Regional air quality forecasting in the Met Office Unified Model™

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1. Introduction

The UKCA (UK Chemistry and Aerosols) programme is developing a new UK community atmospheric chemistry-aerosol global model suitable for a range of topics in climate and environmental change research. Schemes for atmospheric chemistry and aerosols have been coupled to the Met Office Unified Model™ (Met UM), used for forecasting on timescales from hours through seasons to centuries. Based on developments of UKCA for chemistry-climate applications, the **AQUM** (Air Quality in the Unified Model) project is developing a regional air quality forecasting capability. This limited area model version will be operationally running as a test suite for real time forecasting of O_3, NO_x, CO, SO_2 and particulate matter (PM_{10} and $PM_{2.5}$) by spring 2010.

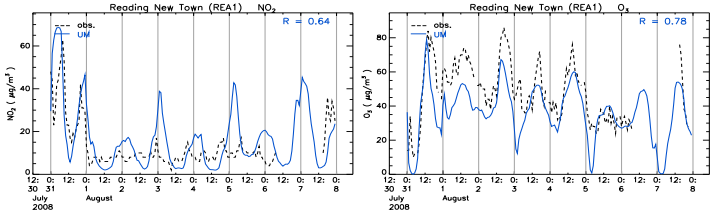
2. Model description

- On-line, real-time forecast model, with near real time (NRT) verification and visualisation.
- 38 vertical levels from the surface to 39 km. Initial horizontal resolution is 12x12 km. Domain covering the UK and Ireland, also including Belgium, Netherlands and most of France and Western Germany.
- Initial and boundary conditions for:
  - Meteorological fields: From the Met Office North Atlantic and European Model (NAE).
  - Chemical fields: From global chemistry forecast of the GEMS-Global Reactive Gases project. At the moment data for O_3, NO_x, CO and HCHO.
- Regional air quality (RAQ) chemistry mechanism based on STOCHEM (Collins et al., 1997). 40 tracers (16 of them emitted), 23 photolysis reactions and ~115 gas-phase reactions. Oxidation of C2-C3 alkenes, isoprene and aromatics included. Removal by wet and dry deposition considered for 19 and 16 species, respectively.

3. First NRT forecast and verification

- Daily forecasts routinely ran non operationally from June to December 2008. A simplified tropospheric chemistry scheme more suitable for climate studies was used initially with the more complex RAQ chemistry implemented later.
- Routine verification against surface observations from the UK Automatic Urban and Rural Network (AURN).

First results show the initial capability for AQ forecasting within the UM, although with high modelled NO_x mixing ratios during the night / early morning hours as well as somewhat low O_3. See e.g. results for a suburban site at Reading:

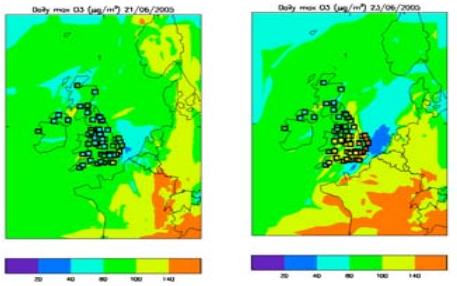


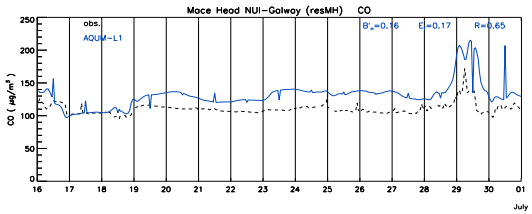
4. Case study: June 2005

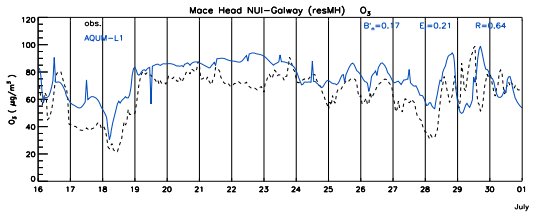
Ozone episode across the SE of the UK on 19–24 June. Seven AURN stations with at least one hourly average above 180 μgm^{-3}. The 12 km mesoscale model was run with initial and LBCs from a global model run. Spin-up for 15 days.

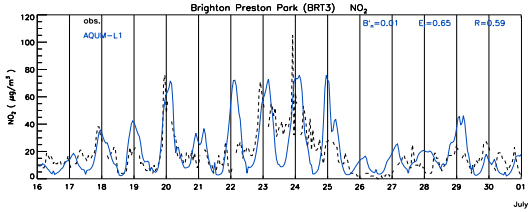
Some results:

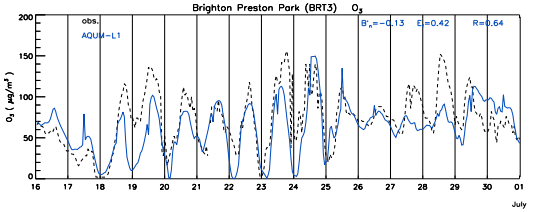
- The model generally reproduces the geographical patterns in the observed ozone concentrations, but not the strong NW-SE gradient during the period of highest ozone concentrations around 23 of June.
- Modelled CO and ozone are in reasonably good agreement with observations at Mace Head, remote marine boundary layer site in the West of Ireland.
- Overall the model reproduces the day-to-day variability for most days but not the observed ozone maxima at suburban and urban background sites in the S/SE of England. See example for NO_2 and O_3 at Brighton.











5. Current and future model development

- Calculation of PM_{10} and $PM_{2.5}$ diagnostics already implemented. Inclusion of forecast for PM_{10}/$PM_{2.5}$ and subsequent evaluation will be done in the near future.
- Implementation of diurnal/weekly cycles of emission rates and possibly vertical profiles of emissions.
- Further improvement of ozone forecasts by using online photolysis and investigating vertical mixing in the model.
- Test suite operationally running by spring 2010.

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References

Collins, W. J., D. S. Stevenson, C. E. Johnson, and R. G. Derwent: Tropospheric ozone in a global-scale three-dimensional Lagrangian Model and its response to NO_x emission controls, J. Atmos. Chem., 26, 223-274, 1997.