International Global Atmospheric Chemistry (IGAC)

ANNUAL PROGRESS REPORT 2013

Section 1

Prepared by:
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Throughout this report, please note collaboration with other IGBP and ESSP projects, IGBP National Committees, networking organisations (IAI, APN), ICSU bodies, etc., and where the work contributes to IPCC and the new ICSU *Earth System Sustainability Initiative*.

1. Key scientific highlights/findings

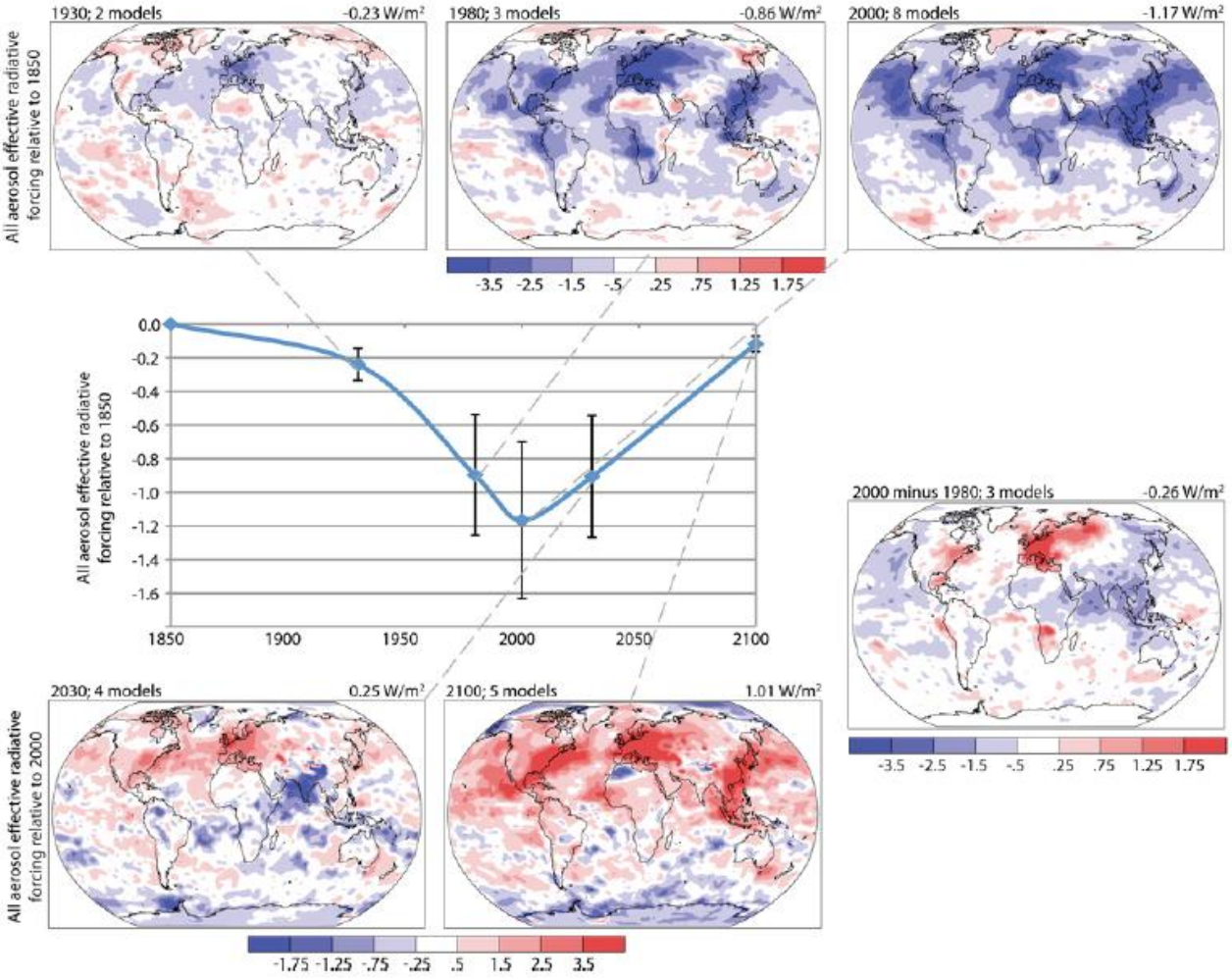
Describe three (or more) recent scientific highlights/findings with text (max. 200 words per highlight), a figure and references. Please focus on results that would not have happened without the project.

Information for: reporting/fundraising & outreach

See following page.

Atmospheric Chemistry and Climate Model Intercomparison Project (ACCMIP)

By analyzing 10 ACCMIP models that assess short-lived climate change drivers in present climate models, specifically those that include aerosols, the authors find that aerosol effective radiative forcing (ERF) masks a substantial percentage of late 20th and early 21st century global greenhouse forcing. Regionally this has resulted in negative net forcing over the majority of industrialized and biomass burning regions through 1980, with strongly negative forcing over east and southeast Asia by 2000. The authors further find strongly positive net forcing by 1980 over the Arctic and Australia, as well as most deserts and tropical oceans. They discern a subsequent trend in increased positive forcing globally, both in terms of magnitude and area.



(Above) Spatial patterns of all aerosol ERF for 1930, 1980 and 2000 relative to 1850, for 2030 and 2100 under RCP8.5 relative to 2000 and for 2000 relative to 1980. The time series shows global mean values all relative to 1850. All ERF values other than at 2000 are based on fractional changes relative to 2000 in models with data available at both times, and uncertainty is assigned as the relative uncertainty at 2000 (1.65 standard deviation as 5–95% confidence interval).

Radiative forcing in the ACCMIP historical and future climate simulations (2013) Shindell, D.T., J.-F. Lamarque, M. Schulz, M. Flanner, et al. Atmos. Chem. Phys., DOI 10.5194/acp-13-2939-2013.

Fundamentals of Atmospheric Chemistry

The authors stress that a checks and balances system of laboratory, observations, and modeling underpinned by fundamental atmospheric chemistry is crucial to the perpetuation of successful scientific research. They note a key instance of the application of this system wherein, motivated by ambient measurements, Haagen-Smit and his co-workers showed through laboratory experiments that ozone is formed when hydrocarbon and NO_X mixtures are exposed to sunlight. The consequence of this was an era of coupled NOx-VOC-O_3 chemistry that remains a central focus of the field (Haagen-Smit and Bradley, 1953). This work played a seminal role in the development of a fundamental understanding of laboratory, modelling and field observations.

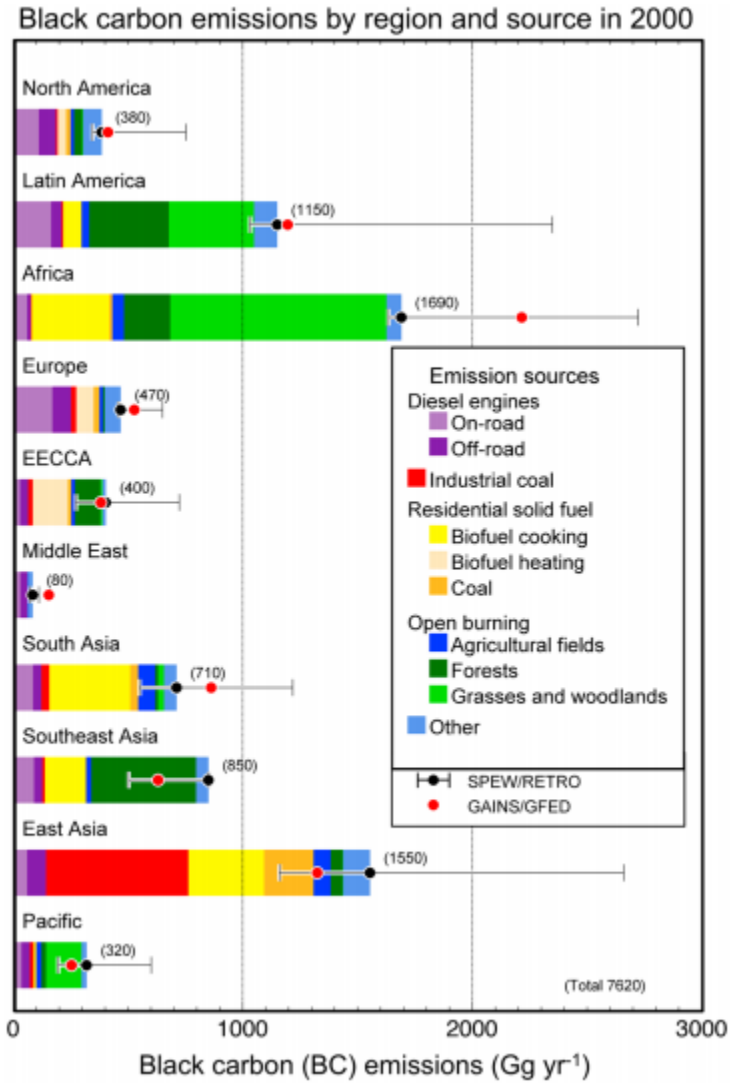
A more recent example is the substantial revision in scientists' understanding of isoprene oxidation chemistry, both theoretical (Peeters et al., 2009) and experimental (Crounse et al., 2011), that indicate the potential for OH regeneration and for reaction products, including short-lived Criegee intermediates, involved in secondary organic aerosol (SOA) formation (Paulot et al., 2009; Lin et al., 2012). The process by which these revisions were conducted followed the prescription of the three-legged stool: work that included gas-phase kinetics, heterogeneous uptake studies, development of reaction mechanisms, and significant analytical technique development, crucial for reconciling models with recent measurements of HO_X and SOA in biogenically impacted environments. The authors continue to note several examples of the dependence of atmospheric chemistry on fundamental research.

The authors conclude that resources must be designated for fundamental research in each of the three focal areas and that despite increasingly complexity of study, a "fundamentals approach" is essential to the future of successful and beneficial atmospheric chemistry.

New Directions: Fundamentals of atmospheric chemistry: Keeping a three-legged stool balanced (2013) Eds. J. Abbatt, C. George, M. Melamed, P. Monks, S. Pandis, and Y. Rudich. Atmos. Env., DOI 10.1016/j.atmosenv.2013.10.025.

Bounding the Role of Black Carbon in the Climate System

The authors of *Bounding the role of black carbon in the climate system: A scientific assessment* find principally that black carbon causes climate change at a scale not previously appreciated. Its direct climate impact is as much as double the findings of past assessments, including AR4, and as such should it be considered the "second most important climate-warming agent after carbon dioxide." Quantitatively its effect is approximately two-thirds that of carbon dioxide at 1.1W/m^2. While the atmospheric interactions of black carbon are complex, the report emphasizes high potential to immediately reduce its warming effect by improving emissions reductions for diesel engines and domestic wood and coal fires. This report was broadcast widely across popular media upon its release and recognized as "likely to guide research efforts, climate modeling, and policy for years to come."



(Above) Emission rates of BC in the year 2000 by region, indicating major source categories in each region. SPEW, GAINS, and RETRO emission data are the same as in Figure 8 of the report. Regions are shown in Figure 7 of the report.

Bounding the role of black carbon in the climate system: A scientific assessment (2013) Bond, T.C., S.J. Doherty, D.W. Fahey, P.M. Forster, et al. J. Geophys. Res.-Atmos., DOI 10.1002/jgrd.50171.

2. Activities

List your activities, e.g., research projects, special events (conferences, workshops), model and data intercomparisons, global datasets, etc.
Information for: reporting/fundraising & outreach.

Current Activities

Atmospheric Composition and the Asian Summer Monsoon (ACAM)
Jointly Sponsored by SPARC
Co-Chairs:
Laura Pan, National Center for Atmospheric Research, USA
Jim Crawford, NASA Langley Research Center, USA

ACAM is an emerging IGAC/SPARC activity that will be developed more fully over the next two years. Scientifically, the initiative focuses on four themes, each representing a key aspect of the connection between atmospheric composition and Asian monsoon dynamics:

1) Emissions and air quality;
2) Aerosols and clouds;
3) Convection and chemistry;
4) UTLS Response to the Asian Monsoon

Organizationally, the initiative invites the participation around four types of activities:

1) organizing data sharing for ACAM-relevant measurements;
2) forming a partnership with the CCMI activity to facilitate two-way interaction;
3) field campaign concept development;
4) sponsorship of training schools on model use for ACAM regional young scientists

As a weather pattern, the Asian monsoon impacts the lives of more than a billion people. With rapid population and economic growth of the regional countries in the recent decade, it becomes a pressing concern that the monsoon convection coupled to surface emissions is playing a significant role in the region's air quality. The uplift of pollutants also enhances aerosol–cloud interactions that may change the behavior of the monsoon. The chemical transport effect of the monsoon system is seen from satellites as an effective transport path for pollutants to enter the stratosphere. The monsoon system is therefore relevant to scales and processes bridging regional air quality, climate change, and global chemistry-climate interaction. Accurate representation of this system in global chemistry-climate models is critical to predicting how this evolving region may contribute to future change. To characterize and quantify the impact of the system, integrated study is essential, including observations (in situ and remote sensing) from the surface through the troposphere and stratosphere as well as modelling from regional to global scales. To be successful in this pursuit, it is necessary to build strong international collaborations to obtain the diverse expertise, resources, and access to the monsoon region for international research teams. The ACAM activity represents a critical step in building these international relationships.

Atmospheric Chemistry & Climate Model Intercomparison Project (ACCMIP)
Co-Chairs:
Drew Shindell, NASA Goddard Institute for Space Studies and Columbia Earth Institute, Columbia University, New York, NY, USA
Jean-Francois Lamarque, NCAR, Boulder, CO, USA

ACCMIP is providing extensive coordinated model simulations, diagnostics, and evaluations of the effect of short-lived species on climate, in coordination with the climate model intercomparison effort (CMIP5). The main focus is on the role of tropospheric ozone and aerosols, which both have substantial climate forcing that vary widely in space and time. ACCMIP will end as an IGAC activity after analysis of the last model output is complete. Future model runs will be part of the IGAC/SPAC Chemistry-Climate Model Initiative (CCMI, see below)

Atmospheric Chemistry & Health (AC&H)
Co-Chairs:
Candice Lung, Academia Sinica, Research Center for Environmental Change, Taipei, Taiwan
Christine Wiedinmyer, NCAR, ACD, Boulder, CO, USA

Research on atmospheric chemistry is motivated by the possible impacts on climate, ecosystems, and human health caused by the changes of atmospheric composition. Research ranges from laboratory measurements on the formation of pollutants, field campaigns on detailed gas and aerosol composition, long term observations at background stations (trend detection), satellite observations, regional and global scale modelling, focusing on short-term periods (weeks) to multi-decadal composition change. Research on health effects of atmospheric pollutants focuses on the relationships between exposure to outdoor air pollution and a range of acute and chronic health effects. This research comprises epidemiologic studies of the effects of short- and long-term human exposure to air pollution and toxicological experiments in animals as well as in-vitro studies of tissues and cells. Epidemiologic studies generally use ground-level measurements of air pollution at a limited number of locations, either alone or as part of spatial and or temporal models, to estimate the exposure of study populations, while toxicological studies use controlled experiments to evaluate toxicity and to understand the mechanism of air pollutants. Despite many shared issues, the atmospheric chemistry and health communities have developed research programs that, for the most part, do not explicitly acknowledge or relate to one another, and, as a result, even basic knowledge is not always widely shared. This initiative brings together these two communities to explore the various and multi-dimensional interactions between atmospheric chemistry and human health, with IGAC leading the atmospheric chemistry research needs.

Air-Ice Chemical Interactions (AICI)
Jointly sponsored by SOLAS
Co-Chairs:
V. Faye McNeill, Columbia University, USA
Thorsten Bartels-Rausch, Paul Scherrer Institut, Switzerland

The IGAC SSC first endorsed AICI in 2003 in light of research demonstrating new processes observed in the polar regions at the air-ice interface. The goal of AICI is to assess the significance of these processes at local, regional, and global scales by bringing together the

laboratory, field, and modelling communities. The first phase of AICI was very successful providing important information on the full range of processes and trace gases that are exchanged at the air/ice and snow/ice interface and how they related to atmospheric chemistry and climate. The first phase resulted in various publications, including a Special Issue in Atmospheric Chemistry and Physics. In June 2011, AICI held a workshop at Columbia University, USA that brought together new insights from AICI studies over the last eight years, including work carried out at part of Ocean-Atmosphere-Sea Ice-Snowpack (OASIS), International Polar Year (IPY), and another IGAC Activity Halogens in the Troposphere (HitT). The past eight years of research produced new insights into cirrus ice and NOY chemistry of the upper troposphere, air-snowpack exchange, and the role of halogen activation in the polar boundary layer. Much discussion during the workshop dealt with novel laboratory results that provide a molecular level understanding of the chemistry in snow and with the challenge to connect those to field observations by appropriate models. The challenge to develop detailed snow-chemistry models that better describe and predict air-snow interactions is considerable given that the chemistry proceeds via multiple steps, the snow is highly heterogeneous, and the number of important trace gases and radicals is numerous. The outcome of the Columbia University workshop was a joint special issue in Atmospheric Chemistry and Physics and Earth System Data on "New Perspectives on Air-Ice Chemical Interactions".

Air Pollution & Climate: A Science-Policy Dialogue
Co-Chairs:
Kathy Law, LATMOS, France
Paul Monks, University of Leicester, UK

As part of its second phase synthesis activities, the IGBP has identified several key areas which cut across research in its own core projects and which also reach out beyond IGBP with the aim of exploring future cross disciplinary research needs. The IGBP Air Pollution & Climate initiative, led by IGAC, seeks to open a science-policy dialogue on the air pollution and climate change challenge. There is still a separation between air pollution and climate change in both the policy and scientific communities. As with many issues, there also exists a divide between the scientific and policy communities that hinders communication and understanding. This activity will come to a close in 2014 upon the publication of a *Strategic Framework for Integrated Programs on Air Pollution and Climate Change*.

Chemistry-Climate Model Initiative (CCMI)
Jointly sponsored by WCRP-SPARC.
Co-Chairs:
Veronika Eyring, DLR, Cologne, Germany
Jean-Francois Lamarque, NCAR, ACD, Boulder, CO, USA
Michaela Hegglin, University of Redding, UK

Increasingly, the chemistry and dynamics of the stratosphere and troposphere are being studied and modeled as a single entity in global models. As evidence, in support of the upcoming Intergovernmental Panel on Climate Change Fifth Assessment Report (IPCC AR5), several groups have performed simulations in the Coupled Model Intercomparison Project Phase 5 (CMIP5) using global models with interactive chemistry spanning the surface through the stratosphere and above. In addition, tropospheric and stratospheric global chemistry-climate models are continuously being challenged by new observations and process analyses. Some recent intercomparison exercises have for example highlighted shortcomings in our understanding and/or modelling of long-term ozone trends and methane lifetime. Furthermore, there is growing interest in the impact of stratospheric ozone changes on tropospheric chemistry

via both ozone fluxes (e.g. from the projected strengthening of the Brewer-Dobson circulation) and actinic fluxes. This highlights that there is a need to better coordinate activities focusing on the two domains and to assess scientific questions in the context of the more comprehensive stratosphere-troposphere resolving models with chemistry. To address the issues, the joint IGAC/SPARC Chemistry-Climate Model Initiative (CCMI) was established to coordinate future (and to some extent existing) IGAC and SPARC chemistry-climate model evaluation and associated modelling activities

Deposition of Biogeochemically Important Trace Species (DEBITS)
Jointly sponsored by WMO
Chair:
Kobus Pienaar, North-West University, South Africa

Wet and dry deposition of chemical species to the earth's surface plays an essential role in controlling the concentration of gases and aerosols in the troposphere. The chemical composition of atmospheric deposition provides important information on many interacting physical and chemical mechanisms in the atmosphere such as emission sources, atmospheric dynamics and transport, atmospheric removal processes, and nutrient cycling in ecosystems. Long-term research on deposition thus provides critical information on natural and anthropogenic influences on the atmosphere and provides information on the temporal and spatial evolution of atmospheric chemistry. Phase I of DEBITS, which was initiated in 1990 under the first phase of IGAC, focused on the development of an international measurement network of stations to monitor the wet and dry deposition of biogeochemically important trace species. As a result of Phase I, DEBITS stations are of the highest data quality and assurance, following the WMO/GAW data quality objectives. In Phase II, the DEBITS science community has adopted a twofold approach to maintain the present operational structure of DEBITS and to support a new integrated approach to deposition flux measurements and impact studies. Despite the efforts of the DEBITS Task and other research, wet and especially dry deposition remains a large unknown in the chemical budget of the atmosphere. The IGAC SSC believes there is still a strong need for international collaboration and integration of research on atmospheric deposition, especially in implementing and maintaining long-term monitoring networks and understanding the chemical/physical properties of deposition.

Fundamentals of Atmospheric Chemistry
Fundamental atmospheric chemistry research provides essential data used in all practical (laboratory, field measurements, remote sensing) and theoretical (climate modeling, pollution modeling, cloud microphysics) aspects of scientific endeavor. These studies encompass a diverse range of areas including gas-phase kinetics, heterogeneous chemistry, chamber studies, photochemistry, spectroscopic and thermodynamic chemical data, and meteorology that together, with the attendant measurement techniques, deliver the data and the constant evolution required to work in the atmospherically relevant physical and chemical regimes. The evolution of atmospheric chemistry research has resulted in more emphasis on field research and modeling than on fundamental research typically done in the laboratory. Therefore, laboratory studies for atmospheric chemistry stand at a cross-roads. In many respects they are decreasing due to shifts in funding towards large field campaigns.. Many of the pioneers and innovators of the last great paradigm shift have begun to retire and there is a risk of a shrinking community, yet the need remains the same if not more in light of challenges such as climate change, climate manipulation, and pollution-related health impacts. In response, IGAC is exploring the need for an initiative on Fundamentals of Atmospheric Chemistry that would

stress the importance of continued fundamental research in atmospheric chemistry but that would explore innovative ways fundamental research could be sustained and possibly move from the laboratory bench to, for example, a component of field research.

Global Emissions InitiAtive (GEIA)
Jointly sponsored by iLEAPS, AIMES
Co-Chairs:
Greg Frost, CU/CIRES and NOAA/ESRL/CSD, USA
Leonor Tarrason, NILU, Norway

Quantification of chemical emissions into the air is a key step in explaining observed variability and trends in atmospheric composition and in attributing these observed changes to their causes on local to global scales. Accurate emissions data are necessary to identify feasible controls that reduce adverse impacts associated with air quality and climate, to track the success of implemented policies, and to estimate future impacts. GEIA is a community effort that builds bridges between environmental science and policy, by bringing together people, data, and tools to create and communicate the highest quality information about emissions. GEIA seeks to enhance access to emissions data, facilitate analysis to improve the scientific basis for emissions information, and strengthen the emissions community.

Halogens in the Troposphere (HitT)
Jointly sponsored by SOLAS
Co-Chair:
Roland von Glasow, University of East Anglia, UK

The primary objective of the SOLAS/IGAC task HitT 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. The goal of HitT is to facilitate international collaboration between laboratory, field, and model activities regarding tropospheric halogen chemistry especially in the following domains: polar regions, salt lakes, marine boundary layer (both remote and coastal), volcanoes, free troposphere, and urban areas. Since HitT was first endorsed as an IGAC ACtivity in 2007, halogens in the troposphere has become a very active research field publishing special issues in Atmospheric Chemistry and Physics on “Radical Chemistry over sunlit snow: interactions between HOX and halogen chemistry at Summit, Greenland" and “The TransBrom Sonne ship campaign in the West Pacific”. HitT also works closely with the AICI IGAC Activity as well as the international multidisciplinary OASIS program. Advancements in atmospheric chemistry research on halogens in the troposphere is leading to several upcoming field campaigns such as the 2012 Tropical Ocean troposphere Exchange of Reactive Halogen Species and Oxygenated VOC (TORERO) field campaign funded by NSF and NCAR, the Surface Ocean Processes in the ANthropocene (SPORAN II) funded by the German Federal Ministry for Education and Research, and HALOPROC II funded by the German Research Foundation (DFG).

Interdisciplinary Biomass Burning Initiative (IBBI)
Jointly sponsored by iLEAPS and WMO
Co-Chairs:
Johannes Kaiser, ECMWF, Reading, UK; KCL, London, UK; MPIC, Mainz, Germany
Melita Keywood, CSIRO, Melbourne, Australia

Biomass burning changes the land surface drastically and leads to the release of large amounts of trace gases and aerosol particles that play important roles in atmospheric chemistry and climate. In addition, there is large uncertainty on how climate change and global change will impact the frequency, intensity, duration, and location of biomass burning in the short- and long-term, making their emissions a large source of uncertainty in future atmospheric composition. Therefore biomass burning and its emissions need to be observed and modelled accurately to understand the composition of the atmosphere and how it changes at different temporal and spatial scales. Significant gaps remain in our understanding of the contribution of deforestation and savanna, forest, agricultural waste, and peat fires to emissions. Coordinated international activities organized by IGAC, iLEAPS, and WMO (e.g., interdisciplinary laboratory measurements and field campaigns that integrate ground-based and airborne observations, as well as detailed analysis of satellite data and numerical modeling results) will help better quantify the present and future impact of biomass burning emissions on the composition and chemistry of the Earth's atmosphere.

Polar Study using Aircraft, Remote Sensing, Surface Measurements, and Models of Climate Chemistry, Aerosols, and Transport (POLARCAT)
Co-Chairs:
Andreas Stohl, NILU, Kjeller, Norway
Kathy Law, LATMOS/IPSL, Paris, France

POLARCAT addresses important gaps in knowledge of the climatically sensitive polar regions, i.e., how they respond to a complex summation of surface exchange processes, vertical transport, unique Arctic air chemistry, and import from and export to mid-latitude regions. The task incorporates intensive aircraft experiments, research ship cruises, monitoring activities at surface stations, ground-based remote sensing, balloon releases, satellite measurements, and a range of different models to test the understanding of Arctic processes against the measurement data sets. The task's efforts have led to a special issue in Atmospheric Chemistry and Physics.

Working Groups

IGAC China Working Group
Chair: Tong Zhu, Peking University China

The sheer magnitude of Chinas landmass coupled with its growing and economically advancing population makes it critical to understand its role in air quality and climate on both regional and global scales. Chinese atmospheric chemists have been conducting frontier research for forty years in areas such as urban and regional air pollution and the climate effects and health impacts of air pollution. IGAC intends to more fully integrate Chinese research experience by establishing its first national working group in China. The goals of the IGAC China Working Group are to:

- Encourage participation of Chinese atmospheric scientists to engage their leadership in international atmospheric chemistry research programs;
- Strengthen ties with IGAC to facilitate the implementation of IGAC related research projects and tasks in China;
- Provide advice or consultation on major research plans in atmospheric chemistry in China to promote funding support;
- Promote academic exchange on atmospheric research in China and internationally, especially with IGBP China Working Groups; and
- Provide a platform in China to facilitate the academic growth and development of young researchers in atmospheric chemistry.

IGAC Americas Working Group
Co-Chairs:
Nestor Rojas, Universidad Nacional de Colombia, Colombia
Laura Dawidowski, CNEA, Argentina

Under the guiding principle of providing equal opportunity for all scientists in the Americas, the IGAC Americas Working Group aims to build a cohesive network and foster the next generation of atmospheric scientists with the ultimate goal of contributing to development of a scientific community focused on building collective knowledge in/for the Americas. There is a priority on bringing together scientists from across the entirety of the Americas. To this end, the Americas Working Group seeks to:

- Improve the collaboration and communication between scientists in Latin America;
- Connect the Latin America community to the international community;
- Train and foster the next generation of scientists;
- Influence and promote a more proportionate distribution of funds for research
- Enhance visibility and credibility of scientists in Latin America

<u>Implementation Committee</u>
Karla Longo, INPE, Brazil
Michel Grutter, UNAM, Mexico
Megan Melamed, University of Colorado, USA
Olga Mayol-Bracero, University of Puerto Rico, Puerto Rico
Carlos Rudama, Universidad de El Salvador, El Salvador
Juan Carlos Antuña, Instituto de Meteorología, Cuba
Marcos Andrade, Universidad Mayor de San Andrés, Bolivia

IGAC India Working Group
Co-Chairs:
Dr. Sachin S. Gunthe, Indian Institute of Technology Madras
Dr. Ramya S. Raman, Indian Institute of Science Education and Research Bhopal

India has been involved in atmospheric chemistry research for over two decades, with atmospheric scientists conducting pioneering research in the field of atmospheric chemistry. The scale of the scientific output from India, however, is highly contradictory to the country's global relevance in atmospheric chemistry, a relevance accelerated by increasing emissions from rapid industrialization and urbanization. The vast geographical extent of India, its growing and economically advancing population, and the role of distinct and cyclic seasons makes it "imperative and precarious" that we make efforts in combining these issues to better understand their role in air quality and climate at a regional scale. Further, we must initiate conclusive efforts in the right direction, a current caveat due to isolated efforts of the scientific community in India. The goal of the India Working Group is to bring the Indian atmospheric chemistry community together to enhance scientific coordination and output from India, while simultaneously improving the scientific understanding of this region of the world at an international level.

Organizing Committee
Dr. Anoop Mahajan, Indian Institute of Tropical Meteorology
Dr. Ramya S. Raman, Indian Institute of Science Education and Research Bhopal
Dr. Lokesh Kumar Sahu, Physical Research Laboratory
Dr. Vinayak Sinha, Indian Institute of Science Education and Research Mohali
Dr. Shubha Verma, Indian Institute of Technology Kharagpur

Japan National Committee
Chair: Hiroshi Tanimoto, National Institute for Environmental Studies, Japan

Under the Science Council of Japan, the IGAC-Japan National Committee has goals to:

- Encourage participation of Japanese atmospheric scientists to engage their leadership in international atmospheric chemistry research programs;
- Strengthen ties with IGAC to facilitate the implementation of IGAC related research projects by Japan;
- Provide advice or consultation on major research plans in atmospheric chemistry by Japan to promote funding support;
- Promote academic exchange on atmospheric research by Japan and internationally, especially with other IGBP-Japan or WCRP-Japan Committees; and
- Provide a platform in Japan to facilitate the academic growth and development of young researchers in atmospheric chemistry.

Conferences and Workshops

- First IGAC Americas Working Group Workshop, 28-30 January 2013, Bogota, Columbia
  - The workshop brought together 24 people from 16 different countries across the Americas. Representatives specifically addressed the current state of research, funding mechanisms, institutional capacity and scientific needs in their respective countries. A major outcome was the formation of an Implementation Committee for the Americas Working Group.
- International Workshop on Changing Chemistry in Changing Climate (C4): Monsoon Focus, 1-3 May 2013, Pune, India
  - Two-hundred-and-eleven, participants, most of whom were from the region, represented 19 different states in India with a further 40 from China, Germany, Ivory Coast, Kenya, Malaysia, Nepal, Nigeria, Pakistan, Switzerland, United Kingdom, and USA. A total of 147 abstracts were selected for oral and poster presentations and 21 invited talks were delivered by eminent scientists from around the world. The workshop addressed the following scientific themes: air quality, transport and transformation of pollution, tropospheric chemistry, and their feedback in a changing climate. The oral and poster presentations described in the four theme foci of the meeting addressed the past, current and future needs of research in the field of atmospheric chemistry, aerosols, Asian monsoon, air quality and its health impacts, and their feedback in a changing climate. The focus of the workshop was initiated as one of the new regional activities of iCACGP at the workshop.
- SPARC/IGAC Chemistry Climate Modeling Initiative (CCMI) Workshop, 13-17 May 2013, Boulder, CO, USA
  - Approximately 130 participants attended the IGAC/SPARC Chemistry-Climate Model Initiative (CCMI, http://www.pa.op.dlr.de/CCMI/) 2013 Science Workshop that was held in Boulder, CO, USA at the Center Green Campus of the National Center for Atmospheric Research (NCAR) from 14-16 May 2013, followed by a Scientific Steering Committee Meeting on the morning of 17 May 2013. Workshop participants' expertise ranged from global chemistry and climate model developers and users, to in-situ and satellite observational experts, with interests in both tropospheric and stratospheric chemistry and climate. Science topics discussed included key observations needed for model evaluation, critical topics in tropospheric and stratospheric chemistry and dynamics as well as stratosphere-troposphere coupling. Examples of process-oriented evaluation of CCMs were presented and discussed.
- Extreme Weather and Climate Events in the Southern Caucasus - Black Sea Region Conference, 3-7 June 2013, Tbilisi, Georgia
  - This workshop addressed the effects of climate change unsustainable development in the Southern Caucus – Black Sea region. Discussion centered on the scientific issues and advancements related to modeling, detection and forecasting of extreme weather events and regional air quality; facilitating knowledge and experience sharing between foreign and local scientists; the feasibility of resolving issues using existing modeling approaches and remote sensing techniques; and identifying strategies for improved forecasting.
- Workshop on Atmospheric Composition and the Asian Summer Monsoon (ACAM), 9-12 June 2013, Kathmandu, Nepal
  - 120 scientists representing 17 countries recently gathered for workshop serving as a step toward building strong international collaborations to obtain the diverse expertise, resources, and access to the monsoon region for international research teams The main body of the workshop was organized around four themes:
    1. Emissions and Air Quality in the Asian Monsoon Region
    2. Aerosols, Clouds, and the Asian Monsoon
    3. Asian Monsoon Convection and Chemistry
    4. UTLS Response to Asian Monsoon

The meeting culminated with a summary session focused on how to continue the community building effort initiated by the workshop.

- Health, Agriculture, and Water Risks Associated with Air Quality and Climate in Asia, 9-12 July 2013, Boulder, CO, USA
  - About 55 scientists from Asia, Europe, and the United States participated in the workshop and 30 more attended the joint air quality and health sessions. Talks on various tools including climate modeling at different scales, emissions, chemical weather forecasting, satellite observations, and adjoint modelling. Presentations on cross-disciplinary activities highlighted air quality and health, urbanization, government policies, and co-benefits of improving air quality and reducing effects on future climate by reducing pollutant emissions. Two breakout sessions were held that discussed needed data or tools to further scientific understanding of the cross-disciplinary activities and important scientific questions addressed by cross-disciplinary projects.
- IGAC SSC Meeting, 30 September – 4 October 2013, Kruger Park, South Africa
  - The 28th Annual Meeting of the IGAC Scientific Steering Committee (SSC), hosted by SSC member Kobus Piennar, focused on synthesizing the achievements of IGAC to date in anticipation of IGBP ending in 2015, and developing IGAC's role as a central project in the new Future Earth initiative that will replace IGBP. The IGAC SSC also reviewed current, emerging and proposed activities during the meeting. There is a great deal of current activity in IGAC with new initiatives in biomass burning, atmospheric chemistry and health, chemistry-climate modelling and a major effort to recognize the importance of fundamentals of atmospheric chemistry nationally and internationally (see Abbatt et al, Atmospheric Environment, 84, 390-391, 2014). Another major topic of discussion at the IGAC SSC meeting was the upcoming joint iCACGP and IGAC symposium/conference to be held in Natal, Brazil in September 2014. The program outline was presented by IGAC SSC member and Scientific Program Committee co-chair Yinon Rudich.
- Capacity Building Workshop on Modeling of Regional Climate and Air Quality for West Africa, 7-11 October 2013, Abidjan, Cote d'Ivoire
  - Overall, about 40 participants attended the workshop, which was divided into theoretical lectures in the mornings and computer lab sessions in the afternoons. Most of the participants were students and researchers from Africa with diverse scientific backgrounds and interests in the fields of climate, hydrology, air quality, and oceanography. Topics presented in morning lectures consisted of (i) the West African climate system, its variability and possible future climate change and (ii) atmospheric chemistry processes (gas and aerosols from natural and anthropogenic sources) and their relation with the West African regional climate. Practical sessions were based on the use of the RegCM4 ICTP regional climate model.
- IGBP/ IGAC Air Pollution & Climate Initiative Workshop, 5-7 November 2013, Boulder, CO, USA
  - This workshop was the next step in an initiative that most recently released *Time to Act: The Opportunity to Simultaneously Mitigate Air Pollution and Climate Change*, a brief report urging a collaborative effort across the natural and social sciences to better inform the policy community. Maintaining this interdisciplinary focus, the November workshop was preceded by a Preliminary Report that set the agenda by compiling findings from interviews of over 50 natural and social scientists, policymakers and private sector representatives on the challenges and potentials for integration. With 32 participants representing 15 countries and each of the four natural science, social science, policy, and private sector communities, the aim was to outline the *Strategic Framework for Integrated Programs on Air Pollution and Climate Change* for release in summer 2014. To this end, workshop participants over the first two days held panel presentations, breakout groups and overarching discussions on themes identified in the Preliminary Report. Panels addressed

current organizational efforts on integration, working with national and regional regulatory and institutional systems, improving interactions across the four communities to facilitate integration, and information needs for effective integrated programs.

- GEIA/IBBI/CCMI Development of a Community Historical Emissions Inventory, 20-21 November 2013, Hamburg, Germany
  - Thirty-five scientists from Europe, North America, Africa and Asia participated in the workshop. The workshop focused on anthropogenic and biomass burning emissions; natural emissions will be addressed in another workshop. The most recent anthropogenic inventories developed in Europe, the USA, the Middle East, Africa and Asia were discussed, with specific focus on different emission sectors, i.e., transportation, industrial activities, shipping, and agriculture. The possibility of updating emissions to the most recent years using inverse modeling techniques was also discussed. The workshop covered advancements in determining recent biomass burning emissions information from satellite observations, such as active fires, burned areas or fire radiative power. Long-term historical time series of fire emissions simulated by dynamical vegetation models were also considered. Emissions data still have large uncertainties, so the participants suggested developing a reference inventory together with well-documented alternative datasets that could be used for sensitivity studies at both the global scale and in different regions. This approach could provide a measure of the uncertainty on the reference inventory
- TF HTAP Modeling Workshop, 5-6 December 2013, San Francisco, CA, USA
  - More than 50 experts attended the meeting in person with another 30 experts participating in portions of the meeting via web conferencing. The main focus of the workshop was the launch of a new round of cooperative global and regional modeling experiments focused on the 2008-2010 time period. As part of the TFHTAP's 2012-2016 work plan, the new experiments are intended to help improve our understanding of the relative role of regional and extra-regional sources of air pollution in different regions across the Northern Hemisphere.

3. Contributions to IGBP Integration/synthesis

(List your activities (ongoing or planned) which contribute to the broader integrative aims of IGBP (interdisciplinary initiatives, joint activities with other core projects, contributions to fast track initiatives and to IGBP synthesis activities).
Information for: strategic development.

- Many of IGAC's research priorities are collaborations with the IGBP core projects SOLAS (Surface Ocean Lower Atmosphere Study) and iLEAPS (Integrated Land Ecosystem Atmosphere Process Study), the World Climate Research Program's SPARC (Stratospheric Processes and their Role in Climate), and the World Meteorological Organization (WMO). Collaboration with IGBP's AIMES (Analysis Integration and Modelling of Earth Systems) project allows for scaling of local data to the regional-to-global scale and for investigating atmospheric chemistry/Earth system feedbacks. Through joint workshops and research projects, IGAC, SPARC, AIMES, iLEAPS, and SOLAS have increasingly been working towards an integrated study of Earth system sustainability science.

- The IGBP Air Pollution & Climate initiative, led by IGAC, seeks to open a science-policy dialogue on air pollution and climate challenge. The aim of the Air Pollution and Climate Initiative is to break down the divides between these two disciplines and clarify the synergies and trade-offs of research and mitigation efforts across a spectrum of air pollution and climate change policies. To this end the initiative released a statement on the air pollution and climate change policy opportunity as part of the Planet Under Pressure Conference 26-29 March 2012 in London, U.K. during a session on *Tackling the Air Pollution and Climate Change Challenge*. Most recently a workshop was held in November 2013 to discuss necessary prerequisites for a drafting of the *Strategic Framework for*

Integrated Programmes on Air Pollution and Climate Change.

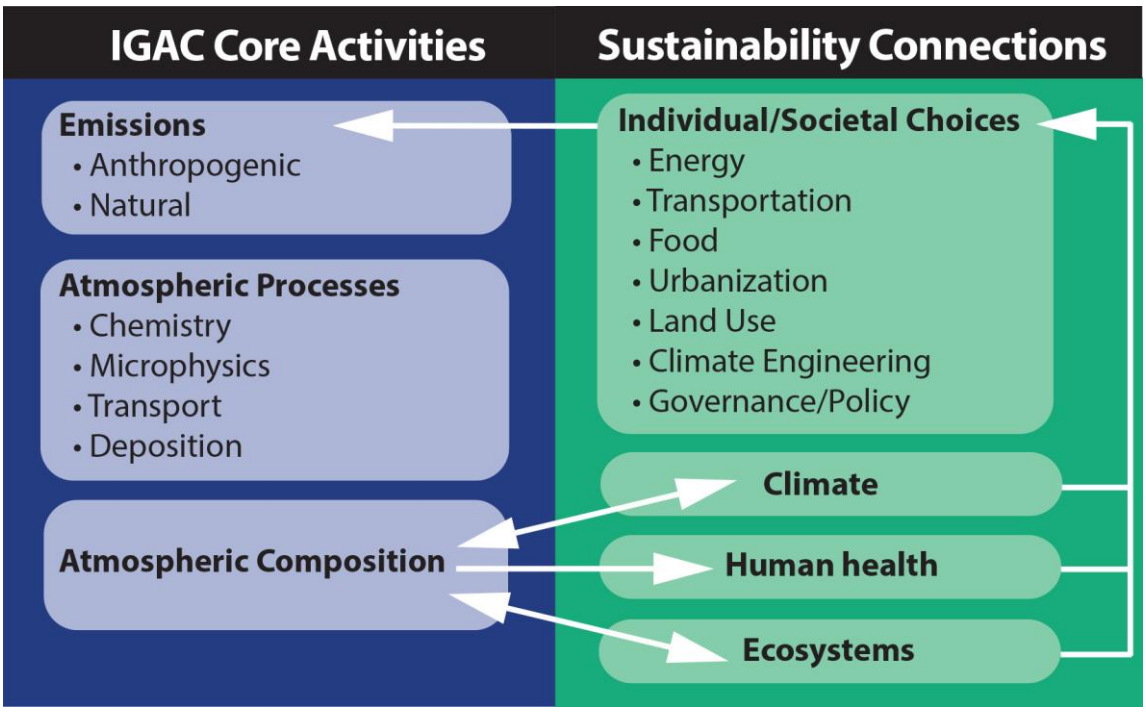
- Current jointly sponsored activities include:
  - ACAM: Atmospheric Chemistry and the Asian Monsoon (IGAC, SPARC)
  - AICI: Air-Ice Chemical Interactions (IGAC, SOLAS)
  - Air Pollution & Climate (IGAC, IGBP)
  - Biomass Burning Initiative (IGAC, iLEAPS, WMO)
  - CCMI: Chemistry-Climate Model Initiative (IGAC, SPARC)
  - DEBITS: Deposition of Biogeochemically Important Trace Species (IGAC, WMO)
  - GEIA: Global Emissions InitiAtive (IGAC, iLEAPS, AIMES)
  - HitT: Halogens in the Troposphere (IGAC, SOLAS)

4. Strategic Outlook

List (a) your goals and priorities for the upcoming 2 years, focusing on strategic issues and (b) major activities planned (workshops, conferences, etc.) with dates or approx. timeframe.
Information for: strategic development, reporting/fundraising & networking.

(a) Goals and Priorities

As IGAC enters into its third phase, and in response to the Future Earth Initiative, its mission is to coordinate and foster atmospheric chemistry research towards a sustainable world. IGAC achieves this by integrating, synthesizing, guiding, and adding value to research undertaken by individual scientists through initiating new activities, acting as a hub of communication for the international atmospheric chemistry research community, and building scientific capacity. More specifically the focus of IGAC's core activities on emissions, atmospheric processes, and atmospheric composition will integrate more closely with sustainability issues including climate, human health, ecosystems, and how individual and societal responses feed back onto the core research-led activities of IGAC. IGAC believes human well-being can be sustained by viewing the environment as a resource that is one of the bases of energy and economic activity. This strategy is outlined in the figure below.



(b) Workshops & activities

Below is a list of IGAC workshops for 2014. IGAC is currently accepting proposals for other workshops to be held under its current activities in the coming year.

- IGAC India Working Group Workshop
  5-6 April 2014
  Bangalore, India

- IBBI Workshop 2014
  23-26 April 2014
  Schloss Ringberg, Germany

- CCMI Workshop 2014
  20-22 May 2014
  Lancaster, UK

- 16th GEIA Conference
  10-11 June 2014
  Boulder, CO, USA

- IGAC Americas Working Group Workshop
  4-8 August 2014
  La Paz, Bolivia

- 13th IGAC Science Conference on Atmospheric Chemistry
  22-26 September 2014
  Natal, Brazil

- Fundamentals of Atmospheric Chemistry
  TBD

5. Contributions to international assessments

List your links and contributions to international assessments such as IPCC.
Information for: strategic development & reporting/fundraising.

- IGAC SSC or community members who were lead authors for AR5 WGI report:
  - Contributors to the IGAC/SPARC Modelling Activity (CCMI)
    - Arlene Fiore (Chapter 11 Lead Author)
    - Drew Schindell (Chapter 8 Coordinating Lead Author)
    - Veronika Eyring (Chapter 9 Lead Author)
    - Dorothy Koch (Chapter 8 Lead Author)
    - Frank Dentener (Chapter 2 Lead Author)
    - Jean-Francois Lamar (Chapter 8 Lead Author)
    - Piers Forster (Chapter 7 Lead Author)
  - Part of IGBP Air Pollution and Climate Initiative
    - Bill Collins (Chapter 8 Lead Author)
    - Jan Fuglestvedt (Chapter 8 Lead Author)
  - Current or Former IGAC SSC members
    - Maria Cristina Facchini (Chapter 1 Lead Author)
    - Yutaka Kondo (Chapter 7 Lead Author)
    - Phillip Rasch (Chapter 7 Lead Author)
    - Graham Feigngold (Chapter 7 Lead Author)
    - Sandro Fuzzi (Chapter 7 Review Editor)

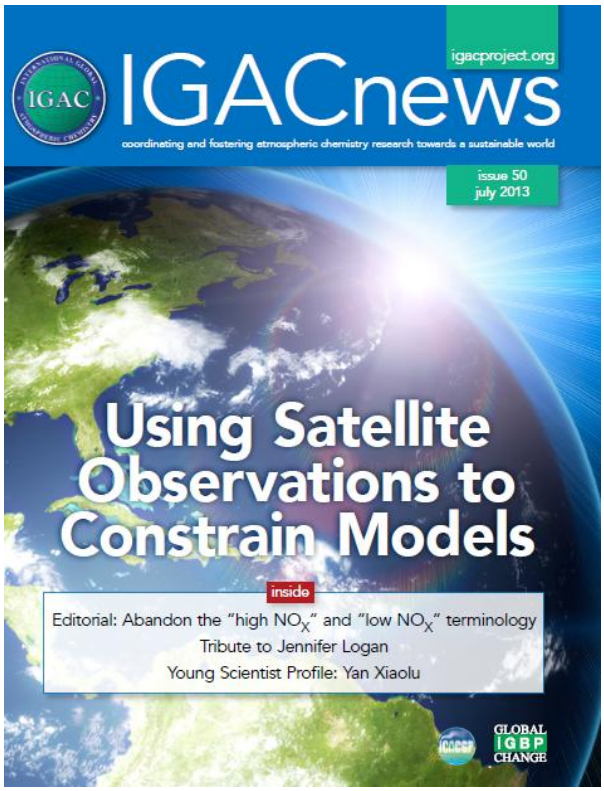
- The IGAC report on Bounding the Role of Black Carbon in the Climate System constituted a direct contribution to AR5. Metrics reported in the publication were determined based specifically on those used in the IPCC process, and terminology was intentionally used for consistency with IPCC assessments. The 232-page report was published in 2013 in the Journal of Geophysical Research.
- The simulations performed for ACCMIP likewise proved instrumental in exploring issues of climate sensitivity, historical climate and climate projections in the lead-up to AR5. The most recent ACCMIP special issue was published in Atmospheric Chemistry and Physics in 2013.
- IGAC activities contribute to the Future Earth Initiative.
- Given that the IGAC community is composed of over 3,000 scientists, it is difficult to account for all links and contributions to international assessments.

6. Communication and Outreach

List networking activities and products (websites, newsletters, outreach products) for the scientific community and beyond (policymakers, the public). Please give details where end-users have been involved in the concept and production.

Information for: outreach, networking & reporting/fundraising

- IGAC website : http://igacproject.org
- The IGAC Newsletter is posted on the website and sent out as an electronic version to ~3,000 scientists. The most recent issue (July 2013 Issue No. 50) featured a scientific editorial on *Using Satellite Observations to Constrain Models,* a tribute to the research career of Jennifer Logan and a Young Scientist Spotlight on Yan Xiaolu, an IGAC Young Scientist Travel Grant awardee for the June workshop of the Atmospheric Composition and the Asian Summer Monsoon activity.



- Updates, reminders, and information about conferences and activities are emailed to ~3,000 subscribers via MailChimp.
- IGAC also continuously works with a graphic designer to design logos for its activities as well as communicate science more effectively through diagrams, figures and graphs.

7. Publications

List (for the period since your last annual report to IGBP): (a) the top 10 most important publications in the peer-reviewed literature as a result of the project and (b) the total number of peer-reviewed publications attributed to the project and listed in your database

Information for: reporting/fundraising & outreach.

(a) The most important publications in peer-reviewed literature over the past year have been the 232-page black carbon assessment and the special issues:

- Bounding the role of black carbon in the climate system: A scientific assessment (2013) Bond, T.C., S.J. Doherty, D.W. Fahey, P.M. Forster et al. J. Geophys. Res.-Atmos., DOI 10.1002/jgrd.50171.
- The Atmospheric Chemistry and Climate Model Intercomparison Project (ACCMIP) Special Issue (2013) Eds. M. Dameris, D. Spracklen, and H. Tost. Atmos. Chem. Phys.
- New perspectives on Air-Ice Chemical Interactions (AICI) Special Issue (2013) Eds. V. F. McNeill, E. Wolff, T. Bartels-Rausch, and H. Pfeiffenberger. Atmos. Chem. Phys.

Additional publications in 2013 include:

- New Directions: GEIA's 2020 vision for better air emissions information (2013) Eds. J. Frost, P. Middleton, L. Tarrason, C. Granier, et al. Atmos. Env.
- New Directions: Fundamentals of atmospheric chemistry: Keeping a three-legged stool balanced (2013) Eds. J. Abbatt, C. George, M. Melamed, P. Monks, S. Pandis, and Y. Rudich. Atmos. Env.
- Megacities and Large Urban Agglomerations in the Coastal Zone: Interactions Between Atmosphere, Land, and Marine Ecosystems (2013) von Glasow et al. AMBIO 42:13–28, DOI 10.1007/s13280-012-0343-9.

(b) In total, IGAC has produced 32 special issues in peer-reviewed journals. The total number of peer-reviewed publications is well in the hundreds since IGAC began in 1990.

8. Training and capacity building

List your capacity-building activities eg. Summer schools, Young Scientist Workshops, lecture series, training & education, etc.

Information for: reporting/fundraising & networking.

- IGAC co-sponsors numerous meetings, workshops, symposiums, and conferences to provide travel grants for young and developing country scientists to attend these events.
- An integral part to IGAC's biennial conferences is its Young Scientists Program, which creates a platform for young scientists to present their research and become connected within the larger network of international scientists. IGAC provides travel grants for young scientists to attend conferences based on both need and merit.
- IGAC sponsors National/Regional Working Groups:
    - The China Working Group continues to increase the level of communication and collaboration of research between scientists in the region as well with scientists internationally.
    - The Americas Working Group held its first workshop in January 2013. The aim of this working group is to foster collaboration between scientists in Latin America and connect the Latin America community with the international community.
    - The India Working Group now has an organizing committee charged with bringing the Indian atmospheric chemistry community together to enhance scientific coordination and output from India, while simultaneously improving the scientific

understanding of this region of the world at an international level.

- The IGAC-Japan National Committee, under the Science Council of Japan has 21 committee members, including a Chair currently sitting on the IGAC SSC. It is working to encourage participation of Japanese atmospheric scientists to engage their leadership in international atmospheric chemistry research programs. Further the National Committee is providing a platform in Japan to facilitate the academic growth and development of young researchers in atmospheric chemistry.
- Additional national/regional working groups are currently being explored and planned for implementation. Areas of interest include Africa and an overarching Asia working group.

9. Project administration and management

Describe the structure of the IPO, Node/foci offices and sponsors. Note any resource concerns.
Information for: reporting/fundraising & networking.

- The International Project Office is located at the University of Colorado's Joint Cooperative Institute for Research in Environmental Sciences (CIRES) in Boulder, Colorado. The Boulder IPO is the primary IGAC project office, with one full-time employee, Executive Officer Megan Melamed, and one part-time research assistant, Jeff Jennings.
- The IGAC IPO is funded at $280kUSD/year from the period of July 20012-June 2015 by awards from U.S. NSF, NASA, and NOAA.
- IGBP provides ~$35kUSD/year to cover the majority of the costs of the annual IGAC SSC meeting.
- European ACCENT Plus provides €18kEuro/year to provide IGAC travel grants for scientists to attend IGAC related meetings, workshops, symposiums, and conferences.

10. Links with the observations community

List: (a) links/activities with the observation community (e.g., meetings attended, activities, data you are providing), (b) the observation and data products you are using from e.g. ESA, NASA, etc., and (c) additional needs.
Information for: reporting/fundraising, networking and strategic development.

Observations are a key component of IGAC activities including ACAM, AICI, CCMI, DEBITS, GEIA, HitT, IBBI and POLARCAT. With over 3,000 scientists across the world, the contributions of the IGAC community to observation networks are too numerous to list here.

11. Other comments

01-27-2013	*Compiled by Jeff Jennings*