MAQS-Health
Multi-Model Air Quality System for Health Research

Providing air quality data for health research

Breathing City Network Meeting
22 September 2021
### MAQS-Health: Project Concept

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Science</th>
<th>Community</th>
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<tbody>
<tr>
<td>• “High resolution prediction capability to support personal exposure for health impacts, through national and local model developments” (objective of Work Package 2B within the SPF Clean Air Programme)</td>
<td>• Development &amp; evaluation of a coupled air quality modelling system spanning national to urban street scales</td>
<td>• An open structure facilitating system development and modification by stakeholders</td>
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<td>• Flexible modular system linking advanced widely used regional chemical transport &amp; local models</td>
<td>• Available to the UK research community for air quality and health via the SPF Clean Air Framework platform</td>
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<td>• Accounts for physical &amp; chemical processes occurring at all relevant spatial and temporal scales</td>
<td>• Compatibility with associated SPF DUKEMS emissions and DIMEX-UK exposure modelling projects</td>
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<td>• Includes a verification system for validation of model predictions</td>
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The Clean Air (W1) programme is led by NERC and the Met Office, with Innovate UK, EPSRC, ESRC, MRC, NPL & Defra as delivery partners.

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Motivation

- Why couple a local model to a regional model?
- What are the advantages of a coupled system?
- How do we evaluate the results from the system?

<table>
<thead>
<tr>
<th>Model feature</th>
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<td></td>
<td>Regional (eg grid based)</td>
</tr>
<tr>
<td>Domain extent</td>
<td>Country (few 1000 km)</td>
</tr>
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<td>Meteorology</td>
<td>Spatially and temporally varying from meso scale models</td>
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<td>Dispersions in low wind speed</td>
<td>Models stagnated flows correctly</td>
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<tr>
<td>conditions</td>
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</tr>
<tr>
<td>Source resolution</td>
<td>Low</td>
</tr>
<tr>
<td>Validity</td>
<td>Background receptors</td>
</tr>
<tr>
<td></td>
<td>Local (eg Gaussian plume)</td>
</tr>
<tr>
<td></td>
<td>City (50km)</td>
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<tr>
<td></td>
<td>Usually spatially homogeneous</td>
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MAQS-Health coupled system concept

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

\[
\text{Concentration within nested domain} = \text{Regional modelling of emissions} - \text{Gridded locally modelled emissions (ΔT)} + \text{Explicit locally modelled emissions (ΔT)}
\]

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 and model resolution, in practice fixed to 1 hour.
**MAQS-Health coupled system concept**

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

  \[
  \text{Concentration within nested domain} = \text{Regional modelling of emissions} - \text{Gridded locally modelled emissions (ΔT)} + \text{Explicit locally modelled emissions (ΔT)}
  \]

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

  \[\text{source} \quad \text{wind speed, } U \quad \sim U \times \Delta T\]

- Assumption valid if variation in meteorology and emissions relatively slow from hour to hour.
**Aim:** to couple local model to regional model without double counting emissions i.e.:

\[
\text{Concentration within nested domain} = \text{Regional modelling of emissions} - \text{Gridded locally modelled emissions (ΔT)} + \text{Explicit locally modelled emissions (ΔT)}
\]

- The local, 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 coupling a local model to a regional model, need to ensure that the locally modelled emissions (gridded and explicit) are **truncated** at the correct time to separate regional and local influences.
MAQS-Health Verification System (VS)

- Essential component of any application of MAQS-Health is validation of concentration outputs from both the regional model and the coupled system against in situ observed data

- The VS has been designed to:
  - provide an automated, standardised method of comparing MAQS-Health coupled system output with in situ observed data
  - be compatible with all MAQS-Health coupled system supported modelled data formats
  - provide easy access to online measured data
  - enable easy model inter-comparison
  - output a wide range of statistics and publication-ready graphs

- Runs in free and powerful R
- Uses David Carslaw’s ‘openair’ tools
- User interface for Windows users
MAQS-Health: System Overview

**LOCAL MODEL COMPONENT**
- Pollutant concentration estimates are needed at resolutions of a few metres at roadside locations in urban areas to assess population exposure accurately.
- At short times, local-scale models capture fine details of dispersion, fast chemistry and effect of street canyons.
- New road source tool: ADMS-Local (based on ADMS-Urban).

**REGIONAL MODEL COMPONENT**
- Regional pollution levels contribute significantly to pollution levels in urban areas.
- Eulerian chemical transport models (CTMs) model regional and global pollutant transport and complex atmospheric chemistry.
- Range of RM options include: CMAQ, CAMx, EMER, WRF-Chem, CHIMERE + Generic.*

**COUPLED SYSTEM**
- Local-scale and regional models to be coupled within a single system.
- Computational complexities include avoidance of double counting emissions + chemistry.

**VERIFICATION SYSTEM**
- Automated comparisons of modelled/ measured.

*Generic RM input format allows coupling with other models e.g. AQUM
Key facts about the MAQS-Health System

- Produces hourly concentrations at a wide range of spatial scales (few metres to 100s of km) in netCDF format
- Compatible with current versions of many regional-scale models* typically in use at UK research institutions: WRF-Chem, CMAQ, CAMx, CHIMERE, EMEP
- Will equip air quality modellers in research roles to produce data for the whole UK at high resolution (few metres) for health research
- Includes integrated tool for verification of results against measured levels

*Generic RM input format allows coupling with other models e.g. AQUM
Beta Testing Modelling Groups and Domains

Beta testing is currently being carried out by modelling groups at the Met Office and project partners the Universities of Birmingham, Edinburgh, Hertfordshire and Lancaster.

Caveat: Domains have not yet been finalised
MAQS-Health is progressing to schedule

Stakeholder engagement I
- Stakeholder requirements Workshop March 2020
- User requirements summary

Initial system design & development
- Local model, coupled system & verification tool

Stakeholder engagement II
- System demonstration Workshop 2 15 June 2021

Beta Testing
- Stakeholders beta test system
- User feedback Workshop 3 October 2021
- System refinements, informed by beta feedback

System Launch
- System launch Workshop 4 early 2022 (with beta results)
- Publications and reports, informed by beta feedback

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Finally...

- Thank you for listening!

- If you want to receive occasional project update emails, including information about the system launch workshop in early 2022, email me at amy.stidworthy@cerc.co.uk