COST action 715
Meteorology applied to Urban Air Pollution Problems

Working Group 3
Meteorology during peak pollution episodes

Status Report

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Abstract

This report forms part of the work of the COST 715 action "Meteorology applied to Urban Air Pollution Problems" (1998 – 2003). It is an interim report produced within the above-mentioned action by Working Group 3 “Meteorology during peak pollution episodes”.

The main objective of this status report is to compile and present a review of available information concerning peak pollution episodes, by the official participants of this Working Group and other interested contributors. However, the report does not attempt to provide a complete description of European research and methods in this area, nor to present an evaluation or critique of the different methods and their potential accuracy. It is the long-term objective of the COST 715 action to draw such conclusions.

The report contains the status reports of 12 countries: Austria, Belgium, Finland, Denmark, France, Hungary, Italy, Norway, Portugal, Spain, the United Kingdom and Macau. The status reports survey the national situation in each country, containing the following information: introduction, main objectives, description of available meteorological and concentration data, available models describing air pollution and numerical weather prediction, other related projects, funding situation, expected benefits and policy relevance, conclusions, references and relevant www pages.

This report is utilized within the COST 715 action as a basis for further work. The report could also be utilized as a starting point by national or local authorities concerned with the problem of air quality episodes.

This report is also available on the www pages of the COST 715 action (www.dmu.dk/atmosphericenvironment/cost715.htm; www.fmi.fi/ENG/ILA/COST715/). Further contributions from other countries, as well as other updates, will be continuously included in subsequent www versions of the report.

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Executive summary

1. Background

1.1 COST 715, Meteorology applied to Urban Air Pollution Problems

The requirements of the European Union Framework Directive on air quality assessment and management present real practical problems for the meteorological community. Some of the meteorological variables needed in urban air pollution assessments are not routinely measured, and the number of meteorological stations in urban areas is commonly limited to only a few sites.

The Europe-wide project on "Meteorology applied to Urban Air Pollution Problems", COST 715, has been set up to review these problems (1998 – 2003). More detailed information on this project is available from the www (www.dmu.dk/atmosphericenvironment/ cost715.htm; see also www.netmaniacs.com/cost). The objectives and work plan of this action have been reviewed by Fisher et al. (2000); the chairperson is Bernard Fisher.

The COST 715 action continues the work of two previous actions, COST 710 and COST 615. COST 710 addressed the harmonisation of the pre-processing of meteorological data for atmospheric dispersion models. It identified the schemes currently used for obtaining the key meteorological variables associated with air pollution (Fisher et al., 1998). The COST 615 action has produced, amongst other matters, an inventory of urban air pollution models (http://www.mi.uni-hamburg.de/technische_meteorologie/cost/ index.html).

The programme of COST 715 is divided amongst the following four working groups (WG).
1. WG 1: Wind field in urban areas,
2. WG 2: Mixing heights and surface energy budgets,
3. WG 3: Meteorology during peak pollution episodes and
4. WG 4: Input data for urban air pollution models.

The WG chairpersons are Mathias Rotach (WG1), Martin Piringer (WG 2), Jaakko Kukkonen (WG 3) and Michael Schatzmann (WG 4).

1.2 Working Group 3, Meteorology during peak pollution episodes

During air pollution episodes pollutant concentrations are at their highest, and the related adverse health impact on the public should therefore be reliably evaluated. The meteorological conditions prevailing during the course of these episodes are at the same time usually the most difficult to model with the computing tools presently available. The European Union Directives nevertheless require practical measures to be taken, if air quality limit values are exceeded.

The official members of this WG include 11 countries: Belgium, Finland, Denmark, France, Hungary, Italy, Norway, Portugal, Spain, the United Kingdom and Macau.

The workplan consists of three workpackages, which were formed in terms of the following European geographic regions:

1. Northern European region (coordinator Erik Berge),
2. Central European region (coordinators Guy Schayes and László Bozó) and
3. Mediterranean region (coordinator Rosa Salvador).

Within each of these regions, the following items will be addressed:

1. Analysis of episodes, in particular the meteorological conditions,
2. Available datasets,
3. Numerical weather prediction models and air quality forecasting methods and
4. Meteorological pre-processors.

Clearly, part of this work is also within the scope of the other WG's.

2. The objectives of the status report

There exist a substantial amount of relevant measured data and modelling methods for the evaluation of air quality episodes in various European countries. However, this information has previously only been presented for specific episodes or cities, or at best, reviewed nationally by certain countries.

This report contains the national Status Reports of the above-mentioned officially participating countries and that of Austria. Although this selection of countries is far from complete in terms of COST cooperation, it does contain participants from Southern, Northern, Western and Eastern Central Europe.

The main objective of this Status Report is to compile and present a review of available information, by the official participants of Working Group 3 and other interested contributors. However, the report does not attempt to provide a complete description of European research and methods in this area, nor to present an evaluation or critique of the different methods and their potential accuracy. It is the long-term objective of the COST 715 action to draw such conclusions.

3. An overview of the Status Reports of participating countries

The status reports of the participating countries survey their national situation, containing the following information: introduction, main objectives, description of available meteorological and concentration data, available models describing air pollution and numerical weather prediction, related other projects, funding situation, expected benefits and policy relevance, conclusions, references and relevant www pages.

The problems are different in the cities of the various European regions. In Northern European cities, ground-based inversions, stable atmospheric stratification, low wind speed and topography are the key factors. Particles and NO_2 are the most important pollutants. Episodes occur typically in winter (NO_2) or spring (particles). In Northern and Central Europe, resuspension of particles from street surfaces is an important source of coarse particles. In Southern and Central European cities, stable atmospheric stratification, low wind speeds, mesoscale circulation, topography and solar radiation are the important factors. Photochemical pollution episodes including O_3, NO_2, various hydrocarbons and particles commonly occur in the summer half of the year. Atmospheric particulate matter pollution is important in episodic conditions over the whole European continent.

Over the whole of Europe, low wind speeds and stable atmospheric stratification tend to cause episodes. Such stagnant meteorological conditions are typical of high pressure situations. Topographical features are important whenever present, e.g., the larger Norwegian cities are partly surrounded by hills or mountains, and complex circulation patterns are therefore formed.

3.1 Available meteorological and concentration data

As expected, urban and regional-scale air quality monitoring and synoptic (larger-scale) meteorological measurements are carried out in all participating countries. However, the availability of meteorological data in urban locations varies substantially, and vertical meteorological soundings are commonly available at only a few locations nationally. There is thus a lack of information on vertical profiles of pollutant concentrations and the relevant meteorological parameters, together with the corresponding vertical surface fluxes, that would be representative for urban areas.

3.2 Available models

The models applied vary widely in the participating countries. In some countries, a variety of models are being developed or are already available for evaluation of air pollution episodes:

- urban and regional-scale atmospheric dispersion models, including photochemical schemes and mesoscale atmospheric re-circulation,
- numerical weather prediction (NWP) models,
- meteorological pre-processing models and
- air quality forecasting (AQF) models, (including deterministic, statistical semi-empirical or empirical, and neural network models).

Some of the participating countries have also developed Urban Air Quality Information Systems (UAQIS).

In Norway, for instance, the leading organisations have jointly developed an air pollution forecasting system, consisting of a fine-scale non-hydrostatic meteorological model and an Eulerian air pollution model with sub-grid treatment of line and point sources. However, in many countries, AQF models are not available. Systematic model evaluation in the course of episodes is also very unusual. Both atmospheric dispersion models and meteorological pre-processing models are often unreliable in the course of episodes.

4 Conclusions

This COST action is expected to contribute to an improved understanding on how to evaluate the meteorological input for urban air quality models, particularly in the case of peak pollution episodes. The action is expected to assist in evaluating practical matters related to episodes, for instance, in estimating the exceeding of guidelines and limit values and in analysing the influence of various measures to control episodes. This project will also contribute to the development and validation of dispersion models and meteorological pre-processors.

The action is a discussion forum for exchanging information, as well as available datasets and models. A key benefit will be the research collaboration that will result from this initiative.

A better comprehension of the meteorological conditions leading to air quality episodes is required in order to identify the key meteorological parameters. Existing measurements of both meteorological and air quality parameters during episodes should be surveyed and made available as widely as possible for model testing and evaluation purposes.

This report is utilized within the COST 715 action as a basis for further work. The report could also be utilized as a starting point by national or local authorities concerned with the problem of air quality episodes.

This report is also available on the www pages of Working Group 3 (www.fmi.fi/ENG/ILA/COST715/). Further contributions from other countries, as well as other updates, will be continuously included in subsequent www versions of the report.

5. References

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Status Report of Austria

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1. Introduction

The largest City in Austria is the capital Vienna (1,6 million inhabitants), followed by a few cities with more than 100 000 inhabitants. The level of pollutants other than ozone in Vienna is mostly moderate to low because of generally good ventilation conditions. Stagnations (Piringer et al., 2000) and occasional transport from neighbouring countries in the east can cause episodes of high concentrations of SO_2, NO_2 and particulate matter, but air quality standards are seldom exceeded.

During anticyclonic weather conditions in spring and summer, high ozone concentrations appear repeatedly (Piringer et al., 1997). WHO ozone standards are often, local warning standards (lowest level calling for public information) occasionally violated. SO_2 concentrations have undergone a dramatic decline during the last twenty years, but other components do not show a definite trend. Most of the other cities with more than 100 000 inhabitants are located in complex terrain. Local wind systems including periods with calm conditions and temperature inversions are very important (Piringer and Baumann, 1999). Especially in winter these weather conditions can lead to episodes of high levels of NO_2 and particulate matter in spite of moderate emission amounts.

This report is prepared by representatives from only two institutions involved in the Austrian research of urban air pollution and urban meteorology. Similar research is occasionally undertaken by BOKU University in Vienna, Institute for Meteorology and Physics (investigations of the urban boundary layer in Linz), and by the Institute of Geography, University of Graz (local field experiments in Graz and surroundings).

2. Main Objectives

The main objectives of the participation of Austria in the COST 715/WG 3 activity are the following:

1. To obtain a better understanding of the meteorological conditions leading to episodes of high pollution concentrations. Particular attention will be focused on low wind speed conditions in valleys and basins of the pre-alpine region.
2. To get an overview of European modelling activities concerning episodes of high pollution concentrations. Identification of gaps in standard meteorological measurements and suggestion of better methods in order to get more suitable statistical data for low wind speed conditions.
3. To provide our expertise in detecting the meteorological structure of the urban boundary layer by vertical soundings with tethersondes and sodars especially during anticipated episodes of high pollution and to learn from other institutions how they proceed.

3. Available meteorological and concentration data

Since 1992, ZAMG, partly in addition, partly in extension to the conventional synoptic and climate stations network, operates the dense semi-automatic meteorological network TAWES with at present more than 120 stations distributed quite regularly across Austria. Meteorological data are provided on-line in 10 min intervals to the ZAMG database. Some of the regional governments in Austria run their own air pollution networks, monitoring regularly SO_2, NO, NO_2, CO, and TSP; a lot of these stations provide basic meteorological information, especially wind. The network consists of more than 100 monitoring stations in Austrian cities and their suburban regions. The regional governments are responsible for the maintenance of stations and the data management. They provide mostly monthly publications of air quality data in booklets and on the web. The Austrian Federal Environmental Agency (Umweltbundesamt, UBA) runs the Austrian ozone monitoring network comprising also about 100 stations.

Intensive field measurement campaigns have been carried out for individual cities as part of research projects. For the city of Graz, campaigns have been carried out in winter 1997/98 and in summer 1998 (Piringer and Baumann, 1999). Data comprising meteorology including vertical soundings by sodars and tethersondes and pollutants including ozone is available on a CD in the netCDF-format. The city of Vienna has been another focal point of field campaigns, especially to investigate the mixing height (Piringer et al., 1998) or to highlight meteorological conditions for high ozone concentrations (e.g. Piringer et al., 1997).

4. Available models

The non-hydrostatic mesoscale model GRAMM (Almbauer and Oettl, 2000) is used for the investigation of urban air quality during episodes of anticyclonic weather conditions. The model includes the RADM-2 chemical reaction mechanism. The model has been applied to the Graz region for two episodes with intensive measurement campaigns (Almbauer et al., 2000). The Lagrangian particle model GRAL (Oettl et al., 2000) deals with the special features of pollution dispersion under low wind speed conditions in the local scale. Emission models for traffic for different scales and resolution have been presented, e.g., by Sturm et al. (1998).

The Austrian regulatory model ON M 9440 is Gaussian and has undergone an international evaluation exercise with a performance comparable to other, also more complex participating models (Olesen, 1995). Besides the ON M 9440 model, ZAMG applies regularly the U.S. EPA - based dispersion model HIWAY, a Lagrangian particle model (Schorling, 1989) and the micro-scale dispersion model MISKAM (Eichhorn, 1989; Eichhorn, 1995).

In the frame of the emergency response system of ZAMG, the TAWES model system TAMOS, the wind field model CALMET (Scire et al., 1990) was adapted to the database of ZAMG (section 3) and developed further (e.g. inclusion of sodar wind profiles), referred to as TAMOS-W (Pechinger et al., 1999). Recently, a meteorological pre-processor (TAMOS-P) was added to the model system (Baumann et al., 2000), consisting of spatial interpolation routines for the meteorological input (Scheifinger and Kromp-Kolb, 2000), the Berkowicz and Prahm (1982a, b) and Holtslag and van Ulden (1982, 1983) schemes to calculate the sensible heat flux and the methods by Gryning and Batchvarova (1990), Venkatram (1980) and Nieuwstadt and Tennekes (1981) to calculate the mixing height. For summer smog case studies, TAMOS-W and TAMOS-P are linked to the urban airshed model CALGRID (Yamartino et al., 1991). In the frame of COST 715, ZAMG will test LUMPS, a Local-scale Urban Meteorological Pre-processing Scheme, developed by Grimmond and Oke (2000).

5. Related national and international projects

Pollution dispersion from covered roadways and tunnel portals – funded by FWF (Austrian Science Fund), 2000 – 2001.

EUROTRAC2, SATURN "Studying Atmospheric Pollution in Urban Areas", 1998 – 2002, national funding.

Development of the emergency response system of ZAMG, funded by the Austrian government (ongoing). Project manager: ZAMG (U. Pechinger).

Investigations of the mixing height at Vienna, funded by the Austrian National Bank (contracts 5522/1995 and 6430/1997). Project manager: ZAMG (M. Piringer).

COST 715 study contract proposal: Validation of net radiation and sensible heat flux time series calculated by various pre-processors (including LUMPS) with measured data in urban areas. Project manager: ZAMG (K. Baumann). Status: to be submitted.

6. Funding situation

The COST 715 research activities will be funded from national sources. Part of the scheduled work coincides with the above mentioned projects. Funding for the study contract will be proposed to EU/COST.

7. Expected benefits and policy relevance

The Austrian participants in the action expect benefits from exchange of information, data sets and models. E.g. the proposed study contract will lead to a co-operation with the UK Met. Office and the University of Basle (data exchange) and the Indiana and British Columbia universities (LUMPS pre-processing scheme). The Graz data set is available on a CD.

8. Conclusions

Austrian cities have different size and surroundings, which necessitates careful planning of field measurements and model runs, if episodes of high pollution concentrations are to be investigated. In the past, measurements, both routinely and in field campaigns including vertical soundings, dominated over modelling. Air pollution measurements reveal that both episodes of NO_2 and particulates, mainly in autumn and winter, and of photochemical smog, mainly in summer, can occur. Different time and space scales are involved, affecting the requirements for experiments and modelling. This COST action should help to improve the meteorological pre-processors for air quality models. It should also give recommendations on how to improve the standard meteorological measurement equipment in order to make the data practicable for the investigation of episodes.

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10. Relevant WWW home pages of the participant

http://fvkma.tu-graz.ac.at
http://www.zamg.ac.at

Status Report of Belgium

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1. Introduction

Due to the absence of very large cities in Belgium, the general air quality is not too bad. However recently, quite a few summer episodes of ozone have been occurring leading to sustained high values for several days. During winter and anticyclonic situations, Belgium can be touched by SO_2 and NO_x pollution, partly due to the proximity of very large industrial regions.

Three Institutions are involved in the Belgian research in the field of air pollution and urban meteorology:

- Inter-regional cell on the environment (**IRCEL**)
  Av. des Arts 10; 1210 Brussels,
- Vlaamse Instelling voor Technologisch Onderzoek (**VITO**)
  Boerentang 200; B-2400 Mol; Belgium and
- Institut d'Astronomie et de Géophysique G. Lemaitre (**ASTR**), (University of Louvain)
  Chemin du cyclotron 2; B-1348 Louvain-la-Neuve; Belgium.

Some other groups are not usually involved in air pollution research but participate occasionally to such activities and thus may contribute to COST 715:

- Royal Meteorological Institute of Belgium (**RMI**)
  Av. circulaire 3; B-1180 Brussels, Belgium and
- Laboratoire de Géographie physique – Université de Liege (**LGP**)
  Pl. de XX aout; B-4000 Liege, Belgium.

2. Main objectives

The main objectives of the Belgian research activity in air quality are:

1. to observe and understand the evolution of the pollution concentration in the country. Since the year 1979 approximately, some VOC and NO_x measurements were made on a routine basis, and
2. to study by the use of adequate models the impact of abatement policies and their economic implications. (project BELEUROS).

3. Available meteorological and concentration data

Air quality data sets are concentrated at IRCEL. Basic meteo data is available in urban regions at 11 places (Brussels 3; Antwerp 1; Liege 4, Ghent 1 and Charleroi 2). Chemical measurements are made at 10 places (Brussels 3; Antwerp 1; Liege 1, Ghent 1 and Charleroi 4). A few more measurements are available out of the urban regions. Most of these data started around 1980. The RMI Royal Meteorological Institute of Belgium (**RMI**) maintains of course supplementary usual SYNOP and climatological data bases. But as we know most of these data are taken outside urban regions (excepted the soundings made in Uccle, near Brussels).

4. Available models

Models for air quality are used at VITO, ASTR and IRCEL.

Models used by the Vlaamse Instelling voor Technologisch Onderzoek (VITO):
- ARPS (Advanced Regional Prediction System, Oklahoma Un.) for mesoscale meteorology
- EMIAD (Emission, Meteorology and Immission in the Antwerp District) for assessment of SO2 and NOx air pollution
- IFDM (Immission Frequency Distribution model, VITO) for local area impact from stacks, etc.
- VITO for forecasting O3 concentrations in Belgium. (Model operated by IRCEL).

Models used by the Institut d’Astronomie et de Géophysique G. Lemaitre (ASTR) :
- TVM (Thermal Vorticity Mesoscale, ASTR and JRC-Ispra) for mesoscale meteorology. This model is coupled to two chemical models using the LCC or RACM schemes of atmospheric chemistry.

Models used by Inter-regional cell on the environment (IRCEL):
- SMOGSTOP (Statistical Model Of Groundlevel Short Term Ozone Pollution (designed by VITO) run on a daily base by IRCEL.

Models used by the Royal Meteorological Institute of Belgium (RMI):
- Regional weather forecast are since two years elaborated with the use of the ALADIN model (from the French meteo service). The output of this model will be used in the BELEUROS project.

5. Related national and international projects

Here follows a list of projects in which the different groups participate.
For VITO:
- SATURN (Studying Atmospheric Pollution in Urban Areas, EUROTRAC-2) no funding
- COST 715 (WG2), EC finances travel-accommodation
- GLOREAM (Global and Regional Atmospheric Modelling, EUROTRAC-2) no funding

- BELEUROS (Modelling of ozone concentrations over Belgium) funded by the Belgian Office for Scientific Technical and Cultural Affairs (OSTC), 1999-2000;
- MESOSCHAAL MODELLEN (Application of regional transport/chemistry models over the Flanders area) funded by the Flemish Environmental Agency (VMM).

For IRCEL:
- Measurement nets funded on a routine basis by respective regional governments (Flanders, Brussels and Wallonia).

For ASTR:
- COST 715 (WG3), EC finances travel-accommodation
- BELEUROS (Modelling of ozone concentrations over Belgium) funded by the Belgian Office for Scientific Technical and Cultural Affairs (OSTC)
- SATURN (Studying Atmospheric Pollution in Urban Areas, EUROTRAC-2) no funding (entering in 2001).
- SEVEX (Seveso Expert System) developed to assess local effects of severe industrial accidents (Walloon Region).

For the RMI:
- ETEX exercices on long range transport of pollutants (internal funding).

6. Funding situation

The funding situation of each programme is indicated in the list above. In summary this year (2000) funding is only available for the following projects related with air quality:
1. BELEUROS: funding from the Federal Science Policy (OSTC) : 1999-2000
2. MESOSCHAAL MODELLEN: funded by the Flemish Environmental Agency (VMM)
3. SEVEX : funded by the Walloon Region(1990-1999) with limited (not funded) actions going on.

7. Expected benefits and policy relevance

Expected benefits are a better understanding and forecasting ability for ozone and other pollutants mainly in and around main cities. The project BELEUROS is intended to be used for experimenting and testing various abatement strategy by emissions reduction and their related costs.

8. Conclusions

Availability of cited models and data is subject to agreement with the concerned partner. A few other groups are involved in global monitoring and modelling of atmospheric pollution, mainly in the stratosphere, but including the stratosphere-troposphere interaction. Due to their global nature, they have not been cited here intentionally. Key priority in policy research is now directed to abatements strategies in relation to their economic implications.

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http://astr.ucl.ac.be

Royal Meteorological Institute of Belgium (RMI) :
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Laboratoire de Géographie physique – Université de Liege (LPG) :
http://www2.geo.ulg.ac.be/climato/ac1.html

Status Report of Denmark

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1. Introduction

In Denmark the air quality is generally good due to relatively small emissions of air pollutants and good natural ventilation conditions. However episodes of high concentrations of ozone can occur regionally during spring and summer in connection with warm and sunny weather, and during winter episodes with high concentrations of air pollution in urban areas can occur during stagnant anticyclonic weather conditions with low wind velocities and poor mixing.

To handle such air-pollution episodes there is established a "Smog and Ozone warning system" headed by Ministry of Environment and Energy, and with participants from the National Environmental Research Institutes (NERI), DMI, Copenhagen Community and Danish National Board of Health. The warning system, which is for SO_2, NO_2 and ozone, is mainly based on actual measurements and a subjective estimation of the development, though DMI since 1997 has run operationally the Danish Atmospheric Chemistry FOrecasting System (DACFOS) and NERI since late 1999 has run the THOR Air Pollution Forecast System.

During the last decade a substantial progress in Numerical Weather Prediction (NWP) modelling and the description of urban atmospheric processes has been achieved. Present NWP models are approaching the necessary horizontal and vertical resolution to provide weather forecasts for the urban scale.

In combination with the recent scientific developments in the field of urban atmospheric physics and the enhanced availability of high resolution urban surface characteristics the capability of NWP models providing high quality urban meteorological data will therefore increase.

2. Main objectives

The main objective for DMI will be to contribute to the validation of the DMI-HIRLAM analysis and forecasts during air pollution episodes in Europe and possibly to improve the boundary layer parametrisations in DMI-HIRLAM (meso/local-scale version). The validation will especially focus on the forecast of wind velocity and wind direction in the urban atmospheric boundary layer, but other parameters important for the urban air pollution, e.g. stability, mixing height, heat-fluxes etc., will also be considered.

The main overall objective could be to identify urban air-pollution episodes around Europe for all seasons and for selected NWP-models to validate analysis and forecasts values of parameters relevant for the air-pollution concentrations, and for a some selected air-pollution models to estimate the importance of the uncertainty of the meteorological input to the total uncertainty of the air-pollution models. In a later phase also improvement of the parametrisations of urban effects and urban boundary layer in some of the NWP-models could be a part of the work.

The strategy/ideas of DMI future work in the field are:

- Possibilities of existing hydrostatic DMI-HIRLAM versions for the meso-scale/local-scale:
  - new land-use classification scheme (Figure 1),
  - high-resolution databases of surface characteristics,
  - new parametrisations of urban effects: roughness, albedo and urban fluxes,
  - new schemes for estimation of mixing height (MH),
  - cloud parametrisation and its effect on deposition and chemical transformation of pollutants,
  - determination of internal boundary layers in urban areas,
  - analytical parametrisation of wind/turbulence profiles from the DMI-HIRLAM fields
  - higher resolution (up to 1-2 km in the horisontal and 51 vertical levels),
  - simulation of urban pollution by a on-line or off-line coupled DMI-HIRLAM/MET-pre-processor/UAP-model.
- Possibilities of a hydrostatic/non-hydrostatic DMI-HIRLAM for the urban scale:
  - higher resolution (up to ½-1 km horisontal and 51 vertical levels),
  - new parametrisations of urban effects: roughness, albedo and urban fluxes,
  - cloud parametrisation and its effect on deposition and chemical transformation of pollutants,
  - effects of land-use classifications and parametrisations of the surface fluxes,
  - simulation of urban pollution by a on-line coupled DMI-HIRLAM/UAP-model.

3. Available meteorological and concentration data

Historical and real-time meteorological data from Danish synoptic and radiosonde stations. Meteorological and concentration data from a number of air-pollution monitoring stations run by NERI and Copenhagen Community. Part of these data are presented on the Internet. Data sets from the Øresund Experiment (Gryning,1985).

4. Available models

DMI-HIRLAM (DMI-HI*gh* ***R****esolution* ***L****imited* ***A****rea* ***M****odel).* The DMI-HIRLAM operational NWP model is run on different areas (G, N, E and D versions of the model) and different horisontal scales, pro tempo (p.t.) respectively 48 km, 16 km and 5,5 km. The vertical resolution is p.t. 31 hybrid level, but will be increased during the period . The DMI-HIRLAM forecasting system consists of pre-processing, analysis, initialisation, forecast, post-processing and verification. Outputs from DMI-HIRLAM is widely used in dispersion simulation (DERMA, DACFOS, RTMOD, ARGOS, RIMPUFF).

DMI's *3D Lagrangian transport model* can calculate forward and backward trajectories for any point in the area. It can utilise meteorological data from the different versions of DMI-HIRLAM and from ECMWF's global model. The data includes p.t. coordinates, orography, height above ground of the trajectories, horizontal wind (u,v), temperature, relative humidity, 10-meter horizontal wind (u,v), surface temperature, precipitation intensity, total cloud cover, surface pressure, surface fluxes of heat, surface fluxess of momentum, height of the mixing layer.

DMI-HIRLAM-TRACER is an integrated NWP-model and dispersion model. It is still in a development phase.

Danish Atmospheric Chemistry FOrecastin System (***DACFOS***) is a back-trajectory receptor-point model. DACFOS is based on the coupling of EMEP's chemical model (EMEP MSC-W's oxidant model) and DMI's 3-D Lagrangian transport model utilising data from DMI-HIRLAM.

Kalman Filtering Model. A statistical tool for adjustment of the DACFOS ozone forecast. The model utilises real-time observations of ozone, predicted values of DMI-HIRLAM meteorological parameters.

3D local scale CFD-model. Model handling air pollution in complex terrain including street canyons based on the CFD methods.

5. Related national and international projects

DMI is participating in the Danish Smog and Ozone Warning System.

6. Funding situation

No external funding.

Have together with several of the other WG3/WG2-participants and others written a PROPOSAL for The Fifth Framework Programme (FP5) Energy, Environment and Sustainable Development , "4. City of Tomorrow and Cultural Heritage 4.1.2 Improving the quality of urban life". The proposal "Integrated Systems for **F**orecasting **U**rban **ME**teorology for Air Quality Information Systems **(FUME)**" will fit well into the work of COST-715.

7. Expected benefits and policy relevance

The overall benefit will be a substantial validation and uncertainty analysis of meteorological parameters for a number of NWP-models for urban air-pollution episodes around Europe in different seasons. A natural benefit will also be an improvement in the NWP-models boundary layer parametrisation and a better determination of the most important meteorological parameters for an optimisation of the urban air-pollution models.

For DMI a benefit will be the verification of the DMI-HIRLAM for episodes with high air pollution concentrations in Europe. DMI also will work on the improvement of the boundary layer parametrisation.

The policy relevance will be a substantial uncertainty analysis of meteorological parameters important in urban air-pollution episodes for a number of NWP-models, and an estimation of the importance of the uncertainty of the meteorological input to the total uncertainty of the air-pollution models.

8. Conclusions

The main overall objective could be to identify urban air-pollution episodes around Europe for all seasons and for selected NWP-models to validate analysis and forecasts values of parameters relevant for the air-pollution concentrations, and for a some selected air-pollution models to estimate the importance of the uncertainty of the meteorological input to the total uncertainty of the air-pollution models. In a later phase also improvement of the boundary layer parametrisations in some of the NWP-models will be a part of the work.

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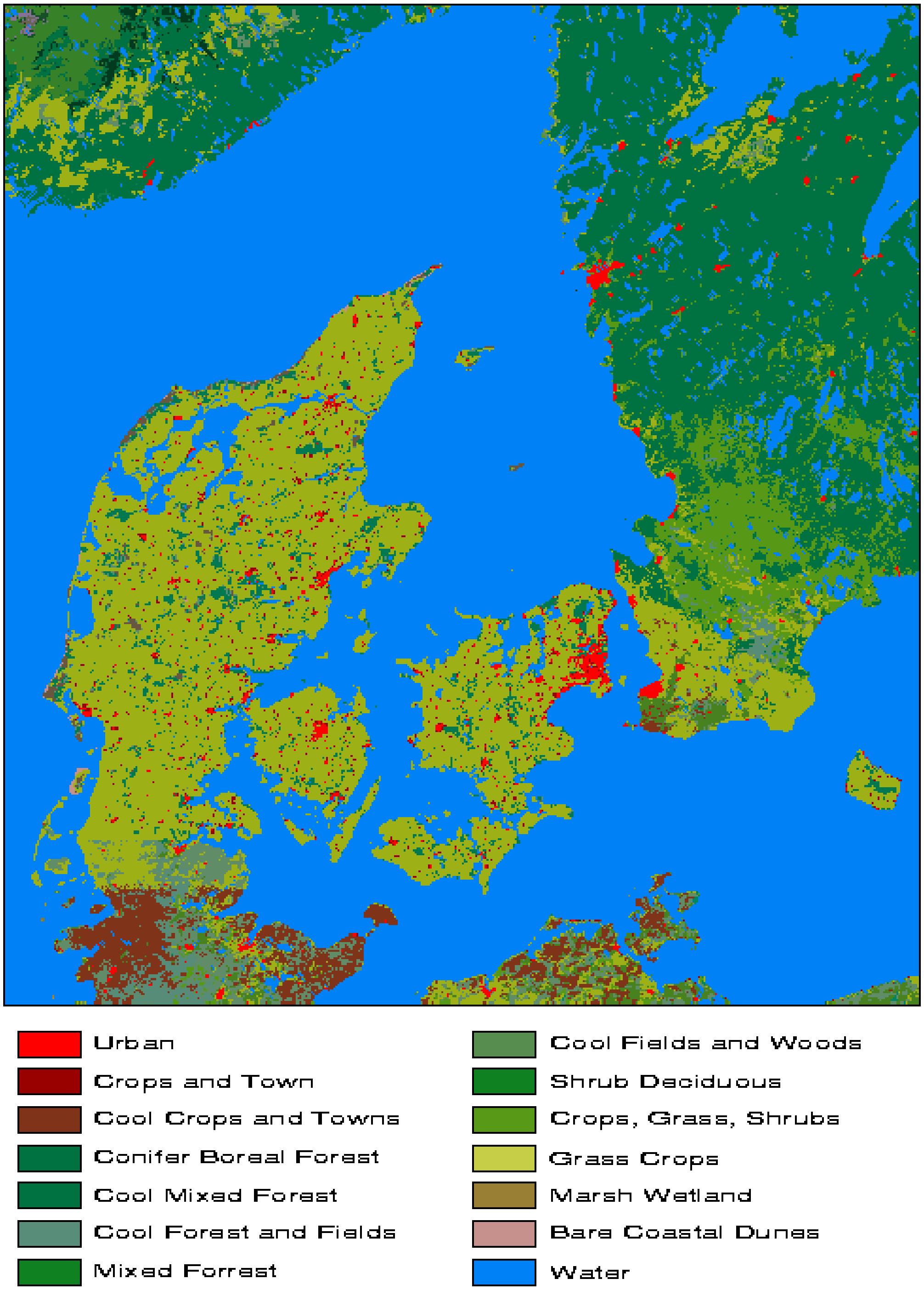

Figure 1. DMI-HIRLAM land use over Denmark. Original data are from the Global Land Cover Characteristics database and from a local database from "Kort og Matrikelstyrelsen" in Denmark. Resolution is about 1 km. For convenience, only a limited number of classes are listed in the legend.

Status Report of Finland

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1. Introduction

Urban air quality has been nationally reviewed, based on the data from urban measurement networks from 42 cities and towns (Kukkonen et al., 1999). These data show that the 1996 introduced national air quality guidelines have been fairly often exceeded in urban areas, most commonly for particulate matter, both PM_{10} and total suspended particles (TSP). Some exceedances have also occurred for NO_2 and CO, at sites with high traffic densities. However, the European Union air quality limit values were only exceeded at one measurement station for TSP.

The topic of “Meteorology during peak pollution episodes” has been addressed in a previous national study “The management of air quality episodes” (Mäkelä et al., 1997 and 1998). A special issue (Railo, 1997) of the Magazine of the Finnish Air Pollution Prevention Society reviewed international experiences in order to control air quality episodes in selected European cities, e.g., Berlin, Paris and Helsinki.

2. Main objectives

We have planned to focus on the following matters within the current activities of COST-715/WG3:

1. Survey and analysis of meteorological conditions leading to air quality episodes.
2. Development and evaludation of computational methods for forecasting air quality, utilising in particular the numerical weather prediction model HIRLAM. This includes also neural network methods.
3. Development and validation of dispersion modelling and meteorological pre-processing methods, for atmospheric conditions prevailing during episodes.
4. Analysis of selected air pollution episodes in the Helsinki metropolitan area, in the light of meteorological observations and analysis, measured concentration data from urban measurement stations, and dispersion model computations.

3. Available meteorological and concentration data

The meteorological database of the Finnish Meteorological Institute (FMI) contains all national synoptic and sounding observations. Pre-processed meteorological data can be produced for any particular location and time period, using this database and a meteorological pre-processing model.

Local authorities are responsible for measurements of urban air quality, including the processing of the measured concentrations and computation of the statistical concentration parameters defined in the national air quality guidelines. In 1993, there were 31 urban monitoring networks comprising in all 112 monitoring stations (Kukkonen et al., 1999, 2000c). The networks include all the cities in Finland, which have more than 50 000 inhabitants.

The concentration statistics from the above mentioned network are inserted into the National Urban Air Quality Database. The database has been developed and updated by the Finnish Meteorological Institute (FMI) over the period 1987 - 1996. Since 1997, this work has been carried out jointly by the Finnish Environment Institute and the FMI.

We have also produced datasets specifically for model evaluation purposes (Kukkonen et al., 2000a,b). These datasets are internationally available.

FMI also conducts nationally the measurements and analyses of the regional and global air quality measurement networks. The results have been compiled into a database.

4. Available models

The following regulatory local-scale atmospheric dispersion models are available at the FMI: the urban dispersion modelling system (Karppinen et al., 2000b,c), various models for dispersion of vehicular pollution (Härkönen et al., 1995, 1996; Kukkonen et al., 2000b), the air pollution information system (Bremer and Valtanen, 1995), the dispersion model for odorous compounds and a hybrid Eulerian dispersion model (Nikmo et al., 1999, Kukkonen et al., 2000d); a review of these has been presented by Kukkonen et al. (1997). All of these models are connected to a meteorological pre-processing model, based on atmospheric boundary-layer scaling. Dispersion and transformation models for larger scales are also available at FMI.

The meteorological pre-processing model MPP-FMI (Karppinen et al., 1998 and 2000a) is based on a slightly modified version of the energy budget method of van Ulden and Holtslag (1985). The model utilises meteorological synoptic and sounding observations, and its output consists of estimates of the hourly time series of the relevant atmospheric turbulence parameters (the Monin-Obukhov length scale, the friction velocity and the convective velocity scale) as well as the boundary layer height.

The HIRLAM model has been used operationally at the FMI since 1990 for the production of short range numerical weather predictions. Currently, the model produces daily four 48 hour regional forecasts and four 36 hour mesoscale forecasts for Northern Europe. FMI participates also in the international HIRLAM development project.

The Air Pollution Information System API-FMI has been developed for disseminating real-time and forecast air pollution information to the public. The system includes:
- computational methods for forecasting air pollution (Bremer, 1993; Bremer and Valtanen, 1995),
- a mathematical model for computing an air quality index and
- a system for disseminating the results to the public in an easily readable form.

Air pollution forecasting methods at FMI can be divided into two categories: (i) application of the weather forecasts of the synoptic situation and meteorological parameters, and (ii) computation of pollutant concentrations, using statistical methods and the urban dispersion modelling system (UDM-FMI, Karppinen et al., 2000b,c).

The statistical methods are based on regression analysis of measured concentrations and meteorological parameters. These correlations have been derived from measurements in the Helsinki metropolitan area. Air pollution forecasts are made for the compounds SO_2, NO_x and CO. The system is applicable in an urban area. It can also be used prognostically, as a warning system for high pollution concentrations.

A spatial air quality index model has also been developed at FMI, which utilizes HIRLAM-data and dispersion model computations. The model produces a forecasted air quality index in 2500 gridpoints in the Helsinki metropolitan area. Work is in progress in order to compare the forecasted index with a corresponding index, based on data from an urban air quality measurement network of the Helsinki Metropolitan Area Council.

5. Related national and international projects

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6. Funding situation

Only intramural funding is directly available for this COST-project. However, part of the scheduled work is overlapping with the above mentioned projects.

7. Expected benefits and policy relevance

The action is also expected to be a discussion forum for exchanging information, as well as available datasets and models. A key benefit will be the research collaboration that will result from this initiative. E.g., cooperation concerning dispersion in stable low wind speed conditions has been initiated with the University of Herfordshire (U.K.)

8. Conclusions

The present COST Action is expected to assist in evaluating practical matters related to episodes, for instance, in estimating exceedances of guidelines and limit values and analysing the influence of various measures in order to control episodes. This project will also contribute to the development and validation of our dispersion models and the meteorological pre-processor. We also expect to exchange information, in particular concerning air quality forecasting methods.

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http://www.fmi.fi/ENG/ILA/pre-proces.html

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http://www.fmi.fi/TUT/MET/hirlam/hir_engl.html

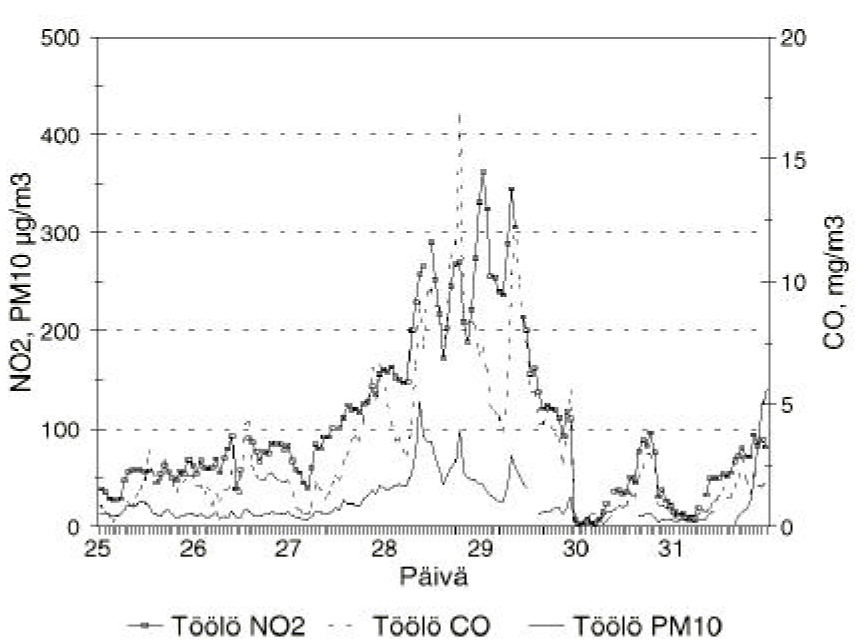

Figure 2. The concentrations of nitrogen oxides (NO_2), carbon monoxide (CO) and thoracic particles (PM_{10}) during a severe air quality episode in December 1995, measured at a station in downtown Helsinki. Source: Helsinki Metropolitan Area Council.

Status Report of France

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1. Introduction

The air quality forecasting is being made in France under responsibility of local air quality association. Local air quality associations are responsible for measurements of urban air quality. They are responsible as well for data processing and delivering information to the public. Météo-France is specially involved in delivering the "best possible" meteorological parameters for air quality forecasting. All the mathematical tools used or in development in order to predict peak episodes encounter difficulties with the description of the meteorological conditions occurring during these pollution episodes, low wind speed, stable stratification close to the ground, etc. The French team is composed of two groups, Meteo-France and the CORIA CNRS laboratory. The participation of the French members is focused on the description and on the forecasting of the meteorological situations which are favourable to peak of pollution.

2. Main objectives

Meteo-France adopted in 1998 an Atmospheric Environmental Guideline (SDEA in french) which is aimed at defining its policy as regard the air quality assessment. Different topics are addressed by SDEA such as delivery of relevant meteorological data, development of regional chemical transport model, relationship with local authorities and air quality associations etc.

SDEA has specially addressed the topic “describing and forecasting the meteorological situations which are favourable to peak of pollution”. Within COST 715/WG3, Meteo-France planned to focus on:

1. the analysis of regional and local meteorological conditions during episodes and
2. the correlation between set of meteorological parameters, including backward trajectories, and air quality index over different cities in France.

The main objective is to determine a 3 to 5 days forecasting system of meteorological contexts which could reinforce a peak of pollution over different cities in France.

The contribution of the CORIA laboratory will consist of observations of the meteorological conditions over urban areas. It is now well known that, for pollutants emitted at ground level, their dispersion is driven by the buffer layer which lies just above the roof level (the canopy or roughness layer). The work will focus on the atmospheric boundary layer changes within this canopy layer, due to perturbations of buildings and human activities. A long time series of meteorological observations will be carried out in the centre of a city up to 30 m above roof level and compared to the same observation obtained outside the urban zone. The aim is to improve the surface parameterisations of flow parameters which are important in dispersion modelling, friction velocity, turbulent fluxes, etc.

3. Available meteorological and concentration data

The meteorological database of Météo-France contains all national synoptic and sounding observations. A special database contains different outputs of the French numerical weather prediction models ARPEGE and ALADIN.

Local air quality associations are responsible for measurements of urban air quality. A project of gathering all the air quality data into a national data base is still in progress under the responsibility of Ministry of Environment. The status of that data base is not completely defined, however under some conditions (research needs for example) these data will be available.

The meteorological observation performed by the CORIA will be made at one urban station located in a city centre. Standard meteorological parameters will be determined. However turbulent parameters, variances of the wind speed fluctuations and turbulent fluxes, will be measured at two heights above the roof level, 10 and 35 m. This urban station is planned to work several months in winter and summer.

4. Available models

The numerical weather prediction model ARPEGE provides twice a day, at 00 and 12 UTC a set of 3 days meteorological forecasts at global or regional scales. For mesoscale applications ALADIN model provides 36 hours forecast, twice a day.

Météo-France participates in the development of air quality forecasting method over Paris. Two systems are under construction, one using neural methods and one using a mixture of dynamical and statistical methods. Both systems are managed by AIRPARIF, the local air quality association responsible for Paris, surroundings and region Ile de France. In that framework Météo-France deals with the meteorological part of both systems. The CHIMERE model operated on a “semi-operational” basis during summer 1999. That model is aimed at forecasting O_3 concentration over Paris and is developed by Laboratoire de Météorologie Dynamique (LMD). It includes a meteorological processing system which computes trajectories and mixing heights based on ARPEGE data.

The neural network method is developed by Orsay university and requires meteorological data which can be direct output from ARPEGE or statistical adaptation of them, specially wind cloudiness and humidity.

5. Related national and international projects

The work planned by the CORIA will be carried out in the frame of the URBCAP project which is the urban ‘spot’ of the ongoing ESCOMPTE project. This one will take place in the Marseille region and it is a ‘heavy’ measurement campaign on the photochemical pollution episodes. The urban station used by the CORIA would be installed in Marseille centre.

The CORIA is involved in the SATURN-EUROTRAC program dealing with urban air pollution and modelling. Close connections with the COST 715 W3 activities exist since urban air pollution modelling needs reliable meteorological data.

6. Funding situation

The two above projects, URBCAP an ESCOMPTE, will founded by the French government, in particular within PRIMEQUAL program, French acronym for local scale air quality research program, conducted by ministry of Environment, and sponsored by other ministries (Health, Transport, etc.)

For Meteo-France, only internal funding is available for this COST project.

7. Comments

Air quality is a new field of activities in Météo-France and two other models could be involved in WG3: meso-NH-C (meso-scale non hydrostatic chemical model) and MOCAGE (large scale chemical and transport model). They are still under development and not “operational” for the moment.

8. Expected benefits and policy relevance

WG 3 is expected to give an help in our main objective, to be able to forecast the meteorological context favourable to peak of pollution episodes at medium range (3 days). We also expected to exchange information with experienced participants.

9. Conclusions

The present COST action is expected to assist in evaluating meteorological situations (at synoptic and urban scale) which can lead to peak of pollution. We also expected to exchange information about air quality forecasting methods.

10. Relevant web pages of the participant

Meteo-France: the French weather service:
http://www.meteo.fr

ESCOMPTE web site: description of the experiment
http://medias.meteo.fr/escompte/index.html

UMR 6614 CORIA
http://www.coria.fr/

Status Report of Hungary

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1. Introduction

Budapest, capital of Hungary is coping with peak pollution episodes mostly in January-February, under calm anticyclonic conditions. In summer, photochemical smog formation initiated by the NO_x, CO and VOCs emissions of traffic in Budapest, occurs downwind of the city if the current weather situation is unfavourable. Respirable fine particles also cause environmental and human health problems during episodes. To investigate this problem, not only the mass concentration of aerosol particles is to be measured but analyses of elemental concentrations are also needed.

2. Main objectives

The Hungarian Meteorological Service has planned to focus on the following issues:

1. Statistical investigation of high CO, SO_2 and PM_{10} concentration episodes during winters in Budapest: relationship between the duration of peak episodes and synoptic situations. Data gained from 8 automatic stations and 2 mobile stations are to be used;
2. Investigation of urban photochemical plumes inside and downwind of Budapest. Precursor measurements in Budapest as well as ozone and PAN measurements at K-puszta (80 km SE of the city) will be involved in the study;
3. High concentrations of toxic elements in atmospheric aerosols ($PM_{2.5}$): are they long-range or local origin ? Source-receptor estimations are to be performed for toxic elements like Cd, Pb, Ni, V, Zn and Cu.

3. Available meteorological and concentration data

Hungarian Meteorological Service (HMS) is responsible for collecting all the synoptic and sounding data in Hungary. There is an extended measurement programme - including vertical sounding - in the outskirts of Budapest. Using a diagnostic wind model the wind speed and velocity can be calculated for several locations in Budapest. HMS is also involved in the smog warning system of Budapest so we have on-line connection to all air quality monitoring sites in the city, measuring SO_2, NO_x, CO, VOCs, O_3 and TSP. A combined deterministic/statistical model is being adapted for the prediction of ozone concentration peaks in the next 10 hours. For urban plume studies 925 hPa trajectories are to be applied.

For estimating the source-receptor relationships of fine particles, chemical mass balance (CMB) method is used. Input parameters are provided through concentration measurements in the plumes of all important point and line sources as well as at selected receptor sites. The advantage of the method is that high resolution meteorological data are not needed for the computations. In Figs. 1. and 2. the variation of ozone concentration is plotted for Budapest, altogether with relevant wind speeds and directions.

4. Available models

- Adapted version of EPA OZIPR model for the prediction of ozone concentration for the next 10 hours;
- Statistical type CMB (chemical mass balance) model for source-receptor investigations of fine aerosol particles.

5. Related national and international projects

1. EUREKA/EUROTRAC/SATURN: Investigation of the source origin of fine particles in Budapest.
2. EU EEA PHARE Topic Link in Air Quality: Evaluation of air quality in Budapest and other PHARE cities

6. Funding situation

At present the Ministry of Environment and the National Research Fund provide financial support for performing the studies. The HMS has joined two FP5 proposals relevant to this topic.

7. Expected benefits and policy relevance

Based on ozone forecasts to be performed at the HMS, public can be informed on the expected air quality during episodes.

Source-receptor modeling provides a relatively simple and effective tool for assessing the relative contribution of selected source categories (traffic, coal and oil heating, industry and waste incineration) to atmospheric concentrations of toxic aerosols (Pb, Cd, As, Cu, Ni, V and Zn) over urban areas. Neither high resolution emission inventories nor sophisticated meteorological field measurements are needed for the estimations.

Based on the results of the multi-site sampling, measurements and modeling activities to be carried out in Budapest, local and long-distance sources can be separated so policy makers can make cost-effective environmental decisions on how to reduce emissions of different sources in Budapest to reach at the best improvement in urban air quality.

Decision makers can also be provided with scenario calculations for the air quality in Budapest using estimations for the expected improvement of energy production and industrial technologies in the next future.

8. Conclusions

It is concluded that sampling and modeling experiments during peak episodes could provide scientific basis for understanding the chemical and physical processes of the atmosphere.

9. Relevant publications

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Bozó L., Labancz K., Pinto J., Baranka Gy. and Kelecsényi S. (1999) Source-Receptor Relationships of Trace Elements in Budapest. Proceedings of EUROTRAC Symposium '98. (Eds:P.M. Borrell and P.Borrell), WITpress, Southampton (in press).

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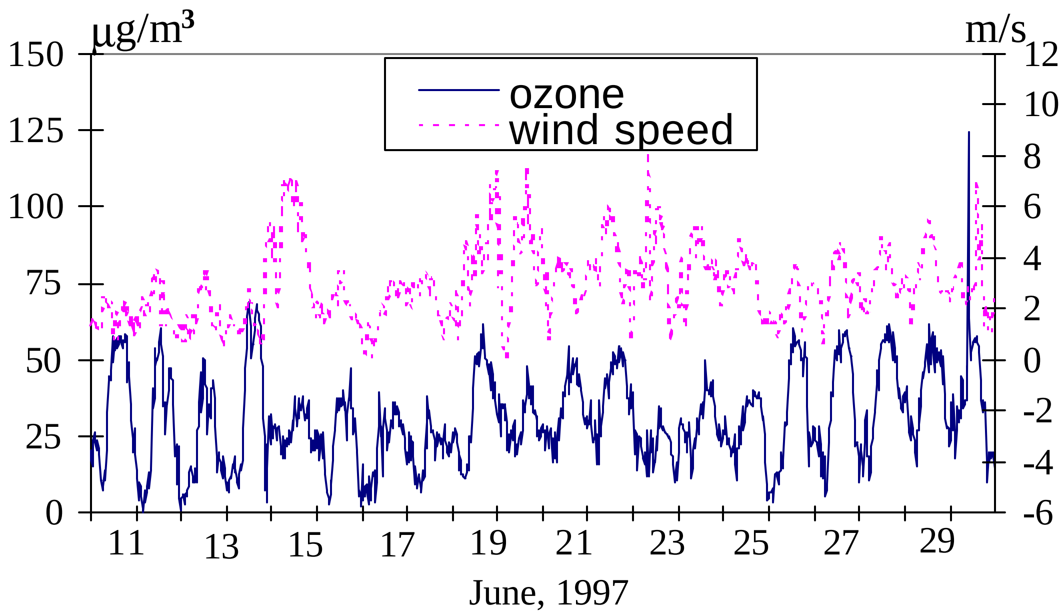
Bozó L., Eerens H., Larssen S., Millán M., Moussipoulos N., Papalexiou S. and Samaras Z. (1998) Urban Air Quality in South-Eastern European Cities. In: Urban Air Pollution - European Aspects (Eds.: Palmgren F., Hertel O. and Fenger J.) 433-464. Kluwer Academic Publisher, Dordrecht .

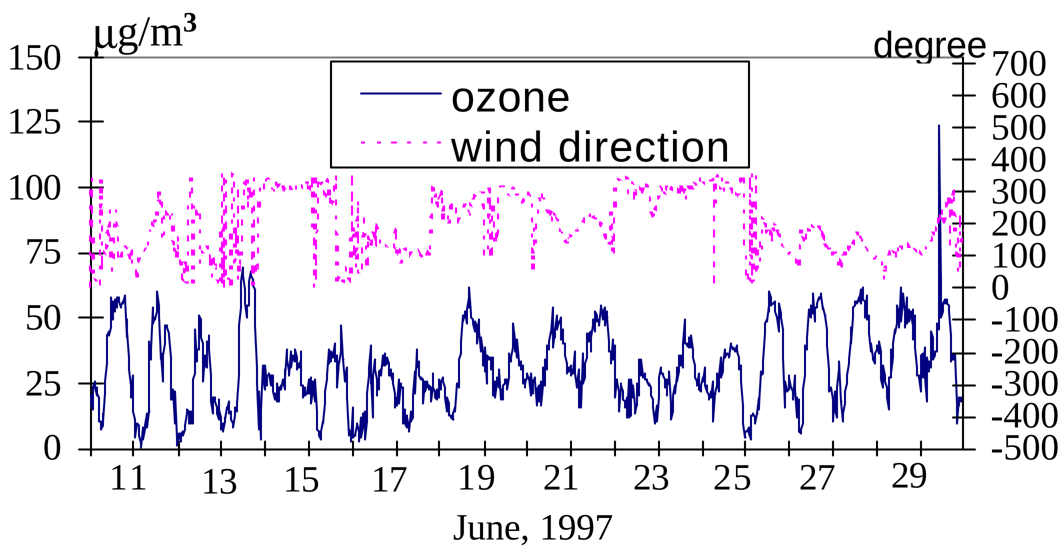
Haszpra L., Bozó L., Sándor V. (1997) Formation and transport of tropospheric ozone in Hungary. In: Tropospheric Ozone Research. Edited by O. Hov, Vol 6, Springer Verlag.

10. Relevant home pages of the participant

Air quality related research activities at the Hungarian Meteorological Service:
http://www.met.hu

Air quality data from urban sites in Hungary; Limit values for gases and particles:
http://www.joboki.hu





Figures 3 a-b. Measured ozone concentration compared with wind speed (upper figure) and wind direction (lower figure) in Budapest during 11 – 29 June, 1997.

Status Report of Italy

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1. Introduction

The major Italian urban areas experience short-term severe pollution episodes during both winter and summer. Heavy pollution conditions are mainly observed during persistent high pressure periods, that cause wind calms and favour pollutant accumulation in the lower atmospheric layers. During winter conditions peaks are observed mainly for NO_X, and PM_{10} concentrations. CO episodes are less frequent, while an increasing attention is being given to benzene and other hydrocarbons, which in many urban areas exceed the long term reference level in a significant manner. The ozone pollution is a main problem all over Italy, where O_3 pollution episodes often occur during summertime. This kind of pollution is relevant not only for the heavy urbanised areas, but even for a large number of medium and small towns and can occur over wide areas, such as the Po valley.

2. Main Objectives

Our main objectives within the current activities of COST-715/WG3 are the following:

1. To obtain a better comprehension of meteorological conditions leading to air quality episodes, focusing on urban meteorology features. Identification of key meteorological parameters from the point of view of pollutant dispersion/reaction modelling.
2. Definition of the degree of reliability and accuracy of operational Global Circulation Models (GCM) and Limited Area Models (LAM) for the urban scale. Possible shortcomings are expected to be due to the unresolved urban areas characteristics but also to a poor description of relevant mesoscale topography.
3. Evaluation of diagnostic and prognostic modelling techniques to properly reconstruct/forecast meteorological fields (in particular surface fluxes, wind field, temperature profile, and turbulence) at urban scale. The applicable modelling techniques have been reviewed in Fisher et al. (1998). The use of these models has the aim to improve information given to urban airshed models, even through the application of suitable interface codes.

3. Available meteorological and concentration data

National synoptic and sounding observations are managed by the Air Force Meteorological Service (SMAM), that distributes data directly, under specific contracts, or through regional authorities. The SMAM also distributes the European Centre for Medium Range Weather Forecast (ECMWF) data products such as analysis fields.

Other surface observations at higher space resolution are gathered by local authorities (Provinces and Regions) and other national organisations such as the Central Office of Agrarian Ecology (UCEA, http://www.politicheagricole.it/UCEA) and the National Hydrographic and Mareographic Service (SIMN, http://www.dstn.it/simn). Most air quality networks, located mainly in the urban or industrial areas, include meteorological stations. Some Regions (Emilia Romagna, Liguria, Piemonte, Veneto, Sardegna,…) operate local meteorological services which perform observations and data analysis. In particular the Emilia Romagna Regional Meteorological Service (SMR-ARPA) operates a radiosounding in S. Pietro Capofiume.

A meteorological radar network covers a large part of northern Italy. The radars are located at S. Pietro Capofiume (Emilia Romagna), Teolo (Veneto), Bric della Croce (Piemonte) and Fossan di Grado (Friuli) and Seravezza (Toscana).

Local authorities (usually Provinces) perform air quality measurements and verify the attainment of air quality standards and the possible exceedance of attention and alarm thresholds. They also control long term air quality trends. In most regions the Regional Environmental Protection Agency (ARPA) is responsible for the air quality networks maintenance and data management, while local authorities (the major of the town) are responsible to take air quality management actions at the urban scale. Regional authorities and Provinces perform long term air quality management and provide emission reduction and control planning.

ENEL (the largest Italian electricity company) is responsible of air quality control networks located nearby its power plants, where both meteorological and air quality measurements are usually performed. At some power plant locations Sound Detecting And Ranging (SODAR) wind profile and Radio Acoustic Sounding System (RASS) vertical temperature profile measurements are also available.

A large number of air quality stations are now operating in Italy. Automatic stations are located mainly in urban areas and measure the pollutants prescribed by Italian and European laws. Ozone stations are generally located in suburban and rural areas. The National Environmental Protection Agency (ANPA) is co-ordinating a national program, with the aim to collect and distribute all the available air quality data on a national basis. To realise this programme ANPA instituted the National Thematic Centre on Atmosphere Climate and Emissions, (CTN/ACE, www.sinanet.anpa.it/rete/ctn/ctn_ace.asp).

4. Available models

The institutions that operate meteorological models and distribute numerical weather predictions in Italy are listed in this section.

- The SMAM is not presently operating weather prediction models. The SMAM distributes ECMWF numerical weather predictions and meteorological analyses products.
- SMR-ARPA, (www.smr.arpa.emr.it):
  - The hydrostatic Limited Area Model (LAM) LAMBO executes operationally 72 hours forecast over Italy. The model runs with two mesh resolutions, the finest horizontal grid-size is 0.125 degrees, about 20 km (Paccagnella et al., 1994). LAMBO products are used by SMR-ARPA and distributed to external customer.
  - A meteorological pre–processor, based on the mass-consistent model CALMET (Scire et al., 1995) and observed meteorological data, is run daily to compute hourly wind and temperature 3-D-fields together with micrometeorological parameters over the Po valley with a 5 km horizontal grid spacing. Moreover the LAMBO forecasts are used to evaluate the boundary layer height and other input variables needed by statistical models on selected grid points near the main urban areas of the Emilia–Romagna region. (Deserti et al. 1999).
- Central Office of Agrarian Ecology (UCEA, www.politicheagricole.it/UCEA/dalam/index.html):
  - 72 hours weather forecasts are produced applying the hydrostatic model DALAM, having a 30 km horizontal resolution over the region limited by the following co-ordinates: 30°N - 56°N; 5°W - 26°E.
- Meteo-Hydrological Service of the Liguria Region (CMIRL, www.cmirl.ge.infn.it):
  - The hydrostatic LAM LILAM, is operated to produce 72 hours forecast, over north-western Italy, with a space resolution around 10 km.
  - The mass-consistent model WINDS (Mazzino et al., 1994) is used to enhance the wind field resolution.
  - 72 hours forecast with the LAM BOLAM (Buzzi et al., 1994) are executed by the Physics Dept.of the University of Genova in co-operation with the Institute of Atmosphere and Ocean Sciences of the National Research Council (CNR-ISAO). A maximum resolution of 6.5 km is obtained over northern Italy.
- CESI, (meteo.cesi.it/previsione.htm):
  - The hydrostatic LAM MEPHYSTO (Bonelli et al., 1998) is operationally executed to produce 48 hours weather forecast over Italy with a resolution of 0.125 degrees. Forecasts and data are distributed inside ENEL and to external customers
  - The non-hydrostatic mesoscale meteorological model RAMS (Pielke et al., 1992) it is used for mesoscale to local scale meteorological applications and as meteorological driver for atmospheric pollutant dispersion models
  - The mass-consistent diagnostic meteorological models MINERVE (Aria Tech., 1995) and CALMET are applied as meteorological driver/pre-processor for local scale dispersion models and for urban/regional airshed models (Pirovano et al., 1999).
- The Laboratory for Meteorology and Environmental Modelling of the Toscana Region (LaMMA, www.lamma.rete.toscana.it):
  - 72 hours weather forecast around Toscana Region is performed applying the non hydrostatic mesoscale model RAMS with a maximum horizontal resolution of 8 km.
  - The meteorological forecast horizontal resolution is enhanced by means of the mass-consistent model MINERVE.

Some local authorities make use of Decision Support Systems (DSS) to support air quality management. Air quality models are implemented inside DSS to forecast the possible occurrence of severe ground level pollutants concentrations in urban areas. Until now statistical and neural network modelling methods have been preferred to deterministic models due to their limited computational demand and their relative simplicity.

- The National Board for New Technologies Energy and Environment (ENEA) operates an air quality control information system called ATMOSFERA for the city of Rome. Among the other functions the system includes statistical and neural network models to forecast next day air pollution.
- The SMR-ARPA operates two statistical models to forecast NO_2 pollution in the Bologna metropolitan area. The first one can forecast the pollution state that can be positive or negative if threshold levels are attained or exceeded. The second one forecasts hourly average ground level concentrations at the monitoring sites.
- The University of Brescia is comparing neural networks and statistical methodologies and verifying their O_3, NO_2 and CO concentrations forecast in the cities of Brescia, Milano and Catania (Schlink and Volta, 1999; Finzi et al., 1998).

Different institutions perform urban air quality modelling on case studies. A review of modelling applications in Italy has been recently done by CTN/ACE, under ANPA supervision. Most studies have been performed in northern Italy. The largest number of investigations have been conducted in Lombardia since 1990, and Emilia–Romagna since about 1995. Other Regions involved in model applications are: Liguria, Lazio, Piemonte, Toscana, Puglia and Campania. Some Regions are applying photochemical models in the frame of Regional Air Quality Reclamation and Control Plans (e.g.: Lombardia, Emilia–Romagna, Piemonte, Lazio). The more widely used photochemical code is CALGRID (Yamartino et al, 1992), but also UAM, PBM and STEM have been applied. Other studies used non reactive dispersion models.

- CESI and the University of Brescia performed different studies on the Lombardia Region, Milan and Brescia urban areas (Calori et al., 1998; Silibello et al., 1998). Near ground wind field and ozone concentrations obtained in a recent nested simulation of summer and winter episodes on the city of Milan are depicted in Figures. The models available and used in the cited applications are the following:
  - The pre-processor POEM is used to build emission scenarios for atmospheric chemistry models.
  - The photochemical Eulerian dispersion model CALGRID has been used to analyse urban and regional O_3 pollution episodes.
  - The atmospheric chemistry model STEM-II (Carmichael et al., 1991) is employed to analyse regional scale pollution taking into account reaction in heterogeneous phase (cloud and fog chemistry).
- The Emilia Romagna ARPA is performing a project called MAAM, involving also CNR-ISAO and ENEA, in the frame of which the following deterministic models are applied:
  - The photochemical box model PBM is used to get a fast evaluation of average O_3 and NO_2 concentrations in the urban area of Bologna.
  - The photochemical Eulerian model CALGRID is applied to analyse the space distribution/evolution of pollutants in different emission scenarios;
  - A non reactive analytical model, adapted to the Bologna area (BOAPRAC) is used to study the traffic related air pollution.
- The Lombardia Region makes use of the CALMET/CALGRID modelling systems that have been applied by various research groups to simulate photochemical episodes in different areas of the Region.

5. Related national and international projects

- CTN/ACE. Aims: to collect, standardise and distribute all the available air quality data on a national basis, encourage and co-ordinate the model employ and implementation, co-ordinate the emission inventory and collect information on climate change. Started in 1999. Funding: ANPA.
- EUROTRAC-2, SATURN, Studying Atmospheric Pollution in Urban Areas, 1998 – 2001. Principal investigator: University of Brescia (G. Finzi).

6. Funding situation

Only intramural funding is available at the moment for COST 715 activities. The work foreseen fits the activities of the CTN/ACE project. Support of the University and Scientific Research Ministry is possible.

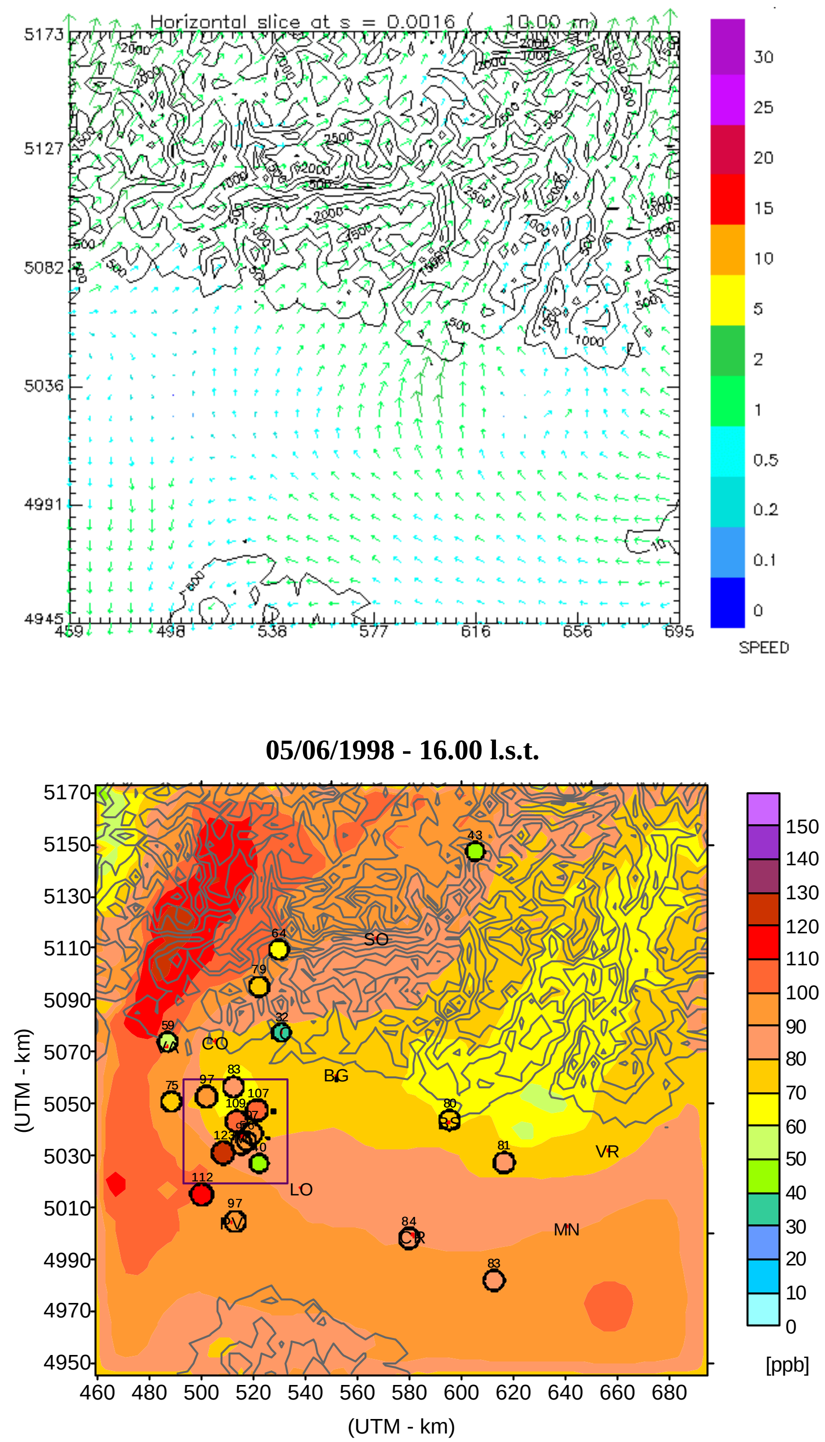
7. Expected benefits and policy relevance

One of the most critical aspect of urban air pollution modelling is the lack of suitable and reliable meteorological information. COST 715 action activities can contribute to improve urban meteorological data processing and urban meteorology modelling capabilities. Guidelines can be built for the description/forecast of urban meteorology during peak pollution episodes, with the final aim of improving the ability of forecasting passive and reactive pollutant concentrations in the urban environment.

8. Conclusions

Urban air pollution is a major concern in many Italian cities of different size and geographic location. Different subjects, from local government agencies to public and private research centres, are working on urban air quality problems, even contributing to international projects (e.g. EUROTRAC2). Some local and regional authorities use modelling tools in the frame of DSS to forecast urban air pollution episodes. Many modelling studies have been and are being performed for air quality control and management in different Italian Regions. Model applications are foreseen to gain interest and to be more widespread over the country in the future.

The urban meteorology is usually poorly described in modelling studies. The available measurements normally include synoptic and urban surface observations. The weather forecasts have horizontal resolutions generally ranging from 10 to 20 km. There is a lack of information about vertical profiles and surface fluxes representative of urban areas. Improvements are needed in urban circulation and micrometeorology modelling and in the access to urban-scale surface characteristics and meteorological information. Another major need of urban air pollution modelling is the development and harmonisation of urban-scale emission inventories.



Figures 4 a-b. Near ground wind field (upper figure) and ground level ozone concentrations (lower figure) over the Lombardia region at 16:00 l.s.t., 05/06/1998. The results were obtained with CALMET diagnostic model and CALGRID model simulations. Coloured circles indicate measurements whose value is shown over the circle. The small square encloses Milan urban area and shows the nested simulation domain.

9. References

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Pielke, R. A., Cotton, W. R., Walko, R. L., Tremback, C. J., Lyons, W. A., Grasso, L. D., Nicholls, M. E., Moran, M. D., Wesley, A. Lee, T. J. and Copeland, J. H., 1992. A comprehensive meteorological modeling system - RAMS. Meteor. Atmos. Phys., 49, 69-91.

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Yamartino, R.J., Scire, J.S., Carmichael, G.R. and Chang, Y.S., 1992. The CALGRID mesoscale photochemical grid model - I. Model formulation. Atmospheric Environment 26A, 1493-1512.

10. Relevant WWW home pages of the participants

CESI, Ambiente
http://meteo.cesi.it

ARPA Emilia-Romagna, Servizio Meteorologico Regionale
http://www.smr.arpa.emr.it; http://www.arpa.emr.it

ANPA, National Environmental Information System
http://www.sinanet.it

Status Report of Norway

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1. Introduction

In Norwegian cities the air pollution is first of all a wintertime problem related to stagnant conditions under high-pressure situations, leading to relatively high levels of NO_2 and PM_{10}. As the larger Norwegian cities are partly surrounded by hills or mountains, complex circulation patterns arise and fine scale meteorological modelling is an essential tool in order to describe and understand the details of the local circulation.

Presently, DNMI and NILU have jointly developed an air pollution forecasting system for the largest Norwegian cities, consisting of a fine scale non-hydrostatic meteorological model and an Eulerian air pollution model with sub-grid treatment of line- and point sources. A large part of our work related to COST 715 is therefore linked to this activity.

2. Main objectives

The main objective of the Norwegian activity within WG3 is to improve our understanding on how to apply, and possibly improve, output data from mesoscale weather prediction models for instance from a model like MM5. The usage of the NWP-data is either as input to meteorological pre-processors (which then generate the necessary dispersion parameters) or directly as input to urban scale dispersion models, in order to calculate realistic urban concentration levels during peak pollution episodes. Peak pollution episodes are of great concern in Norway not only due to the large health impact on the public, but also because they are the most difficult to model with the computing tools presently available. In particular, we are interested in applications to Nordic wintertime situations in cities with complex topography.

In our opinion we would also foresee that the work of WG3 would contribute to improved understanding on how to validate the output from meteorological and urban air quality models. Moreover, existing measurements of both meteorological and air quality parameters during peak pollution episodes should be surveyed and made available for model validation purposes.

3. Available meteorological and concentration data

DNMI is responsible for weather prediction in Norway and the adjacent sea areas. A large number (ca. 200) synop stations are run for Norway. However, only a few stations measure meteorological quantities of particular interest for PBL meteorology and urban air pollution problems (such as for example surface fluxes). Data from the eight radiosondes operated by DNMI do not give sufficient resolution near the surface to be useful either. In the two largest cities in Norway, Oslo and Bergen, data on surface short and long wave radiation fluxes are available. During summertime latent heat fluxes are also measured in Oslo. Approximately 10 stations have an extended measuring program including surface fluxes etc. However, these stations are situated in remote agriculture and forest areas. All the measurements at DNMI are organised in a central database.

On behalf of the Norwegian pollution control authorities, NILU has monitored the air quality of the largest Norwegian cities for several years. In most of the cities only one or two air quality stations have been used, but during certain campaigns several measurement stations have been applied. In addition to the air quality stations, measurements from at least one meteorological site within the urban area have been available giving hourly information about wind and stability conditions. Since the main concern have been on pollution episodes, components like NO_x/NO_2 and PM_{10} have been focused, and most of the monitoring have been performed during the winter season. A number of dual tracer experiments have been carried out to provide data for the difference in dispersion of emissions from home heating and from road traffic, both within and outside urban areas. The measured air quality and meteorological data have been compiled into a database.

4. Available models

At DNMI the following weather prediction and air pollution models are available:

- The weather prediction modelling system at DNMI is built on **HIRLAM** (High Resolution Limited Area Model) as described in Källén (1996). The development of HIRLAM is a collaborative effort between the countries Denmark, Finland, France, Netherlands, Norway, Spain and Sweden. Each country runs operational versions of the model separately. At DNMI a version with 50 km horizontal resolution (HIRLAM50) and 31 layers in the vertical covering a large part of the Northern Hemisphere is run twice per day. A fine scale version of HIRLAM with 10 km horizontal resolution (HIRLAM10) is also run twice per day for north-west Europe and the adjacent seas. This model is nested into HIRLAM50. Both HIRLAM50 and HIRLAM10 are run on the 00 UTC input data and the 12 UTC data (measurements plus boundary values taken from the ECMWF global model).
- The non-hydrostatic MM5-model (The Fifth Generation NCAR/Penn State University Meso-Scale Modelling System, see Dudhia, 1993, Grell et al., 1994) has been nested into the HIRLAM10 and implemented into DNMIs operational routines. Two nests have so far been set up for Oslo and Bergen. The outer nest has 3 km horizontal resolution while the inner nest has 1 km resolution. The model system of HIRLAM10 and MM5 will be run in

a forecast mode for the two cities when high NO_2 and PM_{10} concentrations are expected the winter 1999/2000. The meteorological data from MM5 will be used to run AirQUIS for the two cities (see below).

- The EMEP three dimensional LRTAP-models (EMEP=European Monitoring and Evaluation Programme, LRTAP=Long Range Transport of Air Pollution) are developed and run at DNMI (see Olendrzynski, K, 1999, Jonson et al., 1998, Berge and Jakobsen, 1998). The models estimate the background levels of most gases and $PM_{2.5}$. Information from the LRTAP models is important for initialisation and specification of the boundary values of the urban air quality models.

At NILU the following *urban or local scale dispersion models* are available:

- The Air Quality Information System, **AirQUIS**; http://www.nilu.no/new_web/b-surveill-e.html is currently applied in Norwegian cities for both monitoring and calculating urban air quality. In addition to a user friendly menu and map oriented interface, this system include: an online monitoring system, a measurement database for meteorology and air quality parameters, a consumption/emission inventory database with emission models and an urban scale numerical dispersion model. The dispersion model is an eulerian finite difference grid model with embedded subgrid models for the treatment of line sources and point sources (Grønskei and Walker, 1993; Walker et al., 1999). The grid model and the subgrid models are combined so as to ensure mass continuity. Based on information about population distributions (stationary distributed according to home addresses) exposure levels can be calculated.

- Various gaussian type dispersion models: CONCX, CONDEP, KILDER, INPUFF and TRAFORO.

  CONCX calculates short term downwind concentrations at ground level or in specified receptor points for various distances for selected meteorological conditions. Input to the model consists of source information and the meteorological conditions (wind speed and stability class) for the specific situation under consideration.

  CONDEP calculates long term sector averaged concentrations either in specified receptor points or in a given grid. The input consists of source information from a number of point sources within the area of interest, and a meteorological joint frequency matrix consisting of four wind speed classes, four stability classes and twelve wind direction sectors.

  KILDER is also a model for calculating long term averaged concentrations. In addition to calculating the dispersion from point sources (as in CONDEP) KILDER also includes dispersion from area sources.

  INPUFF is a multiple source gaussian puff dispersion model. The model allows NOx and SO_2 chemistry and (wet) deposition. The model calculates concentration levels at a number of receptor points. As input the model require information about the semi-instantaneous or continuos pointsources within the selected area and the temporally and spatially variable wind field.

- TRAFORO is a model for calculating short term concentration levels from one or several line sources (road links) in various receptor points. Necessary input to the model are wind (speed and direction) and stability classes.

If direct measurements of the dispersion parameters are not available the AirQUIS system make use of NILU's meteorological pre-processor MEPDIM (Bøhler, 1996). This pre-processor makes use of Monin-Obukhov similarity theory to describe the structure of the atmospheric boundary layer (van Ulden and Holtslag, 1985; Holtslag and de Bruin, 1988; Gryning et al., 1987). Depending on the available meteorological input data either the profile method or the energy budget method can be applied. The meteorological input required for the profile method are the vertical profiles of wind and temperature, while for the energy budget method either cloud cover or direct measurements of net radiation are needed in addition to standard meteorological inputs of wind and temperature. The metprocessor then estimates the boundary layer depth (h), the surface heat flux (H_0), the surface momentum flux (τ_0) and the standard deviations of the horizontal and vertical turbulent velocity fluctuations, σ_v and σ_w.

5. Related national and international projects

DNMI and NILU are involved in a project initiated by the Norwegian Directorate of Public Roads on developing a forecast system for peak episodes of wintertime NO_2, $PM_{2.5}$ and PM_{10}. An operational air quality model based on HIRLAM10/MM5 and AirQUIS has been developed and will be tested.

DNMI is also involved in studies of wind and turbulence structures at Norwegian airports situated in complex terrain and assessments of local wind conditions aiming at wind energy use.

NILU are also involved in several urban air quality assessment projects both nationally and inter-nationally. Nationally these projects are mainly financed by the Norwegian pollution control authorities. At present NILU is also involved in such projects in China and Egypt.

6. Funding situation

Funding of this activity is mostly from local Norwegian authorities. Presently, NILU and DNMI are also partners in the "FUME" EU-proposal for the 5th Framework Programme.

7. Expected benefits and policy relevance

The topic of this Cost Action seems to highlighten scientific problems that are relevant for ongoing projects in the field of urban air quality in Norway. Our special interest is within detailed surveys of the present urban air quality in different cities, and the ability of making forecasts of peak pollution episodes.

8. Conclusions

The present activities under WG3 of COST 715 are very relevant for the work on peak air pollution episodes in Norwegian cities. A collaboration between DNMI and NILU has been set up in order to improve the meteorological data coverage and the air pollution forecasts in Norwegian cities. Several relevant meteorological and air pollution modelling systems are available for the forecasting of urban air quality. A considerable amount of surface based meteorological and air quality measurements are also available. However, the meteorological data sets are rather sparse, and often only 1-2 stations are found in each city. Very few vertical profiles and surface flux data are available in the cities.

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10. Relevant www home pages of the participants

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http://www.dnmi.no/eng_index.html

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http://www.nilu.no/new_web/b-surveill-e.html

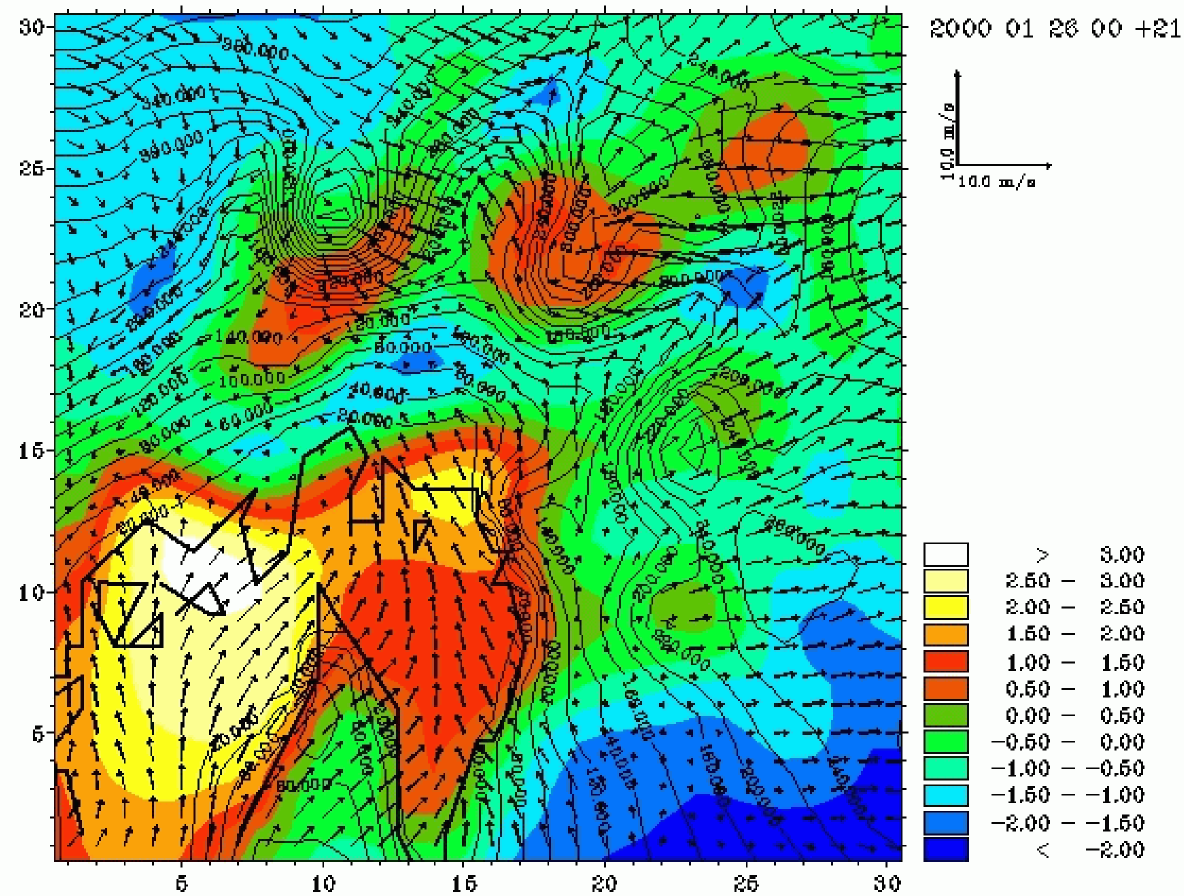

Figure 5. Numerical results from a MM5 operational meteorological prediction, at 21 UTC, 26 January 2000. The values of wind speed and direction (arrows) and temperature (°C) at the height of approximately 8 m are shown in the legend; the solid lines indicate model topography for the Oslo area. The domain size is 31 * 31 km^2, with 1 km grid distance. The centre of the city is located just above the area of 2 to 2.5° in the middle of the domain. Just north of this area, in the northern part of the city, wind speeds are very low and temperatures range from – 1.5 to – 2.0 °C.

Status Report of Portugal

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1. Introduction

Portugal is located in the Atlantic west front of Iberean peninsula. The total area is about 90.000 km^2, including the 9 islands of Açores and the 2 main island of Madeira, located in the Atlantic ocean respectively 1600 km to the west of Portugal mainland and 1000 Km to the SW of Portugal mainland.

The population of Portugal is about 10 million people, and about 2/3 of it is concentrated in a 50 km wide strip along the west coast between 39º N and 42º N, which includes the main Portuguese cities: Setubal, Lisboa, Santarem, Leiria, Coimbra, Aveiro, Porto, Braga, Viana do Castelo (from south to north). In this small area, less than 20.000 km^2, more than 80 % of the Portuguese industries are concentrated, including the heavy industries which are the main stationary sources of the air pollutants (6 thermal power plants, 2 refineries, 4 cement plants, 2 syderurgic plants and 3 chemical and petrochemical complexes).

However, the main source of air pollutants is the road traffic. The total annual emission in Portugal of SO_2, and NO_x of antropogenic origin are estimated as 360 x 10^3 ton and 370 x 10^3 ton, respectively. So, these emissions are equivalent, in average, to 360 kg SO_2 /inh and 4 ton SO_2 / km^2 for sulphur dioxide and 37 kg NO_x / inh. and 4,1 ton NO_x / km^2 for nitrogen oxides.

2. Main objectives

For the Instituto de Meteorologia (IM), the main objectives will be to contribute for the knowledge of the mesoscale circulations in lower troposphere especially in coastal areas in south Europe and to contribute to characterize air pollution episodes, mainly by ozone and suspended inhalable particles (SIP).

Using the meteorological data already available in the main cities of Portugal (AMS) and the data which will be collected in the urban meteorological automatic stations, which will be installed before the end of the year 2000, it will become possible to develop meteorological models which permit to predict risk of high values of air pollutants concentrations. Finally, we intend to apply dispersion models in urban areas and define methodology for meteorological data pre-processing.

3. Available meteorological and concentration data

In Portugal, the responsibility of the operational air quality monitoring is under regional and local authorities; so, in the main cities as well as in the main industrial area there are air quality monitoring networks for different air pollutants, operated by local authorities. The air pollutants more frequently monitored are sulphur dioxide (SO_2), nitrogen oxides (NO_x), total suspended particles (TSP) and ozone (O_3); in major cities, the lead concentration in the air is also measured as well as hydrocarbons near source refineries.

So, in Portugal there are 8 air pollution monitoring networks in cities (Porto and Lisboa) and near industrial areas or thermal power plants (Estarreja, Pego, Carregado, Barreiro, Setubal, Sines) and single air pollution monitoring stations in smaller cities (Coimbra, Setubal, Faro, Funchal). The IM operates 5 stations included in the regional network of the WMO Global Atmosphere Watch (GAW) (Bragança, Viana do Castelo, Castelo Branco, Angra do Heroismo Açores and Funchal, Madeira) as well as 2 stations (Bragança and Viana do Castelo) of the 3 Portuguese EMEP stations.

In a near future, probably before mid 2000, 5 new ozone analyzers will be installed at the rural stations of Bragança, Viana do Castelo, Castelo Branco, Évora and Faro; then, the national ozone analyzers network include 6 rural stations, 5 stations in the industrial areas and 8 to 10 urban stations.

The Portuguese Meteorological Institute (Instituto de Meteorologia, IM) is the state department responsible for operating and collecting all sounding, synoptic and climatological data in Portugal. The IM collect and distributes via GTS the synoptic data every 12 hours from 3 Portuguese radiosounding stations (Lisboa, Lages/Açores, Funchal/Madeira), and every 3 hours from 17 surface synoptic stations (9 in mainland, 5 in Açores islands and 3 in Madeira islands); furthermore, the IM collect the daily synoptic observations, since 6 to 18 UTC, from additional stations in mainland (7) and in Açores (5).

Regarding the modernization of the surface meteorological network, the IM initiated on 1994 the installation of a automatic meteorological stations (AMS) network, with a total of 93 AMS (78 AMS in mainland, 9 AMS in Açores and 6 AMS in Madeira); actually, we are operating already 41 AMS in mainland (17 AMS type I and 24 AMS type II), 4 AMS type I in Açores and 2 AMS type I in Madeira. All AMS are equipped with sensors for air and relative humidity at 1.5 m, air temperature at 5 cm wind direction and speed at 10m, precipitation at 1.5m (0.1mm), rain detector, global radiation at 2.0m and soil temperatures (0.10; 0.20; 0.50; 1.0m); additionally the AMS type I have a pressure sensor and a personal computer connected, for the acquisition, archiving and processing data, enabling the observer to introduce the visual observed data for the SYNOP message, which are collected every hour by regional concentrators (3 in mainland, 1 in Açores and 1 in Madeira) and by the national concentrator placed in Lisboa, at the IM headquarters (Lisboa).

Most of the instrumental data is available for 10 min periods and it is possible to collect the data in different arrangements according by to the users. So, it was defined a set of variables which are particularly useful for air pollution dispersion calculations at local scale; these data are wind direction and speed at 10m height, standard deviation of the wind direction in 10 min, atmospheric pressure, air temperature and relative humidity, solar global radiation, water vapor pressure and soil surface temperature.

During 2000 an automatic meteorological station network in portuguese urban areas will be installed; these urban stations will be placed in urban areas with more than 50.000 inhabitants namely in Lisboa (5 stations), Porto (3 stations) and 1 station in each of the following towns: Faro, Évora, Funchal, Braga, Coimbra, Amadora, Cacém, Barreiro and Vila Nova de Gaia.

4. Available models

For regional dispersion studies we have available in the IM the ECMWF models data and a version of the mesoscale ALADIN model. Furthermore, specially to simulate the characteristics of the sea breeze and the topography influence on the lower troposphere circulation we have used the TVM model (“Topographic vorticity mode Model”). Recently an operational procedure was established in order to calculate (Holzworth model) the daily maximum mixing height and ventilation index in the Lisboa area, based on the radiosounding data in Lisboa aerological station at 12:00 UTC.

5. Related national and international projects

The IM has been part of EC supported Projects on which some field meteorological campaigns have been carried out in the west coast of Portugal in order to document the sea breezes characteristics and the vertical thermo-mechanical structure of the lower troposphere (RECAPMA – “Regional Cycles of Air Pollution in the west – Central Mediterranean Area” and SECAP – “South European Cycles of Air Pollution”.

Nationally, some meteorological field campaigns have also been carried out at Algarve and around the great Metropolitan Area of Lisboa to study the wind fields in these areas and the tropospheric ozone profiles in summer. The meteorological and ozone data at surface and in the troposphere has been archived in a data bank, including the available AMS data in the studied areas.

6. Funding situation

Actually the IM is in a very difficult situation for the development of operational and research activities related with air pollution meteorology since the governmental funds for IM were drastically reduced and even the meteorological operations must be supported by external funds.

7. Expected benefits and policy relevance

The study of air pollution episodes requires us to characterise not only the local eteorological conditions, but also the meteorological conditions at the synoptic scale.

8. Conclusions

If the regional meteorological conditions and the favourable synoptic situations for the air pollution episodes are known (Figure), it will be possible to deliver warnings on the occurrence probability of significant air pollution episodes in urban areas.

9. References

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Instituto de Meteorologia – Portugal
http://www.meteo.pt

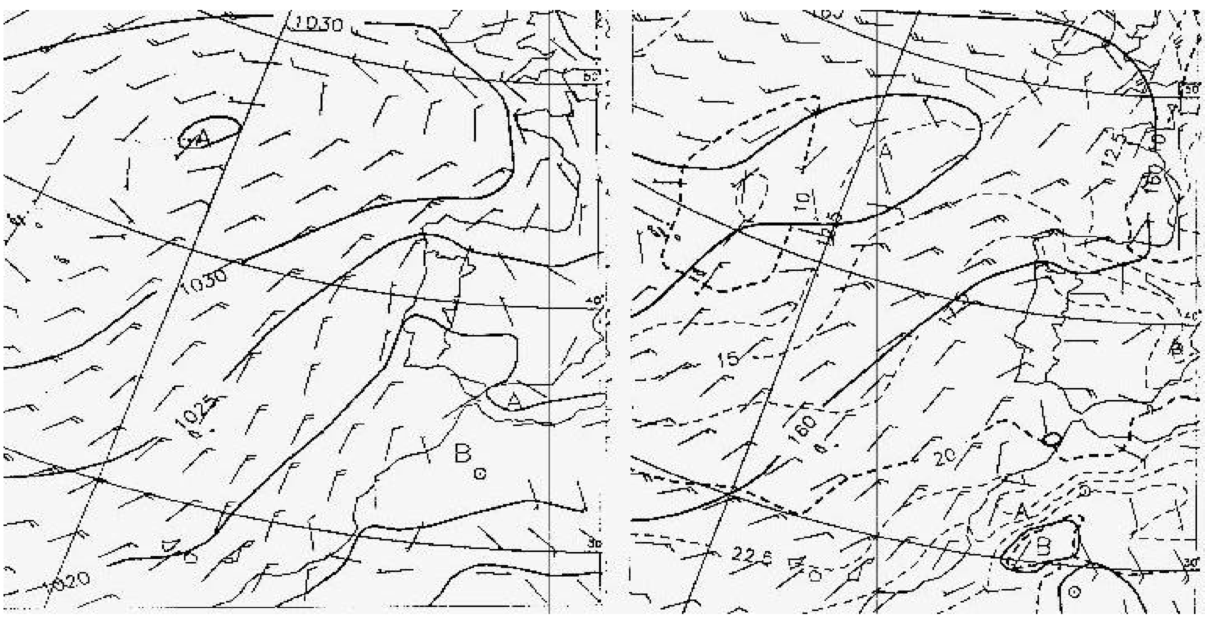

Figure 6. Typical synoptic situation for ozone pollution episode in central Portugal during 10-13 July 1996. Figure on the left-hand-side: Surface wind field analysis on 10 July 1996 – 12 UTC; Figure on the right-hand-side: Analysis of wind field on the 850 hPa pressure level on 10 July 1996 – 12 UTC. Maximum hourly ozone concentration is 251 $\mu g/m^3$. Duration of concentration $O_3 > 135\ \mu g/m^3$ is 21 hours.

Status Report of Spain

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1. Introduction

In Spain, most of the regional and city administrations endowed with an air-quality network have budgets to maintain them and to address general and specific issues such as standards compliance, information to the public and management and urban planning. However, participation in scientific projects only takes place in certain networks and cities with extensive experience, such as Madrid, Barcelona, Sevilla, Bilbao, and Valencia (Millán, et al., 1992; Artiñano et al.,1993; Baldasano et al., 1993; Alonso, et al., 1999; Martin et al., 1999). The urban episodes observed in these cities and their conurbations are mainly due to photoxidants. Three of these cities are coastal and all of them are located in complex topography.

The meteorological conditions that lead to such episodes can be summarized as:

- Pollutants being trapped in confined airsheds under anticyclonic stagnation in winter, i.e., Madrid. The formation and duration of severe episodes over the Madrid basin related to anticyclonic stagnation produce deep surface thermal inversions and subsidence-type inversions at low altitudes, which inhibit pollutant mixing in the lower layers. Under these conditions, the same airmass can recirculate within the airshed for more than a week.
- Mesoscale re-circulations under weak anticyclonic subsidence in summer, i.e., large-scale episodes in southern Europe (Barcelona, Bilbao, and Valencia). The complex layout of the coasts and mountains surrounding the Western Mediterranean basin favours the development of mesoscale atmospheric re-circulations and the formation of ozone reservoir layers above the coastal areas and the sea.

An overview of the administrative situation and responsabilities for environmental issues in Spain was presented in the 3rd Seminar of Air Pollution in Spain (Ricote, 1999). The work conducted by the National Air Quality Reference Centre (depending on the Environment Ministry) includes the overall results of the monitoring inventory.

2. Main objectives

In the current activities of COST 715/WG 3 we would like to contribute with our experience in episodic situations on a complex coastal-terrain site during summer meso-meteorological circulation conditions. CEAM would like to participate in the characterization of air pollution episodes in a southwestern European coastal city, using Castellón as the pilot site for the experiment. In Mediterranean coastal regions the O_3 reservoir layers contribute as much as 60-100 % of the observed O_3 levels around the coastal cities (Millán et al., 1999).

Available data combined with mesoscale analyses and modeling will be used to interpret the observed summer ozone cycles for the monitoring network in the Valencian Community. Our attention will be focussed:

- To determine the meteorological conditions that lead to pollution episodes in the Western Mediterranean area.
- To analyze and model meteorological circulations which favour the formation of pollutants (photo-oxidants and aerosols) within this coastal area.
- To study the formation of reservoir layers of pollutants in this area and the fumigation processes from reservoir layers.
- To determine the interaction between urban and regional scales, and their relation to long-range transport and other mesoscale phenomena.
- To determine NO_2 emission dynamics in coastal urban areas which undergo high levels of photoxidants.

3. Available meteorological and concentration data

Local authorities are responsible for the measurements from their urban air quality networks. An inventory of the monitoring station distribution in Spain is given in Ricote (1999). For the area in which we are focusing our research, the available meteorological and concentration data include historical databases from the intensive experimental campaigns and from the Valencian Community´s Air Quality Network. Since 1986, several EC-supported experimental campaigns have been carried out at this Spanish east-coast site, in the frame of the following projects: MEsometeorological Cycles of Air Pollution in the Iberian Peninsula (MECAPIP) (Millán et al., 1992; 1996), REgional Cycles of Air Pollution in the west-central Mediterranean Area (RECAPMA) (Millán et al., 1997), South European Cycles of Air Pollution (SECAP), and the most recent Biogenic Emissions in the Mediterranean Area (BEMA). The historical database will serve to validate the models.

4. Available models

The meteorological numerical model used by CEAM is the Regional Atmospheric Mesoscale System (RAMS) described in Pielke, et al. (1992). It is a two-way interactive nested grid model, which uses 4DDA nudging schemes for initialization. Optimum grid sizes were defined to incorporate major atmospheric driving forces over the east coast of Spain (Salvador et al., 1999). Our intention is to use RAMS meteorological data linked with the variable-grid Urban Airshed Model (UAM-V). This uses the Carbon Bond Mechanism IV with 38 chemical species and 94 reactions in its more recent version. The UAM-V model also incorporates two-way nested gridding. Application of the photochemical model also requires an accurate emission inventory for improved predictions of pollutant concentrations. We have initiated emission models of the Castellón area (EMMAC and EMMIC emission models, Salazar et al., 1999).

The Thermal Vorticity Mesoscale model (TVM), including coupled chemistry-transport modules based on RACM and EMEP photochemical mechanisms, was also applied to reproduce some of the air pollution patterns observed in this area during the experimental campaign (Thunis et al., 1997). This model configuration has also been used to simulate the evolution in mesoscale ozone concentrations in the area affected by pollutant emissions from the Madrid conurbation (Martin et al., 1999). Moreover, the EMMA model has also been used in the Madrid airshed. This is a complex operational model for large urban areas, which includes a sophisticated three-dimensional mesoscale meteorological model REMEST (based on MEMO and MM5) and an implicit numerical solver for chemistry (http://artico.lma.fi.upm.es/research.html). The neuronal network methodology was applied in the Sevilla airshed to develop a forecast system for ozone concentrations (Martin et al., 1999).

The study of photochemical pollution in the Barcelona area has consisted in the application of the meteorological non-hydrostatic mesoscale model MEMO, the emission inventory model EIMLEM and the three-dimensional photochemical dispersion model MARS (Toll et al., 2000).

5. Related national and international projects

We have contacted local administrative authorities as well as universities and research center in order to update related national and international projects. The results are summarized below:

- MEsometeorological Cycles of Air Pollution in the Iberian Peninsula (MECAPIP). European Finance DGXII. Project Leader**:** Millán Millán.
- South European Cycles of Air Pollution (SECAP). European Funding, DGXII. Project Leader**:** Millán Millán.
- REgional Cycles of Air Pollution in the west-central Mediterranean Area (RECAPMA). European Funding, DGXII. Project Leader**:** Millán Millán.
- Biogenic Emissions in the Mediterranean Area (BEMA). European Funding, DGXII. Project Leader: Paolo Ciccioli.
- IBAIR-CITY- Assimilation and Interpretation of Air Quality Networks in Spain. National Funding. Project Leader**:** Millán Millán. 1998-1999.
- Regional Assessment and Modelling of the Carbon Balance within Europe (RECAB). European Funding, DXII. Manager**:** Millán Millán. 1999-2002.
- Optimization of Air Quality data assimilation in the Valencian Community Network. National funding. Project Leader: Millán Millán.
- Integration of Methodologies and Models for the Prognostic and Analysis of the Weather, Air Pollution and Their Effects. IMMPACTE. Regional Funding. Project Leader: Prof. José M. Baldasano. 1999-2003.
- Atmospheric Modeling and Lidar Techniques applied to the study of an urban environment: Application to the Barcelona Area. European Funding, DGXII. Manager: Prof. José M. Baldasano. 1999-2001.
- Development of an earth observation data converter with application to air quality forecast (DECAIR). DG XII/CEO. Principal Investigator: Prof. Roberto San José. 1999-2001.
- Air Pollution Network for Early Warming and on-line Information Exchange in Europe (APNEE). DGXIII. Principal Investigator: Prof. Roberto San José. 2000-2001.
- Electronic services for a better quality of life (EQUAL). DGXIII.. Principal Investigator: Prof. Roberto San José 1998-2001. http://www.eu-eual.net

- Development and Implementation of a Software System to Control and Prevent Air Pollution in the Industrial area of Huelva. National Funding. Principal Investigator: Fernando Martín. 1996-2000.
- Development of Optima Measurements for the Reduction of the Atmospheric Pollution of Industrial and Urban Origin in the Madrid area. Regional Financing. Principal Investigator: Fernando Martín. 1998-2000.
- Development of Optima Measurements for the Reduction of Atmospheric Pollution of Industrial and Urban Origin. National Financing. Principal Investigator: Fernando Martín. 1999-2001
- Evaluation of the Atmospheric Pollution produced by Particulates in the Community of Madrid. Local Financing. Principal Investigator: Begoña Artiñano. 1999-2001
- Formation and Distribution of Photoxidants in the Madrid area basin. National Financing. Principal Investigator: Begoña Artiñano. 1996-1999.
- Reconstruction of Vertical Ozone Distribution from Umkehr (REVUE). European Funding. Principal Investigator: Sr. Cuevas. 1998-1999.
- Transport of Chemical Species across Subtropical Tropopause (TRACAS). European Funding. Principal Investigator: Sr. Cuevas. 1999.

In addition, the Spanish National Weather Service is involved in European and National research projects related to chemical processes and global climate change; for more information see http://www.inm.es/wwc/html/dtemint.

6. Funding situation

Part of the scheduled work overlaps with the above-mentioned projects led by CEAM.

7. Expected benefits and policy relevance

The benefits of this work will be:

- To increase the scientific knowledge of atmospheric-chemical processes for the whole of Europe and, in particular, for Southwestern Europe where complex topography dominates with land-sea interface. This can be used to optimize the cost of air pollution abatement policies.
- To contribute to the development and application of models for episodic response procedures.
- To optimize the design of the air quality monitoring network for the conditions dominating in southern Europe.
- We also expect to exchange information, in particular concerning air quality forecasting methods.

8. Conclusions

The meteorological components of the diurnal variations in the observed O_3 levels, either due to wind reversals and/or fumigation from the reservoir layer aloft, are just as much a natural part of ozone variability in Europe as are the photochemical processes which generate them. In fact, photochemical production along with the formation of reservoir layers aloft occur during the day, i.e., within one of the stages of the daily cycle, while regional and long-range transport in stratified layers tends to occur during the other half of the cycle, i.e., at night.

It also follows that: regardless of any other consideration, and no matter how elaborated a station classification is, for the interpretation of data from monitoring networks, and for a proper understanding of the ozone production and transport cycles in any region, one must be fully aware of the meteorological processes involved in each site/region.

Finally, the selection of an appropriate modelling system that reproduces and forecasts the photochemical cycles, as well as the proper meteorology, should be made with knowledge and understanding of the physical-chemical processes involved, and always corroborated by experimental validations. These would include emission, meteorological and photochemical model simulations.

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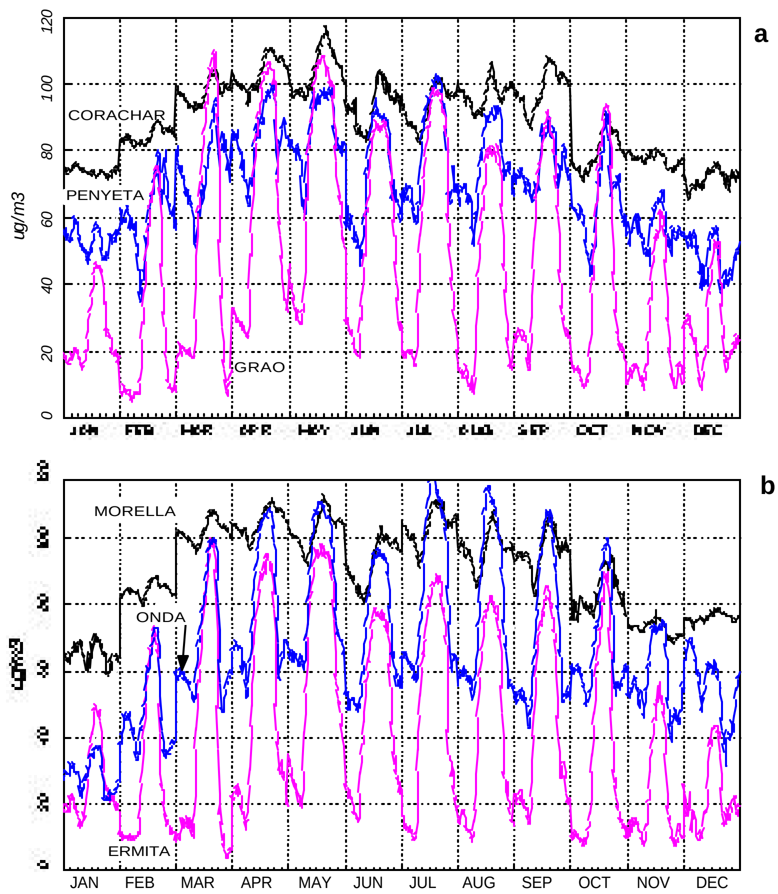

Figure 3

Figure 7. The ensemble averages of the O_3 diurnal cycles for each month of 1997. The absolute values recorded and their annual evolution should be emphasized. These document the existence of chronic-type episodes with persistent medium-to-high O_3 levels for several months (i.e., March-August), as compared with shorter (i.e., one week), peak-type episodes in central Europe. They further confirm the marked differences between the cycles at stations on the coastline, coastal plains, mid-valley and mountain tops, all located within a 100 km square, and between stations located just a few kilometers apart. For people in charge of air quality networks, these cycles can only lead to perplexity and/or exotic conclusions if interpreted in terms of 'typical O_3 cycles' or 'averaged' output from models with a 150 by 150 km horizontal resolution (from Millán, et al.,1999).

Status Report of United Kingdom

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1. Introduction

The United Kingdom National Air Quality Strategy (DETR 1997 and 1999) highlighted the need to manage air pollution within urban areas. The standards and objectives contained within the national strategy are to be met by or before 2005 and have been adopted directly from the recommendations of the Expert Panel on Air Quality Standards (EPAQS) which were based primarily on health effects. Recent studies, such as, Stedman et al (1998) and Sokhi et al (2000) have also indicated that many areas are likely to exceed the UK standards. Special attention is, therefore, required to better manage local air quality and to improve our understanding of the behaviour of atmospheric pollutants.

The study by Sokhi et al (2000) has compared several urban sites within London and has clearly illustrated the importance of road transport as a contributor to episodes of NO_2. Such episodic conditions can occur during stable atmospheric conditions where wind speeds may be very low ($<1 ms^{-1}$). Under such conditions of restricted ventilation pollutant concentrations can exceed standards especially when traffic volumes are also high. Within the UK inversion conditions tend to occur during autumn and winter seasons. Figure 8 illustrates a comparison of NO_2 episodic levels at several London sites. As the figure clearly shows that during the autumn episode levels reached 250ppb well above the hourly air quality standard of 150ppb.

2. Main objectives

Work is underway to identifty the main meteorological parameters that affect the behaviour of major air pollutant types (gaseous and particulate matter). Modelling has been conducted on street and urban scale using PEARL, GAMMA and CALINE 4 models to highlight areas where improvements are needed in relation to meteorological inputs to operational models. In addition work has started to compare various atmospheric stability schemes and their influence on the uncertainty of operational models. Key objectives of the research work are:

1. Analysis of air pollutant data for episodic low wind speed conditions.
2. Identification of areas of improvement regarding use of meteorological data in air pollution models.

3. Comparison of various atmospheric stability schemes for use in urban air pollution models.

3. Available meteorological and concentration data

Considerable data is available for performing the research work indicated above. Synoptic data is available from BADC (British Atmospheric Data Centre). Local meteorological data is also available at several sites within Hertfordshire and in London. With regard to pollutant concentrations hourly concentrations from a range of pollutants and urban sites is available from the National Air Quality Information Archive for UK. This data can be accessed from http://www.aeat.co.uk/netcen/airqual/.

In addition, a major monitoring urban background stations is being commissioned at the University. Measurements at the Station will include:

- Meteorological parameters (such as wind speed, direction, standard deviations.)
- Hourly concentrations of CO, NOx and O_3
- Hourly mass concentrations for PM10
- Gravimetric concentrations of mass for PM10, 2.5, 1 and TSP
- Concentration of volatile organic compounds measured with passive and active methods

4. Available models

Operational models have been developed at the University to assess air pollution on local, urban and regional scales. In addition, other models including NWP codes are being employed within the UK to study the dispersion and forecasting of the weather and urban air quality. These include:

Meteorological Models

- Meteorological pre-processor to calculate atmospheric stability from base meteorological data. The pre-processor will calculate hourly dispersion parameters from nine different stability schemes ranging from the simple Pasquill-Gifford to the more complex approaches relying on boundary layer parameters (developed at ASRG).
- Models for characterising boundary layer parameters such as heat flux have been developed at the UK Meteorological Office.

Dispersion Models

- PEARL model (Luhana and Sokhi 1998) which is used for urban background calculations for CO and NOx. The model uses a multi-box approach and incorporated a meteorological module enabling stability to be estimated from boundary layer parameters. The model will calculate hourly, monthly and annual concentrations. A PM10 version is now being produced.
- GAMMA is a Gaussian grid model that will calculate hourly concentrations of CO and NOx with a PM10 version also underway. It requires input data from the meteorological pre-processor to determine the atmospheric stability. Unlike the ISC model GAMMA allows the calculation of concentrations within a particular grid.

- Other models such as CALINE 4, Aeolius and ADMS-Urban are also available within the UK (Benson 1984, Carruthers et al 1999, Manning et al 2000 and Sokhi et al 1998).

Forecasting Models

- The Unified Model is the name given to the suite of atmospheric and oceanic numerical modelling software developed and used at the UK Met Office. The formulation of the model supports global and regional domains and is applicable to a wide range of temporal and spatial scales that allow it to be used for both numerical weather prediction and climate modelling as well as a variety of related research activities (http://www.met-office.gov.uk/sec5/NWP/NWP_sys.html).
- Boxurb is a forecasting model employed by the UK Meteorological Office (Middleton 1998).

Emission Model

- Emissions model developed at ASRG is used to calculate composite emission factors for CO and NOx. These are then converted to total emissions using traffic flow data.

5. Related national and international projects

ASRG Projects: Project Manager: Dr Ranjeet S Sokhi unless otherwise indicated

1. Development of an operational urban air pollution model for short term and long term calculations – funded by the Thailand Government 1997-2001.
2. Application of a GIS urban and regional air pollution model for use for industrial site selection – funded by the Thailand Government 1998-2001
3. Two projects on measurement and modelling of VOCs in urban areas – funded by EPSRC/BRE and INERIS (France) – 1997-2002
4. Source apportionment of atmospheric fine particles – funded by the British Council, in collaboration with the Hungarian Meteorological Service (Dr Laszlo Bozo) – 1999-2002.
5. EUROTRAC-2, SATURN, "Studying Atmospheric Pollution in Urban Areas - Contributions to modelling and measurements", 1998-2002. National funding. http://aix.meng.auth.gr/lhtee/saturn.htm
6. Remote measurement of vehicle emissions (REVEAL) – EU FPV project 2000-2003, Coordinated by SIRA, UK.

6. Funding situation

The COST715 research activities will be funded from national sources. Part of the scheduled work, however, overlaps with some of the above mentioned projects.

7. Expected benefits and policy relevance

The present COST Action is expected to assist in evaluating practical matters related to episodes, for instance, in estimating exceedances of guidelines and limit values and analysing the influence of various measures in order to control episodes. This project will also contribute to the development and validation of the dispersion models and the meteorological pre-processor. We also expect to exchange information, in particular concerning air quality forecasting methods. A key benefit will be the research collaboration that will result from this initiative.

8. Conclusions

A major area of interest is the improvement of current UAQ models for use in diagnostic and prognostic modes. This crucially depends on how the models treat the boundary layer and hence the stability of the urban atmosphere. This is particularly important when understanding the behaviour of pollution during low wind speed and stable conditions. The effect of such conditions in relation to meeting air quality standards in different regions of Europe needs investigating. Cooperation within the COST715 framework will be essential to this process. In particular joint work on modelling of episodes is being planned with the Finish Meteorological Institute (FMI). Within the UK collaboration between ASRG and other research organisations and networks such as the Meteorological Office and APRIL will be exploited to to address these problems. Results of such collaboration will be presented at international conferences such as the Third International Conference on Urban Air Quality to be held at Loutraki, Greece, March 2001.

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Air Pollution Research in London
http://www.huxley.ic.ac.uk/research/AIRPOLL/APRIL/

UK Meteorological Office
http://www.meto.gov.uk/

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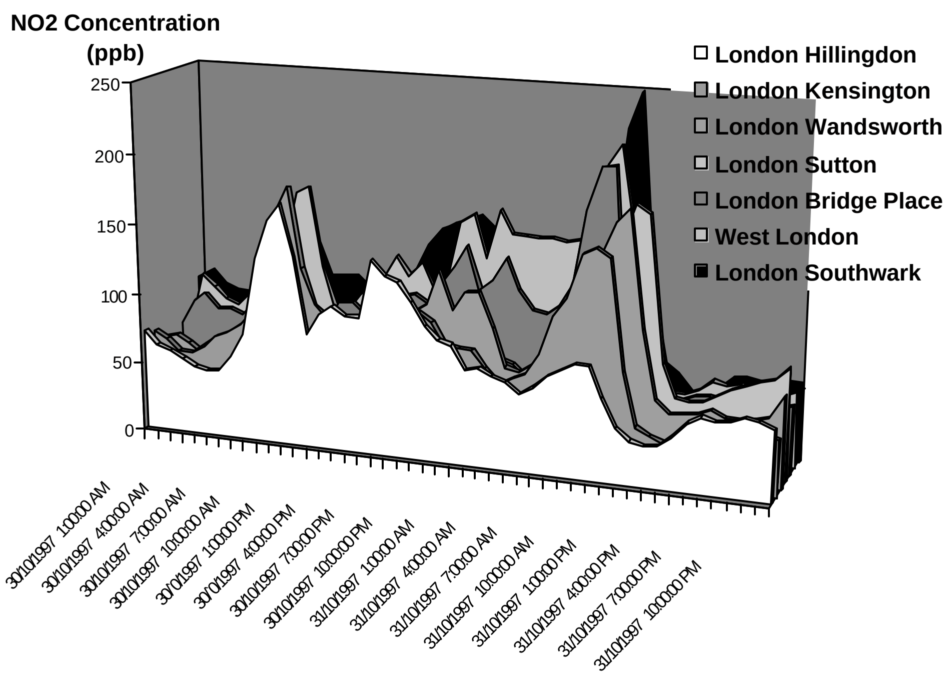

Figure 8. NO_2 episodes at various sites in London.

Status Report of Macau

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1. Introduction

Urban air quality at Macau in 1999 was moderately polluted especially in terms of suspended particulate matter, which is mainly conveyed from adjacent regions. In the northern part of the city, atmosphere is heavily polluted with particulate matter (as measurements of TSP and PM10 show), due to intense vehicular traffic and unfavourable atmospheric mixing conditions. The concentrations of ozone (O3) and carbon monoxide (CO) are also on an elevated level at locations with high traffic densities. In general, air quality is worse in winter (from October to March) than in summer (from April to September).

2. Main objectives

An air quality project has been initiated, which includes the following phases:

1. The first phase of the project, which lasts for four years, addresses the meteorological factors that characterize pollutant transport and dispersion in different temporal scales.
2. The second phase consists of the implementation of Macau air quality monitoring program, with the installation of network stations at locations in the most polluted urban environments.
3. An observational program is then established for studying the thermal and dynamic structure of the lower troposphere at Macau, by utilising acoustic sounding and direct measurements of air temperature and winds in the lower troposphere.
4. By using the automatic air quality monitoring network, an Air Quality Index (AQI) is computed in the Macau area.
5. Computational methods are developed for forecasting air quality, in particular by applying the numerical weather prediction model MM5 (add reference here if possible). Neural network and statistical air quality forecasting methods will also be developed.

3. Available meteorological and concentration data

The meteorological data is obtained from the synoptic surface and upper air information, and Macau local automatic surface meteorological telemetry network, which consists of ten stations measuring at one minute temporal resolution in real-time. The hourly data is recorded in an Oracle database.

The daily concentrations from an semi-automatic network are also available for the users. All the above-mentioned data is saved in the Oracle database.

4. Available models

For regional-scale studies, the Japan Meteorological Agency Regional Spectrum Model will be utilized; however, this model is still under development. For forecasting air quality, the numerical weather prediction model MM5 will be used. Gaussian dispersion model ISCST and neural network and statistical models will also be utilized in the future.

An Air Quality Index will be computed each day, and distributed widely to the public.

5. Related national and international projects

- “An automatic system for forecasting the air quality index for urban area in Macau”, 2000-2001. Project manager: Hongkong University of Science and Technology and Meteorological and Geophysical Bureau.
- “Environmental Impact Study of the Macau Power Plant”, 1999-2002. Funding: Macau Power Company. Project manager: Macau Electricity Company.

6. Funding situation

Apart from the contributions of the government funds, no other external funds are presently needed for the SMG operational development and research activities, relating to air pollution meteorology.

7. Expected benefits and policy relevance

The most important advantages are to obtain a better understanding on air quality problems in Macau, as well as the relationship between meteorology and pollutant concentrations in the Macau urban environment. The local government can utilize the know-how in planning new air pollution abatement policies. In this COST project, we can achieve a better exchange of experience and information with the EU countries.

8. Conclusions

This research could cause a substantial change of the government policies towards solving environmental issues, particularly those related to air quality.

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