2008-2009 Annual Report
International Global Atmospheric Chemistry (IGAC) Project
NSF Award # 0550953

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PARTICIPANTS

Tim Bates at NOAA-PMEL is the P.I. on this grant and continues to act in an advisory role to IGAC. Sarah Doherty, IGAC Executive Officer, is the primary participant on this project, working 75% time on IGAC activities. Some support is provided by an administrative staff at NOAA-PMEL (~10% time) and a graphic designer at the University of Washington Dept. of Atmospheric Sciences works (as needed for IGAC newsletter layout).

While these are the people whose pay is covered under this grant there is much wider body of participants in the IGAC project. The project activities are guided and, in many cases, implemented by the IGAC Scientific Steering Committee, which acts on a volunteer basis. (See table below for a list of IGAC SSC members in 2008-2009).

IGAC Scientific Steering Committee Membership, 2008-2009

Name	Country	Expertise
Gufran Beig	India	Urban air pollution, chemical transport modeling, middle atmosphere trends
Jen-Ping Chen	China-Taipei	Aerosol physics & aerosol-cloud interactions
Jim Drummond	Canada	Ground-, aircraft-, ballon- & satellite-based remote sensing; radiative transfer
Nikolai Elansky	Russia	Field measurements, trace species, toxins
Maria Cristina Facchini	Italy	Chemical processes in multiphase atmospheric systems (aerosols and clouds); organic aerosols & CCN
Graham Feingold	USA	Aerosols-cloud interactions; field measurements
Laura Gallardo-Klenner*	Chile	Inverse modeling, air quality, UT/LS, aerosol-cloud interactions
Allen Goldstein‡	USA	in-situ observations; organic gases and aerosols; biosphere-atmosphere fluxes of reactive trace gases
David Griffith	Australia	Gas phase species, remote sensing, FTIR spectroscopy, isotopic fractionation
Maria Kanakidou	Greece	Gas-particle interactions, modeling, atmos. oxidizing capacity
Abdourahamane Konare	Côte d'Ivoire	Aerosols & climate; interfacing measurements & modeling; emissions inventories
Yutaka Kondo	Japan	Air quality, trace gases, ozone, field measurements, remote sensing
Kathy Law (co-chair)	U.K.	Photochemistry, UTLS, integration of field measurements/modeling

Karla Longo‡	Brazil	Model development; biomass burning; emissions; chemical processes
Celine Mari	France	Mesoscale modeling, atmospheric chemistry and dynamics interactions
Olga Mayol-Bracero‡	Puerto Rico	Organics; field measurements; dust; black carbon
Paul Monks	U.K.	Satellite observations, field measurements, photochemistry, chemical kinetics
Kobus Pienaar‡	South Africa	In-situ observations of deposition; biosphere-atmosphere interactions
Stuart Piketh*	South Africa	Biosphere-atmosphere interactions, aerosol-cloud interactions
Graciela Raga*	Mexico	Air quality, modeling, aerosol-cloud interactions
Philip Rasch	USA	Modeling aerosols, aerosol-cloud interactions, UTLS
Tong Zhu (co-chair)	China-Beijing	Air quality, kinetics, biosphere-atmosphere exchanges

***** *These members rotating off as of January 1, 2009*
‡ *These members new as of January 1, 2009*

ACTIVITIES AND FINDINGS

Implementation of the IGAC 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 as 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.

<u>Initiatives</u>

Atmospheric Chemistry & Climate (AC&C)

AC&C is a joint activity of IGAC and WCRP's SPARC project with the goal of improving understanding of chemistry-climate interactions for improved prediction of climate and air quality. In it's first phase, AC&C includes a set of activities aimed at improving the representation of chemistry-climate interactions/processes in models and a second effort (new as of early 2009) to produce a report "Bounding the Role of Black Carbon in Climate".

Improving chemistry-climate interaction process representation in models

In June, 2008 a planning workshop held in June in Washington, D.C. joint with the Task Force on Hemispheric Transport of Atmospheric Pollutants (TF-HTAP) activity. This arrangement maximized efficiency since many of the same modeling groups will be doing both HTAP and AC&C model runs. More comprehensive plans for three AC&C Activities and commitments from modeling groups to do AC&C runs emerged from the workshop and through subsequent discussions at an October 2008 AeroCom meeting; a June, 2009 CCMVal workshop and a June, 2009 HTAP workshop. The IGAC Core Project Office sent leaders of the AC&C activities to these workshops in order to further coordination of the AC&C activities with the planning of these other activities. The AeroCom modeling groups will be carrying out the aerosol model runs for the "Hindcast" and "Scenarios" activities and coordination with CCMVal is essential for linking, e.g., the tropospheric and stratospheric model runs for ozone.

Following are the three AC&C modeling activities underway:

Decadal (1980-2009) Hindcast

Four separate hindcasts are planned:

~ Inert tracers (CFCs and N2O): To quantify the importance of changing emissions, tropospheric meteorology and stratosphere-troposphere exchange variability

~ Aerosols: To test models' accuracy in reproducing observed past trends in concentrations, chemical composition, optical properties, and aerosol optical depth; to study the effects of trends in emissions; and to understand the impact on aerosol trends of changing meteorology (& natural emissions) vs. changing anthropogenic emissions.

~ Tropospheric Ozone: To understand the effect of large changes over the last few decades in stratosphere-troposphere exchange, emissions, and climate.

~ Methane: To try and match observed trends and variability and quantify the importance of changing anthropogenic and natural emissions and OH variations.

Activity on Vertical Distributions

There are particularly large uncertainties in modeled distributions of trace species in the upper troposphere, even when the same emissions are used. Species at these altitudes are radiatively important, and aerosols that make it to these high altitudes will have a longer lifetime and therefore a large integrated impact. The initial set of model runs for this activity are designed to understand convection and scavenging processes, as these are among the most uncertain and largest "knobs" in the models affecting distributions in the upper troposphere.

Scenarios Activity

A set of "New Scenarios" of emissions Representative Concentration Pathways (RCPs) are being prepared for the next IPCC assessment. This activity will provide well-evaluated distributions of chemically-active trace species for use in models. This activity will also include an Atmospheric Chemistry & Climate Model Intercomparison Project (ACC-MIP) to complement the CMIP portion of the IPCC AR5 simulations. This activity would include diagnostics from the CMIP5 simulations and from additional runs of the composition-climate models, archiving more detailed data on the processes governing the behavior of gas-phase and aerosol species. Additional specific time-slice experiments are also being designed to enable the use and participation of chemistry-transport models.

Representatives from AC&C have been working with the groups generating the Representative Concentration Pathways (RCPs) that will be used in IPCC AR5 and with the AIMES GEIA project, to assure that the AC&C model runs use emissions data sets that are coordinated with those for the long-lived greenhouse gases in AR5, and that they are internally consistent. This has constituted a major effort that will be extremely valuable going into AR5.

Report on "Bounding the role of Black Carbon in Climate"

A new effort under AC&C in 2009 will be to produce a report by July 2010 on black carbon and climate. The goal is to summarize the state of the science of black carbon aerosol as a climate-

forcing agent and, specifically, the implications for mitigation decisions. This initiative began in response to a consistent and persistent call for such a published summary both from the science community and from policymakers and non-governmental organizations (NGOs) who are interested in the possibility of reducing anthropogenic climate forcing in the near-term (10-20 yrs) by addressing aerosol emissions.

The paper is expected to address:
- emission inventories by sector, with uncertainties;
- estimates of black carbon forcing, including choices of forcing metric;
- IPCC AR4 black-carbon forcing estimates and needed modifications to these estimates, including resolution of model differences when possible;
- extent to which model-derived concentrations and forcing are supported or challenged by observations;
- relationship between decreases in black-carbon-rich sources and decreases in associated radiative forcing;
- effect of co-emitted species (e.g., sulfate and organic carbon) on net radiative forcing from specific sources;
- cloud changes attributable to black carbon, presently known as aerosol direct, indirect and semi-direct forcing;
- radiative forcing of black carbon deposition on snow (i.e., albedo reduction).

The paper is also expected to briefly address issues around the feasibility of mitigating global black carbon sources – particularly in developing countries.

Lead authors for the paper are now confirmed and in a first teleconference in June, 2009 a draft outline of the paper was discussed. A first meeting of lead authors is planned for September, 2009 at NOAA in Boulder, Colorado and a second meeting in January 2010 (dates/location TBD).

Aerosols, Clouds, Precipitation & Climate (ACPC)

IGBP's iLEAPS (Integrated Land-Ecosystem Atmosphere Process Study) project, IGAC and the WCRP GEWEX (Global Energy and Water Experiment) project are jointly leading this effort which specifically addresses the impact of anthropogenic aerosols on precipitation processes. ACPC was first proposed as an activity in 2006, and the first ACPC workshop was held in October 2007 in Boulder, Colorado. There it was decided that an ACPC Science Plan and Implementation Strategy would be formulated by a Steering Committee with 2-3 members each from iLEAPS, IGAC and GEWEX. Over the past year, the SP&IS was refined through a series of f meetings of the ACPC Steering Committee members, taking place January, 2008, October, 2008 and April 2009 in Bern, Switzerland. The ACPC SP&IS was distributed for external review by members of the community in April 2009 and we are awaiting these reviews. The SP&IS will go though final revisions in July/August 2009 and will be submitted to the iLEAPS, IGAC and GEWEX Steering Committees thereafter, followed by an effort to secure funding for the research delineated therein.

Mega-cities Assessment

A new effort in 2008-9 is an initiative to produce an assessment report on the role of Mega-cities in atmospheric chemistry. In the context of IGAC, Mega-cities effectively act as large point sources of anthropogenic emissions, with emissions type varying significantly depending on, e.g., the level of economic development, local regulations, weather/climate-driven energy demands, and the level of industrial vs. agricultural vs. domestic activity within the urban area. Their impact at the regional to global-scale on air quality and climate in turn depend not only on the type and magnitude of their emissions but the local geography and meteorology.

Both intensive studies of specific mega-cities (Mexico City, Los Angles, Beijing, and others) and long-term monitoring have provided new understanding of the role of mega-cities in climate and air quality. The IGAC Mega-cities Assessment effort aims to collate the key findings about the

atmospheric chemistry in specific mega-cities around the globe; point out where additional studies are needed; compare and contrast atmospheric chemistry in different types of mega-cities (e.g. Los Angeles in the 1970's vs. Los Angeles present-day vs. Beijing present-day); elucidate how lesson learned in carefully studied mega-cities might translate to other less-studied mega-cities; and provide a integrated view and synthesis of the role of mega-cities in regional to global air quality and climate.

Lead authors for the report have been identified and a first meeting was held in Beijing in May, 2009 to finalize the paper outline, identify additional authors, and finalize the structure of specific chapters. Drafts of some sections of the report have been written, others are in progress, and a second meeting is planned for November, 2009. We expect to have a final report (the form of which is still being decided) and Executive Summary ready for publication by July, 2010.

Mega-cities and Coastal Zone IGBP "Fast Track Initiative"

"Mega-cities and Coastal Zones" was selected as an IGBP "Fast Track Initiative" at their April 2009 Scientific Steering Committee meeting. It is being lead by IGAC and the IGBP projects SOLAS (Surface Ocean Lower Atmosphere Study) and LOICZ (Land Ocean Interactions in the Coast Zone). FTIs are intended to be focused ~3-year efforts with concrete products, and IGBP provides some financial support for the FTI workshops.

Motivating this FTI is that many of the world's mega cities are situated adjacent to the coastal zone. They are inevitably large sources of emissions to the atmosphere and the oceans. The key issue to be addressed under this activity is whether the juxtaposition of large-scale urban emissions adjacent to a coastal environment results in specific, significant, complex and interlinked environmental problems of urban/regional air quality and sustainability of the coastal environment. For example, recent studies have shown that the interaction of halogens released from seasalt can alter photochemical ozone cycling. In turn, the cocktail of emissions from concentrated urban areas most certainly affect near-shore marine productivity, e.g. through the deposition of nitrogen and trace toxins.

The overarching scientific questions to be addressed under this initiative are:
• How do air-sea interactions (such as trace gas emissions and seasalt aerosol formation) within the coastal zone affect air pollution within and around mega cities?
• How do the interactions of large urban emissions and the marine boundary layer affect local climate?
• How do atmospheric deposition of both contaminants and nutrients from megacities affect the productivity of adjacent coastal waters?
There are of course also feedbacks between these issues such as changes in marine trace gas emissions due to changes in marine productivity which will also be addressed.

This initiative is just now in the planning stages, with the first workshop expected in February 2010 and a journal publication planned for late Spring/early Summer 2010.

Other IGAC Activities

7th International Symposium on Advanced Environmental Monitoring organized by the ADvanced Environmental Monitoring and Research Center (ADEMRC), Gwangju Institute of Science and Technology (GIST), Korea, 25-28 February 2008, Honolulu, Hawaii

- Mega-cities: Asia Task team organized a session

European Geophysical Union (EGU) conference, 13-18 April 2008, Vienna, Austria

- HitT Task session on Tropospheric Halogens

Atmospheric Chemistry & Climate Initiative (AC&C) Planning workshop, 9-14 June 2008, Washington, D.C.

- Held joint with the U.S. EPA/European Commission Task Force on the Hemispheric Tranpsort of Atmospheric Pollutants (TF-HTAP).
- Meeting of modelers + some observationalists to plan details of AC&C Activities & to engage broad range of modelling groups
- ~100 attendees; supports 9 participants' travel
- Sponsorship for AC&C workshops has been raised from the U.S. NOAA & FAA (Federal Aviation Administration)

HitT/AICI/SPARC/IGAC workshop on lab studies/kinetics, 16-18 June 2008, Cambridge, U.K.

- Joint IGAC/SPARC workshop, focussing on fruitful areas of research in laboratory studies. Areas of common interest around, e.g., hologens, between IGAC AICI (Air Ice Chemical Interations) and HitT (Halogens in the Troposphere) and SPARC communities.
- ~50 attendees
- Discussions & resulting recommendations published in January, 2009 issue of the IGAC newsletter (*IGACtivities* No. 40).
- Funding support provided by the British Antarctic Survey, IGAC and ESF's INTROP (Interdisciplinary Tropospheric Research: from the Laboratory to Global Change) programme.
- IGAC IPO supported 10 scientists to attend this workshop
- The meeting was organised in five sessions: 1. Surface and bulk properties of ices and clouds; 2. New experimental approaches to the study of ices and aerosols; 3. Halogen activation in the atmosphere; 4. Mercury in the cold; 5. Kinetics of the cold atmosphere.
- The meeting was extremely successful in explaining the issues and capabilities that laboratory, field and laboratory scientists have to each other. It also did a good job of entraining (especially) lab scientists that have not previously been involved in applied ice work. The need for high quality laboratory experiments to provide quantitative data for the interpretation of field data and as input for atmospheric models was stressed. Apart from the recommendations for science questions that need to be answered, a particularly practical outcome of the meeting was the idea that a new communal facility for carrying out experiments at and over ice surfaces was needed. This will require an international effort for the realisation and equipment with the relevant instrumentation. The AICI Task Team is leading the effort to consider how such an idea can be taken forward.

10th IGAC Conference, 7-12 Sept. 2008, Annecy France

- Theme: "Bridging the Scales in Atmospheric Chemistry: Local to Global"
- Special joint sessions with WCRP-SPARC & joint reduced registration fees. ~30 participants attend both conferences.
- 525 participants; funding support to 63 young scientists (student or w/in 5 years of PhD) with funding from NASA, NSF, NOAA, ACCENT, WMO, ESA & Seattle IPO.
- Free real-time web-casting of plenary sessions + all talks posted to web
- Special Young Scientists' Programme, including early ice-breaker, career center, and Young Scientists' Poster Contest.
- 3 winners of YS Poster Contest published articles based on their posters in the January, 2009 issue of IGAC Newsletter (*IGACtivities* No. 40).

Aerosols, Clouds, Precipitation & Climate (ACPC) planning meeting, 7-9 October 2008, Bern, Switzerland

- ACPC is a joint activity of iLEAPS, IGAC and WCRP-GEWEX.
- Meeting was of leads from each project
- Define current state of knowledge re: aerosol/cloud/precip interactions, and outline a path forward for a collaborative activity between the three projects.
- iLEAPS has taken the lead in ACPC; See iLEAPS report for more information

Special session on "Black Carbon: Air Quality and Climate Change", Better Air Quality (BAQ) Workshop, 12-14 November 2008, Bangkok, Thailand

- Special workshop organized by Mega-cities: Asia Task team leads

American Geophysical Union (EGU) conference, 15-19 December 2008, San Francisco, California

- HitT Task session on Tropospheric Halogens

European Geophysical Union (EGU) conference, 19-24 April 2009, Vienna, Austria

- IGAC/SOLAS AICI Task session "Boundary layers in high latitudes" (session AS2.4)
- IGAC/SOLAS HitT Task session "Atmospheric halogenated compounds and their chemical transformations" (AS3.9)

Special workshop on "Short-lived Pollutants and Arctic Climate" at POLARCAT data workshop, 4-6 June, 2009, Durham, New Hampshire, USA

- This workshop aimed to synthesize new knowledge emerging from the POLARCAT/IPY field campaigns, specifically to help inform policymakers around mitigation options for slowing Arctic warming. This workshop included both the scientific community and members from the NGO community and the EPA who are working with the U.S. government to formulate mitigation plans.

2. Findings

Tasks

Activities within IGAC Tasks continued in 2008-09 to enrich our understanding of atmospheric chemistry in the Earth system. Following are brief summaries of the activities under IGAC Tasks during mid 2008 to 2009:

IGAC/SOLAS Air Ice Chemical Interactions Task (AICI):

Five papers have now been published in *Atmospheric Chemistry and Physics*:
http://www.atmos-chem-phys.net/special_issue80.html
(Two of these articles moved from ACPD to ACP in 2007 and three in 2008; the first 3 articles published – Grannas et al., Simpson et al. and Domine et al. have already been cited 46 times between them.)

- Grannas, A.M. et al., An overview of snow photochemistry: evidence, mechanisms and impacts, *Atmos. Chem. Phys.*, **7**, 4329-4373, 2007.

"Photochemical production of a variety of chemicals has recently been reported to occur in snow/ice and the release of these photochemically generated species may significantly impact the chemistry of the overlying atmosphere. Nitrogen oxide and oxidant precursor fluxes have been measured in a number of snow covered environments, where in some cases the emissions significantly impact the overlying boundary layer. For example, photochemical ozone production (such as that occurring in polluted mid-latitudes) of 3–4 ppbv/day has been observed at South Pole, due to high OH and NO levels present in a relatively shallow boundary layer. Field and laboratory experiments have determined that the origin of the observed NOx flux is the photochemistry of nitrate within the snowpack, however some details of the mechanism have not yet been elucidated.

Reductions in sea ice extent in both the Arctic and parts of the Antarctic … will affect the influence of snowpack photochemistry, adding urgency to our current task of understanding and quantifying relevant processes… The modeling studies carried out to date, as well as field observations, suggest that reductions in snowpack emissions are likely to be regionally important, but the direct effect globally has not yet been addressed.

In polar regions, the radiative impacts of ozone are more important than at lower latitudes due to lower concentrations of water vapor. Hansen et al. (2005) have concluded that tropospheric ozone is an important contributor to warming and sea ice loss in the Arctic.

However, in particular through the reactions involving halogens, there is an intriguing positive feedback between sea ice loss, and the contribution of tropospheric ozone to radiative forcing, as loss of sea ice may cause reduced ozone depletion events and higher ozone levels, with increased radiative forcing and warming from tropospheric ozone."

- Domine, F. et al., Snow physics as relevant to snow photochemistry, *Atmos. Chem. Phys.*, **8**, 171-208, 2008.

"This overview details our current understanding of how (the) physical properties relevant to snow photochemistry vary during snow metamorphism… Inasmuch as possible, equations to parameterize these properties as functions of climatic variables are proposed, based on field measurements, laboratory experiments and theory. The potential of remote sensing methods to obtain information on some snow physical variables such as grain size, liquid water content and snow depth are discussed."

- Anderson, P. S. and W. D. Neff, Boundary layer physics over snow and ice, *Atmos. Chem. Phys.*, **8**, 3563–3582, 2008, Atmos. Chem. Phys., 8, 4115-4115, 2008.

"This paper provides a review of the underlying concepts and examples from recent field studies in polar boundary layer meteorology, which will generally apply to atmospheric flow over snow and ice surfaces. It forms a companion paper to the chemistry review papers in this special issue of ACP that focus on processes inking halogens to the depletion of boundary layer ozone in coastal environments, mercury transport and deposition, snow photochemistry, and related snow physics. In this context, observational approaches, stable boundary layer behavior, the effects of a weak or absent diurnal cycle, and transport and mixing over the heterogeneous surfaces characteristic of coastal ocean environments are of particular relevance… This paper provide(s) the main conceptual principals underlying Atmospheric Boundary Layer theory and associated models, and provides examples of useful micro-meteorological equipment to augment polar atmospheric air chemistry campaigns."

- Simpson, W. R. et al., Halogens and their role in polar boundary-layer ozone depletion, Atmos. Chem. Phys., 7, 4375-4418, 2007.

"During springtime in the polar regions, unique photochemistry converts inert halide salt ions (e.g. Br^-) into reactive halogen species (e.g. Br atoms and BrO) that deplete ozone in the boundary layer to near zero levels. Since their discovery in the late 1980s, research on ozone depletion events (ODEs) has made great advances; however many key processes remain poorly understood. In this article we review the history, chemistry, dependence on environmental conditions, and impacts of ODEs."

While the behaviour of OH under the high-bromine conditions is not yet known, "what is established is that very strong oxidation processes do occur, one of the most dramatic examples is the oxidation of mercury leading to its almost complete removal from the gas phase and deposition with impacts on polar ecosystems.… In coastal regions, the oxidation of DMS by BrO and Cl is dramatically increased but also the products are changed compared to "background" chemistry. The production of aldehydes and major effects on the sulfur cycle affect the interpretation of ice cores."

- Steffen, A. et al., A synthesis of atmospheric mercury depletion event chemistry in the atmosphere and snow, Atmos. Chem. Phys., 8, 1445-1482, 2008.

Starting as early as 1995 observations in the Arctic have revealed low concentrations of gaseous elemental mercury (GEM), a finding which was surprising given the known long lifetime of GEM in the atmosphere. "It is now known that, through a series of photochemically initiated reactions involving halogens, GEM is converted to a more reactive species and is subsequently associated to particles in the air and/or deposited to the polar environment." This article reviews research in the polar regions on these Atmospheric Mercury Depletion Events (AMDEs), "the methods used to collect Hg in different environmental media, research results of the current understanding of AMDEs from field, laboratory and modeling work, how Hg cycles around the environment after MDEs, gaps in our current knowledge and the future impacts that AMDEs may have on polar environments… Modeling results demonstrate that there is a significant deposition

of Hg to Polar Regions as a result of AMDEs. Models have also shown that Hg is readily transported to the Arctic from source regions, at times during springtime when this environment is actively transforming Hg from the atmosphere to the snow and ice surfaces. The presence of significant amounts of methyl Hg in snow in the Arctic surrounding AMDEs is important because this species is the link between the environment and impacts to wildlife and humans… Recent changes in the climate and sea ice cover in Polar Regions are likely to have strong effects on the cycling of Hg in this environment; however more research is needed to understand Hg processes in order to formulate meaningful predictions of these changes."

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

AMMA-AC is a component of the larger AMMA project. The size, comprehensiveness (crossing many scientific disciplines as well as the human dimension) and many institutional players involved in AMMA make it difficult to isolate the IGAC AMMA-AC Task contributions specifically. IGAC SSC member Céline Mari is one of the lead organizers of the atmospheric chemistry studies within AMMA, and IGAC has helped co-sponsor several AMMA-AC workshops, including supporting the attendance of African scientists.

In 2008 there were many publications and findings from the AMMA study. A Special Issue of the Journal of Geophysical Research – Atmospheres covered the AMMA dry season Special Operation Period (SOP0), the focus of which was aerosol and radiation measurements. (African Monsoon Multidisciplinary Analysis Special Observation Period 0: The Dust and Biomass-Burning Experiment (DABEX), Journal of Geophysical Research, vol. 113, no. D23, 2008). A Special Issue of Atmospheric Chemistry and Physics (ACP) is in processes, currently as 15 articles in review under ACPD.

Aerosols from both biomass burning and desert dust play an important role in both the north African region and globally, due to long-range transport. The processes that drive the emissions, transport and transformation of these two different types of aerosols results in a system that is both chemically and radiatively complex. The meteorological analyses suggest that the cool, dry, dusty inflow to the region from the north and the east undercuts the warmer, moister biomass burning laden air to the south forcing ascent of the biomass burning layers over the dust layers. Mixing occurs at the boundary between the biomass burning and mineral dust leading a complex internal/external composite of particles. The chemical composition and radiative properties of the biomass burning particles, mineral dust particles, and mixtures of the two received considerable attention at various measurement locations. (*From the overview article by Haywood et al., in the 2008 JGR Special Issue on AMMA*).

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

The field campaigns for POLARCAT began in March 2007 and culminated with intensive measurement campaigns in Spring and Summer 2008 (all in the Arctic region). Data from these campaigns is still being analyzed and synthesized, so it is too early for a balanced report on the scientific results obtained during the various campaigns but a few publications on the first results have already appeared. However, in an initial data workshop (June, 2009, New Hampshire, USA; see above) several things became clear: There is a distinct separation between pollutants aloft and those in the boundary layer. Pollution aloft is highly aged and is characterized by a "background" level of aerosol/ozone/CO, with periodic events (in all cases observed, biomass burning) which lead to higher levels of aerosols and ozone, characterized by a higher organic fraction (aerosols) than the background aerosol. The boundary layer appears to be characterized by lower concentrations of aerosol that are more influenced by anthropogenic pollution than the aerosol in the free troposphere. It is not clear to what extent pollutants in the free troposphere are mixed down into the boundary layer. At least during the period of the field measurements, it

appears that biomass burning plays a large role in generation of the Arctic Haze. Important open questions remain, e.g. about the representativeness of the field measurements; sources of pollution to the eastern vs. western Arctic; transport processes; the fraction of biomass burning emissions which are "natural" vs. "anthropogenic", and the fraction which are due to agricultural vs. forest burning.

Deposition of Biogeochemically Important Trace Species (DEBITS) Task

- Following are results from the IDAF network (IGAC DEBITS in Africa):

  - Martins, J.J. et al., Long-term measurements of sulphur dioxide, nitrogen dioxide, ammonia, nitric acid and ozone in southern Africa using passive samplers, 2007.
    - Spatial distribution of pollutants in southern Africa indicate strong anthropogenic contributions on the Mpumalanga Highveld.
    - Long term annual trends in pollutant concentrations decreased 1994 to 2004, after which a steady increase is observed. (This may be linked to the energy crisis in South Africa)
    - Seasonal trends in pollutant concentrations show maxima during winter time mainly due to increase energy use and biomass burning.

  - Galy-Lacaux, C. et al., Long Term Precipitation Chemistry and Wet Deposition in a Remote Dry Savanna Site in Africa (Niger), 2008.
    - Long term monitoring of wet deposition in a dry savanna of Niger
    - Characterization, interannual and seasonal variation of deposition fluxes
    - Interpretation and relation to main sources of atmospheric gases and particles

  - Adon, M. et al., Long term measurements of nitrogen dioxide, ammonia, nitric acid in Africa using passive samplers, submitted to ACPD, 2009.
    - Characterization and quantification of gases concentrations
    - Quantification of levels in non perturbed sites of west central African sites representative of dry and wet savannas and forested ecosystems
    - Internnual and seasonal variations according variations of climatological parameters and emission sources
    - Focus on nitrogenous gases:Zoom on the sahelian dry savanna ecosystems (Mali and Niger), experimental and modeling approach of nitrogenous gases emissions from soils.

  - Liousse, C. et al., African Aerosols Modeling during the EOP-AMMA campaign with updated biomass burning emission inventories, submitted to ACPD, 2008.
    - Major trends observed during AMMA/IDAF programs over Africa using both surface, vertical measurements and satellite data are well reproduced by our ORISAM/TM4 global model associated with the updated AMMA biomass burning emissions.
    - Seasonal variations of modeled and measured BC concentrations at Djougou (Benin), Lamto (Côte d'Ivoire) and Banizoumbou (Niger) sites.
    - Comparisons between modeled and observed size resolved (PM25 and PM10) atmospheric concentrations of mineral and organic species over Djougou (Benin, Western Africa) and Amersfoot (South Africa, PhD JJ. Martins) for intensive and extensive periods of measurement. Chemical speciation of rain obtained at Lamto (Ivory Coast) is well reproduced by the model.

  - Liousse C. and C. Galy-Lacaux, Urban Pollution in Western Africa, submitted to IGBP letter, December 2008.
    - Recent measurements of gas and particle atmospheric concentrations in a few capitals of Western Africa in the frame of IDAF, AMMA and POLCA programs have shown unexpected levels of pollution which are much higher than the WMO alert

level. For example BC concentrations downtown Bamako are 10 times higher than the one measured in Paris.

Mega-cities: Asia Task

Three goals were established for this Task:
1) Characterize the temporal and spatial changes of aerosols, oxidants, and their precursors primarily by surface measurements near and downwind of urban centers. Temporal variations include diurnal variation, variations associated with synoptic scale disturbances, and seasonal variation.
2) Characterize the composition, mixing state, and physical properties of aerosol in urban air. Determine hygroscopic and radiative properties of aerosol in urban air. These characteristics are important in understanding the impact of aerosol on the radiation budget.
3) Validate emission inventories of trace gases through comparisons of ratios of concentrations of trace species observed in urban air.

In 2008-2009, papers on the two campaigns PRIDE 2006 and CAREBEIJING 2006 conducted in Pearl River Delta and Beijing were prepared /submitted for publication to international journals (JGR, ACP, Science). A number of papers were published also from Korean and Hong Kong groups.

Extensive ground based campaigns, detailed analyses, and modeling works were completed. Through these efforts, the goals 1) and 2) are being successfully achieved.

Some specific results are given below, as an example.

- Important features and causes of the variability of sub-micron (PM1) aerosol in the Beijing area in summer are now understood (Takegawa et al., JGR in press). This is an important step in understanding of aerosol formation processes in the mega-cities in northeastern China.
- The important features of the aerosol observed near Beijing in summer are now well reproduced by a 3-D model (Matsui et al., submitted to JGR).
- The optical properties in the Beijing urban area are determined by in-situ and remote observations.
- It was demonstrated that spatial and temporal distribution of NO_2 over an urban area can be retrieved using an Imaging DOAS technique.

PUBLICATIONS & PRODUCTS

Current IGAC activities, opportunities and related meetings (as well as general information about the organization) are posted on the IGAC web page (http://www.igac.noaa.gov) which is hosted by NOAA-PMEL and maintained by Sarah Doherty, IGAC Executive Officer.

While many peer-reviewed publications result from IGAC Tasks and activities (see “Activities and Findings”), the primary product resulting directly from this grant is the IGAC newsletter, *IGACtivities*. The printing and mailing of the newsletter is taken care of by Academia Sinica in Taipei, but Sarah Doherty (funded under this grant) is fully responsible for planning newsletter issues, recruiting article authors, and editing of the newsletter. A graphic designer at the University of Washington, Dept. of Atmospheric Sciences, is paid to do article layout.

All past issues of the newsletter (now numbering 41 in total) are downloadable from the IGAC web page (http://www.igac.noaa.gov/newsletter/index.php). Three newsletters were produced over the past year and were mailed to ~3,500 scientists as well as posted on our web page.

• Issue No. 39 [September, 2008] Articles on Halogens in the Troposphere; Boundary Layer Processes; Aerosol, Clouds, Precipitation & Climate

• Issue No. 40 [January, 2009] Articles from IGAC Annecy Conference poster award winners; Report from Lab Studies Workshop
• Issue No. 41 [May, 2009] Articles related to the Atmospheric Chemistry and Climate Initiative: AeroCom; Gridded Emissions in Support of IPCC AR5; AC&C Model Intercomparison Project (ACC-MIP)

CONTRIBUTIONS

3. Opportunities for training and development

IGAC Workshops, co-sponsored conference sessions and the biennial IGAC conference are all opportunities for training and development, particularly in that we make a point of providing support to young and developing country scientists to attend these meetings. See "Activities" section of the report for specifics on such meetings/workshops/conferences held over the past year.

4. Outreach activities

IGAC engages the broader community via publication of a scientific newsletter, *IGACtivities*, and through our biennial conferences. *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. (See "Publications & Products").

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, Greece and New Zealand and Cape Town.

The 10th IGAC Open Science Conference was held September 7-12, 2008 at the Imperial Palace in Annecy, France. The theme of the conference was "Bridging the Scales in Atmospheric Chemistry: from local to global", with the following sessions:
1. Chemistry-climate: regional impact on the global scale
2. Biogenic and anthropogenic impacts of urban centres on the regional and global scale
3. Impact of clouds/chemistry on regional and global scales
4. Observing Atmospheric Composition from the Global to the local
5. From the nanoscale to the macroscale: Process studies.

A feature of the 10th IGAC conference was coordination with the 2008 WCRP-SPARC General Symposium, which is taking place the week immediately preceding the IGAC Conference in Bologna, Italy. The last two days of the SPARC conference and the first two days of the IGAC conference were being jointly sponsored by the two organizations and focused on the areas of atmospheric chemistry and climate and the tropical tropopause layer. Special registration fees

were established for both conferences, allowing attendees of one to attend the joint sessions of the other conference for a reduced fee.

As with past IGAC conferences, there was a special Young Scientists Program and young scientists (within 5 years of PhD) could apply for support for travel, registration, etc. As noted above, there were 525 participants in total, with funding support provided to 63 young scientists with funding from NASA, NSF, NOAA, ACCENT, WMO, ESA & Seattle IPO. In addition, the conference featured free real-time web-casting of the plenary sessions, and all of these talks are now available via the web.

The IGAC Seattle project office took an active role in planning the conference program, the young scientists' program, and other aspects of the meeting organization.