

**Final Report, 2003-2006 Grant
International Global Atmospheric Chemistry (IGAC) Project
Award Number 0314662**

Project P.I.: Timothy S. Bates

Report prepared by: Sarah J. Doherty, IGAC Executive Officer

ACTIVITIES & FINDINGS

1. Major research and education activities

The 2003-2006 period saw IGAC into its second phase of activity. The focus of IGAC in Phase II, as given in our Science Plan and Implementation Strategy are:

- *To accurately determine global distributions of both short and long lived chemical species in the atmosphere and to document their changing concentrations over time*
- *To provide a fundamental understanding of the processes that control the distributions of chemical species in the atmosphere and their impact on global change and air quality*
- *To improve our ability to predict the chemical composition of the atmosphere over the coming decades by integrating our understanding of atmospheric processes with the response and feedbacks of the Earth System*

The organizational framework under which we have been pursuing these goals is via the support of Tasks, the co-sponsorship of Workshops, and through Initiatives on focused topics. Under IGAC's Phase II, Tasks are defined to be projects that address specific scientific questions and which require an international research framework. We are also asking that the research objectives be achievable in a 3-5 year timeframe, with follow-on phases contingent on the success of the initial project. Complementary to this "bottom-up" component, the IGAC SSC decided in 2006 to establish IGAC Initiatives, whereby the IGAC SSC identifies areas in need of attention that are not currently being addressed, and a "top-down" effort is made to initiate activity. Initiatives should generally address cross-cutting issues where gains can be made via the integration/synthesis and enhancement of ongoing activities.

Information on IGAC research and articles exploring new subjects or ideas in the field of atmospheric chemistry are disseminated by mail to the IGAC community via the *IGACtivities* newsletter. While the IGAC Seattle office is in charge of the newsletter production/editing, the printing and mailing are done by the IGAC Taipei office. Archived copies of the newsletter, descriptions of our current Tasks, and a list of publications are available via the IGAC web site (<http://www.igac.noaa.gov>). Communication within the IGAC community and new ideas for research are also fostered by bi-annual international conferences.

In Phase II, a concerted effort is being made to collaborate more closely with IGAC's partner projects. In 2003-2006, liaisons (either IGAC SSC members or the IGAC Executive Officer) attended the Scientific Steering Committee meetings of IGBP's iLEAPS (Integrated Land-Ecosystem Atmosphere Process Study), SOLAS (Surface Ocean Lower Atmosphere Process Study) and AIMES (Analysis, Integration and Modeling of the Earth System) projects and the World Climate Research Programme's SPARC project. As described below, this has led to a number of collaborative efforts.

Initiatives

In the final six months of this grant, first steps were taken to start Initiatives on the following topics:

- ~ Atmospheric Chemistry and Climate (*joint with WCRP-SPARC*)

- ~ Improving the representation of wet deposition in models
- ~ Integrating knowledge across various Mega-cities studies, e.g. "Mega-cities Integration"

Progress on these initiatives has and will require active engagement and guidance from the IGAC E.O. and co-Chairs. We expect that in particular the Atmospheric Chemistry and Climate Initiative will be a strong focus of IGAC in the 2006-2009 timeframe. We also expect that additional ideas will emerge with scientific progress, and we will work to engage members of the IGAC community to lead initiatives in these areas as appropriate.

The grant for the IGAC project supported the operational costs of the IGAC Seattle Core Project Office; the salary of the IGAC Executive Officer (E.O., Sarah Doherty); travel support for liaison activities; and travel support for the IGAC community – in particular young and developing country scientists – to attend IGAC co-sponsored workshops and conferences. For the first half of the grant, the Seattle E.O. worked half time on the IGAC grant; thereafter she was employed full time through this grant. This coincided with a shift from having an IGAC project office with Science Officers in Rome, Italy and Taipei, Taiwan, to having these offices support IGAC via travel funds (European office) and newsletter printing/mailling (Taipei office).

Scientific Steering Committee

The IGAC Scientific Steering Committee acts in an advisory and advocacy role. New members of the SSC are nominated by the current SSC (though they can be suggested by anyone in the community, and have been). Approval of nominees must be granted by our parent organizations, the International Geosphere Biosphere Programme (IGBP) and the IAMAS Commission on Atmospheric Chemistry and Global Pollution (ICACGP).

A concerted effort is made to maintain within the SSC a balance in terms of scientific expertise, nationality, gender and maturity in the scientific field. On this last point, young scientists invited to the SSC must have demonstrated excellence in both their research and leadership.

SSC members may serve for up to two three-year terms. Chairs are allowed to remain on the SSC for an additional three years.

The composition of the SSC from 2003-2006 is shown below, where:

M = member

CoC = Co-Chair

GENDER	COUNTRY	FIRST	LAST	2003	2004	2005	2006
m	USA	Tim	Bates	CoC	CoC		
m	Germany	John	Burrows	M	M	M	M
m	China-Taipei	Jen-Ping	Chen				M
m	Russia	Nikolai	Elansky				M
m	Italy	Sandro	Fuzzi	CoC	CoC	CoC	CoC
f	Chile	Laura	Gallardo-Klenner	M	M	M	M
m	Russia	Ilya	Ilyin	M	M	M	
m	India	Achuthan	Jayaraman	M	M	M	M
f	Greece	Maria	Kanakidou				M
m	Japan	Makoto	Koike	M	M	M	M
f	Engl.('03); Fra. ('04-'08)	Kathy	Law	M	M	M	M
m	China-Taipei	Shaw	Liu	CoC	CoC	CoC	
f	Can('03); Switz('04-'08)	Ulrike	Lohmann	M	M	M	

m	New Zealand	Dave	Lowe	M	M	M	M
m	Canada	Randall	Martin			M	M
m	USA	David	Parrish	M	M	M	M
m	S. Africa	Stuart	Piketh			M	M
f	Mexico	Graciela	Raga			M	M
m	USA	Phil	Rasch	M	M	CoC	CoC
f	S. Africa	Mary	Scholes	M	M	M	
m	U.K.	Eric	Wolff	M	M	M	M
m	China-Beijing	Yongfu	Xu	M	M	M	
m	China-Beijing	Tong	Zu				M

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2. Findings

Tasks

Over the past three years, the IGAC SSC has endorsed eight Tasks. These are reviewed annually at our SSC meeting. Brief descriptions of each are given below.

DEBITS Task (Deposition of Biogeochemically Important Trace Species)

DEBITS is a long-standing program of IGAC. In 2003, it entered its second phase, with a new emphasis on:

- determining, at the regional scale and mainly through measurements, the atmospheric removal rates via dry and wet deposition of biogeochemically important trace species;
- working out atmospheric budgets of key elements (S, N, Ca, Cl) at the regional scale;
- establishing the chemical and physical factors that regulate these deposition fluxes and to identify parameters to be included into regional and global atmospheric chemistry models.

The role of the DEBITS task is to coordinate measurements and synthesize data from three measurement campaigns: LBA (eastern South America; esp. the Amazon); IDAF (IGAC DEBITS Africa); and DEBITS Asia (CAAP, "Composition and Acidity of Asian Precipitation" and CAD, "Composition of Asian Deposition").

In 2006, measurements continued in these three DEBITS research networks. A DEBITS workshop was held in South Africa in September, 2006, in coordination with the IGAC Open Science Conference, and there results from the three networks was shared. Recent discussions emerging from this workshop appear very likely to lead to a new IGAC-iLEAPS initiative on assessing dry deposition measurements and the representation of dry deposition in models.

AICI Task (Air-Ice Chemical Interactions)

The AICI Task was endorsed in October, 2003, and is scheduled to conclude in 2007. This Task aims to study the role that chemistry within the snow-pack and ice may play in controlling aspects of boundary layer chemistry. This has been achieved through a combined program of field measurements, laboratory measurements, satellite data retrieval, and modeling studies in both polar regions. AICI has been a co-convenor at sessions at each AGU and EGU meeting since AICI started, thus meeting two principle objective of the Task: to have air-ice interactions become recognized as an important line of study, and to bring together the communities engaged in the various campaigns and experiments relevant to this area. In addition to the AGU and EGU sessions, there was also an OASIS/AICI-related session at the IGAC Open Science Conference in Cape Town (September, 2006). This Task is in the process of concluding, with members in the process of preparing five major review papers of AICI science issues, i.e.: snow photochemistry, tropospheric ozone depletion and halogens, mercury in the polar regions, boundary layer meteorology relevant to AICI, and snow physics. These papers will appear in a special issue of Atmospheric Chemistry and Physics, with submission expected in the first half of 2007.

The AICI Task Team in 2006 also stepped up to play an important coordinating role for atmospheric chemistry within the International Polar Year (IPY). While Phase I of AICI will

conclude with publication of the ACP Special Issue, we anticipate continuation of the Task with a new set of objectives, as "AICI-IPY".

ITCT-2k4 Task (Intercontinental Transport and Chemical Transformation - 2004)

The major aims of the ITCT-2k4 Task are to investigate the oxidant and aerosol formation potentials (relative to dynamical processes) in plumes originating from anthropogenic and natural sources in order to quantify net pollutant export out of North America and pollutant import into regions downwind such as Europe. The heart of this Task was a field campaign. This follows on the ITCT-2k2 project, which investigated (also via an intensive field campaign) the transport of pollutants and dust from Asia to North America.

ITCT-2k4 was endorsed in 2003, and in that year the Task team played a key role in coordinating flight and measurement plans amongst the multiple national campaigns that would take place during Summer 2004 on both sides of the North Atlantic, allowing for semi-Lagrangian measurements to be made during the intensive field phase. In practice, two or three aircraft made multiple, sequential sampling flights into the same air mass during the time required for the intercontinental transport of that air mass. This plan required the close coordination of four aircraft deployed in North America (the NOAA WP-3D and the NASA DC-8), in the mid North Atlantic (the BAe-146) and in Europe (the DLR Falcon). In addition, data from the NOAA Ozone Lidar aircraft, the PICO-NARE surface site, MOZAIC measurements on commercial aircraft, from the European lidar network, and European surface sites were integrated into the analyses. Each of these platforms had its own regionally focused goals, but together they provided coverage during the complete transit of a polluted air mass across the North Atlantic.

The organization and realization of ITCT-Lagrangian-2K4 comprised three steps: a review of previous results, instrument comparison activities (to ensure that measurements on the disparate platforms could be accurately integrated without confounding measurement uncertainties) and flight coordination during the field deployment.

The 2006 calendar year represents the final stage of the ITCT-Lagrangian-2K4 Task. The field deployment was completed in September, 2004, and publications are in the process of being submitted for a special issue of the *Journal of Geophysical Research* which is devoted to the larger ICARTT (the umbrella field program of which the ITCT Lagrangian 2k4 Task is part) program.

Mega-cities: Asia Task

To date, many of the large-scale, coordinated measurements of aerosols and oxidants have taken place in regions well downwind of sources. However, it is only by making measurements near the sources that we will be able to accurately make the link between source emissions and regional-scale air quality and climate impacts. Endorsed in 2003, the Mega-cities: Asia Task Team's goal is to facilitate better coordination between groups making measurements of aerosols and oxidants in and around large cities in Asia. Their activities have included maintaining a centralized web page; holding periodic workshops to increase communication between research groups; organizing instrument intercomparisons; and facilitating collaborative publications.

A key aspect of this project has been the establishment of uniform measurement techniques and data analysis protocols, such that the resulting data sets are both well-constrained and comparable. This will allow regional data sets to be integrated in a way that produces a global-scale understanding of key atmospheric chemistry processes.

Inter-comparisons of various instruments (to measure O₃, CO, reactive nitrogen, and aerosols) that are being used throughout the Asia region were made in Guangzhou and Beijing in July-August 2006. Methods and accuracies for measurement of aerosols (black carbon, inorganic, organic aerosols, and WSOC) were established for use across all Mega-cities: Asia measurements. Through this task, understanding of the diurnal and seasonal variations of different types of PM₁ aerosols and their precursor gases in Asian Mega-cities have been greatly improved. These variations can now be interpreted in terms of varying emissions, formation processes, and meteorological conditions. Measurements of EC, OC, CO, and CO₂ concentrations in Beijing and Tokyo are improving understanding of seasonal and diurnal variations of these species and allowing comparison of these variations in the two cities. These measurements will also be used to help validate emission inventories of EC.

In addition to the work in individual cities, an intensive campaign was conducted in July 2006 in the Pearl River Delta region by a collaborative science team from China (Mainland, Taiwan, Hong Kong), Germany (IFT, MPIC, and KFA), Japan (University of Tokyo, Ibaraki Univ., and NIES), Korea (GIST), and the U. S. (UCI). The objectives of the PRD July intensive campaign were to characterize temporal and spatial changes of aerosol, oxidants, and their precursors; to understand chemical composition, size distribution, hygroscopic properties, and optical properties of aerosols; to quantify ozone formation by measurements and modeling; and to explore the relationship between species of aerosols and gaseous phase.

The CAREBEIJING (Campaigns of Air Quality Research in Beijing) campaign also took place in 2006. This international campaign was conducted in Beijing and surrounding regions with many of the same participating organizations and major instruments that were used for the PRD campaign. This campaign focussed on issues of air quality, with an eye toward the 2008 Olympics to be held in Beijing.

In 2006, first steps were taken to have Mega-cities: Asia become part of a larger, overarching IGAC initiative to coordinate mega-cities studies around the globe (see below).

AMMA-AC Task (African Monsoon Multidisciplinary Analysis-Atmospheric Chemistry)

AMMA-AC was endorsed in October, 2004. AMMA (the African Monsoon Multidisciplinary Analysis) is an international, integrated, multidisciplinary project that aims at addressing both fundamental scientific questions related to the understanding of the West African Monsoon (WAM) variability and the impacts and practical issues related to prediction and decision-making activity. The IGAC Task AMMA-AC specifically addresses the atmospheric chemistry component of AMMA. The first year of this Task involved intensive planning to assure the engagement of scientists in the west African region and coordination amongst scientists from multiple disciplines. 2006 was a key year for AMMA, with the organization of four airborne campaigns during the dry and wet seasons. Five aircraft were deployed during the wet season and one during the dry season, plus intensive measurements were made at ground sites throughout the region.

Data analysis from the first intensive field phase is now underway, as is preparation for further measurements. It is already clear that some of the results and data from this campaign will be directly useful for the IGAC-SPARC "Atmospheric Chemistry and Climate" Initiative described below.

GHOST Task (Global OH Systematic Tests)

The oxidizing capacity of the atmosphere dictates photochemical transformation rates. The main tropospheric "cleansing agent" is the OH radical, which is produced through the photolysis of ozone. OH is highly reactive and thus has a very short atmospheric lifetime. In addition, it is extremely difficult to measure directly, so instead its concentration is determined via proxies. Unfortunately, one of these proxies (a CFC) is now declining to low enough levels that its use for the purpose will soon no longer be viable.

The GHOST Task was formed in 2003 in an effort to provide a new paradigm for constraining OH. The idea was to, initially, use models to study the feasibility of using an artificial passive tracer – which would be intentionally released – to track OH in the same way that CFCs are currently being used. This project has been slow to get off the ground due to lack of interest from the modeling community and lack of resources available to coordinate the effort.

In 2006, a post-doc was hired for this purpose and some progress has been made in the initial model runs needed to execute the GHOST idea. In addition, the GHOST team participated in a workshop in November 2005 on the topic of constraining OH, and since then they have been in better contact with the larger community. In doing so the Task Team has been working on finding a path forward that accommodates both the scientific goals of GHOST and the interests and activities of the larger community working on this problem.

POLARCAT Task (Polar Study using Aircraft, Remote Sensing, Surface Measurements and Models, of Climate, Chemistry, Aerosols, and Transport)

POLARCAT, endorsed by IGAC in 2005, is an effort to coordinate measurements during the International Polar Year (March 2007-March 2009), with the specific aims of studying the long-range transport of pollutants into the Arctic region. This will involve a series of aircraft

experiments at different times of the year in order to follow pollution plumes of varying origin as they are transported into the Arctic and to observe the chemistry, aerosol processes, and radiation effects of these plumes. It will also observe the atmospheric composition in relatively cleaner regions outside major plumes and will take advantage of the long residence times of pollutants in the stably stratified Arctic atmosphere to study ageing processes by targeting air masses that have spent considerable time in the Arctic. Ship-based measurements will investigate processes occurring in the lowest part of the troposphere, such as spring-time tropospheric ozone depletion events. Satellite remote sensing data and surface measurements in the Arctic will be utilized, providing important information on the seasonal evolution of trace gases, aerosols and soluble species in rain and snow over the IPY timeframe. The combined analysis of these longer-term datasets, many of which will continue after IPY, will allow the campaign data to be put into a wider context.

Funding decisions for specific research projects within POLARCAT are still being made, and as such this Task is still in the planning stages. In 2005 and 2006, the main role of the POLARCAT Task team was to ensure that the science being planned in the proposals is coordinated and complementary. The IGAC AICI-IPY Task that is being planned will be a component of POLARCAT.

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3. Opportunities for training and development

Workshops/Meetings:

During the grant period, IGAC co-sponsored a series of workshops on emerging issues in atmospheric chemistry. IGAC support for a workshop was contingent on the organizers making an effort to have a concrete product (peer-reviewed publication, Task/research proposal, or – at a minimum – a newsletter article) result. These workshops offer an opportunity for the research community to learn the latest findings from each other and to feed their specific research into addressing the “big picture” questions in atmospheric chemistry. An effort is made to engage young and scientists in particular in these workshops.

Nitrogen Workshop [May 3-5, 2003; Woods Hole Institute in Massachusetts, U.S.A.]

This meeting was co-sponsored by U.S. National Science Foundation, U.S. Environmental Protection Agency, U.S. NASA, and IGAC. There were 50 attendees, and the IGAC-Seattle contributed \$8,000USD; IGAC-Rome supported the attendance of 3 scientists; and IGAC-Taipei supported the attendance of 2 scientists. A white paper from the workshop can be downloaded from: <http://www.inforum.org/73.0.html>. This effort has fed into the International Nitrogen Initiative, INI, a highly successful IGBP “Fast Track Initiative”.

Organic Aerosols Workshop [May 10-12, 2004; Hyytiälä, Finland]

Co-sponsored by IGAC, iLEAPS & SOLAS, this workshop had 39 attendees, including three IGAC SSC members. The IGAC Seattle and Rome Offices each paid the travel expenses of two attendees. A white paper manuscript on the workshop outcomes was published in *IGACtivities* Newsletter No. 31 (June, 2005).

Halogens Workshop [May 27-28th, 2004; Heidelberg, Germany]

Co-sponsored by IGAC & SOLAS, this workshop had 22 attendees. The IGAC Seattle office contributed ~\$6,000USD of support (about half the total cost needed). A very comprehensive white paper and a new task proposal on Halogens in the Troposphere resulted from the workshop. Through this process, a larger community has been engaged in the HitT activity. The HitT Task proposal was recently (March, 2007) endorsed by the IGAC SSC. The white paper and Task proposal are available at: <http://www.igac.noaa.gov/HitT.php>

Aerosol Indirect Effect Workshop [January 5-7, 2005; Manchester, England]

The Seattle Office contributed \$30,000USD and the IGAC Rome office ~\$15,000USD for travel support and workshop expenses. In addition the Seattle office provided significant logistical support to its organization. This workshop resulted in two manuscripts submitted peer-reviewed publications:

- McFiggans, G, P. Artaxo, U. Baltensperger, H. Coe, M. C. Facchini, G. Feingold, S. Fuzzi, M. Gysel, A. Laaksonen, U. Lohmann, T. F. Mentel, D. M. Murphy, C. D. O’Dowd, J. R. Snider, and E. Weingartner, The Effect of Physical & Chemical Aerosol Properties on Warm Cloud Droplet Activation, *Atmos. Chem. Phys. Disc.*, 5, 8507-8646, 2005.

- Lohmann, U., Feichter, J., Kinne, S., and Quass, J., Approaches for constraining global climate models of the anthropogenic indirect aerosol effect, submitted to Bulletin of the American Meteorological Society, 2005.

Air-Ice Chemical Interactions (AICI) Workshop [*May 29-31, 2006, Grenoble, France*]

This was a workshop to draft papers summarizing the outcomes of the IGAC AICI Task. Five papers are in preparation for peer-reviewed publication. The IGAC Seattle Office supported the attendance of five attendees to the workshop.

SPARC/GEWEX-GCSS/IGAC Workshop: Modeling of Deep Convection and of Chemistry and their Roles in the Tropical Tropopause Layer [*June 12-15, 2006, Victoria, BC, Canada*]

The tropical tropopause layer (TTL) is a transition layer in which the air has mixed stratospheric and tropospheric properties. The TTL has received attention within the WCRP-SPARC community from the perspective of its importance for processes in the tropical lower stratosphere, while research on modeling and understanding of deep convection in the tropics has received considerable attention within the WCRP-GEWEX Cloud System Study (GCSS). The IGAC community is interested in the role of deep convection in transporting and processing chemical constituents and aerosols. The aim of this workshop was to bring together expertise from these communities and related research activities on stratospheric processes and modeling of deep convection and chemistry in the tropics to set the stage for a better understanding of the role of convection in determining the thermal structure and composition of the TTL.

The IGAC Seattle Office provided travel support for seven of the workshop participants and some funds for general workshop expenses, as well as considerable logistical support. The workshop discussions were summarized in an article published in both the IGAC and SPARC newsletters. The workshop participants were very eager about the chance to meet and learn from scientists working on this problem from a different perspective than their own. There was a strong desire expressed to hold a follow-on workshop in ~2 years' time. The outcome of this workshop is also feeding into the IGAC/SPARC Atmospheric Chemistry and Climate Initiative.

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4. Outreach activities

IGAC engages the broader community via publication of a scientific newsletter and through our biennial conferences. Five issues of the *IGACtivities* newsletter were printed and mailed to ~3500 recipients under this grant. *IGACtivities* is primarily comprised of scientific articles, summarizing recent research or the state of knowledge in a given area of atmospheric chemistry, in a way that is somewhat less formal and more accessible to the broader audience than is a journal article.

While the printing and mailing of the newsletter is taken care of by Academia Sinica in Taipei, Sarah Doherty (funded under this grant) is fully responsible for planning newsletter issues, recruiting article authors, and editing of the newsletter. All past issues of the newsletter (now numbering 35 in total) are downloadable from the IGAC web page (<http://www.igac.noaa.gov/newsletter/index.php>)

IGAC's biennial conferences are our primary mechanism for facilitating the dissemination of scientific information across our community. A special effort is made to engage young and developing country scientists in our conferences. Specific activities toward capacity-building include a special Young Scientists' program at our conferences; providing financial support to young scientists in need to participate in our conferences; and providing funding support to individuals to attend IGAC co-sponsored workshops. Travel support is provided based on an assessment of both need and merit. For workshops, in many cases key players have been able to attend only with IGAC financial support.

To make the organization's activities as international as possible, the conference location changes from year to year, reaching for broad geographic coverage. Past conferences have been held in Israel, Japan, the U.S., Australia, Italy and Greece. IGAC's 8th International Conference was held September 4-9, 2004 in Christchurch, New Zealand. The latest findings in atmospheric chemistry were shared amongst the 409 attendees, coming from 38 countries. Because of the excellent meeting attendance and careful planning of the local organizing committee, conference registration fees covered the full cost of the meeting. Using generous contributions from WMO (\$8,000USD), NASA (\$25,000USD), NSF (\$25,000USD), Academia Sinica (\$9500USD), the European ACCENT project (\$25,000USD) and funds from this grant (\$10,000USD) we were able to support the attendance of 62 young scientists from 23 countries.