Development of the Met-UM for Air Quality Forecasting

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1. INTRODUCTION

A regional air quality forecasting capability using the Met Office Unified model (Met UM) has been developed at the UK Met Office, through the AQUM (Air Quality in the UM) project. By spring 2010 it is planned to start running a limited area model configuration as a test suite operationally, for real time forecasting of O3, NOx, CO, SO2 and particulate matter (PM10 and PM2.5). This project has been enabled by the further development of the atmospheric chemistry already present in the UM, i.e the UKCA (UK Chemistry and Aerosols) model, currently used as a research tool for climate and environmental change research projects. AQUM involves the development of a limited area model with a new tropospheric chemistry scheme suited for regional air quality forecasting. In this poster we describe sensitivity tests carried out with the AQUM initial configuration; firstly through the use of an interactive dry deposition scheme for ozone, then secondly with the application of a diurnal emissions cycle to all model emissions, in order to investigate the importance of diurnal cycles of emissions.

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, most of France and western Germany.
- Initial and boundary conditions:
  - Meteorological fields: From the Met Office North Atlantic and European model.
  - Chemical fields: From global chemistry forecast of the GEMS-Global Reactive Gases project. Currently data only for O3, NOx, 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.
- Monthly surface emission profiles obtained through the GEMS project. NOx ship emissions from EMEP, but no VOC ship emissions at present.

3. CASE STUDY – June 2005 Ozone Episode

An ozone episode occurred across South-East England from 19th–24th June 2005. Seven AURN stations recorded at least one hourly average greater than 180 µgm-3, which is the lower limit of the HIGH pollution band defined by DEFRA. The AQUM model was run using initial conditions and LBCs from a global model including standard UKCA atmospheric chemistry.

The plots displayed illustrate results from 3 different runs of the AQUM forecast suite for this ozone episode case study. These were carried out during the development of the model, and aim to show improvements and demonstrate sensitivities:

AQUM runs:

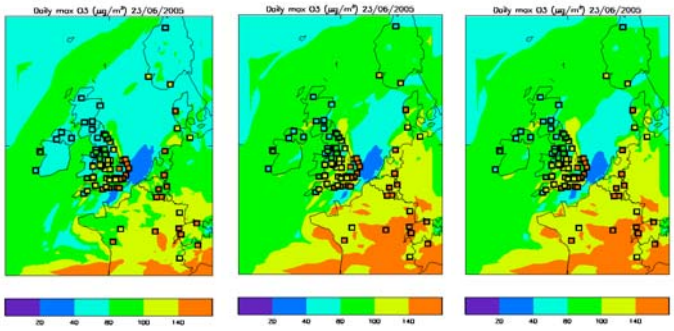
(a) Initial model set-up (**Control**)

(b) Control + Interactive Ozone Dry deposition Scheme (**Int.D.Dep**)

(c) Control + Int.D.Dep + Diurnal Traffic Emissions (**Traffic Cycles**)

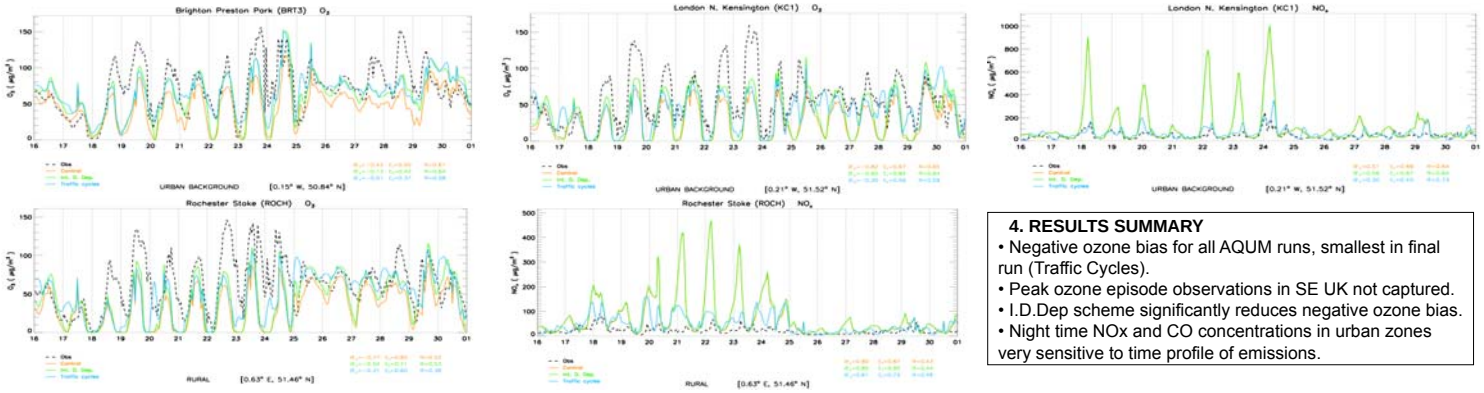
Run (a) is the initial model set-up used for this case study, (b) includes the use of a more sophisticated ozone dry deposition scheme which is a resistance based model (Wesley, 1989), coupled to the Moses surface scheme in the Met UM, and (c) includes the adjustment of the hourly emission rate to represent a diurnal traffic emissions cycle, for all surface emissions of trace gases.

Daily Max Ozone 23rd June



a) Control **b) Int.D.Dep** **c) Traffic Cycles**

Site Specific Forecast + Observations



4. RESULTS SUMMARY

- Negative ozone bias for all AQUM runs, smallest in final run (Traffic Cycles).
- Peak ozone episode observations in SE UK not captured.
- I.D.Dep scheme significantly reduces negative ozone bias.
- Night time NOx and CO concentrations in urban zones very sensitive to time profile of emissions.

5. DISCUSSION

•The control run generally reproduces the geographical patterns in the observed daily ozone maxima, but not the strong NW-SE gradient observed during the period of highest ozone concentrations around the 23rd of June.

•Good reproduction of the daily ozone cycle, but not the observed daily maxima at urban and rural sites in the S/SE of England during episode peak (see N.Kensington and Rochester).

•Occasional excessive night time concentrations of NOx produced at urban (see N.Kensington 24th June) and rural (see Rochester) sites, consequently producing very low night time ozone through destruction by high NO.

•The Int.D.Dep run reduces the general negative bias and gross error of the ozone forecast during the episode (see Brighton), but still does not completely capture the highest observed daily max values in South-East UK during the peak of the episode (see daily max ozone plot and North Kensington time series). Daily minimum concentrations unaffected.

•Using a more sophisticated emissions cycle significantly improves the night time NOx and CO concentrations in urban areas (see N.Kensington for NOx), and consequently reduces the destruction of ozone during the night, partially resolving the very low concentrations seen in the control run. The impact in rural areas is less pronounced, but still reduces the positive bias and error for NOx (see Rochester), indicating the importance of the diurnal emissions cycle in AQUM.

•Future work involves more accurate diagnosis of ozone forecast errors, further case studies to investigate the performance of AQUM in forecasting aerosols and the development and evaluation of a facility for visibility forecasts.

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