Application of the Met Office Unified Model for Air Quality Forecasting

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Contents

- Introduction
- Initial model configurations
- Near Real Time Verification
- Case study results – June 2005
- Conclusions and future work

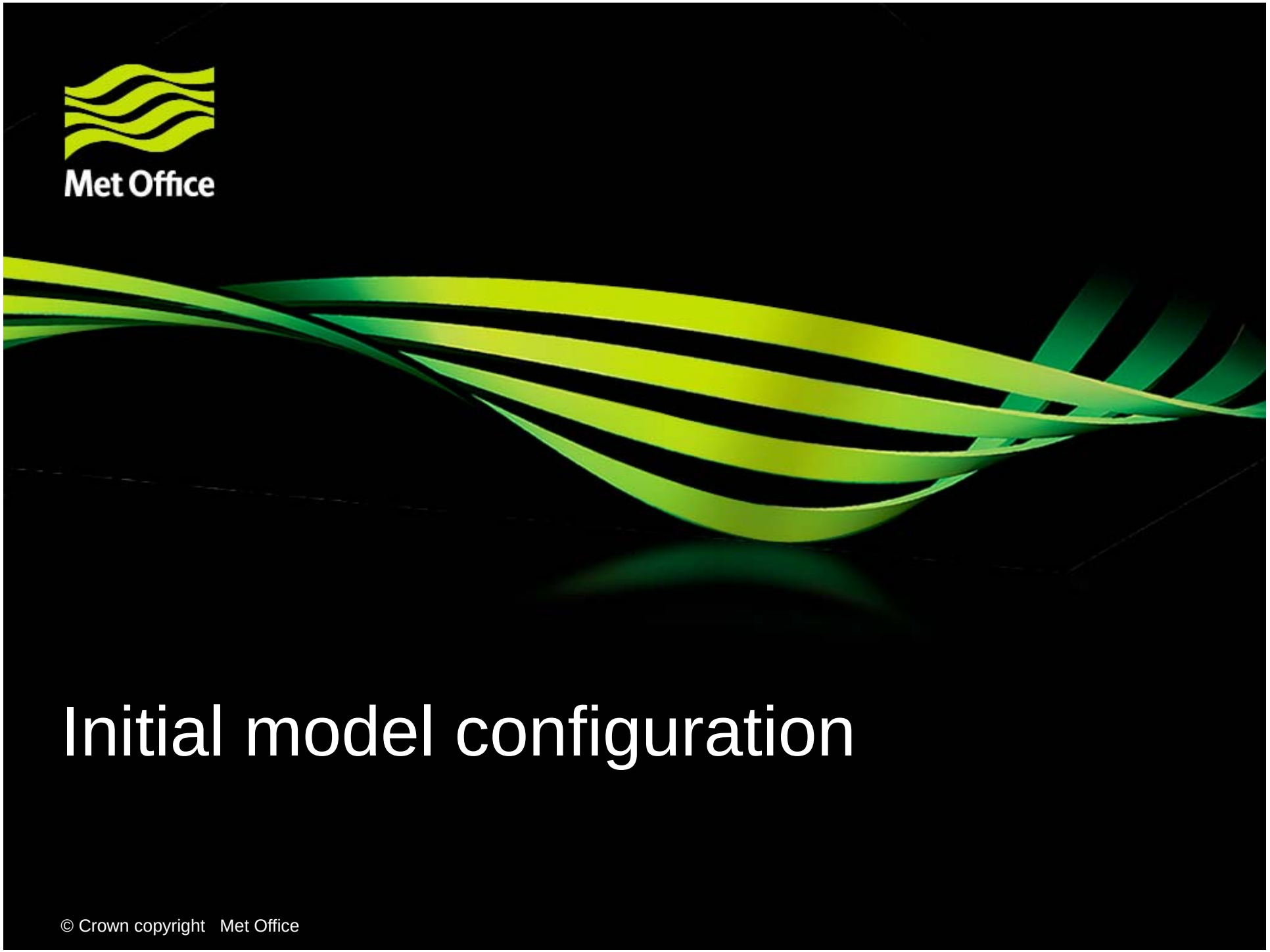
Introduction

UKCA – United Kingdom Chemistry and Aerosols model

- Joint NERC-Met Office project
- Project partners – Met Office Hadley Centre and the Universities of Cambridge and Leeds.
- Develop, evaluate and make available a atmospheric chemistry-aerosol **global** model
- Based on Met Office Unified Model (MetUM) – used for forecasting on timescales from hours through seasons to centuries

Air Quality in the Unified Model - AQUM

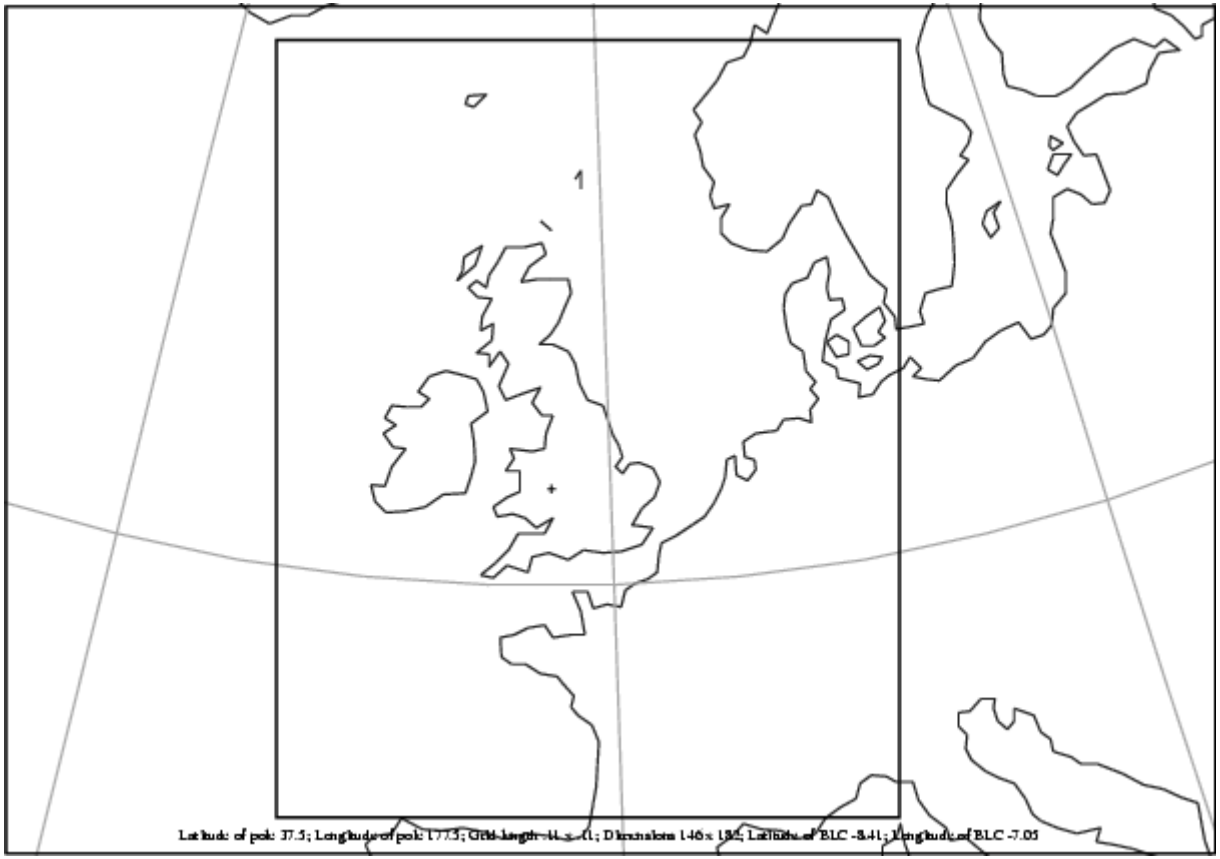
- Objective - create operationally running forecast of UK O_3, NO_x, CO, SO_2 and particulate matter by March 2010
- Develop UKCA by creating a limited area model version
- Uses global chemistry forecasts from the GEMS-Global Reactive Gases project (daily T +72 forecasts) for lateral boundary conditions (LBCs)
- An on-line, real-time forecast model, with near real time verification and visualisation



Initial model configuration

Resolution

- 12x12 km with a domain covering the UK and Ireland plus most of France and Germany
- 38 model levels from 20m to 39 km



Lateral boundary conditions for AQ forecasts

- Daily transfer of GEMS-GRG forecast fields: O_3, NO_x, CO and HCHO
- Met data (initial and boundary conditions) from Met Office North Atlantic and European Model (NAE) – domain covers most N. Atlantic and Europe at 12km
- Combine GEMS and NAE data to generate LBCs

Chemistry schemes

- ‘Standard Tropospheric Chemistry’. 26 tracers (9 of them emitted), 27 photolysis reactions and ~100 gas-phase reactions. Oxidation of methane, ethane and propane. Used for initial testing of the forecasting suite
- Regional AQ mechanism. 40 tracers (16 of them emitted), 23 photolysis reactions and ~115 gas-phase reactions. Oxidation of both C2-C3 alkenes, isoprene and aromatics. Used for case studies and later forecasts.

First near real time forecasts

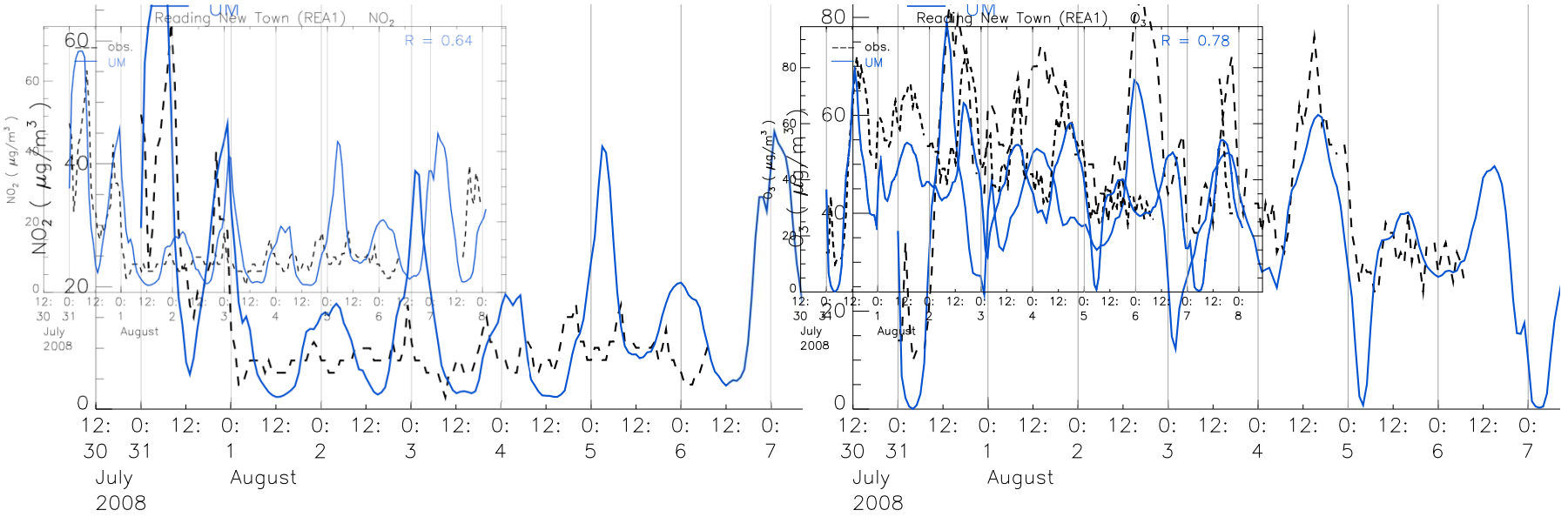
- Ran one 48 hour forecast per day from June – December 2008 on NEC SX-8
- Timings very variable as running on a user account
- Suite started at 03:25 UT after NAE 0Z run.
- Earliest results around 05:30 UT
- Used the ‘standard tropospheric chemistry’ scheme initially with the more complex chemistry implemented later

Near real time verification

Near real time verification

- Routine verification against Automated Urban and Rural Network data (AURN) from NetCen has been set up
- Used data from Remote, Rural, Suburban and Urban Background sites but not Roadside or Kerbside sites
- Limitations due to accuracy of reported data, especially for CO, convertor type for NO_2
- Allows forecast skill to be monitored in near real time
- All data archived for possible later analysis

Verification – example plots



- Daily updated plots
- Time series at all stations
- Bias and gross error at stations and by station type

Case study – June 2005

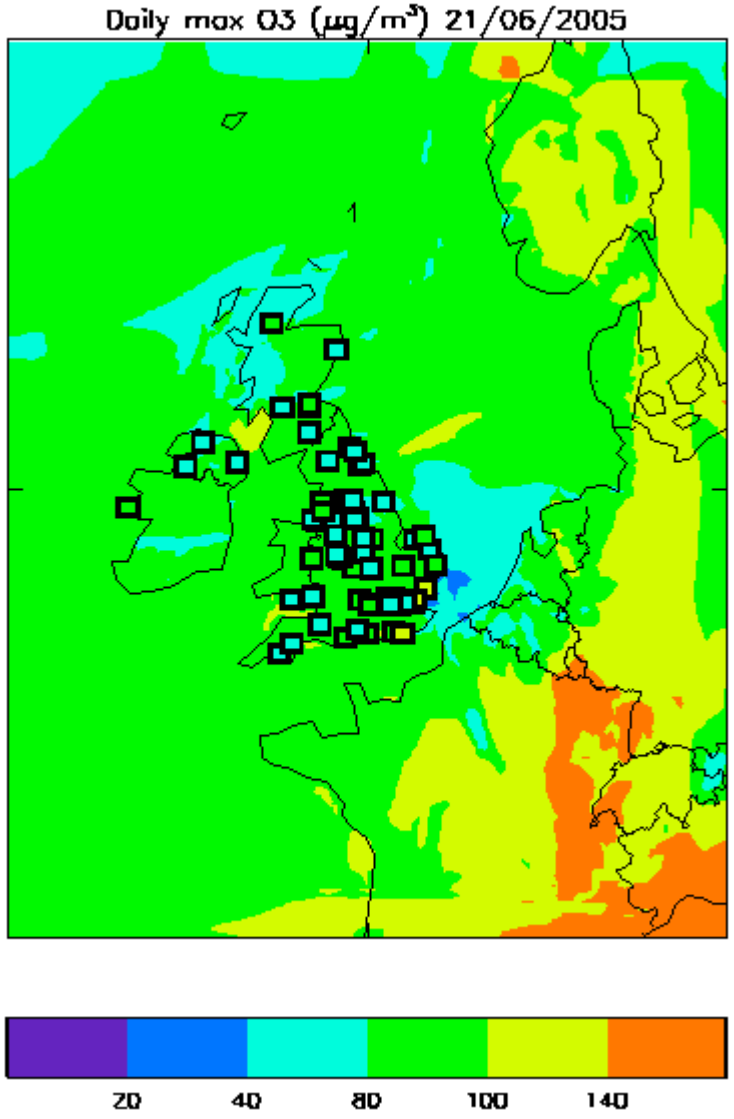
Why June 2005?

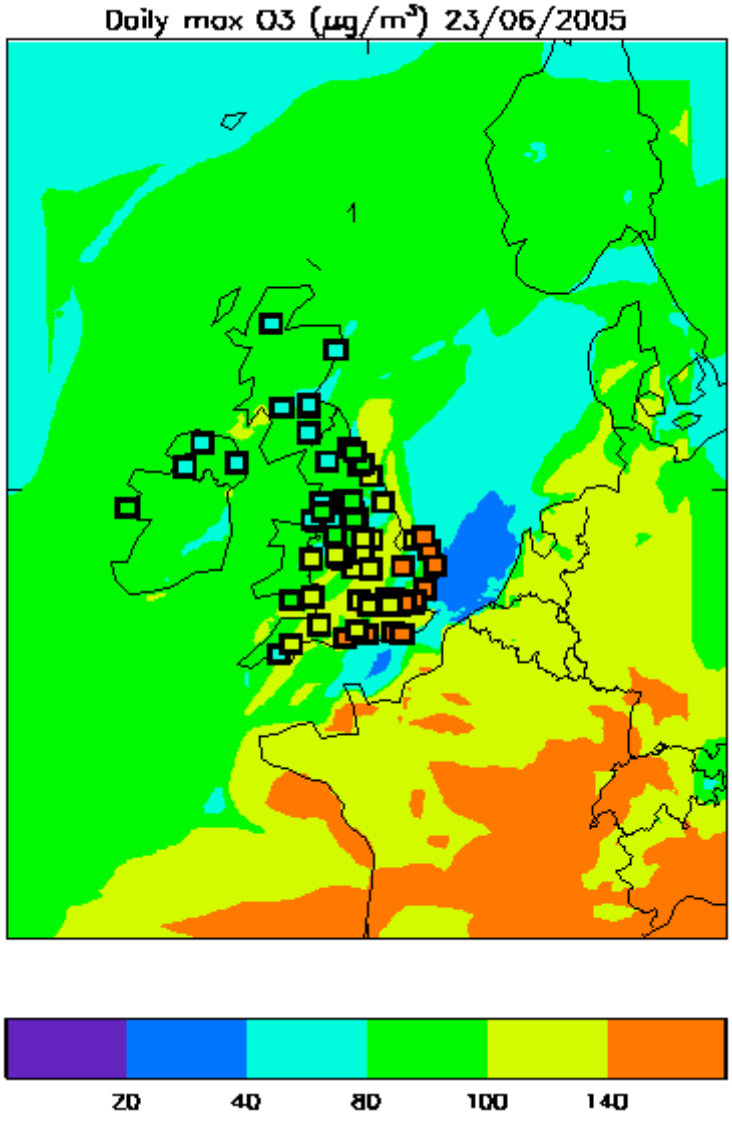
- Ozone episode across the SE of the UK. 19th - 24th of June, 7 AURN stations with at least one hourly average > 180 μgm^{-3} (HIGH)
- Highest hourly concentration at Weybourne (on the North Norfolk coast) on the 24th June: 202 µgm-3
- Done case study for 2003 – results similar to 2005

Case study set up

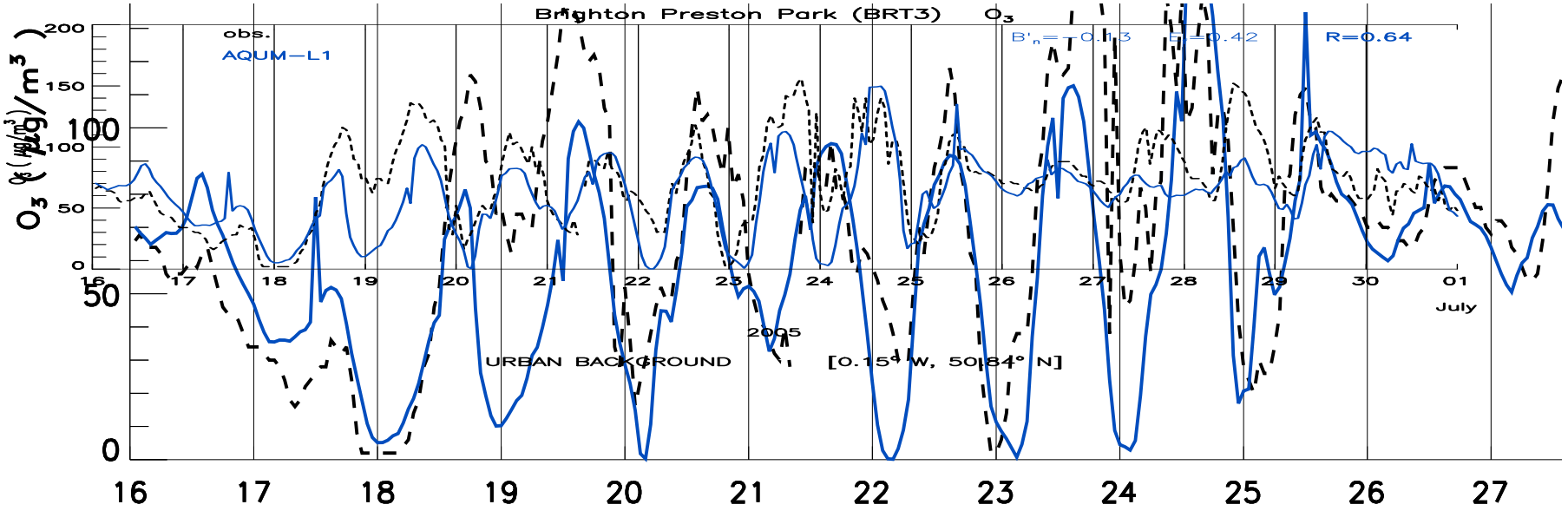
- Global 1.25º x 0.833º L38 model run to generate lateral boundary conditions
- 12 km UK-Mes limited area model
- Regional AQ chemistry
- Meteorology based on daily analyses, chemistry free running
- Global model spin up 1-16/6/2005, LBC output 16-30/6/2005
- LAM run 16-30/6/2005

Mesoscale model results - maps





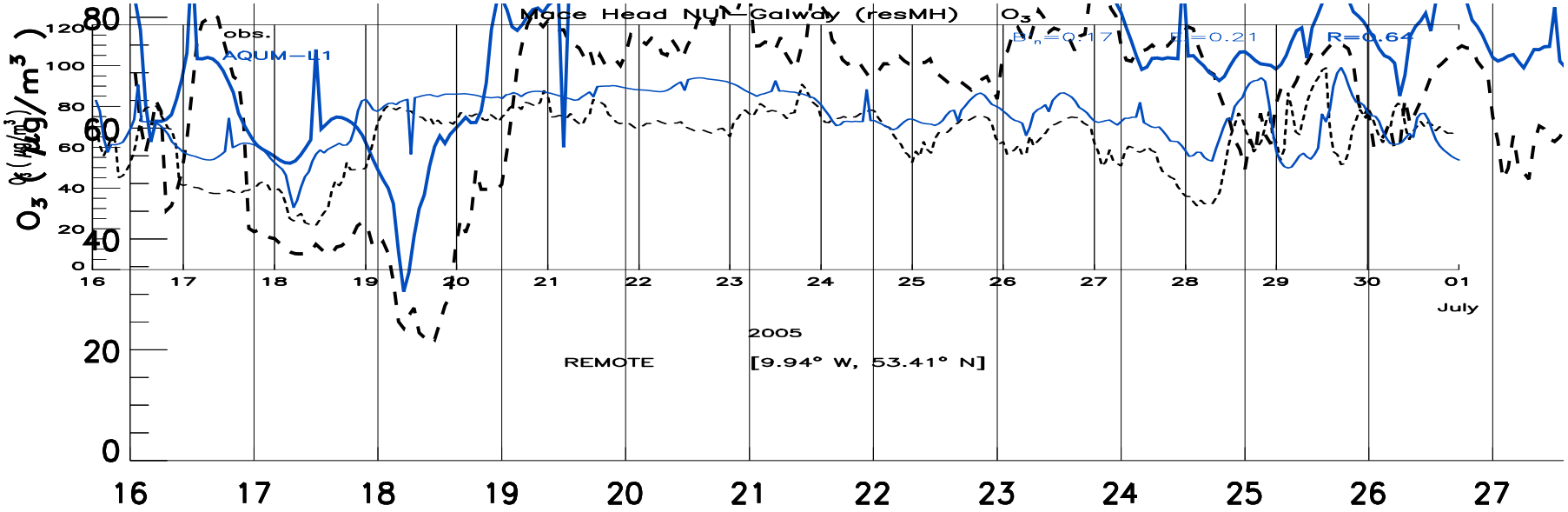
Mesoscale model results – stations (1)



2005

URBAN BACKGROUND [0.15° W, 50.84° N]

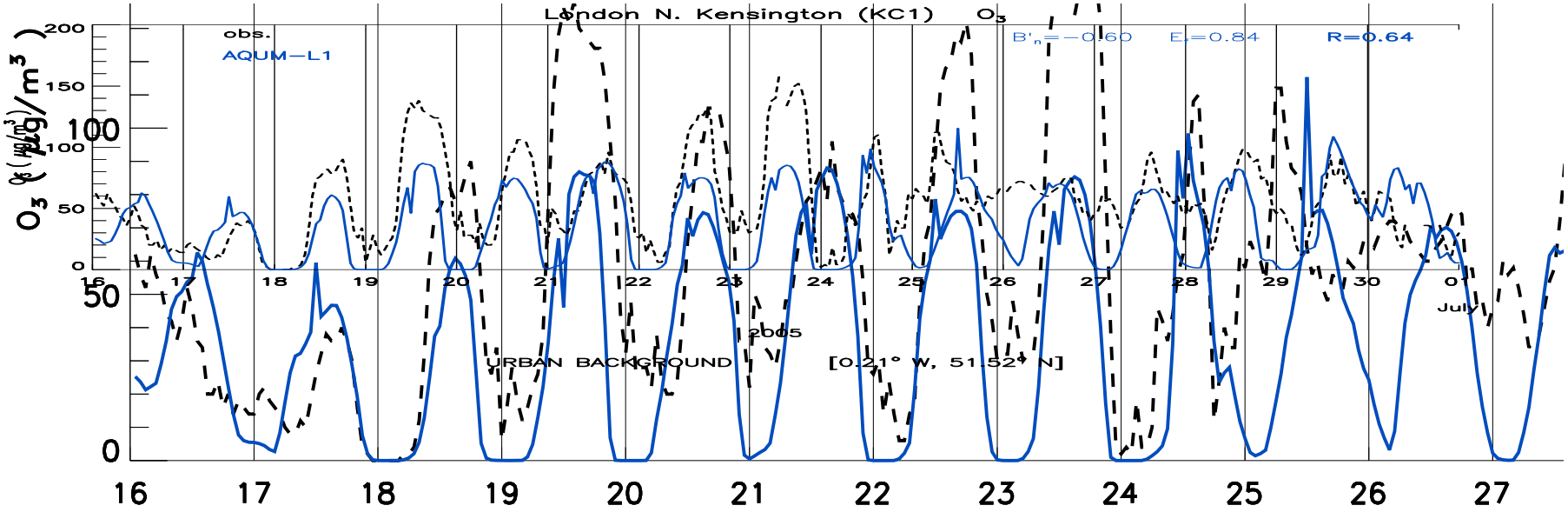
Mesoscale model results – stations (2)



2005

REMOTE [9.94° W, 53.41° N]

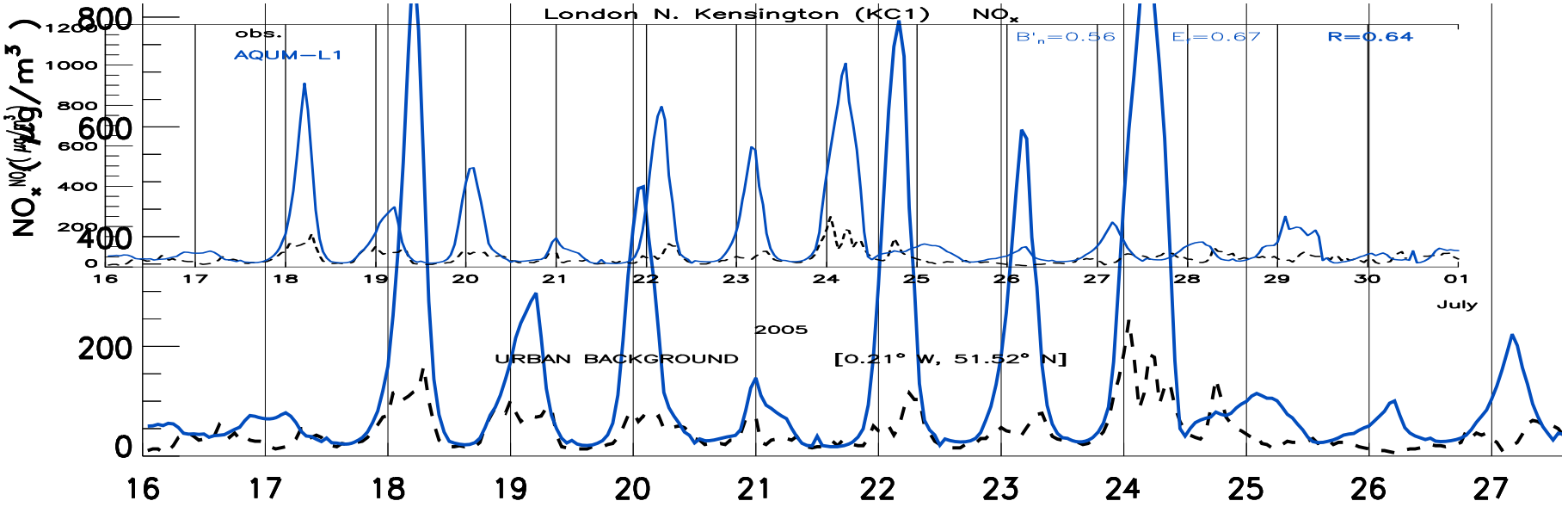
Mesoscale model results – stations (3)



2005

URBAN BACKGROUND [0.21° W, 51.52° N]

Mesoscale model results – stations (4)



2005

URBAN BACKGROUND [0.21° W, 51.52° N]

Conclusions and further work

Conclusions and further work

- Initial capability for AQ forecasting shown and case studies for evaluating future model performance have been developed
- Initial study shows some promising results
- Further investigation and development needed
  - Diurnal/weekly cycles of emission rates and vertical profiles of emissions
  - Online not offline photolysis
  - Include aerosol in forecasts
  - Get acceptance as a test suite in operations

Acknowledgements

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  - Colin Johnson, Fiona O’Connor, Olaf Morgenstern, Graham Mann
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  - Maria Athanassiadou
  - Piers Buchanan, Douglas Boyd, Richard Forbes

Questions and answers