

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

University of
Hertfordshire **UH**



CERC

Lancaster
University



UNIVERSITY OF
BIRMINGHAM

Requirement

- “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)

Science

- Development & evaluation of a coupled air quality modelling system spanning national to urban street scales
- Flexible modular system linking advanced widely used regional chemical transport & local models
- Accounts for physical & chemical processes occurring at all relevant spatial and temporal scales
- Includes a verification system for validation of model predictions

Community

- An open structure facilitating system development and modification by stakeholders
- Available to the UK research community for air quality and health via the SPF Clean Air Framework platform
- Compatibility with associated SPF DUKEMS emissions and DIMEX-UK exposure modelling projects



Met Office

NPL
National Physical Laboratory



Department
for Environment
Food & Rural Affairs

**Clean Air
Programme**

The Clean Air (W1) programme is led by NERC and the Met Office, with Innovate UK, EPSRC, ESRC, MRC, NPL & Defra as delivery partners.

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?

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	Reactions over short-time scales
Source resolution	Low	High
Validity	Background receptors	Background, roadside and kerbside receptors

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MAQS-Health coupled system concept

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

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

Eqn (*)

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

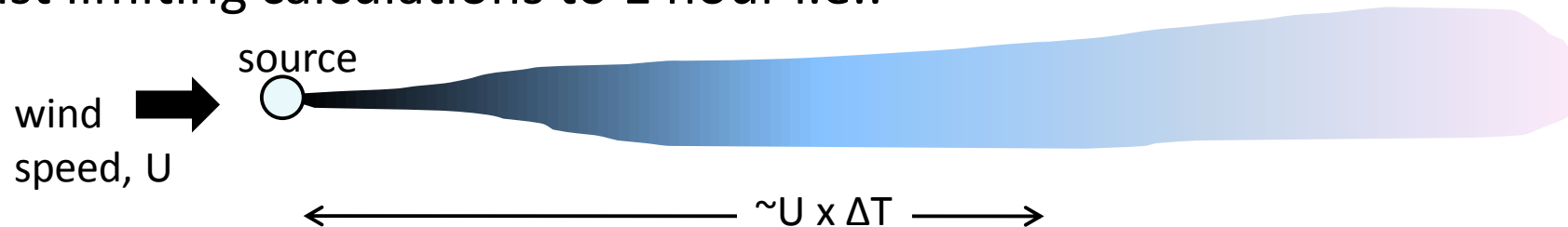
ΔT varies with meteorology and model resolution, in practice fixed to 1 hour

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



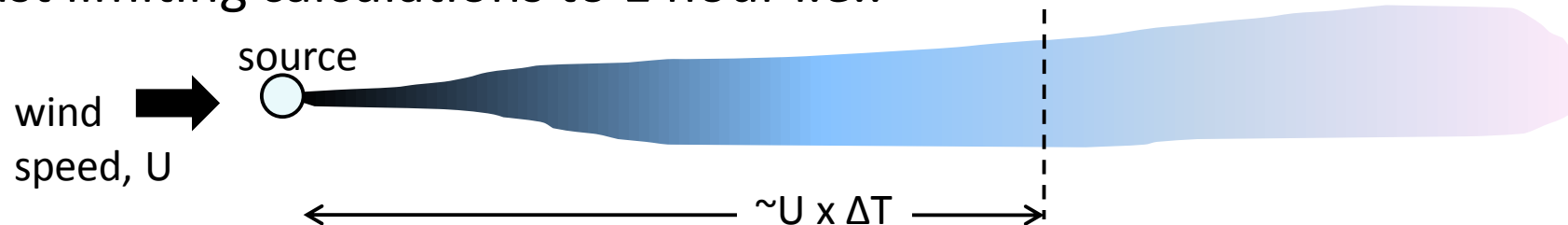
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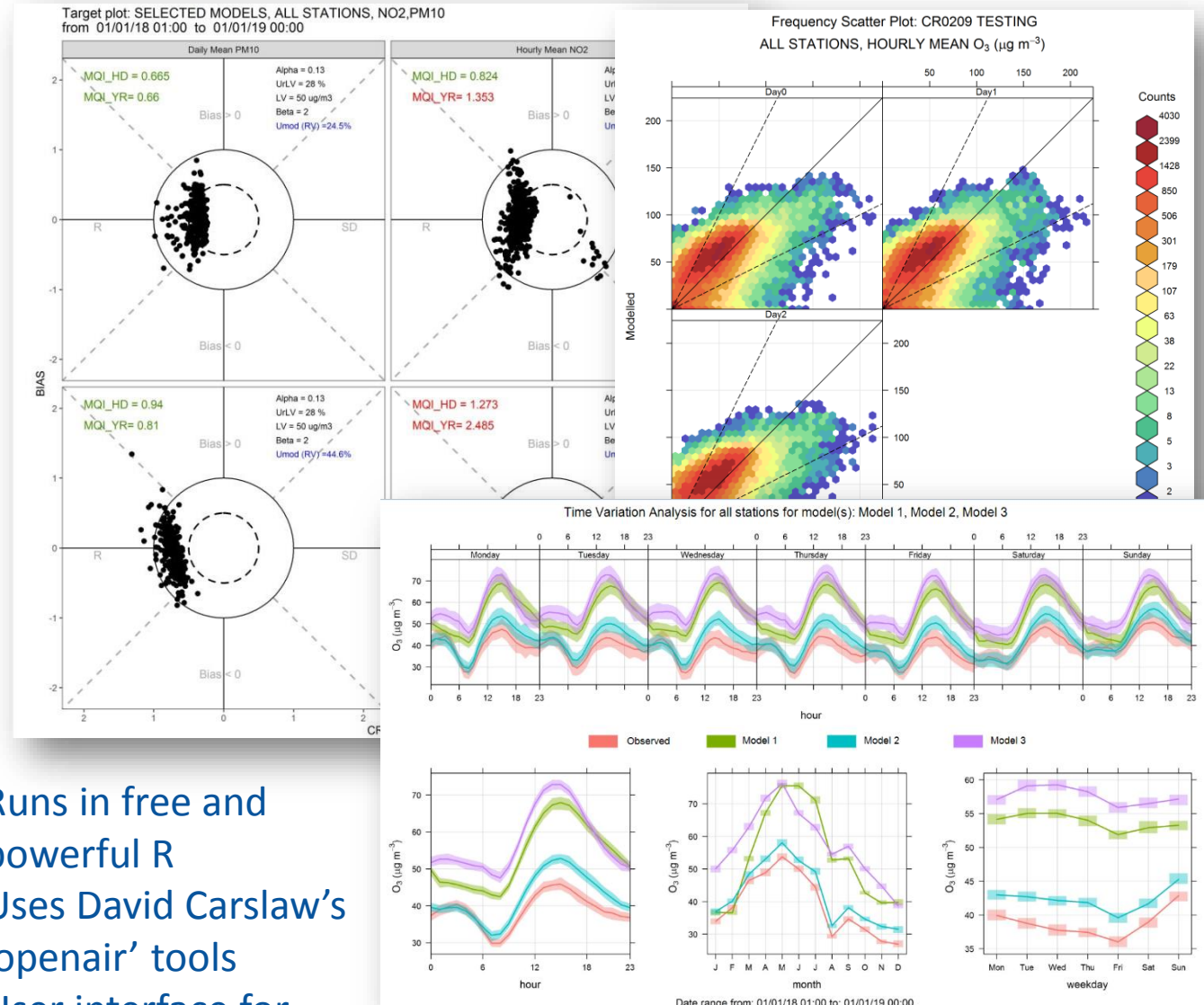


- Assumption valid if variation in meteorology and emissions relatively slow from hour to hour.
- When coupling a local model to a regional model, need to ensure that the locally modelled emissions (gridded and explicit) are **truncated** (- - -) at the correct time to separate regional and local influences.

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, EMEP, WRF-Chem, CHIMERE + Generic***

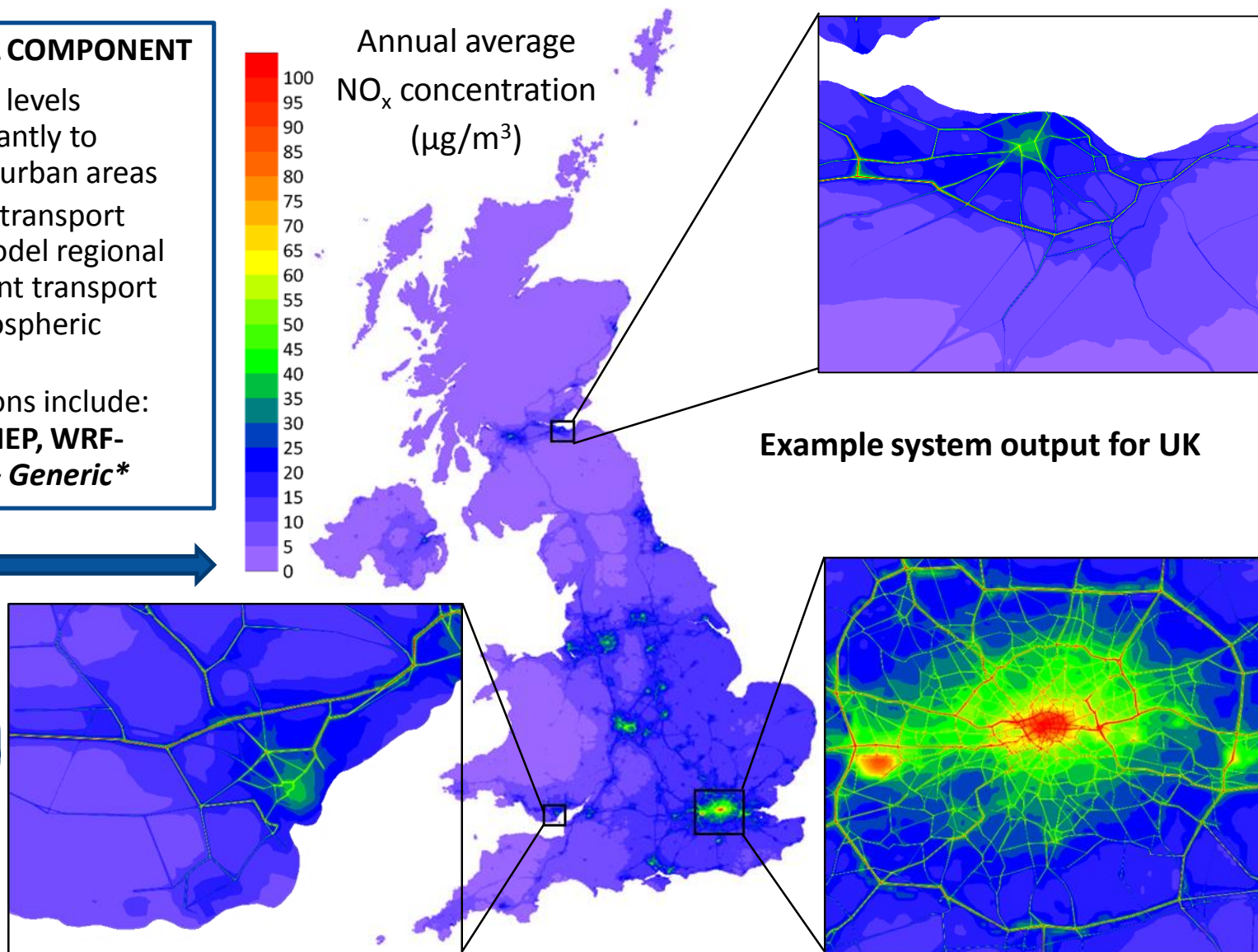
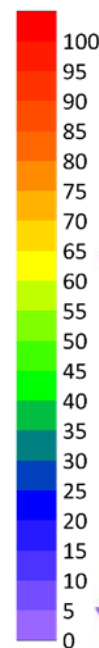
COUPLED SYSTEM

- 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

Annual average
 NO_x concentration
($\mu\text{g}/\text{m}^3$)



Example system output for UK

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

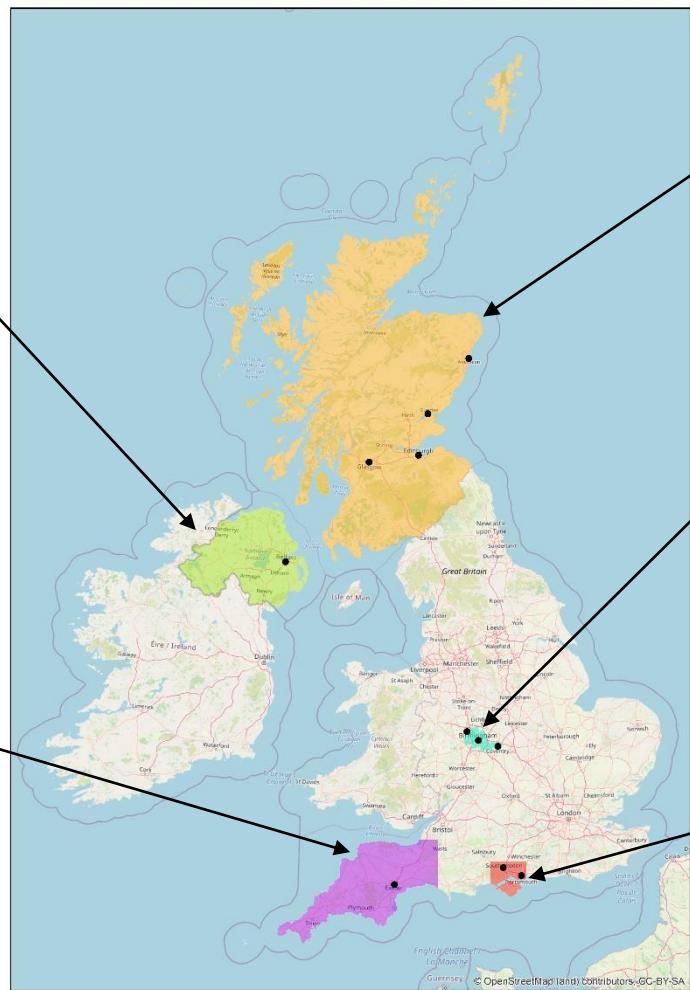
Includes integrated tool for verification of results against measured levels

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**.

Organisation: Lancaster University
Domain: Northern Ireland
Cities: Belfast
Regional model: WRF-Chem
Group lead: Prof Oliver Wild

Organisation: Met Office
Domain: South-West England
Cities: Exeter
Regional model: AQUM
Group lead: Dr Rachel McInnes



Organisation: Edinburgh University
Domain: Scotland
Cities: Edinburgh, Glasgow, Aberdeen, Dundee
Regional model: EMEP
Group lead: Prof Ruth Doherty

Organisation: Birmingham University
Domain: West Midlands
Cities: Birmingham, Wolverhampton, Coventry
Regional model: CMAQ
Group lead: Prof William Bloss

Organisation: University of Hertfordshire
Domain: Portsmouth and Southampton
Cities: Portsmouth, Southampton
Regional model: CMAQ
Group lead: Prof Ranjeet Sokhi

MAQS-Health: Project Timeline

MAQS-Health is progressing to schedule



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