7.18 A NEW GENERATION OF MODELLING NEEDS FOR ENVIRONMENT AND HEALTH IMPACT

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INTRODUCTION

With environmental policies, the coupling of anthropogenic emissions with cost effectiveness has been attempted for years. The aim was to identify and then introduce the most environmentally friendly and best economical scenarios in order to achieve compliance with health standards for the coming decades. Despite the history of attempts and the significant reduction in emissions, pure reductions or even deterioration were observed for air-quality concentrations as is shown for NO_2 and O_3 respectively at Figure 1 and Figure 2 below.

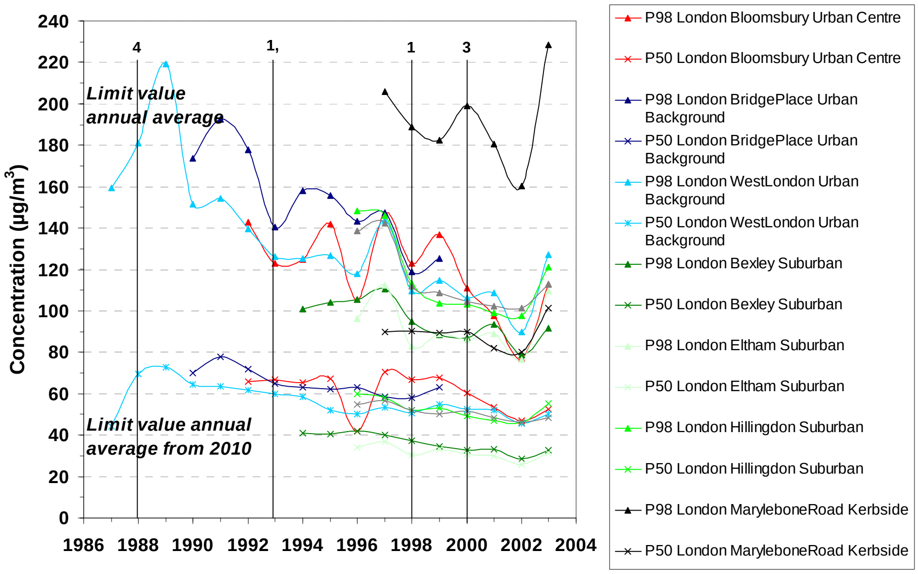

Figure 1. The 50%tile and 98%tile concentrations for NO_2 at the various urban centre, urban background, suburban and roadside locations in London.

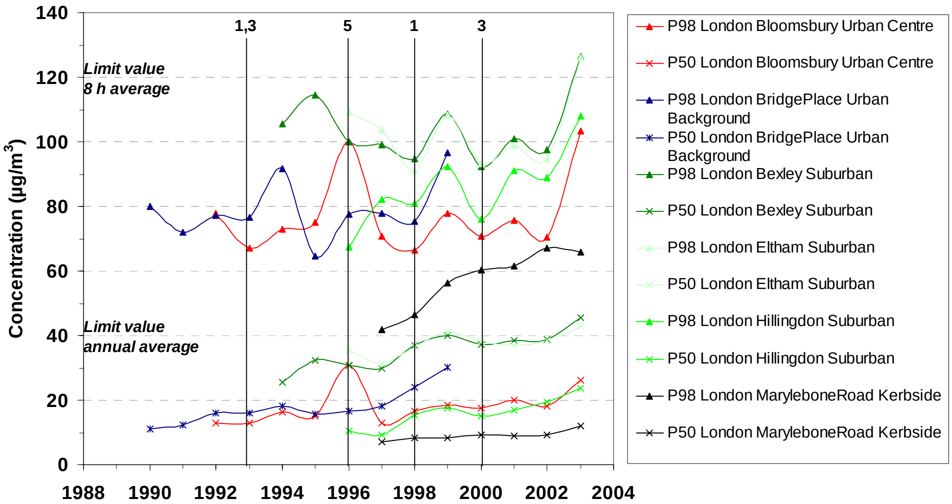

Figure 2. The 50%tile and 98%tile concentrations for O_3 at the various urban centre, urban background, suburban and roadside locations in London.

Although this was already foreseen by the two AutoOil programmes (DG-ENV, 1996 and 2001) few modelling innovations were possible in the past decade which improved the understanding of interrelations between legislation on emissions and air-quality and identify new effective policy responses based on innovative approaches. This means that in western world there are not any scenarios which will achieve more net emission reductions while being at the same time, financial feasible and cost effective.

For these reasons and in order to focus on the consequences of atmospheric pollution, a new environment and health policy will be introduced for addressing problems which were linked until now only indirectly. This new Community Action Programme on environment and public health is proposed at the European Commission for 2004-2008 which takes into account the environment as a major health determinant. This action plan will be approved in June 2004 (DG-ENV 2004) and introduce new challenges for integration between atmospheric modelling and human health. New developments in modelling are needed for providing a fresh insight in environment and health issues. This work highlights new directions and describes a new generation of modelling needs for the deployment and assessment of such policies. The remaining of this abstract focuses on the aspects related with air pollution although the issues discussed are valid for many other aspects of environmental protection. In particular this work describes the enhancement of Air-Quality Modelling Systems, the coupling of different nature of modelling tools characterising the conditions of human health and the utilisation of new "state of art" technology.

ENHANCING AIR-QUALITY SYSTEMS

Current systems made through monitoring, analysis, research, and development. Monitoring provides the data necessary to determine trends in emissions, air quality, and various health and ecosystem outcomes. Research and development furnish advances in the fundamental understanding of the science and impacts of air pollution, the instruments needed for monitoring, and the technology available for controlling emissions. Thus, science and technology provides a fundamental basis for sound decisions; at the same time furnish tools to continually improve air quality and the understanding of its interactions with human activities.

Although the input from science and technology is important, this is not the sole determinant of success for air-quality management. From past monitoring shown above, it is evident that there is a need alternative plans which should be implemented by competent authorities in the context of diverse social, economic, and political considerations. Successful air-quality management requires addressing the multi-country and cross-boarder transport of pollution, adaptation of pollution management systems to climate change and approach the assessment and control of pollutants as "one atmosphere" from many emission sources.

Across-Border Transport of Pollution

During the late 1980s and 1990s, it was realized that controlling local emissions alone was insufficient to meet the standards of atmospheric pollution for some pollutants in some areas. It became apparent that air quality even in small urban areas can be influenced by even longer range pollutant transport; namely, transport across national boundaries and even between continents. Analyses of data sets gathered from space-based and airborne stations in combination with computer models indicate that air pollutants from Asia, Africa, and Europe reach America, and, in turn, pollutants from North America reach Europe. The implications for Europe are 2-fold:

- Pollutant emissions from other continents are probably causing an increase in background concentrations of pollutants in the northern hemisphere. For example, ozone has increased by factor greater than 3 in the past 100 years due to emissions from throughout the hemisphere (Staehelin et al. 1994, Scheel et al. 1997).
- It is essential to know the potential of each member state to influence other countries for a specific type of pollutants (something which was until now wrongly assessed by coarse grid type of models used for acidification studies in the past).

For this purpose we should develop, implement, and utilize sophisticated remote-sensing tools to document and track the phenomena. It might be necessary, to abandon initiatives with limited generalisation and pursue collaborative projects which assess the geographical impact of pollutant emissions and can identify hot spots with greater spatial and temporal resolution

Adaptation of Air Pollution Management Systems to Climate Change

There appears to emerge a consensus within the scientific community that there is a warming trend which will continue or even accelerate in the coming decades. Precursor emissions and photochemical reactions that result in the production of secondary pollution tend to increase with warmer temperatures. Hence, increase the frequency, the severity and persistence of episodes. The modelling system for pollution management must be flexible and vigilant in the coming decades to ensure that pollution mitigation strategies remain effective and sufficient as our climate changes. At the same time, air pollution and human-induced climate changes have one important common need: they both need assessment of apportionment of emission sources in order to be able to effectively abate their contribution in the future Multi-pollutant approaches that include mitigation of climate warming as well as air pollution may be desirable, so member states and international organisations need to considered implementing such programs soon.

"One Atmosphere" Approach for Assessing and Controlling Air Pollutants

Unfortunately air pollutants do not have political and statutory boundaries and they do not co-exist in the atmosphere without chemical interactions. Hence, when humans and ecosystems are exposed to air pollution they are simultaneously exposed to a complex array of contaminants which are not necessarily inert. Moreover, pollutants that affect humans can affect ecosystems, and, perhaps more important, these pollutants apart from the ecosystem, can also directly or indirectly affect human health and activities, because society depends on ecosystems for essential environmental services. Such interactions require understanding the dispersion and interaction of multiple pollutants, develop strategies that span multi-country air sheds, and understand the impacts on human health and ecosystem from simultaneous multi-pollutant exposure. It will also require better understanding of the range of important emissions and will need to develop innovative multi-pollutant control technologies and pollution prevention practices. Such type of models and emission data are not currently available and will require a significant effort before these will verified and tested against the annual logistics from all member states in Europe.

COUPLING OF DIFFERENT NATURE OF MODELS

The management of atmospheric is a major and complex undertaking. However the initiatives on Environment and Health need to go several steps further. They need to implement modules which account for pollution across different media, need to tightly couple air quality and socio-economic models and incorporate tools for assessing the risk by actual exposure.

Accounting for Pollution at Different Media

Pollutants are also transported between the atmosphere and other media such as water and soil. The multimedia effects of air pollutants greatly increase the complexity of abatement strategies. However for assessing the impact on human health, contamination of water supplies and food should be taken into account. A prime example of such phenomena is found in an examination of the reactive nitrogen cycle, where nitrogen compounds generated from food and energy production are having profound effects on air and water quality and on ecosystem function and climate. Persistent organic pollutants tend to stay in the environment and can accumulate in human tissue. They can appear as air pollutants, but they can also contaminate water, soils, and the food chain. Recognition of multimedia effects requires a new rethinking of the currently available approaches for setting air pollution standards and for linking air quality policy with other environmental policies.

Estimating Costs and Benefits

Over the past 30 years, the EU15 gross domestic product and total vehicle-km travelled increased by more than 2-fold, and its energy consumption increased by a factor of about 1.5. However, over the same period, EUROSTAT reported that the total aggregate of emissions that directly affect six criteria pollutants has decreased by 25%. This trend suggests that member states have been able to decouple, to some extent, pollutant emission rates from economic activity. However, this decoupling does not necessarily mean equivalent benefits in pollutant concentrations. Legislative actions and Clean Air initiatives might play a role in reducing emission, however there also other elements (like for example increased income, pure technological advances or taxation) which are the main causes of the decrease in pollutant concentration. For this reason, classical approaches with off-line calculations like on acidification and Emission Ceilings are certainly not sufficient to pick up trends, especially if the fiscal data (linked to emissions) are decoupled from air-quality modelling.

Even more uncertainty is added when the benefits are compared with health effects, which requires a monetization of the benefits-a typically controversial and difficult process. Despite such difficulties, cost-benefit analysis is often used to evaluate the merit of certain regulations. For US, EPA (1997) estimated that the benefits that have accrued in human health and welfare as a result of achieved decreases in pollutant emissions have been substantial. The estimated benefits include about 100,000 to 300,000 fewer premature deaths per year and 30,000 to 60,000 fewer children each year with intelligence quotients below 70. However, these estimates are highly uncertain. They require direct quantification of the human health and welfare responses to air quality changes. Because it is difficult to isolate the effects of air pollution exposures from those of other risk factors as a result, assessments of the benefits of pollution control often rely on complex models instead of direct evidence and hence are subject to possible modelling uncertainties.

Access Risk Determined by Actual Exposure

The adverse effects on humans and ecosystems are ultimately determined by the actual exposures and sensitivity of humans and ecosystems to a complex selection of air pollutants found in the atmosphere. However, there is a significant need for tools which account for actual risks borne by people and ecosystems in addition to air-quality modelling. Such tools that target explicitly the risks would be a challenging task. Pollutant concentrations can vary considerably in time and space, and pollution sources that contribute to exposure may do so to different extents during the various peak episodes.

An additional complication arises when some individuals or groups, certain ecosystems, habitats, or species are more susceptible to those peaks rather than the average conditions.

Such uncertainties have been considered inadequately in the development of regulatory strategies. Even more some populations are subject to extra-ordinary exposure to pollutants from industrial facilities, transportation or even to simply high exposures that are generated indoors through many sources, including the use and off-gassing of consumer products. For such complex exposures, the existing modelling tools need to be modified substantially. More comprehensive multi-pollutant monitoring systems would be required for those pollutants posing the most significant risk, and enhanced efforts will be required to couple such processes in tools that have been proven adequate in air-quality characterisations.

USE “STATE OF ART” TECHNOLOGY

The member states of the European Union are already a technological society with complex characteristics which are continuously changing. The future years will be determined by complex interaction of social, economic, political, and technological forces as well as natural phenomena that might occur independently. In order to implement the actions described in the previous sections technological advancements will be required. Such advancements are:

- Implementation of new tools for more representative assessment of air-quality on real time, a challenging wireless network for data collection, the handling of massive data and the utilisation of innovative satellite techniques.
- Enhanced tools for modelling health and exposure assessment will require Grids computing and Grid enabling computational services of the type described by Mineter et al, 2004.
- It will also require technological changes in diagnostic tools at various anthropogenic activities (e.g. on-board diagnostics at automobiles, advanced exposure instruments, new navigation instrumentation) and indirect measures such as taxation which introduce society changes different to what we have been accounted until now.

All these can be based on existing innovations on research and monitoring programs that can quantitatively document the links between air pollution, health and the function of ecosystems. Such a programme will also need to emphasise the performance rather than the process and use standards and goals for the protection of ecosystems.

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