Developments in air quality forecasting

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Rural forecasting

- **Empirical approach:** In the rural environment there are assumed to be no major local sources - all the pollution is imported from distant sources and is assumed to be in photo-stationary equilibrium. This scenario is amenable to an empirical approach.
- The time series of pollutants, whether NO_x, O_3 or PM_{10}, is modelled as a Markov chain whose coefficients are parameterised according to the following conditions:
  - Time of the forecast;
  - Yesterdays measurement;
  - Forecast wind speed, u;
  - Forecast wind direction, ϕ;
  - Temperature, T;
  - Incident shortwave radiation;
  - Forecast changes in u over t+24;
  - Forecast changes in T over t+24.
- Model parameters derived from two years of recent measurements, validated using a third years data.
- Results, with for example 94% of index correctly forecast, are substantially better than a simple auto-correlation which is which accurate to around 70%.

Rural forecasting: accuracy

Total moderate and high episodes

Out of 334 observations	Monitored	Forecast
Episodes	81	49
High episodes	1	5
Moderate episodes	80	44

Episodes Forecast = correct f'cast/total observed

% Index correctly forecast	94%
% Episodes correct	99%
% High Episodes correct	100%
% Moderate Episodes correct	81%

Forecast Accuracy

= correct /(correct + mis-forecast + not-forecast)

% Episode accuracy	87%
% High accuracy	25%
% Moderate accuracy	74%

South East England O_3

SE England: Calculated and monitored daily maximum ozone concentration ($\mu g/m^3$)
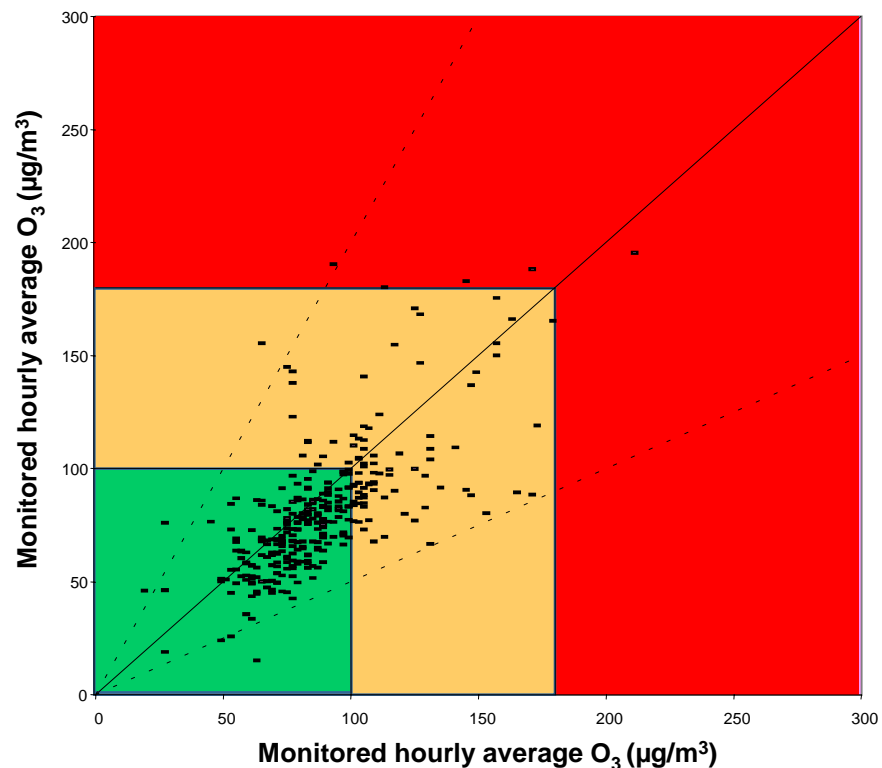
Stations used to derive & validate model: Lullington Heath, Harwell and Rochester.

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Urban forecasting

- CERC urban forecasting system based on the ADMS-Urban model.

- Inputs:
  - Detailed or 'model' emissions inventories.
  - Meteorological forecasts.
  - Background data from regional forecast system or climatology.

- Outputs:
  - Forecasts of air quality to street scale resolution.
  - Forecasts of 'idealised' situations eg urban kerbside, urban background.

- Dependencies:
  - Up to date inventories.
  - Accurate met and background data.

- Developments:
  - Mechanistic chemistry scheme (CBMIV).
  - Variation of residence time of compounds in the urban environment,

Forecast of PM10 in London for 03/11/05 24 hour maximum

PM10 (ug/m3)
> 64
60 - 64
56 - 60
52 - 56
48 - 52
44 - 48
40 - 44
36 - 40
32 - 36
28 - 32
< 28
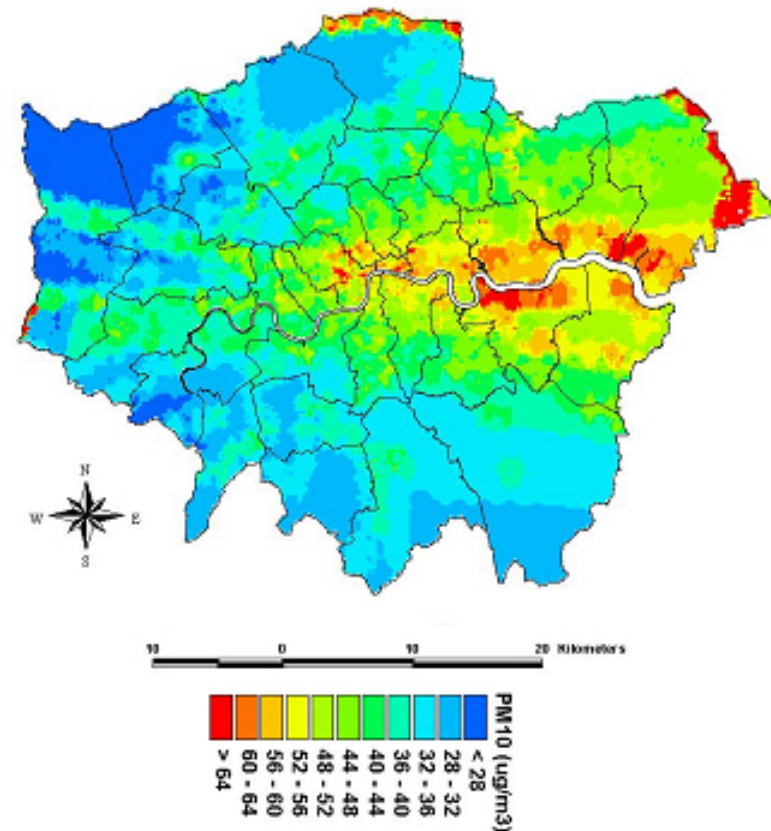
Urban forecasting: accuracy

Total number of monitored and forecast moderate and high episodes, Glasgow 2001

Out of 334 observations	Monitored	Forecast
Episodes	13	12
High episodes	5	3
Moderate episodes	8	9

Episodes Successfully Forecast, 2001
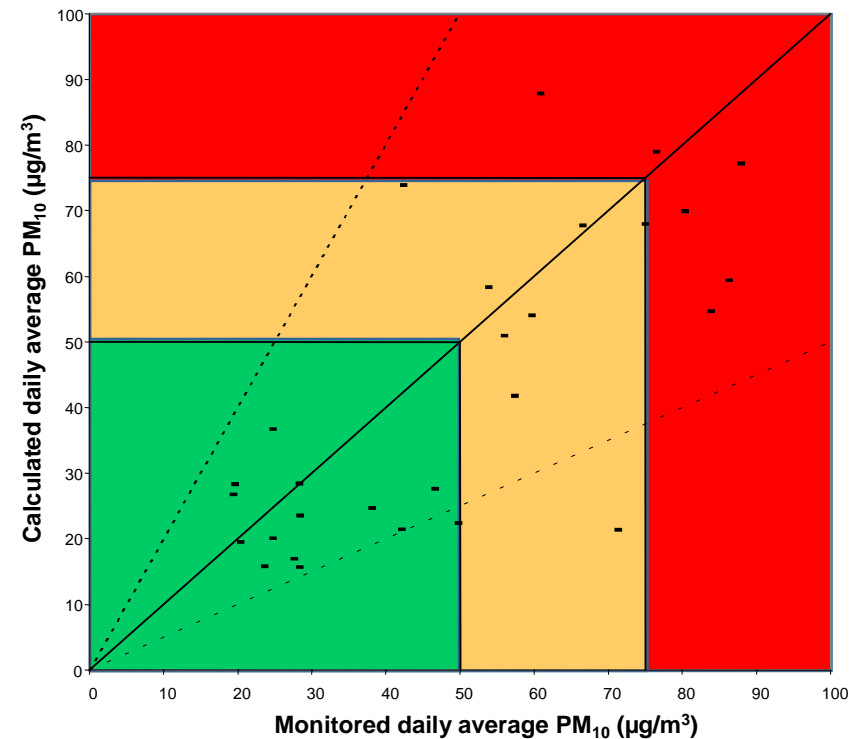
% Index successfully forecast	93%
% Episodes successfully forecast	92%
% High episodes successfully forecast	60%
% Moderate episodes successfully forecast	75%

Forecast Accuracy, 2001

|	
% Episode accuracy	71%
% High accuracy	50%
% Moderate accuracy	55%

Glasgow March 2003

Glasgow Kerbside: Calculated and monitored daily average PM_{10} concentration ($\mu g/m^3$)

Regional forecasting

- Collaboration with Rheinish Institute for Environmental Research, U. Köln.

- Operational t+48 hour forecasts using
  - NCEP AVN forecasts,
  - Emissions described using a 5km grid derived from EMEP & CERC inventories.

- System uses MM5 to derive met fields.

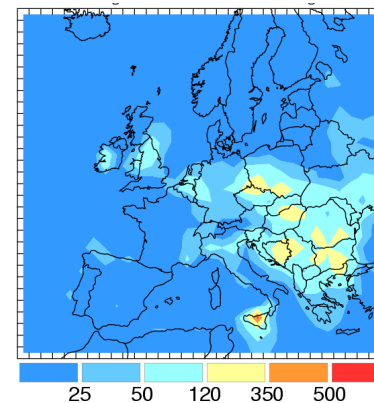- EURAD CTM used for forecasts; 3 nested grids: CO:125km, N1: 25km, N2: 5km
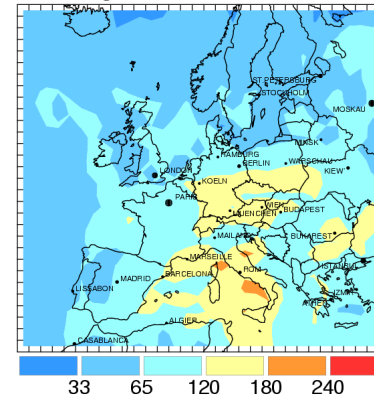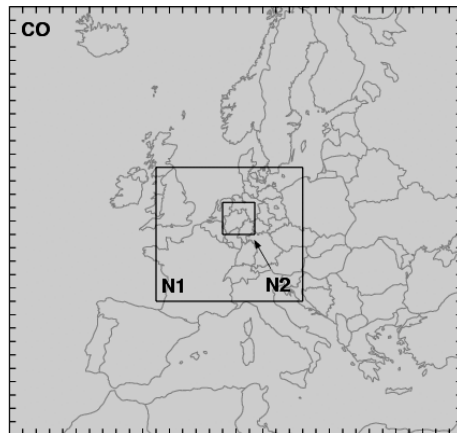
Ozone forecast for 02/5/17, ug/m^3

SO$_2$ forecast for 02/5/17, ug/m^3
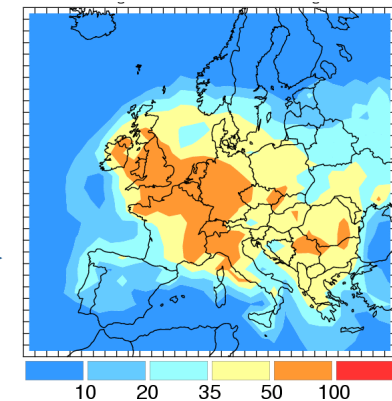
PM$_{10}$ forecast for 02/5/17, ug/m^3

The future: Lifecare

Project for operational monitoring and forecasting of regional-global air pollution, air composition and surface UV incorporating near real-time satellite data.

Operations & co-ordination:

- Deutsches Zentrum fur Luft- und Raumfart
- Cambridge Environmental Research Consultants
- University of Cologne

Data provision:

- European Centre for Medium Range Weather Forecasts via Deutscher Wetterdienst
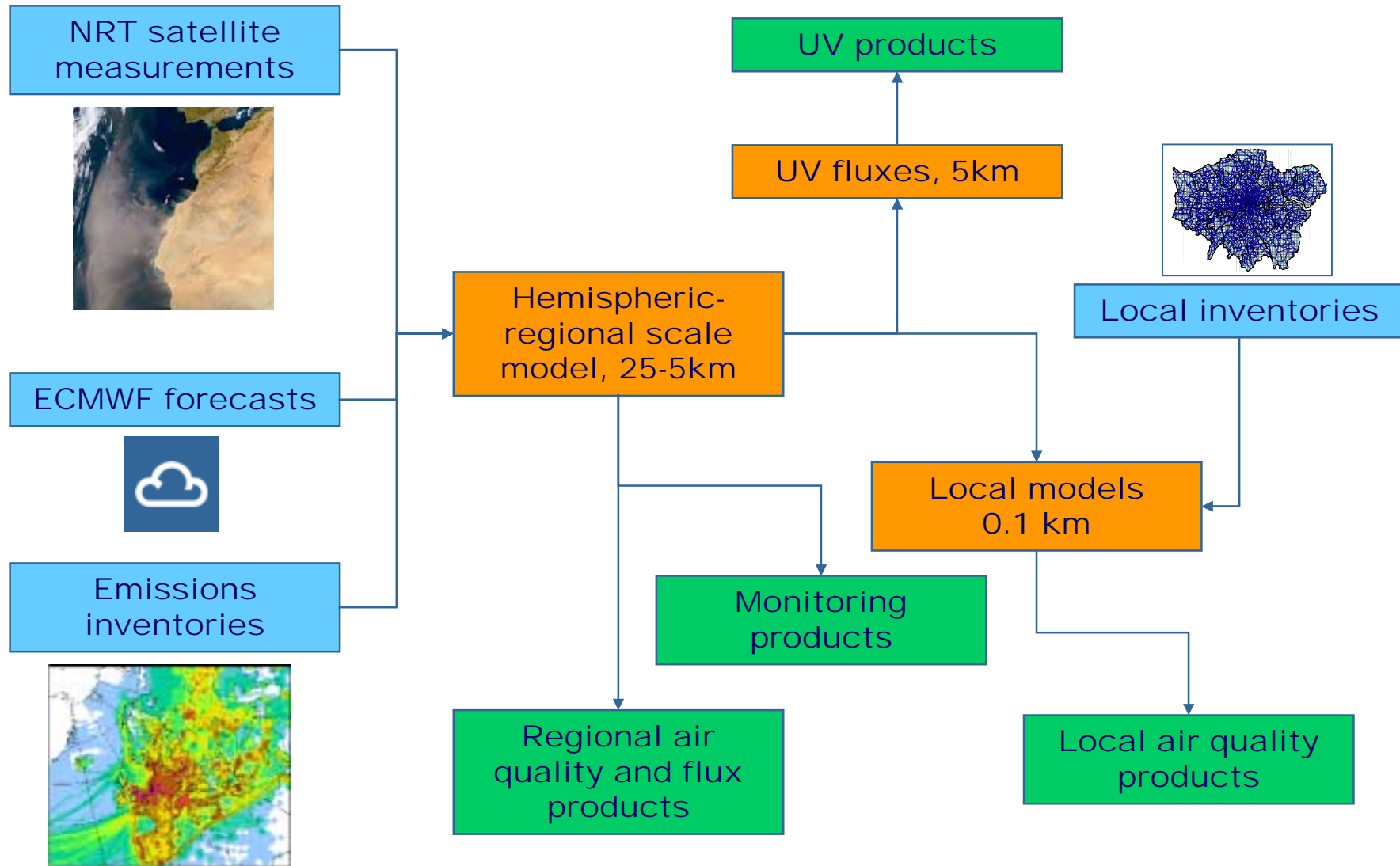- DLR

Users:

- Federal Environment Agency Austria
- Berufsverband Deutscher Dermatologen
- Camden and Islington PCT
- Press Association Weather Services

Lifecare background

- LifeCare was a proposed service under the European Space Agency/Framework 6 Global Monitoring for Environment and Security programme.

- GMES is intended to develop applications with social benefits for ESA remote sensing products and provide services to public sector environmental authorities.

- Failed in the first ITT, but has been invited for revision for future ITT or ad-hoc development.

- Lifecare will use satellite measurements of air composition as boundary conditions for regional and local scale models and for a stratospheric model to calculate total ozone and hence UV inidicators.

Lifecare system

NRT satellite measurements

ECMWF forecasts

Emissions inventories

Hemispheric-regional scale model, 25-5km

UV products

UV fluxes, 5km

Local inventories

Local models 0.1 km

Monitoring products

Regional air quality and flux products

Local air quality products

Lifecare products

- UV forecast data, on Europe and Continental scale, at 5 km resolution.
- Air quality forecast data on Continental scale, European scale and regional scale (e.g. Central Europe).
    - Particulates, O_3, NO_2, resolution of 5km – 1km.
- Air quality forecast data on local scale for pilot cities.
    - London;
    - Lyons;
    - Rome;
    - Budapest.
- Health related products.
    - forecast hospital admissions, allergen concentrations.
- Monitoring of total ozone column, tropospheric ozone.
- Monitoring of NO_2, aerosol.
- Trans-boundary fluxes.

Lifecare products: UV maps

sunburn time
2002 05 09
12 UTC
Skin Type 2

<15   30   45<
Minutes

DLR
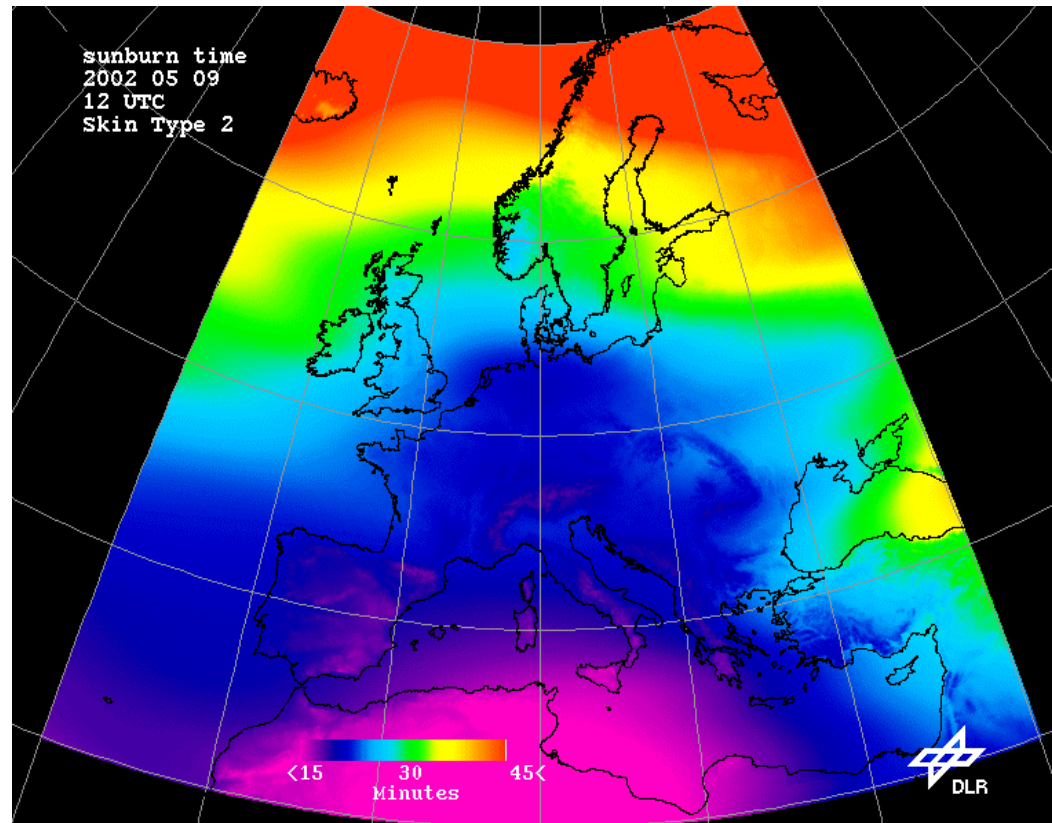
- Figure shows effect of stratospheric sub-tropical intrusion on burn times (M. Bittner, DLR).

- UV index maps for travellers/regional papers. For example see www.uv-check.de.
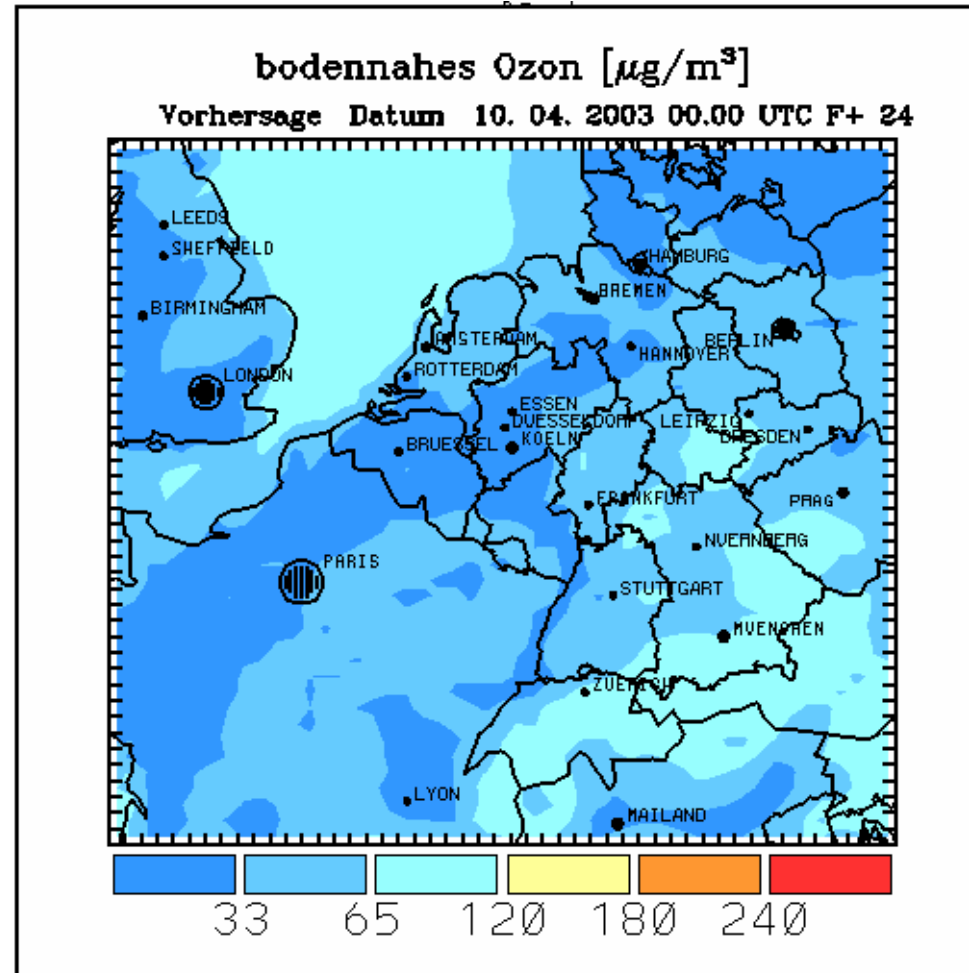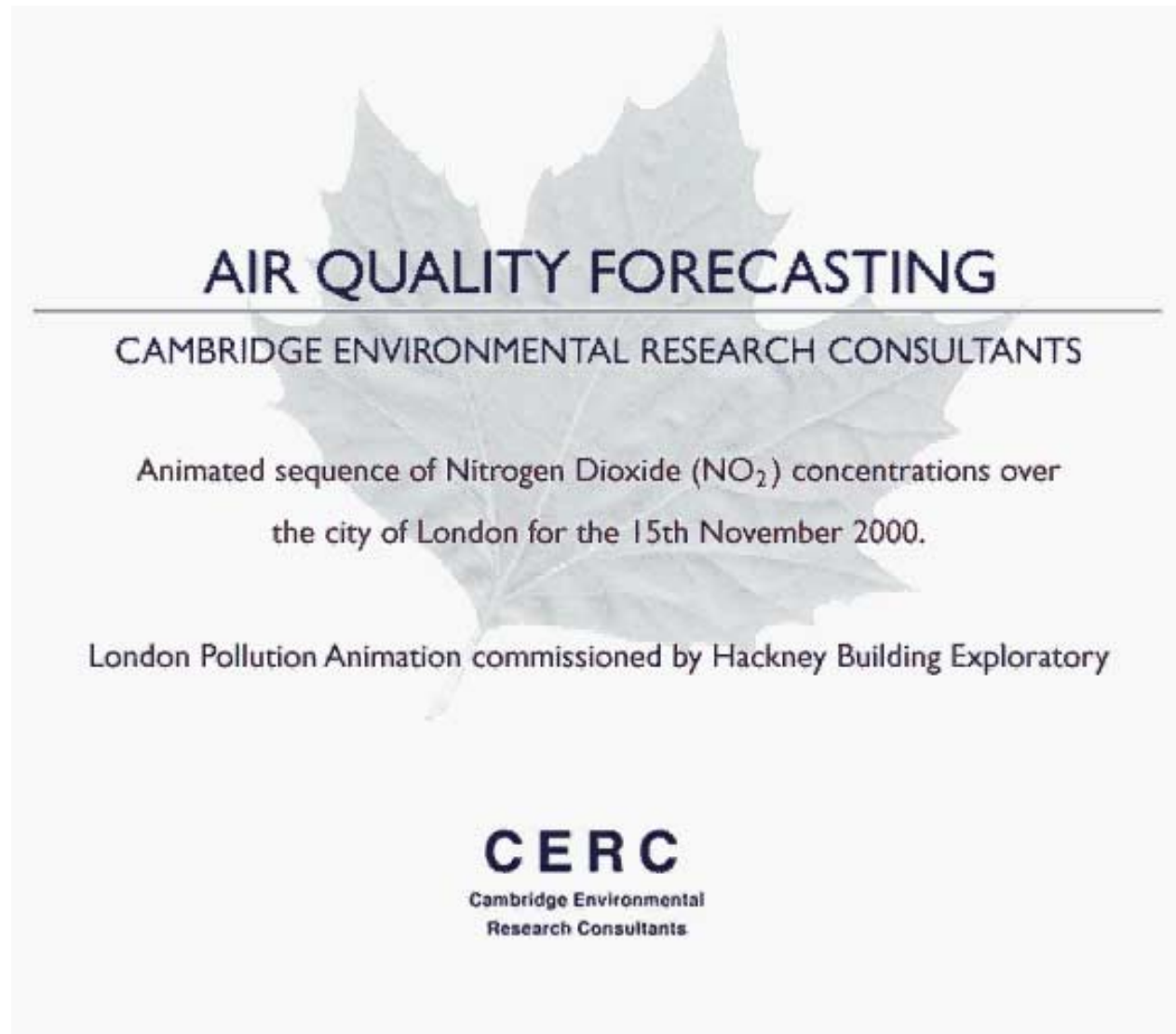
Lifecare products: Regional AQ

Figure shows 25km resolution O_3 forecast for European region. Courtesy H. Jakobs, RIU.

Lifecare products: Local AQ

AIR QUALITY FORECASTING

CAMBRIDGE ENVIRONMENTAL RESEARCH CONSULTANTS

Animated sequence of Nitrogen Dioxide (NO_2) concentrations over the city of London for the 15th November 2000.

London Pollution Animation commissioned by Hackney Building Exploratory

CERC
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Conclusions

- Urban forecasts on fine scales can be made using an advanced Gaussian dispersion model if emissions inventories met forecasts are sufficiently accurate.

- Rural forecasts of ozone, PM_{10} in the UK are amenable to forecasting using empirical methods.

- Advances in operational regional forecasting systems through the improvement of emissions inventories, mesoscale models and satellite and ground based data assimilation will provide benefits for both regional flux estimates, rural forecasts and urban forecasts.