Traveling Toxins

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The majority of atmospheric pollution moves over great distances, crossing national borders. The deposition of harmful compounds may even be global

The first signals evidencing the trans-border flow of air pollution in Europe was the rapidly proceeding process of acidification and eutrophication discovered in the Scandinavian lakes in the 1960s, which could not be explained by emissions from the given country. The cause, as it soon turned out, was an inflow of acidic pollution (chiefly sulfur and nitrogen oxides) coming from other European countries, including a significant contribution from Poland. Similar processes were found to be causing the degradation of the Sudeten forests: pollution coming from the brown coal power stations sited on the joint borders between Poland, Czechoslovakia, and Germany, an area known as the "black triangle." It became obvious that these phenomena could be comprehensively monitored and limited only through coordinated international cooperation. The first serious initiative in this direction was the signing of the Long-Range Transboundary Air Pollution Convention (LRTAP) in Geneva in 1979.

It is impossible to gain any reasonable grasp of an issue so complicated without using computer models. The longest-running operational tool for measuring the state of air pollution on the Europe-wide scale is the EMEP model set up as part of the LRTAP. Its


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Power generation and industry are among the main sources of atmospheric pollution task is to monitor the implementation of the decisions of the Geneva Convention. The model works in the Meteorological Synthesizing Center - West at the Norwegian Meteorological Institute (Oslo).

In Poland, work on models of air pollution transfer began as far back as the 1960s. Commissioned by the Ministry of Administration, Land Development and Environmental Protection, single models of the pollution transport in the air were developed. Since then, Poland has created or adapted dozens of programs at various levels of advancement; however, the vast majority of them were experimental or were only used for individual episodes.

Pollution transmission

Pollution enters the atmosphere both from natural sources (for example volcanic eruptions, oceanic emissions, organic pollution) and as a consequence of human activity. It can appear in various forms, such as gas (SO_2, CO_2, NO_x, NH_4, O_3), three-phase (aerosols) or two-phase (dust pollution or micro-organisms). Primary pollutants - those which are emitted directly from the source - undergo chemical reactions in the atmosphere which give rise to secondary pollutants, often even more dangerous to the environment. The main gaseous secondary pollutants are nitrogen compounds - nitrogen dioxide (NO_2) deriving from the primary pollutant NO - and ozone (O_3) arising as a result of photochemical reactions. Although a high concentration of ozone is very desirable in the stratosphere, where it forms a filter against harmful ultraviolet radiation reaching Earth, in the troposphere it has a harmful effect on both human health and vegetation, and is also then a greenhouse gas. Decreasing the concentration of tropospheric ozone has no effect on the level of stratospheric ozone because they do not mix. Because it binds easily with NO, the lifetime of ozone in the lower atmosphere is relatively short. In the higher layers of the troposphere, however, it may last from a few days up to as much as two weeks. In this time it can cover considerable distances, and when it drops lower it can strongly influence the concentrations in its new location.

A growing number of epidemiological studies in this area indicate the important influence of small PM10 particles, and in particular PM2.5, on increased incidence of respiratory and circulatory diseases and higher mortality connected with them. Particles may be primary or secondary, of anthropogenic or biogenic origin, and organic or inorganic. Anthropogenic particles are emitted by fuel burning processes, industrial processes, by transport, and also by agriculture. Small particles, like gases, can travel large distances. In addition to this, some gaseous compounds form aerosols containing particles of very small diameter. Technologies which limit gas emissions also affect the emission of particles. This is why a reduction strategy for small particles can only be developed in combination with strategies for gases.

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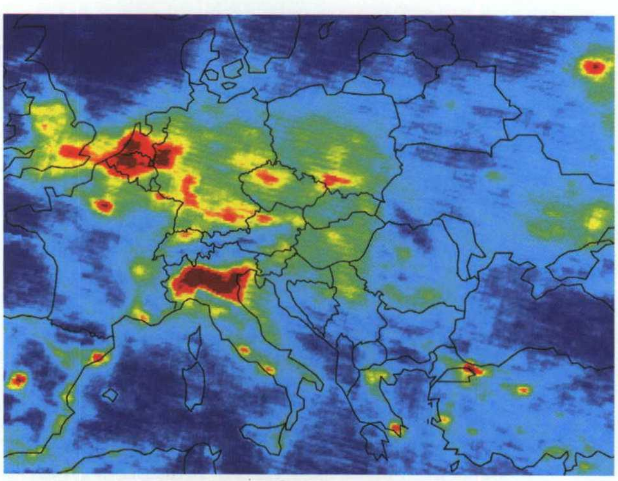

Distribution of the annual average NO_2 concentration across Europe in 2004 (measured using the Vertical Column Density method)

Models and their applications

However, environmental quality planning efforts are not limited to monitoring and reacting to infringements of required standards - more pro-active emission-reduction strategies are now increasingly being developed. Under the auspices of the European Union, research is being done on defining and implementing a pollutant emission reduction strategy which will enable us to diminish the existing threats to ecosystems and human health to the greatest degree. Integrated Assessment Models (IAMs) are being created, which contain models of pollutant emission, its spread in the atmosphere (including the mutual interactions between particular compounds, chemical changes, alterations in concentration levels, and so on), the sensitivity of particular environmental elements and human health to particular pollutants, protective measures, and the costs of emission reduction. Solutions like these enable us to evaluate the economic effectiveness of specific environmental protection solutions in a quantitative way, and compare a variety of scenarios from the perspective of alternative power generation technologies, the use of alternative sources, available methods of limiting emissions, and their costs.

For research at the level of a country or its regions, it is absolutely essential to have a more precise inventory of the sources of emissions, and also more precise modeling of pollutant dispersal, especially from Large Combustion Plant (LCP) sources, and the use of higher resolution for dispersed emission sources. Larger countries should also ensure that the national level model are linked to the models for specific provinces (e.g. Poland's voivodships), working at a suitably smaller spatial scale. It is only these models which will serve as the basis for

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An image of the ESA's Evsat satellite observing the Earth's atmosphere

planning repair programs, because they will have to be implemented in a specific area. Via the mediation of the national model it is possible to coordinate the pollution flow processes between provinces.

Having considered the virtues of this system, some countries have begun to construct national IAM computer systems. The importance of the issue is signaled by the interest in the European Network for Integrated Assessment Modelling (NIAM - www.niam.scarp.se), whose goal is to offer a forum for the exchange of experiences and set standards for such systems. The network includes teams from Austria, Belgium, Canada, Germany, Ireland, Italy, the Netherlands, Spain, Sweden, the UK, and also Poland: from the AGH University of Science and Technology, the Systems Research Institute of the Polish Academy of Sciences, the Institute for the Ecology of Industrial Areas, the Department of Environmental Protection and Education, the Warsaw University of Technology, the Gdańsk University of Technology and the University of Wrocław.

Investment in environmental protection can be very expensive, but a failure to invest may cause severe long-term effects. Because the funds available are usually limited, they need to be used in a rational way, i.e. providing the maximum protective effect for the minimum necessary investment, and it is precisely this that the use of integrated modeling can help achieve. In spite of much fragmentary work being carried out in the field of air pollution modeling, Poland still lacks simulation tools with the right parameters (discretization of areas, inventorization of emissions from particular sources) for integrated air quality management.

The activities being carried out in Poland on limiting the emission of medium-scale pollutants (such as sulfur dioxide, nitrogen oxides, and particulate matters), and specifically in relation to particulate matter concentrations, do not enable us to meet the required standards, and so it may become necessary to begin costly repair programs. In order for it to be possible to make a realistic evaluation of the influence of particular pollutant sources and to choose optimal emission reduction strategies, Poland should have a national IAM matched to the spatial scale of the country and containing all the essential parameters for that scale. Unfortunately, the creation of such a system - including of models comprehensively covering the emission of pollutants, their spread in the atmosphere, the effects on human health and nature, and finally computer-assisted decision-making in fighting atmospheric pollution - will require significant funding. So far Poland has competent teams and a general desire to cooperate on creating such a system, but lacks donors ready to fund the right project. ■

Further reading:

Holnicki P. (2006). *Modelowanie propagacji zanieczyszczeń atmosferycznych w zastosowaniu do kontroli i sterowania jakością środowiska [Modeling the Propagation of Atmospheric Pollution for Application in Environmental Quality Monitoring and Control]*. Warsaw: Akademicka Oficyna Wydawnicza EXIT.

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Markiewicz M.T. (2004). *Podstawy modelowania rozprzestrzeniania się zanieczyszczeń w powietrzu atmosferycznym [Fundamentals of Modeling the Spread of Pollution in Atmospheric Air]*. Warsaw: Oficyna Wydawnicza Politechniki Warszawskiej.