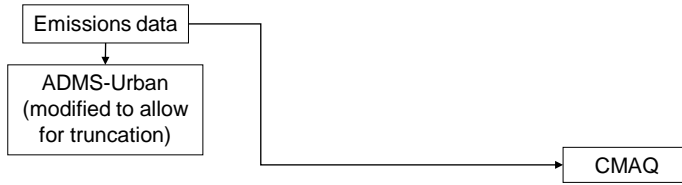
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Emissions data

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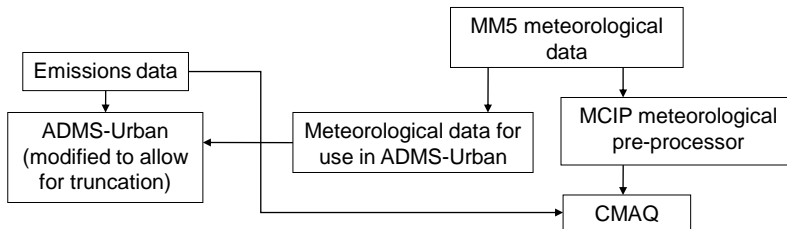
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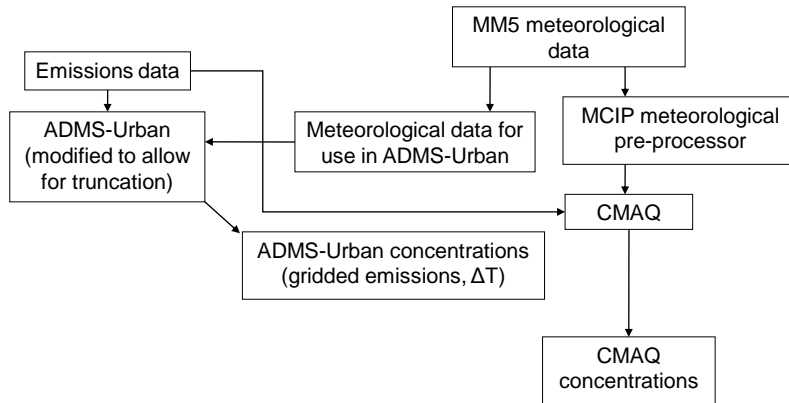
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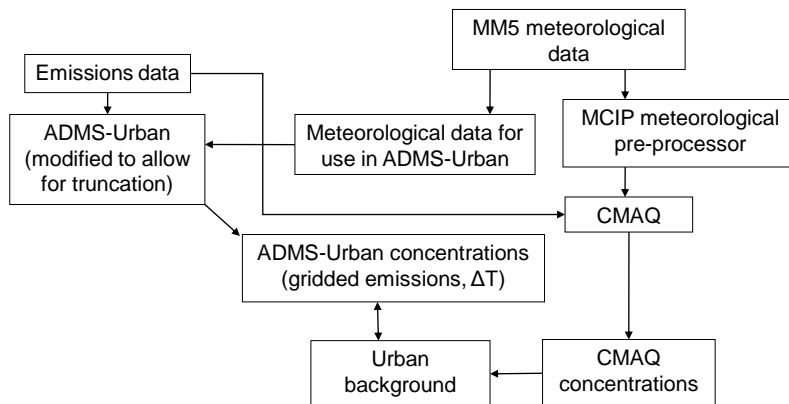
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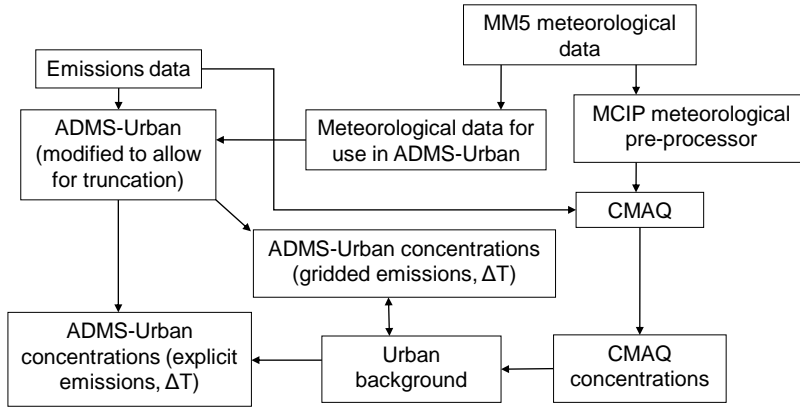
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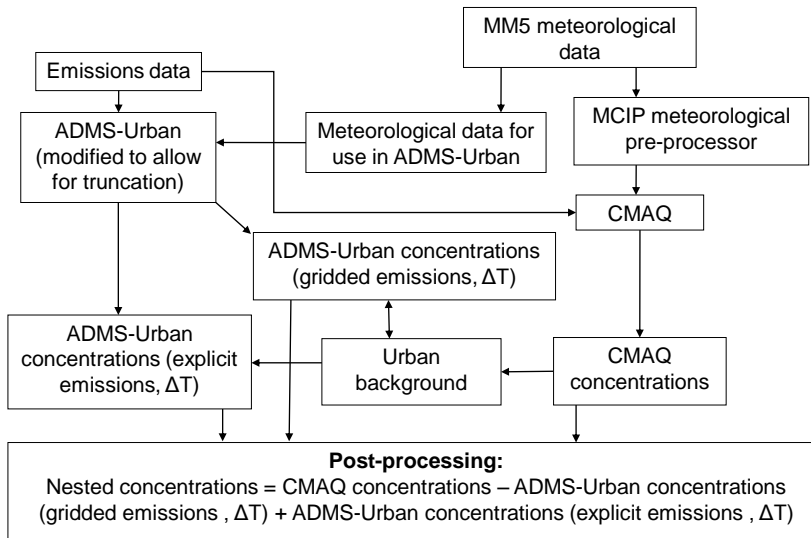
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CMAQ/ADMS-Urban nesting system



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Preliminary modelling Model set up (I)

- **Simplified model set up**
- Domain:
 - Regional model : south east England
 - Local model : ~ congestion charging zone in central London
- Emissions:
 - London Atmospheric Emissions Inventory (detailed) and UK National Atmospheric Emissions Inventory (1 km² grid)
 - Only detailed emissions of NO_x, NO₂ and ozone
 - Emissions from large point sources neglected
- Meteorology
 - Output from the meso-scale model MM5
 - 2 x 5 day periods (summer, winter)

Preliminary modelling Model set up (II)

- **Simplified model set up**
- Regional model:
 - Domain 120 km by 120 km, centred on nested domain
 - Emissions were aggregated onto 3 by 3 km² grid cells
 - All emissions released within the lowest layer of CMAQ vertical grid
 - Simplified initial and boundary conditions
 - CB-05 version 5 aerosol mechanism and aqueous chemistry
- Local model
 - Domain 9 km by 9 km
 - Emissions from all major roads modelled explicitly
 - Source-receptor travel time/mixing time ΔT limited to 2 hours

Preliminary modelling Model results

- 17 continuous monitors within nested modelling region:
 - All recorded NO_x and NO₂ concentrations
 - 5 recorded ozone
 - Classified according to location: kerbside, roadside and urban background

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$$\text{Concentration within nested domain} = \text{Regional modelling of emissions} - \text{Gridded locally modelled emissions } (\Delta T) + \text{Explicit locally modelled emissions } (\Delta T)$$

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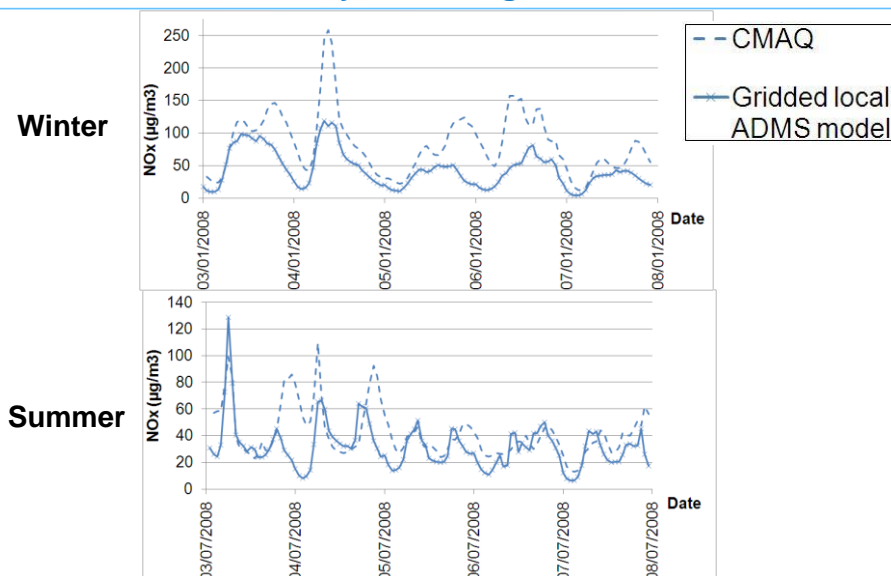
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Preliminary modelling Model results: validity of nesting



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Preliminary modelling Model results

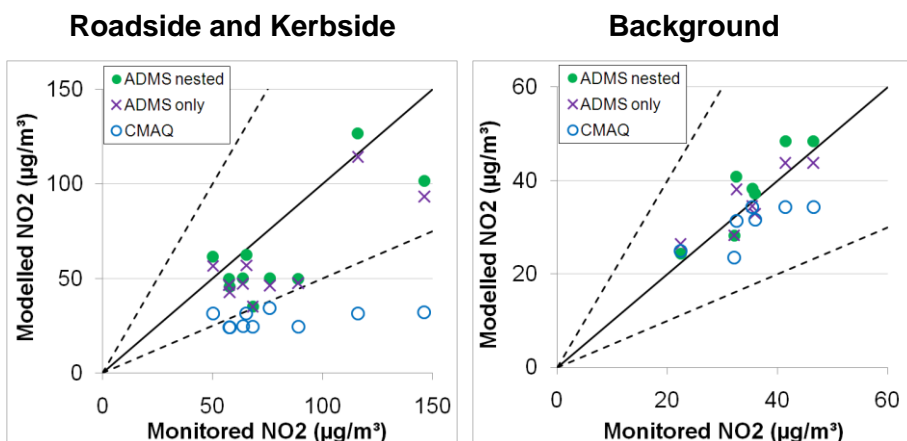
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- Model results at receptors:
 - ADMS-Urban nested within CMAQ
 - CMAQ only
 - ADMS-Urban only

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Preliminary modelling Model results: receptors – NO₂

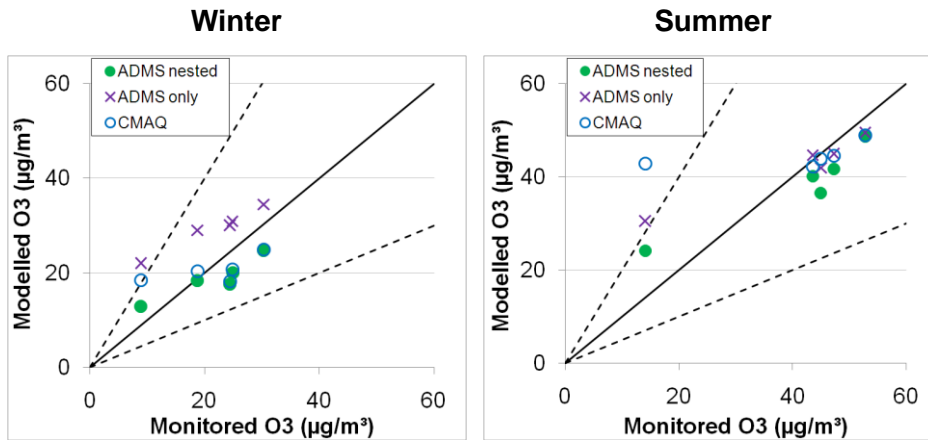


(Summer)

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Preliminary modelling Model results: receptors – O₃



(All sites)

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Preliminary modelling Model results

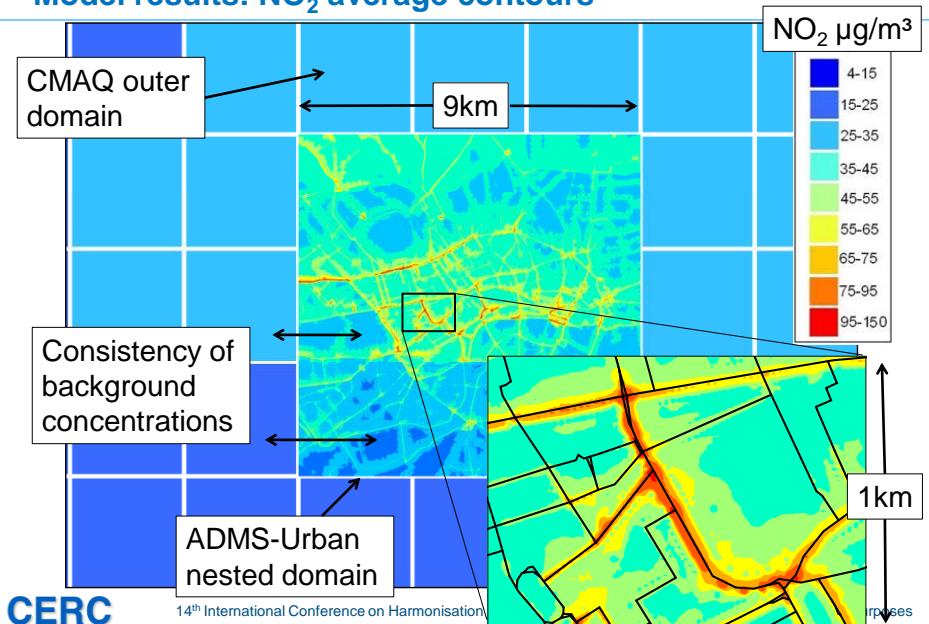
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 - ADMS-Urban only
- Contour output:
 - ADMS-Urban nested within CMAQ

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Preliminary modelling Model results: NO₂ average contours



Discussion

- Presented consistent methodology for nesting local model within a regional model
- Preliminary model results encouraging, despite simplifications
- This approach allows for modelling of:
 - chemical reactions over large and small temporal and spatial scales
 - spatially varying meteorology
 - low wind conditions
 - local modelling (street canyons, noise barriers, cuttings etc)
- Model validation at *all* sites: background, roadside and kerbside
- Future developments of system