

INTERNATIONAL ACTIVITIES*

THE INTERNATIONAL INSTITUTE FOR APPLIED SYSTEMS ANALYSIS (IIASA)

Laxenburg/Austria

Growing interest in international cooperation directed to environmental and related issues has suggested that from time to time, *JES* offer its readers material describing the work of some of the important world research organizations.

The following description of the International Institute for Applied Systems Analysis (IIASA) and the information concerning its current program in environmental research and a specific project in connection with acid depositions is the first of a series of such presentations.

IIASA IN BRIEF

IIASA, the International Institute for Applied Systems Analysis, is a nongovernmental, interdisciplinary research institute founded in October 1972 on the initiative of the academies of sciences or equivalent institutions in twelve countries. The Institute's member organizations now comprise scientific and professional bodies in sixteen countries.

The governing body is the IIASA Council, which is composed of one representative from each of the National Member Organizations (NMOs). The Chairman of the Council and of its Executive Committee is *Academician Jermen M. Gvishiani*, Deputy Chairman of the USSR State Planning Committee (GOSPLAN), and one of the founding fathers of IIASA. Vice Chairmen are *Professor Ognyan Panov* of the Bulgarian State Committee for Research and Technology and *Professor Wouter Tims* of the Center for World Food Studies, Free University of Amsterdam, Netherlands. Heading the Finance Committee

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is *Senator Michael J. L. Kirby* of Canada. Chairman of the Research Committee is *Professor Dr. Gerhart Bruckmann* of the University of Vienna, Austria.

IIASA's Director is *Professor Thomas H. Lee* (USA), from the Massachusetts Institute of Technology and formerly with the General Electric Company. Deputy Directors are *Professor Vitali Kaftanov* from the USSR Institute of Theoretical and Experimental Physics, and *Professor Boris Segerstahl* from the Research Institute of Northern Finland. The former Directors of IIASA are *Professor C. S. Holling* (Canada) of the University of British Columbia (1981-1984), *Dr. Roger Levien* (USA) of the Xerox Corporation (1975-1981), and *Professor Howard Raiffa* (USA) of Harvard University (1973-1975).

IIASA's objectives are to initiate and support individual and collaborative research on problems associated with social, economic, technological and environmental change, and thereby to assist scientific, industrial and policy communities throughout the world in tackling such problems.

RESEARCH IN FOCUS

Research is currently underway in four major areas.

Environment

The Program is investigating the interaction of human development activities and the environment. The objective is to provide useful information on how to manage those interactions that could comprise the sustainable development of the biosphere. Among the issues being addressed are acid deposition, climate impacts on agriculture, management of large international rivers, and shortcomings of existing environmental monitoring systems. Program Leader is *Professor Robert E. Munn* of Canada.

Population

Demographic research is seeking a better understanding of the causes, dynamics, and socioeconomic and health-related implications of the growing number and proportion of older people in industrial societies. *Professor Nathan Keyfitz* of the United States is leading this Program.

Technology-Economy-Society

This new Program focuses on the dynamics of technological development and associated management issues, such as appropriate strategies and institutional structures. The goal is to identify those economic and social conditions under which technologies can evolve and how such developments in turn affect economic and social structures. IIASA Director *Lee* is currently serving as Acting Leader.

System and Decision Sciences

New concepts, theories, and mathematical techniques are being explored to support analyses of the behavior of dynamic systems under conditions of uncertainty, of stochastic optimization problems with unknown or only partially known parameters, and interactive decision support systems. Program Leader is *Professor Alexander Kurzhanski* of the Soviet Union.

SCIENTIFIC RESOURCES AND SERVICES

Researchers

There are some seventy scientists from twenty countries currently working at IIASA. Normally scientists stay at the Institute for one or two years, with some remaining longer to provide the necessary continuity. The scientific staff represents multiple disciplines, including computer sciences, mathematics, economics, sociology, and ecology. The efforts of this research core are expanded through guest scholars supported by outside organizations, collaborative relations with institutions and individuals, and interaction with over one thousand IIASA alumni throughout the world.

Young Scientists' Summer Program (YSSP)

Each summer IIASA offers a three-month combined work and study program for young scientists, mainly from countries with member organizations. The program, launched experimentally in 1977, has grown to involve nearly sixty participants annually. Scholarships are awarded to outstanding participants; the Peccei Scholars (as they are called in recognition of the late *Dr. Aurelio Peccei's* contributions to the ideals of IIASA) receive financial assistance for a further study period at the Institute. A newsletter is issued periodically to meet the information needs of around two hundred and fifty members of the YSSP Alumni Association.

Finances

The Institute's budget for 1986 amounts to about 140 million Austrian schillings (equivalent to approximately 8 million U.S. dollars). These are derived mainly from contributions of member organizations, and are augmented by external grants from government agencies, international organizations, private foundations, and industry.

Computer Services

Scientific computing is performed at IIASA on VAX 11/750 and VAX 11/780 systems, and on microcomputers. Text processing, teleconferencing, financial accounting and similar activities are handled on a PDP 11/70. Both computers run under the UNIX operating system.

Dissemination

Dissemination activities are an integral part of the research strategy. The Institute conveys the results of its research through various mechanisms including research reports, executive summaries, conference proceedings, the *Annual Report*, the quarterly journal *OPTIONS*, and the newsletter *IIASA This Month*. The IIASA Editorial Board reviews manuscripts for Institute publication. The major share of the Institute's research is documented in scholarly journals and commercially published books. Distinguished statesmen and scholars are regularly invited to deliver lectures at the Institute. These include the *Dr. Bruno Kreisky Lecture Series*, which began in 1984 with a lecture by *Dr. Kreisky* entitled *Is There a Chance for a New and Global Détente?*

In addition, presentations to selected audiences and similar events serve to highlight the Institute's work. These efforts are particularly important during the final stages of research. For example, the study of the world food and agriculture system is nearing completion, so that the emphasis is now on broad dissemination of the methodological and analytic results.

PROMOTING INTERNATIONAL COOPERATION

The Institute's nongovernmental and interdisciplinary nature has given it a unique ability to bridge gaps of understanding between scientific disciplines, between nations, and between the scientific, industrial and policy communities.

Collaborating Networks

Currently IIASA is collaborating with institutions and individuals in over forty countries, as well as with members of the United Nations family and other international and regional organizations. Collaboration takes various forms, including case studies, comparative analyses, data exchanges, methodological development and applications, joint authorship of publications, and cosponsorship of meetings and other activities. These networking relationships extend individual efforts substantially; equally importantly, they promote more realistic and international thinking about problems and solution approaches.

Scientific Meetings

IIASA-sponsored or cosponsored meetings provide a timely platform for discussions of topics that are being addressed in research at IIASA and collaborating institutions. In 1985 forty-five meetings were held at Laxenburg or in countries with National Member Organizations.

IIASA Advisory Board

The Board, established in 1985, serves as a vital link with potential users of IIASA research results. It represents a new forum for an expanded East-West

dialogue among scientists, industrialists and members of the policy community. The Board is currently composed of sixty-one leaders from twenty countries. The Chairman is *Mr. Donald Kendall*, Chairman and Chief Executive Officer of Pepsico, USA. Vice Chairmen are *Professor Umberto Colombo*, President of the Italian National Committee for Research on Nuclear and Alternative Energy (ENEA); *Dr. Karlheinz Kaske*, President and Chief Executive Officer of Siemens AG, Federal Republic of Germany; *Dr. Valeri A. Pekshev*, Deputy Chairman of the State Bank of the USSR; and *Mr. George Pirinski*, Deputy Minister for Foreign Trade, Bulgaria.

For more information on IIASA contact Jean-Pierre Ayrault, Secretary to IIASA.

NATIONAL MEMBER ORGANIZATIONS AND COUNCIL MEMBERS

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ENVIRONMENTAL RESEARCH PROGRAM

The substantive research projects to be carried out within the framework of the Environmental Program in 1986 are as follows.

Ecologically Sustainable Development of the Biosphere

The Biosphere Project has become the central theme within the Environment Program, and the main focus will be on it through the three-year period 1986-1988. It aims to study the long-term interactions between human activities and the environment. It seeks to identify the processes that are most likely to compromise the long-term sustainability of development of the biosphere, and to devise appropriate technological strategies and institutional structures to deal with these threats.

Acid Rain

The already established IIASA Acid Rain Project (see *OPTIONS* 1984/1), for the investigation of the origins, atmospheric transportation and effects of the chemical substances involved, is being expanded and refined to increase its usefulness still further.

Climate Impacts

An established project supported by the United Nations Environment Program, the IIASA Climate Impacts Project is approaching a successful conclusion of the present work program, which deals with the vulnerability of food production in climate-sensitive areas (see *OPTIONS* 1984/4).

Water Policy

Current IIASA research in the vitally important water resources field will terminate in early 1986 with the conclusion of the Regional Water Policies Project. This is to be followed by a study on "Decision Support Systems for Managing Large International Rivers."

Research being carried out under IIASA's Environment Program has three main cross-cutting themes:

1. *Environmental monitoring* – The optimization of environmental monitoring systems is a badly neglected field of study. Much of the information in data banks was collected for specific purposes, and is often used inappropriately to try to solve new problems. IIASA intends to try to correct this situation, at the same time meeting the needs of the various Projects in the Environment Program. Several topics have already been identified for study:

- Design of ecological monitoring systems.
- Optimization of monitoring systems (jointly with the System and Decision Sciences Program).

- Design of early warning systems.
- Improvement of the design of existing acidic deposition networks, including those for monitoring of effects.
- Design of monitoring systems for post-EIA (environmental impact assessment) evaluations.
- Selection and optimal use of ecological and environmental data banks.

The common goal here is to guide the development of existing and future systems, so that they are better able to meet specific user needs. The underlying principle is that monitoring should be undertaken within an integrated framework that takes into account both the environment and the biosphere. IIASA's efforts to design conceptual frameworks for monitoring systems are related to a number of international programs such as UNEP GRID and ICSU Global Change.

2. *Historical reconstruction* – The historical reconstruction of cases in which regional economic development has degraded/preserved/enhanced the environment and biosphere is of great interest. Following a workshop held in Bulgaria in October 1985, a funding proposal is being developed that will include the elaboration of several comparative case studies in different regions, e.g., the Lithuanian SSR in the USSR, the Seto Inland Sea and coastal areas in Japan, the Balkans, and an agricultural region of Central Poland. The final recommendations and decisions on the choice of development strategies could then be prepared by national teams in 1987. They might include:

- an analysis of environmental consequences of various alternatives in development of industrial, agricultural and other sectors of the economy in the case-study regions or countries,
- the final version of the system of models explicitly adapted for use in the case-study regions or countries,
- publications of methodological results.

A related topic to be undertaken is “Rationalization of Dendrochronological Sampling and Analysis Methodologies.” Special attention will be given to the use of tree-rings as an early indication of forest dieback. The work will be under the direction of Academician Leonardas Kairiukstis, Deputy Head of the Environment Program at IIASA.

3. *Uncertainty/environmental risk assessment* – A small scoping workshop on Environment Risk (including risk perception) was held at IIASA in November 1985, sponsored jointly by the Environment and Systems and Decision Sciences (SDS) Programs. Co-sponsors providing financial support included UNIDO, UNESCO/MAB, US EPA, Canadian FEARO, and Canada Health and Welfare.

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ACID RAIN: PROJECT SUMMARY

The Issue

Governments of North America and Europe are under increasing pressure to take remedial action against acidification of the environment. Also increasing is the amount and diversity of scientific and engineering research devoted to this subject. The link between political decisions and scientific evidence concerning acidification has not been very strong, although an increasing number of countries have started separate research programs on acidification. The most common policy discussed in Europe for controlling acidification impacts is a 30 percent reduction of sulfur emissions by 1993 relative to their 1980 level. Although this policy will be costly to virtually every European country, the actual benefits of this policy in protecting the natural environment are rarely investigated. This is understandable since acidification of Europe's environment involves a bewildering array of factors and interrelationships. But augmenting scientific information about the problem will not necessarily lead to identification of suitable policies for controlling acidification of the environment. This information must also be structured in a form *usable* to decision makers. The RAINS (Regional Acidification Information and Simulation) model attempts to do this. The purpose of the model is to provide a tool to assist decision makers in their evaluation of control strategies for acidification in Europe.

Research Strategy

This project is investigating the long-term effects of acid deposition in Europe. Its specific objective is the development of a policy-support system of models that could be used at international and national levels in the effort to develop concerted strategies for emission reduction.

IIASA's model of acid deposition is an interactive set of submodels with graphical output. The model has been developed in collaborating with the UN Economic Commission for Europe and in the context of the Geneva Convention on Long Range Transboundary Air Pollution. The overall framework of the RAINS model consists of three linked compartments: *Pollution Generation*, *Atmospheric Processes*, and *Environmental Impacts*. Each of these compartments can be filled by different substitutable models. The four submodels currently available are *Sulfur Emissions*, *EMEP Long Range Transport*, *Forest Soil Acidity and Lake Acidity*. Submodels for direct sulfur impact on forests and groundwater acidification are in an advanced stage of development. Submodels which deal with NO_x emissions and costs of controlling SO_2 emissions deposition will be added to the model.

Results to Date

The *Sulfur Emissions* submodel calculates sulfur emissions for each of twenty-seven European countries based on a user-selected *energy pathway* for each country. Presently five energy pathways are included in the RAINS data base, covering high and low future energy use. The sulfur producing fuels are broken down into brown-, hard-, and derived coal; light and heavy fuel oil and crude oil. For natural gas and fuel wood separate categories are available. The energy demand sectors include power plants, refineries, industry, transport, and domestic use. To reduce sulfur emissions, the user may specify any combination of four control alternatives: switch to low sulfur fuels, physical or chemical fuel cleaning, desulfurization units and combustion modifications.

The sulfur emissions computed for each country are then input to the *Sulfur Transport* submodel, which consists of a number of source-receptor matrices derived from the EMEP model (the Co-operative Programme for Monitoring and Evaluation of Long Range Transmission of Air Pollutants in Europe). This submodel computes sulfur deposition and concentration in Europe.

Next, the *Forest Soil Acidity* submodel calculates average pH levels in European forest soils. Three key concepts are used: acid stress, buffer capacity and buffer rate. The latter two parameters are available for eighty soil types. The *Lake Acidity* submodel computes lake acidity levels as a function of catchment characteristics and local acid deposition. Each watershed is divided into four spatial sectors: snowpack, upper and lower soil layers and lake volume. Different modules of this submodel compute the hydrology and flux of ions contributing to acidity and alkalinity of the lake water. The submodel has been

applied using data from Swedish and Finnish lakes. Implementation for Norway is underway.

The preliminaries of a *Direct Forest Impact* submodel were set up by specifying the approach, determining its data requirements, and finding collaborators in different countries. Development of the stand model has started and preliminary model simulations have been carried out. Collecting data for the data bases of environmental factors, forest resources, and stand growth parameters is continuing.

Groundwater Acidity has been one of the topics of the 1985 Young Scientists' Summer Program (YSSP). A first description of a modeling approach has been produced and will be extended during the 1986 YSSP.

In the first half of 1986 two additional submodels have been worked out. Preliminary results of a cost-of-control submodel are now available. Together with the optimization submodel, the cost submodel is currently used to formulate targetted reduction strategies, as alternatives to the flat rate policy.

Sensitivity and Uncertainty Analysis were among the major topics of the research in 1985. Results of this work include a thorough sensitivity analysis of the Forest Soil Acidity submodel and the development of a methodology for uncertainty analysis which has been applied to the Sulfur Transport submodel. Application of the methodology to the Sulfur Emissions submodel is currently carried out.

The time horizon of RAINS is 1960 to 2030. The time resolution of the model is one month to one year so that seasonal differences in, e.g., lake acidity may be simulated. The model covers all of Europe including the European part of the USSR. The special resolution is roughly 100 x 100 km.

To operate the model, a user must select an energy pathway, a pollution control strategy and (an) environmental impact indicator(s). In an interactive fashion a model user can quickly evaluate the consequences of many different policies using the model's output, which includes deposition and soil acidification maps for Europe, and maps of lake acidity for Finland and Sweden.

RESEARCH SCHEDULE AND EXPECTED RESULTS

In 1986 research efforts focus on:

1. improving existing data bases and submodels;
2. expanding the model to include costs analysis and additional submodels: NO_x emissions, NO_x transport and deposition, direct forest impacts of air pollutants and groundwater acidification;
3. model testing and uncertainty analysis;
4. development of other operational modes to RAINS, for example, implementing searching techniques and optimization algorithms;
5. applying the model to policy analysis; and
6. distributing RAINS to international and national institutions for their use in policy analysis.

Existing Submodels

In 1986 a complete revision of the *Pollution Generation* compartment has started. The number of energy pathways available to the user has been enlarged. Most recent information on emissions of SO₂ has been incorporated into the model. Comparison with SO₂ inventories from agencies like OECD will start in the fall.

The work on the *Sulfur Transport* submodel includes investigations about the effect of climate change on the source-receptor relationships. Furthermore, this submodel will continue to be the focal point of the uncertainty analysis (see below).

The *Lake Acidity* submodel will be extended to include Norway. Data collection and discussions about including other countries will continue. Uncertainty analysis is being carried out.

Additional Submodels

The *Pollution Generation* compartment will be enlarged with a model for estimating the emissions of NO_x and hydrocarbons. In collaboration with OECD a first estimate of NO_x emission for all European countries will be available soon. A transport model for NO_x and photo-oxidants will be added to the *Atmospheric Processes* Compartment.

Since a lot of attention is focused by the expected model users, e.g., the decision makers negotiating in the context of the Geneva Convention, on the costs and benefits of pollution control, in 1986 a cost submodel will be added to RAINS. This submodel calculates costs for user specified control scenarios. Preliminary country specific cost functions are available. A network of experts in this field including representatives from the FRG, Sweden, Netherlands, USA, and USSR, has been initiated.

The *Direct Forest Impact* submodel will incorporate the response of forests to air pollution and other environmental factors with the assumption that pollutant impact takes place through growth rates. The forest submodel can be used in two ways. First, the user can specify a location, and the system identifies the environmental characteristics (ETS, rainfall, soil type, probability of drought), the possible forest types, and the pollutant input. The stand model simulates stand development in terms of species combination, stand biomass, and stand density. Secondly, the results will be integrated over Europe by combining sensitive areas, determined by the stand model, and severe pollutant inputs. The model will incorporate the possibility of comparing different hypotheses on the relationship between air pollutant stress and individual tree growth rate.

Groundwater Acidity was studied in 1985 (see above). One YSSP participant was granted a Peccei Scholarship and will continue to develop the submodel in 1986, together with 1986 YSSP participants.

Model Testing and Uncertainty Analysis

A vigorous testing program is currently underway to strengthen the confidence of users in the RAINS model estimates. Part of the approach involves conventional model validation and verification. However, there is some doubt whether a true verification can be performed on a model with a spatial resolution of 100 x 100 km.

A less conventional approach is also being taken by acknowledging that model uncertainty exists and that it should be incorporated explicitly in RAINS. This uncertainty analysis involves three steps:

1. identification and classification of uncertainty;
2. screening and ranking of uncertainty sources; and
3. quantitative evaluation of aggregate uncertainty due to its most important sources.

Currently a Monte Carlo simulation framework is available to assist in establishing cumulative quantitative estimates of uncertainties through the different submodels. The sulfur emissions and sulfur transport submodels have been subjected to this uncertainty analysis.

Other Operational Modes

At this stage RAINS is a tool for scenario analysis, but it is not yet suitable for the development of optimal control strategies covering many countries. As a start, an *optimization* algorithm developed by Canadian scholars has been added to the system. Furthermore, the model is now linked with the MINOS linear programming package and is used in combination with the sulfur transport and cost-of-control submodels. First results of this work will be presented at meetings of Convention for Long-Range Transboundary Air Pollution. Collaboration with IIASA's Systems and Decision Sciences Program and the Central Institute for Cybernetics and Information Processes in Berlin (GDR) will produce a multi criteria optimization algorithm.

Application and Distribution

After having established uncertainty estimates the RAINS model could be applied to evaluate currently discussed reduction strategies of acidifying compounds. Questions like "What will be the effect of 30, 50, or 60 percent reductions of SO₂ emission in Europe on forest soil acidity?" can be addressed using the model. Also the effects of different energy scenarios on environmental impact indicators can be evaluated with the model RAINS. A major application of the model is foreseen in the deliberations at the Geneva Convention on Long Range Transboundary Air Pollution. In addition to this type of model use, both scientists and decision makers in several countries (*inter alia* Hungary, Norway,

and the Netherlands) are interested to use the RAINS model and to build a national acidification model using the RAINS structure as a starting point. In the past RAINS has been demonstrated in Bulgaria, GDR, Hungary, the Netherlands, and France using the international computer network. The Norwegian Ministry of the Environment has commissioned a consultancy firm to produce a version of RAINS for a micro-computer. This version will be available in the fall of 1986.

Meetings and Publications

Throughout the research period the project team solicits peer review for the different submodels. The most recent review meeting of this type took place in April 1986.

As was the case in 1985, we will organize a working meeting in Poland (April 1987) where the major topic of discussion will be the analysis of uncertainties in models for the long-range transport of air pollutants.

Next to a number of working papers and collaborative papers issued in 1984 and 1985, articles have been submitted to and accepted by journals in the areas of ecology, environmental management, and atmospheric sciences. A separate list of publications is available.

In 1986 we will start to prepare a book that contains a technical and detailed description of the model. Also a non-technical description of RAINS will be prepared.

Since one of the fundamentals of the project is to use existing work as much as possible, the collaborative network is quite extensive. It includes institutes and universities dealing with atmospheric sciences, long-range transport of air pollution modeling, soil science and geology, limnology and hydrology, and forestry in the Nordic countries, the Netherlands, USA, USSR, Canada, Poland, GDR, FRG, and Hungary. Many visits and small meetings take place throughout the year to obtain advice, data, models, and peer review on the separate submodels of RAINS.

INTENDED USERS OF THE RESULTS

We expect that the model users will be mainly decision makers concerned with the costs and benefits of acid deposition abatement, i.e., scientific advisors and administrators affiliated with governments. Some of these users may have scientific backgrounds, but all of them are principally concerned with policy development. The users include the Executive Body of the Geneva Convention, the Netherlands Supplementary Research Programme on Acidification, the Finnish Research Project on Acidification (HAPRO), the Hungarian Planning Bureau and National Environment Office, Norconsult A.S. in Oslo, Shell International, The Hague, and ENEA in Rome.

RESEARCH TEAM

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Guest Scholar:	Maximillian Posch (Austria)
Peccei Scholar:	Maria Holmberg (Finland)
Research Assistants:	Markus Amann (Austria), Wolfgang Schöpp (Austria), Miyoko Yamada (Japan)
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1986 YSSP Participants:	Barbara Lübker (FRG), Carolina Schulte Fishedick (Netherlands), John Johnston (USA), Michael Sutton (USA), Lena Maxe (Sweden)

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- L. Hordijk, A Model for Evaluation of Acid Deposition in Europe, in *Systems Analysis and Simulation II*, A. Sydow, M. Thoma and R. Vichnevetsky (eds.), Akademie-Verlag, Berlin, GDR, pp. 30-39, 1985.
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