Application of UKCA in an air quality forecast model

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Introduction

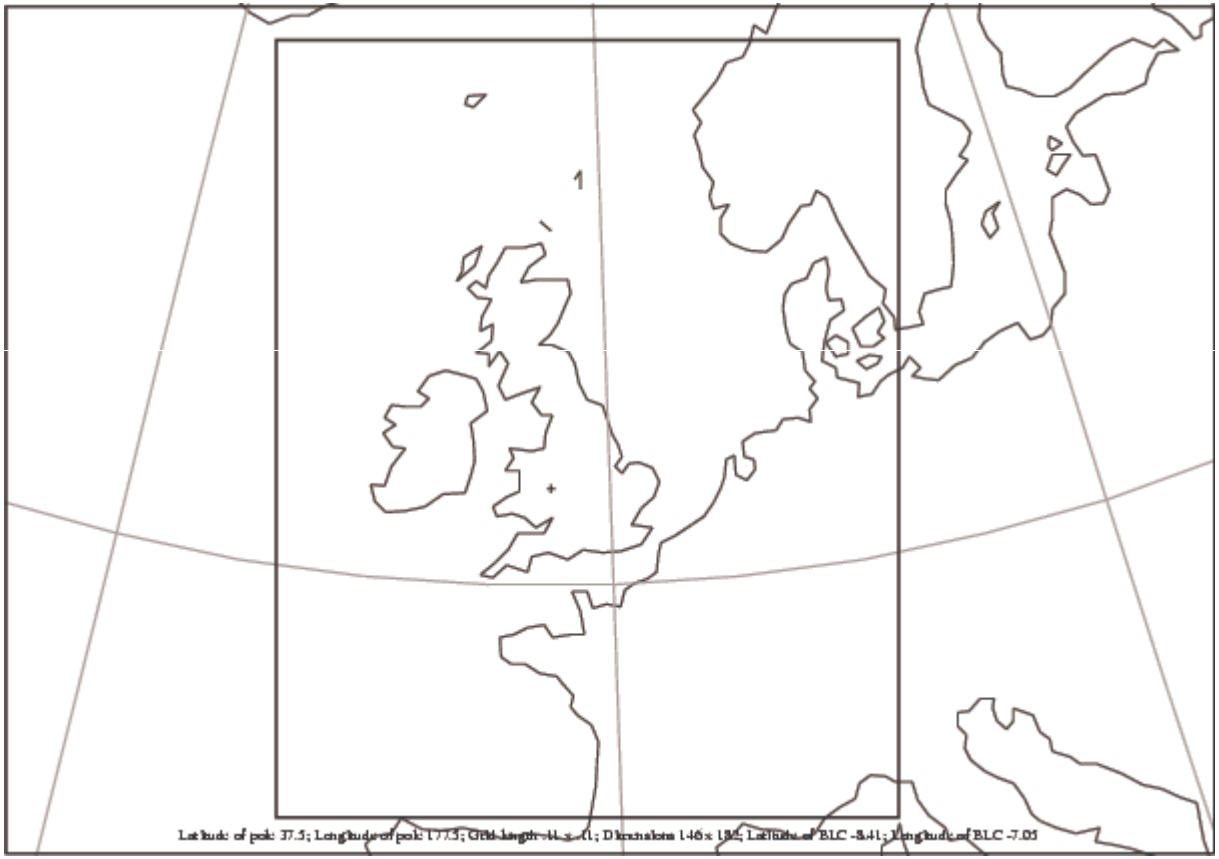
Air Quality in the Unified Model - AQUM

- Objective - create operationally running test suite forecasting O_3, $NO_{x,}$ CO, SO_2 and particulate matter by March 2010
- Builds on development of UKCA for chemistry-climate applications
- Uses global chemistry forecasts from the GEMS-GRG project
- Contributions from Hadley Centre, Numerical Modelling and Atmospheric Dispersion groups at the Met Office

Initial model configurations

Resolution

- Initial horizontal resolution is 12x12 km with a domain the same as the old UK-Mesoscale model
- 38 model levels from the surface to 39 km



Lateral boundary conditions for AQ forecasts

- Daily transfer of forecast fields from GEMS-GRG in Grib format.
- Only data for O3, NOx, CO and HCHO
- Met data from North Atlantic and European Model
- Using a combination of standard UM tools generate LBCs
- Case studies - use global model run to make LBCs

Chemistry schemes

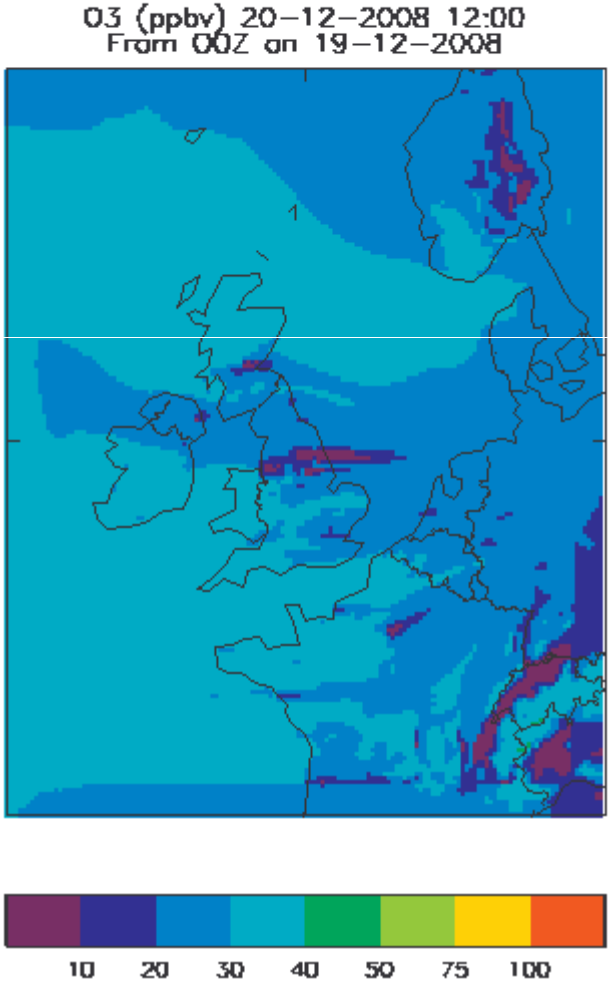
- Two chemistry schemes have been used so far
  - ‘Standard Tropospheric Chemistry’. 26 tracers (9 of them emitted), 27 photolysis reactions and ~100 gas-phase reactions. oxidation of methane, ethane and propane. Used for initial test of the forecasting suite
  - Regional AQ mechanism. 40 tracers (16 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. Based on STOCHEM chemical mechanism

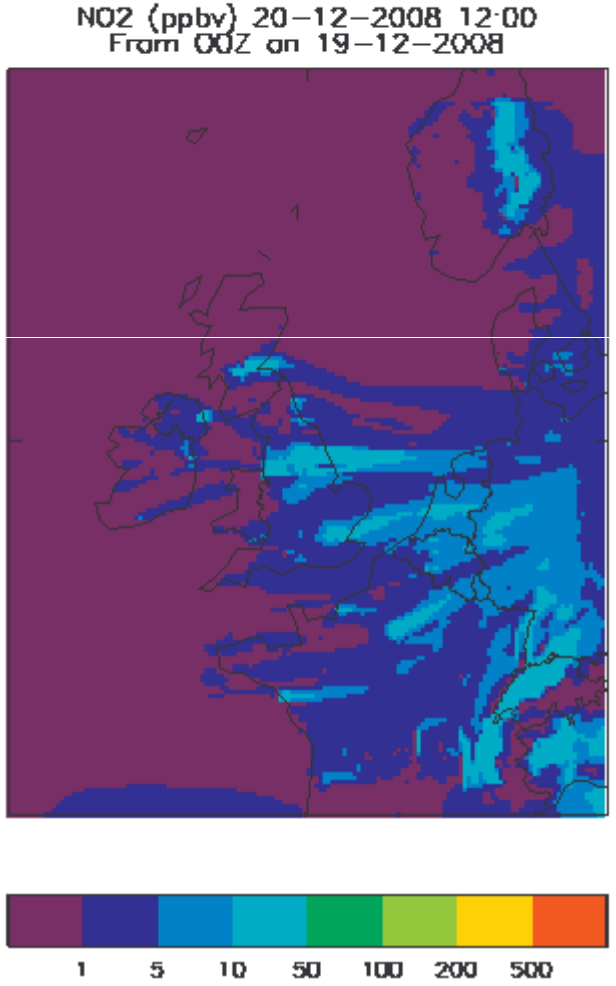
First near real time forecasts

Near real time forecasts

- Ran 1 forecast per day non operationally from June – December 2008 on NEC SX-8
- Timings very variable as running on a user account
- Suite started at 04:25 UT after NAE 0Z run.
- Earliest results around 07:00 UT
- Used the ‘standard tropospheric chemistry’ scheme initially with the more complete chemistry implemented later
- Suite control is via SCS as used in Operations

Example Forecast 19/12/09



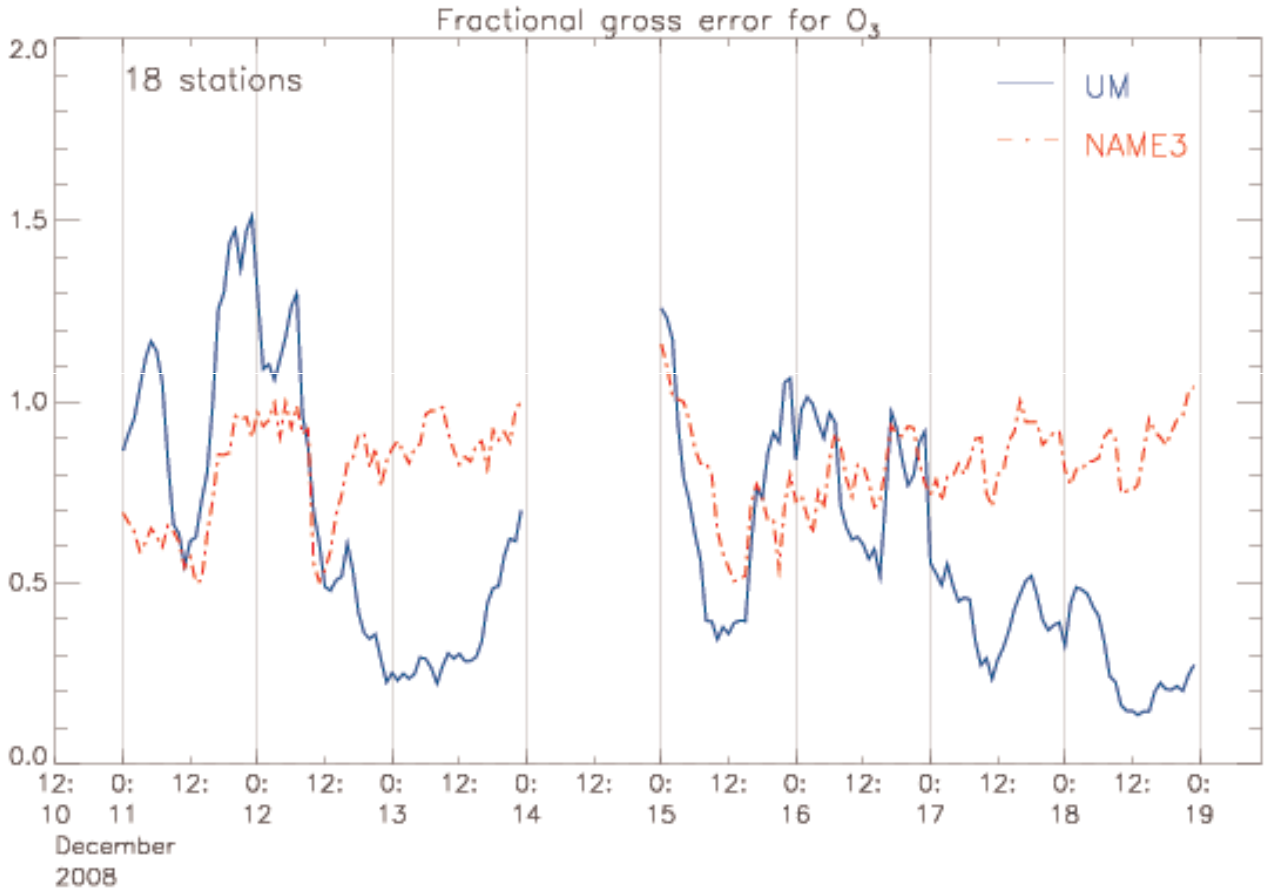


Near real time verification

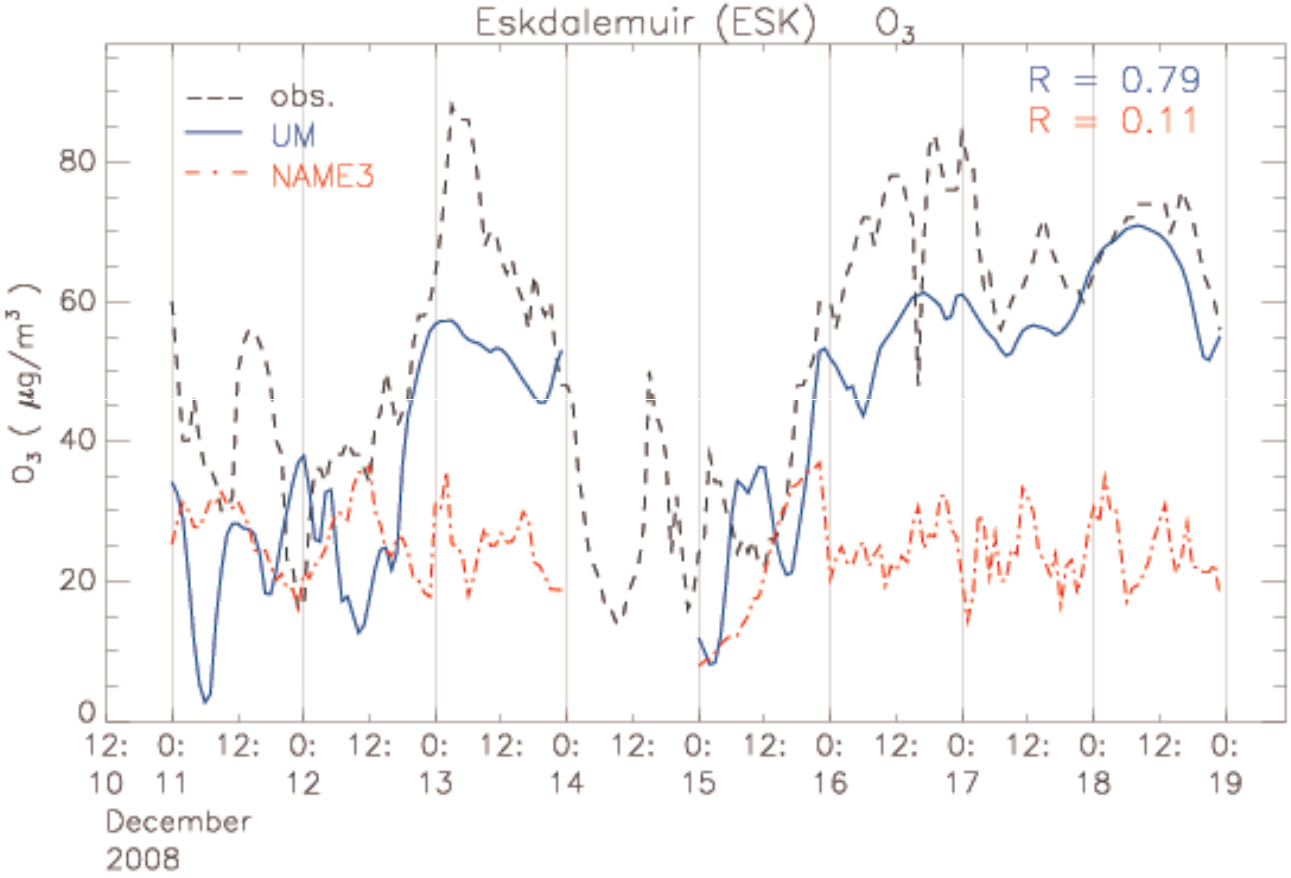
Near real time verification

- Routine verification against Automated Urban and Rural Network from NetCen data 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 NO2
- Quick method of checking nothing too bad happening to forecast
- All data archived for possible later analysis

Example plots – mean over 18 rural/remote stations



Example verification at Eskdalemuir



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)
- Not as severe as 2003
- 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 this
- Only preliminary investigations so far

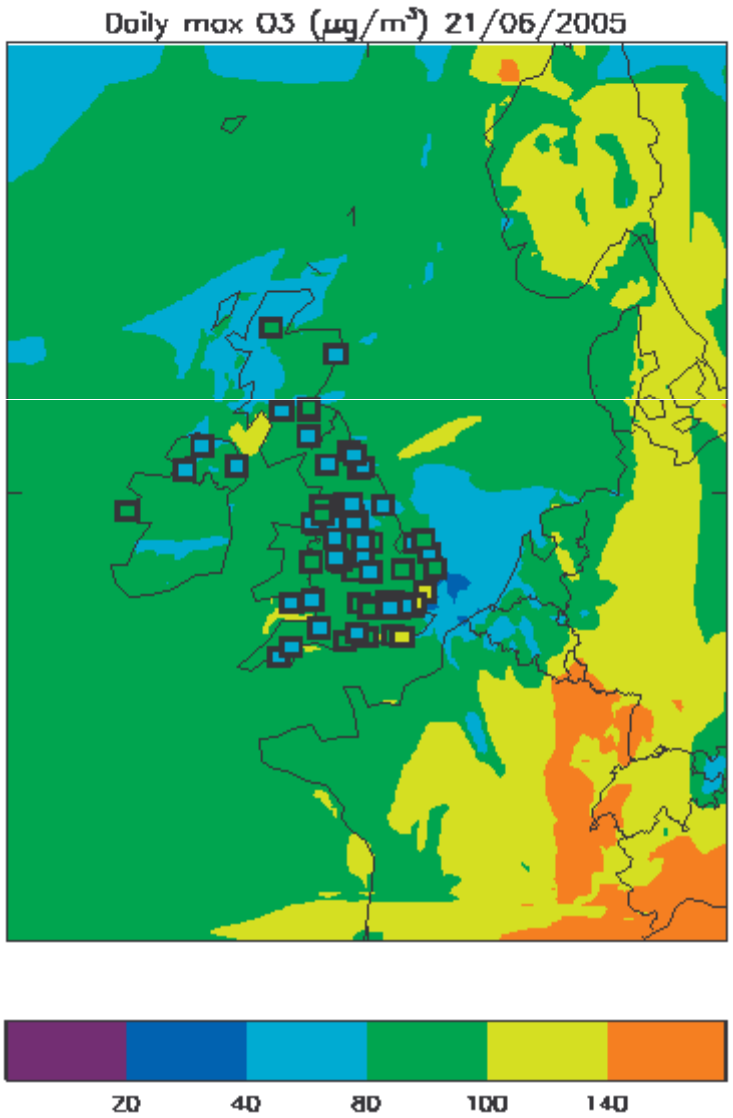
Global model case study set up

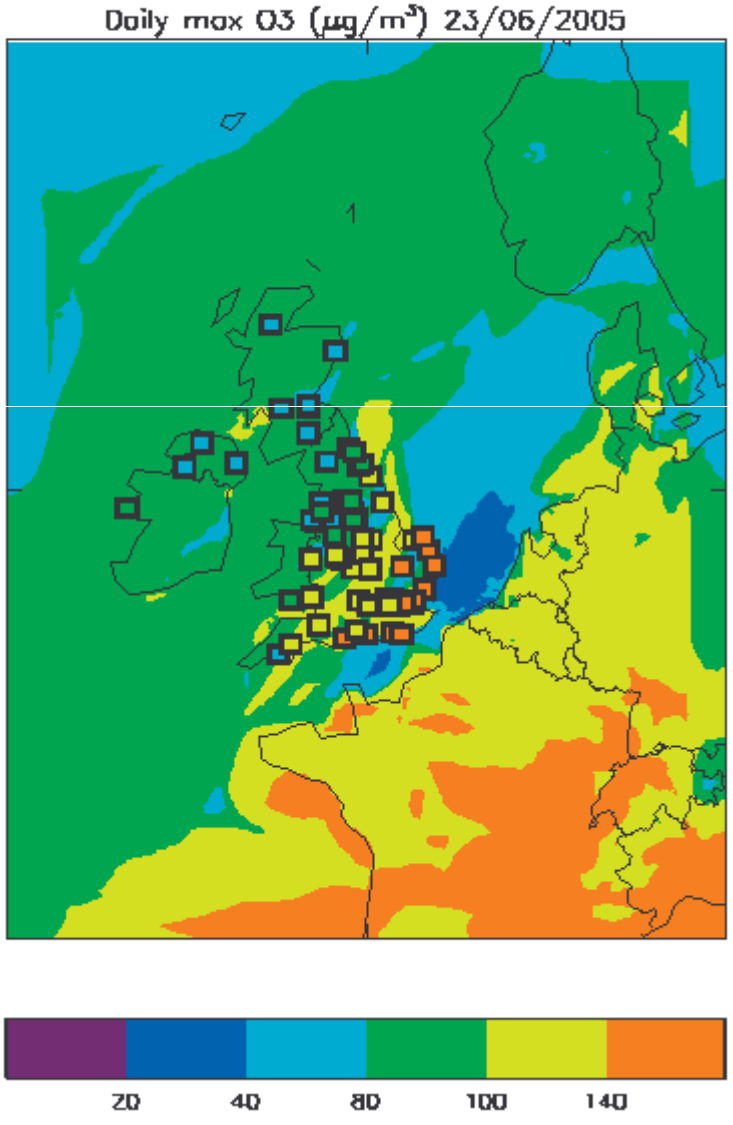
- Global N144 (1.25^{o} x 0.833^{o}) L38 model
- Regional AQ chemistry
- Initial chemical fields from a climate model monthly mean
- Run in an SCS suite
- Reconfigure meteorology daily from global analyses, transplant chemistry from previous day's T+24 dump
- Meteorology based on analyses, chemistry free running
- Spin up 1-16/6/2005, LBC output 16-30/6/2005

Mesoscale model case study set up

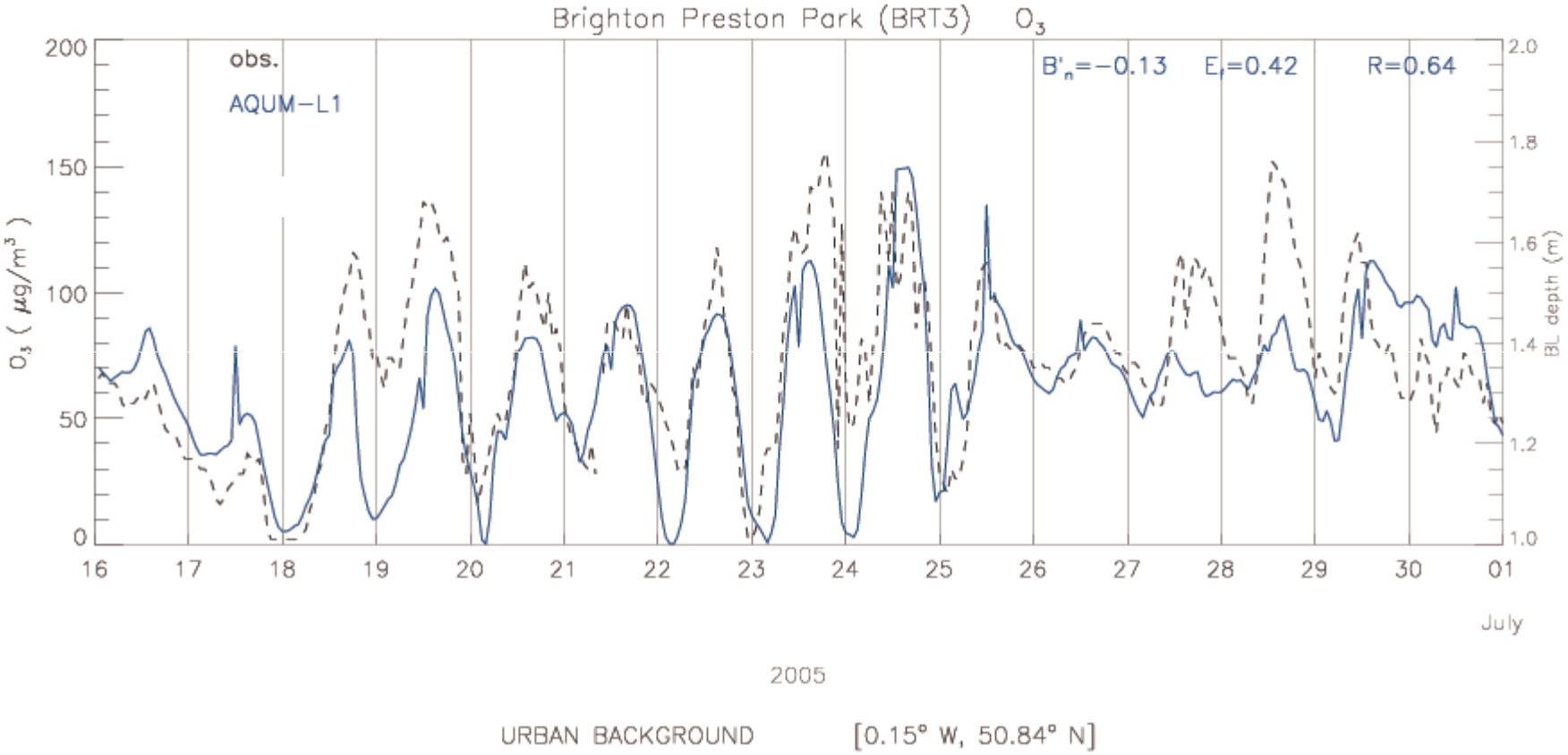
- 12 km UK-Mes model
- Initial chemistry, LBCs from global model
- Set up as for global - Meteorology based on analyses, chemistry free running
- Run 16-30/6/2005

Mesoscale model results - maps

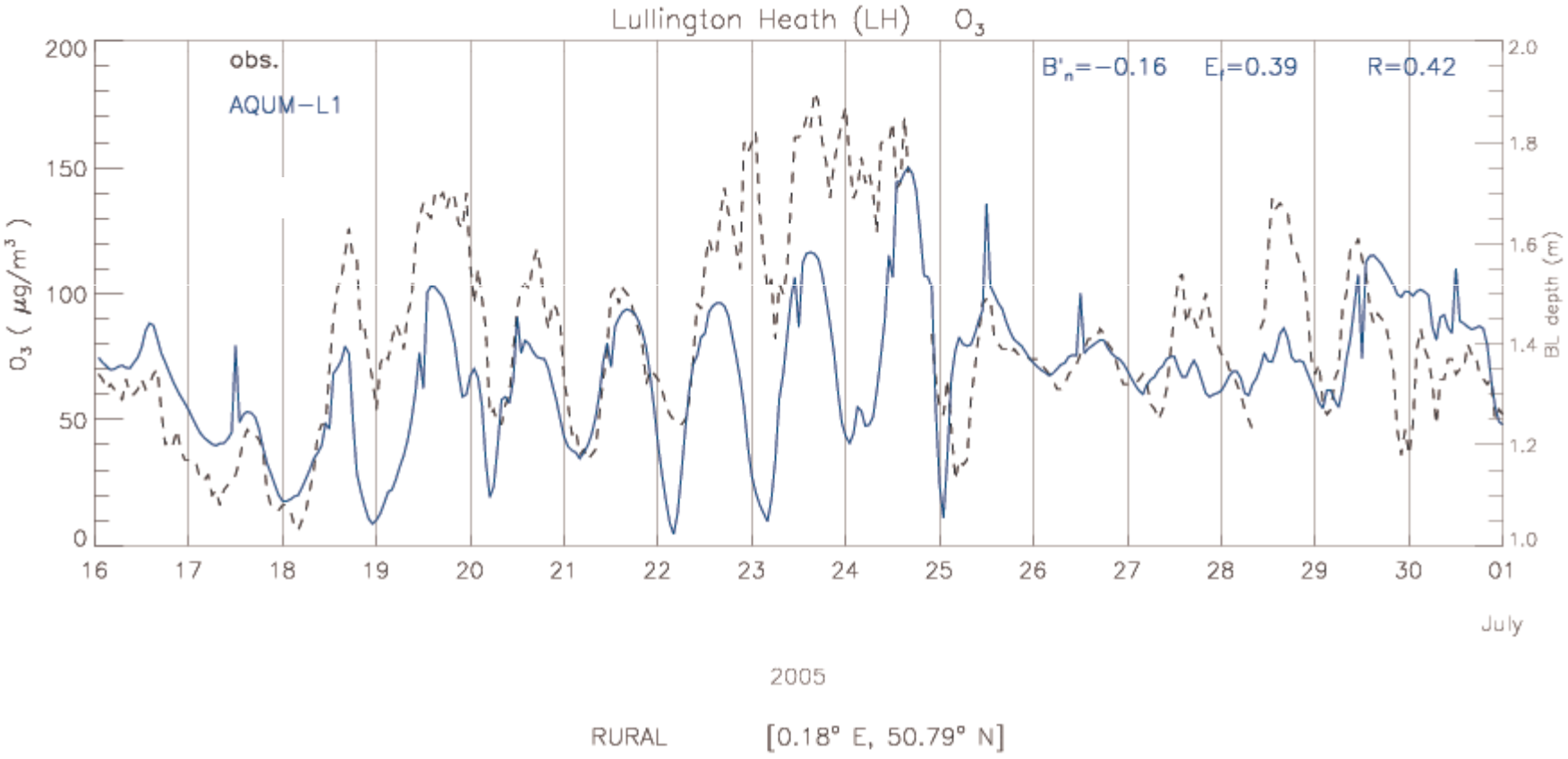




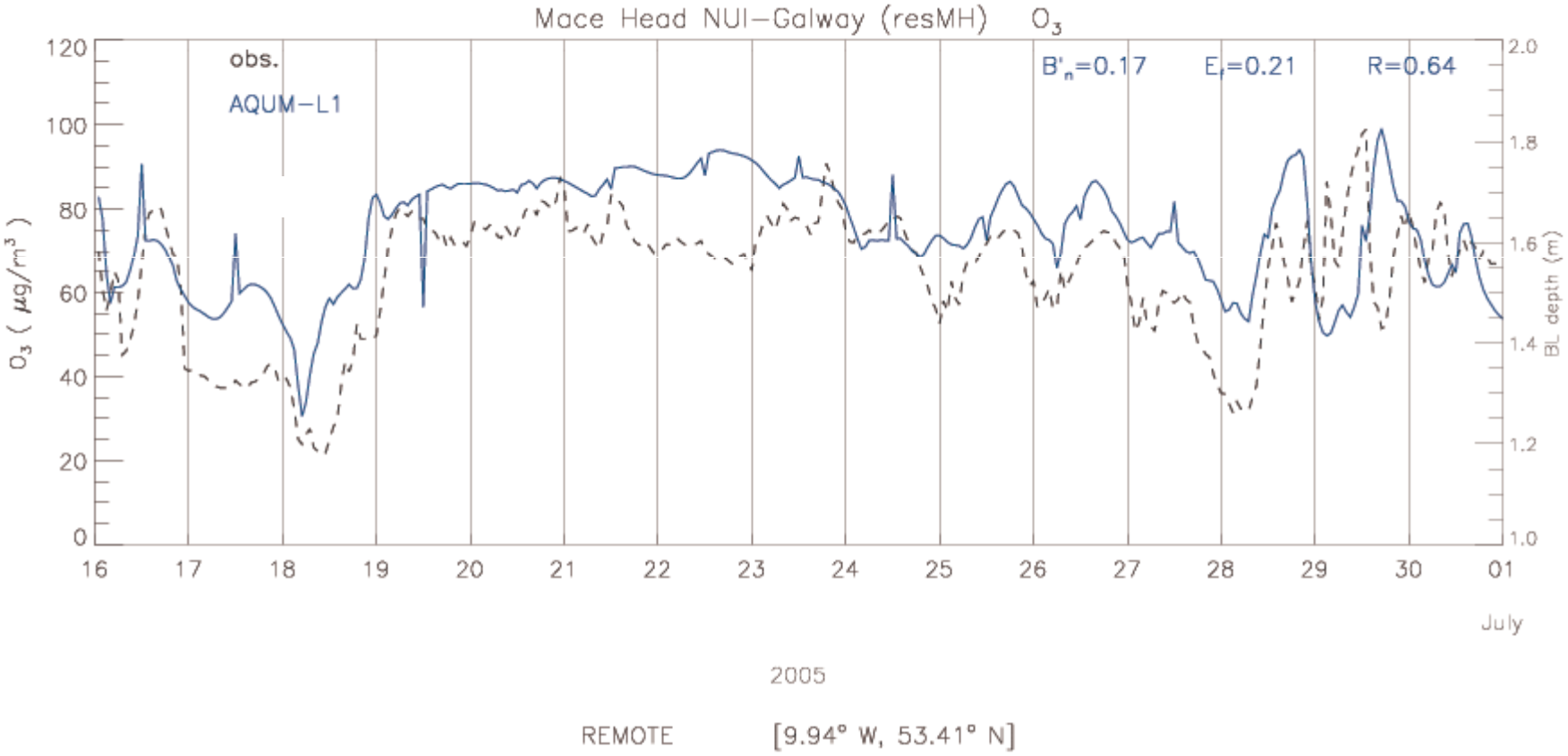
Mesoscale model results – stations (1)



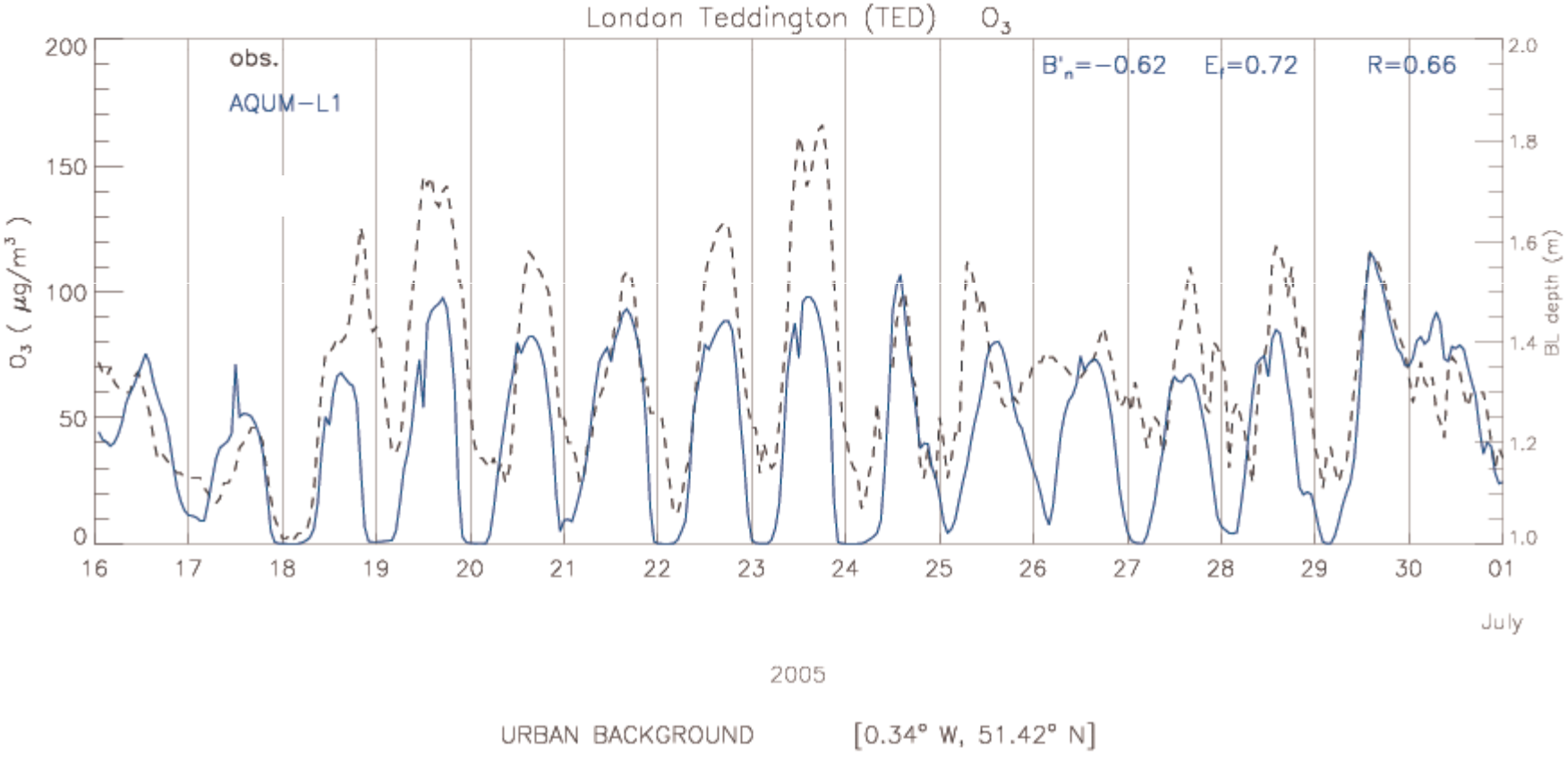
Mesoscale model results – stations (2)



Mesoscale model results – stations (3)



Mesoscale model results – stations (4)



Conclusions

Conclusions

- 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

Future work

Future work

- Ensure all code to run UKCA in a LAM configuration and new chemistry scheme are lodged – needed for operational acceptance but also of benefit to wider community
- Diurnal/weekly cycles of emission rates and vertical profiles of emissions
- Further improvement of ozone forecasts
  - Vertical mixing
  - Online not offline photolysis
- Port suite to new IBM supercomputer
- Test limited area version of AQ forecast model with aerosol (initially not MODE)
- Get acceptance for adoption as a test in the operational suite

Questions and answers

Error measures

- Fractional Gross Error

$$E_f = \frac{2}{N} \sum_i \left| \frac{f_i - o_i}{f_i + o_i} \right|$$

- Mean Normalised Bias

$$B'_n = \frac{2}{N} \sum_i \left(\frac{f_i - o_i}{f_i + o_i} \right)$$