

**2009-2010 Annual Report  
International Global Atmospheric Chemistry (IGAC) Project  
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**PARTICIPANTS**

The Seattle International Project Office continues to act as primary IGAC project office, now with two employees (Sarah Doherty, Executive Officer & Collen Marquist, Programmatic Manager). Sarah is working 25% time on research, 75% on IGAC activities; Collen works 50% time for IGAC. This office is funded equally by the U.S. NSF, NOAA and NASA agencies. The IGAC office grant was renewed in July 2009 for three years. With the grant renewal, the IGAC project office was moved from NOAA's Pacific Marine Environmental Lab to the Joint Institute for the Study of the Atmosphere and Ocean (JISAO), a joint NOAA/University of Washington enterprise. Both are located in Seattle, Washington. (*Contact: Sarah Doherty*)

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 2009-2010).

**IGAC Scientific Steering Committee Membership, 2009-2010**

<b>Name</b>	<b>Country</b>	<b>Expertise</b>
Mary Barth <sup>‡</sup>	USA	Clouds and chemistry; chemistry in and around thunderstorms; weather research forecast modeling coupled with aqueous chemistry
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
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)* <i>staying on through 2010 ex-officio</i>	U.K.	Photochemistry, UTLS, integration of field measurements/modeling
Mark Lawrence‡	Germany	numerical modeling of chemical weather; chemistry-climate interactions in the troposphere
Karla Longo	Brazil	Model development; biomass burning; emissions; chemical processes
Shih-Chun Candice Lung‡	Taiwan	aerosols, public health and sustainable development
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
Rokjin Park‡	South Korea	Regional-scale modeling of atmospheric chemistry; coupling to observations
Kobus Pienaar	South Africa	In-situ observations of deposition; biosphere-atmosphere 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, 2010

‡ These members new as of January 1, 2010

## ACTIVITIES AND FINDINGS

### 1. Activities

The role of the IGAC Core Project Office is to help execute IGAC activities, as recommended by the Scientific Steering Committee. IGAC activities are also steered by recommendations from our parent organization, the International Geosphere Biosphere Program (IGBP). The 2009 IGAC SSC meeting discussions (October, 2009) and IGBP annual Steering Group meeting (March, 2010), resulted in the following decisions:

- A collaborative effort is to be established with the Global Emissions Inventory Activity to: a) reconcile local and global emissions inventories, which often are quite different, thereby also increasing communication between the local air quality and climate communities, and b) to improve meta-data (uncertainties, etc.) associated with emissions inventories.
- Work with WCRP-SPARC to promote laboratory studies, starting with and building on needs identified at the June, 2008 IGAC/HiT/AICI/SPARC Lab Studies workshop in Cambridge, U.K. A brief report has been submitted to Nature Geosciences, and we are developing a white paper highlighting the scientific areas which are being limited by the lack of recent laboratory studies and spectroscopic studies, as a way of determining research needs.
- IGAC will provide logistic and possibly financial (travel) support for a South/Central American summer school on "Atmospheric Chemistry: fundamentals and modeling," pending support for the workshop within the region. Date/location and level of IGAC engagement/support is in discussion.

- The Atmospheric Chemistry and Climate Initiative activity aimed at examining what controls the distribution of short-lived species in the upper troposphere is in the process of being re-defined. The original idea for this activity has not gained traction and is lacking leadership. New results from studies of the upper troposphere, interest within the SPARC CCMVal community, and observations from the AMMA-AC IGAC Task have all provided impetus for establishing a new set of plans for this activity. Michaela Hegglin (SPARC/CCMVal) and Mary Barth (IGAC SSC) are leading this effort. A first meeting with the IGAC community will be held at our biennial conference (July 2010; Halifax, Canada) with a more comprehensive meeting to include stratospheric chemistry-climate modelers in fall, 2010.
- The IGAC SSC noted the need to define a specific research plan for a first activity of the iLEAPS/IGAC/WCRP-GEWEX Aerosols, Clouds, Precipitation and Climate (ACPC) initiative. The Science Plan and Implementation Strategy for ACPC was completed in 2009. This document nicely lays out the science issues and a framework for pursuing ACPC science goals. At a meeting 27-28 September 2010 in Germany, IGAC representatives to ACPC will work with iLEAPS and GEWEX to establish the first ACPC research activity.
- IGAC is leading the development of two new IGBP-level Synthesis activities. The aim of these activities is to provide integration across the scientific disciplines in key areas of global environmental change research. The outcomes will identify gaps for further exploration and help form a baseline for international policy. IGAC is formulating plans for Synthesis activities in:
  - *Atmospheric Pollution and Climate*: The goals are to generate a synthesis for policy makers on current state of knowledge on the role and interactions between air pollutants and climate including assessment of uncertainties and identification of gaps; explore and quantify possible mitigation options within socio-economic and scientific context; and in partnership between policy makers and scientists, assess and develop new metrics to quantify co-benefits/trade-offs of past and possible future pollutant reduction strategies from different emission sources on air quality/health, ecosystems and climate.
  - *Aerosols*: The focus of this synthesis will be on the time-evolution of, in particular, organic aerosols.

#### Activities July 2009-May 2010:

- IGAC “Future Directions” workshop, 15-17 September 2009, London, U.K.
  - Invitational workshop of 17 leading researchers in atmospheric chemistry from around the globe.
  - Visioning exercise on where atmospheric chemistry research is going in the 5-20year time-line; what research framework should be used to decide priorities; and what this means for IGAC and the international projects/programs in terms of programmatic structure and implementation mechanisms.
  - Workshop outcome discussed at October 2009 IGAC SSC meeting, and is being used to set near-term (next 5 years) research priorities for IGAC. (See Section 4 below)
  - Resulting “ACES” (Atmospheric Chemistry in the Earth System) provided to IGBP, to ICSU as input to their long-term “visioning” meeting (December, 2009) and to a U.S. National Science Foundation (NSF) panel (the “Belmont Group”) charged with analyzing what international research capability is needed to deliver the knowledge needed to support human action and adaptation to regional environmental change.
- IGAC SSC meeting, 25-29 October 2009, Kyoto, Japan
  - Coordinated with WCRP-SPARC SSG meeting; 1 day joint SSC/SSG meeting
  - Included one day IGAC/SPARC science workshop with Japanese scientists, organized by Dr. Yutaka Kondo (IGAC SSC) and Dr. Masato Shiotani (SPARC SSG).
- “Megacities Assessment” 2<sup>nd</sup> lead authors’ meeting, 17-19 November 2009, Beijing, China
  - IGAC-lead activity to collate and synthesize current knowledge of atmospheric chemistry in megacities, in the context of both air pollution and climate
  - Co-sponsorship by WMO-GURME. WMO staff will provide final editing, formatting, printing and distribution of the report as a book. Travel and other meeting costs were funded by Chinese national contributions

- A first draft of the report is complete, with contributions from a large number of cities around the globe. We are now working on the synthesis section of the report and hope to have it ready for publication by the end of this year.
- “Mega-cities and Coastal Zones” was selected as an IGBP “Fast Track Initiative” at their April 2009 Steering Committee meeting. It is being led 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. 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 megacities?
  - How do urban and oceanic emissions interact to affect atmospheric chemistry in the marine boundary layer?
  - How do atmospheric deposition of both contaminants and nutrients from megacities affect the productivity of adjacent coastal waters?
  - How do the interactions of large urban emissions and the marine boundary layer affect local and regional climate?

An invitational workshop of scientific specialists with diverse experience addressing particular aspects of this issue was held in Norwich, UK in May, 2010, and a journal publication is planned for late Summer/early Fall 2010.

- “Bounding the Role of Black Carbon in Climate” Report, lead authors’ meetings 9-11 September 2009, Boulder, Colorado; 25-28 January 2010, Tokyo, Japan; 26-28 May 2010, Boulder, Colorado.
  - This report is being produced under the IGAC/SPARC Atmospheric Chemistry and Climate initiative. It was in part motivated by a call from policymakers to provide a summary of the best current knowledge on the climate impacts of black carbon. The report is being written specifically to allow readers to connect changes in emissions from a given source (e.g. diesel vehicles, biomass burning, etc.) to a change in radiative forcing, accounting for the climate impacts of co-emitted species (e.g. organic carbon, sulphate). Co-benefits (e.g. health) will be considered but not covered in detail in the report.
  - The U.S. NOAA program provided \$150kUSD in supplemental funding specifically in support of this activity
  - Drafts of all chapters have been completed and are scheduled to be finalized for submission to *Atmospheric Chemistry and Physics* by 1 August 2010.
  - 2<sup>nd</sup> lead authors’ meeting included a 1 day science workshop on black carbon with Asian scientists. The workshop and overall local meeting planning was provided by Dr. Yutaka Kondo (IGAC SSC & “Bounding BC” report lead author).
- The Seattle IGAC project office supported the participation of African atmospheric chemists at the 3<sup>rd</sup> International AMMA conference, Ouagadougou, Burkina Faso, 20-24 July 2009. This was followed by a meeting in Côte d’Ivoire in May, 2010 of north African scientists, lead by IGAC SSC member Abdourahamane Konare, to discuss the future of IGAC research within north Africa. Dr. Konare will be reporting on the meeting outcomes at our July 2010 SSC meeting.
- Model runs for the Atmospheric Chemistry & Climate Initiative “Hindcasts” and “Future scenarios” of short-lived species have started and will continue through 2010. We recently raised sufficient funds for the “Hindcasts” lead (Peter Hess, Cornell Univ.) to hire a post-doc to coordinate these runs and their analysis. The “Future Scenarios” model runs have been designed to contribute to an Atmospheric Chemistry and Climate Model Intercomparison Project (“ACC-MIP”) which will complement the well-know climate model MIP. These model runs and their analysis will provide important data on the role of short-lived forcers in climate for IPCC AR5.
- The 11<sup>th</sup> IGAC open science conference will be held 11-16 July 2010 in Halifax, Canada as a joint conference with CACGP. We expect attendance of >500 scientists and as in the past we will feature a single plenary; a focus on poster sessions; a young scientists’ program; and travel support for young scientists. The IGAC Core Project Office assisted with conference planning, taking the lead in raising funds for and organizing the panel review of applications for travel support by Young Scientists (students, or within 5 years of receiving PhD) for conference attendance.

## 2. Findings

Activities within IGAC Tasks continued in 2009-10 to enrich our understanding of atmospheric chemistry in the Earth system. The extensive scientific results that emerge from IGAC Tasks are too numerous to recount in total here. Instead we give examples of progress over the past year from three of IGAC's Tasks.

### **POLARCAT**

Data analysis from the POLARCAT Spring and Summer campaigns was in full swing in 2009, and is ongoing. A POLARCAT data workshop co-sponsored by IGAC (2-5 June 2009; Durham, New Hampshire) highlighted initial findings, providing new insights as well as raising new questions. Initial analysis indicates that pollution at low altitudes is dominated by sulfate (in agreement with surface data records), with influences from large local sources (e.g. the Kola peninsula in the eastern Arctic), but significant plumes aloft are dominated by biomass burning aerosol. This is quite a different view than the classical picture of Arctic haze. These measurements also raise several questions: First, are the POLARCAT campaign data representative or are they biased a) because they were made in a year of particularly intense springtime biomass burning in Siberia and b) because of the dominance of measurements in the western vs. eastern Arctic? Second, to what degree do the biomass burning aerosol mix down into the boundary layer and/or get deposited on the snow surface vs. get transported straight through the Arctic? Third, what are the dominant scavenging mechanisms for these aerosol in the Arctic, and is there preferential scavenging of biomass vs. fossil fuel-sourced aerosol?

The POLARCAT measurements of aerosols, CO and ozone also allowed for testing and validation of ozone, CO and aerosol fields in models, as well as providing insight into the sources of ozone in the Arctic. These data are being used to assess the relative roles of stratospheric ozone injection, direct transport of tropospheric ozone into the Arctic and local ozone production.

These findings are in the process of being published, many as contributions to an *Atmospheric Chemistry and Physics* special issue, which is open for submissions through 2010 ([http://www.atmos-chem-phys-discuss.net/special\\_issue104.html](http://www.atmos-chem-phys-discuss.net/special_issue104.html)).

### **AMMA-AC**

2009 was also a year of ongoing data analysis for the African Monsoon Multidisciplinary Analysis Atmospheric Chemistry (AMMA-AC) IGAC Task. While the broader AMMA campaign is focused on understanding the mechanisms underlying the monsoon cycle, AMMA-AC is looking at the interplay between the monsoon cycle, natural and anthropogenic emissions, the resulting atmospheric distributions, and the transport and transformation of atmospheric constituents. A science workshop 20-24 July 2009 in Ouagadougou, Burkina Faso, provided new data sets and insights, including:

- Improved natural and anthropogenic emission inventories – in particular emissions from 2-wheel vehicles (not previously quantified), ammonia from cattle faeces (not previously quantified), domestic fires (previously underestimated), dust (field measurements to construct emission model), emissions from vegetation (evaluated with observed isoprene concentrations).
- Data on how mesoscale convective systems (MCSs) modify the chemical and physical properties of aerosols, and ozone production in the upper troposphere.
- Provision of a regional and seasonal picture of gases and particles (in particular reactive nitrogen and ozone, dust and carbonaceous aerosols).
- New data sets showing very high concentrations of air pollutants in those cities for which there are observations.
- First quantification of the influence of convection on the chemical composition in the upper troposphere.
- Findings on how the vertical location of aerosol over the African continent affects its long range transport pathways.
- Finding that the extent of the influence of biomass burning in the southern hemisphere on W. Africa during the wet season was more important than expected – in particular the transport to the upper troposphere via uplift over Central Africa.
- Finding that the chemical composition in the upper troposphere over W. Africa is impacted by long range transport from Asia.

- Indications that the radiative impact of dust particles affects precipitation at regional scales.
- Provision of a regional picture of the optical properties and direct radiative impact of aerosols.
- Provision of a regional and seasonal picture of wet and dry deposition of nitrogen and mineral dust.

### **Megacities: Asia**

The IGAC Megacities: Asia task is an effort to coordinate studies of atmospheric chemistry in and downwind of urban areas in China, Japan, Thailand, and South Korea. Emphasis has been placed on instrument inter-calibration, on establishment of “best-practice” methods for making measurements, so data sets from across Asia are comparable, and in multi-national field campaigns within the Asian region, such as the Pearl River Delta. In its first phase (2003-2007) this task focused on measurements within the urban areas. In phase II there is a stronger focus on the regional impacts of megacities. A number of publications under this task, some of which are called out in Section 7, have brought new insights in 2009. Some highlights include:

- While NO<sub>2</sub> over most parts of Asia have decreased over much of Asia in the period 1994-2007, GOME and SCIAMACHY satellite show an increase in atmospheric NO<sub>2</sub> in China’s three fastest developing coastal regions. A study by Wang et al. report that this has resulted in an ~0.94 ppbv/yr increase in background ozone concentrations from 1994–2000 to 2001–2007 at a coastal site in Hong Kong, when air masses originated from Eastern China, with similar changes in the other two continent-influenced air mass groups. No ozone trend was observed when sampling air originating from the marine environment. The authors note the significance of this in the context of efforts to mitigate urban ozone concentrations within Hong Kong and also point out that their finding is consistent with studies which also show increasing ozone concentrations in the background air of the western U.S. coast, attributing this to increasing Asian emissions (Jaffe and Ray, 2007; Oltmans, et al., 2008; Parrish et al., 2009). Observations by Xu et al. (2009) in eastern China of ozone trends, diurnal cycle tendencies and variability from 1991 to 2006 show a more complex behavior: While daily maxima in ozone have been increasing, daily minima in ozone have been decreasing. As with the long-term trends in average concentration at Hong Kong, these changes can be attributed to increases in NO<sub>2</sub> emissions in eastern China. These studies together reveal the complexity of understanding the regional-scale impacts of changing emissions of ozone precursors, which have a non-linear effect on ozone concentrations.
- The importance of black carbon as a climate forcer and the potential to mitigate short-term warming by decreasing black carbon (BC) emissions have received prominent attention in the past couple of years. Critical to understanding how black carbon is affecting climate is knowledge of the burden of black carbon in the atmosphere, yet emissions inventories of BC are highly uncertain, especially within many Asian countries where, importantly, BC emissions are increasing. Zhou et al. (2009) used ambient measurements of BC and other constituents in the summer of 2005 in areas influenced by plumes from Beijing and Shanghai enabled them to provide BC emissions estimates for these urban areas. In addition, their measurements revealed that diesel vehicles and marine vessels are the dominant sources of BC in the summertime for these cities, with diesel engine emissions playing a particularly strong role in Shanghai. Therefore, this study, in addition to providing constraints on the emission inventories for these two areas, has provided information that is useful in the context of mitigation decisions.
- The number and size distribution of atmospheric aerosol (particles) is an important determinant in their role in climate, both through their direct radiative forcing and through their effects on clouds. In the past, it was believed that new particles formed in the atmosphere only in very clean conditions, because when a large number of particles were already present in the atmosphere particulate precursor gases would condense onto existing particles, rather than forming new particles. However, a large number of studies over the past few years have observed new particle formation even under very polluted conditions. A study by Gao et al. (2009) at a suburban site in the Yangtze River Delta, near Shanghai, in summer 2005 observed number counts of ultrafine (10–100 nm) particles 2–3 times higher than those reported in the urban areas of North America and Europe, with the relative fractions of ultra-fine particles to total particle count also 20–30% higher. The new particle formation events leading to this were characterized with a larger number of nucleation-mode particles, larger particle surface area, and larger condensational sink than usually reported in the literature. These suggest an intense production of sulfuric acid from photo-oxidation of sulfur dioxide in this region.

- Gao, J, T Wang, X H Zhou, W Wu, W X Wang, (2009), Measurement of aerosol number size distributions in the Yangtze River Delta in China: formation and growth of particles under Polluted Conditions, *Atmos. Environ.*, 43, 829-836.
- Jaffe, D and J Ray, 2007: Increase in surface ozone at rural sites in the western US, *Atmos. Environ.*, 41, 5452–5463.
- Oltmans, S.J, A S Lefohn, J M Harris, and D S Shadwick, 2008: Background ozone levels of air entering the west coast of the U.S. and assessment of longer-term changes, *Atmos. Environ.*, 42, 6020–6038, 2008.
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## 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 Collen Marquist, IGAC Administrative Specialist.

While many peer-reviewed publications result from IGAC Tasks and Activities, 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 42 in total) are downloadable from the IGAC web page (<http://www.igac.noaa.gov/newsletter/index.php>).

## TRAINING AND CAPACITY BUILDING

The IGAC Core Project Office helped build scientific capacity through the following activities in the past year:

- A highlight of AMMA-AC (as well as AMMA more broadly) has been the direct involvement of African scientists. These scientists will carry on longer term measurements in the region, thereby building scientific capacity, and have been fundamental in connecting scientific findings with the human/societal dimension (e.g. impacts, mitigation options). IGAC has provided extensive travel support for African scientists working on the atmospheric chemistry components of AMMA to attend AMMA workshops/conferences.
- The Megacities: Asia task has included an effort to establish “best-practice” methods in atmospheric chemistry measurements across Asia (China mainland, Hong Kong, China-Taiwan, Japan, Korea, Thailand). This has included educating young scientists, and has lead to an increase in knowledge and improved measurement practices across these regions. Participation in the overarching Megacities Asia Task has also increased the national and international visibility of the individual scientists involved, as well as increasing scientific collaboration across international boundaries.
- The IGAC DEBITS (Deposition of Biogeochemically Important Trace Species) Task has also included the training of local scientists in the study regions (Brazil, Africa, Asia) on how to measure wet and dry deposition and interpret the results and in doing so has increased local scientific capacity.

- In writing the Megacities Assessment report we have brought together scientists and data sets from around the globe. This led to increased international collaboration (e.g. Parrish and Zhu, 2009; Parrish et al., 2009). Ultimately, the goal is for this effort to help under-studied cities mitigate air pollution using lessons learned in well-studied cities.
- Part of the funding under this grant is allocated to supporting young scientists (students or those within 5 years of receiving their PhD) to attend our biennial international science conference. The next IGAC conference is being held joint with iCACGP at Dalhousie University in Halifax, Canada. This past year we raised additional funds from external sources for this cause, in order to supplement the funds under this grant. Young scientists were selected for support based on merit and achieving a geographic balance, as decided by a panel of reviewers organized by the Seattle IPO.

### **Outreach activities**

- IGAC website : <http://www.igac.noaa.gov>
- *IGAC* Activities Newsletters are mailed to ~3,600 scientists and are available to download on our web page Academia Sinica continues to support IGAC by printing and mailing the *IGAC* Activities newsletter (~3x/year), and covering the associated costs. While this support was originally anticipated to end in 2008, Dr. Liu has graciously extended this support, at least through 2010. However, a major task for the Programmatic Manager has been to convert the hard copy mailing list to an email listserv so the newsletter can be distributed electronically in the future. This has afforded a major overhaul of the membership mailing list resulting in an update of the last fifteen years.
- Advocates for air pollution control, e.g. from the International Council on Clean Transportation (ICCT) and Clean Air/Cool Planet, participated in the POLARCAT “Short-lived Species and Air Pollution” workshop in June, 2009 both to share with the scientific community what they were communicating to policymakers and to learn the latest state of the science. Members of these organizations were instrumental in urging the Arctic Council of nations to adopt a resolution to decrease black carbon emissions in order to slow Arctic warming. The findings about the strong role of biomass burning emissions in Arctic aerosol led them to advise policymakers at the December 2009 Copenhagen conference to focus on Siberian biomass burning specifically. As a result, the U.S. has committed funds to decrease black carbon emissions, with commitments from other Arctic Council nations expected to follow.
- The IGAC/SPARC AC&C “Bounding the Role of Black Carbon in Climate” results from a call from this same community to provide a review of the state of knowledge on this topic. We have specifically included members of the air quality policy community (e.g. U.S. EPA and Chinese specialists in mitigation economics) in the writing of the report to assure that it is crafted to be useful to these communities.