Air Quality Modelling for Health Impacts Studies

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Met Office Air Quality and Composition team

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- UK wide poor air quality

- In some places the highest index 10 reached

- Combination of pollution from

  - local sources

  - Secondary particulates from Europe

  - Saharan desert dust

(Daily Mail April 2nd 2014)

'HealthAir': Present Day and under a Future Climate

- HealthAir Project: http://www.gla.ac.uk/research/az/airpollution/

  - Collaboration between Met Office and Universities of Southampton, Glasgow

  - Bayesian spatio-temporal modelling of chronic health impacts of air quality in UK

  - Present day and future climate modelling

  - 5-year (2007-2011) reanalysis dataset giving hourly UK pollutant fields at 12km resolution over UK

  - Developing a new capability to improve the consistency between estimates of present day and future climate air quality
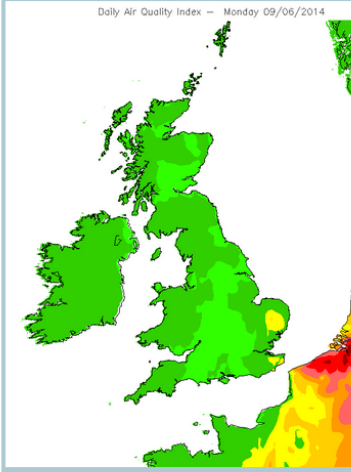
Met Office national AQ forecast for Defra

- As of 1st April 2014 the Met Office began providing the national AQ forecast for Defra

  - UK maps of Daily Air Quality Index

  - Descriptive text forecast for Today, Tomorrow and Outlook

 - Tweets

  - www.uk-air.defra.gov.uk

Present day AQ simulations

- Health impact modelling requires reliable estimates of pollution concentration

- Aim: provide a high quality, gridded dataset of pollutant air concentrations for the whole UK

  - Hour-by-hour from 1st Jan 2007 to 31st Dec 2011

  - Using the National Atmospheric Emission Inventory appropriate to each year

  - Using high quality meteorological data

AQUM: Integrating air quality and weather forecasting

- The weather forecast model (MetUM) has been developed to include atmospheric chemistry and aerosols

  - Build on the UKCA foundation laid by Climate Research

  - A partnership with UK academia

- We now use different configurations of the same Unified Model to generate predictions of

  - Weather

  - Air Quality

  - Climate Change

- A flexible framework for modelling whole atmosphere composition from ~city to global spatial scales
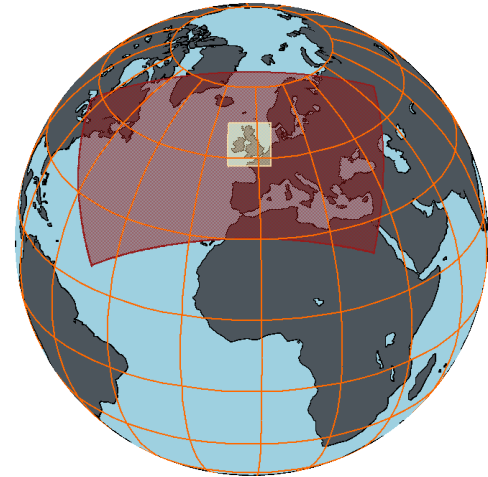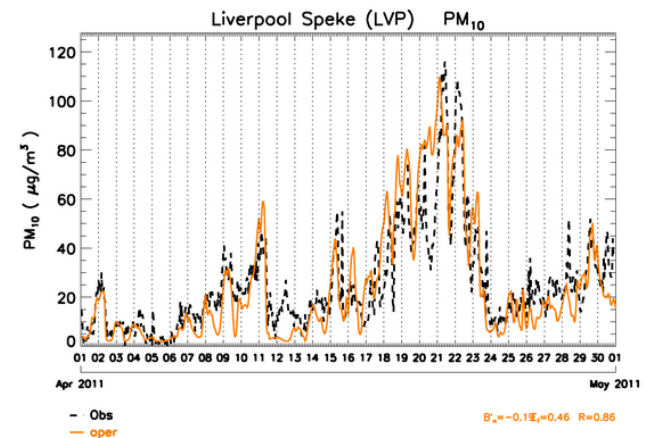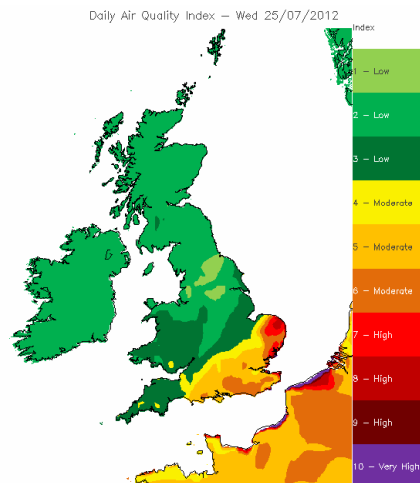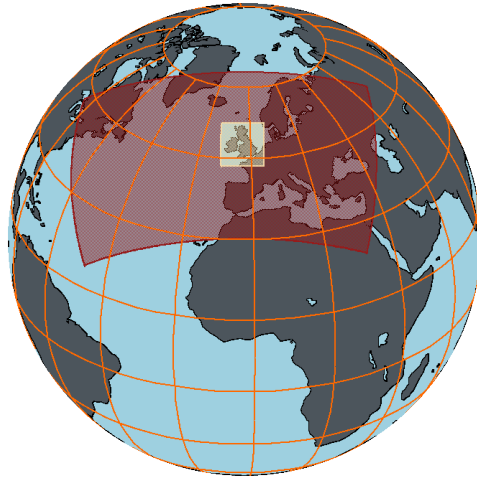
AQUM forecast and modelling system

Met Office

Model

Observations

Forecast / model

Verification

On-line modelling with AQUM

- AQ modelling in the UM offers advantages:

  - On-line modelling, which allows:

    - closer integration of meteorology and chemistry

    - Potential for including feedbacks between composition and meteorology

      - Influence of composition on radiation, cloud physics and visibility forecasting

  - Incorporation of lateral boundary fluxes from a global model

DGLCB Time mean
Atmos Atmosphere tracer 1 (conventionally O3) at 20.00 metres
From 28/ 6/2005 to 28/ 6/2005

VT 20050628 22Z

0   50   100   150   200
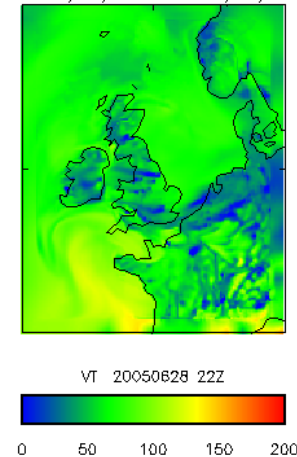
AQUM domain

AQUM has a sophisticated representation of atmospheric chemistry

- 'Regional Air Quality' chemistry scheme

  - 58 species (40 transported); 16 emitted

  - 12 VOCs incl. C2-C3 alkenes and alkanes

  - 116 gas phase reactions; 23 photolysis reactions

  - Removal by dry and wet deposition

- CLASSIC aerosol scheme incl. nitrate, sulphate and dust

- On-line photolysis

- LBCs

  - Meteorology from Met Office global model

  - Chemistry and aerosols from a global chemistry model (MACC)

Pollutant Emissions

Synthesis of

- National Atmospheric Emission Inventory (NAEI) @ 1km over UK

- shipping @ 5km

- European inventory from MACC @ 5km

New emissions: NOx
205.73550 kg/s

kg/m2s

1e-16. 1e-15. 1e-14. 1e-13. 1e-12. 1e-11. 1e-10. 1e-9. 1
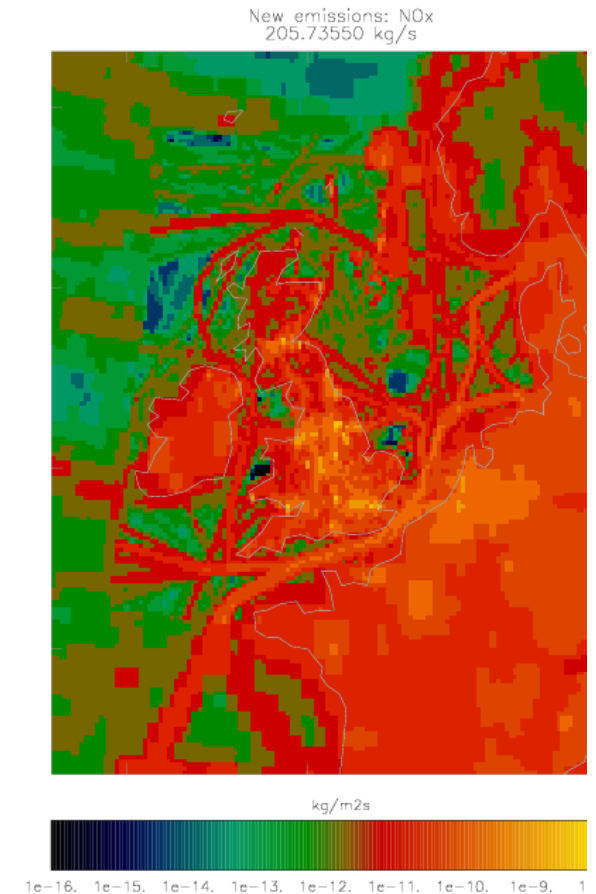
Routine air quality observations

- Defra fund the Automatic Urban and Rural Network (AURN)

- Network of sites spanning roadside, urban background and rural locations across the country

- Hourly measurements available in near-real-time at
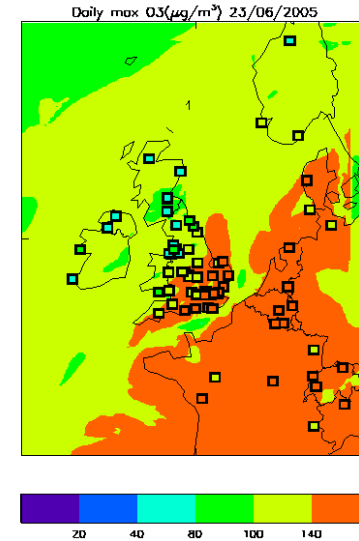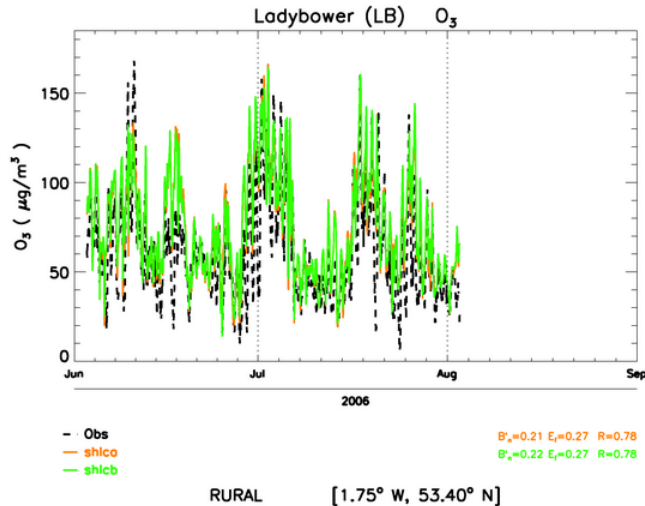
http://uk-air.defra.gov.uk

- Archived data are also available

- Measurements for London provided by King's College at

http://www.londonair.org.uk/ LondonAir/Default.aspx
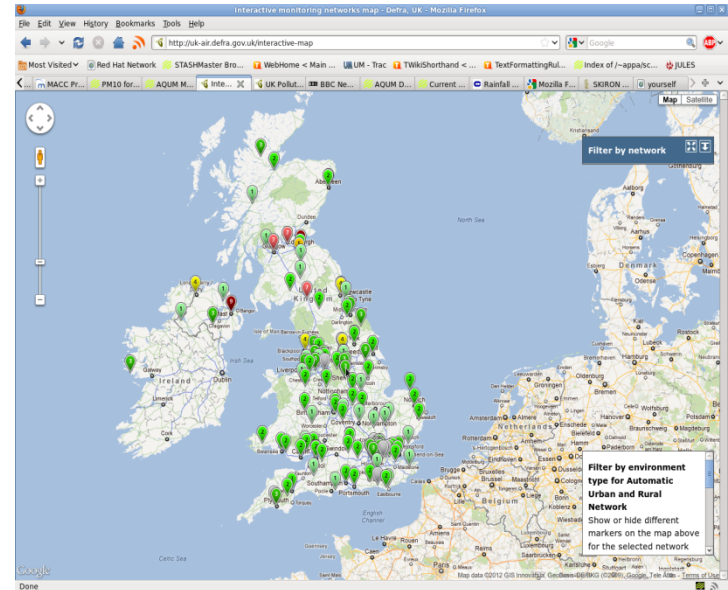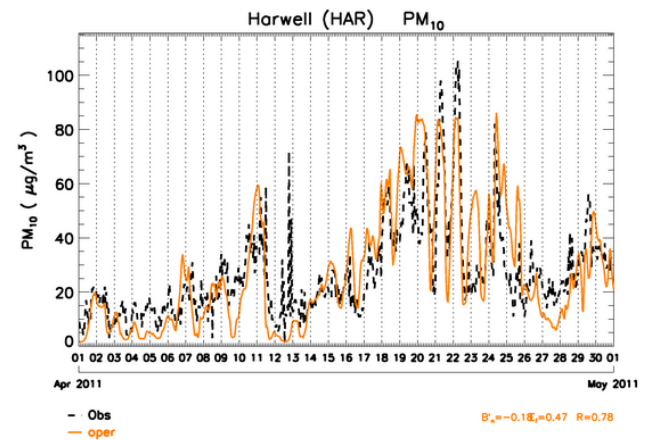
Near-real-time verification

- We conduct routine verification against observations from the UK Automatic Urban and Rural Network (AURN)

  - Surface measurements of SO2,O3, NO2, NO, CO and PM10 and PM2.5 are available

- This provides a rapid method of evaluating the forecast on a daily basis

- Constant objective evaluation aids our model development
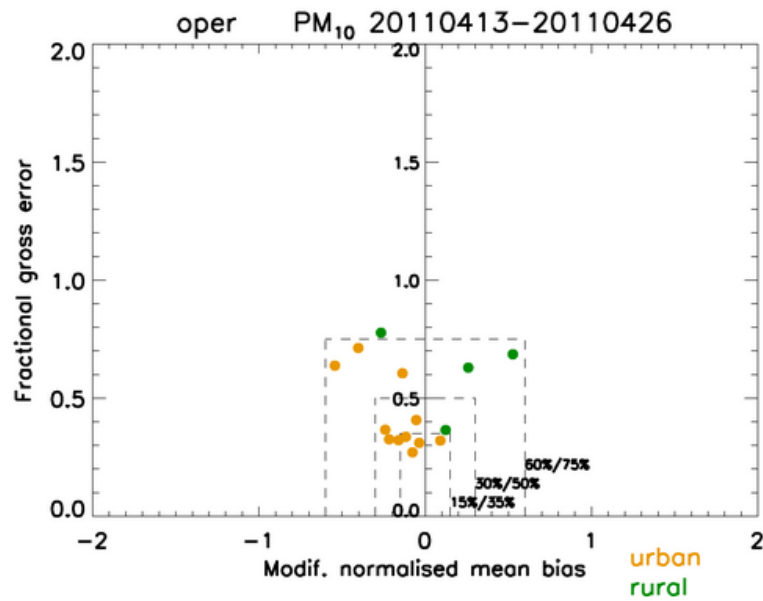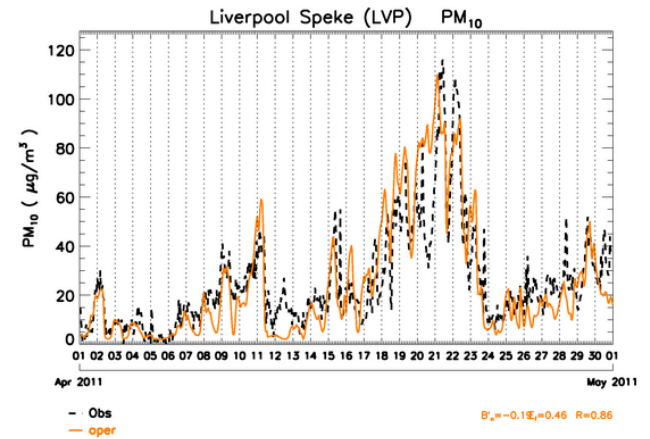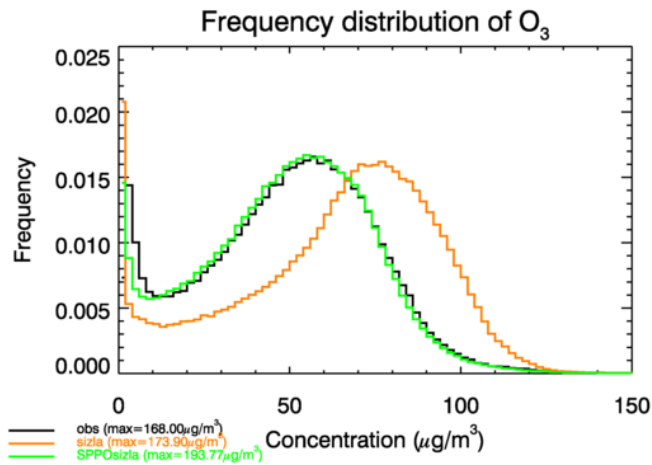
Model evaluation

Daily AQ Index

- Index computed from concentrations of ozone, NO2, SO2, PM10, PM2.5

- Different time averaging period for each species

- Introduction of PM2.5 since 2012
  - Fine particulates are now a major contributor to the number of poor air quality episodes

Daily Air Quality Index

The new bandings for the Daily Air quality Index are detailed in Table 1.

Band	Index	Ozone Running 8 hourly mean µgm⁻³	Nitrogen Dioxide hourly mean µgm⁻³	Sulphur Dioxide 15 minute mean µgm⁻³	PM2.5 Particles 24 hour mean µgm⁻³	PM10 Particles 24 hour mean µgm⁻³
LOW						
	1	0-33	0-66	0-88	0-11	0-16
	2	34-65	67-133	89-176	12-23	17-33
	3	66-99	134-199	177-265	24-34	34-49
MODERATE						
	4	100-120	200-267	266-354	35-41	50-58
	5	121-140	268-334	355-442	42-46	59-66
	6	141-159	335-399	443-531	47-52	67-74
HIGH						
	7	160-187	400-467	532-708	53-58	75-83
	8	188-213	468-534	709-886	59-64	84-91
	9	214-239	535-599	887-1063	65-69	92-99
VERY HIGH						
	10	240 or more	600 or more	1064 or more	70 or more	100 or more

Table 1: Daily Air Quality Index bands

The new daily air quality index comes in three parts and includes additional advice for susceptible individuals, alongside advice for the general population:

A. Instructions on how the index should be used;

B. The short-term health effects of air pollution and action that can be taken to reduce impacts;

C. Health advice linked to each band to accompany the air quality index.

These are detailed below:

# Statistical post-processing of observations

- Recent pollutant measurements from the national network can be used to improve forecasts

- We have developed a methodology to adjust the current AQUM forecast, according to local observations

- Large improvements in forecast skill have been demonstrated, especially for PM
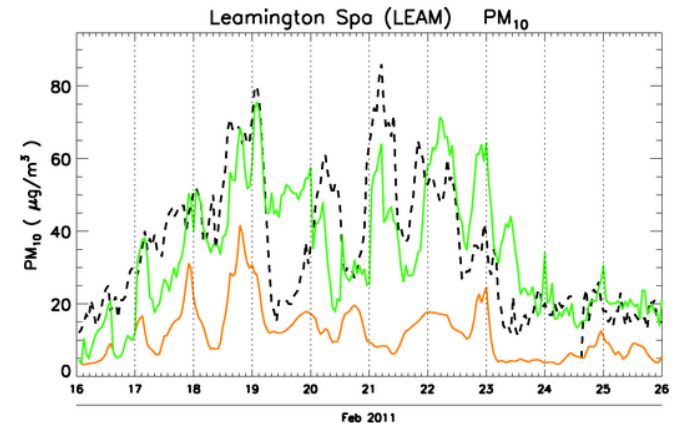
--Raw model forecast

--Adjusted forecast

Impact of reanalysis on present day AQ datasets: 2007
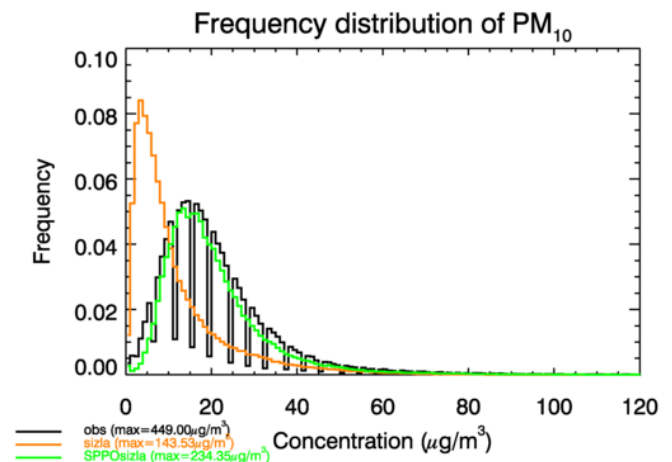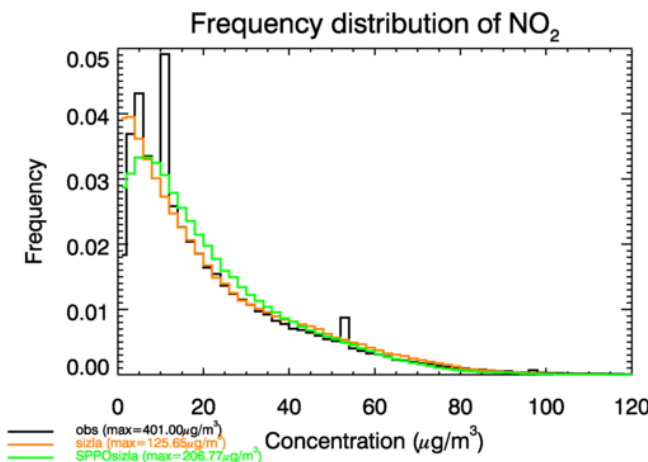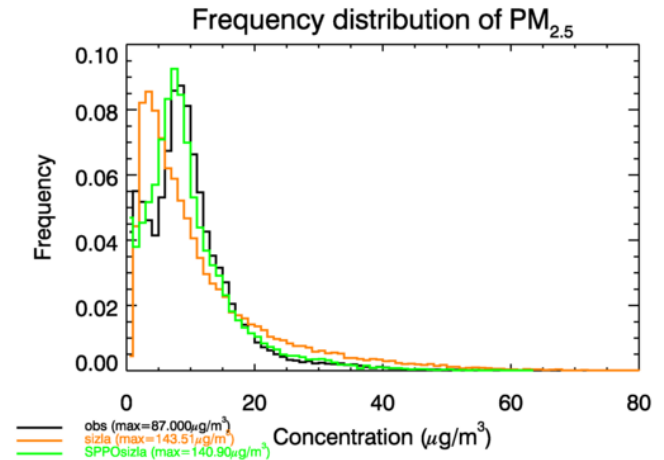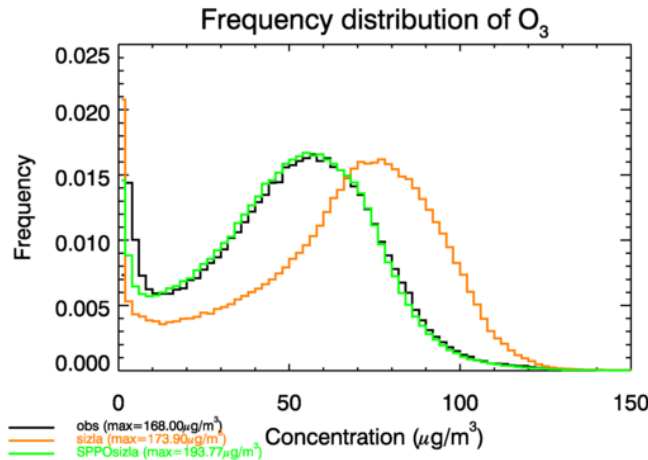
Model performance against observations for 2007: ozone

	Raw Model	Post-Processed
Correlation	0.72	0.91
Bias (μgm^{-3})	14.93	0.50
RMSE (μgm^{-3})	25.38	10.30
FAC2	0.78	0.91
Hit rate	0.49	0.60
False alarm ratio	0.90	0.33
ORSS	0.85	0.99

Model performance against observations for 2007: PM$_{2.5}$

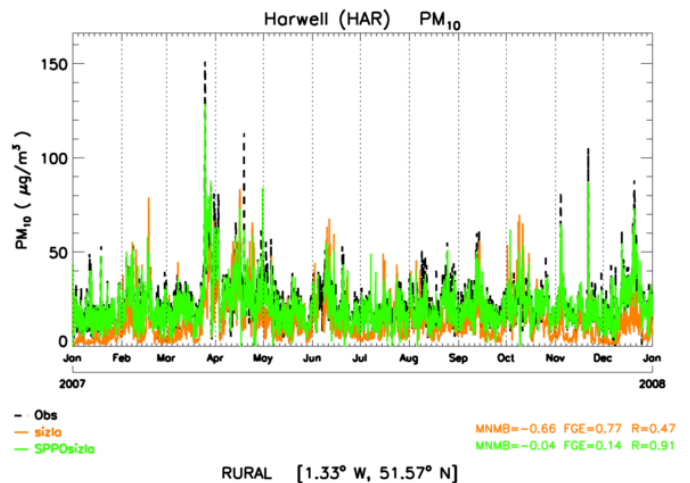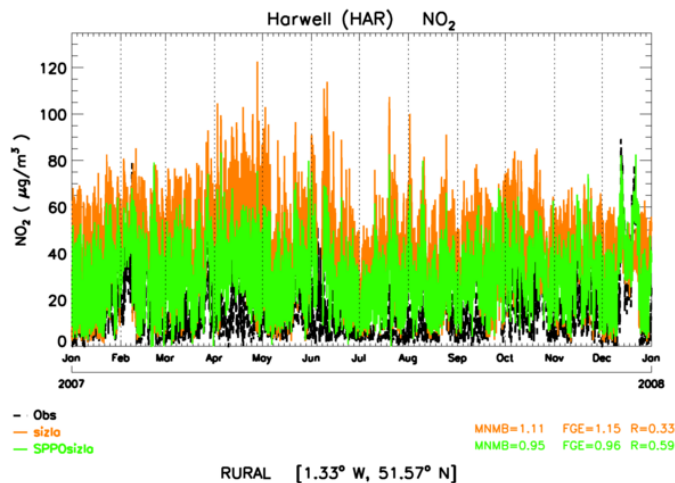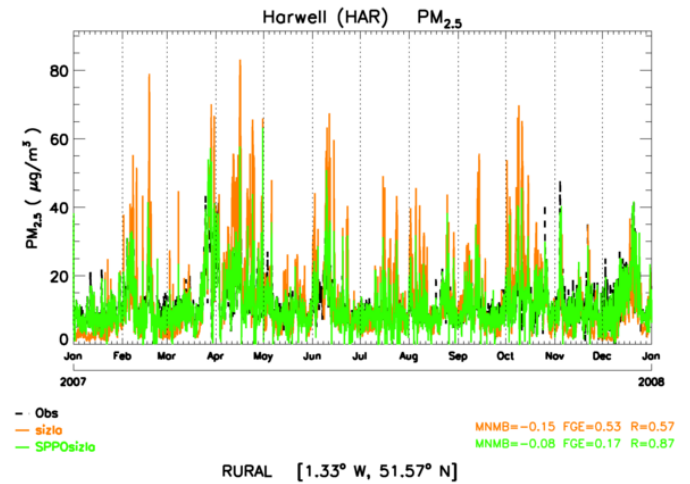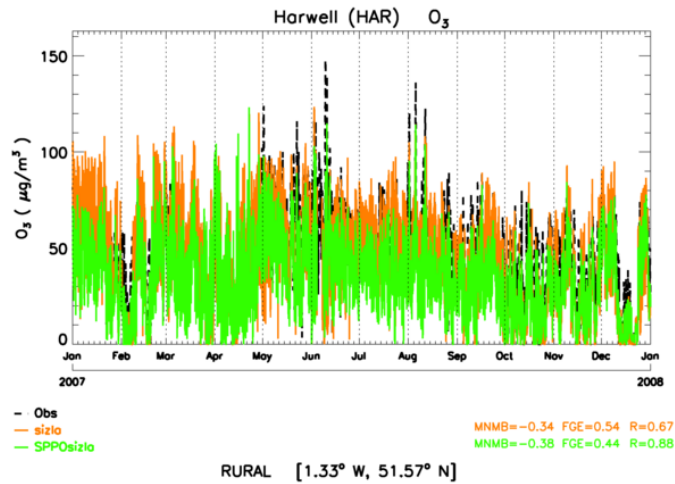|	Raw Model	Post-Processed
Correlation	0.56	0.88
Bias (μgm^{-3})	2.62	0.46
RMSE (μgm^{-3})	9.51	3.64
FAC2	0.63	0.86
Hit rate	0.46	0.73
False alarm ratio	0.89	0.28
ORSS	0.89	1.00

Present day dataset:

Hourly mean, surface air concentrations of

- O3, SO2, NO2, PM10, PM2.5

- A 2-D, gridded field at ~12km resolution in netCDF format

Annual time series: Harwell

Future Climate Simulations

- Aim to maintain as much consistency between present day and future climate runs

- Climate runs employ 3-level nesting:

  - Global Climate Model

    - Regional Climate Model

      - UK air quality model

- Final dataset generated by identical model set-up to present day runs
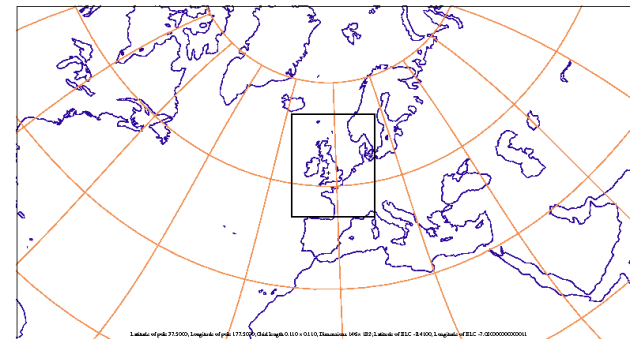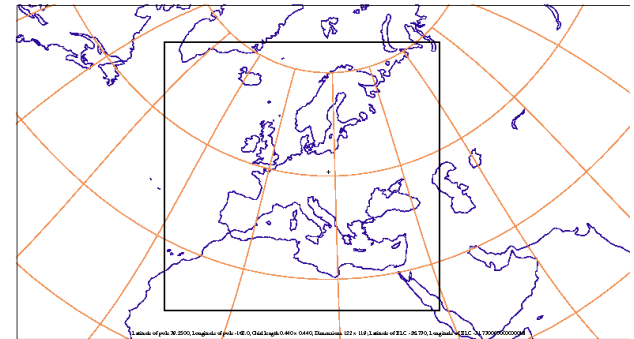
Summary

- As part of HealthAir the Met Office has delivered a high quality dataset of hourly pollutant concentrations over the whole UK for 2007-2011

- Work is in hand to deliver a dataset for 2050 under different climate and emissions scenarios

- These datasets are a valuable resource for air quality modelling and health impacts studies.

Hourly ozone field: 24th August 2013