Center for Technology in Government

AIRNow-I Shanghai:
Crossing Cultures, Sharing Knowledge

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Executive Summary

AIRNow-International (AIRNow-I) is an initiative led by the US Environmental Protection Agency (EPA) to redesign the US air quality monitoring and public reporting system to be scalable, interoperable, portable, and affordable to any country. Its guiding vision is a readily usable world wide platform for sharing air quality information to improve public health.

This case study assesses the internationalization of AIRNow through the lens of a collaborative project between EPA and the Shanghai Environmental Monitoring Center (SEMC) in China. We trace the history of air quality policy and management in both countries and then explore the structure and dynamics of their joint effort to build AIRNow-I Shanghai. Our goal is to understand the influences of the separate Chinese and American contexts on the participants and their interactions, and to identify the ways in which they bridged many types of contextual distances to produce results.

After four years of technical exchanges followed by two years of system development, AIRNow-I Shanghai made its official debut on May 10, 2010. EPA had spent approximately $1.5 million and China about RMB 900 thousand on the direct costs. Both sides had invested nearly six years in learning and relationship building as well as joint system development. Several months earlier the core system developed for AIRNow-I Shanghai had replaced the old domestic AIRNow software in the United States. The full case presents a comprehensive look at the process of engagement from the perspectives of participants in both countries. In this summary, we highlight the accomplishments, challenges, and lessons learned that can help inform other transnational efforts to share and exchange knowledge and information.

Accomplishments

For China and Shanghai

- A new air quality information monitoring, management, and reporting system with AIRNow-I at its core.
- Successful experimentation with a totally new international cooperation model.
- Successful public use of the system during World Expo 2010 in Shanghai.
- Cultivation of a well trained cross-functional team at SEMC.
- Staff development and scientific training for Chinese scientists and technicians.
- Enhancement of Shanghai's reputation for leadership within China.
- A foundation for regional air quality data sharing and collaboration in the Yangtze Delta

For the US, EPA, and STI

- A new domestic AIRNow system with greater capacity for growth and innovation.
- Completion of the AIRNow-I platform for global use.
- Enhancement of EPA's international leadership position in air quality monitoring and improvement.
- Deep on-the-ground experience working on a familiar topic in an unfamiliar culture.
- Understanding of substantive air quality issues and challenges in another part of the world.

Joint accomplishments

- Tangible outcomes associated with the 10-year bi-lateral agreement between China and the United States to cooperate on clean air and energy.
- Trusted working relationships for future cooperation.
- A technical basis for subsequent regional air quality strategies in China and other countries.
- A variety of re-usable tools and techniques for communication and collaboration.

Challenges and lessons learned

The AIRNow-I Shanghai project faced considerable challenges due to differences between the countries and organizations. Some of these differences reflect the divergent social, economic, and political contexts in the United States and China, others reflect differences in goals, organizational factors, typical approaches to work, technical capabilities and the resources available for the effort. First, the United States and China had different reasons for participating and sought different, but not necessarily incompatible, goals. In addition, political and organizational cultures combined to create quite different contexts for the work in the two countries. Language presented another challenge. Much work was done remotely over the phone, few of the Chinese were initially comfortable with spoken English, and only one member of the American team was familiar with Mandarin. Neither side started with enough money to support the work they wanted to do and neither country provided funding from regular operating budgets. Physical distance also imposed challenges from crossing over 12 time zones to the expenses of travel for the face-to-face work that was necessary to build trust and to design, develop, build, test, and implement the system.

Given the accomplishments as well as the challenges presented in this case, we offer these lessons for future engagements in transnational knowledge sharing.

Consider the broad historical and political context. Efforts like AIRNow-I are not general exercises in international engagement. They are specific investments in a particular policy domain where the countries involved can be in different stages of development and pursuing different policy goals. Developing a shared understanding of similarities and differences in context and history should be among the first steps in these initiatives.

Find the mutual benefit in separate national intentions. The nations participating in a transnational knowledge network are likely to have somewhat different intentions and goals. Success of the network depends on finding an adequate overlap among these different goals such that progress is made toward separate objectives, while also achieving an acceptable level of mutual benefit.

Give critical attention to the early phase of engagement. The cultural, political, organizational, technological and other differences among participants present many opportunities for misunderstanding and wrong assumptions. The early period of engagement is therefore critical for establishing shared understanding about fundamental goals, roles, expectations, capabilities, resources, limitations, and working assumptions.

Recognize the power of personal commitment and individual leadership. The individuals involved in complex transnational projects all have responsibilities associated with their organizational positions, but the success of these efforts is strongly linked to personal commitment and leadership that goes beyond formal position. These individual contributions are a necessary complement to organizational action.

Recruit participants who can work in multiple languages and cultures. Transnational projects require at least some participants who speak multiple languages and are comfortable working in more than one culture. Ideally, these would be people who have lived and worked for substantial periods in these different contexts and appreciate how values, norms, and beliefs underlie perceptions, relationships, and actions.

Employ multiple methods and channels of communication. Since the participants in a transnational network are likely to be separated by physical location as well as by time, language, and culture, the chances for mis-communication and non-communication are high. These risks can be mitigated by employing and coordinating multiple forms and channels of communication at the technical, managerial, and policy levels.

Be open to different forms of knowledge sharing and knowledge building. Transnational projects like AIRNow-I are not typical transfer projects in which a donor builds a factory or gives a complete system to recipient. Rather, they are long term engagements in which two or more countries work together to create value in the form of knowledge, expertise, and shared results. This kind of work requires patience and genuine openness to a mutual learning process.

Assemble complementary, adequate, and appropriate resources. Many kinds of resources go into transnational knowledge sharing projects, including expertise, data, funding, technology, facilities, and relationships. In a successful effort, each participating entity brings some collection of resources to the table that are commensurate with both its own interests and its commitment to the network goals. Different funding sources, rules, and cycles can make this difficult, but not impossible, to achieve.

Leverage external opportunities. Tying the effort to a highly visible domestic or international event provides a strong incentive to innovate, accept new forms of international cooperation, and find internal resources to support the work.

Plan the duration and intensity of the effort for the "distance" to be covered. Transnational knowledge sharing appears to need a long gestation period of relationship building before explicit goals are set or projects are launched. Once underway, the work of the network is inevitably slowed by differences in location, language, culture, and political and organizational considerations. When these differences are large, the time period for achieving sustainable results is likely to be measured in years rather than weeks or months.

Build in a path to sustainability. To achieve long lasting mutual benefits, the plan for any transnational knowledge sharing project needs to include a path to sustainability that makes sense in the context of that particular effort. A rough strategy and resource estimate for sustaining the effort should be part of the plan.

The findings and lessons of AIRNow-I Shanghai show that the AIRNow-I system can be successfully implemented and customized outside the United States and most likely can be replicated in a wide variety of national settings. But despite consistency in the technology, strong cultural influences will make the process of engagement different with each new partner. The challenges and lessons learned in this first international partnership provide a set of guidelines for successfully carrying these efforts into other parts of the world.

Introduction

Air quality is a global concern. Human and environmental health are threatened by emissions from automobiles, power plants, manufacturing, agricultural practices, and a wide variety of personal actions and decisions. Regulatory approaches like the Clean Air Act in the United States and the European Commission Directive on Ambient Air Quality Assessment and Management aim to reduce or prevent air pollution. They do so by setting and enforcing stringent air quality standards that reflect maximum allowable emission levels for pollutants like particulates, ozone, and sulfur dioxide, which can cause or exacerbate respiratory and cardiac conditions in children and adults. These laws require local air quality monitoring and nationwide reporting of pollution levels. They also mandate mitigation programs when quality levels fall below established standards. These laws have had an undeniably positive effect on air quality, although they can be enforced only within the boundaries of the countries that have adopted them. Unfortunately, the air we breathe does not respect political or geographic boundaries – problems that affect air quality in one part of the globe eventually affect quality elsewhere.

Regulation and enforcement are the typical governmental approaches to environmental management, but since the 1990s developed countries have also used a second approach–public reporting, education, and outreach using air quality monitoring data. The same kind of data that measures and tracks air quality for the purposes of regulation can also provide communities, organizations, and individuals with knowledge that they can use directly to achieve better health and healthier environments. The US initiative in this area is called AIRNow (airnow.gov). It gathers and integrates hourly reports from a network of monitoring devices all over the United States and Canada. That data is used to forecast immediate health risks and provide easy-to-understand maps and graphic displays of air quality conditions based on the national Air Quality Index. AIRNow also supplies data to government agencies and researchers for analysis, and to the media for public outreach and education. AIRNow represents not only vast amounts of voluntarily reported scientific data, but a broad community of stakeholders who share a commitment to improving air quality through information sharing and dissemination across government and with the American public.

AIRNow-International (AIRNow-I) is a recently established program to revamp the AIRNow system to be scalable, interoperable, portable, and affordable to any country. It represents a major step toward a vision of a readily usable world wide platform for sharing air quality information to improve public health.

What follows is a case study of the first steps in the internationalization of AIRNow, embodied in a collaborative project between the US Environmental Protection Agency (EPA) and the Shanghai Environmental Monitoring Center (SEMC) within the Shanghai Environmental Protection Bureau (SEPB) in China. We trace the history of air quality policy and management in both countries and then explore the structure and dynamics of their joint effort to build AIRNow-I Shanghai. Our goal is to understand the influences of the separate Chinese and US contexts on the participants and their interactions, and to identify the ways in which the participants bridged many types of contextual distances to produce results. We conclude with a summary of challenges faced and lessons learned that can help inform other transnational projects to share, exchange, and create knowledge and information.

Historical context

AIRNow-I Shanghai rests at the confluence of separate streams of development in environmental awareness, policy making, and management in the United States and China (Figure 1).

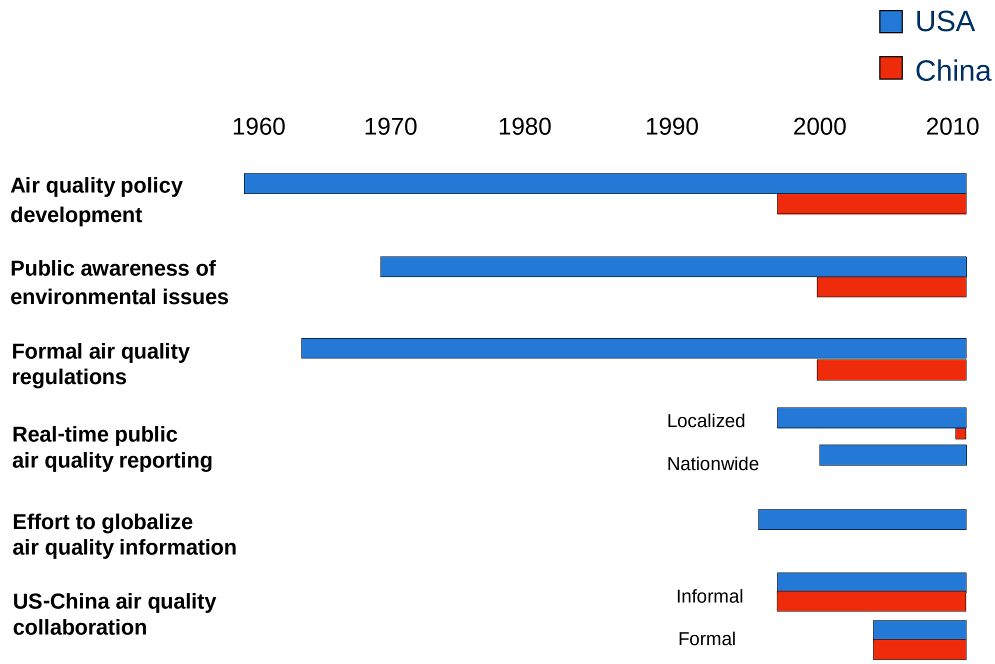

Figure 1. Historical context of AIRNow-I Shanghai

Brief history of US Air quality monitoring and information policy

The US government and the US public have garnered half a century of experience in recognizing and confronting environmental issues. In 1963, the landmark Clean Air Act established the responsibility and authority of the federal government to protect air quality as a matter of public health. Widespread public awareness of environmental issues was well-established by the 1970s. National Ambient Air Quality Standards (NAAQS) for commonly occurring pollutants were adopted in 1970 and EPA itself was created in 1971. At the same time, state governments were assigned the responsibility to monitor and maintain compliance with or "attainment" of the standards. State-installed monitoring networks collect the data and report it quarterly to EPA. EPA uses that data to determine whether states are complying with the standards, and if not, what enforcement actions are required. States that fail to attain or maintain the standards are required to develop and implement remediation plans.

While the traditional regulatory approach described above continues, a second strategy has emerged that focuses on public outreach. While mandated and decentralized state reporting provides data for regulatory enforcement and assessment of long-term trends, the data is neither usable nor timely enough for other activities that could contribute to the national goals of clean air and public health – goals that require real-time data and forecasts in easy-to-interpret formats (White, et al., 2004). As a result, most citizens remained uniformed about air quality in their cities and neighborhoods, even when it reached potentially hazardous levels.

In 1994, the State of Maryland Department of the Environment began a short-lived but instructive pilot program to map state ozone information as a way of presenting the data in a publicly understandable form. In 1996, EPA Region 1 pooled funds with Maryland through an association called NESCAUM (New England States for Coordinated Air Use Management) which arranged to have voluntarily submitted hourly ozone data from 13 New England and Mid-Atlantic states plus Washington, DC compiled into an animated map. EPA Region 1 posted the resulting ozone maps and forecasts on the Web three times a day. The effort was popular but faced continuing organizational, financial, and technological challenges. A similar effort was also underway in California in a cooperative arrangement among large cities and the Central Valley region, supported by a local air quality and meteorological consulting firm, Sonoma Technology, Inc. (STI). During the same time period, the Clinton Administration launched a grant program called Environmental Monitoring for Public Access and Community Tracking (EMPACT) to provide sustainable public access to clear, accurate, and useful environmental monitoring information in the largest US metropolitan areas to help people make day-to-day decisions about their health and the environment (US EPA, 2001). In 1998, the EPA Office of Air Quality Planning brought these separate efforts under EPA by providing states with grant funds to upgrade their monitoring networks, centralizing the data repository, and obtaining a policy commitment that the hourly data would be used only for public outreach, not for determining whether states were in compliance with the Clean Air Act standards (Stoddard and Linder, 2004).

This national-level project to produce ozone and particulate matter maps became known as AIRNow. AIRNow operates out of a centralized Data Management Center, operated by STI under contract to EPA, that receives real-time ozone and particle pollution data from 2,000 sensors deployed by more than 115 US and Canadian agencies as well as air quality forecasts from over 300 US cities. A Data Management System (DMS) handles data ingest, quality checks, and file maintenance, while an Information Management System (IMS) produces information products such as maps and graphs for public use. A back-end system and password-protected website called AIRNow-Tech allows the organizations that contribute data to have direct access to the full national database for research, analysis, and planning. AIRNow maintains an informational website (airnow.gov) where near real-time ozone and particulate matter maps and city air quality forecasts are posted (Figure 2). Current air quality is shown with point and contour maps that are animated with color-coded pollutant concentrations according to the Air Quality Index (AQI). The information is also made available to media outlets such as CNN and USA Today (White, et al., 2004).

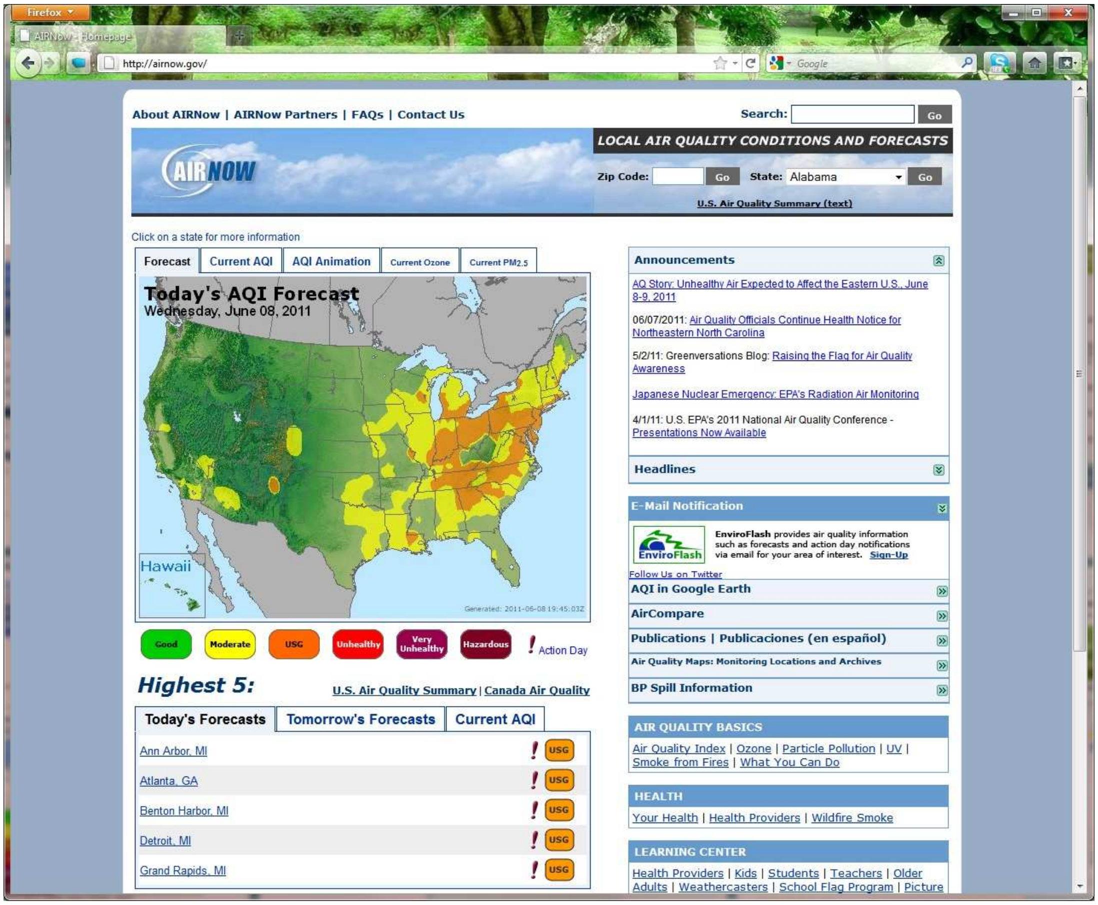

Figure 2. AIRNow public web site

AIRNow provides the public with air quality information that can be used to make daily lifestyle decisions by helping people take precautionary measures to avoid or limit their exposure to predicted unhealthy conditions. In addition, many communities have initiated air quality action or awareness days, based on air quality forecasts, to implement voluntary programs to reduce pollution and improve local air quality. Washington, DC, for example, offers free public bus rides on code red air quality days to reduce the number of cars on the road. EPA works closely with state and local agencies to also provide educational materials about the many voluntary measures they can take to reduce air pollution (Wayland, et al., 2002).

Over the past decade, international interest in AIRNow prompted EPA to conceptualize an international version of the program. AIRNow International (AIRNow-I) embodies EPA's effort to lead and support a worldwide community of air quality data sharing. AIRNow-I is intended to eventually support real-time air quality information worldwide by developing and deploying mainly open-source software that focuses on standardization, interoperability, portability, and affordability.

Brief history of China air quality monitoring and information policy

The Chinese government's development of air quality policy and action is much more recent but is similar to the early phases of the US experience, beginning with the adoption of quality standards and a variety of local reporting requirements. These policies and actions coincide with China's opening to global engagement and foreign investment and the rapid urbanization and economic development that has taken place in the past decade.

Before 2000, public awareness of environmental quality issues in China was quite limited. Since that time, awareness and demand for better air quality has grown, at least in the economically prosperous eastern provinces and major cities such as Shanghai and Beijing. While the forces favoring rapid development are formidable, voices inside and outside government for a better balance between economic growth and environmental quality are gaining some strength. For example, a recent head of the Ministry for Environmental Protection advocated for adopting a "Green GDP" economic measure to take into account both the costs and contributions to the environment that result from economic growth, such as investments in clean energy technologies. In a more visible way, the 2008 Beijing Olympics and the Shanghai World Expo both provided strong impetus for local environmental monitoring and remediation as both cities prepared to receive foreign visitors and to present China to the wider world.

Environmental regulation by the central government began in earnest in 2000 when the Law of the People's Republic of China on the Prevention and Control of Atmospheric Pollution was adopted. In the same year, the State Environmental Protection Administration (SEPA) of the People's Republic of China (now the Ministry of Environmental Protection, MEP) and China Meteorological Administration jointly required 47 cities to release air quality forecasts on the nation's most influential television network, China Central Television (CCTV), starting in 2001. Also in 2000, the Department of Science and Technology released guidelines for environmental monitoring devices to promote the development of the environmental monitoring industry.

In 2001, the State Council, China's highest administrative authority, approved *The National Tenth Five-Year Plan for Environmental Protection* (2000-2005), which required the air quality in over 50% of cities above prefecture level to attain the second level on a three-level National Air Quality Standard and established the city air quality daily report and key city air quality forecast system. Soon thereafter, in 2002, the Demarcation Plan of Air Pollution Control Key Cities designated 113 cites as air pollution control key cities, which were required to reach the second grade of the national standard during the tenth five-year plan. In 2003, the 2003-2005 *National Pollution Control Plan* was adopted requiring these 113 cities to set up automatic air quality monitoring systems. In 2005, additional technical specifications were released for both automatic and manual air quality monitoring.

In 2007, the State Council approved the *National Eleventh Five-year Plan for Environmental Protection* (2006-2010), which set the next five-year targets, requiring 75% of key cities to exceed the second grade National Air Quality Standard. The Plan also included overall planning for the prevention and control of regional air pollution in urban clusters in such areas as the Yangtze River Delta, Pearl River Delta, and the Beijing-Tianjin-Hebei region. In the same year, the first Environmental Air Quality Monitoring Standard (Trial) was released, followed a year later by a *National Environmental Monitoring Plan*, which requires all cities to begin air quality monitoring work. Cities above the prefectural level must implement daily reporting and submit annual monitoring data to the China National Environmental Monitoring Centre (CNEMC), while the 113 key cities must submit daily monitoring data. This requirement was supported by a technical regulation regarding the requirements for daily air quality reporting and forecasting.

In 2010, China's monitoring focus moved from the local to the regional level with the issuance of the *Guideline Promoting Air Pollution Joint Prevention and Control to Improve Regional Air Quality* by the Ministry of Environmental Protection, National Development and Reform Commission, Ministry of Science and Technology, and six other ministries. The Guideline adopts a new idea of "Five Unifying" elements, including planning, monitoring, supervising, estimation, and coordination. In addition, the guideline identifies the Yangtze River Delta, the Pearl River Delta, and the Beijing-Tianjin-Hebei region as the key regions in leading joint prevention and control and improved air quality measurement systems, and city air quality grading management systems. These regions are receiving particular attention, although this approach is still at a very early stage.

The effect of this decade of environmental policy development has been uneven in different parts of China. Western areas remain poor and without the technical and financial resources to mount a sustainable monitoring effort, while eastern China and the major cities have implemented monitoring networks of increasing sophistication. China's policies recognize these differences and impose more stringent requirements in those areas economically and technologically able to implement them.

Evolution of environmental cooperation between the United States and China

Chinese and American researchers began discussions of environmental issues starting in the 1980s, but engagement between the two governments began in earnest during the Clinton Administration (1993-2001) in recognition of China's growing economic and strategic importance and the environmental impacts of its rapid growth. In December 2003, after more than a decade of bi-lateral discussions and scientific exchanges, the State Environmental Protection Administration (SEPA) and the US EPA signed a memorandum of understanding to undertake a joint strategy for clean air and energy cooperation. The goal of the agreement is to foster collaborative efforts to reduce air pollution and greenhouse gas emissions that are a consequence of China's rapidly expanding economy. Reduced emissions to address severe local, regional, and transboundary air quality problems are necessary to achieve improvements in public health and environmental quality.

A Working Group on Clean Air and Clean Energy was established under the MOU to help strengthen regional coordination of clean air and energy management and prioritize pollution source categories affecting air, environment, and public health for attention and remediation.

The regional coordination strategy focuses on capacity development including mechanisms for transferring expertise, tools, and management capacity, first in the Beijing region and then to other regions, provinces and cities in China. This work includes adaptation of advanced monitoring, measurement and modeling tools and the identification of options for reducing and controlling emissions. The strategy also supports Chinese efforts to strengthen regulations, institutions, and coordination across all levels of government and to coordinate clean air strategies with other domains such as transportation. Finally, it encourages private sector investments, improved public outreach and information dissemination, and training for a variety of partners.

In a parallel international development, the Group on Earth Observations (GEO) was formed in 2005 as an outgrowth of the G8 Summits (www.earthobservations.org/index.html). GEO is a voluntary partnership of 86 countries and the European Commission plus 61 international organizations. It provides a framework to support the use of Earth observation data for decision-making. China, the European Commission, South Africa, and the United States co-chair the Executive Committee of the partnership. GEO is facilitating the development of a Global Earth Observation System of Systems (GEOSS), a platform through which Earth observation data and tools can be contributed and shared among the member countries. GEOSS will support data accessibility and sharing by linking together existing and planned observing systems and supporting the development of new systems where needed (Barrie, et al 2010). The idea is to allow members to benefit from sharing systems and data rather than investing in their own satellites, sensing systems, and data resources. GEOSS contemplates shared data and models in nine "societal benefit areas" including weather forecasting, climate change, and human health and well-being. The overall objective is to develop and implement sustainable systems and communities of practice that share data to inform national, regional, and global users as they address these cross-cutting issues. AIRNow-I is a US contribution to the human health and well-being benefit area (White, 2010).

In order to move from concept to practice, US EPA began to seek possible international partners to work jointly on development and testing of the system in another country. Shanghai, China became the first partner and the joint initiative became known as AIRNow-I Shanghai.

Participants in AIRNow-I Shanghai

The AIRNow-I Shanghai project involved a small number of organizations and individuals in China and the United States. Although few in number, they represent a variety of organizational forms, philosophies, and cultures as described briefly below.

United States

In the United States, EPA is the nation's environmental management agency with broad authority to set standards and regulate activities that affect the environment and human health. It also carries out a considerable amount of public awareness and education about environmental topics. EPA's purview covers air, water, land, ecosystems, toxins, and related areas. The agency does not have an international component in its formal mission because it is not a cabinet-level department. Instead, as a so-called "science" agency, EPA is often included in international engagements where its expertise serves as a benefit or inducement to cooperation on related topics. Its direct leadership role in AIRNow-I was therefore somewhat unusual and consequently the participants within the agency used both routine and novel strategies to initiate and sustain the effort.

Within EPA, the Office of Air Quality and Planning Standards (OAQPS), part of the Office of Air and Radiation, played the leading role in AIRNow-I Shanghai. Located in Research Triangle

Park, North Carolina, OAQPS's primary mission is to preserve and improve air quality in the United States. It compiles and reviews data, develops regulations to limit and reduce air pollution, assists states and local agencies with monitoring and control, and makes information about air pollution available to the public.

Dale Evarts is a policy-level official in the Office of Air Quality Planning and Standards whose responsibilities include building international collaborations. In that role, he serves as the Secretariat for the Working Group on Clean Air and Clean Energy established by the bi-lateral MOU with China. For the AIRNow-I Shanghai project. Evarts was responsible for securing resources for the US contribution to the project and managing the overall relationship between EPA and the key Chinese environmental organizations. The day to day technical and management work related to the project was led by Phil Dickerson and John White, both from the Outreach and Information Division of OAQPS, who have also been responsible for the US domestic AIRNow system since its creation in the mid-1990s.

Sonoma Technology, Inc. (STI), an employee-owned firm in Petaluma, California, is the main contractor responsible for building and maintaining AIRNow. STI's 70 employees include atmospheric scientists, engineers, and programmers. STI provides services for government, industry, university, and non-profit organizations in the areas of air quality, climate change, metrological services, policy development and analysis, software and website development, and training and public outreach. STI operates the national AIRNow Data Management Center (DMC), working with the full range of AIRNow stakeholders to ingest, manage, and distribute data and public information products.

Two STI employees played major roles in the development of AIRNow-I Shanghai: Tim Dye and Alan Chan, both meteorologists with extensive experience in air quality analysis and forecasting and associated information technologies. Dye's experience dates to the earliest days of AIRNow, where he worked first with local and state governments and then with EPA to develop the nationwide program. Chan, who manages the DMC, was born in Hong Kong but educated in the United States, also brought his knowledge of both languages and cultures.

The relationships among these organizations are depicted in Figure 3. Although the chart shows hierarchical arrangements and the relationship between EPA and STI is embodied in a formal contract, the working-level relationships are actually quite informal and interdependent. EPA makes the policies and provides the funding, STI implements and manages the program. A great deal of mutual experience and trust is evident in the relationships. The participants use several structured management tools to plan, organize, and document the work, and STI makes regular reports to EPA. However, the general tenor of the relationship gives the impression of a well-integrated distributed team of respected professionals, rather than a formal command and control arrangement.

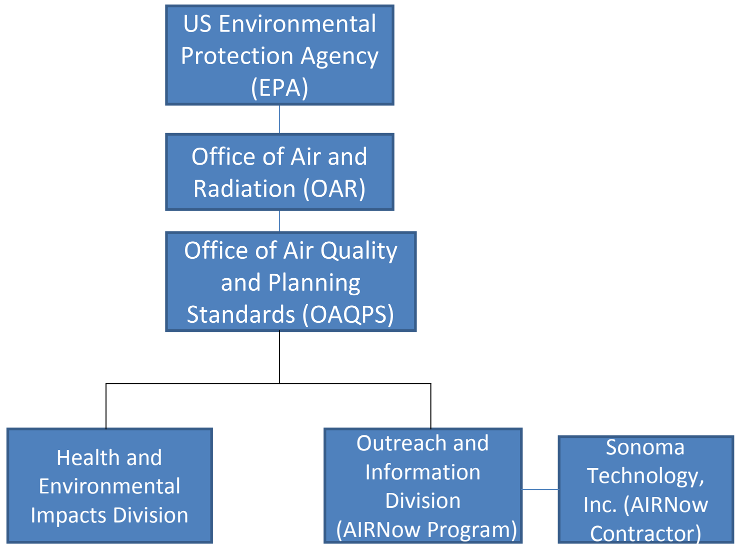

Figure 3. Relationships among the US participants in AIRNow-I Shanghai

China

In China, the Shanghai Environmental Monitoring Center (SEMC) was the focal organization for the project. Established in 1983, SEMC is a quasi-public part of the Shanghai Environmental Protection Bureau (SEPB) responsible for environmental quality and pollution source monitoring in Shanghai's administrative jurisdiction. SEMC is the center of an environmental monitoring network of about 60 monitoring stations in the metropolitan districts of Shanghai. Besides serving local clients, SEMC also serves multinational companies on environmental impact and baseline studies.

The SEMC team on AIRNow-I Shanghai was led by Jackie (Qingyan) Fu, an experienced environmental scientist who worked for the Shanghai Environment Science Institute before joining SEMC in 2003 and spent several months at Argonne National Laboratory in the United States working with American scientists on air quality measurement issues.

SEMC includes a number of subdivisions. Two of them, the Information Department and the Air Quality Monitoring and Forecasting Department were directly involved in AIRNow-I Shanghai. In the Information Department, Director Hanzhen Wang exercised direction over technology development and implementation. Lu (Lucas) Tao was the core technician with a background in software applications and user needs. He was also responsible for managing the work of Suhui Company, the contractor that built customized software modules to meet local needs. Chenyuan (Walter) Lin also served in a technical role bringing experience with system implementation and knowledge of daily forecasting. Jessie Wang is an environmental analyst and administrative assistant with strong English skills, so she played both an analytical role and a coordination and communication role in the project. In the Air Quality Monitoring and Forecasting Department, Song Gao and Quan Bao worked with the data to produce forecasts and other information products.

While SEMC had day-to-day technical and management responsibilities, essential roles were played by higher level organizations and officials who gave the approvals and resources for the effort. The Ministry of the Environment (MEP) is the highest level organization in environmental protection in the Chinese government system. MEP develops and organizes the implementation of national policies and plans for environmental protection, drafts laws and regulations, and formulates administrative rules and regulations for environmental protection, including environmental monitoring and information release. MEP provided administrative approval and policy support for the project, two essential resources for any government initiative in China.

The Shanghai Environmental Protection Bureau (SEPB) is a unit of Shanghai Municipal Government but its programs are directed by MEP policies. In this dual position, SEPB implements national environmental strategies, policies, laws and regulations, but also establishes municipal strategies and plans, regulates municipal environmental quality standards, handles local environmental accidents, and manages environmental monitoring and data analysis for Shanghai. SEPB's International Cooperation Division supports exchanges among Chinese and foreign experts.

The relationship among the Chinese participants is illustrated in Figure 4. Here the hierarchical arrangement is quite strict and the relationships between one level of organization or one level of government and another are very formal. The responsibilities of lower level organizations are defined and controlled by higher level ones. When an organization seeks to do something outside the boundaries of already well-defined work, it obtains explicit higher level permission or consent before acting. Similar hierarchies exist between different ranks of individuals within an organization. However, the Chinese practice of "guanxi," or the building of a network of life-long personal and professional relationships and obligations, is intertwined with the formal organizational structures and lines of reporting and control. Thus strong interpersonal networks are a main (usually indirect) channel for the communication and negotiation that lead to organizational decisions and actions.

Figure 4. Organizational relationships among Chinese participants in AIRNow-I Shanghai

Motivations for participation in AIRNow-I Shanghai

Given their histories, the United States and China are on similar paths related to air quality policy and the use of air quality information. However, China is near the beginning of a journey the United States has been taking the journey for a much longer period of time. The motivations on both sides for collaborating on AIRNow-I were therefore compatible, but they also differed in significant ways. Both countries are interested in modern technological systems and software for air quality reporting and forecasting. However, their desired uses for the data are different: the United States is at a point where open and broad sharing of air quality information with the public and the international community is a leadership priority. In Shanghai and China, the need for robust, high quality data is also clear, but it is targeted for internal government use, to help policy makers understand air quality problems and to use quality data to mitigate air pollution from the sources. Additionally, Shanghai wants to be seen as a leader in China for this kind of scientific advancement and technological development.

EPA sought international partners to help develop AIRNow-I and selected Shanghai as the first pilot site. Accordingly, an agreement between EPA and SEPB was signed in 2008 to develop a state-of-the-art air quality notification and forecasting system for Shanghai and deploy it for use during the 2010 World Expo. Internationally, AIRNow-I Shanghai provided EPA with the opportunity to pilot the AIRNow-I concept in a real world international setting. Given US and GEO goals to build and support tools and relationships for open and broad sharing of environmental data, AIRNow-I Shanghai represented an important step toward building the technical capability to do so outside the United States. Domestically, AIRNow-I Shanghai also represented an opportunity for EPA to substantially improve the US version of AIRNow by making it more standardized, interoperable, flexible, and scalable.

The main motivations for MEP to support the project were to introduce technically advanced air quality information management and analysis techniques to help improve air quality in China and to build a showcase for potential nationwide expansion. MEP also saw the project as a way to serve World Expo 2010 air quality management needs. SEPB supported AIRNow-I Shanghai for several reasons. First, growing attention to air quality and a desire for more information among local residents signaled a growing need for advanced air quality management and reporting techniques, especially the ability to conduct pollution forecasts. Second, the Shanghai government was determined to hold a successful World Expo in 2010. The event provided a major opportunity to showcase Shanghai to the world as well as to other parts of China. EXPO represented not only a rare opportunity to publicly demonstrate the value of air quality monitoring, but a world stage and a hard deadline for doing so. Air quality information posted on the Expo website represented part of the city's strategy and consequently air quality management was built directly into the EXPO planning process.

For SEMC, the project was an opportunity to modernize its technology and to develop new scientific skills, teamwork, and management capacities in support of improving the city's air quality management program. It also supported Shanghai's drive for a leadership role among China's cities and provinces. The technological benefits of the partnership were salient, but less important than the political value. SEMC already had considerable technical expertise and could probably have developed a similar system on its own without the security concerns presented by adopting an American system. However, SEMC also recognized the influence that an international partnership could have on its ability to acquire governmental support and resources. Thus AIRNow-I Shanghai was a means to draw positive attention to its work from MEP and the Shanghai Municipal Government. The opportunity for international collaboration and knowledge exchange was also strongly supported by the International Cooperation Division of SEPB, which provided funds and sustained executive support to bring experts from STI and EPA to Shanghai for training and technical exchanges over several years leading up to the actual AIRNow-I Shanghai system development project.

The making of AIRNow-I Shanghai

Selecting Shanghai as the pilot site

Starting around 2000, international conferences, professional visits, and technical exchanges involving environmental agencies, universities, and other experts demonstrated growing interest in an international version of AIRNow. In the course of these activities, discussions began within EPA about a partnership effort to internationalize AIRNow.

By around 2004, several countries were possible candidates for an initial pilot, but the MOU between the United States and China provided an established bi-lateral framework for exploring cooperation. Initially, the top leaders at MEP were skeptical of EPA's interest, especially because environmental data in China is considered highly sensitive and subject to strict security. Recognizing this concern, EPA executives and policy officials continuously communicated directly with MEP officials to build understanding of the air quality improvement goals underlying AIRNow-I, as well as the opportunity it presented to share knowledge, experience, and lessons learned from one country to the other. These discussions set the stage for the technical experts at OAQAP and STI to introduce the specifics of AIRNow-I to Chinese leaders.

As the prospects for a partnership improved, an early consideration was finding the right partner within China. Initially, EPA approached Beijing which was planning the upcoming 2008 Olympic Games. STI and EPA representatives traveled to Beijing for the 2004 International Environment Forum and met with the Beijing Environmental Protection Bureau to discuss the possibilities. They explored whether the increasing international attention being paid to air quality and other environmental issues in the city where the athletes would be living and competing, plus the expected crowds of international spectators, offered a ripe situation for implementing an advanced air quality monitoring and forecasting system. However, consumed with the complexity and scale of the preparations for the Games themselves, Beijing declined.

In Shanghai, Jackie Fu (who had come to know several EPA officials and experts over the previous years) had learned about the US visit to Beijing while attending an earlier conference. Although Shanghai had not been invited to the Forum, Fu brought a team of four people from SEMC on an overnight train ride to meet informally with the Americans and discuss the possibilities of a pilot in Shanghai. According to STI's Tim Dye:

> "We met in the hotel for two hours in a room not much bigger than this one [a small meeting room at STI]. There were four folks from Shanghai and we hit it off. They asked lots of good questions, they were engaged, and we were freely exchanging ideas, very good questions. The whole dialogue was really good. Here we found people that were really excited about this."

From the US point of view, SEMC's strong interest in the concepts of AIRNow, the initial success of that first meeting, and the fact that Shanghai had an established network of air quality monitoring sensors made the city a serious candidate for a partnership. Moreover, the SEMC team seemed dissatisfied with its existing technology and also eager to improve its forecasting abilities, both areas where the Americans were well advanced. Moreover, among Chinese cities, Shanghai is more open to commercial and scientific connections throughout the world.

Other cities and provinces, such as Hong Kong, were also under consideration at this point but, as detailed discussions moved to the Ministry of Environmental Protection, which had to formally authorize any effort within China, Shanghai emerged as the logical choice. As both sides continued to meet, it became clear that Shanghai had the elements that could make an AIRNow-I system succeed; it was a mainland city without special administrative autonomy (as exists in Hong Kong). Therefore, it would be a good test of the concept in the standard Chinese political system. The SEMC staff had a clear desire and the technical background to implement such a system. SEPB seemed willing to find resources to fund some scientific exchanges to get started. Moreover, an extensive and expanding monitoring infrastructure was already in place. In addition, the US representatives recognized that Shanghai is often a leader for the rest of China. A successful implementation there might have a good chance of being extended to the surrounding region and to other areas of the country – an important goal for both EPA and GEO.

From the Chinese side, however, a great deal of internal negotiation was needed. Jackie Fu recounted the barriers her team faced in getting high-level support for the project. First, in addition to sharing MEP's strong concerns about the security of environmental data, key leaders in SEBP knew little about AIRNow and were unconvinced that a system based on American experiences would be relevant in China. Second, the project as a whole was a conceptual leap regarding organization, management, and communication that she characterized as "beyond the current development level of China." She described the historically conservative environment of SEMC, which had been slow to recognize growing public concern about environmental problems and therefore slow to adopt non-traditional approaches to its work, including the need to work across disciplines and organizational boundaries.

As no initiative in Chinese government takes place without the express approval of higher level leaders, a long process of behind the scenes discussion, demonstration and persuasion was needed. Min Shi, Deputy Director of the International Cooperation Office at SEPB was a key ally in this effort. She noted how concern about data sharing was allayed once key executives understood that AIRNow-I was a suite of advanced software, not an open information repository. The prospects for staff development and skill enhancement were also viewed favorably. However, most often credit was given to Jackie Fu's "invincible" vision, persistence, ability to communicate, and skill in coordinating across different organizational levels and units. According to Min Shi, "She has great passion in international cooperation and has the power to coordinate among different departments and to talk to the higher level. Jackie Fu tried to persuade the different departments to see the advantages of AIRNow-I and made cross-boundary coordination work."

Jessie Wang explained the challenge in this way: "If there is support of the leadership there will be economic investments, so the key point is to appeal to the benefits and advantages of the technology, and fight for the support of peers, leadership, and the environmental protection agency. We must promote the work together [but] the system is not a decoration; we must also persuade them with actions."

In this environment, several visits by the EPA Administrator and other high-ranking EPA officials with the Mayor of Shanghai and the Director of SEPB were instrumental. According to Jackie Fu, "you can't underestimate the effects of these visits. Each time these visitors symbolically meet with our Mayor or launch a press conference, shaking hands with the Director, all of these behaviors exert a subtle pressure" that reinforced the seriousness of American interest and helped push support for the project from the top down in the traditional Chinese manner.

Developing the capability to collaborate

During the first three or four years of the effort, neither funding nor political support was sufficient to enter a more formal working relationship to jointly develop a system. This delay in building an actual system proved to be fortuitous as it provided an extended period for familiarization and relationship building. Lacking sufficient political and financial support to move forward with system development, both sides committed some money and time to a series of "technical exchanges" where staff from SEMC, EPA, and STI traveled between the China and the United States over a period of about three years, essentially sharing knowledge and information related to air quality reporting and forecasting. These exchanges focused mainly on air quality forecasting, with the experts from STI taking the lead in providing the expertise through training programs. The exchanges also provided more detailed information about the AIRNow system in the United States and how it worked, and more detailed information about existing air quality monitoring and reporting systems and practices in Shanghai.

A number of these visits to Shanghai by STI and EPA staff were financed through the efforts of Min Shi and her predecessors in the SEBP International Cooperation Bureau to obtain funding from the Shanghai Foreign Experts Bureau. Although these repeated visits seemed routine to the US participants, for China the fact that the same foreign experts were brought back multiple times for the same project was actually unprecedented. It represented a sharp departure from Chinese policy and practice of supporting only one visit by any particular expert and was made possible only by the persistence and unusual willingness of Shi and Fu to challenge the conventional practice and use these kinds of resources to help support an entire project over a period of several years.

Participants in both countries characterized this period of exchanges as capacity building in terms of both technical knowledge and for learning more about one another as individual professionals. While most of the events could be narrowly viewed as knowledge transfer about forecasting from the United States to Shanghai, from a broader organizational and social perspective, they were also beginning to develop familiarity and the capability to work together, creating the foundations for personal relationships and a starting level of trust among the organizations involved. The Americans observed the eagerness of the Chinese participants to acquire new skills and expertise, their inquisitiveness, and ability to learn quickly. Several Chinese interviewees commented on the professionalism, friendliness, and sincerity of the American team and how those characteristics were the basis for an atmosphere of growing collegiality and trust. As Jackie Fu observed:

> From 2004 to 2008, China and the United States maintained this project only by their will and intention. Neither the U.S. nor China side provided funding [for system development], thus the project was maintained solely as a technology exchange with a little funding from Shanghai Foreign Expert Bureau to invite US experts to China to give lectures. During this period, many Chinese staff were sent to the United States to learn more about AIRNow. Through this mutual understanding procedure, China finally considered AIRNow as a better method to improve its own air quality information management system and agreed to introduce the AIRNow system.

Meanwhile, Dale Evarts and senior EPA officials continued to build relationships focused on larger environmental issues between the two countries through periodic visits to Shanghai and Beijing. These contacts by top leaders from EPA were immensely important to the Chinese because they visibly demonstrated the sincerity of American intentions. Accordingly, they helped cement the political support for the project in MEP and in Shanghai.

Building the system

Working jointly on actual system development finally began in April 2008 when the EPA and SEPB signed an agreement laying out their goals and responsibilities for the project. SEPB had committed funding for the Shanghai side of the effort. The US team was finally able to secure funding to support STI's work from EPA's Research and Development Office, which had a budget to support innovative initiatives to encourage international sharing of air quality information under EPA's participation in GEO. Phil Dickerson described the long, dual-level process of getting funding:

> We started shopping around early on this AIRNow-I idea to EPA's GEO folks. And then I went on to some of the GEO summits and got to talk about it . . . GEO helped us with some funding afterwards but the real impetuous for working with Shanghai was Dale's work in China as part of his role as the international coordinator of the Office of Air Quality Planning & Standards.

Once the US and Shanghai teams moved into the development phase, a more focused and detailed working relationship began to emerge. The information and knowledge sharing that occurred during the previous several years helped the participants get to know each other as fellow scientists and technicians. However, trust, communication, and collaborative work processes still needed to evolve and mature as the work became more technical, specific, and results-driven. The participants had to learn how to actually work together across time, distance, and cultural differences. Dye commented on the importance of being sensitive to the cultural differences by "being open, listening, being respectful." Jackie Fu emphasized the importance of openness by the Chinese, noting that this project could be neither a case of accepting US technology wholesale, nor one of automatically rejecting foreign ideas, but rather a way to learn on both sides.

But cultural differences were still evident, especially with regard to the official status of individuals and their organizations. For example, while the working relationships between STI and SEMC became quite informal, Phil Dickerson expressed surprise at being treated "like a dignitary" owing to his stature as a representative of EPA and some disappointment that he was not expected to "roll up his sleeves" and get to work during visits to Shanghai. Alan Chan noted that in some communications with higher level Chinese managers, the STI staff asked EPA staff to speak for the whole US team, given their higher status as government representatives. On the other hand, Jackie Fu was especially pleased to discover that the Americans did not treat the effort "like a business" deal but as a true partnership. However, despite differences in initial expectations, all the participants noted the hospitality and personal helpfulness they received from each other. John White said "anything you ask for, they will do for you" and Lu Tao expressed appreciation for being accompanied at meals and leisure activities when he visited the United States, which he found "unusual for Americans."

While the two groups had technical expertise and terminology in common, everyday language was a significant challenge. Although several of the SEMC personnel understood English, only Alan Chan on the US team understood Mandarin. Thus, by virtue of his technical background and personal history, Chan became an indispensable link between the two teams. Among the American participants, he spent by far the most time on the project, making trips to Shanghai that lasted several weeks at a time. John White noted Chan's role as a very positive factor: "He definitely helps to bridge the two parties, especially because he has the conceptual knowledge" as well as the language skills. These were important not only in face-to-face communications, but especially in the bi-weekly phone calls between the two teams when Chan served as technical expert, troubleshooter, and translator for both sides. Tim Dye expressed the importance for STI:

> I don't know if I would have taken on something this big without someone like Alan. We've been talking about international work and how could we do more. But we have to have either a really strong in-country support or presence, or another firm we're teaming with, or staff here that are interested in the culture and the language. Because a lot of things are said, subtle things, in Chinese that are really important that I'm never going to hear without someone like Alan on the team.

Face-to-face meetings were also critical to problem solving. For example, telephone and email discussions about problems with the STI-designed user interface could not fully resolve the problems. However, in a visit to Shanghai, EPA's Phil Dickerson could readily see the not-uncommon need to rework software designed by expert programmers so it would be more intuitive and streamlined for regular users. Once he saw and understood the problem in person, Dickerson found additional resources for STI to rework the interface so it would not be an impediment to implementation.

Information technology and collaboration tools helped bridge the language, cultural, and even physical distances between the US and Chinese teams. Email proved to be a very important form of communication as the Chinese team could read English quite well and the written information could be the focus for more precise questions and discussions. The teams also began using software that enabled the Chinese to record what they were doing with the software on their computer screens. This allowed the US team to see what steps the Chinese team was following when running into a problem. They began holding the bi-weekly conference calls over Skype, which made them more affordable and flexible. Alan Chan summarized the variety of communication and collaboration tools:

> We've exchanged . . .1,000 emails through the entire project. We've had 50 or so phone calls. Initially, it was a regular conference call but we've been using more of the WebEx online presentation now, because we can give control to them and look at their screen and see what they're doing. They can see what we're doing to change something and some of that has been really helpful.

In March and April 2010, the existing Shanghai system and AIRNow-I began to run in parallel to test performance, data flow, and usability. Lu Tao described the importance of this phase: "It's really a relative matter to say whether the technology is complete or the implementation is comprehensive enough. We need to fully understand the status of the software in real practice and move it step by step rather than all at one go." Quan Bao in the SEMC Air Quality Forecasting Department stated that AIRNow-I offered "plenty of advantages" but there were also plenty of problems to work through including data compatibility between the old and new systems. For Song Gao, the data in AIRNow was more timely and flexible but it still needed work to fit with China's different standards and data quality considerations. But all of these were viewed as typical problems of new technology and the good working relationships that had been built over the years made it relatively easy to address them.

Given the limitations of the funding on the US side and the urgency to have the system ready for the World Expo on the Shanghai side, time pressures began to mount and two uncertainties took on greater importance. As their confidence in the system grew, the SEMC team began to place a high priority on the need to demonstrate the value of the project in a memorable and tangible way to their executive and political leaders. For the American team, the underlying questions of public information release, and whether the Chinese would allow the US team members access to Shanghai's data, took on greater prominence. These uncertainties came together in the final push to create a vivid public demonstration of the system's operation and value.

In the months lead leading up to the May 2010 launch, Jackie Fu began to talk to EPA about the need for a showcase component to convey to Chinese leaders the value of their support for the project. However, when she brought this up during a visit to EPA in North Carolina, the EPA managers misunderstood her concern as a desire for more help with the public website. After they started to work on that assumption, it became clear to Dickerson that "we had made a wrong turn." They asked Alan Chan bring it up in the regular conference calls and by translating back and forth it became clear that she was asking for "some sort of whiz bang display to show her higher ups. . . We had been so focused on getting the system running that we really had not thought beyond that, but it makes perfect sense that they would want something like that." Work effort was redirected to create a large digital display with special lighting and visualizations that would convey in broad terms the value of the software, data resources, and analytical tools, which were crucial but essentially invisible except to the technicians. At the same time, SEMC was gearing up to do the air quality forecasts that were so important to the Expo planners. In addition, after many months of speculation about data access, the STI and SEMC team developed a data confidentiality agreement and STI was given access to the Shanghai monitoring data for reliability testing and assistance to the Chinese forecasters. While the data was not shared in the sense that it was available to the Americans for their own use, the fact that they could see and analyze the data to support the Chinese effort was the clearest indication of the trust that had been built between the two teams.

EPA and STI were on hand for the launch of AIRNow-I Shanghai. It was marked by an official Chinese ceremony – a brief public appearance by senior leaders to mark the occasion with a vivid visual demonstration, handshakes, and short prepared remarks. In fact, as Jackie Fu explained, "Even compared to five years of hard work, we shouldn't underestimate the importance of that half-hour ceremony. . . senior leaders saw the realistic and practical results of AIRNow-I . . . the video and lighting ceremony on May 10 drew good publicity [in China and the United States] and now we know the management level supports us."

Moving ahead

Today, AIRNow-I Shanghai is implemented and in daily use. New forecasting skills are in place and a variety of locally-developed software modules make use of the core data. But the work is taking a new direction toward a future in which air quality monitoring and management moves from a local to a regional concern. From the beginning, Dale Evarts had expressed hope that this would be an outcome of the project:

> Shanghai, Suzhou, Nanjing, the whole lower Yangtze Delta region is now working together as a region to share emissions inventories, which they need to do if they're going to do the forecasting they want to do, establish a monitoring network, and share monitoring information that they all can feed into a central file server that would then produce the info and the maps and so on. So, yes, the ground work is being laid.

Juan Liu, Deputy Director of SEMC agreed, taking a more philosophical view of the process of building regional cooperation: "We had the idea of cooperation in common, but our rhythm and steps were not quite the same . . . We have regional consensus on the need [but] it's a long process from being strangers to knowing each other, to understanding each other. [And] only when the Ministry showed up, could action begin." The 2010 ministerial Guidance document on regional cooperation has now set the stage for regional action. Several Chinese interviewees stressed the importance of continued EPA involvement in this new phase, citing the successful collaboration embodied in AIRNow in the United States and EPA's long experience in working with diverse communities toward the goals of environmental protection.

Accomplishments

After four years of technical exchanges and professional visits followed by two years of system development, AIRNow-I Shanghai made its official debut on May 10, 2010 a few days after opening ceremonies for the World Expo. EPA had spent approximately $1.5 million and China about RMB 900 thousand on the direct costs. Both sides had invested nearly six years in learning and relationship building as well as in joint system development. Shanghai had a new core system and SEMC had developed a diverse but well-integrated team to operate and expand it. Several months earlier the core system developed for AIRNow-I Shanghai had replaced the old domestic AIRNow software in the United States. The same system was now running in both countries. Dye remarked that it was a much improved system, ready for domestic innovation as well as international deployment.

Jackie Fu recalled that there were five high pollution days just before the opening of Expo:

> Relying on the new daily air quality forecasting system, consulting with Yangtze Delta cities, and a new team of forecasters, we made an excellent forecast, which allowed time for pollution control efforts. As a result, the director of SEPB came to their office every day "to try to understand the whole operation, which presented us the opportunity to display all the AIRNow tools to our leaders.

These tangible results are part of a larger set of accomplishments, summarized below:

For China and Shanghai

China and Shanghai achieved a variety of important policy, management, and technology goals.

- *A new air quality information monitoring, management, and reporting system with AIRNow-I at its core.* This new system is faster, more agile, and capable of adaptation to changing needs. It generates spatial distribution graphs of pollution and supports air quality forecasting to help respond to pollution problems in the greater Shanghai area. Five locally-developed modules connect the core system to existing systems and processes that address specific local information needs. The local monitoring network was also upgraded as part of the project.
- *Successful experimentation with a totally new international cooperation model.* In the past international cooperation consisted of professional exchanges or the traditional development approach of giving or transferring a process or system from a more developed country to a less developed one. This project began with traditional technical exchanges but then moved into a cooperative development process involving shared knowledge, expertise, and responsibility, as well as resource contributions from all parties. The result was a broadened appreciation among different government departments for different forms of international cooperation with emphasis on its value for cultivating staff, enhancing organizational capabilities, and fostering mutual learning.
- *Successful public use of the system during World Expo 2010 in Shanghai.* An Expo air quality website was established using data and visual information drawn from AIRNow-I. This website released real-time air quality information to the public for the first time anywhere in China. Jackie Fu emphasized how important it was to show the public interest value of the system by presenting environmental information in ways anyone can understand, something that had never been attempted before due to the dominant view that this information is valuable, but only to technicians and scientists.
- *Cultivation of a well trained cross-functional team at SEMC.* Each member of the team was exposed to new ideas about the connections between technology, environmental science, and project management. The adoption of these ideas and the ability to combine an array of skills into a cohesive team is rare in Chinese institutions and marks a new way of working in SEMC that will serve it well in future initiatives.
- *Staff development and scientific training.* During the whole process, China sent more than 20 staff to the United States to exchange ideas and technology and many more Chinese participated in training programs provided in China by American experts. Those staff are now better prepared to play substantial future roles in air quality information management and analysis.
- *Enhancement of Shanghai's reputation for leadership*. The project presented an opportunity for Shanghai to demonstrate its ability to lead implementation of important new policies through both innovation and advanced use of information and technology.

For the US government, EPA, and STI

From the US perspective, the AIRNow-I Shanghai project delivered several important results.

- *A new domestic AIRNow system.* The domestic AIRNow system was rebuilt "from the ground up" within the context of AIRNow-I Shanghai. The technological advances and system upgrades that were created for the AIRNow-I Shanghai system were also needed in the US system to allow it to continue to grow in size and expand its array of services to domestic users. The project provided essentially a brand new system for the United States and laid the groundwork for the next level of enhancements such as web-based services, which were suggested by the SEMC team.

- *Completion of the AIRNow-I platform for global use.* Both US AIRNow and AIRNow-I Shanghai have the same technical capability to share air quality related data – and that capability is now ready to be deployed in other interested countries. This project successfully operationalized the AIRNow-International concept and represents its first real world implementation. As a contribution to GEOSS, AIRNow-I is fully developed and ready for more widespread adoption in interested countries in other parts of the world.
- *Enhancement of EPA's international leadership position in air quality monitoring and improvement*. The AIRNow-I Shanghai project solidified not only EPA's leadership role in air quality management, but also demonstrated through concrete action the agency's commitment to sharing knowledge and expertise on a global scale. The fact that this project was a bi-lateral knowledge exchange rather than a one-way technology transfer demonstrated EPA's ability to work in a joint problem-solving partnership within a sensitive political environment. The success of this approach has already increased interest in the AIRNow-I program from other countries such as Mexico, Indonesia, and Brazil.
- *Understanding of air quality challenges in another part of the world.* While the science of air quality monitoring is universally useful, the conditions in which it applies and the environmental issues it addresses can differ markedly from place to place. The project provided the American team valuable substantive knowledge about these challenges in the very different geographic, demographic, and economic context of Asia.
- *Deep on-the-ground experience working on a familiar topic in another culture.* Both EPA and STI gained deep knowledge about what it takes to work with people and organizations in a different culture and in an international setting. While technology and technical skills did provide a common language for some of the work, they also needed to find ways to bridge a host of other contextual factors or "distances" in order to bring the project to a successful conclusion.

Joint accomplishments

For both the United States and China, the project led to several important joint accomplishments.

- *Tangible outcomes associated with the 10-year bi-lateral MOU.* First, AIRNow-I Shanghai represented several tangible outcomes directly linked to the 10-year agreement, in particular its goals regarding capacity building and adaptation of advanced monitoring, measurement, and modeling tools. Joint experience with AIRNow-I Shanghai represents strong evidence for the value of continued cooperation between MEP and EPA on the overarching goals of the agreement, especially as China advances its air quality improvement policies and practices at regional and national scales.
- *Trusted working relationships and a technical basis for regional air quality strategies China.* The successful AIRNow-I Shanghai implementation has provided an impetus for greater regional air quality cooperation within China and discussions have begun about the

importance of looking at air pollution and reduction as a regional problem that needs regional cooperation as part of the solution. The SEMC team is currently in discussion with other provinces in the Yangtze Delta region about developing a regional air quality monitoring and reporting network. The vision for this network includes potentially using the AIRNow-I Shanghai system as the basis for the regional system. Such a partnership, if successful, will be a significant accomplishment for both China and the United States. EPA and STI are continuing to work with the SEMC team as well as Zhejiang and Jiangsu provinces to support this initiative.

- *A variety of re-usable tools and techniques for communication and collaboration.* The EPA-STI team and the SEMC team jointly created not only the software, but several reusable technical tools and strategies for successfully working collaboratively across cultural and physical distances. Given the language and cultural differences, 12-hour time change, and significant physical distance, both sides effectively leveraged information technologies (e.g., demonstrations, videos, and WebEx) as well as non-traditional business practices (e.g., conducting remote testing and forecasting, conducting conference calls during non-business hours, incorporating social engagements with work visits to build relationships) to bridge these distances.

Challenges and lessons learned

The AIRNow-I Shanghai project faced considerable challenges due to differences between the countries and organizations. Some of these differences reflect the divergent social, economic, and political contexts in the United States and China, others reflect differences in goals, organizational factors, typical approaches to work, technical capabilities, and the resources available for the effort.

First, the US and Chinese participants had different reasons for participating and sought different, but not necessarily incompatible, goals that can be traced to the goals of AIRNow-I and the goals of the bi-lateral MOU. AIRNow-I, following US EPA and GEO visions for global data resources, seeks ultimately to support and encourage better policies and practices through widespread sharing of real-time air quality data across community, regional, and national boundaries. On the other hand, the MOU lays the foundation for air quality monitoring and data use in the context of China itself. This internal capacity-building focus reflects China's earlier stage of development with respect to environmental policy and management, a stage that the United States experienced decades earlier.

For EPA, the main reason for developing an international version of AIRNow was to begin to build a global network of air quality monitoring systems with the capacity to share standardized data across governments worldwide. This goal is linked to EPA's commitment to the voluntary Group on Earth Observation (GEO) and represents a major contribution to the GEO System of Systems (GEOSS). The fundamental US objective is to monitor, protect, and improve air quality globally by making timely air quality information available to the public and expert users. The project was simultaneously a means to modernize the initial US version of AIRNow to make it more sustainable domestically and readily adoptable in other countries.

By contrast, Shanghai SEMC and SEPB saw the project as an opportunity to improve air quality monitoring, forecasting, and data management internal to the government, first for Shanghai, and eventually as the spearhead for a regional effort involving the cities and provinces of the Yangtze Delta. Although some public information was presented during the 2010 World Expo, this was a modest and time-limited activity. The main focus was to improve air quality monitoring, forecasting, and management capabilities within the government for purposes of regulating activities that contribute to local and regional air quality problems.

Thus the partners in AIRNow-I Shanghai pursued somewhat different, but not incompatible goals. The Shanghai partners followed the vision laid out in MOU for better environmental analysis and management in China; the US partners emphasized the vision embodied in GEOSS of international information sharing. These intentions, while different, both contribute to improvements in air quality for significant parts of the world (i.e., EPA's fundamental goal). However, the uses of the information (public notification and education in the United States, and government regulation for Shanghai) are quite dissimilar. These differences were not fully appreciated through most of the project.

Second, political and organizational cultures combined to create quite different contexts for the work in the two countries. In policy terms, China considers air quality information to be confidential and subject to tight security measures; the United States treats it as open information and promotes release to the public in a variety of forms. Government organizations in China seek formal approval and assured funding ratified by successively higher level authorities before they will take action on almost any matter. In the United States, government agencies have a fair amount of autonomy and discretion in many activities as long as they are within the scope of their missions. For example, the Shanghai team used a variety of standard and unconventional means to explain and promote the project to initially unwilling leaders. Through persistence and persuasion, they eventually obtained several levels of formal permission for an international project, as well as allocations of funding. Once those approvals were in place, they could move forward relatively rapidly toward the approved goals with limited, but assured, resources. On the other hand, because EPA has global goals but no official international portfolio, its international work is more a matter of opportunity and situation. Consequently, the AIRNow team at EPA began informal work on AIRNow-I Shanghai under the broad terms of the bi-lateral MOU, but without a fixed budget from regular appropriations. Instead, the group leaders succeeded in obtaining funds from the R&D budget. As a result, as the project unfolded and needs changed, EPA had the freedom to adjust its strategy and work plan, but was also repeatedly looking for funding for its portion of the project.

Language presented another important challenge. Several of the Shanghai staff understood or spoke English, although their fluency levels varied considerably and only Jackie Fu had lived for any length of time in an English-speaking country. Only one of the Americans, Alan Chan, was familiar with Mandarin (and fluent in a second Chinese dialect – Cantonese). Chan was the only person in either country who was also bi-cultural, having been raised in Hong Kong but educated and employed for years in the United States.

Both groups identified funding as a serious challenge. Neither side started with enough money to support the work they wanted to do, and neither MEP nor EPA provided funding from their regular budgets, although both eventually gave strong political support. For EPA, funding was never assured from one year to the next, making planning especially difficult. As a result, the participants used a variety of unconventional methods to get the funds they needed.

The challenges of physical distance were also substantial, especially toward the end of the project just before the opening of Expo. At that point, the half-day time difference between San Francisco or Washington and Shanghai meant that work done in the United States on a Friday would be accessible to those in Shanghai on Monday, a critical delay when last minute work needed to be accomplished and tested. More typically, the challenge of physical distance was evident in the cost of travel for the face-to-face work that was necessary to design, build, test, and implement the system.

Lessons

Given the accomplishments as well as the challenges presented in this case, we offer eleven lessons for future engagements in transnational knowledge sharing.

Consider the broad historical and political context

Efforts like AIRNow-I are not general exercises in international engagement. They are specific investments in a particular policy domain where the countries involved can be in different stages of development and pursuing different policy goals. Developing a shared understanding of similarities and differences in context and history should be among the first steps in these initiatives. For example, Chinese and American air quality policies are currently on similar paths but at different phases in their evolution and operating in substantially different political, social, and economic systems. The air quality standards in the United States and the uses made of air quality data reflect a mature policy operating in an open and decentralized political system. In China these policies are in an early stage and designed to operate in a centralized political system and a society that typically defers to governmental authority. These differences shape the assumptions, goals, and expectations built into any joint effort and can cause confusion and misunderstandings about what is intended and what is possible at any point in time.

Find the mutual benefit in separate national intentions.

The nations participating in a transnational knowledge network are likely to have somewhat different intentions and goals. Success of the network depends on finding an adequate overlap among these different goals such that progress is made toward separate objectives, while at the same time achieving an acceptable level of mutual benefit. In short, national intentions need to be clear and compatible, but not necessarily the same. However, sustainability of the network may be affected by differences in ultimate goals. In the case of AIRNow-I Shanghai, the mutual benefit of progress toward improved global air quality was served by the different national goals – improved air quality monitoring and management in China, and creation of an internationally available, standardized monitoring and public reporting system by the United States. However, these different national goals may make sustained investment in the bi-lateral effort less feasible.

Give critical attention to the early phase of engagement

The cultural, political, organizational, technological and other differences among participants present many opportunities for misunderstanding and wrong assumptions. The early period of engagement is therefore critical for establishing shared understanding about fundamental goals, roles, expectations, capabilities, resource limitations, and working assumptions. These understandings can be revisited and refined as time goes on, but if left unexamined until work is already in progress, they can undermine the project by wasting time and resources, or generating conflict, confusion, and unexpected problems.

Recognize the power of personal commitment and individual leadership

The individuals involved in complex transnational projects have responsibilities associated with their organizational positions, but the success of these effort is strongly linked to personal commitment and leadership that goes beyond formal position. In this project, Dale Evarts maintained a patient, open policy dialog with a variety of Chinese officials and managers that began long before AIRNow-I and continues beyond its implementation. Although EPA supported the effort from a policy perspective, it could not have proceeded or concluded successfully without Phil Dickerson's persistent advocacy and search for funds to pay for the work. In China, Jackie Fu had not only to find the funds, but also to convince a skeptical leadership hierarchy that the project was worth doing at all. Alan Chan served simultaneously as technical expert and cultural liaison for both sides. These examples of the power of individual contributions are a necessary complement to organizational action.

Recruit participants who can work in multiple languages and cultures

In some transnational networks, the participants share fluency in a single language and represent modest differences in culture. This might be the case in a collaboration between Canada and United States, for example. In other networks, both language and cultural context present considerable hurdles to collaboration and learning. These networks require at least some participants who speak multiple languages and are comfortable working in more than one culture. Ideally, these would be people who have lived and worked for substantial periods in these different contexts. Although it is very helpful for participants to be able to speak and understand more than one language, this is not the same as having "fluency" in different cultural contexts. It is easy to observe the outward trappings of culture, such as traditional food or architecture. But because culture is embedded in thinking and behavior, it is difficult for outsiders to discern and appreciate the values, norms, and beliefs that underlie perceptions, relationships, and actions. Cross-cultural knowledge sharing therefore requires serious attention to the apparent and subtle ways in which culture shapes interactions.

Employ multiple methods and channels of communication

Since the participants in a transnational network are likely to be separated by physical location as well as by time, language, and culture, the chances for mis-communication and non-communication are high. These risks can be mitigated by employing and coordinating multiple forms and channels of communication. Face-to-face engagement, while expensive, is essential for certain purposes (such as establishing initial understandings and working out complex or sensitive problems). Sometimes technology offers a common "language" that helps bridge traditional language differences. While e-mail and conference calls were useful for routine work, when the AIRNow-I Shanghai team had difficulty describing a problem or idea about the system, they often succeeded in working it out by using demonstrations and visualizations that tapped into their common technological knowledge. All found these techniques more effective than error-prone attempts to explain things in writing or orally, especially over the phone. Tools are only part of the package, however. The channels for personal and official communication need to be open at several levels so that different needs and messages can be conveyed. In this case, a continuous top-level policy conversation set the stage, established the boundaries of the technical and operational work, and at times helped to emphasize the various value propositions for the different participants.

Be open to different forms of knowledge sharing and knowledge building

Transnational projects like AIRNow-I are not typical technology transfer projects in which a donor builds a factory or gives a complete system to recipient. Rather, they are long term engagements in which two or more countries work together to create value in the form of knowledge, expertise, and shared results. This kind of work requires patience and genuine openness to mutual learning. In this case, both countries brought considerable technical expertise to the project, as well as specialized knowledge in different domains. While the Americans were more advanced in using air quality data for forecasting and public outreach, the Chinese had greater knowledge of local demographic and economic conditions including the effects of rapid urbanization and industrialization. In this context, they worked together to develop the core AIRNow-I data management system, while the Chinese simultaneously developed customized modules linked to domestic systems and regulatory requirements.

Assemble complementary, adequate, and appropriate resources

Many kinds of resources go into transnational knowledge sharing projects, including expertise, data, funding, technology, facilities, and relationships. In a successful effort, each participating entity brings resources to the table that are commensurate with both its own interests and its commitment to the network goals. Knowledge and expertise, and to some extent data and technology, are readily exchanged resources and they have the potential to expand as a consequence of the work. However, it does not appear necessary to exchange funds in order to succeed, although sufficient unilateral funding to support the work of each participant is clearly needed. As the AIRNow-I case demonstrates, different funding sources, rules, and cycles can make this difficult, but not impossible, to achieve.

Leverage external opportunities

Take advantage of highly visible domestic or international events, such as EXPO and the Olympics, that are major commitments for the non-US partner. In these circumstances, the partner has a strong incentive to innovate, is more likely to accept new forms of international cooperation, and is in a better position to find the internal resources to support the work. In this case, both sides strongly agreed that EXPO 2010 was a crucial piece of the puzzle and that the system would probably not have been completed without it.

Plan the duration and intensity of the effort for the “distance” to be covered

Transnational knowledge sharing appears to need a long gestation period of relationship building before explicit goals are set or projects are launched. Once underway, the work of the network is inevitably slowed by differences in location, language, culture, and political and organizational considerations. When these differences are large, the time period for achieving sustainable results is likely to be measured in years rather than weeks or months. Consequently, sponsors and participants should be prepared for long term commitments, although the intensity of activity could vary widely over time.

Build in a path to sustainability

To achieve long lasting mutual benefits, the plan for any transnational knowledge sharing project needs to include a path to sustainability that makes sense in the context of that particular effort. In this case, while AIRNow-I was successfully developed and deployed for the city of Shanghai, its fundamental, long term value lies well beyond Shanghai itself. The system has the potential to undergird regional air quality improvement efforts in China with high quality information and analysis. Shanghai's experience and expertise plus EPA's home-grown understanding of collaboration at the regional and national levels can be instrumental in helping these efforts take hold and grow, but this new effort demands resource commitments that goes beyond the original plan.

Conclusion

The findings and lessons of AIRNow-I Shanghai show that the AIRNow-I system can be successfully implemented and customized outside the United States and most likely can be replicated in a wide variety of national settings. But while the system will be mostly the same from place to place, the process of engagement will be different with each new partner. The challenges and lessons learned in this first international partnership provide a set of guidelines for successfully carrying this effort into other parts of the world.

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The mission of the Center for Technology in Government (CTG) at the University at Albany is to foster public sector innovation, enhance capability, generate public value, and support good governance. We carry out this mission through applied research, knowledge sharing, and collaborative problem solving at the intersection of policy, management, and technology.

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