IGACtivities NewsLetter
of the International Global Atmospheric Chemistry Project

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January 1996

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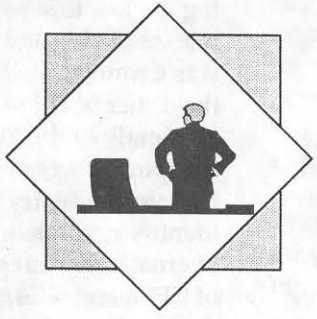


A Note From the IGAC Chair:
Ronald G. Prinn

The 1995 NOBEL PRIZE IN CHEMISTRY:

A first for atmospheric chemistry and global change studies

It was with great pleasure that I learned during the WMO-IGAC Scientific Conference in Beijing this past October that three valued colleagues whom I have known for over twenty years were awarded the 1995 Nobel Prize in Chemistry. Paul J. Crutzen (Max Planck Institut für Chemie), Mario J. Molina (Massachusetts Institute of Technology), and F. Sherwood (Sherry) Rowland (University of California at Irvine), received the award "for their work in atmospheric chemistry particularly concerning the formation and decomposition of ozone". This is the first Nobel Prize in atmospheric chemistry and the first in the broader areas of environmental and global change science. These are the areas now addressed by IGAC and IGBP.

It is particularly noteworthy that Paul Crutzen played significant roles in the formation of both IGAC and IGBP and is serving currently as the vice-chair of the IGAC Scientific Steering Committee. Sherry Rowland is also active in IGAC, measuring hydrocarbons and other species using aircraft over the globe, and Mario Molina is doing fundamental work in the laboratory on heterogeneous atmospheric chemical reactions very relevant to IGAC.

While we think of ozone depletion as a contemporary issue, the story really began more than two billion years ago when blue-green algae evolved on Earth. Their photosynthesis led to an oxygen-rich atmosphere. Oxygen, pumped with the sun's ultraviolet radiation, produced the first ozone layer. Perhaps around this same time, there also evolved bacteria with the capability to convert nitrogen compounds in soils and water into molecular nitrogen and nitrous oxide. The nitrogen would come to dominate our atmosphere, and with the nitrous oxide emissions came an important process limiting the thickness of the ozone layer.

The contemporary ozone depletion issues effectively began in the 1930s with the invention of an extremely useful class of nearly inert chemicals called chlorofluorocarbons (CFCs), and in the 1970s with proposals for a global fleet of supersonic commercial aircraft which would fly in and exhaust gases into the lower stratosphere.

Crutzen, Molina, and Rowland played leading roles in elucidating the ways in which these natural and artificial emissions affect the ozone layer which protects the global biosphere from harmful ultraviolet radiation. Their initial proposals instigated a large international research program on the ozone layer and also proved to be a catalyst for a much wider-ranging study of the complex chemical and biological connections which exist on Earth.

The first connections began to be made when Paul Crutzen published two papers in 1970 and 1971 proposing that catalytic reactions involving nitric

oxide and nitrogen dioxide (let me call them the "Crutzen" reactions) are a major ozone destruction mechanism. In the natural stratosphere the major source of these nitrogen oxides is the reaction of electronically excited oxygen atoms (themselves produced from ozone) with nitrous oxide. As pointed out concurrently by Harold Johnston, supersonic aircraft deposit these catalytic nitrogen oxides directly into the stratosphere. The second connection was made when in two papers in 1974 and 1975, Mario Molina and F. Sherwood Rowland proposed that the nearly inert chlorofluorocarbons and chlorocarbons (CCs) were dissociated by ultraviolet light in the stratosphere to produce chlorine atoms and chlorine monoxide. Only a short time before that, it had been recognized that these chlorine species catalytically destroy ozone through the so-called "Stolarski-Cicerone" reactions which I name here after their discoverers. The CFCs were widely used in the 1970s for refrigeration, air conditioning, aerosol can propellants, solvents, plastic foam puffing agents, and a myriad of other applications. The major CC was trichloroethane (methyl chloroform) which was widely used as a cleaning agent in the electronics and automobile industries. Measurement of the CFCs and CCs in air became possible in the early 1970s with the invention of the electron capute detector by James Lovelock.

These early proposals of ozone depletion led to a rapid expansion of research in stratospheric chemistry. For a variety of reasons, including potential ozone depletion by the Crutzen reactions, plans for large supersonic aircraft fleets were shelved in the mid-1970s. There was also enough early confidence in the Molina-Rowland theory that several countries in the mid-1970s phased out the use of CFCs in certain trivial uses, particularly aerosol cans. Nevertheless, even as evidence for the Crutzen, Molina, and Rowland theories mounted, the observational evidence for actual depletion of ozone was equivocal. Due to changing wind patterns, the thickness of the stratospheric ozone layer is highly variable in space and time and therefore small long-term changes in its thickness are very difficult to detect. A series of international assessments were begun in order to periodically examine the validity of these ozone-depletion hypotheses. It was a watch-and-wait phase. The situation changed dramatically with the publication of the discovery of the Antarctic Ozone Hole by Joseph Farman and colleagues in 1985. A remarkable thinning of the ozone layer was occurring every spring over Antarctica and the thinning was increasing with time. However, this very evident ozone depletion was not explained by the then-current ozone-depletion theories. These theories did not include the chemistry instigated by reactions involving the stratospheric ice clouds prevalent over Antarctica in winter due to the extremely cold temperatures occurring there. The scientific assessments accelerated and the first significant CFC regulatory policy negotiations began with the 1985 Vienna Convention leading to the 1987 Montreal Protocol. Simultaneously, several researchers, including James Anderson, were gathering evidence for unexpected chlorine, bromine, and nitrogen chemistry in the Antarctic spring atmosphere. Theoretical and laboratory studies involving Susan Solomon, Molina, Crutzen, and others was establishing the fact that reactions on ice particles can lead to release of chlorine monoxide. A new catalytic cycle was demonstrated by Molina and colleagues involving the dimer of chlorine monoxide which operates efficiently in the Ozone Hole. The pieces of the scientific puzzle were beginning to come together and the chemical industry was at the same time gearing up to identify and manufacture suitable CFC and CC alternatives. I am glad to say that global observations of CFCs and CCs carried out in the Advanced Global Atmospheric Gases Experiment (AGAGE) and NOAA Climate Monitoring and Diagnostics Laboratory networks now show that the Montreal Protocol is indeed working. My AGAGE colleagues and I were able to report earlier this year that the major CC trichloroethane is the first ozone-depleting gas to actually show a dramatic decrease in the atmosphere. Carbon tetrachloride and CFC-11 are now also slowly decreasing.

The ozone depletion story is not ending however with the Nobel Awards and successful implementation of the Montreal Protocol. Removal of long-lived CFCs from the atmosphere will still take many decades so we will be living with a perturbed ozone layer well into the next century. Also, AGAGE and other measurements show nitrous oxide levels are continuing to rise slowly and we have still not established why. That is one of many problems that IGAC, with help from other IGBP projects, can hopefully soon solve.

Ozone is also a chemically and radiatively important species in the troposphere and the work by Paul Crutzen on tropospheric ozone over the past twenty years has been an important contribution to our current knowledge in this area. Paul, I, and many others are, however, frustrated at the lack of observations of tropospheric ozone necessary to define the global distribution and trends for this critically important gas. Hopefully, the International Tropospheric Ozone Years (ITOY) proposed as a major initiative under the IGAC Global Tropospheric Ozone Network (GLONET) Activity, will receive special impetus with the Nobel Committee's recognition of ozone research. (See "In the News" Section of this Newsletter).

Thus there is still much work remaining. Nevertheless, the remarkable contributions by three members of our community are a great pleasure to acknowledge. Congratulations Paul, Mario, and Sherry for a job well done!

Update on IGAC's Global Tropospheric Ozone Network (GLONET) Activity and the International Tropospheric Ozone Years (ITOY)

Contributed by V.A. Mohnen, Fraunhofer-Institut für Atmosphärische Umweltsforshung, Germany

Introduction

The main driving force of global atmospheric observations and atmospheric chemistry research is the need to develop sound environmental policy related to the following questions:

- What is the effect of human activity on stratospheric and tropospheric ozone? How is the UV flux at the surface of the Earth changing in response to changes in the ozone column density?
- How is surface climate sensitive to the atmospheric concentrations of greenhouse gases and aerosols, and what factors control these concentrations?
- How is the oxidizing power of the atmosphere changing with time, and what is the influence of human activity?
- How is regional air quality degraded by industrial and other anthropogenic emissions in populated areas of the world?

The answers to these questions are being sought--in part--by IGAC-GLONET, and the resulting data sets are used by policy makers to resolve major scientific issues.

Ozone O_3 plays a central role in most of the key physical, chemical and radiative processes in the troposphere. It has become apparent that: (1) O_3 vertical distribution significantly influences the radiative forcing of the troposphere-surface climate system; and (2) the photodissociation of O_3 defines the "oxidation efficiency" of the free troposphere. Because of these roles, it is imperative that we gain a much more detailed knowledge of its global horizontal and vertical distribution and long-term concentration trends in the troposphere than current O_3 measurement programs will permit.

Goals

To address the stated problems, GLONET is organized initially into three tasks. The first emphasizes improvements in the quality of O_3 profile measurements. The second identifies geographic regions where new stations are critically needed for achieving representative global coverage and develops a strategy for needed network expansion. A third encompasses initial planning for a worldwide O_3 and related species intensive measurement program in the 1998-1999 time frame to establish a global data base for validation of chemistry/transport models: The International Tropospheric Ozone Years (ITOY).

Recent World Meterological Organization (WMO) assessment reports and articles in the reviewed literature characterize the state of knowledge regarding tropospheric O_3 trends as very sketchy. The majority of stations are located in northern midlatitudes. There are less than 15 stations with long-term records (> 15 years), and most of these are located in Canada, Europe and Japan, with only one in the U.S. and one in Australia. Among these stations the data quality and sampling frequency are uneven. There is only one station in the tropics with a record from 1979, and the sampling frequency has been low. An increase in measurement frequency is needed at many of the existing stations, and new stations are required in regions where there are none. The assurance of continuity is required at several of the stations established in recent years. By far the greatest need is for improved data quality, for both present and future measurement stations. This is the focus of two of the three initial tasks of GLONET.

Several national and international efforts (e.g., the WMO's Global Atmosphere Watch, GAW) are underway towards building a representative global network of ozonesonde stations, and GLONET is committed to support such efforts. However, prior to any expansion, and in order to optimize the use of existing networks for accurate measurements of tropospheric O_3 profiles, it is absolutely essential that certain tasks be accomplished:

- Intercalibration and intercomparison of existing ozonesonde types;
- Agreement on measurement frequency and timing;
- Agreement on procedures for data processing and analysis.

Task 1:

Past field intercomparisons between different ozonesonde sensor types have shown that there have been relative differences of the response to ozone between different sensor types and that these relative differences may have been changing with time. The accuracies of the sensor types were generally not assessed during the intercomparisons because there was usually no reference standard to which the ozonesondes could be compared.

To address the question of the accuracies of different ozone sensors, the Institut für Chemie der Belasteten Atmosphäre at Jülich, Germany, developed an environmental simulation chamber (ESC) capable of simulating ozonesonde flight conditions. Chamber pressure is controlled between 10 and 1000 hPa, temperature between 200 and 300 K, and ozone concentration is measured by a UV photometer standard which is calibrated to an estimated accuracy of 2% (Figure 1 and Table 1).

An experiment will be conducted at the Jülich ESC in February 1996 to assess the performance of different ozone sonde sensor types. Goals of the Jülich Ozone Sensor Experiment (JOSIE) are to:

- Characterize different ozone sensor types used in GAW under controlled laboratory conditions, and thus provide a statistically robust data base to determine precision and accuracy of ozonesonde measurements as a function of sensor type, altitude, and ozone level;

- Develop and update standard operating procdures (SOPs) for both pre-flight operations and post-flight data reduction, to ensure homogeneous data quality for the ozonesonde stations operating in GAW/GLONET.

The experimental setup for the simulation of the vertical ozone soundings in the chamber is shown schematically in Figure 1. In several simulation experiments, four different types of ozonesondes can be "flown" simultaneously and compared to the UV photometer. Two different types of vertical profiles of pressure, temperature and ozone concentrations will be simulated. The first type of profile will be a typical mid-latitude profile taken from the U.S. Standard Atmosphere (1978) for 40-50^{o}N with a tropopause height of 12 km. The second type of profile relates to typical tropical conditions of high convective activity, high tropopause of 18 km and low tropopause temperature which means extremely low ozone values in the middle and upper troposphere.

The pressure and temperature in the ESC will change according to ascent velocities of 5 m/s up to a burst altitude corresponding to 35 km. During the ascent profiling, several tests will be performed to characterize the response time of the different ozone sensors. Special attention will be given to the "background current" signal in the troposphere as well as the stratosphere.

Task 2:

GLONET will also conduct in 1996/97 in-flight intercomparison of ozone-sondes and airborne UV-photometers as an additional confirmatory check of ozonesonde performance using coincident aircraft measurements of ozone (and perhaps other trace gas species) during specific ozonesonde ascents. In so doing it is recognized that simultaneous aircraft measurements are not considered redundant with the chamber studies, but instead provide the unique capability to investigate statistical aspects of sampling representativeness and effects of co-varying fields of potentially interfering pollutants such as SO_2 and NO_X. Key objectives of this aircraft comparison include the following:

- Obtain near-coincident ozone measurements using ozonesondes and airborne UV-photometer for intercomparison;

- Obtain high temporal resolution aircraft measurements of free tropospheric ozone to enable subsequent investigation of the spatial representativeness of individual ozonesonde profiles;

- Investigate the covariability on different spatial scales of ozone and pollutants such as SO_2 and NO_X using aircraft data.

General features of aircraft measurements to accomplish these objectives involve deployment of the German DLR Falcon research aircraft, equipped with an onboard UV ozone photometer suitable for ozone measurement in the low-pressure environment of the tropopause region. The aircraft will be used to make correlative ozone measurements for intercomparison with ozone data obtained by sondes launched from Hohenpeissenberg, Payerne, and possibly Uccle.

The ozonesonde flights and aircraft flight plan will be coordinated to enable near-coincident measurements of ozone by each instrument for subsequent intercomparison. The fast-response aircraft instruments will also continuously monitor ozone, NO_X and SO_2 as the aircraft proceeds from one balloon location to the next, and during ascent and descent, hence enabling the desired analysis of the spatial variability, both horizontal and vertical, and covariability of these trace gases.

Task 3:

From considerations of the causes of O_3 variability, the size of the region of the atmosphere effectively sampled above a fixed observation station, and trend prediction analysis, it has been concluded that an increase in measurement frequency and a major expansion of the current number of O_3 measurement stations would be necessary to detect regional and global trends of tropospheric O_3 with an accuracy of 1% per year.

This task is strategically designed to coordinate with and build upon existing multinational research/monitoring programs aimed at measuring and assessing long-term tropospheric O_3 concentrations. In particular, the GLONET approach will complement ongoing efforts in WMO's Global Atmosphere Watch (GAW) programme, IAMAS's International Ozone Commission (IOC) and other major programs concerned with surface O_3 measurements.

In particular, GLONET will support to the maximum extent possible the ongoing efforts of its sub-project "International Tropospheric Ozone Years" (ITOY). The main objective of ITOY is to carry out a global scale measurement campaign of O_3 and its most important precursors, including hydrocarbons, CO and NO_X, during a period of at least one year. The main purpose of such a campaign is to establish a global data base for validation of chemistry/transport models to be used for assessing the current and potential future anthropogenic impact on the chemical composition of the troposphere. A key component of ITOY will be an expanded network of ozonesonde (and perhaps lidar) stations, with additional sites particularly in tropical and subtropical areas. Measurements from aircraft, ships and satellites will also be a fundamental part of ITOY.

For more detailed background on ITOY, see IGBP Global Change Newsletter No. 19. Current information on ITOY planning may be obtained from Dr. Petteri Taalas, (Finnsh Meteorological Institute, Section of Ozone and UV Research, Siltasaarenkatu 12A, POB 503, 00101 Helsinki, FINLAND, phone: (+358-0) 1929 253, fax: (+358-0) 1929 537, e-mail: petteri.taalas@fmi.fi).

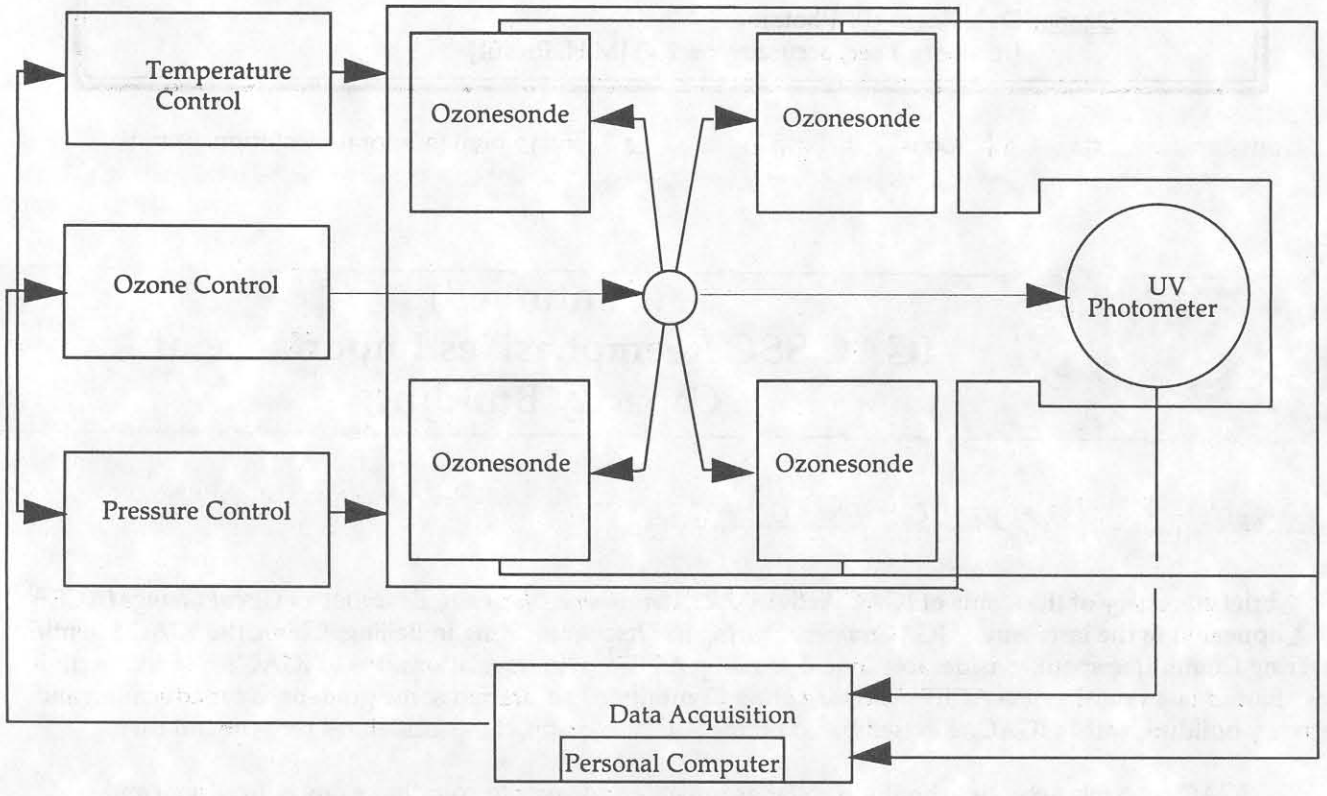


Figure 1: Experimental Setup for the Simulation of Vertical Ozone Soundings

TABLE 1
Specifications of Ozonesounding Simulation Facility at Jülich, FRG

1. Test room volume -- 500 liter (80x80x80 cm)

2. Separate temperature control of walls, door and circulating air inside the testroom (cooling power = 20 KWh)

3. Computer controlled simulation according to "real" atmospheric conditions:

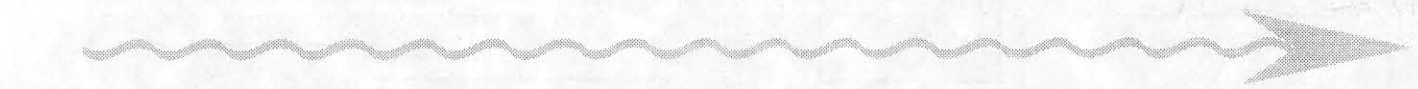
   a) *Pressure:* 10-1000 hPa

   b) *Temperature:* 200-300°K
      - dynamic: Rate = 2 K/min
      - static: Fluctuations < +0.1 to -0.2 K

   c) *Ozone:* 5-10000 ppbv (0.1-30 mPa)

4. Reference:

   Ozone: Dual Beam UV-Photometer
   (response 1 sec, accuracy < ± 2%) [M.H. Proffit]



(Continued)
IGAC SSC Reemphasizes Importance of Capacity Building

Contributed by Alex Pszenny, IGAC Core Project Office, U.S.A

A brief summary of the status of IGAC Activity 7.2: *Atmospheric Chemistry Education in Global Change* (ACE^{ED}) appeared in the last issue of IGAC*tivities*. During its October meeting in Beijing, China, the IGAC Scientific Steering Committee spent considerable time discussing ACE^{ED} and its relationships to IGAC's research Activities. Earlier last year the new ACE^{ED} Coordinating Committee had drafted some guidelines for education and capacity building within IGAC. Revised based on the SSC discussion, these guidelines recommend that:

> IGAC research Activities should in so far as possible endeavor to coordinate any educational and capacity building efforts they undertake with IGAC Activity 7.2: *Atmospheric Chemistry and Environmental Education in Global Change* (ACE^{ED}). They should also seek to identify and provide opportunities for scientific capacity building in developing countries.
>
> Specifically, IGAC researchers are encouraged to:
>
> - Invite and provide opportunities for scientists and students from developing countries to participate in IGAC research projects, including evaluation of data and publication of results,

- Establish fellowships/traineeships for students from developing countries at institutions in developed countries and provide opportunities for academic exchange programs. Early priority should be given to young research scientists who are already employed in a research institution,

and in cases of research projects to be conducted within developing countries:

- Contact and involve local scientists in the experiment/project planning and execution from the project's inception,
- Provide for prior academic and technical training for local scientists to enhance participation opportunities in research projects,
- Establish long-term partnerships with research scientists and universities in developing countries, and
- Identify within proposals the option for leaving research equipment in the developing countries upon completion of the experiment/project.

The IGAC Scientific Steering Committee urges all Activity Conveners and Coordinating Committee members to keep these guidelines in mind as current research projects continue and, especially, as new ones are planned. For further information about ACE^{ED} contact the Activity's Convener: Prof. K.L. Demerjian, Atmospheric Sciences Research Center, State University of New York, 100 Fuller Road, Albany, NY, 12205, USA; Tel: (+1-518) 442-3820; Fax: (+1-518) 442-3867; Email: kld@atmos.albany.edu.

IGAC*tivities* NewsLetter

Edited by Alex Pszenny and Elaine Robbins
Logos by Linda Kubrick

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Dear Reader,

We delayed this issue of IGAC*tivities* for three weeks in anticipation of receiving two "science features" on IGAC research results pertaining to ozone. However, such contributions are voluntary and, as we all know, volunteer efforts sometimes must be given lower priority than we might like. We decided today that we could wait no longer. We regret any inconvenience that the late appearance of this issue may cause you.

We are planning the next issue for March. Contributions — especially "science features" on some aspect of research conducted as part of one of IGAC's Activities — are welcome. If you would like to provide one, please let us know.

The Editors
January 4, 1996

Announcements

CALL FOR PAPERS

5th International Conference
Atmospheric Sciences and Applications to Air Quality
18-20 June 1996
Seattle, Washington USA

OBJECTIVES

The 5th International Conference on Atmospheric Sciences and Applications to Air Quality will bring together scientists from around the world to discuss issues related to the atmospheric environment. The previous ASAAQ meetings were held in Seoul twice, Tokyo and Shanghai. Based on the success of these meetings we are organizing the 5th ASAAQ meeting. The 5th ASAAQ meeting will be the first held outside of Asia. A special issue of *Atmospheric Environment* will be devoted to this conference.

CONFERENCE CHAIRMEN

G.R. Carmichael, Chair
The University of Iowa, Iowa City, IA, USA
M. Ruby, Co-Chair
Envirometrics, Inc., Seattle, WA, USA

CONFERENCE TOPICS

This conference will focus broadly on the issues of atmospheic science and air quality, with a particular emphasis on the Pacific Rim and Asia regions. However, papers are welcome from all areas of atmospheric science and air quality. Topics to be covered include (but are not limited to):

- acid deposition
- urban environments
- regional modeling
- integrated assessment models
- tropospheric chemistry
- ocean-atmospheric chemistry
- air quality meteorology
- monitoring of air pollutants and greenhouse gases.

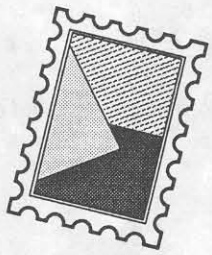
CALL FOR PAPERS

Papers are invited on the topics outlined above which are consistent with the theme of the conference. Informative abstracts in English (200-400 words) should be submitted by January 15, 1996. Submit abstracts to:

Prof. Greg Carmichael
Center for Global & Regional
Environmental Research
The University of Iowa 204 IATL
Iowa City, IA 52242, USA
e-mail: gcarmich@icaen.uiowa.edu
Telephone: (319) 335-3332
Fax: (319) 335-3337

For a registration form and further information contact:

Environmetrics, Inc.
4803 Fremont Ave. N
Seattle, WA 98103 USA
Telephone: (206) 633-4456
Fax: (206) 633-4835



Announcements (Continued)

SECOND CALL FOR PAPERS

INTERNATIONAL WORKSHOP ON NO_X EMISSION FROM SOILS AND ITS INFLUENCE ON ATMOSPHERIC CHEMISTRY

National Institute of Agro-Environmental Sciences
Tsukuba, Japan
March 4-6, 1996

Under the auspices of IGAC and SCOPE, the Science and Technological Agency of Japan and the National Institute of Agro-Environmental Sciences are sponsoring an International NO_X Workshop. The purpose of this Workshop is to integrate existing field and laboratory studies on NO and N_2O emission from soils in the world, and to make clear what we know about NO production and consumption processes and their controls. We also want to clarify what is known about the ratio of NO to N_2O emissions in different ecosystems and the quantity of NO_X emitted regionally and globally. Using the current understanding of NO_X emissions from soils can we evaluate the impact of soil NO_X emissions on regional and global atmospheric chemistry?

We invite papers, to be presented as posters, from scientists who are conducting research concerning soil NO_X emissions and their interaction with the biosphere, or other topics directly related to the purpose of the Workshop. One page abstracts of papers are requested before 15 January 1996. Selected volunteered papers will be invited to submit full manuscripts to be considered for publication in the workshop proceedings in a special issue of the Kluwer Academic Publishers *Journal of Nutrient Cycling in Agroecosystems*. If you are interested in presenting a paper please send abstracts to Dr. Haruo Tsuruta or Dr. Arvin Mosier:

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3-1-1 Kannondai
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Open Science Meeting
7-9 March, 1996
Tsukuba, Japan
Paddy Fields: Control of Greenhouse Gas Emission and Sustainable Agriculture
Introduction/Overview/Country Report/ Case Study/Execution

Persons interested in participating should contact Dr. Katsu Minami, Japan International Research Center for Agricultural Sciences, Environmental Research Division, Ohwashi 1-2, Tsukuba 305, Japan, Tel: 81-298-38-6306, Fax: 81-298-38-6651, email: minami@jircas.affrc.go.jp