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Air Quality Data Use, Issues, and Value in Georgia

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Acknowledgements

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Executive Summary

This case describes the air quality conditions and related programs and issues centered in the area around Atlanta, Georgia and is part of a larger study to assess the potential benefits of enhancing air quality monitoring data from ground sensor networks with data gathered by satellites.

GEORGIA AIR QUALITY CHARACTERISTICS AND DATA

Over the past 40 years, Georgia has faced problems with various pollutants including ozone, particulate matter, lead, and sulfur dioxide. Air quality problems are especially prevalent in the Atlanta metro area, which has experienced rapid population growth and business development, with associated increases in emissions from vehicle usage and industrial sources. In the late 1990s, state rules and determinations associated with emission control technologies for stationary sources produced significant improvements in air quality. In the mid-2000s, the state adopted rules for electric utility generation that continued the downward trend in emissions. At the same time, ongoing improvements in vehicle engine technology and frequent turnover in vehicles in Georgia further reduced emissions. Local outreach campaigns suggesting voluntary actions (and frequent yellow, orange, and red days) have successfully raised public awareness of air quality concerns.

Despite these achievements, the combination of population growth and expanding highway travel with Georgia's warm, dry, and sunny summers produce frequent ozone problems and elevated amounts of PM2.5. Atlanta and 20 surrounding or nearby counties currently do not meet either the annual standard for PM2.5 or the 8-hour standard for ozone, or both. Today, the emission sources yet to be controlled are diffuse and more difficult to address because they involve convincing millions of individuals and small business to each contribute small improvements from changes in behavior, processes, and technology. The primary contributor to ozone pollution now comes from mobile sources, mainly vehicle traffic, while stationary sources and burning in rural areas are the main contributors to particle pollution.

Over the past 40 years, Georgia has faced problems with various pollutants including ozone, particulate matter, lead, and sulfur dioxide. Air quality problems are especially prevalent in the Atlanta metro area, which has experienced rapid population growth and business development, with associated increases in emissions from vehicle usage and industrial sources.

Georgia's air quality monitoring network currently comprises 53 stations including 28 that measure PM2.5 and 20 for ozone. The remaining stations monitor other pollutants. Meteorological stations are also part of the network. The vast majority of monitors are located in the Atlanta Metro Region. The continuous monitors in the network transmit data hourly after an initial validation has been performed. The hourly data is then used for daily consensus pollution forecasts and also reported to AirNow. The daily forecasts are communicated to the public via websites, news outlets, community organizations, and social media to protect public health. Other government and community groups use the forecasts and the monitoring data for varied purposes including permitting, preparation, and execution of state implementation plans to address non-attainment areas for environmental and public health research, outreach, and education.

GAPS AND WEAKNESS IN EXISTING MONITORING DATA

Existing air quality data are extensive, but incomplete and imperfect. Interviewees discussed the following gaps and weaknesses that affect their work:

- **Gaps in the monitoring network.** The most obvious and important gap in existing AQ data are a consequence of the monitoring network itself. Monitors are concentrated around Atlanta and a few other cities while large portions of Georgia are not directly covered by the network.
- **Interpolation of ground monitor data to describe larger geographic areas.** AirNow uses mathematical interpolation of the ground sensor readings to estimate pollution concentrations in surrounding areas. For some areas of the state, this is a reasonably good way to fill the data gap. However, large areas without monitors, plus complex meteorology, make these estimates unreliable for local use in many places.
- **Targeting and content of public outreach messages.** The challenge is to target appropriate messages to different groups and to send useful information to people all over the state. The main goal of AirNow is to inform sensitive groups to limit their exposure, but often information is too simplistic and not targeted directly to the groups or individuals who could benefit from air quality information.
- **Limitations of the data for research purposes.** Few of the research studies we learned about need near-real time AQ data, but access to detailed historical information that reports hourly readings for small geographic units would be very useful for public health studies and policy analysis.

POTENTIAL VALUE OF SATELLITE-ENHANCED DATA

Satellite data and related products that record particulate pollution in a 4 km grid are becoming available for regular use. If fully exploited, this new data resource could potentially deliver the following benefits:

- Fill gaps in the ground sensor network. Satellite data products could fill coverage gaps in the existing network to support routine forecasts and advisories to the public.
- Support design and deployment of the regulatory monitoring network. While satellite data and fusion products are not intended for regulatory decisions, they ultimately might improve performance of the state's regulatory mission by helping them optimize their network design.
- Support state-level AQ modeling for longer range planning and priority setting. Modeling is used to predict the dispersion of air pollution and assess both the impact of pollution sources and potential control strategies. Satellite data would provide additional detailed data with greater geographic coverage for use in these models and for model evaluation.
- Improving understanding of air quality under stagnant meteorological conditions. The lack of monitors in rural areas makes it difficult to assess the full impact of some point source pollutants from industry sites or military bases. Meteorological conditions can cause stagnation and local re-circulation of these air-borne pollutants under light and variable or calm winds. Except in cloudy conditions, satellite data could supplement the ground monitors to provide a more complete picture of these situations.

- Improve regional and local analysis of air quality conditions. Satellite data could provide localized analysis of air quality conditions for a variety of stakeholders ranging from employers interested in identifying areas where a large number of employees are commuting, local health departments interested in better information about the air quality of their specific county or area of responsibility, to certain industries interested in how their usual practices contribute to their operating and healthcare costs and working conditions.
- **Improve data for state and local government functions.** Satellite data could increase confidence in the coverage, accuracy, and timeliness of the information state and local governments use for many routine responsibilities ranging from air quality forecasting, to advisories due to special events such as smoke from fires, to the issuance of burn permits.
- **Enhancing public health and policy research.** Researchers identified two main types of potential value from satellite data: improving the granularity, spatial coverage, and validity of air quality data for public health research and policy analysis; and providing data to extend this kind of research beyond urban centers to rural and agricultural areas.
- **Supporting science education and workforce development.** Several opportunities exist for using satellite products with school age children in the classroom including incorporating actual satellite products in the K-12 science curriculum and increasing student interest in science, technology, engineering, and math by highlighting the organizations that develop and use these products and encouraging students to consider the types of careers they offer.

STAKEHOLDER RECOMMENDATIONS FOR FURTHER DEVELOPING SATELLITE DATA PRODUCTS

Interviewees represented different stakeholder groups and consequently offered different kinds of recommendations regarding the future development and use of satellite data and fused data products. Substantial differences are associated with different users and uses of the data, which together indicate its versatility and value for different purposes. Some of the recommendations focus on the regulatory environment and the need for precise data to demonstrate attainment and progress toward attainment of the NAAQS. Others reflect scientific and technical viewpoints about how more or different data can inform analysis, forecasting, planning, policy making, or enforcement.

- Use satellite data to “ground truth” the monitors and vice-versa to assure data quality and credibility.
- Provide meteorological data to complement the satellite data, accompanied by information accounting for the uncertainties introduced by frontal systems and other conditions that affect satellite readings.
- Invest in technologies that allow data from ground sensors and from satellite sensing to be gathered, compared and fused for the same time periods.
- Support research in satellite sensing technologies that permit measurement of other pollutants, especially ozone.
- Provide training and technical support to scientific, administrative, and research users of ground sensor data, satellite data and fusion products.
- Provide satellite imagery and data separately from a fused ASDP product.
- Give priority to developing satellite data products for experts rather than for direct public use.
- The development of satellite data products for use by experts rather than by the direct public

This case is part of a larger study to assess the potential benefits of enhancing air quality monitoring data from ground sensor networks with data gathered by satellites. The study considers this question from the community-level view through three case studies in Denver, Atlanta, and Kansas City. This case begins with an overview of US air quality policy and regulatory programs and the companion AirNow Program for public outreach. In the subsequent sections we describe the air quality conditions, issues, and stakeholders in the Atlanta-area case. We summarize current uses of air quality data as well as its benefits, gaps, and weaknesses. We conclude with a discussion of ways that satellite-sensed data can expand the uses and enhance the socio-economic value of this kind of information.

NATIONAL AIR QUALITY MONITORING AND AIRNOW

The Clean Air Act, last amended in 1990, requires EPA to set standards for six criteria pollutants that make up the National Ambient Air Quality Standards (NAAQS): carbon monoxide, nitrogen dioxide, ozone, particle pollution, sulfur dioxide, and lead. All are considered harmful to public health and the environment. The NAAQS sets two kinds of standards:

- **Primary standards** provide public health protection, including protecting the health of "sensitive" populations such as asthmatics, children, and the elderly.
- **Secondary standards** provide public welfare protection, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings.

This study is concerned with two criteria pollutants: ozone and fine particulate matter with a diameter less than 2.5 microns (called PM2.5). NAAQS for ozone is 0.075 parts per million (ppm) by volume (measured as an 8-hour average), and for PM2.5 the standard is 35 micrograms per cubic meter of air (µg/m3) for the 24-hour, and 12 µg/m3 for the annual average[i].

The Clean Air Act, last amended in 1990, requires EPA to set standards for six criteria pollutants that make up the National Ambient Air Quality Standards (NAAQS): carbon monoxide, nitrogen dioxide, ozone, particle pollution, sulfur dioxide, and lead. All are considered harmful to public health and the environment.

State-operated networks of more than 2000 monitors located throughout the United States measure ozone and fine particle pollution. These networks were established as part of the implementation of the Clean Air Act and are in place for the primary purposes of determining compliance with the NAAQS and for informing both state and national level assessments and policy decisions related to air quality improvement. States perform extensive quality checks on this data and report data quarterly to EPA to be used to assess compliance with, or "attainment" of, the NAAQS.

EPA operate the AirNow program to provide Air Quality Index (AQI) information to the public and the media in real-time. Data from the monitoring networks flow directly from the monitors to AirNow. As the national repository of real-time air quality data and forecasts for the United States, AirNow simplifies air quality reporting to the general public by combining concentrations of five criteria pollutants (all except lead) into a single index available to the public every day. As illustrated below, the AQI is divided into six categories associated with different levels of threat to human health. For example, an AQI of 50 or less indicates "good" air quality and is indicated by the color green in maps

or scales. An AQI of 151-200 is labeled “unhealthy” and indicated by orange. Each level beyond “good” includes recommendations for reducing exposure.

The AirNow program obtains its data from the same state-operated monitoring networks used for regulatory compliance with the NAAQS. The regulatory data go through a painstaking and time-consuming quality assurance process and are reported to EPA by the states every quarter. However, while accuracy is the most critical feature of the data for compliance purposes, timeliness is equally important for the purposes of AirNow. Consequently, the AirNow program applies a less extensive quality control process (dealing with missing data, grossly out of range readings, etc.) in order to provide hourly updates on ozone and PM2.5. These hourly reports support daily pollution forecasts to the media and other stakeholders and are intended to be timely enough to influence individual behavior. For example, declaration of community-level action or awareness days based on air quality forecasts trigger voluntary programs, such as carpooling, to reduce pollution and improve local air quality. The same forecasts coupled with public health messages help individuals, especially those with high sensitivity to pollution such as asthmatics or young children, avoid or limit their exposure.

AirNow also maintains an informational website (http://airnow.gov, left) where near real-time ozone and particulate matter maps and city air quality forecasts are posted for public access. In addition, the AirNow program offers a password-protected website, called AIRNow-Tech, which allows the organizations that contribute data to have direct access to the full national database for research, analysis, and planning. States use this same daily data, either through AirNow-Tech or directly from their own EPA-approved monitoring networks, for similar but more localized forecasting, analysis, and public reporting.

EXISTING SENSOR NETWORKS

The ground sensors and the data they collect about ambient air-quality are governed by federal regulations in 40 CFR Part 58[ii]. These regulations establish data standards such as timeliness and validation as well as requirements for the scientific precision of the instruments that collect the data, and specifications for quality assurance processes to assure data quality. Monitoring stations in the networks may house single or multiple sensors specialized for measuring different pollutants. The networks are designed and operated by the states (and some tribal and local agencies and federal installations) with the advice and approval of EPA.

The placement of sensors in the state monitoring networks follows a set of complex design criteria that specify detailed factors for each type of pollutant, with special consideration for measuring exposure in large population centers. The federal regulations further require an annual monitoring network plan and periodic network assessment to continually consider updates that respond to changing conditions[iii]. Subject to public comment and EPA approval, states may move, add, or decommission monitoring stations or sensors in response to changing needs.

Monitoring networks that meet these extensive regulatory requirements, however, do not necessarily provide full geographic coverage due to the expense of designing, installing, and maintaining monitors of exacting scientific quality. Rough estimates of the cost are around $100,000 to deploy a monitoring station, and about $50,000 per year to maintain one, although the costs can vary widely according to the specific pollutant(s) to be measured, the complexity of the monitoring station, its distance from the home base of the organization that maintains it, and other factors. As a result, sensors are deployed as strategically as possible and their actual readings are used to demonstrate compliance with the NAAQS. When reported to AirNow, however, the monitoring data are interpolated using complex algorithms to estimate conditions in surrounding geographic areas in order to provide forecasts for most communities. In some areas, however, no reasonable estimates are possible due to distance, topography, and other factors, so AirNow does not report conditions for these areas.

The AirNow Satellite Data Processor (ASDP)[iv] system is currently under development to partially compensate for these gaps in the ground sensor network for fine particles, which enables the blending or fusing of surface PM2.5 measurements and satellite-estimated PM2.5 concentrations, providing additional spatial air quality information to AirNow in areas without existing surface monitoring networks. The ASDP system, while currently working only with satellite estimated PM2.5, is building the capability necessary to implement a wider range of remote sensing capabilities for additional pollutants. At present, data are available from two daily satellite passes over the US at mid-morning and early afternoon. The satellites gather data within a 4 km grid for all areas in the US where atmospheric and other conditions allow. Dense cloud cover, snow cover, and desert landscapes prevent the satellites from taking readings in those conditions.

Community Context

This case presents a summary of air quality conditions and related programs and issues centered in the area around Atlanta, Georgia. However, because air quality conditions are affected by natural processes, layers of government policies, and human and organizational activity, the case is not limited to the Atlanta Metro Area but also includes information reflecting two larger contexts: the State of Georgia and EPA Region 4 which covers the southeastern US. Interviewees for this case represented the EPA Region 4 Air Quality Monitoring and Technical Support Section, the Air Protection Branch of the Georgia Department of Natural Resources Environmental Protection Division, the Air Quality and Technical Resource Branch of the Georgia Department of Transportation, The Clean Air Campaign, and the Rollins School of Public Health at Emory University, and the public policy program at Georgia Institute of Technology.

Physical and Socioeconomic Characteristics of the Region

The State of Georgia is one of 8 southeastern states that comprise EPA Region 4; the others are Alabama, Florida, Kentucky, Mississippi, North and South Carolina, and Tennessee. As shown on the map below, northern Georgia, including the area around Atlanta, has a complex geography including the Piedmont Plateau, the Blue Ridge Region, the Appalachian Ridge and Valley Region with varied elevations as high as 4800 feet, although none of these features significantly affects the transport of pollutants across the area. The rest of the state has few distinguishing physical features and is made up mainly of flat plains. The Okefenokee National Wildlife Refuge covers 400,000 acres at the border between Georgia and Florida. Georgia also has an extensive Atlantic coastline including deep water ports and barrier islands.

Georgia's mixed economy has industrial concentrations in aerospace, agribusiness, and defense and hosts several large military bases including Fort Stewart, Fort Benning, Fort Gordon, Moody and Robins Air Force Bases, and Dobbins Air Reserve Base. The Atlanta Metro Region is

Source: mapresources.com

Georgia's main population center and one of the fastest growing metropolitan areas in the United States. In 2012, the 10-county Atlanta region was home to 4.2 million of Georgia's 9.9 million residents. Growth in the Atlanta metro region has been accompanied by sprawl across a larger 28 county area surrounding the city. Atlanta is the terminus of an extensive air, rail, and highway transportation network, including the world's busiest airport, Jackson-Hartsfield. Economically, service industries employ the largest number of workers in the region, but trade and manufacturing are also important. The metro area is home to major corporations including Coca-Cola, AT&T, Delta Air Lines, Home Depot, UPS, and Georgia-Pacific as well as 38 colleges and universities. Although considerably smaller, Georgia's other major cities include Macon in central Georgia, Savannah on the Atlantic coast, Columbus near the Alabama border, and Augusta on the border with South Carolina. The rest of the state is mainly forested or agricultural, including numerous US Department of the Interior, and US Department of Agriculture land holdings.

HISTORY OF AIR QUALITY IN THE STATE AND REGION

Over the past 40 years, the Atlanta region has experienced rapid population growth and business development, with associated increases in emissions from vehicle usage and industrial sources. Burning is a third substantial contributor to particle pollution. Thousands of acres of permitted burning takes place under the authority of the Georgia Forestry Commission (GFC) each year, although burning on military installations and US Department of Interior and Agriculture lands occurs year round without state or local permits. Wild fires are also relatively common. During this period, strengthening of the NAAQS has led to violations for ozone and PM2.5, despite major reductions in anthropogenic emissions.

In preparation for the 1996 Summer Olympics, government and business leaders agreed that concerted action was needed to address air quality issues to prepare Atlanta for the athletes and hundreds of thousands of visitors. The Clean Air Campaign was established in May 1995 with the mission to improve air quality by promoting employer-supported education and behavioral changes, such as reducing vehicle traffic through carpooling, remote work, and other measures. City-wide acceptance of these changes during the two-week period of the Games produced dramatically improved mobility and air quality, and significantly decreased emergency room visits for respiratory complaints. This positive public experience became the foundation for an active outreach and education program that continues today.

In the late-1990s, the Georgia Department of Natural Resources took major steps to improve air quality by targeting stationary sources of emissions, mainly from smoke stacks and coal-fired power plants emitting large amounts of NOx, volatile organic compounds (VOCs), and particulate matter. A more rigorous multi-pollutant rule was developed through an extensive stakeholder consultation process to negotiate effective controls over stationary sources through a variety of measures including selective catalytic reduction (SCR) systems to reduce NOx emissions and wet scrubbers to reduce SO2 emissions. Electric generating unit (EGU) controls were adopted in the mid-2000s.

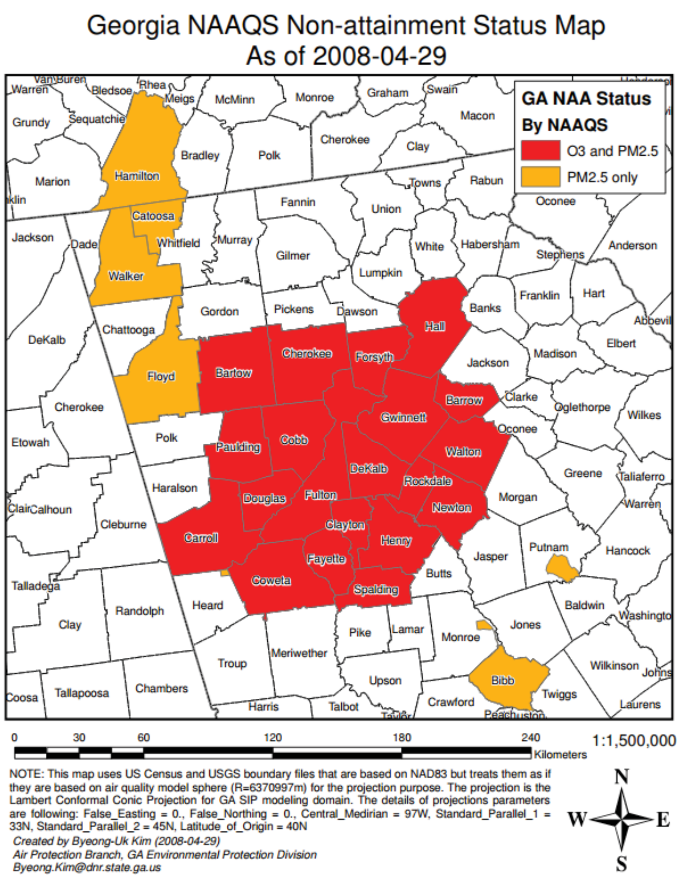
In addition, around 2008, Georgia and other southeastern states cooperated in a federally-sponsored effort called VISTAS to reduce regional haze in natural wildlife areas. The state continues to address haze conditions through targeted actions in designated areas within the state.

CURRENT AIR QUALITY ATTAINMENT ISSUES

Given the concerns and responses summarized above, air pollution from major industrial sources has dropped considerably. Nationwide improvements in vehicle engine technology and frequent turnover in vehicles in Georgia have also produced major reductions in individual auto emissions. Local outreach campaigns encouraging voluntary actions (and frequent yellow or moderate, orange or unhealthy for sensitive groups (USG), and red or unhealthy AQI days) have successfully raised public awareness of air quality concerns. Nevertheless, Georgia, and particularly the Atlanta region, face ongoing challenges for air pollution that stem from both natural and man-made conditions. The combination of population growth, expanding highway travel with Georgia's warm and sunny summers, and dry stable conditions, is a recipe for ozone problems and for elevated components of PM2.5.

Significant reduction in industrial sources during the 1990s and 2000s was an intensive and difficult process, but it was probably the "low hanging fruit" because initiatives by relatively few emission sources produced large improvements to air quality. The areas for attention today are more diffuse and more difficult to address because they need to involve millions of individuals and small business, each contributing small improvements from changes in behavior, processes, and technology. The largest source of air pollution in Atlanta is from mobile sources, mainly vehicle traffic. According to the 2011 American Community Survey, the Atlanta region has the 5th longest commute time in the nation. Consequently, reduction in vehicle miles traveled (VMT) is a high priority air quality goal.

Parts of Georgia have failed, or had difficulty meeting, the national ozone standard for over 30 years and particulate matter continues to be an issue in many of the same locations. Currently Atlanta and 20 surrounding or nearby counties do not meet either the annual standard for PM2.5 or the 8-hour standard for ozone, or both. Non-attainment areas are shown on the map below.



Source: Georgia EPD

When a state is in non-attainment of any part of the NAAQS, it is required to work with a wide range of stakeholders to develop a State Implementation Plan (SIP) that identifies and monitors specific actions to come into compliance. For Georgia, this responsibility lies with the Air Protection Branch of the Environmental Protection Division of the Georgia Department of Natural Resources (Georgia EPD). The current SIP focuses mainly on reducing stationary sources of pollutants. Mobile sources are indirectly addressed through gasoline formulation and vehicle inspection and maintenance requirements of the Clean Air Act. In addition, Georgia EPD works closely with the state Department of Transportation (DOT) on transportation conformity to assure future highway and transit projects are consistent with air quality goals. DOT provides travel demand modeling and other services supported by the Congestion Mitigation and Air Quality Improvement (CMAQ) Program of the Federal Highway Administration (FHWA). Designated non-attainment areas work with an interagency group including Georgia EPD, Georgia DOT, FHWA, EPA, the Georgia Regional Transportation Authority and the relevant Metropolitan Planning Organizations (MPOs) in the affected areas. Currently seven MPOs are involved including Atlanta, Macon, Columbus, Augusta, Hall, Floyd, and Chattanooga. In addition, Bartow County currently is forming as an eighth MPO.

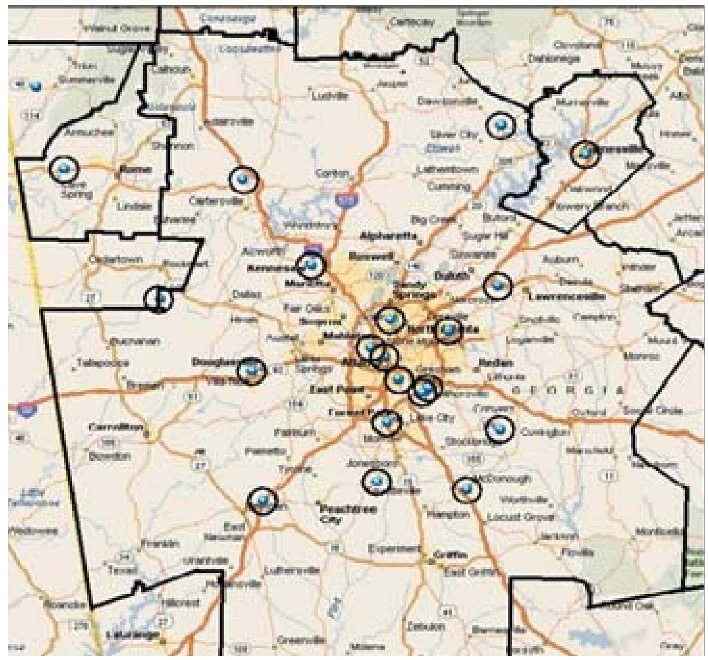
Air Quality Data Characteristics

GEORGIA AQ MONITORING NETWORK AND OTHER AQ DATA SOURCES

In the early 1970's, the Georgia Environmental Protection Division assumed responsibilities for ambient air monitoring from the state health department which had been monitoring air quality since the 1950s. The sampling network currently consists of 53 stations located across the state including 28 for PM2.5 and 20 for ozone. Several stations are highly sophisticated with instruments such as a gas chromatograph to measure precursors for ozone. Meteorological stations are also part of the network. According to the 2013 Georgia Annual Ambient Air Monitoring Plan, the data are used for a variety of purposes including "to determine whether air quality standards are being met, to assist in enforcement actions, to determine improvement or decline of air quality, to determine the extent of allowable industrial expansion, and to provide air pollution information to the public."

Most monitoring stations measure the criteria pollutants to document attainment or non-attainment of the NAAQS. Particulate monitors, including particles with diameters less than 10 μg/m3 (PM10) and PM2.5, and ozone monitors are the most abundant and widespread types, but monitors are also in place to measure the other criteria pollutants as well as specialized sensors for photochemical analysis. Stations are concentrated around the Atlanta metro region where air quality and human exposure to pollutants is of most concern. The map below shows the locations monitoring stations for the Atlanta/Sandy Spring/Marietta area.

The continuous monitors in the network transmit data hourly after data have been subjected to initial validation, and then data are used for daily pollution forecasts. After initial hourly validation, these data also go through an extensive cycle of quality assurance audits to ensure accuracy before being reported to EPA quarterly for compliance purposes. The hourly data are also reported to AirNow after the initial validation process.



Source: Georgia Department of Natural Resources.

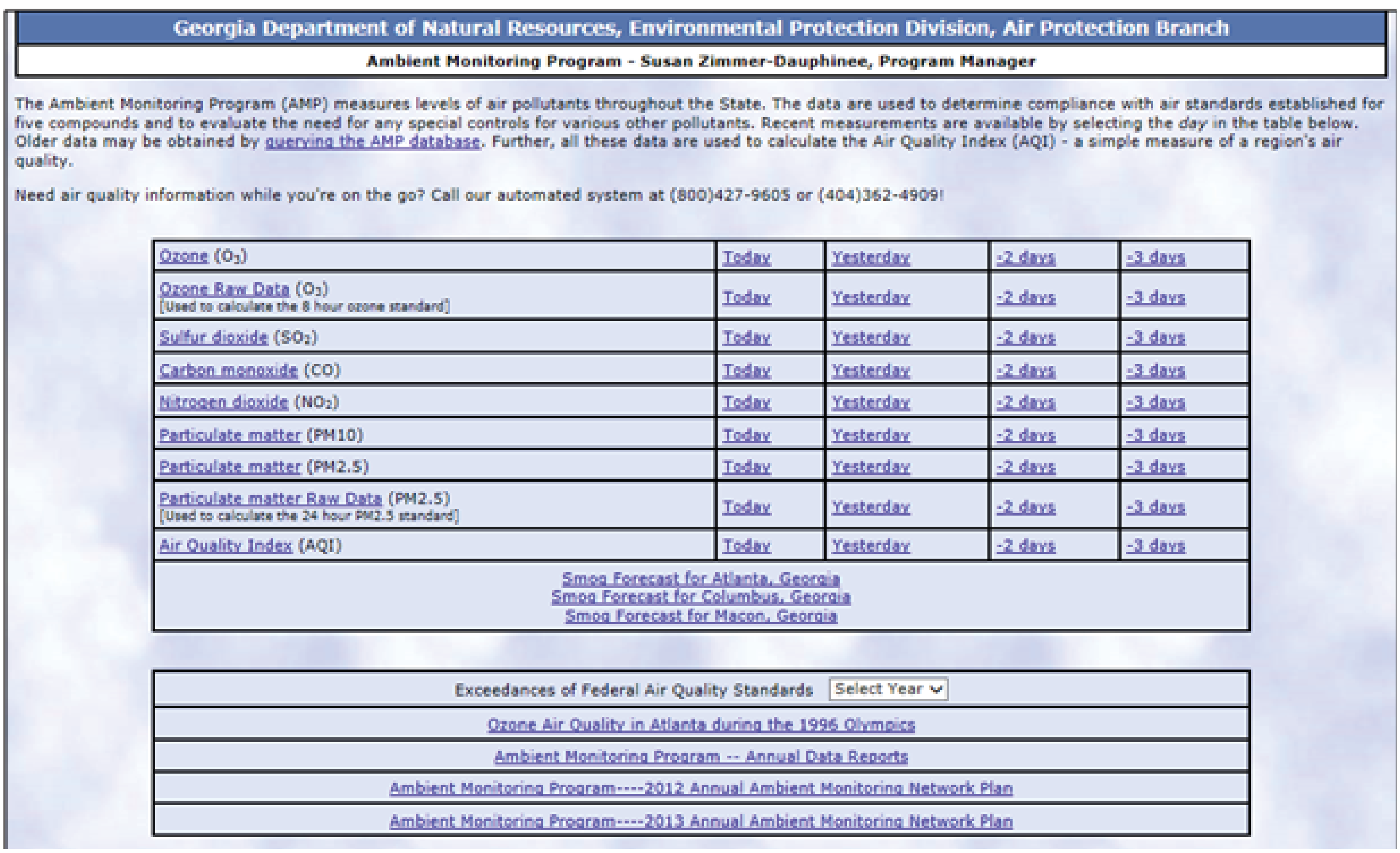
In addition to the annual network monitoring plan, the state conducts a more extensive five-year network review to assess whether major changes to the network are warranted to account for changing social and economic conditions. Georgia DNR officials are mostly satisfied with the current configuration of the network for monitoring and measuring pollutants and tracking meteorological conditions. However, they indicated that although there are currently no non-attainment situations in rural south central Georgia, the placement of monitors in that region would be beneficial to provide a more complete picture of the atmospheric conditions throughout the state. Network expansion is a costly proposition, however. GDNR officials estimated the cost of operating and maintaining the existing network at around \$2.5 million per year and the cost of configuring and deploying a new monitoring station anywhere from \$5000 to \$750,000 depending on the instrumentation, plus the cost of annual operation and maintenance.

USERS AND USES OF AQ DATA

During the interviews in Atlanta with staff from the respective federal and state air quality responsible agencies, university researchers, and the not-for-profit Clean Air Campaign we learned about the different users and uses of existing air quality data and other sources of information. Below is a summary of those users and uses.

The ***EPA Regional Office*** uses AirNow and AirNow-Tech to monitor conditions in the eight state region. Staff refer to both systems regularly, particularly in the summer when they create ozone-watch maps and disseminate them to EPA, state, and local contacts. They also make use of a variety of data sources to track cross-state transport of pollution.

During emergency situations the staff uses both systems on a daily basis, explaining, "emergency response is where our big use is for AirNow data." During the BP oil spill in the Gulf of Mexico, the Regional staff generated graphs every day for EPA headquarters and all the affected state and local air quality agencies "so the responders in the Gulf could know if there's any potential problem that was happening in real time … and then they could formulate some type of response or strategy." To do this they set up 10 additional monitors to measure air toxics plus a special section of the AirNow website for reporting data about the spill with some related messaging about conditions around the Gulf coast. This example sharply delineates the strengths and uses of different sources of AQ data. The interviewees pointed out that "EPA has its own database of certified audited really



Georgia Department of Natural Resources, Environmental Protection Division, Air Protection Branch

Ambient Monitoring Program - Susan Zimmer-Dauphinee, Program Manager

The Ambient Monitoring Program (AMP) measures levels of air pollutants throughout the State. The data are used to determine compliance with air standards established for five compounds and to evaluate the need for any special controls for various other pollutants. Recent measurements are available by selecting the *day* in the table below. Older data may be obtained by querying the AMP database. Further, all these data are used to calculate the Air Quality Index (AQI) - a simple measure of a region's air quality.

Need air quality information while you're on the go? Call our automated system at (800)427-9605 or (404)362-4909!

Ozone (O_3)	Today	Yesterday	-2 days	-3 days
Ozone Raw Data (O_3) [Used to calculate the 8 hour ozone standard]	Today	Yesterday	-2 days	-3 days
Sulfur dioxide (SO_2)	Today	Yesterday	-2 days	-3 days
Carbon monoxide (CO)	Today	Yesterday	-2 days	-3 days
Nitrogen dioxide (NO_2)	Today	Yesterday	-2 days	-3 days
Particulate matter (PM10)	Today	Yesterday	-2 days	-3 days
Particulate matter (PM2.5)	Today	Yesterday	-2 days	-3 days
Particulate matter Raw Data (PM2.5) [Used to calculate the 24 hour PM2.5 standard]	Today	Yesterday	-2 days	-3 days
Air Quality Index (AQI)	Today	Yesterday	-2 days	-3 days

Smog Forecast for Atlanta, Georgia
Smog Forecast for Columbus, Georgia
Smog Forecast for Macon, Georgia

Exceedances of Federal Air Quality Standards [Select Year]
Ozone Air Quality in Atlanta during the 1996 Olympics
Ambient Monitoring Program -- Annual Data Reports
Ambient Monitoring Program----2012 Annual Ambient Monitoring Network Plan
Ambient Monitoring Program----2013 Annual Ambient Monitoring Network Plan

Source: GEPD Ambient Monitoring Program website: http://www.georgiaair.org/amp/

high-quality standard reference data. So if we're looking back into the past for a couple of years prior, we can rely on that data and not AirNow. But if we want more real-time and current information, AirNow is the easiest method to get that."

The Regional staff is also actively involved with the states and communities in the region. For example, they often field calls from individuals with concerns or questions about air quality and refer them directly to AirNow for accessible, easy-to-understand information.

Beyond AirNow and AirNow-Tech, the EPA Regional staff use specialized air quality data to conduct periodic risk-based screening of air toxics to try to better understand the components and possible trajectory of air quality problems over time and in response to specific concerns about contamination and other acute risks. The Regional Office partners with states and community groups to plan and conduct short-term air toxics studies noting that these studies are expensive to produce due to the cost of the monitoring methods and the need for expert analysis of pollutants that are not part of the NAAQS.

The ***Ambient Monitoring Program*** within the ***Georgia Environmental Protection Division, Air Protection Branch***, is responsible for a network of 53 monitoring sites throughout Georgia. The data from the continuous monitors is posted to their website hourly. Specific measures are also presented for the recent past, and users can query the Ambient Monitoring Program database for historical data (http://www.georgiaair.org/amp/).

In addition to the reports from the monitoring stations, a team of forecasters from the state and ***Georgia Institute of Technology*** use a variety of other data sources to develop daily pollution forecasts including National Weather Service national forecast models, computer weather models, AirNow-Tech, satellite products that include NASA's MODIS satellite imagery, the NOAA air quality forecast model, and linear regression and 3D models developed by the Georgia Institute of Technology. The team comprises 11 individuals,

Source: GEPD Ambient Monitoring Program website: http://www.georgiaair.org/smogforecast/Facebook Page (CDPHE APCD 2)

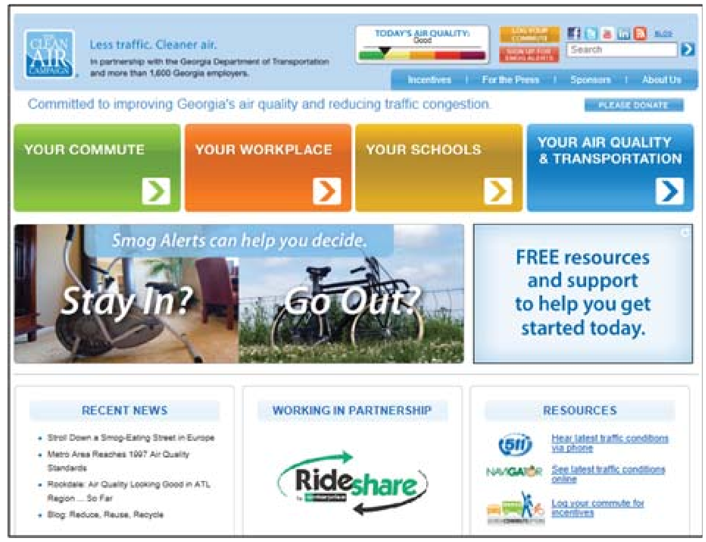
most of whom are volunteers, who participate in the daily consensus forecasting process when they are able. All forecasters who participate on a given day develop their own individual forecasts and then they log into a secure website to discuss their predictions. After this discussion, the official forecast is formulated and released to the public around 3:00 PM, via AirNow, the Georgia EPD Ambient Monitoring Program website, and messaging conducted by Georgia Institute of Technology and The Clean Air Campaign. Once a forecast is announced, it triggers a set of activities including alert signage along major highways, reports in the local newspapers, and messaging to the public regarding recommended changes in commuting or outdoor activity plans for the next day (such as jogging, football practice, strenuous exercise). Although traditional and electronic media outlets could update these messages frequently to give more timely information to the public, these other actions are not easily changed, so EPD does not update the forecast after the official announcement.

Georgia EPD also uses AQ data for air toxics studies to better understand the patterns and formation of pollutants in different parts of the state. However, resources for this work have been deeply cut in recent years, reducing the number of studies from about 15 to about 4 per year.

AQ monitoring data are used by the *Planning and Regulatory Development Unit* of Georgia EPD Air Protection Branch to develop an implementation plan for areas that fall out of attainment for any of the pollutants in the NAAQS. To develop and revise these plans, staff mainly use data directly from the state's Ambient Monitoring Program, rather than AirNow. This work also makes use of ambient monitoring data, speciated hydrocarbon data, dispersion and photochemical modeling, and positive matrix factorization (PMF) analysis "to help us understand what's going on chemically in the atmosphere so we can meet the NAAQS requirement." Areas that are considered serious, severe, or extreme for ozone non-attainment make use of this specialized data.

The Planning and Regulatory Development Unit is also responsible for developing and administering rules concerning air quality, as well as fire planning, smoke management, and regional haze, serving on both regional and national committees. They use AirNow data selectively for specific projects or questions, but largely rely on the state's own monitoring data and university or other experts who may be using a variety of data sources in their work.

The ***Georgia Department of Transportation*** and ***Atkins Global***, an international consulting firm, together use a number of modeling tools and data sources to predict the air quality impacts of highway transportation in non-attainment areas. They conduct a systemic analysis using the EPA MOVES model by inputting demographic and transportation data from surveys and Census products to model and predict the impact of highway transportation on air quality. The goal is to make a transportation conformity determination about proposed projects that compares future vehicle emissions against either a baseline (usually for PM2.5) or an emissions budget (for ozone). Individual highway projects are required to obtain approval under this systemic model before work can go forward. The Georgia Department of Transportation does not use AirNow data directly for this work but instead relies on the air quality data embedded in the EPA MOVES model plus inputted data to model different pollutants. For ozone for example, these inputs include average summer ozone level, temperature, fuel types, road types, and vehicle types, among others.



Source: The Clean Air Campaign website: http://www.cleanaircampaign.org/

The ***Clean Air Campaign (CAC)*** is a non-profit organization created in 1995, in advance of the 1996 Atlanta Summer Olympics, to improve air quality and reduce traffic in the region. Since then, it has expanded its reach and added a school-based education unit, Clean Air Schools. CAC is funded primarily by the Georgia Department of Transportation and the federal CMAQ program with additional support from corporate and foundation sponsors. The organization currently works with over 300 schools and 1,600 employer partners. The CAC uses the daily forecasting information provided by Georgia EPD to issue color-coded alert levels, with any level above yellow (moderate AQI) generating an automatic email to their listserv of 20,000 subscribers in the Atlanta metro area. Additionally, the CAC communicates air quality information via its Facebook page, Twitter feed, and LinkedIn portal.

Extensive employer-focused programs at CAC include consulting with businesses to show the cost-benefit of air

Source: The Clean Air Campaign Facebook Page: https://www.facebook.com/CleanAirCampaign and Twitter Feed: https://twitter.com/cleanairga

quality improvement measures and helping employers initiate programs that contribute to air quality improvements, such as teleworking and employer-sponsored carpooling. This work includes webinars, seminars, a menu of 12 services called Georgia Commute Options, and various promotional and recognition campaigns to highlight the benefits achieved by specific employers that adopt these measures. Employer-oriented programs emphasize productivity benefits, overhead reduction, and human resources impacts that improve competitiveness.

The ***Clean Air Schools*** programs are focused on reducing air pollution and traffic in school zones by discouraging idling by cars and buses, and encouraging students to carpool, walk, and use mass transit. In addition, the program manages a website (http://www.blogonair.org/) that provides a forum for students to blog about air quality issues and to quantify their air-friendly activity through "AirCreds." CAS has also launched programs that involve teachers, parents, and students in problem-solving classroom projects to assess and address air quality issues in their own schools. CAC has produced a set of toolkits that can be adopted by schools anywhere in the country. The Clean Air Schools program does not currently use EPA data on air quality.

CAC does not use official AQ data from AirNow or similar sources to quantify the impact of its programs, but it estimates from self-reported activity by participants that commuting alternatives reduced vehicle travel in 2010 by 1.4 million miles each work day, at a savings of $150 million in gas and vehicle expenses.

Researchers at ***Emory University, Rollins School of Public Health***, use AQ data to conduct a range of research on exposure to air pollution and associated health effects. Specific studies involve different approaches to this broad question. One study is tracking the exposure of a set of

Source: OnAir Blog: http://www.blogonair.org/

volunteers as they go through their daily activities. Another links cohorts of individuals in a given locale to health records, medical encounters, hospital admissions, and similar activities over time to try to understand the effects of long-term exposure associated with a particular place, economic class or other variables. For some studies, the researchers collect their own air quality data. The work we discussed in our interviews does not make direct use of AirNow data but it sometimes uses the underlying monitoring data collected by Georgia DPA, usually obtained through colleagues at Georgia Tech who work closely with DPA.

A researcher from the ***Georgia Institute of Technology, School of Public Policy*** generally focused on the challenge of bringing technical and social or behavioral sciences together to understand the effects of environmental policies or to inform future policy decisions. One line of inquiry looks at the relevance and impact of different kinds of health or behavioral messages for different purposes and audiences. For example, what is the optimum content of an air quality advisory for day care providers vs. for parents of preschoolers generally vs. for the general population? Another is to understand how an AirNow-type program helps achieve regulatory compliance by identifying areas or time periods for specific reduction in emissions rather than trying to “achieve attainment wholesale across the board.” This research did not draw data from AirNow but, again, relied on the underlying Georgia EPD data and the expertise of the members of the forecasting team at Georgia Tech.

GAPS AND WEAKNESS IN EXISTING AQ MONITORING DATA

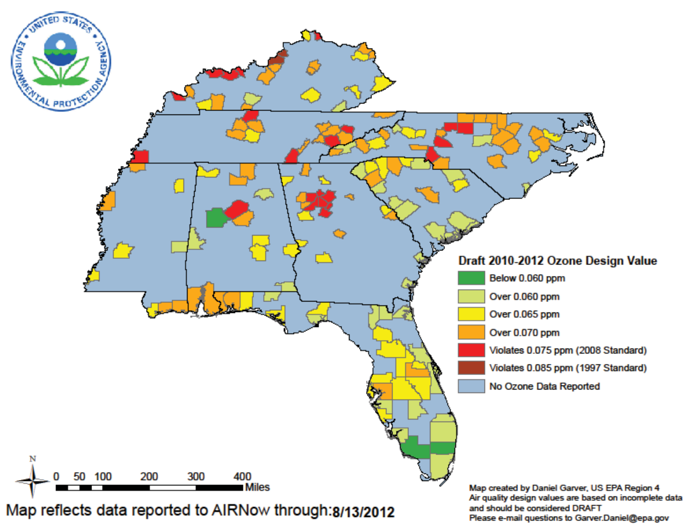
Gaps in the monitoring network

The most obvious and important gap in existing AQ data is a consequence of the monitoring network itself: large portions of Georgia are long distances from the ground-based monitors in the regulatory network. While the state is consistently evaluating the coverage and effectiveness of its network and the need for additional monitors, resource constraints result in a monitoring network concentrated around Atlanta and other cities that comprise the larger population centers. Although monitors are placed for maximum compliance with EPA’s design criteria, they still leave large parts of the state with either estimates of pollution measures or no data at all. The map below, prepared by EPA for ozone monitoring shows the extent of this gap for the entire eight-state region.

Theses gaps limit the state’s overall ability to provide timely and accurate air quality information to some areas, but it is neither economically nor politically feasible to place enough monitoring stations throughout the state to eliminate the gaps. As a consequence, existing AQ information is inadequate to fully understand both current conditions and longer-term trends statewide.

Interpolation of ground monitor data to describe larger geographic areas

AirNow uses mathematical interpolation of the ground sensor readings to estimate pollution concentrations in surrounding areas. Because Georgia has relatively simple



Source: EPA Region 4

topography, this can often be a reasonably good way to fill the data gap. However, long distances and weather patterns can also make these estimates unreliable for local use. Thus a two-part problem exists – (1) at times the interpolated data is incorrect and thus it mis-characterizes the exposure in certain areas, or (2) at times the interpolated data is correct, but since it is not verified by direct observations users consider it unreliable. This data gap problem is unlikely to be filled with more ground monitors because of the expense of deployment, operation, and maintenance. However, under the right atmospheric conditions, good quality satellite data could substitute for, or verify, interpolation in some areas to provide more accurate localized readings and forecasts and more confidence in the data.

Targeting and content of public outreach messages

The Atlanta region has had air quality problems for many years and interviewees agreed the general level of public awareness is relatively high and widespread. People are used to experiencing many days every summer when the AQI is orange (USG), or red (Unhealthy). The challenge is not so much to raise awareness but to target appropriate messages to different groups and to send useful information to people all over the state. In recent years, EPA funding for public education and outreach has been cut and although funding is available through the Federal Highway Administration CMAQ Program, it cannot be used to advise about human health effects. Consequently most of the messages fall into the category of "spare the air," that is "reduce emissions." Both health and conservation messages are needed, but interviewees noted that the messages need to be better targeted to have the desired effects. For the general population, "spare the air" messages are appropriate (e.g. fill gas tanks or mow the lawn in the evening, carpool, take public transport) since they are more likely to encourage behaviors that reduce pollution and apply to nearly everyone. However, the behavioral recommendations associated with AirNow are mostly intended to inform sensitive groups to limit their exposure, but some interviewees say they are too simplistic and mainly posted on websites or announced on the news rather than sent directly to groups or individuals who care about them and could benefit from them.

Limitations of the data for research purposes

Few of the research studies we learned about need near-real time AQ data, but access to detailed historical information that reports hourly readings for small geographic units would be very useful for public health studies and policy analysis. In other words, researchers need data that is both spatially and temporally differentiated.

Potential Value of Satellite-Enhanced Data

During each interview we presented examples of the satellite and satellite-enhanced AirNow products produced by the STI team developing the ADSP. Each example focused on the greater Atlanta metro region and was drawn from past dates selected by STI to highlight different daily conditions and the capabilities and limitations of the ASDP. We asked the interviewees to consider how they might use these products in light of their intimate knowledge of the case study region and to suggest the value of these products in their jobs or for the stakeholders they serve. The rest of this section describes the main benefits identified.

FILLING GAPS IN THE GROUND SENSOR NETWORK

A consistent theme across the interviews was that satellite data could be used by government and other users to supplement the existing ground-based network. Interviewees agreed that both the satellite data and the fused product could fill coverage gaps in the existing network to support issuance of burning permits, routine forecasts, and advisories to the public. Georgia DNR officials are satisfied that the current network captures the data necessary to comply with the NAAQS, but at the same time others pointed out that complex weather patterns push pollutants around the state or create areas of temporary stagnation that may be far from a monitor. While the pollutant levels in unmonitored areas may not approach non-attainment status, all agreed that statewide satellite data could increase awareness of air quality issues and, more important, provide useful, granular data for localized use.

Gaps in the monitoring network are addressed as far as possible by AirNow by estimating or extrapolating air quality measurements from sensors at the monitoring sites to areas farther away. However, as described in the previous discussion of gaps and weaknesses, distance from the monitor and topographic and meteorological conditions can make these estimates inaccurate. In these instances, the satellite data could supplement the monitoring data. The accuracy of the satellite measurements is affected by local conditions such as cloud cover associated with frontal systems or cumulus convection, so this supplementation would not always be possible, but in many instances the satellite data could add considerable granularity by providing direct local measurements for forecasting and public information purposes.

An expert at the EPA Region 4 Office explained it this way:

> "The monitors are really, really accurate at the spot that they're at. But then how do you spread that out across a large area? … The big wide open spaces get even more pronounced when you go further west but even in the middle between Atlanta and Columbus there's a big triangle with this county in the very middle, you don't have a great idea of what the actual air quality is. And the satellite can help capture that."

SUPPORTING DESIGN AND DEPLOYMENT OF THE REGULATORY MONITORING NETWORK

While everyone interviewed clearly understood that the satellite data and fusion product are not intended for regulatory decisions, they did recognize how they ultimately might improve performance of the state's regulatory mission. Due to a combination of economic, geographic, and political factors, Georgia cannot place ground sensors in all the places needed to provide complete coverage. However, the state constantly evaluates its network against current and emerging air quality conditions in an effort to optimize the network they do have. They occasionally place monitors in new locations, sometimes as part of the regulatory network and sometimes as exploratory efforts to better understand the conditions in a certain location. The state does use other air quality information such as "non-state" and "non-reference"[v] monitors to help identify some of these areas, but the satellite products could be an important additional information source especially in those areas without ground monitoring of any kind. The interviewees agreed that satellite data could help identify those areas in the state where the expensive investment in an additional monitor could provide the greatest value.

Staff in the Georgia Department of Natural Resources Ambient Monitoring Program and Planning and Regulatory Development Unit – those responsible for the network design and the quality of the data – described how satellite data could help them determine where new monitors could be located. According to one expert, "While that data couldn't be used to determine nonattainment or attainment… it would tell you where your problems are to start with. OK, this is it; this is where you need to move a monitor. Or you need a plan for this area."

Experts from EPA Region 4 concurred, "It'd be great to see if one of our monitors is often surrounded by something picked up in the [satellite] data that's a max concentration. And I think it changes year to year and the question is, how stable is the max concentration. Is it forever there or does it adjust over the years . . . And then the question is, what's creating that hot spot? Is it upper atmosphere? Or occurring more at ground level?" "So I think it would be a good tool as far as network assessment."

SUPPORTING STATE-LEVEL AQ MODELING FOR LONGER RANGE PLANNING AND PRIORITY SETTING

Satellite data could also be valuable in helping improve air quality modeling. At the federal and state levels air quality modeling is used to predict the dispersion of air pollution and assess both the impact of pollution sources and potential control strategies. According to one state expert in charge of planning and regulatory development, modelers would benefit from having multiple data sources and the satellite data could provide them with an "important feedback mechanism." He went on to add, "This [the satellite data] gives you more data than our monitoring network. You can't ever have enough data. Because right now we've got a grid for the state and we've got a dozen or so, what, 11 monitors in Atlanta. And they're trying to project 20 counties with 11 data points. So it'd be helpful to have more data points."

Improving understanding of meteorological effects from stationary sources

When reviewing examples of the satellite products for the Atlanta region, an expert from Georgia DNR talked about how meteorological conditions and a lack of monitors made it difficult to assess the impact of some point source pollutants. For example, due to a combination of proximity to the Atlantic Ocean, relatively large point pollution sources such as power plants and large military bases, and sparse ground monitor coverage, at times it is difficult to track air quality conditions in southeast Georgia. Satellite data might be used to supplement the ground monitors in these areas.

The interviewee explained how one of the pollution controls implemented in 1980s required power plants to significantly increase the height of their smoke stacks so the pollution was released high enough to be pushed down wind and become diluted in the atmosphere. However, depending on meteorological conditions that type of pollution can persist in an area or can be circulated to another area. While reviewing the satellite products he noticed the rather high air quality reading for PM2.5 around a well-known power plant noting that "these stacks are a thousand-foot high. However, sometimes there's an inversion. Because that's one of the issues we have in the southeast. The Bermuda High [off the Atlantic Ocean] gives you that stagnant air that allows things to just recirculate right here in the center of the state and it goes from Columbus to Macon to Atlanta," the same area in southeast Georgia that has the sparsest coverage of ground monitors. Under cloud-free conditions, satellite data from inferred aerosol optical depth (AOD) measurements, along with available ground monitor data and meteorological data, could help determine if and where that PM pollution is traveling.

HELP IMPROVE REGIONAL AND LOCAL ANALYSIS OF AIR QUALITY CONDITIONS

All the experts we talked to recognized the potential value of the satellite data to provide more localized analysis of air quality conditions. While the interviewees questioned exactly how localized or granular the current 4km resolution of the satellite data would be, they all agreed would be an improvement from the current network coverage. The mix of stakeholders whom the interviewees thought could benefit from this information ranged from employers interested in identifying areas where a large number of employees are commuting, to local health departments interested in better information about the air quality of their specific county or area of responsibility, to certain industries such as fleet vehicle companies interested in how their usual practices are contributing to both their costs and the working conditions in and around large depots.

The Clean Air Campaign interviewees described their diesel idle reduction program:

"We have a diesel idle reduction program that helps much in the same way that the No Idling program for schools works. It's kind of a toolkit kind of approach with some supporting things that might motivate an employer to draft a policy prohibiting drivers of fleet vehicles, for example, from keeping their engines on above a certain threshold of time. The motivation there is, obviously, for fuel savings and employee health when they're near loading docks and facilities and things like that. . . I'm trying to figure out what a four-kilometer footprint looks like for some of these things. To really be able to zoom down on something and say this is what's going on right now, because there are a lot of fleet vehicles that are all traveling around a stockyard. And then be able to maybe show later if they were to institute a policy for reducing idling, does that look a little different afterwards, in terms of a before-and-after scenario."

One EPA expert added that the satellite data could help them look at the air quality in various neighborhoods in relation to how it was being affected by the large rail yard in Atlanta, "[The satellite data] makes it a lot more interesting for neighborhoods and communities in a metropolitan area. Because otherwise it's kind of a broad brush stroke and you can fill in some of that information. It'd be interesting to look at case studies, how often that changes the value for a neighborhood by adding that realistic heterogeneity of the plumes and the particles."

And for the local health department stakeholder, a representative from the Clean Air Campaign observed, "We are starting to work with some of the departments of health in the districts too, or in the counties, so I'm thinking, gosh, Fulton County has this whole health promotion action coalition that just started and they don't have any of this data. They have an actual separate asthma coalition for the county. This would be really helpful for some of the work that they're doing too, to be able to offer these to health agencies."

IMPROVING DATA FOR STATE AND LOCAL GOVERNMENT FUNCTIONS

Satellite data could support a number of daily responsibilities of state and local governments. These daily uses range from air quality forecasting, to advisories due to special events such as smoke from fires, to routine regulatory activities such as issuance of burn permits. Interviewees consistently stated that satellite data could increase their confidence in the coverage, accuracy, and timeliness of the information they use for decisions or provide to others.

For example, southern Georgia near the Florida border is a large area of frequently prescribed burning. In that region only two monitors (Albany and Valdosta) support the counties' ability to look at air quality as a determining factor in deciding the number and scope of burn permits to issue.

"Every one of these counties has an office that permits for that county. I mean, if they had data for their county and [could know] 'Well, what's the air quality data?' If they had that feedback, they might decide "Well, I'm only going to issue a couple thousand acres this day instead of 20,000."

State experts noted that satellite information, in conjunction with meteorological data, LIDAR, and profiler data, could help with their daily pollution forecasts. "I could see any additional information is always useful for forecasting as long as it's taken and understood. And the more information you have, the better the tools that we have, the better forecast we can put out or understand what's going on atmospherically." More data and more diverse data would also provide a better understanding of the residual ozone.

ENHANCING PUBLIC HEALTH AND POLICY RESEARCH

Interviews with researchers from Emory University and Georgia Tech identified two main types of potential value from satellite data: improving the granularity, spatial coverage, and validity of air quality data for public health research and policy analysis; and providing data to extend this kind of research beyond urban centers to rural and agricultural areas.

The researchers we interviewed agreed that satellite data would be a good resource for understanding the spatial dimension of exposure to air pollution, especially if it could be collected for very small units of geography. In addition, researchers at Emory discussed how satellite data could be used to confirm air quality readings from other sources such as stationary ground monitors, personal monitors, or other available sources. According to one, "I'm interested in seeing areas of similarity or concordance that are robust to the exposure assignment metric. It would add confidence to our results that even using a crude method of exposure like a central site for a population might be sufficient in terms of figuring out what the temporal relationship is between air pollution and health outcome." Another noted, "It's important to me to get some sense of what [Georgia DPA and EPA are] measuring and compare it to the data I actually generate" to figure out the best way to characterize air pollution exposure for different populations.

While in general, regulators and researchers appreciate the logic and value of placing monitors in high population areas, researchers also discussed the potential public policy and even economic value of better air quality data in rural agricultural areas. One researcher discussed how improved air quality data in rural agricultural areas could support research on how various air quality conditions impact the health and productivity of farm workers – studies that would have both public health and economic value. For example, satellite data might enable studies to associate levels of productivity with ambient air quality in small scale areas with findings that might inform both public policies and business practices.

SUPPORTING SCIENCE EDUCATION AND WORKFORCE DEVELOPMENT

Interviews with staff at the Clean Air Campaign identified several opportunities for using satellite products with school age children in the classroom environment including using actual satellite products in the K-12 curriculum and increasing student interest in science, technology, engineering, and math, the so-called STEM fields, by highlighting the organizations that develop these products and encouraging them to consider the types of careers they offer.

The satellite products could provide school age children with a learning tool for using and understanding maps and spatial relationships, and exploring how scientific information like air quality data is collected, managed and used. Most importantly, satellite products could be used to teach them about air quality conditions not only for their state but for their own communities and help them “place themselves within the data.” The person in charge of the CAC school programs added, “Curriculum directors for the districts would, I think, really be excited to be able to provide this to their students.” And the data need not be real-time or necessarily complete. For these purposes, selected historical information sets would be sufficient.

In addition, emphasizing scientific and analytical skills, and introducing the agencies involved in developing these types of data products, could promote students’ interest in STEM fields. The satellite products could increase the visibility of and interest in federal agencies such as EPA and NASA as future employers and interviewees recommended including information about the agencies and companies involved in creating and using the information along with the data itself. Teachers and visiting experts could describe the types of government, academic, and business careers that would become open to them.

Stakeholder Recommendations

for Satellite Data Products

Interviewees represented different stakeholder groups and consequently offered different kinds of recommendations regarding the future development and use of satellite data and fused data products. Substantial differences are associated with different users and uses of the data, which together indicate its versatility and value for different purposes. Some of the recommendations focus on the regulatory environment and the need for precise data to demonstrate attainment and progress toward attainment of the NAAQS. Others reflect scientific and technical viewpoints about how more or different data can inform analysis, forecasting, planning, policy making, or enforcement.

Use satellite data to "ground truth" the monitors and vice-versa to assure data quality and credibility.

Satellite data would be a new source for most users of AQ information. As such, its quality and reliability need to be assured. One way to do this would be to periodically compare time-matched ground sensor readings on clear days to satellite readings on the same days in the small grid area surrounding each sensor. If the readings are substantially the same, the two sources could be considered equivalent quality for many purposes and satellite readings in areas more distant from the sensors could be considered valid. Another approach would be to test satellite readings in remote areas against readings from good quality mobile ground sensors in the same locations. A third would be to substitute satellite readings for a subset of ground sensor readings and compare the combined results to the results from the full set of ground sensors. All of these would help to establish the validity of satellite data and document its strengths and limitations relative to both sensor readings and interpolated results. In this regard, a public health researcher noted, "what's interesting is not so much where are the differences . . . but the areas of concordance which can lend some confidence" to data from both sources.

Provide meteorological data to complement the satellite data

Georgia is subject to complex weather patterns that transport pollutants around the state. Forecasters told us the value of satellite data would be greatly enhanced if time-matched meteorological information were also provided. The combination of pollution measures and weather patterns would help them produce better pollution forecasts. A supplemental LIDAR system and a radar wind profiler system would help identify residual components of ozone.

Invest in technologies that allow data from ground sensors and from satellite sensing to be gathered, compared and fused for the same time periods.

Nearly all interviewees noted that the potential benefits of satellite data and especially of a fused product, depend on finding a way to synchronize the data from the ground and satellite sources. Ideally, the readings from both sources would be recorded frequently so that information could be compared, fused, or adjusted using measurements from both sources taken at the same time of day. Investments in geosynchronous satellites or other technologies that collect data throughout a 24-hour period seemed far preferable to algorithms that attempt to compensate mathematically for missing data and widely different time frames.

Support research in satellite sensing technologies that permit measurement of other pollutants, especially ozone.

Both PM2.5 and ozone are serious health hazards, especially with long-term exposure. Interviewees could see the definite benefits of satellite data for filling in the gaps and improving the granularity of PM2.5 data gathered in the sensor network. Some pointed out it would be especially useful to have data on ozone because it is more insidious as a health risk. PM2.5 is often accompanied by visible dust, smoke or haze as well as eye and respiratory irritation. Ozone is invisible and less likely to prompt individuals to change their behavior absent public health information and outreach.

Provide training and technical support to scientific, administrative, and research users of ground sensor data, satellite data and fusion products.

Data users need information and training about the nature and limitations of the satellite data in order to make informed judgments about whether and how to use it. Modelers, researchers and others wanted to have a detailed explanation of how the two data sets are fused to create ASDP products before he could decide about its use in forecasting, modeling, or other kinds of studies. A standard description of this process would help a technical user understand how the fusion is done and whether the result would be relevant or useful in any given application. Webinars or other training programs could introduce them to the range of AQ data available, its pros and cons, and suggestions about how it can be applied to support different responsibilities.

Provide satellite imagery and data separately from a fused ASDP product.

The fused product has potential value as an eventual replacement or point of comparison for current AirNow products. However, interviewees noted that looking at the separate map representations of the satellite data and the AirNow data was often more helpful than looking at the fused product because they could readily see the difference (or agreement) in the readings and interpret their implications for actual conditions. The separate stories can often tell a more complete or complex story than the fusion. In its current form, the fused product not only masks differences in granularity and time scale, it also makes certain standard assumptions about which data source is more reliable—assumptions that may not be appropriate in all circumstances.

Give priority to developing satellite data products for experts rather than for direct public use.

Because of its complexity and limitations, interviewees recommended making satellite products available and understandable to various kinds of experts to enhance their work. For example, satellite readings in unmonitored areas could allow government or community agencies to craft more localized public health messages, improve permitting decisions, or develop local guidelines or programs directed at schools, day care centers, and other facilities where air quality affects vulnerable groups. Most interviewees felt the satellite products, especially the fusion product, would not be helpful to the public directly because interpretation demands more than a lay person's knowledge and appreciation for the data and what it represents. As an substitute for a near-real time public product, Clean Air Campaign staff saw how historical satellite images, data and maps could be used in schools to develop analytical and problem solving skills as well as to introduce and encourage students to consider career paths in which data analysis is a critical competency.

Appendix 1

List of Interviewees

Environmental Protection Agency, Region 4, Air, Pesticides, and Toxics Management Division; Air Toxics and Monitoring Branch, Monitoring and Technical Support Section

- Ryan Brown, Environmental Scientist
- Daniel Garver, Environmental Scientist
- Darren Palmer, Environmental Scientist

Georgia Department of Natural Resources, Environmental Protection Division, Air Protection Branch

- Jim Kelly, Program Manager, Planning and Regulatory Development Unit, Planning and Support Program
- Bill Murphey, Unit Manager, Meteorology Unit
- Susan Zimmer-Dauphinee, Program Manager, Ambient Monitoring Program

Georgia Department of Transportation, Air Quality and Technical Resource Branch

- Habte Kassa, Planning Engineer III
- Patti Schropp, Senior Transportation Planner at ATKINS Global

The Clean Air Campaign

- Brian Carr, Director of Communications
- Lesley Carter, School Communications Manager
- Gretchen Gigley, Director of Education
- Jenny Schultz, Communications Specialist
- Mike Williams, Director of Employer Services

Rollin School of Public Health, Emory University

- Jeremy Sarnat, Associate Professor, Department of Environmental Health
- Matthew Strickland, Assistant Professor, Departments of Environmental Health and Epidemiology

Indiana University (formerly of School of Public Policy, Georgia Institute of Technology)

- Douglas Noonan, Associate Professor School of Public and Environmental Affairs

Appendix 2

List of Acronyms

Items Pertaining to Air Quality Science, EPA, NASA, and National Policies

ASDP: AirNow Satellite Data Processor

40 CFR Part 58: Ambient Air Quality Surveillance Siting Criteria for Open Path Analyzers

CMAQ: Congestion Mitigation and Air Quality Improvement Program

CO: Carbon Monoxide

GASP: Geometric Autonomous Shuttle

GOES: Geostationary Operational Environmental Satellite

MODIS: Moderate Resolution Spectroradiometer

NOx: generic term for mono-nitrogen oxides, NO and NO2

OAPQS: EPA Office of Air Quality Planning and Standards

PIO: Public Information Officer

QA: Quality Assurance

SIP: State Implementation Plan

VOC: Volatile Organic Compounds

Colorado-specific items

DNR: Georgia Department of Natural Resources

GDOT: Georgia Department of Transportation

GRTA: Georgia Regional Transportation Authority

EPD: Georgia Environmental Protection Division

SCR: Selective Catalytic Reduction (control technology for NOx and SO2)

VISTAS: Visibility Improvement State and Tribal Association of the Southeast

Appendix 3

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Appendix 4

National Ambient Air Quality Standards (NAAQS)

The Clean Air Act, which was last amended in 1990, requires EPA to set National Ambient Air Quality Standards (40 CFR part 50) for pollutants considered harmful to public health and the environment. The Act identifies two types of standards. Primary standards provide public health protection, including protecting the health of "sensitive" populations such as asthmatics, children, and the elderly. Secondary standards provide public welfare protection, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings. EPA has set NAAQS for six "criteria" pollutants listed below. Units of measure for the standards are parts per million (ppm) by volume, parts per billion (ppb) by volume, and micrograms per cubic meter of air (µg/m3). The standards shown in the table below are effective October 2011.

Pollutant [final rule cite]		Primary/ Secondary	Averaging Time	Level	Form
Carbon Monoxide [76 FR 54294, Aug 31, 2011]		primary	8-hour	9 ppm	Not to be exceeded more than once per year
			1-hour	35 ppm	
Lead [73 FR 66964, Nov 12, 2008]		primary and secondary	Rolling 3 month average	0.15 µg/m3 (1)	Not to be exceeded
Nitrogen Dioxide [75 FR 6474, Feb 9, 2010] [61 FR 52852, Oct 8, 1996]		primary	1-hour	100 ppb	98th percentile, averaged over 3 years
		primary and secondary	Annual	53 ppb (2)	Annual Mean
Ozone [73 FR 16436, Mar 27, 2008]		primary and secondary	8-hour	0.075 ppm (3)	Annual fourth-highest daily maximum 8-hr concentration, averaged over 3 years
Particle Pollution Dec 14, 2012	PM2.5	primary	Annual	12 µg/m3	annual mean, averaged over 3 years
		secondary	Annual	15 µg/m3	annual mean, averaged over 3 years
		primary and	24-hour	35 µg/m3	98th percentile, averaged over 3 years
	PM10	primary and secondary	24-hour	150 µg/m3	Not to be exceeded more than once per year on average over 3 years
Sulfur Dioxide [75 FR 35520, Jun 22, 2010] [38 FR 25678, Sept 14, 1973]		primary	1-hour	75 ppb (4)	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		secondary	3-hour	0.5 ppm	Not to be exceeded more than once per year

(1) Final rule signed October 15, 2008. The 1978 lead standard (1.5 μg/m3 as a quarterly average) remains in effect until one year after an area is designated for the 2008 standard, except that in areas designated nonattainment for the 1978, the 1978 standard remains in effect until implementation plans to attain or maintain the 2008 standard are approved.

(2) The official level of the annual NO2 standard is 0.053 ppm, equal to 53 ppb, which is shown here for the purpose of clearer comparison to the 1-hour standard.

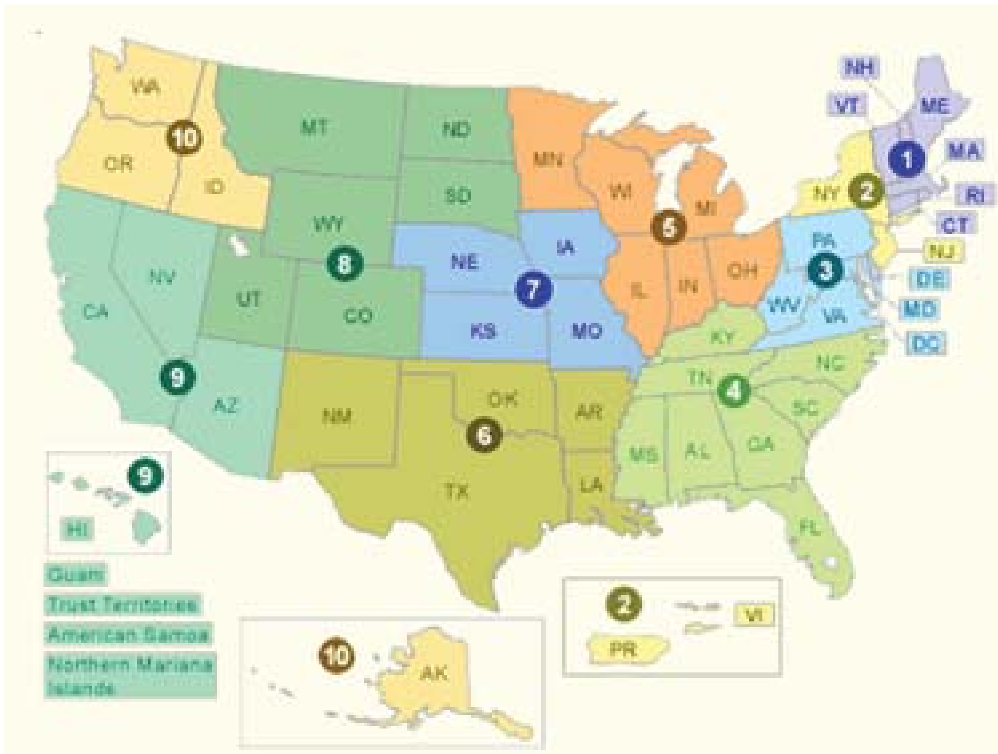
(3) Final rule signed March 12, 2008. The 1997 ozone standard (0.08 ppm, annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years) and related implementation rules remain in place. In 1997, EPA revoked the 1-hour ozone standard (0.12 ppm, not to be exceeded more than once per year) in all areas, although some areas have continued obligations under that standard ("anti-backsliding"). The 1-hour ozone standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm is less than or equal to 1.

(4) Final rule signed June 2, 2010. The 1971 annual and 24-hour SO2 standards were revoked in that same rulemaking. However, these standards remain in effect until one year after an area is designated for the 2010 standard, except in areas designated nonattainment for the 1971 standards, where the 1971 standards remain in effect until implementation plans to attain or maintain the 2010 standard are approved.

Appendix 5

Case Study Methodology

This study, funded by NASA and in partnership with EPA and Sonoma Technology, Inc., addresses the ways in which current AirNow source data and data products contribute to socioeconomic benefits today and how satellite-enhanced data might contribute to different or greater benefits in the future.



To understand the potential benefits of adding satellite data to AirNow, we put that data in a larger context including the flow of air quality monitoring data among different stakeholders. Within the regulatory process that requires compliance with the NAAQS established under the Clean Air Act, data are collected hourly but organized and reported quarterly to the US Environmental Protection Agency by the air quality agency in each state. States that do not meet the air quality standard are required to develop and implement action plans to come into compliance. Most of the improvement in air quality in the U.S. can be attributed to the adoption and enforcement of these standards which have influenced both public policy and private enterprises. AirNow uses essentially the same data for non-regulatory purposes, but use this data in near-real time, before extensive quality assurance has been performed. State air quality agencies use AirNow data to forecast air quality conditions for the next day and to inform the public and the media about potentially unhealthy conditions so they can take action to reduce pollution and protect human health.

Most research on the benefits of air quality regulation and information rest on complex mathematical models or surveys that cover extensive regions of the US or the entire country. By contrast, this study attempts to understand the value of monitoring data from a community-level view through three case studies: Denver, Atlanta, and Kansas City located respectively in EPA Regions 4, 7 and 8.

Using these communities as a focus, we take localized contexts into consideration to address the following questions:

- Who are stakeholders in air quality information in the case study area? What are their needs and capabilities?
- Who uses AirNow source data and data products now and how do they use it?
- What techniques or strategies seem to have the most positive effect on public awareness and behavior? What evidence is available on these effects?

- What gaps or weaknesses in current data reduce its usability and usefulness for different kinds of users?
- To what extent could NASA satellite data ameliorate these problems or provide for new or expanded uses?
- What other activities, information, or capabilities would enhance the usability and usefulness of AirNow data for informing and educating the public about air quality and its effects on health and quality of life and for furthering the goals of the Clean Air Act?

We organize the analysis according to a public value framework that assesses the impact of existing AirNow source data and data products along several dimensions including economic, social, strategic, quality of life, stewardship, and mission impacts.

The case studies involved 23 face-to-face and three telephone interviews with responsible officials and leaders in these communities representing EPA, state agencies, local public health authorities, regional planning and outreach organizations, university researchers, and relevant others. Interviews were transcribed and coded to identify factors associated with each of the research questions and the various indicators of public value. The study data also include regulatory documents, news media, local and state websites and reports, and a previous research studies in these three sites.

ENDNOTES

[i]The full NAAQS is found at http://www.epa.gov/air/criteria.html and in the Appendix.

[ii]For more information about 40 CFR Part 58 see http://www.gpo.gov/fdsys/pkg/CFR-2002-title40-vol5/pdf/CFR-2002-title40-vol5-part58.pdf.

[iii]See Ambient Air Monitoring Network Assessment Guidance. Prepared by STI 2007, pp. 2-1 – 2-3.

[iv]The AirNow Satellite Data Processor Website is located at http://asdp.airnowtech.org/

[v]"Non-state" monitors refer to federal agency monitors such as Forestry Service or other monitors owned and maintained by local governments or communities. "Non-reference" monitors refer to those monitors not certified by EPA for providing regulatory quality data.

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