

Air quality, urban heat islands and climate change

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Cambridge Environmental Research Consultants
Environmental Software and Services

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 - Modelling for Defra: the effect of climate change on air quality

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Air quality and other health indicators

CERCs suite of models

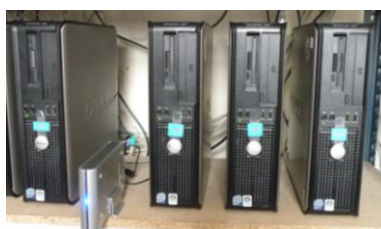
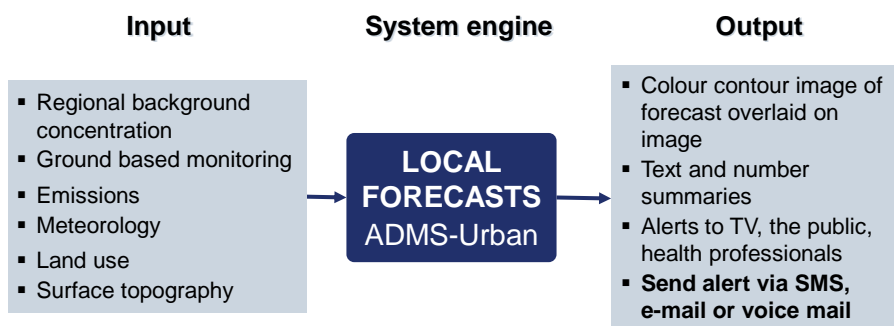
- CERC have developed a range of environmental software tools that model:
 - Air pollution
 - Accidental releases
 - Air flow over complex terrain
- The ADMS – Atmospheric Dispersion Modelling System – models combine:
 - Most up-to-date understanding of the physics of the lower levels of the atmosphere, in
 - Easy to use computer modelling systems for atmospheric emissions.
- ADMS-Urban:
 - Has been developed to model all emissions from urban areas
 - Is ideal for use within an air quality forecasting system.

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Air quality and other health indicators

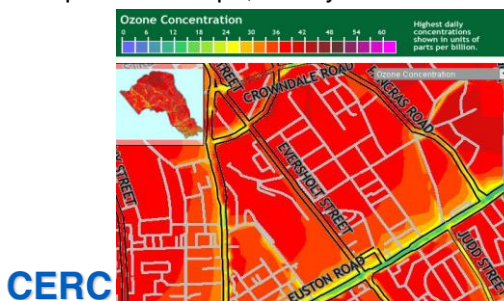
Forecasting : *yourair* system



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Air quality and other health indicators Forecasting : PROMOTE I and II

- Under PROMOTE I **pollution alerts** were trialled, starting with the London Borough of Croydon
- The forecasts linked forecasts from regional models with ADMS-Urban modelling at local scale
- Evaluation showed high degree of satisfaction from users
- Under PROMOTE II pollution alerts were launched across London
- Also under PROMOTE, **UV forecasts and alerts** were developed for parts of Europe, mostly for the Mediterranean area and Greenland.



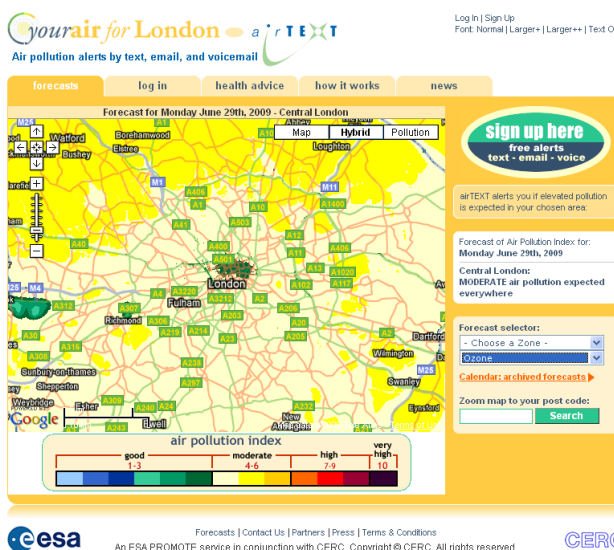
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Air quality and other health indicators Forecasting : London airTEXT

- London airTEXT system
- Over 6,000 subscribers
- Self-subscription
- Covers Greater London plus Slough
- Evaluation by University of Brighton ongoing
- www.airtext.info



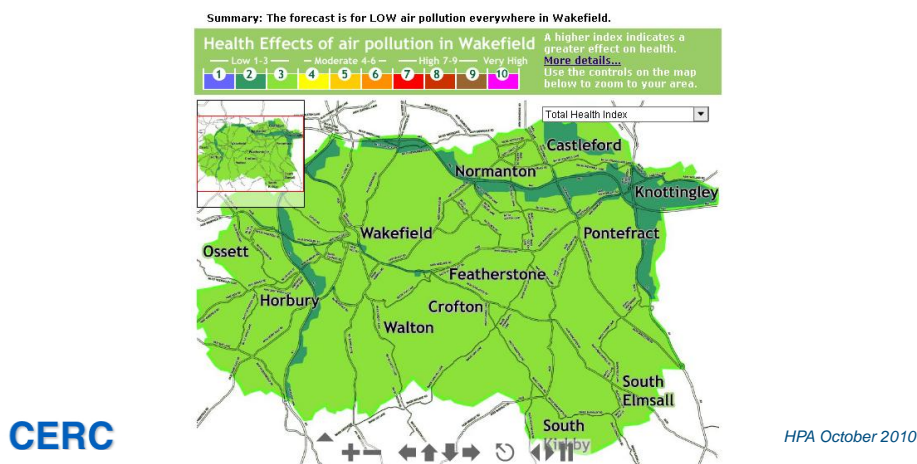
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Air quality and other health indicators

Forecasting : *yourair* system in Wakefield

- Service targeted at those with COPD
- Issues **pollution, hot weather and cold weather alerts**
- Now funded by PCT, evaluation ongoing



Air quality and other health indicators

Extension to AQ forecasting system: PASODOBLE project

- CERC's involvement in EU project PASODOBLE (Promote Air Quality Services integrating Observations – Development Of Basic Localized Information for Europe) includes:
 - Information for the public, and the sports and tourism industry: Evolution of city air quality forecasting alert services for:
 - UV
 - Pollen
 - Hot and cold weather.
 - Development of air quality indices for tourism, sport and leisure in parts of London for display at venues (for example, on overhead monitors, blackboards).

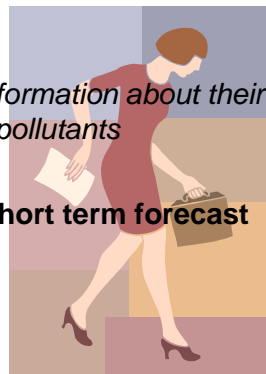
Air quality and other health indicators

Exposure: GENESIS project

- 9 million Euro ICT project making generic tools for environment and health.
- **Air** and **water quality** thematic pilots i.e CERC trial the generic tools and develop specific ones.
- Partners include: Imperial College, STM (St Mary's hospital) & University of the West of Scotland.

A person in the street wants to receive daily information about their predicted personal exposure to various key pollutants

- Example case study: **Daily calculation of short term forecast exposure for a person in the street**



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Air quality and other health indicators

Exposure: GENESIS project

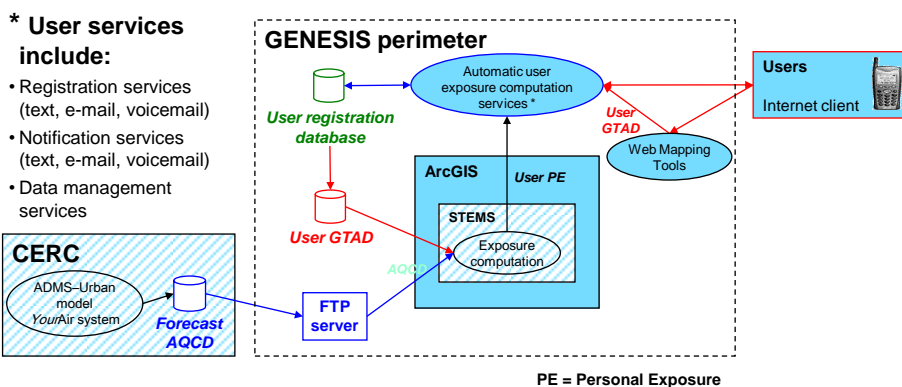
- *Data requirements:*
 - Air Quality high spatial resolution Concentrations Datasets (AQCD)
 - e.g. generated by ADMS-Urban, long-term output (.glt) files from a model run
 - Generalised Time-Activity Dataset (GTAD)
 - typical time-tagged routes and activity of population sub-groups during part of 1 day
 - “activity” may be: in car, cycling, walking, exercising indoors, etc.
 - Residential Density Dataset (RDD)
 - Dose-Response Relationship (DRR)
 - description of the change in effect on a person caused by differing levels of exposure (or doses) to a stressor (e.g. a modelled pollutant such as PM10)
 - there can be a DRR per health condition, population sub-group, pollutant & location

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Air quality and other health indicators Exposure: GENESIS project

- Daily calculation of short term forecast exposure for a person in the street



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Air quality and other health indicators HPA Olympic air quality group

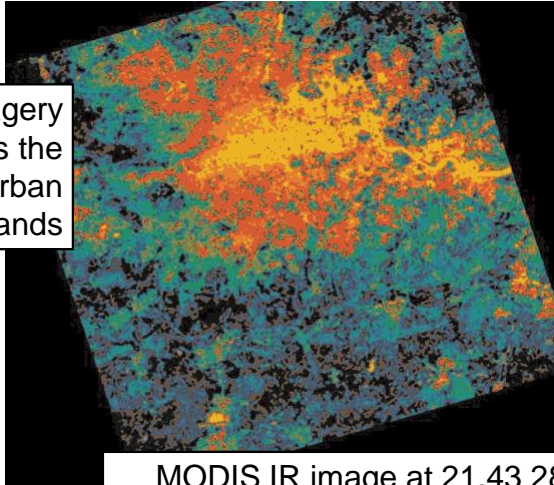
- Members:
 - Key groups involved in air quality
- Goals:
 - To provide information regarding current and forecasted air quality levels
- CERC's involvement
 - Extension of the AirTEXT service to cover the Olympic period.
- No funding!

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Urban Heat Islands

Satellite imagery clearly shows the presence of urban heat islands



MODIS IR image at 21.43 28/07/06

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Urban Heat Islands LUCID project

- LUCID: The development of a Local Urban Climate model and its application to the Intelligent Development of cities (<http://www.lucid-project.org.uk/>)
- Partners: UCL, London School of Hygiene and Tropical Medicine, University of Reading, Arup and others.
- 3 years (plus 6 months) project.
- 3 core objectives:
 - to develop a new integrated tool to model the local climate in urban areas
 - to use the model to explore the complex relationships between the projected changes to regional climate and local urban climate and the impact on energy used in buildings.
 - to evaluate the impacts of local temperature and air quality on health as the result of a changing climate.

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Urban Heat Islands ADMS developments

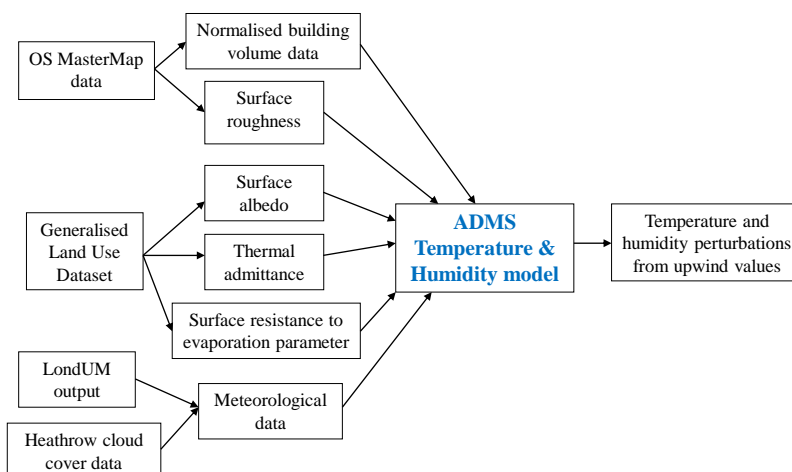
- **ADMS Temperature and Humidity** model has been developed as part of the LUCID project.
- Models perturbations to upwind boundary layer profiles
- Model used on a 1-50km² domain, with a resolution down to 10's of m.
- Includes diurnal variation of heat storage, but *currently* not storage over longer time scales.
- Applications include:
 - Urban planning tool
 - Estimate health impacts of increased temperatures/humidity
 - Incorporate urban temperature and humidity field into ADMS dispersion calculations
- Current status:
 - Draft User Guide
 - Model used in UCL student dissertation
 - Other publications in preparation

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Urban Heat Islands ADMS developments

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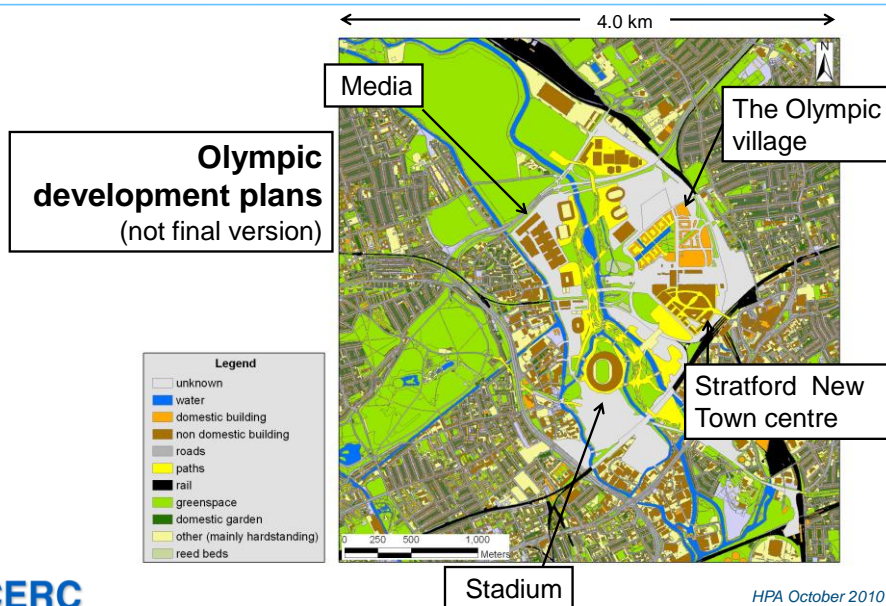
Urban Heat Islands Olympic case study

- 3 scenarios considered:
 - pre-Olympics,
 - London Olympics 2012,
 - the Olympic legacy (around 2016)
- Temperature perturbations due to changes in:
 - **land use** modelled using ADMS Temperature and Humidity model
 - **anthropogenic heat** modelled using ADMS-Urban

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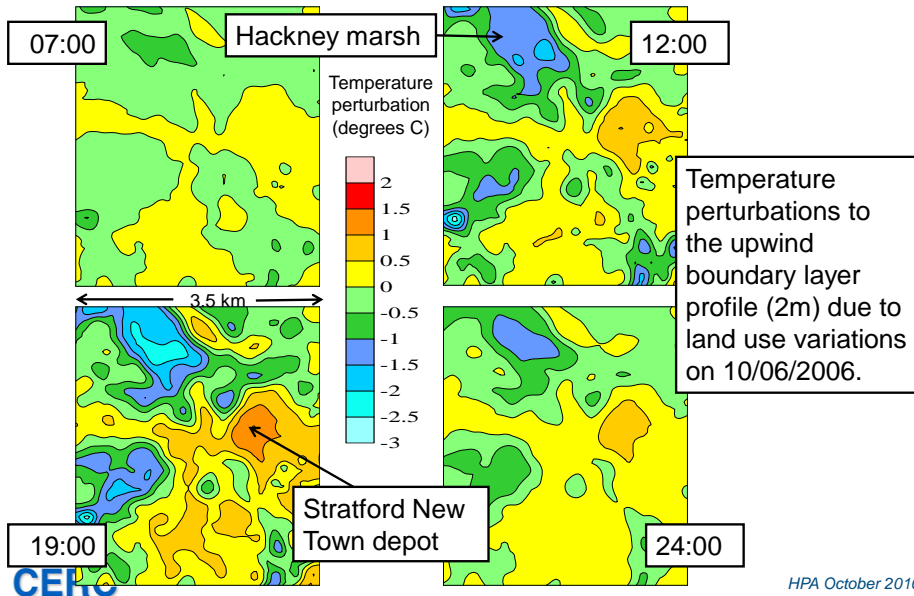
Urban Heat Islands Olympic case study



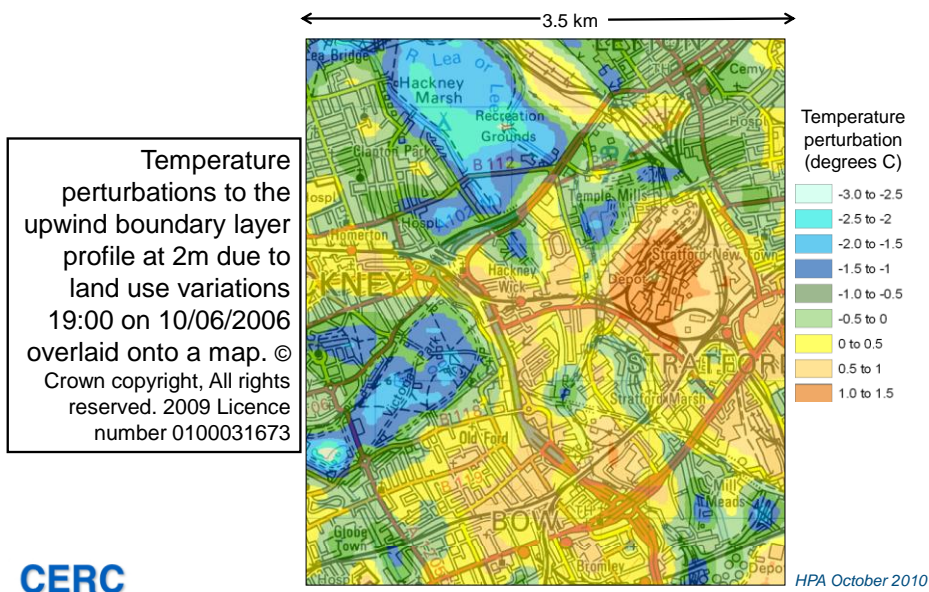
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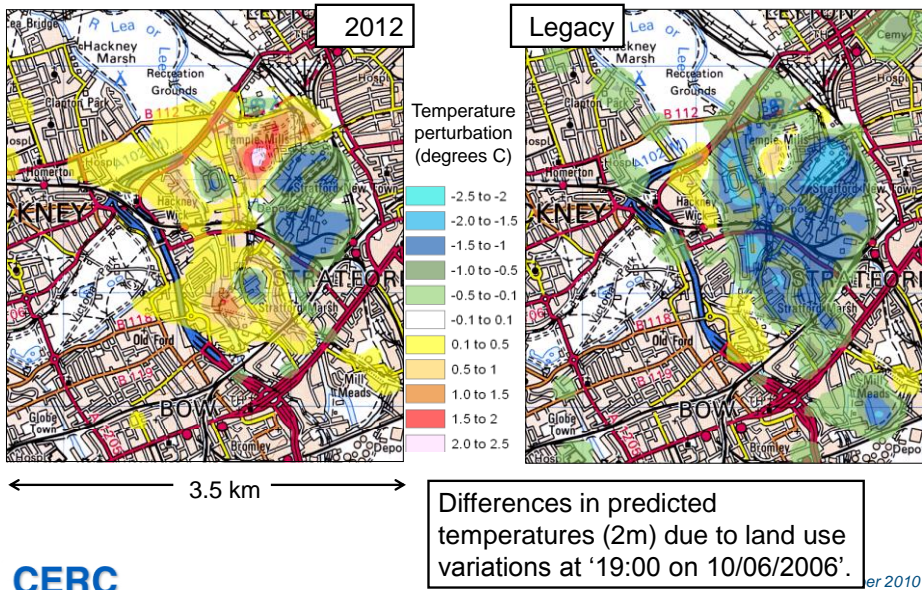
Urban Heat Islands Olympic case study: pre-Olympics



Urban Heat Islands Olympic case study: pre-Olympics



Urban Heat Islands Olympic case study: 2012 and legacy

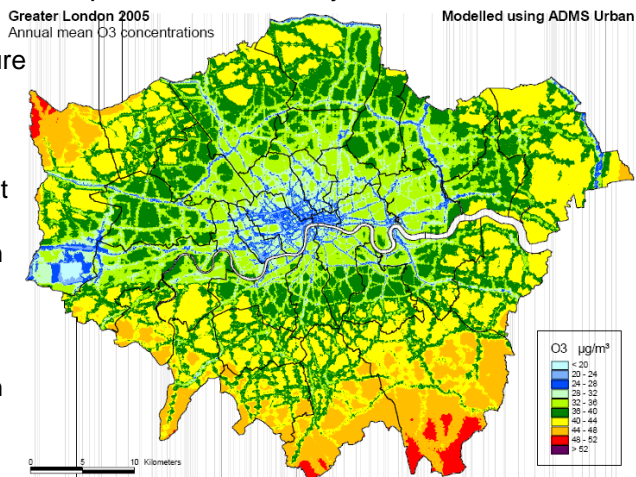


Urban Heat Islands LUCID: Health and climate

- London School of Hygiene and Tropical Medicine analysing the relationship between mortality in London and:

- Local temperature
- Local air quality

- ADMS-Urban run at 50 000 postcode locations in London for 2003 and 2006
- NO_x , PM_{10} and Ozone statistics analysed in relation to mortality rates.



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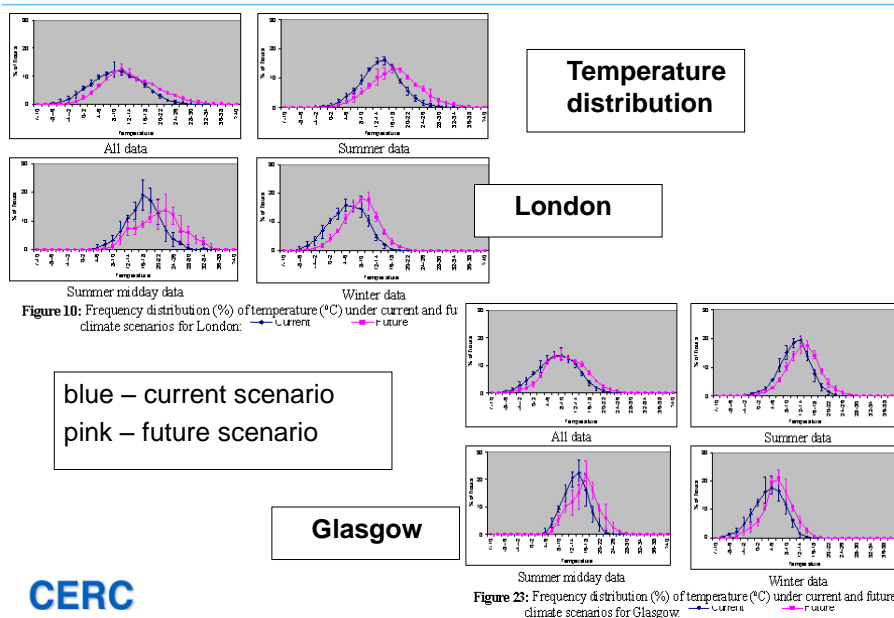
Climate Change Local Impact of Climate Change on Air Quality

- Met Office Climate Models used to derive local meteorological datasets:
 - hourly sequential datasets:
 - 1971, 1976, 1981, 1986, and
 - 2071, 2076, 2081, 2086.
 - Models used HadCM3, HadAM3H as input to HadRM3H
 - SRES A2 scenario
- Met datasets used as input to air dispersion calculations
 - single isolated sources – ADMS 3
 - urban air quality – Rural predictor and ADMS-Urban

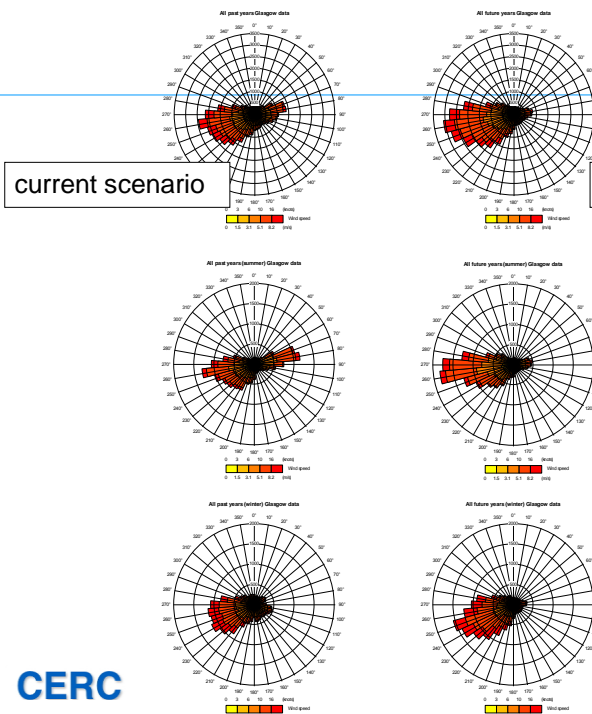
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Climate Change Local Impact of Climate Change on Air Quality



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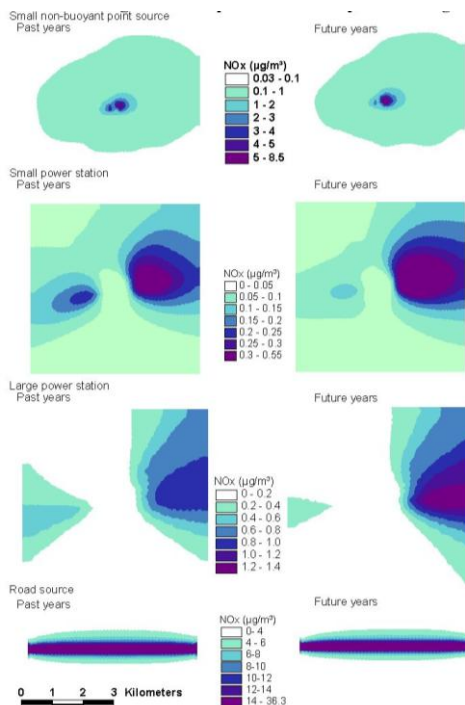
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Wind roses for Glasgow under the current and future climate scenarios.

All year, summer and winter roses are presented.

For each scenario, the results are for the four years combined.



Results

Long term average of NOx for:

- past (1971, 1976, 1981, 1986), and
- future years (2071, 2076, 2081, 2086)

calculated using ADMS 3.2 (point sources) and ADMS-Urban (road source) with Glasgow meteorological data.

Note the scale bar does not relate to the large power station plot which covers 16x16km; all other plots are 6x6km and do relate to the scale bar.

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Climate Change Local Impact of Climate Change on Air Quality

Calculated changes in spatial maxima of various NO _x concentration statistics		Annual average (µg/m ³)	Maximum hourly average (µg/m ³)	99.8 th percentile of hourly average (µg/m ³)	99 th percentile of hourly average (µg/m ³)	98 th percentile of hourly average (µg/m ³)
Small point	Past	6.82	405.83	141.92	59.89	49.91
	Future	8.53	341.66	144.82	62.22	52.20
	% change	25.07	-15.81	2.04	3.89	4.59
Small power station	Past	0.41	12.81	6.66	5.22	4.44
	Future	0.55	12.35	6.81	5.59	4.78
	% change	34.15	-3.59	2.25	7.09	7.66
Large power station	Past	0.98	89.40	47.19	30.71	18.71
	Future	1.36	88.53	49.71	36.07	25.92
	% change	38.78	-0.97	5.34	17.45	38.54
Road	Past	36.34	883.19	702.99	491.45	393.97
	Future	33.65	868.49	668.37	470.18	363.13
	% change	-7.40	-1.66	-4.92	-4.33	-7.83

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Glasgow met data

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Year	Annual average			
	NO _x (ppb)	NO ₂ (ppb)	O ₃ (ppb)	PM ₁₀ (µg/m ³)
1971	18.77	8.18	24.28	17.19
1976	14.69	7.84	24.38	16.69
1981	14.82	7.07	25.10	16.94
1986	18.57	7.97	29.50	18.12
19xx average	16.71	7.77	25.81	17.23
2071	12.37	7.48	32.58	17.81
2076	12.65	7.34	31.46	17.63
2081	12.81	7.57	31.85	18.06
2086	11.97	7.06	27.94	17.18
20xx average	12.45	7.36	30.96	17.67
Change (%) 19xx to 20xx	-25.5	-5.3	+20.0	+2.6

Annual average background values from the rural predictor - London

Average predicted annual average concentrations across all sites

Years	NO _x ppb	NO ₂ ppb	O ₃ ppb	PM ₁₀ µg/m ³
1971	57	25	11	21.1
1976	52	25	11	20.5
1981	49	23	12	20.5
1986	60	28	14	22.3
19xx average	55	25	12	21.1
19xx range	49 to 60	23 to 28	11 to 14	20.5 to 22.3
2071	49	27	17	21.6
2076	48	25	17	21.2
2081	49	26	17	21.7
2086	48	25	13	20.9
20xx average	48	26	16	21.4
20xx range	48 to 49	25 to 27	13 to 17	20.9 to 21.7
Average difference (20xx - 19xx)	-6.1	0.5	4.0	0.3

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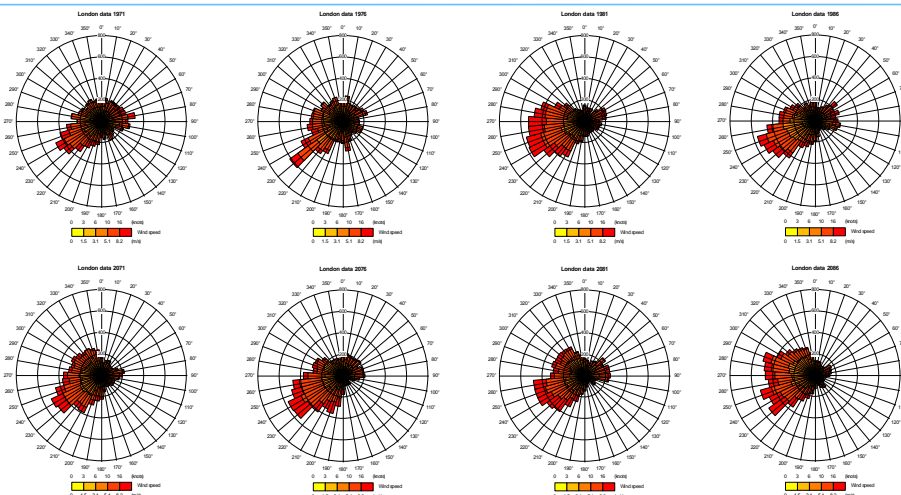
Summary

- CERC develop software and applications that model:
 - Air quality and other health indicators
 - Local changes in temperature and humidity due to changes in land use and anthropogenic heat
- CERC's forecasting services are used to alert vulnerable members of the community to risk of high air pollution levels, so that they can change their behaviour.
- CERC have been involved in projects looking at the effects of climate change on air quality.

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Climate Change Local Impact of Climate Change on Air Quality



Climate Change Local Impact of Climate Change on Air Quality

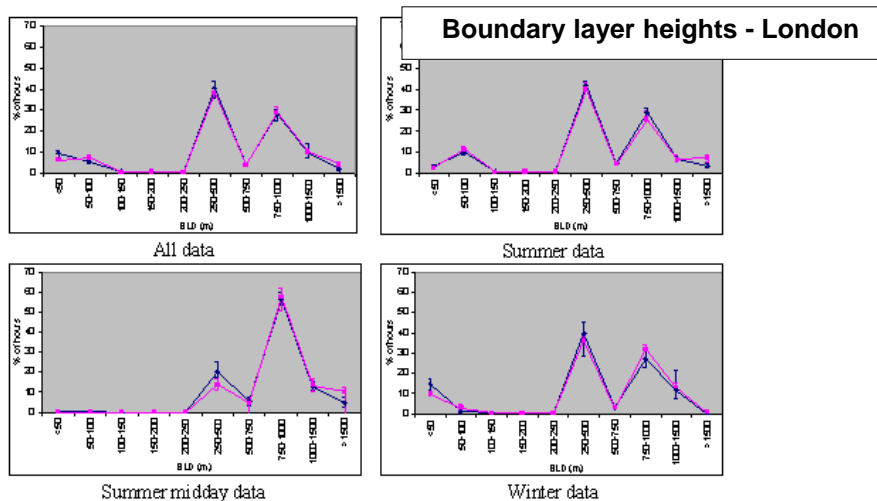


Figure 9: Frequency distribution (%) of boundary layer depths (m) under current and future climate scenarios for London: — Current — Future

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Climate Change Local Impact of Climate Change on Air Quality

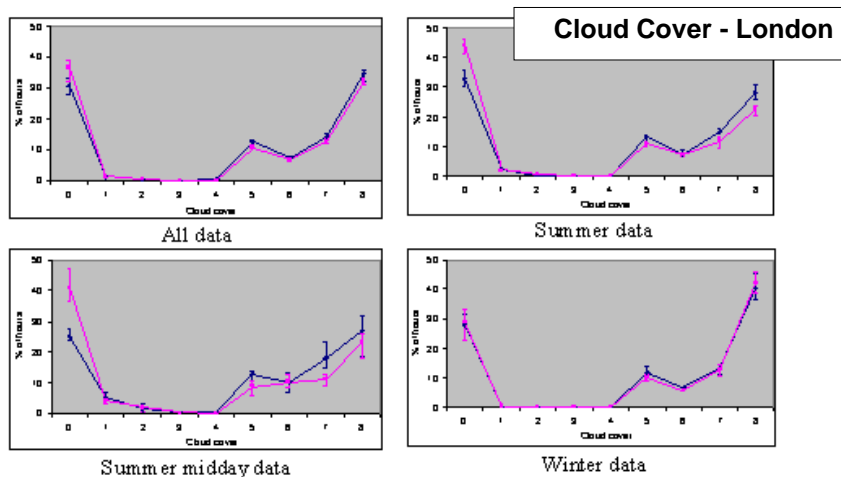


Figure 6: Frequency distribution (%) of cloud cover (oktas) under current and future climate scenarios for London: — Current — Future

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