A comprehensive urban atmosphere database: the URGENT archive at BADC

British Atmospheric Data Centre
http://www.badc.rl.ac.uk/

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Urban Regeneration and the Environment
http://urgent.nerc.ac.uk/

Introduction

The British Atmospheric Data Centre (BADC) is the body appointed by the Natural Environment Research Council (NERC) to archive, maintain and distribute data issued by atmospheric research projects based in the UK **(Figure 1).** As such, BADC has been designated as one of the four data centres to archive data delivered by URGENT (Urban Regeneration and the Environment), a 7-year thematic programme launched by NERC in 1996. The programme addresses scientific and monitoring issues related to the pollution of urban and suburban water, soil, ecology and air. Air data are currently being archived at the BADC.

Figure 1. The BADC home page at *http://www.badc.rl.ac.uk/*

The URGENT air projects

Among the 41 URGENT projects, 14 are closely related to the urban and suburban atmospheres. They address issues as diverse as urban meteorology, dispersion of pollutants, homogeneous (gas phase) and heterogeneous chemistry, aerosol particle size distribution and composition, particle toxicity, impact of tree planting on chemical composition, etc. **Table 1** displays the type of activities of the 13 projects that will have archived data or documentation at BADC by the end of the programme – data from the 14th project (*Urban Tree Planting*) will be archived at the Centre for Ecology and Hydrology (CEH). Most projects conduct field experiments or observation, sometimes associated with some technological development, and 8 projects are involved at various degrees in model development. A few are carried out in collaboration with industry or local authorities.

Table 1. Type of research activities led by the URGENT air projects.

URGENT Air Science Activities						
Project code GST/02/...	Research subject	Universities	In situ observations/ experiments	Technology development	Model development	Extra-academic participation
1971	West Midlands climatology	Birmingham Birkbeck	•	•		•
1974	Dispersion of gaseous pollutants	Bristol	•	•		
1981	Urban air pollution	Birmingham Leeds UEA Cambridge Met Office	•		•	•
1982	Organics in airborne particles	KCL	•	•	•	•
1986	Chimney emissions	Leeds			•	
2090	Laser detection of peroxy radicals	Oxford		•		
2222	Particles physicochemistry and toxicity	Cardiff	•			
2225	Boundary layer vertical structure	UMIST	•			
2228	Gas phase chemistry	Leeds			•	
2231	Urban meteorology	Reading Salford Surrey	•		•	
2244	Urban aerosol	CEH UMIST BAS	•		•	
2254	Particle size distribution of vehicular emissions	Leeds			•	
2802	Dispersion of particles	Birmingham	•		•	

Table 2. Inventory of URGENT air data currently held at BADC.

URGENT Air Data General Inventory	
Dynamical, radiative and meteorological data	
Pressure	
Potential temperature	
Short wave radiation	
Temperature	
Wind	
Reynolds' stress	
Shear stress	
Moisture	
Dew point temperature	
Photodissociation rates	
$j(O(^1D))$	
$j(NO_2)$	
Chemical compounds	
Inorganic molecules and neutral radicals	
Ozone	O_3
Hydroxyl	OH
Hydroperoxyl	HO_2
Water vapour	H_2O
Nitric oxide	NO
Nitrogen dioxide	NO_2
Total nitrogen oxides	NO_x
Ammonia	NH_3
Nitrous acid	HNO_2
Nitric acid	HNO_3
Sulphur dioxide	SO_2
Carbon	C
Carbon monoxide	CO
Organic molecules	
Hydrocarbons	
Alkanes	
Ethane	C_2H_6
Propane	C_3H_8
2-methylpropane (Isobutane)	$CH_3\text{-}CH(CH_3)\text{-}CH_3$
Butane	C_4H_{10}
2-methylbutane (Isopentane)	$CH_3\text{-}CH(CH_3)\text{-}CH_2\text{-}CH_3$
Pentane	C_5H_{12}
2-methylpentane	$CH_3\text{-}CH(CH_3)\text{-}CH_2\text{-}CH_2\text{-}CH_3$
3-methylpentane	$CH_3\text{-}CH_2\text{-}CH(CH_3)\text{-}CH_2\text{-}CH_3$
Hexane	C_6H_{14}
Heptane	C_7H_{16}
Alkenes	
One double bond	
Ethene (Ethylene)	C_2H_4
Propene	$CH_2\text{=}CH\text{-}CH_3$
2-methylpropene (Isobutene)	$CH_2\text{=}C(CH_3)\text{-}CH_3$
1-butene	$CH_2\text{=}CH\text{-}CH_2\text{-}CH_3$
Trans-2-butene	$CH_3\text{-}HC\text{=}CH\text{-}CH_3$
Cis-2-butene	$CH_3\text{-}CH\text{=}CH\text{-}CH_3$
Trans-2-pentene	$CH_3\text{-}HC\text{=}CH\text{-}CH_2\text{-}CH_3$
Cis-2-pentene	$CH_3\text{-}CH\text{=}CH\text{-}CH_2\text{-}CH_3$
Two double bonds	
1,3-butadiene	$CH_2\text{=}CH\text{-}CH\text{=}CH_2$
2-methyl-1,3-butadiene (Isoprene)	$CH_2\text{=}C(CH_3)\text{-}CH\text{=}CH_2$
Alkynes	
Ethyne (Acetylene)	C_2H_2
Aromatic hydrocarbons	
Monocyclic	
Benzene	C_6H_6
Methylbenzene (Toluene)	$CH_3C_6H_5$
Polycyclic	
Naphtalene	$C_{10}H_8$
Other organic compounds	
Formaldehyde	CH_2O
Peroxyacetylnitrate (PAN)	$CH_3C(O)OONO_2$
Ions	
Ammonium	NH_4^+
Chloride	Cl^-
Nitrate	NO_3^-
Sulphate	$SO_4^{=}$
Particulate Matter	
$PM_{2.5}$ density	
PM_{10} density	
Total PM density	
Particle number density	
Particle surface area	

Highlights from the URGENT air archive

Table 2 is the BADC directory of URGENT air substances and parameters. It is updated as data sets are submitted to the archive and reflects the variety of the nature of the data produced. Most data are stored in NASA Ames format. Since projects are currently submitting data to the BADC, the archive is presently in expansion. Three examples are illustrated below, giving a flavour of the diversity of disciplines involved.

Observation, Modelling and Management of Urban Air Pollution or *PUMA* (see GST/02/1981 in Table 1) involves a large consortium of several universities and integrates observation and modelling of atmospheric dynamics as well as chemistry of both urban and suburban areas. The project focuses on the West Midlands region (**Figure 2**). During the 2 PUMA campaigns, that underlined the different behaviours of the urban atmosphere in summer and winter (and revealed in particular interesting features of 2 distinct ozone production regimes), the trajectory calculator provided by the BADC was used by the investigators to determine the likely origin of the collected air and dust samples (**Figure 3**).

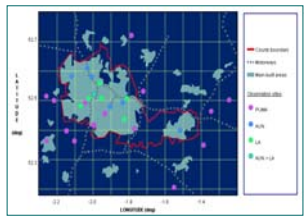

Figure 2. The 2 PUMA campaigns of Summer 1999 and Winter 2000 took place in and around the West Midlands county, the surface of which is largely occupied by Birmingham city and its suburbs (West) and by Coventry (East). An online map provided by BADC displays the observation sites, the main built areas and the highway network. Each dot is a link to a summary of the data collected at the corresponding site.

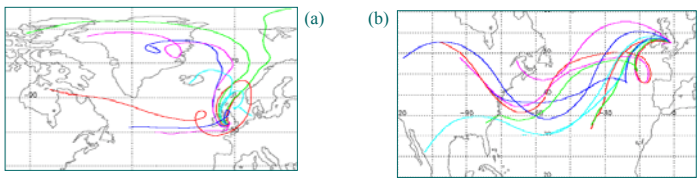

Figure 3. Two examples of 5-day air parcel backward trajectories calculated in the framework of the PUMA campaigns, arriving above (a) Halfpenny Green Airport on 7 June 1999, noon and (b) Withybrook Equestrian Centre on 3 March 2000, noon. The colours refer to 11 different pressure levels at arrival, from 100 to 1000 hPa.

An instrumented Aircraft Facility to Provide Vertical Profiles of Wind, Temperature, Turbulence, Sensible Heat, Aerosol and Trace-Gas Concentrations and Fluxes within the Urban Boundary Layer. In connection to the PUMA campaigns and modelling activities, this project (see GST/02/2225 in Table 1) focused on the boundary layer above the same region. The UMIST aircraft, equipped with 7 instruments, collected a range of in situ meteorological and chemical data, as well as particle number densities. **Figure 4** displays examples of results from 2 of the 14 successful flights.

Figure 4. The UMIST CESSNA aircraft based at Woodford (middle) flew over the West Midlands in June-July 1999 and February 2000. Examples of flight tracks are shown left and right, while Paluch diagrams show characteristic thermodynamic properties of the urban boundary layer over the PUMA model domain for the 2 corresponding flights. Total water mixing ratio and wet equivalent potential temperature represent two conserved properties that can be used to determine mixing between different levels in the atmosphere. The results of 18th June show significant inhomogeneity in the boundary layer but little mixing with the free troposphere above. The results of the 22nd June flight show the boundary layer is reasonably well mixed. – *Courtesy of Martin Gallagher and Karl Beswick, UMIST.*

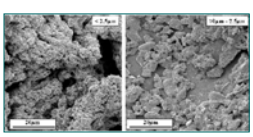

Figure 5. Field Emission SEM images of particles collected on a Hi-Vol PUF filter. There is a very clear separation of mostly vehicle exhaust emission particles into the < 2.5 µm fraction and mostly mineral grains and biogenic particles into the 2.5 - 10 µm fraction. – *Courtesy of Roy Richards and Tim Jones, Cardiff University.*

PM2.5 and PM10 particles (**Figure 5**) collected by the *Airborne Particulate Pollutants Physicochemistry and Toxicity* project at various sites in South Wales (see GST/02/2222 in Table 1) were analysed and instilled into rat lungs to study their ability to induce inflammation, increase permeability or initiate epithelial damage.

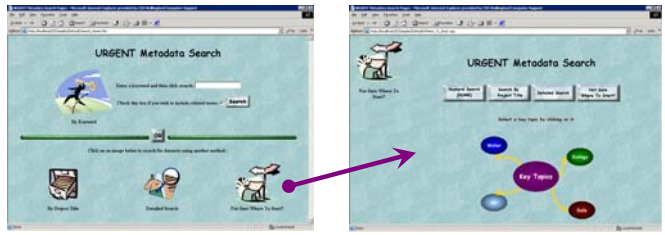

Figure 6. Pages of the Web based URGENT metadata gateway developed at CEH.

Access to data

During the submission and validation period (for each project, one year after its end date), access to the corresponding data set is restricted to the participants to the URGENT programme to allow them to exchange data in the framework of internal collaborations and to publish their results. The URGENT air archive at BADC will start to be open to the public domain in September 2002. The release process should be completed by September 2003, by which date all URGENT air data will be directly downloadable from the BADC Web site. All the documentation pertaining to the archive is publicly available from the BADC Web site.

An online general URGENT metadata gateway is currently developed at CEH and should become functional by the autumn 2002. It will allow users of both scientific and non-scientific backgrounds to search and identify URGENT data sets of interest to them. Each data set will be described by a standard set of *metadata* and a link to its archive location will be supplied.