

**2006-2007 Annual Report
International Global Atmospheric Chemistry (IGAC) Project
Award Number 0550953**

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Overview

The IGAC Project continues to be run out of the NOAA Pacific Marine Environmental Lab facility, with Timothy Bates as P.I. and Sarah Doherty as the IGAC Executive Officer. The project activities are guided and, in many cases, implemented by the IGAC Scientific Steering Committee, which acts on a volunteer basis. Members of the IGAC SSC are listed in the Appendix of this report.

In 2006, the IGAC Science Plan and Implementation Strategy was at long last published and has been distributed by mail and at conferences and meetings. The document can be downloaded as a .pdf from the IGAC web site (<http://www.igac.noaa.gov>) or hardcopies can be obtained from the project office (igac.seattle@noaa.gov).

Implementation of the project science plan is via four main pathways:

- 1) Tasks – Research activities with a specific set of scientific goals that are achievable in a 3-4 year timeframe, with requirements around data accessibility, data QA/QC, multi-national inclusion, and capacity-building components. Tasks are proposed to and endorsed by the IGAC SSC and are reviewed annually and on an as-needed basis.
- 2) Workshops – IGAC will co-sponsor (e.g. by providing organizational and/or financial assistance) focused workshops on specialty topics. In most cases, there is a requirement that these workshops be structured to produce a tangible outcome, such as journal publication(s) or research plan(s).
- 3) Initiatives – This implementation mechanism is new to IGAC in 2006. Here the SSC identifies areas in atmospheric chemistry that are in need of attention but which are not currently being addressed by the community. The idea is to try to use a “top-down” approach to initiating an activity which, in the end, will require engagement by the research community.
- 4) Communications/Networking – This covers a myriad of activities, including biennial conferences, a newsletter (mailed to ~3500 researchers around the world), our web page, and miscellaneous networking activities conducted throughout the year.

Tasks

Activities within IGAC Tasks continued in 2006 to enrich our understanding of atmospheric chemistry in the Earth system. Following are brief summaries of the activities under IGAC Tasks during 2006, including one new IGAC Task (“HitT”):

- AICI Task (Air-Ice Chemical Interactions)

AICI aims to study the role that chemistry within the snow-pack and ice may play in controlling aspects of boundary layer chemistry. This is being 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).

The AICI Task was endorsed in 2003, and is scheduled to conclude in 2007. In 2006, several important field campaigns contributing to AICI made substantial progress. These and other data from campaigns over the past three years fed into discussions at an AICI Workshop, held in Grenoble, France, May 29-31, 2006. The meeting was mainly focused on preparing the outline of three major review papers of AICI science issues, i.e.: snow photochemistry, tropospheric ozone depletion and halogens, and mercury in the polar regions. Two additional overview papers (on boundary layer meteorology relevant to AICI, and on snow physics) are also planned. These papers have now in-press and will appear in a special issue of Atmospheric Chemistry and Physics later in 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".

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

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. 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. Some highlights of the 2006 field season include:

 - An ozone soundings network is providing insights to the role of dynamics in driving the vertical structure of ozone and other chemical constituents (e.g. CO, H₂O) in the atmosphere in this region.
 - Information on vertical structure/distribution is also being revealed by measurements of CO and ozone over West Africa region derived from MOZAIC-AIR NAMIBIA, commercial aircraft-based measurements which provide a daily horizontal transect from South Africa to Europe.
 - Variations in NO_x and VOC emissions with the annual and seasonal cycle of the vegetation and soil moisture are starting to be understood, based on a combination of measurements and models. NO emission from soils represent an important part of total NO emissions. Also studied were: the impact of soil moisture on the local and mesoscale dynamics, the emissions from the mega-city of Lagos, the differences between daytime and nighttime dynamics and chemistry, the impact of rainfall on NO_x emissions, analysis of the fast photochemistry of the region, and the composition of southern hemisphere biomass burning emissions transported northwards into West Africa.
 - Aerosols and radiation measurements were studied extensively during the dry season experiment. Areas of study included the mixing of dust aerosols and biomass burning particles over the Niger/Mali/Nigeria/Benin region; observations of aerosol radiative properties from an airborne lidar; the optical, chemical and microphysical properties of the aerosols from measurements at several ground

sites; and aircraft measurements specifically looking at the deposition of dust over the Atlantic ocean.

- A series of north-south meridional transects performed by five aircraft were used to study the latitudinal and vertical gradients of air masses. Intrusions of southern hemispheric biomass burning plumes were observed at different levels over the ocean.
- The role of convective systems in producing mineral dust through local soil erosion and apportioning their relative contribution to the total column dust was explored during the AMMA wet season June-July campaigns.
- High-altitude aircraft and balloons were used to study the impact of large continental meso-scale thunderstorms systems (MCS) on the lower stratosphere. The project has been particularly successful, providing clear indication of deep fresh overshooting of tropospheric air, including ice particles, into the stratosphere up to 420-450 K potential temperature levels. In addition, large amounts of NO_x were measured near cloud out-flow regions.
- Models were used extensively throughout the field campaigns both for measurement planning and for understanding airmass origin.

The next year will be dedicated to the scientific analysis of the SOP campaigns and modeling activities. Some enhanced observations will continue in 2007 (e.g. ozonesoundings).

➤ 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.

We are currently in the process of starting a new activity to re-assess our understanding of dry depositional processes and to translate lessons from the DEBITS (and other) field measurements into improved model representation. This idea is borne out of discussions at the DEBITS September 2006 Workshop. This new activity would be a joint effort of IGAC-DEBITS, and iLEAPS.

➤ 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.

➤ 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.

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.

The goal of the ITCT-Lagrangian-2K4 Experiment was to directly observe the evolution of the aerosols, oxidants and their precursors from emission over North America, trans-Atlantic transformation and transport, and impact on aerosol and oxidant levels over Europe. 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. 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.

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 PICONARE 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.

This past year comprised the data analysis and manuscript preparation phase of the Task. Some of the results from ITCT-2k4 are discussed in Section 2 above, and a list of ITCT-2k4 publications are given in Section 4 below.

➤ Mega-cities: Asia Task

This task aims to make a comparable set of studies of atmospheric chemistry around mega-cities in the Asian region, with an interest both in air quality and radiative/climate impacts.

- Data acquisition and analysis has been ongoing since the Task was endorsed in 2003
- 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) have been established for use across all Mega-cities: Asia measurements.
- Understandings on the diurnal and seasonal variations of different types of PM₁ aerosols and their precursor gases 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.
 - 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 are 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 modelling; 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.
 - Ongoing measurements also continued in mainland China, China-Taipei, Japan, and Korea, with coordination and data-sharing via a Mega-cities: Asia web page. However, there continue to be problems with local agencies not releasing data for public use.
 - Over the past year, first steps have been taken to have Mega-cities: Asia become part of a larger, overarching IGAC initiative to coordinate mega-cities studies around the globe (see below).
- POLARCAT Task (Polar Study using Aircraft, Remote Sensing, Surface Measurements and Models, of Climate, Chemistry, Aerosols, and Transport)
- POLARCAT is an effort to coordinate measurements during the upcoming International Polar Year (March 2007-March 2009), with the specific aims of studying the long-range transport of pollutants into the Arctic region. POLARCAT will execute a series of aircraft experiments at different times of the year in order to follow pollution plumes of different 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 2006, the main role of the POLARCAT Task team was to ensure that the science being planned in the proposals is coordinated/complementary. As part of this effort, the POLARCAT team held a planning meeting during the IGAC Open Science Conference in September, 2006.
 - The IGAC AICI-IPY Task that is being planned will be a component of POLARCAT.
- HiT Task (Halogens in the Troposphere)

- This Task originated out of a May, 2004 workshop on this subject, co-sponsored by IGAC and IGBP's SOLAS (Surface Ocean Lower Atmosphere Study) project. A very comprehensive white paper reviewing the state of knowledge about halogens in the troposphere, their importance, and the key areas of uncertainties resulted from the workshop. This white paper was used as the basis for the more focused HitT Task, which was endorsed by IGAC in March, 2007
- The primary objective of the project HitT – Halogens in the Troposphere - is to determine and quantify the importance of reactive halogen compounds (RHCs) in tropospheric chemistry and climate forcing. Key themes are the influence of RHC on the oxidative capacity of the atmosphere, the ozone budget, as well as in aerosol nucleation and growth.
- HitT will take advantage of the International Polar Year (IPY, 2007-2008), which will include many measurements across, in particular, the Arctic. These measurements will help elucidate snow and ice chemical reactions that may be leading to observed high-bromine surface ozone depletion events and to investigate the role of halogens in the marine boundary layer.
- The HitT Task also comprises laboratory measurements, e.g. of kinetic rates of key reactions.

Workshops/Meetings:

IGAC co-sponsored several workshops the past year, mostly around the new Atmospheric Chemistry and Climate Initiative. (Note that the SPARC/GEWEX-GCSS/IGAC Workshop in June, 2006 is feeding into this initiative). In addition, we supported a workshop for the IGAC AICI Task, where planning for four summary papers was started.

- *Air-Ice Chemical Interactions (AICI) Workshop*, May 29-31, 2006, Grenoble, France
- *SPARC/GEWEX-GCSS/IGAC Workshop: Modelling of Deep Convection and of Chemistry and their Roles in the Tropical Tropopause Layer*, June 12-15, 2006, Victoria, BC, Canada
- *Atmospheric Chemistry & Climate Initiative Scoping Meeting*, August 7-9 2006, Boulder, Colorado, USA
- *SPARC/IGAC Session: Atmospheric Chemistry & Climate*, ESSP OSC, November 9-12, 2006, Beijing, China
- *Atmospheric Chemistry & Climate Initiative 1st Workshop*, January 22-23, 2007, Geneva, Switzerland
- *Halogens in the Troposphere Task planning meeting*, April 21, 2007, Vienna, Austria
- *POLARCAT Planning Meeting*, June 4-6, 2007, Paris, France

Travel costs for liaison activities were also covered, allowing either an IGAC SSC member or the IGAC Executive Officer to attend the steering committee meetings of related projects (e.g. IGBP's iLEAPS, SOLAS, and AIMES Projects and WCRP's SPARC Project). We continue to consider such liaison travel to be critical to IGAC's goal of advancing atmospheric chemistry research within the context of the Earth system.

Initiatives

A major activity of IGAC in 2006-7 was spearheading a new joint initiative with WCRP's SPARC (Stratospheric Processes and their Role in Climate) project, on "Atmospheric Chemistry and Climate". This initiative seeks to improve the representation of chemistry/climate interactions in models. Four main research activities have been identified, as have two cross-cutting activities. Steering committees for each have been formed and are in the process of being finalized, and

detailed planning for each activity is in progress. A more comprehensive report on this activity is included as a supplemental document.

IGAC was separately approached by researchers interested in improving the representation of wet deposition in models and in re-assessing our state of understanding of dry deposition measurements and modeling. An article was written for the *IGACtivities* Newsletter regarding the wet deposition initiative, describing the activity and inviting participation. We expect that both of these efforts will see progress in 2007 and will contribute directly to the Atmospheric Chemistry and Climate Initiative.

In addition, we worked with year with IGBP's iLEAPS (Integrated Land-Ecosystem Atmosphere Process Study) project and the WCRP GEWEX (Global Energy and Water Experiment) project on scoping out a new initiative on "Aerosols, Clouds, Precipitation and Climate". This initiative is still very much in the planning stages, with an outline for the activity established at a small workshop in March in Mainz. A workshop in October 2007 will convene key players from the IGAC, iLEAPS and GEWEX communities to discuss the current state of science and to put together a plan of action to make progress on the interactions between aerosols, clouds, precipitation and climate.

Meetings were also held at the September IGAC Conference and at the December AGU Conference to start up an activity to integrate/coordinate different studies (Asia, central and S. America, Africa, Europe, U.S.) looking at the regional to global-scale impacts of mega-cities and metro-agro complexes on atmospheric chemistry.

IGAC 2006 Conference

The 9th IGAC Open Science Conference was held, joint with CACGP and WMO, September 17-22, 2006 at the Cape Town International Convention Center, South Africa. The theme of the conference was "Atmospheric Chemistry at the Interfaces". There were 410 attendees, with 77 attendees from African countries (S. Africa, Kenya, Malawi, Zimbabwe, Zambia, Republic of the Congo, Tanzania, Botswana, Cameroon & Côte d'Ivoire). Thanks to generous support from NASA, the funds provided under this grant, and contributions from WMO, European ACCENT, Univ. of Witwatersrand, and CACGP, travel support was provided for 49 young scientists. The program featured a special Young Scientists' Program, as well as sessions on IGAC-iLEAPS, IGAC-SOLAS and IGAC-SPARC cross-cutting topics. Steering groups for the various IGAC Tasks (POLARCAT, AICI, Mega-cities) also used the conference as an opportunity to have side-meetings. The Mega-cities Integration and Wet Deposition initiatives were also kick-started at this conference.

Future Plans

With the rotation off the SSC of Sandro Fuzzi (Italy), Makoto Koike (Japan) and Dave Lowe (New Zealand), three new SSC members joined the IGAC SSC in January 2007: Celine Mari (France; lead on the AMMA-AC Task), David Griffith (Australia) and Yutaka Kondo (Japan; lead on the Mega-cities: Asia Task).

A leading activity of IGAC in 2007-8 will be to continue to work with SPARC to move the Atmospheric Chemistry & Climate Initiative forward. We expect to support the attendance of some participants to steering committee meetings/workshops for the AC&C activities as needed. In 2008 there will need to be one or more workshops to kick-off the simulations planned for the four implementation activities.

As noted above, initial steps have been taken to start focused efforts on improving the representation of wet deposition and dry deposition on models. Both of these would be sub-activities related to the Atmospheric Chemistry & Climate Initiative. The issues of wet and dry

deposition involve separate processes and, to some degree, different research communities. Thus we anticipate two parallel efforts, each of which will assess the state of knowledge, areas where improvement is needed, and plans for addressing open issues.

IGAC will collaborate with iLEAPS and WCRP-GEWEX to plan the new activity on Aerosols, Clouds, Precipitation and Climate, starting with the October 2007 workshop (Boulder, Colorado). It is expected that a set of science foci and research plans will emerge from this workshop.

A first meeting was held in December 2006 to begin the integration of the many research projects that have recently emerged to study the regional to global-scale impacts of mega-cities and metro-agro complexes on atmospheric chemistry. We will continue to pursue this effort in 2007-2008.

We anticipate endorsing a new phase of the AICI Task in 2007: Air-Ice Chemical Interactions – International Polar Year (AICI-IPY).

The 10th IGAC Open Science Conference will be held 7-12 September 2008 in Annecy, France. As usual, we plan to raise funds to support ~40-50 young scientists to attend the conference. A special effort is being made to have this be a carbon-neutral event.

Appendix

IGAC Scientific Steering Committee Membership, 2006

Name, country	Expertise
John Burrows, <i>Germany</i>	Remote sensing, air quality, photochemistry
Jen-Ping Chen, <i>China-Taipei</i>	Aerosol physics & aerosol-cloud interactions
Nikolai Elansky, <i>Russia</i>	Field measurements, trace species, toxins
* Sandro Fuzzi, <i>Italy</i> (co-chair)	Organic aerosol (bio- & marine), aerosol-cloud interactions
Maria Kanakidou, <i>Greece</i>	Gas-particle interactions, modeling, atmos. oxidizing capacity
Laura Gallardo-Klenner, <i>Chile</i>	Inverse modeling, air quality, UT/LS, aerosol-cloud interactions
David Griffith, <i>Australia</i>	Trace gas measurements (remote sensing & in-situ), surface fluxes & exchanges
Achuthan Jayaraman, <i>India</i>	Aerosols, modeling, field measurements, air quality
* Makoto Koike, <i>Japan</i>	Air quality, photochemistry, field measurements
‡Yutaka Kondo, <i>Japan</i>	Ozone, aerosols, air quality, field measurements
Kathy Law, <i>UK</i> (co-chair)	Photochemistry, UTLS, integration of field measurements/modeling
* David Lowe, <i>New Zealand</i>	Photochemistry, trace gases, atmos oxidizing capacity
‡Celine Mari, <i>France</i>	Mesoscale modeling, interactions between atmospheric chemistry and dynamics, coupling measurements & models
Randall Martin, <i>Canada</i>	Remote sensing, air quality, photochemistry

David Parrish, <i>USA</i>	Photochemistry, trace gases, field measurements
Stuart Piketh, <i>South Africa</i>	Biosphere-atmosphere interactions, aerosol-cloud interactions
Graciela Raga, <i>Mexico</i>	Air quality, modeling, aerosol-cloud interactions
Philip Rasch, <i>USA (co-chair)</i>	Modeling aerosols, aerosol-cloud interactions, UTLS
Eric Wolff, <i>UK</i>	Photochemistry, air-ice chemical interactions, paleo
Tong Zhu, <i>China-Beijing</i>	Air quality, kinetics, biosphere-atmosphere exchanges

* *Rotating off as of January 1, 2007*

‡ *New members as of January 1, 2007*