Air & Waste Management Association

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THE MAGAZINE FOR ENVIRONMENTAL MANAGERS

FEBRUARY 2014

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Applying Satellite Data to Air Quality Management

Research conducted by the NASA Air Quality Applied Sciences Team (AQAST) shows that Earth science data are a great potential resource for air quality managers

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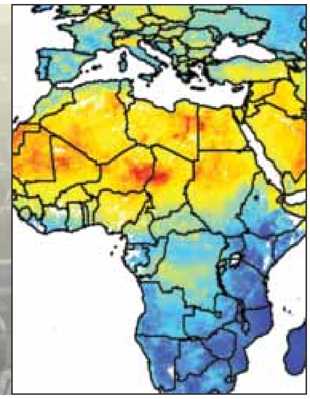

FEATURES

COLUMNS

ASSOCIATION NEWS

DEPARTMENTS

EM, a publication of the Air & Waste Management Association (ISSN 1088-9981), is published monthly with editorial and executive offices at One Gateway Center, 3rd Floor, 420 Fort Duquesne Blvd., Pittsburgh, PA 15222-1435, USA. Periodicals postage paid at Pittsburgh and at an additional mailing office. Postmaster: Send address changes to EM, Air & Waste Management Association, One Gateway Center, 3rd Floor, 420 Fort Duquesne Blvd., Pittsburgh, PA 15222-1435, USA. GST registration number: 135238921. Subscription rates are $310/year for nonprofit libraries and nonprofit institutions and $465/year for all other institutions. Additional postage charges may apply. Please contact A&WMA Member Services for current rates (1-800-270-3444). Send change of address with recent address label (6 weeks advance notice) and claims for missing issues to the Membership Department. Claims for missing issues can be honored only up to three months for domestic addresses, six months for foreign addresses. Duplicate copies will not be sent to replace ones undelivered through failure of the member/subscriber to notify A&WMA of change of address. A&WMA assumes no responsibility for statements and opinions advanced by contributors to this publication. Views expressed in editorials are those of the author and do not necessarily represent an official position of the Association.

Looking Back, Looking Forward

by Michael Miller
president@awma.org

At the beginning of each year, the calendar provides us with a natural excuse for a fresh start. So as we begin our new year, I'd like to take a moment in this month's message to reflect on our recent past and look toward the year ahead.

Looking back, I have been pleased with the progress we have made as an Association. Our Web site has been improved, membership has been stabilized, finances are under control, and we have offered a number of new webinars that have been well received. In addition, we have been reaching out to other organizations to coordinate joint programs of mutual interest. This is all in addition to our ongoing professional development courses, workshops, publications, job placement services, and scholarship programs. When one steps back and takes in everything this Association offers, it is a very impressive portfolio.

These services do not happen in a vacuum, however. It is you, the members, who put in the sweat equity to help make this all occur. Thus, I would like to thank each and every one of you for your contributions on the local, regional, national, and international level that help make all this happen. I wish I could call you all out by name, but you know who you are.

Looking forward, I am very excited about 2014. We have welcomed new Board members, a new President-Elect, and new representatives on many of our various committees and task forces. One of my jobs this month is to appoint people to many of these roles (sort of feels like a national leader appointing those in his/her administration). By the time you read this, I will have reached out to many of you asking you to serve on these committees. I also hope that many of you will be working at your local Section and Chapter level to offer your talents in similar capacities. As I mentioned in last month's message, leadership development is one way each of you can contribute not only to the Association, but also to your own professional development.

As I write this, the Board of Directors is getting ready to begin working on a new strategic planning process and I will share with you the key elements of that strategy in a future message. By the time you read this, however, we should be well on our way to socializing that strategy with members and I hope you all have an opportunity to read the plan and weigh in. After all, this organization is built on its members and the value they receive.

Belatedly, let me take time to thank outgoing Immediate Past President Merlyn Hough, outgoing President and new Immediate Past President Sara Head, and outgoing Board members Jeanne Ng, Laki Tisopulos, and Daniel Weiss, for their leadership in 2013; and to welcome new Board members: President-Elect Dallas Baker, Jayme Graham, Kim Marcus, and Chris Nelson. I would also like to thank Executive Director Jim Powell and his staff in Pittsburgh for their hard work in simplifying processes, cutting costs, and getting us refocused on member value. And, finally, I would like to thank all of you for your support, hard work, and creative thinking to make the Air & Waste Management Association the best it can be.

A&WMA's 107th Annual Conference & Exhibition

Navigating Environmental Crossroads

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Professional Development Courses

The Air & Waste Management Association will offer a variety of high-quality courses that provide continuing education and professional development opportunities at a reasonable cost. Listed below are the courses that will be offered prior to the Annual Conference on Sunday, June 22 and Monday, June 23 in Long Beach, California. Please visit **http://ace2014.awma.org/courses** for the most up-to-date information and in-depth course descriptions.

Sunday, June 22, 2014

AIR-175: Odor Management for Industrial Plants and Municipalities; *Thierry Page, CEO-Odotech and Ray Porter, Senior Knowledge Leader Odotech*
AIR-185: ISO 50001; *Don Macdonald, LEED AP/Lead Auditor*
AIR-284: Boilers, Process Heaters, and Air Quality Requirements; *Leo Stander, BCEE*
AIR-286: Fundamentals of Air Quality Modeling; *Paolo Zannetti, DR.,QEP*
AIR-293: An Introduction to Air Pollution Control; *Leo Stander, BCEE*
AIR-298: Introduction to the CALPUFF Modeling System; *Gale Hoffnagle, CCM, QEP and Michael Newman*
AIR-299: AERMOD Air Dispersion Modeling; *Jesse The', Ph.D., P. Eng. and Cristiane Thé M. Sc.*
EMGM-194: Twelve International Standards that Every EH&S Professional Needs to Understand; *David Elam Jr. CIH, CMQ/OE, PMP, QSTO (I-IV)*
EMGM-285: Environmental Health Risk and Hazard Risk Calculations; *Ryan Dupont, Ph.D and Louis Theodore,Ph.D.*
EMGM-350: Ethics & Sustainability Workshop for Environmental Professionals; *Ram Ramanan, PhD, MBA, PE, BCEE and Hal Taback, MSE PE BCEE QEP REA*
EMGM-352: Sustainability Reporting: GRI-G4 Guidelines; *Yogendra Chaudhry, Ph.D., EP, CRSP*
MNG-185: Making the Business Case for Sustainability: **7 Business Trends Support Green Initiatives, Services and Products**; *Trudy Heller, Ph.D.*

Monday, June 23, 2014

AIR-135: Fundamentals of Air Pollution Meteorology and Dispersion Modeling; *Anthony Sadar, CCM*
AIR-182: Air Permitting - The Basics; *Leo Stander, BCEE*
AIR-198: Fire on the Mountain: Climate, Air Quality and Wildfire; *Kip Carrico, Ph.D.*
AIR-220: Principles of Industrial Ventilation; *Geoff Scott PE; and Brian Eagle*
AIR-295: Air Quality Engineering; *Mark Rood, Ph.D., BCEEM*
AIR-298: An Introduction to CALPUFF Modeling System; *Jesse The´, Ph.D., P. Eng. and Cristiane Thé M. Sc.*
GENWTR-180: Biotreatment of Air and Wastewater; *Rakesh Govind, Ph.D.*
EMGM-230: Environmental Forensics - Source and Fate of Contaminants in Air, Soil, and Water Samples; *Philp Paul, Ph.D.*
EMGM-345 ISO 14001: Environmental Management Systems; *Yogendra Chaudhry, Ph.D., EP, CRSP*
EMGM-351: Project Management Essentials for Environmental, Health, and Safety Professionals; *David Elam Jr. CIH, CMQ/OE, PMP, QSTO (I-IV)*
MNG-120: Entrepreneurship for Environmental Scientists and Engineers; *John McKenna, Ph.D*
WASTE-150: US DOT/PHMSA Training for Hazmat Employees; *Daniel Stoehr*
WASTE-160: US EPA RCRA Training for Hazardous Waste Personnel; *Daniel Stoehr*

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Sunday, June 22, 2014 - Monday, June 23, 2014

AIR-290: California Air Quality Permitting; *Joseph Hower, PE, DEE*
AIR-292: Comprehensive Continuous Emission Monitoring System; *Ben Sehgal*
GEN-100: Environmental Practices Review/GENESMP-100: Environmental Science Management and Policy; *Jim Donnelly, QEP, Principal*

http://ace2014.awma.org/

The NASA Air Quality Applied

by **Daniel J. Jacob** (Harvard University), **Tracey Holloway** (University of Wisconsin – Madison), and **John D. Haynes** (NASA Headquarters)

The February issue was coordinated by **Prakash Doraiswamy** and **Susan Wierman**, both members of *EM*'s Editorial Advisory Committee (EAC).

Earth science data and tools produced by NASA and other research agencies are a great potential resource for air quality management. They offer unique information on emissions and their trends, pollution monitoring and exposure, attribution of exceptional events, transport on interstate and international scales, and links to climate change. The NASA Air Quality Applied Sciences Team (AQAST) focuses on tapping this resource and delivering the specific products that air quality managers need, in a format that they can readily use. AQAST continuously seeks to expand its scope and services, and we hope that this issue of *EM* will inspire readers to follow our activities and partner with us in the future.

Satellite observations are of central interest to AQAST. Satellites have revolutionized our observation system of atmospheric composition over the past two decades, providing continuous data for the entire Earth. Many of the species observed from space are directly relevant to air quality, including particulate matter (PM), ozone, carbon monoxide, nitrogen dioxide, formaldehyde, ammonia, and methane. Satellites can monitor concentrations, track interstate and international transport, identify and quantify emissions, and diagnose exceptional events. Capabilities for observing air quality from space began in 1995, have been increasing steadily since, and will continue to expand in the future. The TropOMI instrument of the European Space Agency (ESA), to be launched in 2015, will provide daily global mapping with 7x7 km^2 resolution. The NASA TEMPO instrument, to be launched in geostationary orbit in 2019, will provide hourly data over all of North America with 2x2 km^2 resolution.

The potential of satellite data to benefit air quality management is too great to be ignored. AQAST bridges the gap between air quality managers and satellite data products. Articles in this month's issue report recent achievements, including Liu for PM monitoring, Hu et al. for air quality forecasting, and Streets et al. for quantifying emissions. AQAST also develops user-friendly tools such as the Wisconsin Horizontal Interpolation Program for Satellites (WHIPS) to access satellite data imagery for selected domains and times, and the Remote Sensing Information Gateway (RSIG) to download processed data in easy-to-read formats. AQAST collaborates with the NASA Applied Remote Sensing Training (ARSET) in holding regular training workshops for air quality managers and analysts. Many AQAST members are air quality modelers and understand the special challenges—and also the opportunities—of working with satellite data for air quality applications.

But AQAST is not only about satellites. It also seeks to exploit Earth science data collected from aircraft and surface sites. For example, it partners with the ongoing NASA DISCOVER-AQ series of aircraft campaigns providing detailed information on air quality processes in different areas of the country (Baltimore-Washington, California Central Valley, Houston, and next year the Colorado Front Range). AQAST further uses Earth science models to address emerging problems in air quality, such as intercontinental transport of pollution and climate-aerosol-chemistry interactions. The articles by Fiore et al. and Mickley et al. are examples of these activities.

AQAST was established in 2011 with the appointment of 19 members each with five-year terms. All

Sciences Team (AQAST)

AQAST projects involve close partnerships with air quality managers at the local, state, regional, and national levels. Projects are often initiated by requests from air quality managers. AQAST is designed to be highly flexible in allowing members to shift resources quickly as air quality issues evolve. Each AQAST member manages individual projects, and members also pool their expertise in annual "Tiger Teams" responding to immediate needs. This year's Tiger Teams were recently selected after extensive polling of air quality managers and external review. Detailed descriptions of all current AQAST projects and air quality partners are posted on the AQAST Web site at http://aqast.org. The site also provides information on publications, presentations, tutorials, meetings, and other activities by AQAST members. News and public resources related to AQAST may be found at http://aqast-media.org.

AQAST can already chalk up many important successes. For example, it provided North American background ozone estimates for the U.S. Environmental Protection Agency's (EPA) Integrated Science Assessment (ISA) toward revision of the ozone National Ambient Air Quality Standard (NAAQS). It partnered with the U.S. National Park Service to quantify and attribute nitrogen deposition to national parks. It developed a user-friendly tool (GLIMPSE) to quantify the climate applications of different air quality management options. On a local level, AQAST provided nowcast support to track and characterize the plume from a major landfill fire in Iowa in 2012, it analyzed the air quality implications of the forest fires in Colorado in 2012, and it supported the first designation of an exceptional ozone event in Wyoming as due to stratospheric influence. All these activities were done in cooperation with state and local agencies. AQAST is also involved in outreach to the public including a network of "ozone gardens" to demonstrate the harmful effects of ozone on vegetation.

AQAST members.
From left to right, top to bottom: Russ Dickerson (U. Maryland), Arlene Fiore (Columbia), Greg Carmichael (U. Iowa), Daniel Jacob (Harvard), Dan Cohan (Rice), Daven Henze (U. Colorado), David Edwards (NCAR), Dick McNider (U. Alabama), Jack Fishman (Saint Louis U.), Tracey Holloway (U. Wisconsin), Edward Hyer (Naval Research Lab), Yang Liu (Emory), Pius Lee (NOAA), Brad Pierce (NOAA), Ted Russell (Georgia Tech), David Streets (Argonne), Jim Szykman (EPA), Anne Thompson (NASA), Bryan Duncan (NASA). Learn more about members' areas of expertise and get contact information at www.aqast-media.org/#!expert-contacts/cfvg.

AQAST holds twice-yearly meetings in various parts of the country to connect with the air quality management community. These meetings are open to all and air quality managers are particularly encouraged to attend. Our last meeting at Rice University in January 2014 drew more than 100 air quality managers and research/applications partners. At this writing, our next meeting will be at Harvard University in June 2014, and the following one is tentatively scheduled for December 2014 in Atlanta.

We hope that this issue of *EM* will make you want to learn more about AQAST and how it can help address your air quality management issues. Do not hesitate to contact us! We aim to be of service and look forward to hearing from you. **em**

AQAST meeting at the University of Maryland, June 9-11, 2013.
Participating air quality managers included members of state agencies (Maryland, Virginia, Delaware, Connecticut, North Carolina, New Jersey), regional agencies (NESCAUM, MARAMA), and national agencies (EPA, NOAA). Presentations from the meeting are posted at http://aqast.org/meetings/2013_jun.

Monitoring $PM_{2.5}$ from Past, Present,

by Yang Liu

Yang Liu is an assistant professor of environmental health in the Rollins School of Public Health at Emory University, Atlanta, GA. E-mail: yang.liu@emory.edu.

Applying satellite remote sensing data in $PM_{2.5}$ exposure assessment and health effects research.

Environmental epidemiologic studies worldwide have established a robust association between exposure to ambient fine particulate matter ($PM_{2.5}$, i.e., airborne particles with an aerodynamic diameter less than or equal to 2.5 µm) and adverse health outcomes, including respiratory and cardiovascular morbidity and mortality.[1] Exposure to ambient $PM_{2.5}$ was recently estimated to be the eighth leading factor of the global burden of disease, contributing 3.2 million premature deaths worldwide in 2010.[2] In addition, the health effects associated with $PM_{2.5}$ exposure have shown no apparent threshold at lower concentrations as they are being detected at typical $PM_{2.5}$ levels in developed countries such as the United States and Canada.[3] On October 17, 2013, the International Agency for Research on Cancer

Space for Health and Future Directions

(IARC) of the World Health Organization announced that it has classified outdoor air pollution and separately particulate matter (PM), as carcinogenic to humans (Group 1).[4]

Since 1997, $PM_{2.5}$ has been one of the six air pollutants in the United States regulated under the National Ambient Air Quality Standards (NAAQS). Most studies of the associations between $PM_{2.5}$ and health have relied on ground measurements from regulatory monitoring networks, such as the U.S. Environmental Protection Agency's (EPA) Air Quality System to estimate exposure to $PM_{2.5}$. Although ground measurements are considered the most accurate, this approach has two major weaknesses.

First, these monitors are sparsely and unevenly distributed in space. The United States has the most extensive monitoring network in the world, but its approximately 1,200 stations are located in only 30% of the 3,100 counties in the continental United States. For some pollutants and some counties, this coverage is adequate to represent human exposure. Health effects researchers may assign people living within 20–40 km of a $PM_{2.5}$ monitor the same exposure level, even though emissions from traffic and industrial sources can cause substantial heterogeneity in $PM_{2.5}$ levels at finer scales.[5,6] Ignoring within-city contrasts may underestimate the effect of $PM_{2.5}$ exposure on the health outcomes.[7,8]

Second, the limited coverage of ground monitors restricts epidemiological studies to areas near monitoring sites; approximately 30% of the U.S. population lives in suburban and rural counties without any coverage. The composition of rural $PM_{2.5}$ tends to differ from urban $PM_{2.5}$ due to different emission source profiles.[9,10] Compared to ground monitors, a major advantage of satellite data is its broad spatial coverage.

Satellite Aerosol Optical Depth and $PM_{2.5}$

Although satellite remote sensing has been used to track particle air pollution events since the 1970s,[11] most quantitative studies of atmospheric particles began after the launch of NASA's Terra satellite in December 1999. The most robust parameter that current passive aerosol sensors such as the Moderate Resolution Imaging Spectro Radiometer (MODIS), the Multiangle Imaging Spectro Radiometer (MISR), and the Visible Infrared Imaging Radiometer Suite (VIIRS) can readily retrieve is aerosol optical depth (AOD).

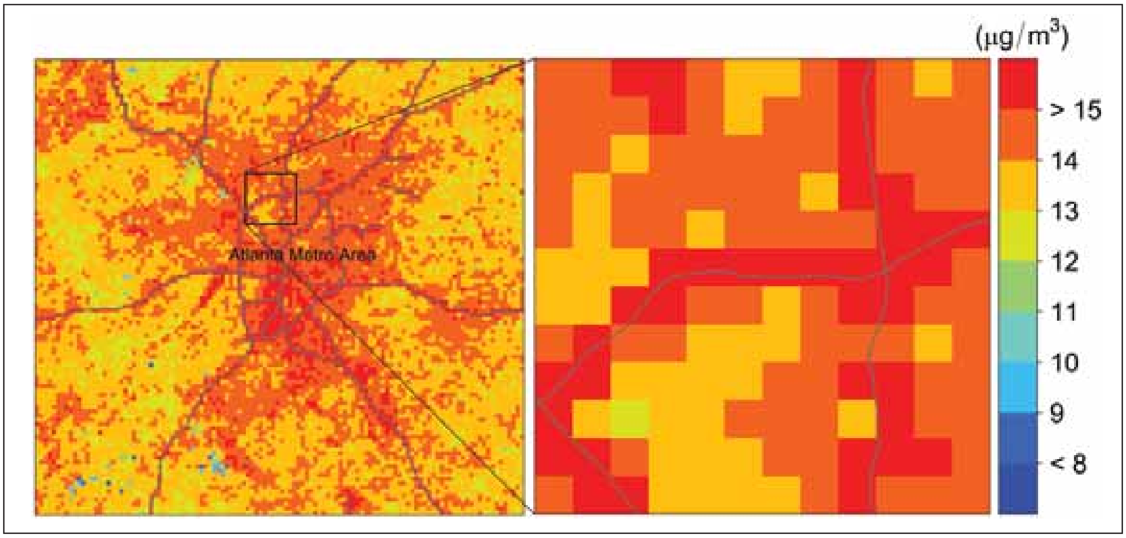
AOD is defined as the integral of aerosol extinction coefficients along the entire vertical atmospheric column. As an optical measure of particle abundance, its relationship with ground-level $PM_{2.5}$, assuming a well-mixed boundary layer and no pollution layers aloft, can be expressed as follows[12]

$$PM_{2.5} = \frac{4\rho r_{eff}}{3f(RH)\times Q_{ext,dry}} \times \frac{f_{PBL}}{H_{PBL}} \times AOD = \frac{f_{PBL}}{H_{PBL}} \times \frac{1}{S} \times AOD \quad (1)$$

Where *r* is particle density (g/m^{-3}); r_{eff} is particle effective radius; *f(RH)* is the ratio of ambient and dry extinction coefficients; $Q_{ext,dry}$ is particle extinction efficiency; f_{PBL} is the AOD fraction in the boundary layer; H_{PBL} is the boundary layer height; and *S* is particle specific extinction efficiency (m^2/g^{-1}) at ambient relative humidity (RH).

Equation 1 clearly shows that the $PM_{2.5}$–AOD relationship is a function of particle size distribution, composition, and vertical distribution. Since measurement of these properties is rare, directly applying Equation 1 to estimate $PM_{2.5}$ concentrations using satellite AOD is difficult. Over the past decade, two approaches have been developed to alleviate the data scarcity issue.

Figure 1. Left: MAIAC estimated annual mean $PM_{2.5}$ levels at 1 km resolution in Georgia, USA, 2003. Right: $PM_{2.5}$ gradient in the 10x10 km^2 box in the left panel.



The first (called the statistical model hereinafter) involves the development of empirical statistical models to estimate $PM_{2.5}$ concentrations with AOD as the primary predictor. Early studies often employed linear correlation and univariate regression as primary analytical tools.[13-15] Soon meteorological and land-use parameters were introduced into the models as covariates to account for changing particle optical and chemical properties.[16,17] For example, the following regression model was proposed to estimate daily $PM_{2.5}$ concentrations in the eastern United States:[16]

$$\ln(PM_{2.5}) = \beta_0 + \beta_1 \times season + \beta_2 \times region + \beta_3 \times distance\_to\_coast + \beta_4 \times site + \beta_{RH} \times RH + \beta_{PBL} \times H_{PBL} + \beta_{AOD} \times AOD \quad (2)$$

Where *region* is defined as a three-level categorical variable (New England, Mid-Atlantic, and South-Atlantic); *site* is defined as a three-level categorical variable (rural, suburban, and urban); and *distance_to_coast* is defined as a dichotomous variable (≤100km and >100km).

The second approach (called the scaling model hereinafter) relies on atmospheric chemistry models to simulate $\frac{f_{PBL}}{H_{PBL}} \times \frac{1}{S}$ in order to establish the association between AOD and $PM_{2.5}$ using the following equation:[18,19]

$$PM_{2.5} = \frac{Simulated\ PM_{2.5}}{Simulated\ AOD} \times Satellite\ AOD \quad (3)$$

Where an atmospheric chemical transport model (CTM) provides simulated $PM_{2.5}$ concentrations and AOD in each modeling grid cell.

The development of these two approaches up to 2009 was summarized in the 39th Annual A&WMA Critical Review by Hoff and Christopher.[20] Since then, more sophisticated statistical models with non-linear or multi-level structures have been developed to allow the $PM_{2.5}$–AOD relationship to take a non-linear form and to vary in space and time.[21-24] In the meantime, satellite-retrieved land-surface properties and other information have been considered in the scaling model to restrict modeling areas to where satellite AOD and CTM simulations are of sufficiently high quality.[19]

Applications of the Two Approaches

Two factors determine that the statistical models generally have greater prediction accuracy when compared with the scaling model. First and most important, ground $PM_{2.5}$ measurements are used to calibrate the model, which ensures model predictions to have little overall bias. Second, statistical models include land use and meteorological data as covariates and their more flexible structure effectively reduces the impact of the measurement errors in AOD and other variables on model predictions. However, the requirement of extensive ground data support hinders their applications outside only a handful of developed countries. As a result, the primary goal of these models is to provide accurate daily to annual average $PM_{2.5}$ concentration estimates to fill the data gaps left by central monitors.

For example, Figure 1 shows satellite-estimated annual mean $PM_{2.5}$ concentration surface in Georgia using a two-stage spatial statistical model with the

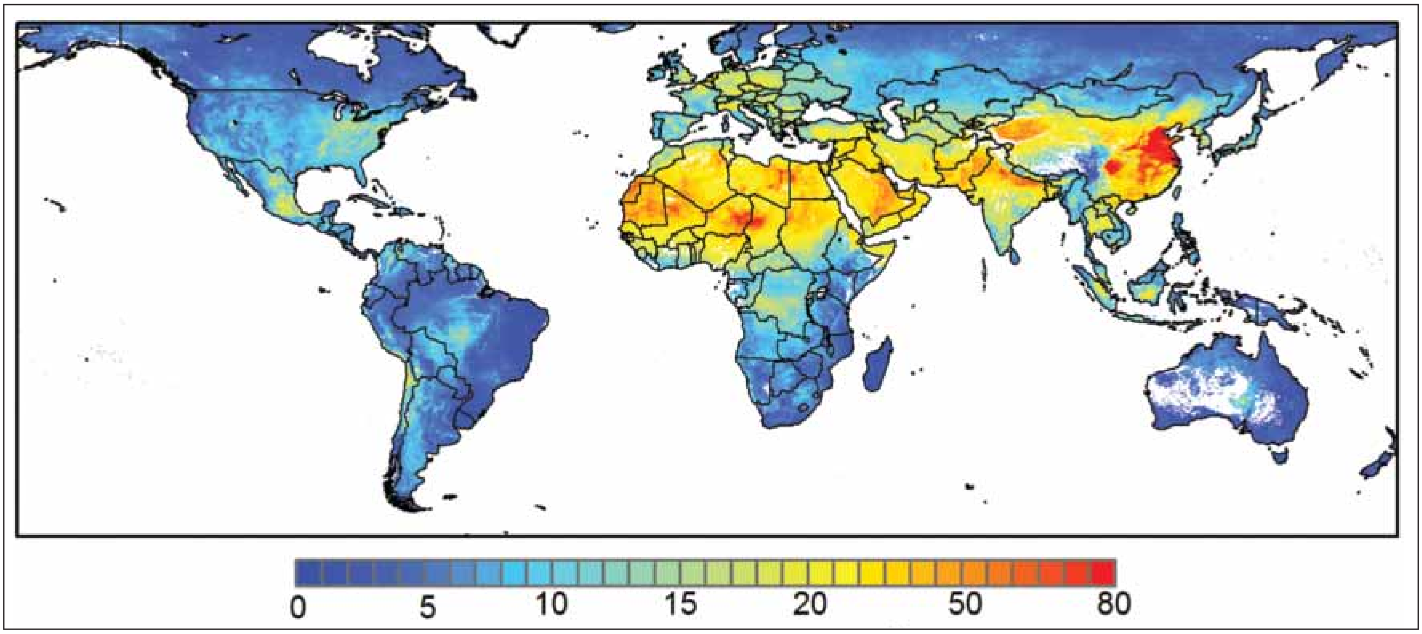


Figure 2. Global satellite-derived mean $PM_{2.5}$ concentrations averaged over 2001–2006.

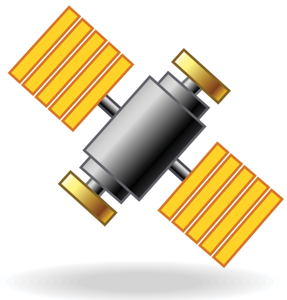
Multiangle Implementation of Atmospheric Correction (MAIAC) AOD data.[25] This model has a model fitting R^2 of 0.83 and mean fitting error of 1.9 μg/m³ for daily $PM_{2.5}$ concentration. The detailed spatial texture of the predicted $PM_{2.5}$ surface at 1 km resolution would be of great value to regional air pollution epidemiological studies that have been historically limited to the proximity of central monitors.

The scaling model provides a more straightforward physical basis for relating satellite AOD measurements to the spatial and temporal pattern of surface $PM_{2.5}$ concentrations. Because satellite AOD and CTM results are generally available globally, $PM_{2.5}$ concentrations can be predicted in regions without any ground measurements. For example, Figure 2 shows the global distribution of mean $PM_{2.5}$ concentrations at 10 km spatial resolution averaged between 2001 and 2006.[19] The correlation coefficient over the United States between satellite-estimated long-term average $PM_{2.5}$ concentrations and ground measurements is 0.77. It provides the much-needed coverage over the developing countries with heavy air pollution and sparse or no routine air quality monitoring. However, this great advantage over the statistical models comes at a cost.

Without the calibration of ground $PM_{2.5}$ measurements, the scaling model tends to have higher prediction errors than those from the statistical models. In addition, not being able to include a model intercept partially limits its ability to account for the errors in AOD retrievals and CTM simulations that vary in space and time. Another potential issue is that Equation 3 does not readily produce error statistics (e.g., a 95% confidence interval for predicted $PM_{2.5}$ concentrations), although such information has not yet been widely used in epidemiological studies.

The gap-filling ability of both the statistical and scaling models frees air pollution health effect studies from being limited to areas covered by ground monitoring networks. In the United States, suburban and rural populations, which have been historically underrepresented, have been included in studies linking exposure to $PM_{2.5}$ and acute myocardial infarction and adverse birth outcomes.[26,27] The 2010 Global Burden of Disease project combined satellite data, global chemical transport models, and ground observations to estimate worldwide long-term exposure to ambient $PM_{2.5}$.[28]

To date, a handful of studies have examined the associations between satellite-predicted $PM_{2.5}$ and health outcomes. For example, Madrigano et al. (2013) examined the association between MODIS-based long-term area exposure to $PM_{2.5}$ and acute myocardial infarction (AMI) in Worcester, MA, and reported that an interquartile range (IQR) increase in area $PM_{2.5}$ (0.59 μg/m³) was associated with a 16% increase in the odds of AMI.[26] Crouse et al. (2012) investigated the association between satellite-based long-term exposure to ambient $PM_{2.5}$ and



cardiovascular mortality in a cohort of 2.1 million Canadian adults, and found similar results between satellite-derived estimates and ground-based measurements.[29] Studies of $PM_{2.5}$ acute health effects using satellite data have not been reported yet.

Prospectives for the Future

Monitoring particle pollution from space is still in its infancy. As the abilities of satellite aerosol sensors and CTMs improve with time, we will likely see both modeling approaches generate more accurate $PM_{2.5}$ estimates to significantly advance our understanding of the impact of ambient $PM_{2.5}$ on population health at urban to global scale.

Monitoring particle pollution from space is still in its infancy.

Nonetheless, a few challenges remain. Missing AOD values due to clouds and bright surfaces cause on average 40–50% data loss, which affects the prediction coverage of both approaches. Further research is needed to evaluate the impact that this non-random lack of data may have on satellite-based health effect studies, and to develop methods to fill the data gaps left by clouds. In addition, most current models were developed and evaluated in developed countries with low to moderate $PM_{2.5}$ levels. Model performance in heavily polluted regions including megacities in developing countries as well as rural areas with severe biomass burning activities must be carefully examined. **em**

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A Clearer View of Tomorrow's Haze
Improvements in Air Quality Forecasting

A look at current approaches to air quality forecasting, as well as capabilities of air quality forecasting systems, enabling technologies, and future directions.

By Yongtao Hu, M. Talat Odman, Pius Lee, Daniel Tong, Scott Spak, and Armistead G. Russell

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While most of us are quite used to seeing, and relying upon, detailed weather forecasts many days in advance, people who are sensitive to air pollution (e.g., asthmatics) and air quality managers likewise plan their activities depending on air quality forecasts. As with weather forecasts, the accuracy of air quality forecasts is important, as is how far in advance they can be supplied. If you are sensitive to air pollution, you may not want to plan an activity that will be curtailed (perhaps catastrophically so) due to unexpectedly poor air quality. Further, air quality managers rely on forecasts to potentially

The clearer picture satellite data provide makes it much more feasible to accurately forecast future air quality.

reduce emissions (e.g., "Spare the Air" alerts, http://sparetheair.org/) or alert the public to potentially harmful air quality, but they do not want to take potentially costly actions unnecessarily.

In response to the increasing demand, air quality forecasts are available, both from local agencies as well as nationally in many countries, and their accuracy and abilities are improving. Most recent forecasting systems have concentrated on forecasting either ozone (O_3) or particulate matter (PM, including $PM_{2.5}$, which is PM whose particles are less than 2.5 µm in diameter), criteria pollutants of widespread concern, though air quality forecasting systems have been developed for other pollutants. Advancing technologies are allowing forecasters to provide more accurate estimates of air quality days in advance. Of particular interest is the integrated use of advanced air quality models and satellite observations to provide air quality information and forecasts where the lack of ground-based observations hindered past efforts. The much clearer picture that satellite data provide about pollution (both pollutant concentrations and emissions) "right now" makes it much more feasible to accurately forecast future air quality.

Air Quality Forecasts

Probably the most widely known and utilized forecasts are those given by AIRNow (http://www.airnow.gov). AIRNow reports local forecasts made in about 300 U.S. cities. How the individual city AIRNow forecasts are done, and who does them, can differ, relying on trained forecasters with local expertise who can use a wide variety of methods, as described below. One of the primary pieces of information available to the local experts is the NOAA National Air Quality Forecasting Capability (NAQFC) forecasts for the continental United States,[1] which can be supplemented by other forecast methods and expert assessment. NAQFC forecasts are derived from an air quality modeling system similar to those used to develop state implementation plans,

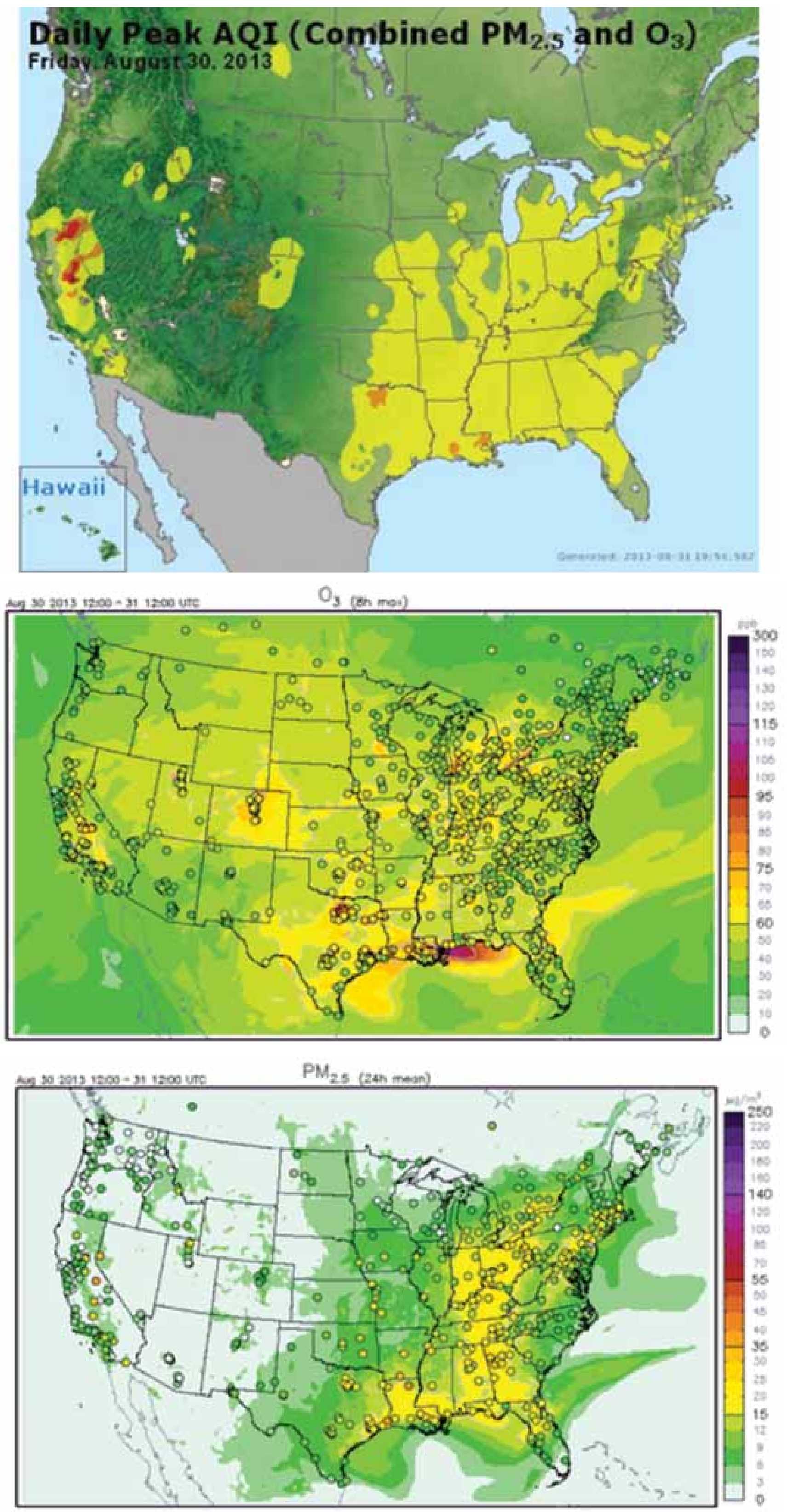

Figure 1. NAQFC and AIRNow Forecasts for August 30, 2013. (a) AIRNow AQI; (b) NAQFC O_3; and (c) NAQFC PM.
Forecast O_3 and PM concentrations are converted to the color scale associated with the health-informative AQI: (0–50 green; 51–100 yellow; 101–150 orange; and 151-200 red).
The color-coded circles in the NAQFC forecast maps show the corresponding monitored values inserted afterward for evaluation purposes.

except that they are operated in a forecast mode (see Figure 1). As discussed below, the NAQFC, like many advanced systems, is benefiting from improving computational resources and greater and more rapid data availability, particularly from space.

Methods

Air quality forecasting can be based on empirical/statistical or air quality model-based (or simply "model-based") methods, or combinations of more than one method (ensembles). Empirical methods are based upon finding relationships (typically historical) between air quality and other factors relevant to the forecast location. Model-based methods use meteorological and air quality models.

Empirical

Empirical (or statistical) models are based upon past trends. They range in complexity from persistence to multivariate methods (including cluster analysis, classification and regression tree, regression and neural networks).[2] Persistence simply says that the tomorrow's air quality is the same as today's. Regression analysis is based on deriving an equation relating tomorrow's O_3 or PM to the current concentration, as well as other variables, such as forecast meteorology.[3] One of their main advantages is, once constructed, they are readily applied with low computational expense.

Model-Based

Air quality models are taking a growing role in air quality forecasting. Like their meteorological model cousins, their capabilities are growing as they become more comprehensive with greater fidelity to atmospheric processes, and as the rapid increase in computational resources enables them to improve their resolution and their ability to forecast further in to the future. Air quality model-based systems generally use forecast meteorology and historic emission estimates to provide forecasts. Such systems are based on dispersion models (like AERMOD[4]) for local forecasts of primary pollutants (e.g., soot from fires) and chemical transport models (CTMs) such as the Community Multiscale Air Quality (CMAQ) model[5] for regional forecasts of chemically-reacting pollutants such as O_3 and PM.

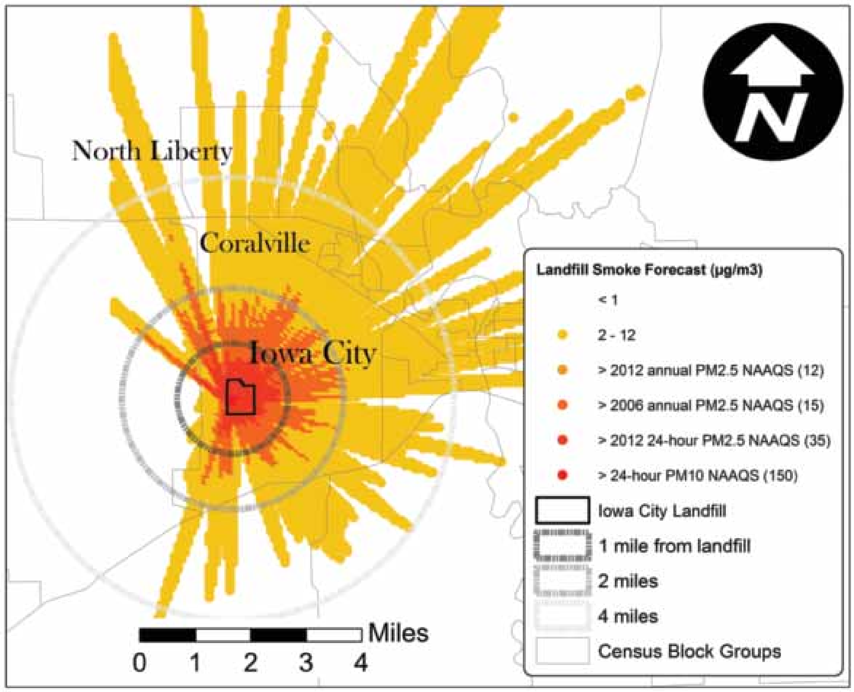

Figure 2. Iowa City Landfill Fire Air Quality Forecasting System.
The system is based on AERMOD, improvised to predict local impacts of the 2012 Iowa City Landfill fire at 100 m resolution over the Iowa City/Coralville metropolitan area. Plume color-coded by NAAQS for particulates exceeded due to the fire during the two-week event: none (yellow), annual $PM_{2.5}$ (orange), 24-hr $PM_{2.5}$ (red), and 24-hr PM_{10} (dark red). Grey concentric circles indicate 1-, 2-, and 4-mile buffers from the fire.

The NOAA NAQFC provides what is probably the most widely utilized CTM-based forecast in the United States. This system takes advantage of using the U.S. National Weather Service meteorological predictions[6] as input to CMAQ. Europe employs the European Centre for Medium-Range Weather Forecasts (ECMWF) weather forecasting model to drive their Copernicus forecasting system, using a global model to provide boundary conditions to regional models.[7] Other air quality model-based forecasting systems include the "Hi-Res" system (using CMAQ down to a 4-km horizontal resolution over the Southeast United States),[8] Airpact (4-km resolution for the Northwest United States; http://lar.wsu.edu/airpact), and the BAMS MAQSIP-RT system.[9] While these forecasting systems largely began by providing O_3 forecasts, there is a growing trend toward providing $PM_{2.5}$ forecasts as well.

A major advantage of model-based systems is that they provide predicted air quality over the complete domain and map out where pollutant hotspots will likely occur. This is important when conducting field experiments to plan when and where to sample (e.g., when planning aircraft sampling to capture plumes from cities and major sources).[10,11] Model-based forecasts are also used for cases where there are insufficient historical data to develop an accurate empirical system (e.g., when forecasting the impacts of fires, either planned or unplanned.)[12] Such forecasting systems can be developed rapidly in response to emergency situations. In 2012, when the Iowa City landfill caught fire with the liner of 1.5 millions shredded tires generating a thick toxic plume that raised immediate health concerns, a forecasting system was rapidly applied to forecast the plume impacts (see Figure 2), using AERMOD dispersion modeling driven by a weather forecast model and assimilated MODIS cloud properties.

Ensemble

Most of us are quite used to seeing forecasts of hurricane paths where different tracks calculated by different models are shown. The calculated tracks diverge with time, providing an "ensemble" estimate of the path, with a range of possibilities, plus a best estimate. The ensemble is not just a regular average because modelers know from experience some models do better than others. The same is done in air quality forecasting (and for weather forecasts as well). Results from multiple models are combined, with increased weight given to approaches that are found to be most accurate for that type of event (i.e., one method might be better for high pollutant days, another for low pollutant days). For example, the GSFC/PSU-ERM (Ensemble Research Model) uses forecast parameters that are sampled, combined and "trained" by using observations in near-real time.[11] The ECMWF-Copernicus system uses an ensemble of seven regional CTMs.[7]

Expert

Any one, or more, of the methods discussed above can be used to inform one or more experts that then provide a forecast based on the information provided, but adding human interpretation (often based upon years of involvement and knowledge of pollutant dynamics in a specific location, as well as knowledge of the strengths and weakness of other forecasting methods). As an example, the PM and O_3 forecasts developed for cities in Georgia by the Georgia Environmental Protection Division (EPD) use an expert panel approach. This effort began in 1996 for the Atlanta Olympics, and involved a model-based system and empirical methods to inform an expert team that links together on a daily basis to develop a final forecast by consensus.[8]

Forecast System Performance

The utility of air quality forecasts is highly dependent upon their accuracy. For the typical systems designed to provide routine O_3, and more recently $PM_{2.5}$, forecasts, the results are solid, showing that while there are still improvements to be made, reasonably accurate information can be provided to air quality planners and the public. The Hi-Res system[7] provides both PM and O_3 forecasts,

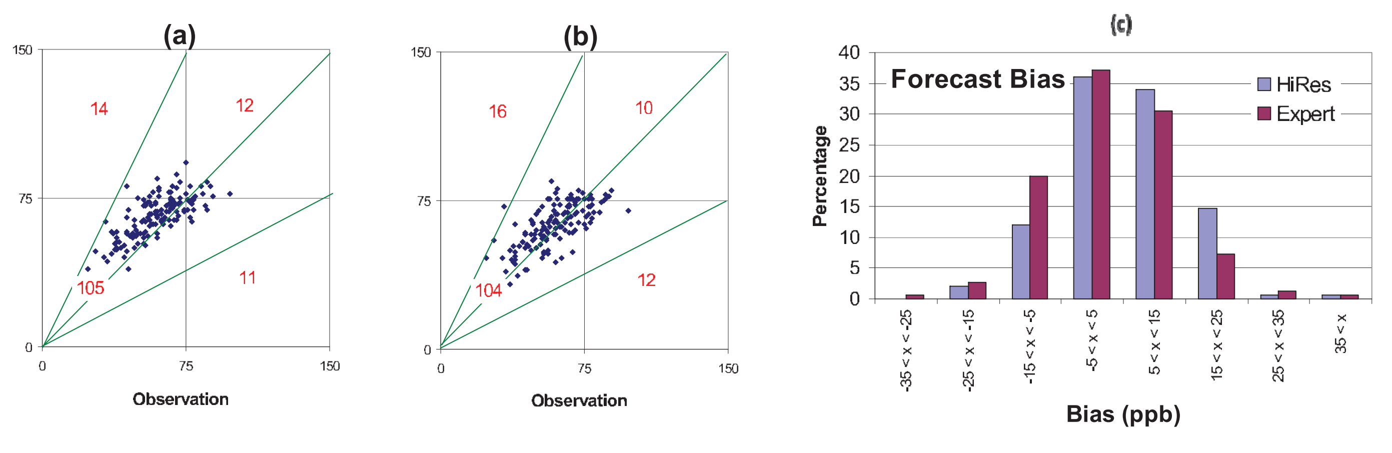

Figure 3. Performance of Model and Expert Consensus Approaches.
(a) HiRes modeled daily maximum 8-hr O_3 forecasts for the 2010 summer season compared to the (b) EPD expert analysis consensus. The (c) forecast bias frequency plots for the HiRes and expert systems show similar distributions. The mean normalized bias (MNB) and mean normalized error (MNE) for the model forecast were 14% and 18%, respectively, compared to 9% and 17% for the consensus. Modeling guidelines suggest that having an MNB and MNE of 20% and 35% are sufficient when simulating past periods, showing the forecasts now meet guidelines for conducting historic simulations.

and is a primary component of the Georgia EPD expert-analysis based forecast. The performance of the Hi-Res O_3 forecast and the expert team consensus are close (see Figure 3).

Looking Forward

While forecasting systems already provide credible forecasts days in advance, their ability to make accurate extended range forecasts is being enhanced by the NASA Air Quality Applied Sciences Team (AQAST) addressing current weaknesses. One key to making an accurate forecast, be it for tomorrow or three days from now, is having an accurate representation of today's air quality, not only locally, but wherever the air masses come from. However, it is unlikely that there are monitors at those locations (most air masses come from layers well above the surface where monitors don't exist at all). AQAST teams have demonstrated the use of satellite data to provide better spatial and temporal information to improve forecast accuracy. The ECMWF system uses satellite observations in the global model.

Another step forward addresses a second weakness: current model-based forecast systems use historic emissions inventories that are not fully up to date nor capture shorter term emission trends. Using ground- and satellite-based measurements, it is possible to dynamically update emission inventories using chemical data assimilation.[13] This can be particularly important for sources that can vary dramatically, such as biogenic emissions, biomass burning (e.g., wildfires, prescribed burns and home heating), and dust.

Forecast energy demand can also be used to forecast related emissions,[14] which can be particularly important when peaking units, that have higher emissions, are used on hot summer days. The ability to forecast how specific sources (say, cars or a specific facility) will impact O_3 and PM nationally is being explored to help target controls. Improving forecast accuracy and increased forecast system capabilities will become even more important if air quality standards are tightened as more areas will seek to use this information to more effectively improve air quality. **em**

AKNOWLEDGMENT
The research described in this article was made possible, in part, by funding from the U.S. National Aeronautics and Space Administration and the Georgia Department of Natural Resources. Any opinions expressed are those of the authors and not the funding agencies.

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Using Satellite Observations to Measure

by David G. Streets, Benjamin de Foy, Bryan N. Duncan, Lok N. Lamsal, Can Li, and Zifeng Lu

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How accurately can the emissions from a coal-fired power plant be measured from space? Might it one day be possible for a satellite to determine whether a plant is in compliance with emission regulations? This article reviews the current capability of space-borne instruments to detect and quantify power plant emissions and comments on the possibility of enhanced capability in the next five to ten years.

On July 15, 2004, NASA launched the Aura satellite from Vandenberg Air Force Base. It assumed a sun-synchronous orbit at a height of 438 miles with daily global coverage at an equator crossing time of 1:45 p.m. local time. Aura carried a variety of instruments, and one of the most successful of them has been the Ozone Monitoring Instrument (OMI), developed by a Dutch/Finnish team. OMI is an ultraviolet/visible spectrometer that measures the solar radiation backscattered from Earth in the spectral range of 270–500 nm.[1] Trace gases absorb some of this radiation at characteristic wavelengths, and the amount of the absorption can be related to the concentration of the trace gas in the column of air through which the radiation passes. The principal gases that can be detected by OMI are ozone (O_3), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and formaldehyde (HCHO). We should stress that

Power Plant Emissions and Their Trends

OMI is not the only satellite-borne instrument with these features; three other instruments, GOME-1[2] on the European ERS-2 satellite (1995–2003), GOME-2[3] on the European METOP-A satellite (2006–present), and SCIAMACHY[4] on the European ENVISAT (2002–2012), have or have had similar capability; however, what follows in this article focuses on OMI retrievals between 2005 and 2011.

Processing of the raw instrument measurements is a complex procedure involving, among other things, fitting to a reference spectrum, conversion from slant column density to vertical column density, partitioning of stratospheric and tropospheric components, and adjustments for surface reflectivity, surface topography, and the presence of clouds. At the end of this sequence of adjustments, an estimate of the number of molecules in a column of air above Earth's surface is obtained. OMI has high spatial resolution with a footprint of up to 13 km (along track) x 24 km (across track). It is easy to see, therefore, that if the column of air is centered over an isolated point source of emissions, the OMI signal will be representative of all the molecules within an area of 13 km x 24 km around the source. If there are no other significant emissions in that area, if no molecules enter the area from outside, and if chemical conversion within the area is

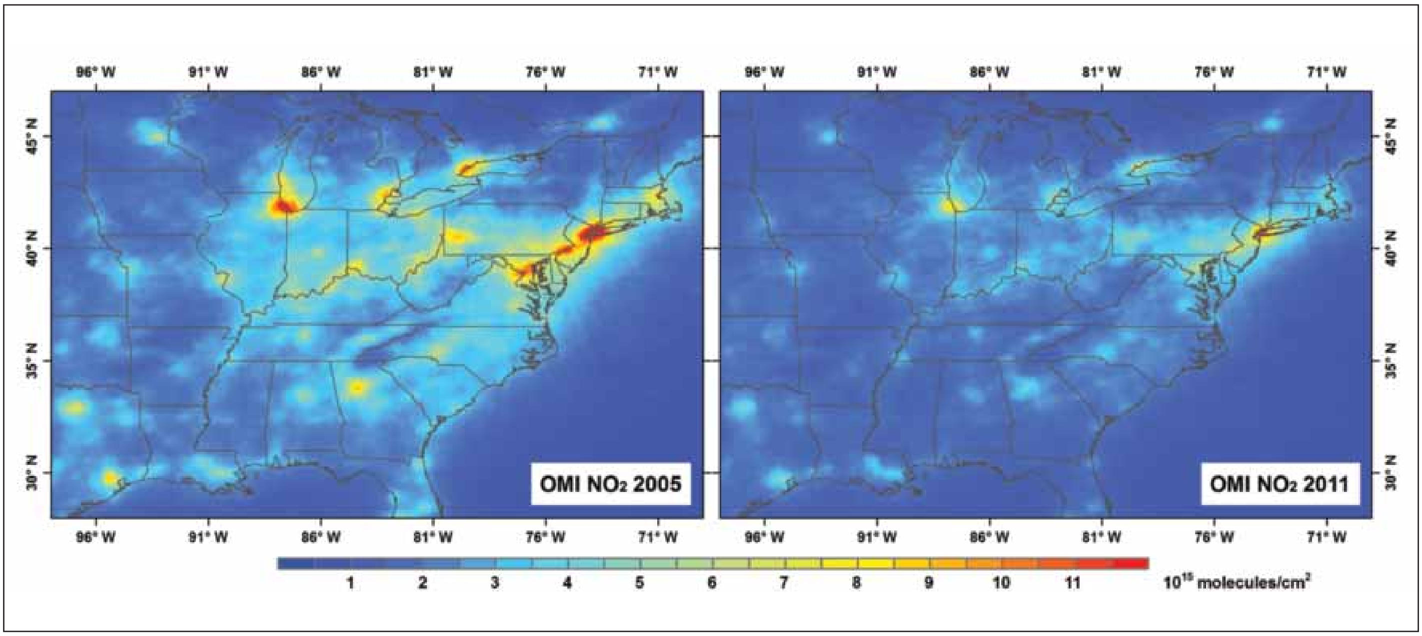

Figure 1. Annual average OMI NO_2 column density ($\times 10^{15}$ molecules cm^2) for the eastern United States for 2005 (left) and 2011 (right), showing emission reductions achieved by tighter emission standards.

minimal, then the OMI signal ought to be closely related to the emissions of the point source. Hence, we can see the potential usefulness of satellite observations in estimating emissions.[5]

NO_2 Emissions Data

By far the strongest absorption by emitted pollutant species is that caused by NO_2. For this reason, initial applications of satellite observations to U.S. power plant emissions focused on nitrogen oxides (NO_x) emissions and their trends. Three major studies were published, covering all plants in the eastern United States for the period 1999–2005,[6] 13 isolated power plants in the western United States in 2005,[7] and 23 large plants throughout the country for the period 2005–2011.[8] In these studies, various NO_2 retrievals were compared with modeled NO_2 columns and with NO_x emissions from Continuous Emissions Monitoring Systems (CEMS) stack measurements. Agreement between satellite and ground-level measurements was generally good, and it was possible to demonstrate that plant NO_x emissions had declined over time as plants complied with the requirements of the 1998 NO_x SIP Call and the 2005 Clean Air Interstate Rule (CAIR) by using low-NO_x retrofit technologies. Even more dramatic breakthroughs were possible in China and India,[9-12] where large new power plants with high emission rates had been constructed since the satellite instruments commenced operation—meaning that it was possible to examine the space-based signals with and without the plant operating.

Most recently, 55 of the more remote power plants in the United States, located away from large built-up areas, were studied over the period 2005–2011 by Duncan et al.,[13] who concluded that it is practical to use OMI NO_2 data to assess changes of emissions from power plants that are associated with the implementation of emission control devices (ECDs), though careful interpretation of the data is necessary. They showed that there is a clear response of OMI NO_2 data to NO_x emission reductions from power plants associated with the implementation of ECDs, though this response varied among facilities. They discussed some of the causes of this variability, which include the magnitude of a facility's NO_x emissions, seasonal variation of the NO_x lifetime, proximity to urban areas, changes in regional NO_x levels, lack of statistical significance, and retrieval issues.

The main challenge for estimating emissions from power plants using NO_2 column data over the last decade is that emissions from mobile sources, the primary source of NO_x emissions, have also decreased substantially. Duncan et al.[13] found that OMI data indicated a 30–40% decrease in NO_2 levels for much of the eastern United States, which is slightly larger than the decrease indicated by Air Quality Monitoring System (AQS) surface site data. Consequently, one must account for any trend in NO_2 associated with changes in mobile emissions when estimating emissions from power plants. Figure 1 shows the change in OMI NO_2 columns over the eastern United States from 2005 to 2011. While large decreases in NO_2 levels occurred almost everywhere, some of the largest changes occurred in the Ohio River Valley, where many coal-fired power plants are located.

SO_2 Emissions Data

The other major species related to power plant emissions that can be detected by OMI is SO_2. However, absorption by SO_2 mainly occurs at shorter wavelengths where much stronger ozone absorption exists, and therefore only relatively large SO_2 sources can be seen from space. Early work focused on the largest natural and man-made sources, such as volcanoes[14-16] and metal smelters.[17,18] Because SO_2 emissions from U.S. power plants are relatively low after compliance with the acid rain provisions of the Clean Air Act Amendments of 1999, attention was initially focused on China, where many new power plants have large SO_2 emissions from uncontrolled coal burning. Li et al.[19] showed that it was not only possible to examine newly constructed SO_2-emitting power plants with OMI, but it was also possible to study the compliance progress of plants scheduled to install flue-gas desulfurization (FGD) equipment under government rules between 2005 and 2008.

Figure 2 shows results for four of the power plants in the Inner Mongolia region of China that were studied by Li et al.,[19] but using updated SO_2 and NO_2 retrievals.[20] These plants are relatively far away from other large point sources and urban centers. We show the relative changes in OMI SO_2 and NO_2 retrievals, as well as in SO_2 emissions calculated from coal-use statistics, with and without FGD units, all normalized to the year 2006. The OMI NO_2 trends (green lines) confirm that each plant operated continuously throughout the period and tended to increase its level of operation and NO_x emissions. The blue lines show OMI SO_2 trends. For two plants, Tuoketuo and Huhehaote, the OMI SO_2 trend is in good agreement with calculated SO_2 emissions, confirming the start of FGD operation in 2006, as was required by government regulations. For the other two plants, Shuozhou complied about one year early (2006 instead of 2007), whereas the Datong plant delayed compliance by at least two years (2007 instead of 2005 or earlier). In a country like China, where there are many remote plants only loosely controlled by the Ministry of Environmental Protection, the capability to detect compliance from space is clearly valuable.

Oversampling Technique

A powerful technique to improve the OMI detection limit is called “oversampling,” in which the original OMI data at 13 km x 24 km resolution are resampled at finer resolution (say, 2 km x 2 km) around the source. This reduces noise and enhances weak signals, enabling smaller sources to be studied. The oversampling technique was originally developed for NO_2[21-24] and later adapted for SO_2,[25,26] resulting in the ability to quantify a reduction in SO_2 emissions from power plants in the Ohio River Basin of approximately 40% between 2005/2007 and 2008/2010.[26] With oversampling enhancements, it has been estimated that OMI can detect SO_2 emission sources larger than 70,000 tons/yr,[26] recently lowered to 50,000 tons/yr in India.[20]

Future Work

Despite the demonstrations of good agreement between OMI measurements and ground-level emission estimates, particularly of NO_2, there remain issues to be resolved. The tool is not yet developed to the point where it can be reliably used for regulatory purposes. As discussed above, the many factors influencing the strength of the OMI absorption signal make it difficult to assemble a statistically representative observational dataset indicative of emission strength. More work is needed to develop quantitative relationships and characterize uncertainties.

One of the shortcomings of OMI is that it only yields one observation per day, due to being in sun-synchronous orbit. What would dramatically enhance its utility is if it were in geostationary orbit over North America. After a great deal of support and promotion by the atmospheric science community, there are now considerable prospects for such a capability in the future. Two new NASA satellite missions are on the drawing board that would study tropospheric gases and aerosols from

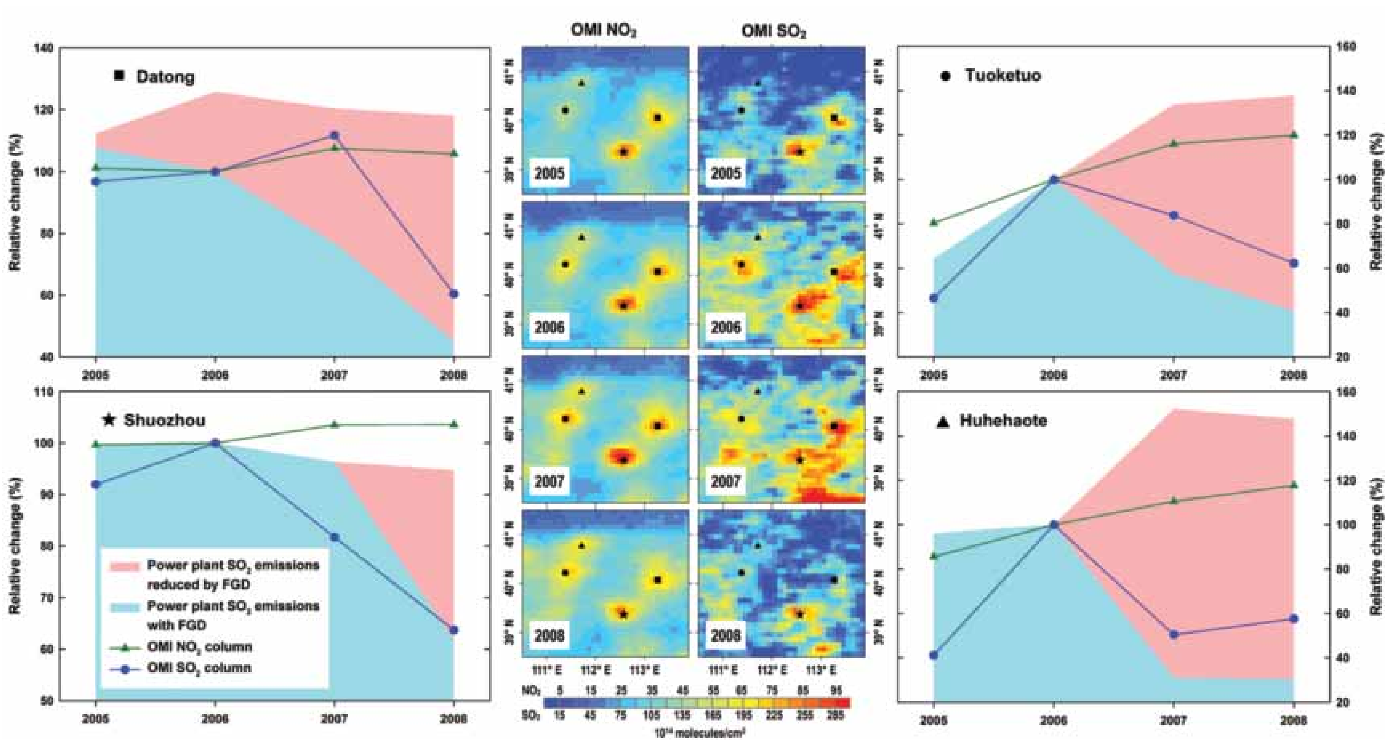

Figure 2. OMI NO_2 and SO_2 columns in the vicinity of four power plants in Inner Mongolia, China (center); and normalized OMI columns and SO_2 emission trends calculated from coal-use statistics with and without FGD (outer) over the period 2005–2008.

geostationary orbit above North America: the Geostationary Coastal and Air Pollution Events (GEO-CAPE) mission[27] and the Tropospheric Emissions: Monitoring of Pollution (TEMPO) mission.[28] Launch dates are likely to be in the 2017–2020 timeframe or even later, depending on funding availability. The great advantage of these satellites is that they would provide continuous, continental-scale mapping of pollutants at something like hourly, 4 km x 4 km resolution. The potential to better characterize point-source emissions would be enhanced dramatically once these instruments begin to return data. **em**

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ACKNOWLEDGMENT
The authors acknowledge funding from the NASA Air Quality Applied Sciences Team (AQAST). They wish to express their gratitude to the present (John Haynes) and former (Lawrence Friedl) NASA program managers and to the AQAST lead, Daniel Jacob. Thanks also to Jesse Allen (Sigma Space Corporation). Argonne National Laboratory is operated by UChicago Argonne, LLC, under Contract No. DE-AC02-06CH11357 with the U.S. Department of Energy.

Detecting and Attributing Episodic High Background Ozone Events

by Arlene M. Fiore, R. Bradley Pierce, Russell R. Dickerson, and Meiyun Lin

A summary of recent work by AQAST members that combines satellite products, in situ measurements, and models to detect and attribute observed episodic high-ozone events to three specific background sources: wildfires, stratospheric intrusions, and Asian pollution.

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The present formulation of the National Ambient Air Quality Standard (NAAQS) for ozone (O_3) considers the fourth highest daily maximum 8-hour average concentration to determine attainment status within specific areas. In order to achieve compliance with the 8-hour O_3 NAAQS, the three-year average of this statistic must not exceed the designated level, currently 75 parts per billion (ppb). The U.S. Clean Air Act Section 319 (b)(3)(B), however, recognizes that events can episodically exceed thresholds for O_3 and other NAAQS due to influences beyond the control of domestic air agencies. Such "exceptional events" can be exempted from counting toward regulatory decisions, such as non-attainment determinations, if air agencies can demonstrate that specific components of background O_3 led to the observed exceedance (see sidebar, "What Are Background Ozone and Exceptional Events?" on page 25). The origin of individual high O_3 events thus needs to be understood and contributions from individual sources quantified. This attribution to specific sources becomes increasingly important as the O_3 NAAQS is tightened (i.e., the threshold lowered), as has been proposed on the basis of health evidence.[1]

Ozone source attribution is confounded by a lack of coincident measurements of related species (e.g., water vapor, carbon monoxide) at sufficient spatial resolution that could enable an unambiguous attribution from observations. Many background events, however, are associated with broad, synoptic-scale features evident from satellite products and resolved in models. Following are examples from recent work by AQAST members that combines satellite products, in situ measurements, and models to detect and attribute observed episodic high O_3 events to three specific background sources: wildfires, stratospheric intrusions, and Asian pollution. While the ground-based and space-based measurements are usually provided on a daily basis, the in situ aircraft and sonde measurements in the examples below are generally not routinely available.

Wildfires

In early July 2002, lightning sparked several fires in central Quebec that consumed approximately 2.5 x 10^9 m^2 of forest. A massive smoke plume, visible from space (see Figure 1) was swept by the meteorological conditions to the heavily populated areas of the U.S. East Coast.[2] Coincident with the arrival of the smoke was an air pollution event in which ambient monitors in Maryland exceeded the O_3 NAAQS. Was the fire to blame?

Fires generate aerosols and O_3 precursor gases such as carbon monoxide (CO) and volatile organic compounds (VOCs), but not necessarily nitrogen oxides (NO_x) needed alongside the VOCs to produce O_3, and thus, do not always lead to substantial O_3 production.[3] Measurements from aircraft (see Figure 2) revealed a peak ozone mixing ratio over Maryland of nearly 160 ppb, more than twice the current 75-ppb ozone NAAQS threshold, coinciding with enhanced fire effluents (aerosols and CO), but not U.S. anthropogenic emissions (e.g., sulfur dioxide).

These in situ measurements, combined with numerical simulation and lidar records, demonstrated that the O_3 pollution layer generated by the fires mixed down to the surface, leading to the observed ground-level O_3 above the NAAQS. A similar approach can be used to identify high fine particulate matter ($PM_{2.5}$) events resulting from wildfires. On the basis of this integrated analysis of in situ measurements, satellite products, and model data, the Maryland Department of the Environment

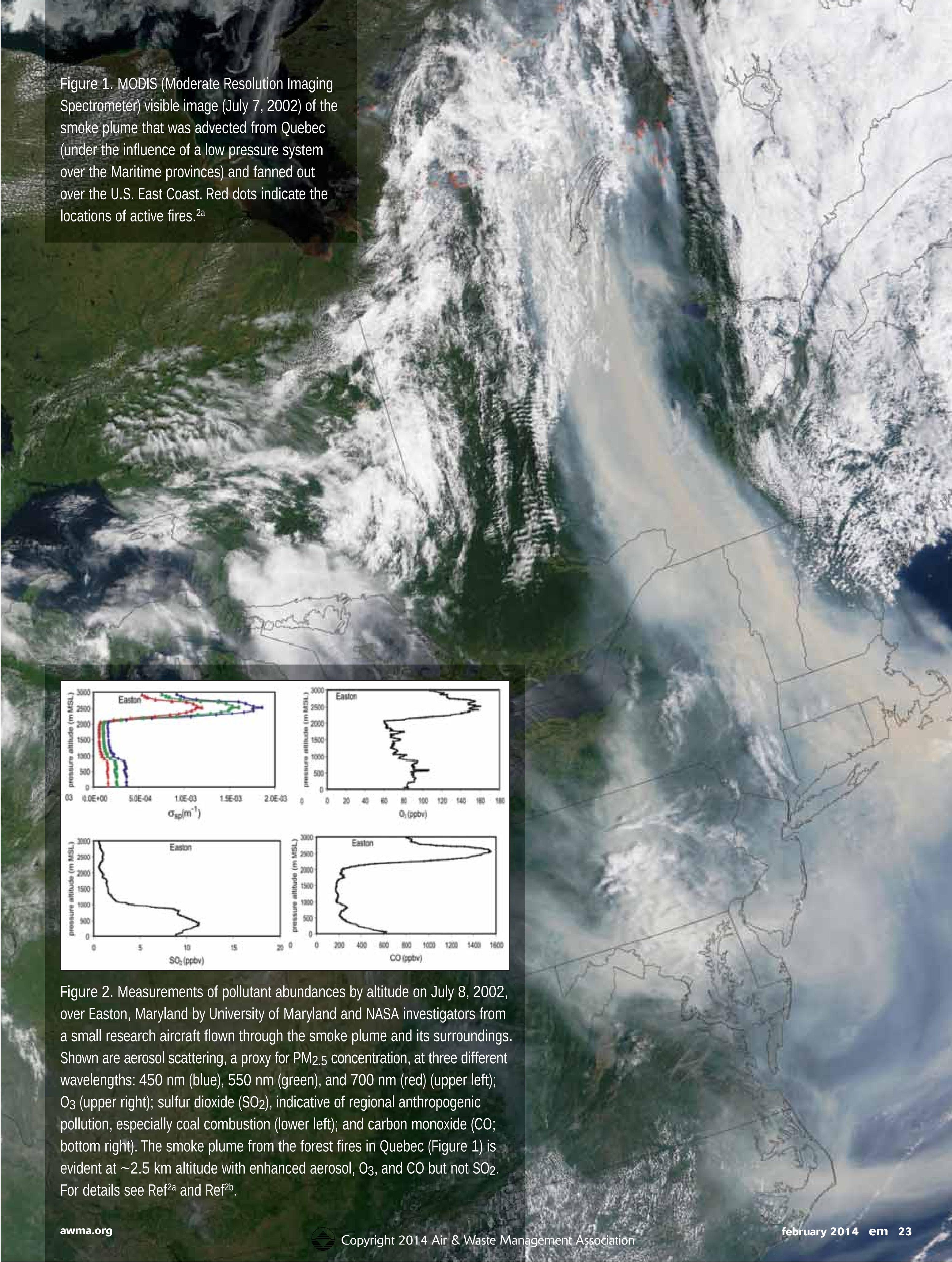


Figure 1. MODIS (Moderate Resolution Imaging Spectrometer) visible image (July 7, 2002) of the smoke plume that was advected from Quebec (under the influence of a low pressure system over the Maritime provinces) and fanned out over the U.S. East Coast. Red dots indicate the locations of active fires.[2a]

Figure 2. Measurements of pollutant abundances by altitude on July 8, 2002, over Easton, Maryland by University of Maryland and NASA investigators from a small research aircraft flown through the smoke plume and its surroundings. Shown are aerosol scattering, a proxy for $PM_{2.5}$ concentration, at three different wavelengths: 450 nm (blue), 550 nm (green), and 700 nm (red) (upper left); O_3 (upper right); sulfur dioxide (SO_2), indicative of regional anthropogenic pollution, especially coal combustion (lower left); and carbon monoxide (CO; bottom right). The smoke plume from the forest fires in Quebec (Figure 1) is evident at ~2.5 km altitude with enhanced aerosol, O_3, and CO but not SO_2. For details see Ref[2a] and Ref[2b].

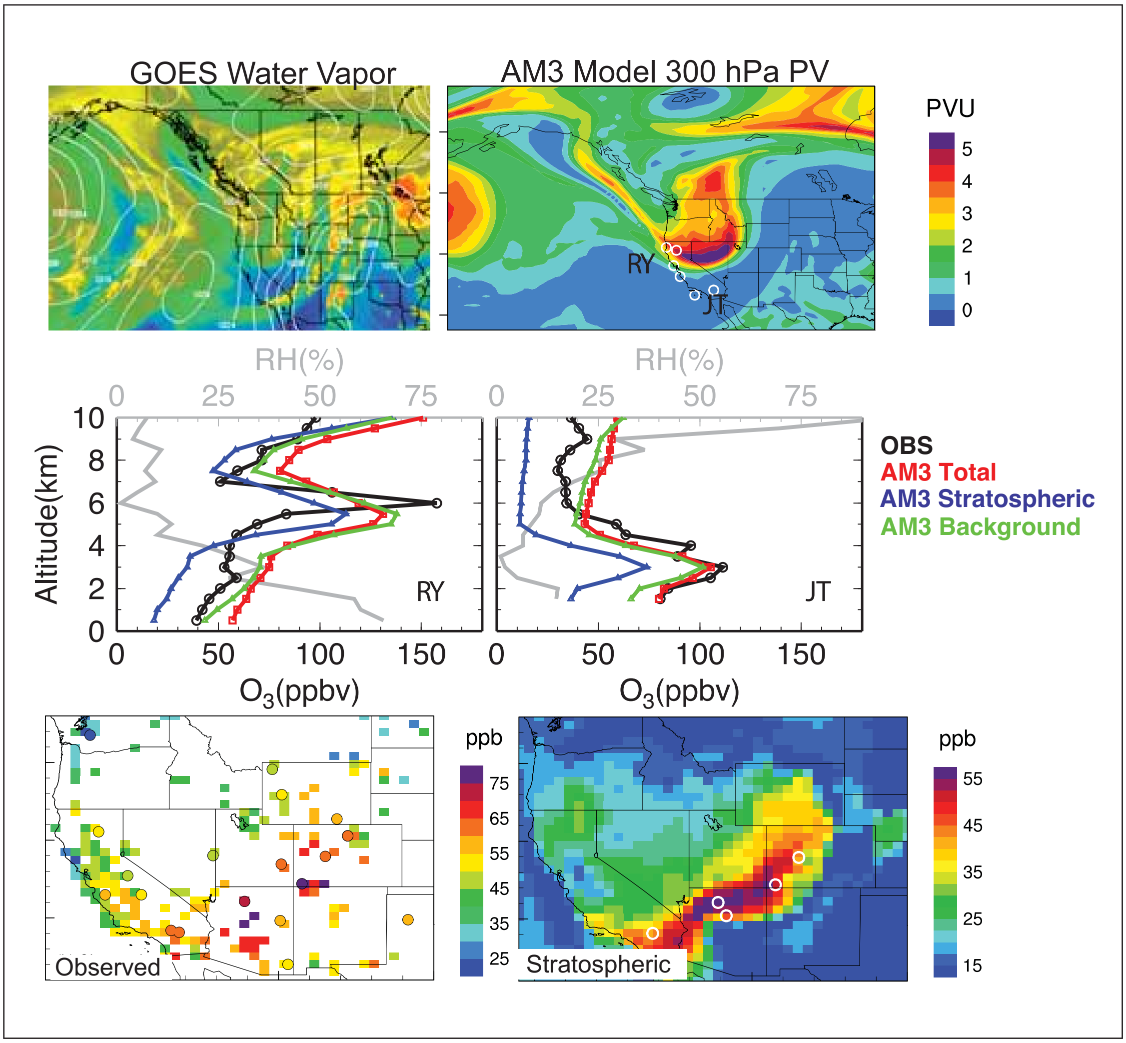


Figure 3. Example of integrating satellite, in situ, and model data to demonstrate the role of a stratospheric intrusion in enhancing surface O_3 over the western United States.

The GOES water vapor images show dry air in the mid-to-upper troposphere (blue colors in upper left; contours show sea level pressure) on May 28, 2010, coincident with a tongue of enhanced potential vorticity (PV), a dynamical marker for stratospheric air, simulated by the AM3 model (upper right). O_3 measured by balloon sondes on May 28, 2010 (black line in middle panels), launched at the locations indicated in the upper right panel, show an enhanced O_3 layer at ~6km in northern California (Point Reyes; RY) and another in the lower troposphere (~3 km) in southern California (Joshua Tree; JT) associated with dry air (grey line, relative humidity). The AM3 model (red line) attributes this high O_3 layer to North American Background (NAB) O_3 (green line), predominantly due to stratospheric influence (blue line; using approach described in Ref[4]). Ground-based monitors record a surface O_3 enhancement on May 29, 2010, extending southwest-northeast over Arizona and Colorado (bottom left) in the same region where the AM3 model simulates elevated stratospheric O_3 levels (bottom right). Adapted from Ref[4].

requested, and the U.S. Environmental Protection Agency (EPA) granted, "exceptional event" status during this episode for both O_3 and $PM_{2.5}$.

Stratospheric Intrusions

Thirteen stratospheric intrusions were found to contribute to raising western U.S. surface O_3 levels during April through June of 2010 (see Table 1).[4] Figure 3 shows one of these events, diagnosed using the GFDL AM3 model[5] and a suite of observations. On May 28, 2010, space-based observations of upper tropospheric water vapor show dry air where the GFDL AM3 model simulates high potential vorticity (PV; a marker for stratospheric air). The model and balloon sonde measurements show layers with enhanced O_3 descending in altitude southward along the coast of California. These enhancements are attributed by the model to stratospheric influence, consistent with measured dry air (low relative humidity).

A model simulation of North American Background (NAB) O_3 (see sidebar) indicates that the observed enhancements are not mainly associated with domestic O_3 pollution. The following day (May 29, 2010), the model indicates a surface influence from stratospheric O_3 coincident with observed regional surface O_3 enhancements. In light of events such as those demonstrated in Figure 3, EPA recently formed a stratospheric O_3 intrusion (SI) working group consisting of federal government scientists and air quality managers, with input from state and local agencies and academia. One of their foci is to provide satellite-based support for SI forecasting and related exceptional event analysis.

The Infusing satellite Data into Environmental Applications – International (IDEA-I; http://cimss.ssec. wisc.edu/imapp/ideai_v1.0.shtml) software package is being adapted to provide satellite based

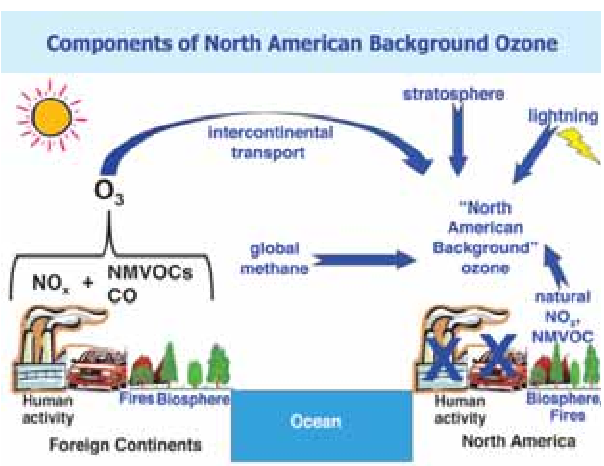
SI forecasting capabilities. IDEA-I is an open source, globally configurable version of Infusing satellite Data into Environmental air quality Applications (IDEA)[6] that provides a satellite-based aerosol forecasting, visualization, and data synthesis tool. An expansion of IDEA-I includes SI trajectory forecasts initialized using real-time, space-based measurements of O_3, temperature, and water vapor to identify signatures of stratospheric air (dry air with high O_3) within the troposphere. IDEA-I SI forecasts use measurements from several instruments aboard satellites: the Atmospheric Infrared Sounder (AIRS), the Infrared Atmospheric Sounding Interferometer (IASI), and the Cross-track Infrared Sounder (CrIS; http://cimss.ssec.wisc.edu/cspp/ uwhsrtv_edr_v1.2.shtml). When potential SI profiles are identified (based on three criteria: pressures below 500 hPa, O_3 above 80 ppb and dew point depressions of more than -15 °C), forward trajectories are initialized and used to predict

What Are Background Ozone and Exceptional Events?

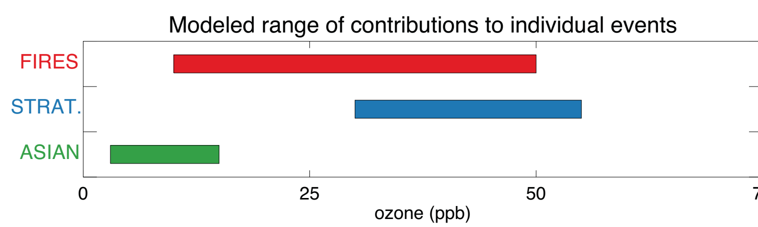
North American Background (NAB) O_3 is the concentration of O_3 in surface air that would occur in the absence of North American anthropogenic emissions.[11] NAB O_3 thus includes O_3 produced from natural nitrogen oxides (NO_X) and non-methane volatile organic compound (NMVOC) precursors, from foreign anthropogenic precursors, from global methane (including U.S. methane emissions which are not regulated), and transported from the stratosphere (see schematic). By definition, estimating background relies on models.

Ozone concentrations measured at remote sites, termed "baseline O_3" by a recent National Research Council report,[12] provide important constraints on model NAB estimates. NAB O_3 levels vary with altitude, season, and synoptic conditions, with the highest levels generally occurring over the high-altitude western United States during spring.[13] The figure below shows model-based ranges for maximum episodic contributions from fires,[14] stratospheric intrusions,[4] and Asian pollution[10,15] to high O_3 events in U.S. surface air. These model estimates motivate a need for accurate observational constraints to attribute unambiguously observed high O_3 events to sources other than North American anthropogenic emissions.

Such attribution could qualify the event for "exceptional event" status under the U.S. Clean Air Act. An exceptional event is a NAAQS exceedance that would not have occurred but for the influence of sources beyond the control of U.S. air agencies, and can be exempted from the dataset used for regulatory determinations, such as classifying a region as non-attainment.



Sources of North American Background (NAB) O_3 (blue labels and arrows). The blue Xs over North American human activities leading to O_3 precursor emissions indicate that those sources are not included in the definition of NAB O_3.



Range of contributions from components of North American Background (NAB) O_3 estimated with regional or global atmospheric chemistry models to individual high O_3 episodes in surface air. Shown are estimates for wildfires (FIRES),[14] stratospheric intrusions (STRAT.),[4] and Asian pollution (ASIAN).[10, 15] These components add to local and regional pollution, and can contribute to total surface ozone exceeding the current 75 ppb threshold for the U.S. O_3 NAAQS.

Table 1. Stratospheric ozone intrusion events over the western United States from April–June 2010, adapted from Reference 4.[4] The event shown in Figure 3 is highlighted in bold.

Event Date(s)	Major surface impact regions	Peak daily maximum 8-hr average O_3	Number of exceedances at ground sites	Type of observations used to detect the intrusion
Apr. 7	Colorado, New Mexico	71	-	satellite
Apr. 9	Wyoming	75	1	satellite
Apr. 12–15	Four Corners Region	86	13	satellite
Apr. 21–23	Colorado, New Mexico	72	-	satellite
Apr. 28–29	Colorado, Wyoming	69	-	satellite
May 11–13	Arizona, New Mexico, W. Texas	74	-	satellite, lidar, ozonesondes,
May 18–21	Wyoming	74	-	satellite, ozonesondes
May 22–24	Colorado, New Mexico	79	4	satellite, lidar, ozonesondes
May 27–29	**Arizona, California, Colorado**	**82**	**5**	**satellite, ozonesondes**
Jun. 7–8	Idaho, Utah, Wyoming	76	3	satellite, ozonesondes
Jun. 9–14	California, Utah, Spread in Southwest	73	-	satellite, ozonesondes
Jun. 16–17	Colorado	67	-	satellite, ozonesondes
Jun. 22–23	Colorado	77	1	satellite

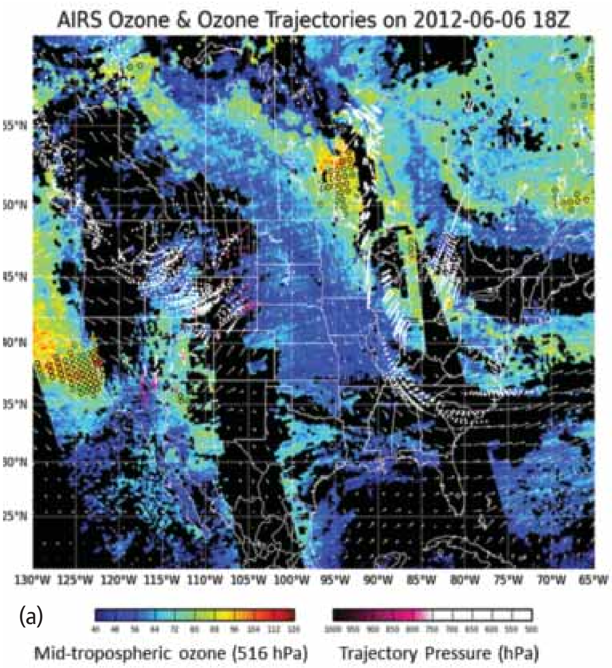
whether these stratospheric air masses are likely to impact the surface over the next 48 hours.

Figure 4 illustrates the IDEA-I SI trajectory forecasts along with model simulations and in situ measurements. These images provide corroborating evidence to demonstrate that a deep stratospheric intrusion led to a surface O_3 event above the NAAQS threshold. Figure 4a shows an IDEA-I SI forecast indicating downward transport of high O_3 air over northeastern Wyoming and Montana on June 6, 2012, when the Thunder Basin monitor in northeastern Wyoming reached 100 ppb at local noon. Enhanced O_3 (above 80 ppb) and PV (above 1.5 PVU) over central California on June 5, 2012, from the Real-time Air Quality Modeling System (RAQMS)[7] indicates stratospheric air extending down into the troposphere along the northern flank of a relatively strong (45 ms^{-1}) jet at 120°W (see Figure 4b). Elevated O_3 levels were also measured by the NASA Ames AJAX project as the aircraft[8] intersected the analyzed SI event (see Figure 4c). This analysis is included in a submitted exceptional event demonstration package (by Wyoming Department of Environmental Quality/Air Quality Division to EPA; http://deq.state.wy.us/aqd/ExceptionalEvents/June_6_2012Thunder Basin/June_6_2012_SI_Package.pdf).

Asian Pollution

A comprehensive review of Asian pollution impacts on North American surface O_3 was recently published.[9] Figure 5 demonstrates a new approach to identifying days with the highest potential for importing Asian pollution into western United States surface air.[10] Daily CO columns from the AIRS instrument aboard the Aqua satellite are correlated with a time series of Asian O_3 pollution estimated with the GFDL AM3 model, sampled at Grand Canyon National Park, Arizona, and lagged by two days. The region over the eastern North Pacific Ocean with higher correlations implies that the AIRS CO columns are generally enhanced there two days before the model simulates Asian pollution reaching Grand Canyon National Park. While the correlations are not sufficiently strong to use directly as a predictor, they imply there is useful information in the space-based observations. The region identified here could be used to initialize the IDEA-I model (as for the stratospheric intrusion application) and forecast Asian pollution plumes reaching U.S. surface air.

Figure 4. Example analysis used to document a stratospheric intrusion that led to a high-ozone event in excess of the U.S. NAAQS threshold and included in an exceptional event demonstration package.



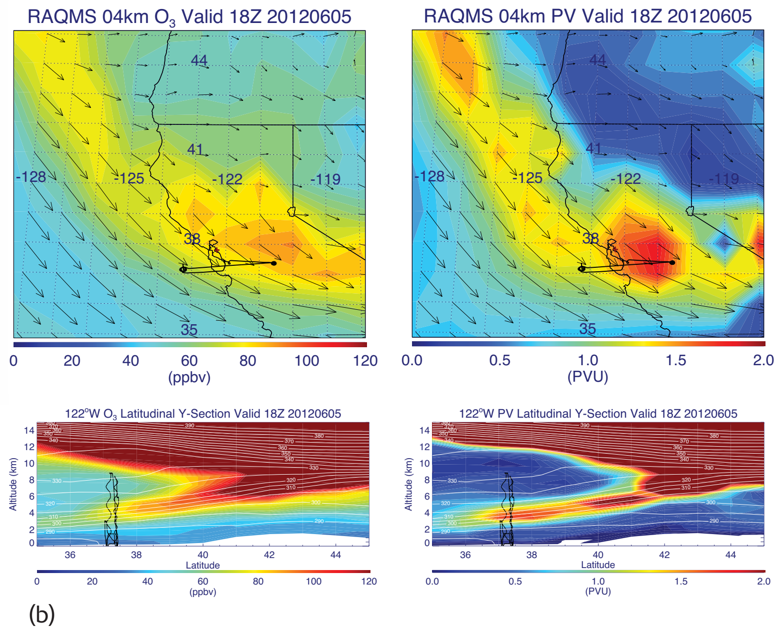


Figure 4a. IDEA-I SI forecast (magenta and white trajectories over Wyoming, Idaho, and Montana) valid at 18Z (11:00 a.m. MST) on June 6, 2012, initialized with mid-tropospheric O_3 measured by the Atmospheric Infrared Sounder (AIRS) instrument aboard the Aqua satellite on June 4, 2012. The IDEA-I SI trajectories are initialized in regions of high O_3 (open circles) off the coast of California and show the downward transport (magenta indicates high trajectory pressures near the surface) of the high O_3 air over northeastern Wyoming and Montana. The initial mid-tropospheric O_3 (516 hPa) observed with the AIRS instrument is also shown (blue-to-red color scale) along with mid-tropospheric winds (500 hPa; white arrows) from the NOAA Global Forecasting System (GFS), which are used to predict the trajectory movement. Note that the AIRS data indicate high O_3 over Canada (north of Minnesota) and trajectories were initialized there, but they never made it into the boundary layer (white trajectories over Tennessee and South Carolina).

Figure 4b. Maps at 4 km altitude (top) with wind vectors (black arrows) and cross sections at 120° W (bottom) of O_3 (ppb, left) and potential vorticity (PV; PVU, right) on June 5, 2012, at 1800 UTC from the Real-time Air Quality Modeling System (RAQMS) analyses.[7] RAQMS stratospheric O_3 analyses are constrained through assimilation of near-real-time (NRT) O_3 profiles from satellite instruments: the Microwave Limb Sounder (MLS)[16] above 50 hPa and NRT cloud cleared total column O_3 from the Ozone Monitoring Instrument (OMI),[17] both aboard the Aura satellite. Also shown is the AJAX flight track (black; measurements shown in Figure 4c). Note: the tropopause fold indicated by the tongue of relatively strong PV and high O_3 extending from the lower stratosphere into the mid-troposphere (lower panels). Reproduced from Ref[8].

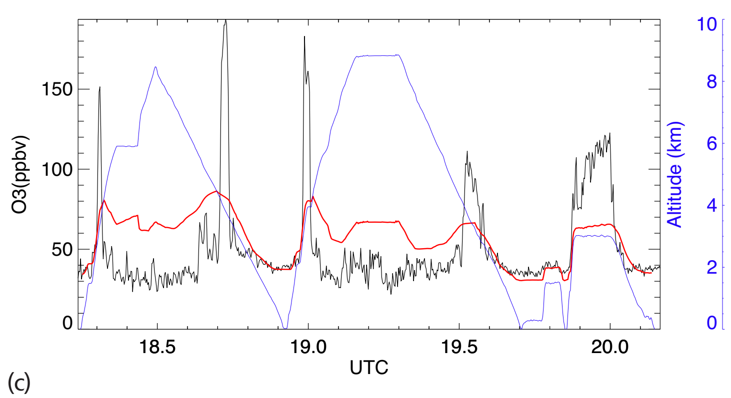


Figure 4c. Time series of observed in situ (black) and RAQMS analyzed (red; see Figure 4b) O_3 (ppb) along part of the Alpha Jet Atmospheric eXperiment (AJAX) Flight 47 track on June 5 2012. The altitude (km) of the aircraft is shown in blue. Reproduced from Ref[8].

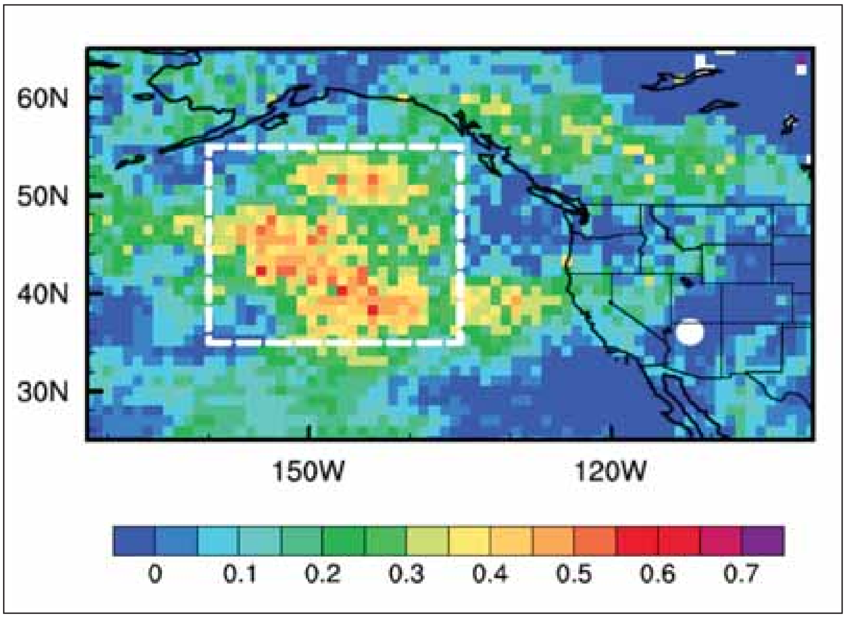


Figure 5. Correlation coefficients (r) at each 1°x1° grid box of May–June 2010 daily CO columns measured by the AIRS instrument on the Aqua satellite and model (AM3) estimated Asian anthropogenic enhancements to daily maximum 8-hour average O_3 at Grand Canyon National Park (white filled circle), Arizona, with a two-day time lag. The rectangle indicates the region where AIRS CO can be used to derive a space-spaced indicator of Asian influence on surface O_3 in the western U.S. Asian O_3 pollution is estimated as the difference between a standard AM3 model simulation and one with Asian anthropogenic emissions set to zero. Adapted from Ref[10].

Summary

The examples above from NASA AQAST members combine in situ and remotely sensed data with numerical simulations to attribute O_3 events measured at ground monitoring sites to three specific sources of background O_3: wildfires, stratospheric intrusions, and Asian pollution. Air agencies can use these integrated analyses to support "exceptional event" claims for situations where multiple lines of evidence indicate that the event would not have occurred but for the influence of sources outside of their control. NASA AQAST is working to make these tools and analysis techniques publicly available. **em**

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EPA Underestimating Methane Emissions, Researchers Say

The U.S. Environmental Protection Agency (EPA) has significantly underestimated methane emissions, researchers said in a study published in the *Proceedings of the National Academy of Sciences*.

The study, "Anthropogenic Emissions of Methane in the United States," found that EPA's methane emissions estimates were particularly off in states with large ranching and natural gas exploration industries and could be under-counting emissions by as much as 50% nationwide. The disparity calls into question the agency's estimates of methane emissions, the study said.

The study estimates that U.S. methane emissions in 2007 and 2008 were approximately 33.4 teragrams of carbon each year. That amount is between 7% and 8% of global methane emissions and 150–170% greater than EPA's Emissions Database for Global Atmospheric Research (EDGAR) estimates for those years, the study said. During those years, Texas, Oklahoma, and Kansas together accounted for 24% of U.S. methane emissions, or 3.7% of all greenhouse gas emissions (GHG) nationwide. Anthropogenic emissions account for 50–65% of global methane emissions, the study said.

In a statement, EPA said it is "committed to using the best available data for our inventory and continually seeks opportunities to update and improve our estimates." The agency said "research studies like these will add to our knowledge base of GHG emissions and will help us refine our estimates going forward." The study was performed by researchers from the Carnegie Institution for Science, Harvard University, National Oceanic and Atmospheric Administration, and other organizations. **em**

Report: Climate Data Should Be 'Clear, Actionable' for Financial Decisions

Information related to climate change and its impacts should be translated into "clear and actionable" terms for financial decision-makers from the public and private sectors, according to a report released by the American Meteorological Society's Policy Program.

While the study of the science of climate change is extensive, much of the information has proven difficult to communicate effectively to financial decision-makers and other "user communities" that need it, the report said. "Climate science is not well understood outside the scientific community," Paul Higgins, director of the American Meteorological Society's Policy Program, told Bloomberg BNA. "This is the biggest challenge for climate change risk management, in my view."

Assessments of climate change impacts, such as the Intergovernmental Panel on Climate Change's (IPCC) report and the U.S. National Climate Assessment, would be more valuable if they were translated into easily accessible levels of risk, according to the report. The report's three-piece framework is less complex than the 10 likelihood categories outlined by the IPCC, which the report said are useful among climate experts but "likely constitute barriers to communication with outside users and lay audiences." **em**

Environmentalists Criticize Approval of PCB Waste Disposal in Non-TSCA Landfills

Allowing electric utilities to dispose of certain polychlorinated biphenyl (PCB) remediation wastes in landfill facilities not approved under the Toxic Substances Control Act (TSCA) should not be permitted by EPA, environmental and public interest groups said.

In comments submitted to the agency, the groups said EPA's preliminary approval to dispose of the wastes was not allowed under 40 C.F.R. Section 761.61(c) or TSCA Section 6. The groups also said EPA's action could pose an unreasonable risk to human health and the environment, did not include an environmental justice assessment as required under Exec. Order No. 12,898, contained insufficient notification requirements, and failed to provide adequate notice of waste disposal.

In a Sept. 30 preliminary approval, EPA said that members of the Utility Solid Waste Activities Group could dispose of non-liquid PCB wastes in facilities such as municipal solid waste landfills, provided they comply with public comment, notification, and recordkeeping requirements. The PCB wastes would need to have concentrations of less than 50 parts per million under the approval. **em**

Compiled by Mark Williams, *BNA Bloomberg, www.bna.com. Note: All amounts in U.S. dollars.*

Interactions between Climate Change and U.S. Air Quality

An overview of AQAST activities examining the interactions between climate change and U.S. air quality. These activities utilize Earth System data and models, in addition to satellite observations.

by L.J. Mickley, A.M. Fiore, and D.K. Henze

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In response to health concerns and subsequent regulations, U.S. air quality has shown remarkable improvement in recent years. Eight-hour averages of surface ozone (O_3) have declined by nearly 20% since 1990, while 24-hr averages of fine particulate matter ($PM_{2.5}$) have dropped by 25%.[1] However, unusual weather can interrupt that trend, as was seen in the hot dry summer of 2012, when Chicago and St. Louis experienced double the average number of O_3 episodes from the previous four years. A key question is whether such summers will become more common under climate change. More generally, will the day-to-day weather that accompanies climate change work against decades of air quality regulation?

Since particles and tropospheric O_3 are themselves radiative forcing agents, trends in their concentrations can, in turn, influence regional and global climate. A new direction in air quality research takes into account both the health and climate impacts of pollutants, and attempts to identify those emission controls that maximize the benefits to society.[2,3] The NASA Air Quality Applied Sciences Team (AQAST), which bridges the gap between NASA science and the needs of air quality management, has contributed toward this research and provides new tools for air quality managers.

Background

In much of the United States, cold fronts associated with the low pressure systems known as cyclones provide the main mechanism for ventilating surface

air and ending pollution episodes.[4,5] Model studies point to more heat waves and fewer mid-latitude cyclones in a future, warmer atmosphere,[6,7] suggesting that the frequency of pollution episodes may increase in the absence of additional emissions controls. For $PM_{2.5}$, increasing temperatures in a future climate could increase the emissions of some precursors such as ammonia and biogenic compounds, but simultaneously shift gas-aerosol partitioning toward the gas phase.[8,9] An AQAST-funded effort reviews the impacts of climate change on air quality.[10]

Both O_3 and $PM_{2.5}$ affect regional or hemispheric climate. Tropospheric O_3 absorbs infrared radiation upwelling from the Earth and is a major greenhouse gas. Particles interact with incoming sunlight and can lead to both regional cooling and warming. Light-colored particles like sulfate reflect sunlight and result in cooling, while black carbon particles (BC) absorb sunlight, warming the atmosphere but cooling the Earth's surface directly below. By providing nuclei upon which water can condense to form clouds, particles can increase cloud cover. BC deposited on snow and ice surfaces changes the surface albedo, decreasing the fraction of sunlight reflected to space and allowing warming.

Policy-makers rely on a metric of climate influence called radiative forcing to compare the impacts of one chemical species against another. Radiative forcing is reported in units of Wm^{-2} and represents the imbalance in the Earth's radiative budget introduced by a given species. The Intergovernmental Panel on Climate Change (IPCC)[11] estimates a global mean radiative forcing of tropospheric O_3 at +0.40 Wm^{-2}, and -0.90 Wm^{-2} for particles. By comparison, the global mean radiative forcing for carbon dioxide (CO_2) is +1.82 Wm^{-2}. The relatively short lifetimes of O_3 and particles (days to weeks) result in steep horizontal gradients in their forcings, which has implications for regional climate.

Results From AQAST

Effects of Climate Change on Ozone Air Quality

For a recent AQAST project, present-day and future meteorological fields from the NASA GISS climate model were applied to GEOS-Chem, a global chemical transport model.[12] The study found that higher temperatures and increased stagnation enhanced monthly mean O_3 by 2–6 parts per billion (ppb) across the United States in summer, indicating a "climate penalty." There remains uncertainty, however, in the biogenic component in this response. While warmer temperatures increase biogenic emissions, elevated CO_2 levels may suppress these emissions through biochemical mechanisms within the leaf.[13]

Climate change may also increase the flux of stratospheric O_3 into the troposphere over mid-latitudes.[14] Results from another AQAST study which relied on satellite observations and the GFDL chemistry-climate model point to a large contribution from stratospheric intrusions in springtime high O_3 events at high altitudes in the West.[15] We infer that such events may increase in frequency or severity in the future.

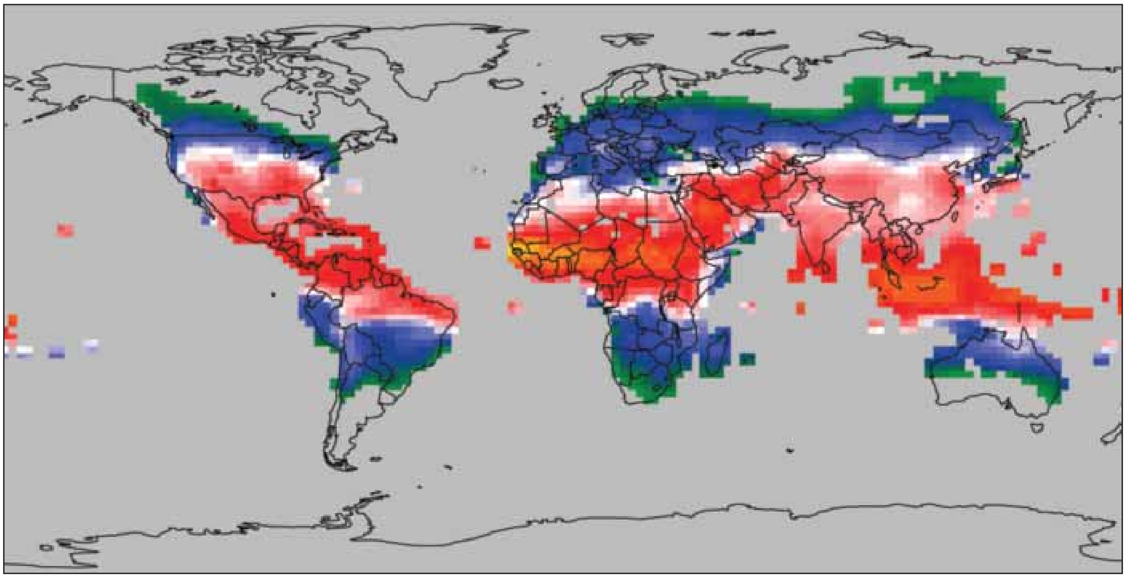
Effects of Climate Change on $PM_{2.5}$ Air Quality

The sensitivity of the Earth's climate to changing greenhouse gases varies from model to model. To gain confidence in predictions of the impact of future climate change on $PM_{2.5}$ air quality, two AQAST projects have employed results from an ensemble of climate models archived for the fourth IPCC. The first analyzed 1999–2010 surface observations to identify the dominant meteorological modes driving $PM_{2.5}$ variability across the United States.[16,17] Using the IPCC ensemble, Tai et al.[17] found that the projected trends in these modes would likely have minimal impacts on $PM_{2.5}$ in the 2000–2050 timeframe.

The second study examined the impact of changing wildfire on U.S. air quality. Yue et al.[18] diagnosed observed relationships between area burned and meteorology, and then applied these relationships to 2050s meteorology from the IPCC ensemble. A robust result is that the warmer, drier atmosphere of the 2050s will likely lead to increased fire activity. In contrast to the first study, $PM_{2.5}$ air quality in this study significantly worsened due to enhanced

Both O_3 and $PM_{2.5}$ affect regional or hemispheric climate.

Figure 1. The impact of NO_X emission locations on O_3 radiative forcing, shown here relative to the impact of these emissions on O_3 concentrations for August 2006. In regions where this ratio is greater than one, changes to NO_X emissions are especially efficient in driving O_3 radiative forcing. From Bowman and Henze.[19]



wildfire activity by 2050. Summertime surface organic carbon particles over the West increased by 50–70%, while black carbon increased by approximately 25%, relative to 2000. This work emphasizes the need for careful forest management as climate changes.

Linking Emissions to Ozone and Aerosol Radiative Forcing

In considering the climate impacts of pollutant, policy-makers are often faced with complex choices that simultaneously affect the abundance of many co-emitted species. There is thus a push to consider the radiative forcing of emissions rather than concentrations of the resulting species. Recent AQAST work has developed a new approach to quantifying the radiative forcing of air pollution emissions at much higher spatial scales than previously explored, 250 km rather than continental.

In Bowman and Henze,[19] satellite observations of O_3 radiative forcing from the Tropospheric Emission Spectrometer were combined with GEOS-Chem. Significant regional variability was found—in some places by more than a factor of 10—in how efficiently O_3 trapped heat in Earth's atmosphere, depending upon the locations of precursor emissions (see Figure 1). In regions such as the Southeast United States where strong convection carries O_3 aloft, the O_3 forcing showed large sensitivity to nitrogen oxides (NO_X) emissions.

In another AQAST effort, Henze et al.[20] used GEOS-Chem to consider the emissions of primary particles and particle precursors, and found that the emissions controls required to attain a specific radiative forcing target varied spatially by up to a factor of 4. These AQAST efforts demonstrate both the need and a means for incorporating spatially refined radiative forcing into the design of air quality and climate change mitigation policies.

Climate and Air Quality Co-Benefits

Policy-makers seek emissions strategies that have co-benefits for both health and climate. To address this issue, AQAST has incorporated the emissions-specific forcings from Henze et al.[19] into a new decision support tool, GLIMPSE.[21] The GLIMPSE model provides insights into the consequences of technology and policy decisions on human health, ecosystems, and global climate. The utility of GLIMPSE was demonstrated by analyzing several future energy scenarios under existing air quality regulations and potential CO_2 emission reduction policies. Opportunities were found for substantial co-benefits in setting air quality targets for both climate change mitigation and health benefits. Though current policies which prioritize public health protection increase near-term warming, establishing new policies that also reduce greenhouse gas emissions could offset warming in the near-term and lead to significant reductions in long-term warming.

AQAST also explored another approach for accounting for the co-benefits of emissions controls on climate and health. For this study, the EPA-MARKAL model of the U.S. electricity sector was used to examine how imposing emissions fees based on estimated health and environmental damages might change electricity generation.[22] Fees were imposed on the life-cycle emissions of the criteria pollutants (sulfur dioxide, nitrogen oxides, and particulate matter) and greenhouse gases from 2015 through 2055. One key finding was that fees imposed solely on pollutants did not significantly affect greenhouse gas emissions. Conversely, charging fees only on greenhouse gas fees reduced NO_x emissions up to ~10%, with only a slight increase in sulfur dioxide emissions. Therefore, carefully formulated fees may be needed to achieve significant reductions in both greenhouse gases and the criteria pollutants.

Summary

Average surface temperatures over the continental United States are projected to increase by 1–3 °C by the mid-21st century.[11] By providing information and tools based on Earth System science, AQAST can aid policy-makers in designing air quality strategies that maximize the benefits to human health and global climate. **em**

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Integrating Satellite Data into Air Quality Management

Experience from Colorado

by Sarah Witman, Tracey Holloway, and Patrick J. Reddy

A first-person perspective on the potential gains of applying satellite data to forecast air quality from Patrick J. Reddy, lead forecast meteorologist at Colorado's Department of Public Health and Environment.

Sarah Witman and **Tracey Holloway** are with the Nelson Institute Center for Sustainability and the Global Environment (SAGE), University of Wisconsin-Madison; and **Patrick J. Reddy** is with the Air Pollution Control Division, Colorado Department of Public Health and Environment. E-mail: Tracey Holloway tahollowa y@wisc.edu.

Air quality management has changed dramatically since 1990. Desktop computers were not yet commonplace back then, and the Internet was practically nonexistent. In those days, satellite data were also primitive: typically grainy, black-and-white images that were a challenge to decipher. Today, computers and access to online data are fundamental to air pollution analysis and regulation. However, despite the boom in satellite data quality and availability, many air quality managers have not yet tapped into these high-value resources.

The Colorado Department of Public Health and Environment has, however, been active in using space-based data. The agency has applied satellite data to forecast air quality; write up exceptional event reports on blowing dust and ozone intrusions; analyze specific air quality events, including wildfire smoke; and characterize relationships between meteorology, emissions, and air quality. The experience of Patrick Reddy, lead forecast meteorologist at the Department's Air Pollution Control Division, offers a first-person perspective in the potential gains from satellite data analysis.

Eyes in the Sky

Suspended tens of thousands of miles above Earth, satellites have a unique perspective on the atmosphere. Different chemicals absorb and emit specific wavelengths of radiation, allowing satellite detectors to "see" gases and aerosols, even some invisible to the human eye. With many satellites passing over Earth every day, we get a continuous record of key air quality information, from gases and particles in the air to fires on the ground.

In evaluating satellite data for air quality applications, there are some limitations. Satellite data reflect the full atmosphere, or a wide slab, versus "nose level" values; polar-orbiting satellites provide a once-a-day (or less frequent) snapshots; data reflect a footprint average (e.g., for NASA's Ozone Monitoring Instrument [OMI] instrument, a minimum area of 13 x 24 km^2), versus a single point; and, on cloudy days or over snow-cover, most satellite data products are unavailable.

Despite limitations, satellite data can fill important, policy-relevant data gaps. Above all, satellites provide more spatial data coverage than any other source. This big picture view allows air quality managers to track smoke plumes back to forest fires, or dust storms back to deserts. For air quality managers, satellite estimates of nitrogen dioxide (NO_2) can be particularly useful, as NO_2 is a criteria pollutant, as well as a precursor to ozone and nitrate aerosols. Because most tropospheric NO_2 originates from surface emissions, and NO_2 has a relatively short

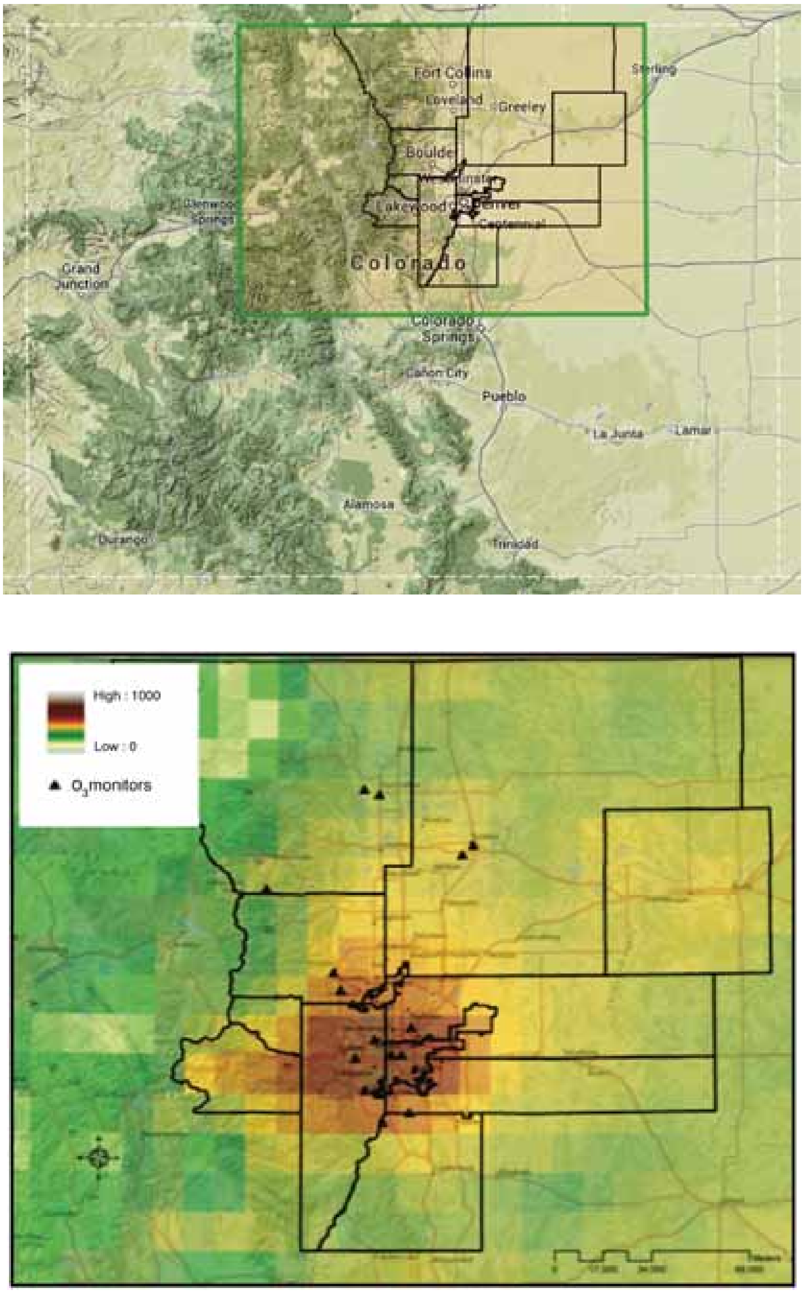

Figure 1. (a) Topographic map of Colorado, with Denver-area counties and subregion marked for comparison with part (b) created with ZeeMaps.com; (b) 2009–2012 July mean tropospheric NO_2 (units of 10^{13} mol/cm^2) over the Denver, Colorado, area, as detected by the OMI instrument. Brown and yellow show emissions migrating from valley cool pool into higher terrain. Black lines represent county borders.

Figure presented by Patrick Reddy at the Fall 2012 Meeting of the American Geophysical Union. Full presentation available at: http://www.colorado.gov/airquality/repository/mmei_file.aspx?file=Patrick+Reddy+AGU+fall+2012d.pptx.

lifetime (minutes to hours), the satellite retrievals of NO_2 may be directly linked back to regulated sources.

The primary satellite NO_2 instrument that an air quality manager might select is OMI onboard the NASA Aura satellite, complemented either by the coarser resolution Global Ozone Monitoring Experiment (GOME)/GOME-2 instruments, or the Scanning Imaging Absorption Chartography (SCIAMACHY) instrument, both onboard European satellites.

Martin[1] offers an overview of air quality monitoring data from space, including additional information on OMI, GOME, GOME-2, and SCIAMACHY. The primary issue determining data choice is usually spatial resolution, where OMI emerges as the strongest candidate because it can see features at the finest scale of any available NO_2 instrument. However, not all data are available for all years: OMI data are available from 2004 to present, GOME from 1996 to 2003, GOME-2 from 2007 to present, SCIAMACHY from 2002 to 2012.

Finally, time of day may affect a user's choice. The NASA Aura satellite, containing OMI, passes over a location in the early afternoon,[2] whereas The MetOp satellite from the European Space Agency, containing GOME-2, passes over in the morning. Using both data sets together provides two snapshots of the same location each day. Looking at satellite NO_2 informs the spatial distribution of the pollutant, day-to-day variability, and—if data from both detectors are used—even some level of diurnal variation.[3] These data, in turn, can be linked to emission trends, pollution events and weather patterns.

Beyond NO_2, satellite platforms provide information a wide range of gas-phase species, as well as particulate abundance and characteristics. Even in cases where the satellite does not measure the exact species of interest, sometimes space-based data may be used as proxies for other atmospheric characteristics. For example, satellites cannot detect total volatile organic compounds (VOCs), but the OMI instrument does detect formaldehyde (HCHO). Past studies have shown how satellite HCHO can be used to estimate VOC abundance.[4]

Tales from the Front Range

Colorado is part of the U.S. Environmental Protection Agency (EPA) Region 8, where the Rocky Mountains and other topographic features affect the NO_2 distribution in a way that would be nearly impossible to assess from ground-based data alone. Using space-based data, air quality managers can see detailed NO_2 distributions by month, or in some cases by day, across all of Colorado and neighboring states. Figure 1a provides an overview of this region's topography, and Figure 1b shows an example of satellite-detected NO_2 distributed throughout canyon areas.

In 2009, there was debate as to whether the Front Range region operated as a nitrogen oxides (NO_x)-sensitive regime, suggesting that NO_x controls would be effective in controlling ozone (O_3) levels.

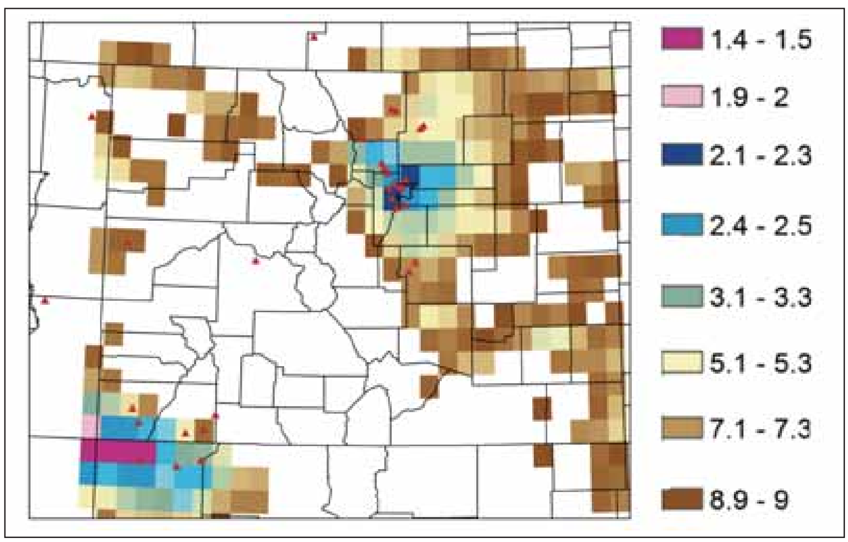

Figure 2. Ratio of tropospheric HCHO to tropospheric NO_2 over the Colorado Front Range area, derived from mean $GOME_2$ satellite measurements for July 2007 and 2008. A ratio of above 1.0 may indicate a NO_x-sensitive ozone production regime. All ratios in this region show ratios are above 1.0. Gridded data from KNMI TEMIS (http://www.temis.nl/airpollution/no2.html).

Figure courtesy of Patrick Reddy, from presentation "2009 Ozone Season Review: Briefing to the Colorado Air Quality Control Commission," September 17, 2009 (Figure legend adjusted for clarity). Full presentation available at http://www.colorado.gov/airquality/repository/mmei_file.aspx?file=OZ+2009+AQCC+Presentation+Sept+Els+without+xtras.ppt.

The Rocky Mountains and other topographic features affect the NO_2 distribution in a way that would be nearly impossible to assess from ground-based data alone.

O_3 is not directly emitted, but forms in the atmosphere from chemistry between NO_x (NO_2 + NO) and VOCs. High O_3 pollution may be produced with high NO_x relative to VOCs (a so-called VOC-sensitive O_3 regime) or with high VOCs relative to NO_x (a NO_x-sensitive regime). Characterizing the O_3 regime is essential for effective control policies, otherwise expensive regulations may not have the intended effect. At the time, NO_x controls were contentious. Some participants in the policy stakeholder process argued that reducing NO_x would *increase* O_3, typical of a VOC-sensitive regime. Thus, whether NO_x controls would be effective or detrimental depended on one issue: whether the region was in a NO_x-sensitive or VOC-sensitive O_3 regime.

Around this same time, Bryan Duncan, a scientist at the NASA Goddard Space Flight Center in Maryland and now a member of the NASA Air Quality Applied Sciences Team (AQAST), showed how the ratio of OMI HCHO to OMI NO_2 could be a powerful way to determine the O_3 regime over a wide spatial area.[5] This approach, known as "indicator ratios," was first applied to ground-based measurements,[6] and earlier applied to satellites using GOME data.[7]

Inspired by Duncan's work, Reddy gave a presentation to the Colorado Air Quality Control Commission, introducing satellite data to show that on average the Front-Range was NO_x-sensitive (as shown in Figure 2, taken from his 2009 presentation). NO_x controls were eventually passed by the Commission, although it is hard to characterize the specific role of satellite-based analysis in the policy process. In general, this type of analysis can complement ground-based measurements, modeling, and other weight-of-evidence approaches, in the broader context of decision-making on emission controls.

Signals Transmitted and Received

Satellite data analysis in Colorado highlights how space-based platforms, and new ways of using atmospheric data, can support air quality management. Reddy's own involvement in satellite applications, following his use of indicator ratios to Front Range O_3 control, has been supported in part by new collaborations with members of NASA AQAST. NASA AQAST encourages air quality managers from across the United States to partner in their activities by contacting team members, attending biannual meetings, or following updates on team web sites (www.aqast.org and www.aqast-media.org) and Twitter (@NASA_AQAST).

Although many states have begun to use satellite data for air quality management, a range of factors can influence the time devoted to learning and using spaced-based data products. In-person workshops and online webinars provided by the NASA Applied Remote SEnsing Training (ARSET; http://airquality.gsfc.nasa.gov) program can help agencies build capacity and facilitate the use of satellite data for air quality applications.

For resources and instructions for calculating O_3 indicator ratios, please visit *www.sage.wisc.edu/airquality_ratios*. **em**

AKNOWLEDGMENT
Support was provided by the NASA Air Quality Applied Sciences Team (AQAST). We also appreciate valuable input on this project from Bryan Duncan.

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Oil and Gas Regulations Still Two Years Away

Canada has faced years of delays around the development of regulations for oil and gas industry emissions. Now, the wait looks to be even longer.

In an extensive 2013 year-in-review interview with *Global News*, Prime Minister Stephen Harper said that greenhouse gas (GHG) regulations for Canadian oil and gas companies could still be two years away, as he focuses on remaining in lock-step with U.S. policy on emission reductions.

"As you know, this is an integrated sector continentally, and I am, our government is, certainly prepared to work with the United States on a regulatory regime that will bring our emissions down," said Harper. "So that's what I'm hoping we'll be able to do over the next couple of years."

While Canada decided to adopt the same national 2020 GHG reduction target as the United States, the two countries have very different emissions profiles. According to the National Roundtable on the Environment and the Economy, oil and gas account for 23% of Canada's emissions. In the United States, meanwhile, the U.S. Department of State shows that oil and gas sector emissions account for just 6% of the country's total GHG emissions.

Experts suggest that Canada's lack of oil and gas regulations is the primary reason it's not expected to meet its 2020 climate target, while the United States remains on track to meet its goal. **em**

Northern Gateway Pipeline Takes Big Step Forward

A joint review panel from the National Energy Board has recommended approval of the Northern Gateway pipeline proposal designed to connect Alberta's oil sands to tankers on the coast of British Columbia. However, a number of debates still lay ahead.

The Canadian federal government has six months to make the final decision about the $7.9-billion pipeline proposal. During that time, the feds will consult the 429-page panel report that outlines 209 conditions Enbridge must meet if the pipeline is to be built.

Alberta wants the pipeline to help capitalize on emerging markets in Asia, but the project has generated concerns over environmental impacts and First Nation rights. Presently, Alberta is forced to ship oil to the U.S. at discounted prices.

In a poll released by Harris-Decima in November 2013, a majority of Canadians said they were in favor of the Northern Gateway project.

A copy of the joint review panel's report is available online at http://gatewaypanel.review-examen.gc.ca/clf-nsi/dcmnt/rcmndtnsrprt/rcmndtnsrprt-eng.html. **em**

Saskatchewan Updates Recycling Regulations to Cover Diesel, Antifreeze

Saskatchewan's new environmental regulations for recycling used antifreeze, plastic antifreeze, and diesel exhaust fluid containers came into effect on January 1, 2014.

The Used Petroleum and Antifreeze Products Collection Regulations (RRS. c.E-10.21 Reg 6) increase the number of petroleum products that can be recycled. Used oil, used oil filters, and used plastic oil containers are already eligible for recycling in Saskatchewan. The size of containers for recycling also increases from 30 liters to 50 liters to reflect changes in packaging.

The recyclable petroleum products are managed by the Saskatchewan Association for Resource Recovery Corp. (SARRC). The Association currently operates the provincially-approved, industry-led recycling program for used oil, used oil filters, and used plastic oil containers up to 50 liters. To fund the program, SARRC's 179 members will be adding an environmental handling charge similar to that on new petroleum products, to the price of antifreeze (concentrate and pre-mix), antifreeze containers (up to 50 liters), and diesel exhaust fluid containers (up to 50 liters), effective April 1, 2014. **em**

Canadian Report is compiled with excerpts from *EcoLog News* and the *EcoCompliance.ca* newsletter, both published by EcoLog Information Resources Group, a division of BIG Information Product LP. For more Canadian environmental information, visit www.ecolog.com. *Note: All amounts in Canadian dollars.*

Can Windows and Other OSs Play in the Same Sandbox?

by Jill Gilbert

Jill Barson Gilbert, QEP, is president of Lexicon Systems, LLC. E-mail: jbgilbert@lexicon-systems.com.

Last year, my Windows 7 notebook hiccupped as I led a week-long series of workshops. My client asked if I was ready to buy a Windows 8 PC. I replied that, most likely, my next computer would be a Mac. With today's software delivery models, I predicted that moving from Microsoft Windows to the Apple OS X operating system (OS) would have minor impact.

Windows and Apple once were polar opposites, one associated with business and the other with students and creative types. Today, they can coexist in business. While most business networks rely upon Windows servers and software, they can accommodate both Windows and OS X devices. The line in the sand between the two OSs is not as sharp as it was, largely a result of two market forces:

1. The Internet delivers OS-independent software in the form of Software-as-a-Service (SaaS)[1] and Cloud[2] apps.
2. A mobile workforce with ultraportable gadgets demands anywhere, anytime information access.

Even as most business networks rely upon Windows servers and software, they can allow Windows- and OS X-based devices to play nicely in the workplace. Whether IT departments are eager to take on this challenge is another issue.

Internet vs. Traditional Delivery Models

The Internet continues to grow at amazing rates (see sidebar on page 42) and organizations of all sizes can benefit from Internet-delivered software. Customers pay subscription fees to access up-to-date software apps and the vendor performs maintenance and upgrades. Pure SaaS vendors operate a single version of the software, so all customers receive upgrades at the same time; other vendors may host multiple software versions, allowing more flexibility regarding upgrade timing.

In contrast, older, client/server software delivery requires large up-front license fees rather than "pay-as-you-go" subscriptions. Many organizations carefully evaluate whether to perform software upgrades due to long implementation cycles, plus training, and ongoing maintenance expense. Those that skip major upgrades or wait until the software is past its prime deny users the features and benefits that others experience—possibly to a competitive advantage.

As with other enterprise software, the trend in environment, health, and safety (EH&S) is Internet delivery of full-featured applications. For office tasks, SaaS versions offer fewer features than the desktop versions. However, users that need advanced features can use desktop versions that integrate with the Cloud software. Google and Microsoft offer SaaS versions and Apple is not far behind (iWork Cloud apps were in beta testing as of December 2013).

Mobile, Ultraportable Technology

Employees started the Bring Your Own Technology (BYOT) trend with smartphones and tablets; some want to use the latest notebooks at work—their own or the company's. The blurred line between OS allows vendors to market three diverse types of computers to businesses, from Ultrabooks to MacBooks to Chromebooks.

Ultrabooks and MacBooks sit at the top and middle of the price spectrum. ***Ultrabook*** is an Intel designation for thin and light, powerful Windows notebooks with the latest processors and solid state

Internet Growth Projections

- Global IP traffic increased more than fourfold in the past 5 years, and will increase threefold over the next 5 years.
- Traffic from wireless and mobile devices will exceed traffic from wired devices by 2016.
- Nearly half of all IP traffic will originate with non-PC devices by 2017.

Source: Cisco Visual Networking Index, Forecast and Methodology, 2012–2017, May 29, 2013; www.cisco.com/c/en/us/solutions/collateral/service-provider/ip-ngn-ip-next-generation-network/white_paper_c11-481360.html.

drives (SSD) in place of hard disk drives (HDD). Their fourth-generation "Haswell" processors are fast and responsive, with twice the graphics performance and 50% more battery life than their predecessors.[3] A ***MacBook*** is a thin, light, and fast Apple OS X notebook with a Haswell processor and an SSD,[4] available in a range of models.

Chromebooks sit at the low end of the price spectrum. A ***Chromebook*** is a small and fast "thin client" powered by the Google Chrome OS, with limited disk space, aimed at users that access most all their apps and store their data on the Internet.[5] A variety of vendors produce Ultrabooks and Chromebooks, while only Apple produces MacBooks.

Making the choice

Back to my mission… should I purchase a Windows or Apple notebook? As in any good system selection, first I established needs and selection criteria. Then I evaluated several hardware configurations from different vendors.

An Ultrabook with ample memory and a large SSD would meet my needs. I could use newer versions of familiar software. Surprisingly, an Ultrabook cost more than a MacBook with comparable specs, partly from the high cost of the SSD. For total cost of ownership, I needed to consider the cost of periodic software and system "crashes" and a moderate amount of ongoing maintenance, and a shorter life.

A MacBook with ample memory and a large SSD would meet most of my needs. I would need alternatives to my Windows flowchart and project management apps. The MacBook Pro had a better display and cost less than the Ultrabook. For total cost of ownership, I needed to consider the cost of a slight learning curve, though would expect fewer software and system "crashes," little ongoing maintenance, and a longer life.

We are close to the time when the OS no longer matters to knowledge workers and IT professionals. SaaS and Cloud apps accessed on wireless and ultraportable devices let us work unchained from PCs; all we need is a Web browser and a user account.

If your organization embraces BYOT and/or hardware/OS options, then understand how this change will impact your work.[6] For many, OS choice boils down to personal preference. By the way, I bought a Mac. **em**

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1. Software-as-a-service (SaaS) or "on-demand software" is a software delivery model with software and associated data hosted in the Cloud. SaaS solutions normally utilize a multi-tenant architecture; the application serves multiple businesses and users, and partitions its data accordingly. See http://en.wikipedia.org/wiki/SaaS.
2. The Cloud describes a number of computing concepts. In this case, it refers to network-based services that can be scaled up or down on the fly without affecting the end user. See http://en.wikipedia.org/wiki/Cloud_computing.
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Notes from the 1st Clean Fuels and Vehicles Forum in the ASEAN Region

The 1st Clean Fuels and Vehicles Forum in the ASEAN Region brought together key stakeholders to engage, network, and discuss stricter and harmonized clean fuels and vehicles standards at the regional level.

by **Ritchie (Chee) Anne Roño**, Program Officer, and **Glynda Bathan**, Deputy Executive Director, Clean Air Asia

Clean Fuels and Vehicles Forum, November 2013.
Photo courtesy of the Singapore NEA.

The Southeast Asian road transport sector consumes an estimated 139,874 kilotons of oil annually.[1] As a result of a rapid increase of private cars and motorcycle use in recent years, the region's energy demand has greatly expanded and current transport policies fall short to meet the transport emission reductions targets for carbon dioxide (CO^2) by 2050.[2] While most Association of Southeast Asian Nations (ASEAN) countries have set cleaner vehicle and fuel quality roadmaps, there's a wide variation between standards and their implementation among the different member countries, which was one of the topics of discussion during the 1st Clean Fuels and Vehicles Forum in the ASEAN Region, held November 2013 in Singapore.

The event was organized by Clean Air Asia and the Singapore National Environment Agency (NEA). Supporting partners included the Climate and Clean Air Coalition and Partnership for Clean Fuels and Vehicles under the United Nations Environment Programme (UNEP) and the German International Cooperation (GIZ), with private sector support from MAHA, Asian Clean Fuels Association (ACFA), and Shell.

High-level government officials from Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Philippines, Singapore, Thailand, and Vietnam, including a representative from the ASEAN Secretariat, as well as government representatives from China, Hong Kong, and Australia, participated in the Forum.

Experts were invited to present master classes designed for senior policy-makers in the ASEAN region. The master classes included:

- Strengthening fuel quality and emission standards for light-duty vehicles. led by Dr. Axel Friedrich, GIZ consultant, and Vance Wagner of the International Council on Clean Transportation with inputs from the Vehicle Emissions Control Center of the Ministry of Environmental Protection in China;
- Formulating fuel economy policies and standards, led by Bert Fabian of UNEP Transport Unit and Rob Earley of Clean Air Asia with country experiences from government representatives of Indonesia, Thailand, and Vietnam; and
- Periodic testing and inspection for in-use vehicles, by Michael Walsh, an international expert on fuels and vehicles.

Forum participants, November 2013.
Photo courtesy of the Singapore NEA.

Motor Vehicle Pollution and Health

In his keynote speech, Michael Walsh, gave an update on the global trends in motor vehicle pollution control. He underscored that health concerns continue to be the major driver of vehicle emission regulations, particularly ultrafine particles, which is becoming one of the more serious concerns at the global level. Road transport is a significant source of these toxic pollutants, especially in urban areas where these are often highly concentrated.

Recent studies completed by the World Health Organization confirm that outdoor air pollution causes lung cancer. Sufficient evidence points to diesel exhaust as a carcinogen and particulate matter, a major component of outdoor air pollution, as carcinogenic to humans.[3]

Walsh also revisited the elements of a comprehensive vehicle pollution control strategy: clean vehicle technologies, transport and land use planning, clean fuels, and appropriate maintenance. "It is important that fuels and vehicles must be viewed as part of a single system, rather than as individual components independent of each other," Walsh noted.

Roadmap for Clean Fuels and Vehicles

Clean fuels and vehicles policies are instrumental in reducing transport energy demand and associated environmental and health impacts from vehicle emissions. The Roadmap for Cleaner Fuels and Vehicles in Asia is the outcome of a long process that began with a meeting 10 years ago in July 2003 in Singapore, where Clean Air Asia held the Dialogue for Cleaner Fuels in Asia with 12 major multinational and national oil companies. The dialogue was the first regional effort of this scale to bring the oil companies in Asia around the table to discuss how they plan to introduce cleaner fuels for transportation in the region.

Since the launch of the Roadmap in 2008, various developments have been taking place as governments adhere to the adoption of a national roadmap aligned to this regional document.

Thailand moved to Euro 4 vehicle emission standards and 50-parts per million (ppm) sulfur in fuels as of the end of 2012 and Singapore mandated 10-ppm sulfur in diesel in July 2013 in anticipation of the move to Euro 5 diesel vehicles starting January 2014. Euro 4 standards for gasoline vehicles will be implemented in Singapore by April 2014.

The Vietnamese government has confirmed availability of 50-ppm sulfur in fuels by 2016 to meet Euro 4 vehicle emission standards and the move to Euro 5 and 10-ppm sulfur in fuels by 2021. Brunei Darussalam, Malaysia, and the Philippines are also planning the move to Euro 4 and 50-ppm sulfur in fuels by 2015/2016.

It was proposed during the Forum that all ASEAN member countries target to move to fuels of 50-ppm sulfur by 2015/16 and 10-ppm sulphur by 2019, and vehicle standards of Euro 4 by 2015/16 and Euro 6 by 2020. The development of a harmonized roadmap for cleaner fuels and vehicles, including fuel economy policies, will be raised officially at the relevant ASEAN working groups.

Way Forward

Air pollution from road transport is increasingly becoming a challenge as countries in the ASEAN region increase cross-border trade. The wide variation of standards and policies implemented among member countries potentially impedes the move toward a single ASEAN Economic Community, which, when fully implemented, will create an integrated market and production base for vehicles in the region. As a region, it would be essential for the countries to aim for harmonized regulations and approach toward cleaner fuels and vehicles.

This highlights the importance for collaboration among ASEAN member countries. The need to harmonize vehicles and fuel quality standards was acknowledged by Forum participants, but may require varying time frames for implementation depending on the readiness of the countries.

1st Clean Fuels and Vehicles Forum in the ASEAN Region, Singapore, November 2013

Organized by:

Clean Air Asia; National Environment Agency (Safeguard · Nurture · Cherish)

In partnership with:

ASEAN; UNEP; giz; United States Environmental Protection Agency; Partnership for Clean Fuels and Vehicles; CCAC Climate and Clean Air Coalition

Supported by:

Maschinenbau Haldenwang MAHA; acfa Asian Clean Fuels Association; Shell

Forum participants expressed that the Forum has been a very useful platform for knowledge-sharing and networking. Because achieving consensus among all member countries within the formal ASEAN framework could be a long-term process, events such as this one held in Singapore help increase awareness on the issues, identify next steps toward development of more stringent vehicle emission and fuel standards for the ASEAN member states, and provide impetus for harmonization of these standards.

A complete report and Forum presentations are available online at www.cleanairinitiative.org/portal/node/12102. **em**

Asian Connections is a quarterly column sponsored by A&WMA's International Affairs Committee. A&WMA has invited Clean Air Asia (www.cleanairasia.org) to contribute one column each quarter to highlight air quality and climate change issues in Asia. The Clean Air Asia Center serves as the secretariat of the Clean Air Asia Partnership, a nonbinding, multi-stakeholder network of government agencies, nongovernmental organizations, research institutions, international organizations, and private sector firms committed to improving air quality in Asia. A&WMA has collaborated and partnered with Clean Air Asia dating back to 2006.

References

1. Clean Air Asia, 2010 estimates.
2. Low-Carbon Transport Study in Southeast Asia. See www.cleanairinitiative.org/portal/whatwedo/projects/LowCarbonTransportSoutheastAsia.
3. World Health Organization, 2013. See www.iarc.fr/en/media-centre/iarcnews/pdf/pr221_E.pdf.

House Approves Legislation to Give States Greater Role in Site Cleanups

The House approved legislation Jan. 9 that would eliminate a requirement that the U.S. Environmental Protection Agency (EPA) review its waste regulations every three years, grant states a greater role in site cleanups, and force federal facilities to follow state and local laws during site cleanups under the superfund statute.

The Reducing Excessive Deadline Obligations Act (H.R. 2279) was passed on a vote of 225–188. Senate consideration of the measure is unlikely, and the White House threatened to veto the measure should it reach President Barack Obama's desk.

The bill—which incorporates the text of the *Federal and State Partnership for Environmental Protection Act* (H.R. 2226) and the *Federal Facility Accountability Act of 2013* (H.R. 2318)—would modify the Resource Conservation and Recovery Act (RCRA) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

Two amendments from Democrats on the legislation were defeated on the House floor. Republicans speaking on the House floor ahead of the vote said the legislation would strengthen the federal and state partnership in cleaning up contaminated sites, reduce the burden on EPA to review its waste regulations, and ensure federal facilities were held to the same standard as private sites.

The bill's sponsor, Rep. Bill Johnson (R-Ohio), said the measure "reduces unnecessary red tape" and aims "to improve the federal and state relationship when dealing with hazardous waste."

Democrats countered that the legislation was poorly thought out, didn't adequately address the concerns of the Defense and Justice departments and would increase litigation and delay cleanup of contaminated sites. "This is a poorly crafted bill that offers nothing for the public," Rep. Paul Tonko (D-N.Y.), ranking member of the Energy and Commerce Subcommittee on Environment and the Economy, said on the House floor. "This is bad policy and poorly crafted legislation."

Details of Measures

Under the bill, Section 2002(b) of RCRA would be changed to require the EPA administrator to review and revise regulations "as the Administrator determines appropriate." The current statute requires the EPA to review and, if necessary, revise waste regulations every three years (42 U.S.C. 6912(b)).

Federal facilities, such as military bases or other former defense sites, would have to comply with relevant state and local laws during the superfund process under the text of H.R. 2318. Provisions from H.R. 2226 would require consultation with affected states regarding removal or remedial actions at contaminated sites, formally expand the role of states under CERCLA, and establish a cost-sharing system for state contributions in removal and remediation actions.

The text of H.R. 2279, as approved by the House, is available at http://docs.house.gov/billsthisweek/20140106/CPRT-113-HPRT-RU00-HR2279_xml.pdf.
—*By Anthony Adragna, Bloomberg BNA* **em**

News Focus is compiled from the current edition of *Environment Reporter*, published by the Bureau of National Affairs Inc. (Bloomberg BNA). For more information, visit www.bna.com.

A&WMA's Education Council Webinar Committee is looking for new members!

The Webinar Committee is a great opportunity for young professionals to network with experts in a variety of fields, develop marketing skills, and grow into their own profession.

If you are interested in helping to plan webinars, recruit speakers, and assist with marketing for the growing webinar program, please contact:

Robin Lebovitz, A&WMA Education Programs Associate at rlebovitz@awma.org or +1-412-904-6020. **em**

2014 Webinar Committee
Chair: Carol Clinton
Co-Chair: Ron Huffman
Committee Member: Christine Simmons

Member in the News

Long-time A&WMA member and current Board member **W. Brent Nixon, Ph.D, P.E.**, has been announced as CTLGroup's new President and Chief Executive Officer.

Dr. Nixon will take over the responsibilities currently held by Timothy Tonyan, who has served as Interim President and Chief Executive Officer since June 14, 2013. Dr. Tonyan will serve as Senior Vice President of CTLGroup. In his new role, Dr. Tonyan will report directly to Dr. Nixon and will focus his attention on business development, project management of multidisciplinary teams, promoting CTLGroup's expertise within the industry, and managing of major client accounts.

Dr. Nixon will lead this global expert engineering consulting and material sciences firm into the future with unmatched enthusiasm for the pursuit of technical excellence, client satisfaction and corporate performance. With trusted experience as a 30-year engineer and military veteran in the construction industry, he brings executive management, operational, and business development expertise with highly technical professionals and mission-focused teams in operational, professional service and academic organizations.

In the past 11 years as a Corporate Officer and Vice President of Science and Engineering at Environmental Chemical Corporation (ECC), he was instrumental in the evolution of ECC from a small remediation company into a global design-build, disaster response and remediation firm of 600 employees with annual revenue of $700 million. **em**

In the Next Issue…

Sustainability Reporting

How various industries approach sustainability reporting continues to evolve, frequently differing based on specific industry and/or business focus, and the geographic reach of operations. The March issue will describe how industries approach sustainability reporting and what they've learned from the reporting experience.

Also look for…
PM File
YP Perspective
IPEP Quarterly

JOURNAL

FEBRUARY 2014 • VOLUME 64

Listed here are the papers appearing in the February 2014 issue of *EM*'s sister publication, the *Journal of the Air & Waste Management Association*. For more information, go to www.tandfonline.com/UAWM.

Siting a municipal solid waste disposal facility, Part II: The effects of external criteria on the final decision

Application of magnetically modified sewage sludge ash (SSA) in ionic dye adsorption

Modeling of methane oxidation in landfill cover soil using an artificial neural network

Development of a chemical kinetic model for a biosolids fluidized-bed gasifier and the effects of operating parameters on syngas quality

Evaluation of light-duty vehicle mobile source regulations on ozone concentration trends in 2018 and 2030 in the western and eastern United States

Changes in weather and climate extremes: State of knowledge relevant to air and water quality in the United States

Transverse approach between tunnel environment and corrosion: Particulate matter in the Grand Mare tunnel

Statistical evaluation of a new air dispersion model against AERMOD using the Prairie Grass data set

Open burning and open detonation PM_{10} mass emission factor measurements with optical remote sensing

Comparison of stack measurement data from R&D facilities to regulatory criteria

em • calendar of events

2014

FEBRUARY

20 **A&WMA's Midwest Section Annual Meeting, Overland Park, KS; www.midwestawma.org**

24–27 4C Environmental Conference, Austin, TX; www.4CConference.com

MARCH

Mar 30 – Apr 2 The 29th International Conference on Solid Waste Technology and Management, Philadelphia, PA; www.solid-waste.org

MAY

13–14 Oil & Gas Environmental Compliance Conference – Appalachian Basin, Washington, PA; oilandgas.awma.org

JUNE

24–27 A&WMA's 107th Annual Conference & Exhibition, Long Beach, CA; ace2014.awma.org

AUGUST

19–22 2014 Power Plant Pollutant Control "MEGA" Symposium, Baltimore, MD; megasymposium.org

SEPTEMBER

10–11 Vapor Intrusion, Remediation, and Site Closure, Philadelphia, PA; siteclosure.awma.org

Events sponsored and cosponsored by the Air & Waste Management Association (A&WMA) are highlighted in bold. For more information, call A&WMA Member Services at 1-800-270-3444 or visit the A&WMA Events Web site: www.awma.org/events.

To add your events to this calendar, send to: Calendar Listings, Air & Waste Management Association, One Gateway Center, 3rd Floor, 420 Fort Duquesne Blvd., Pittsburgh, PA 15222-1435. Calendar listings are published on a space-available basis and should be received by A&WMA's editorial offices at least three months in advance of publication.

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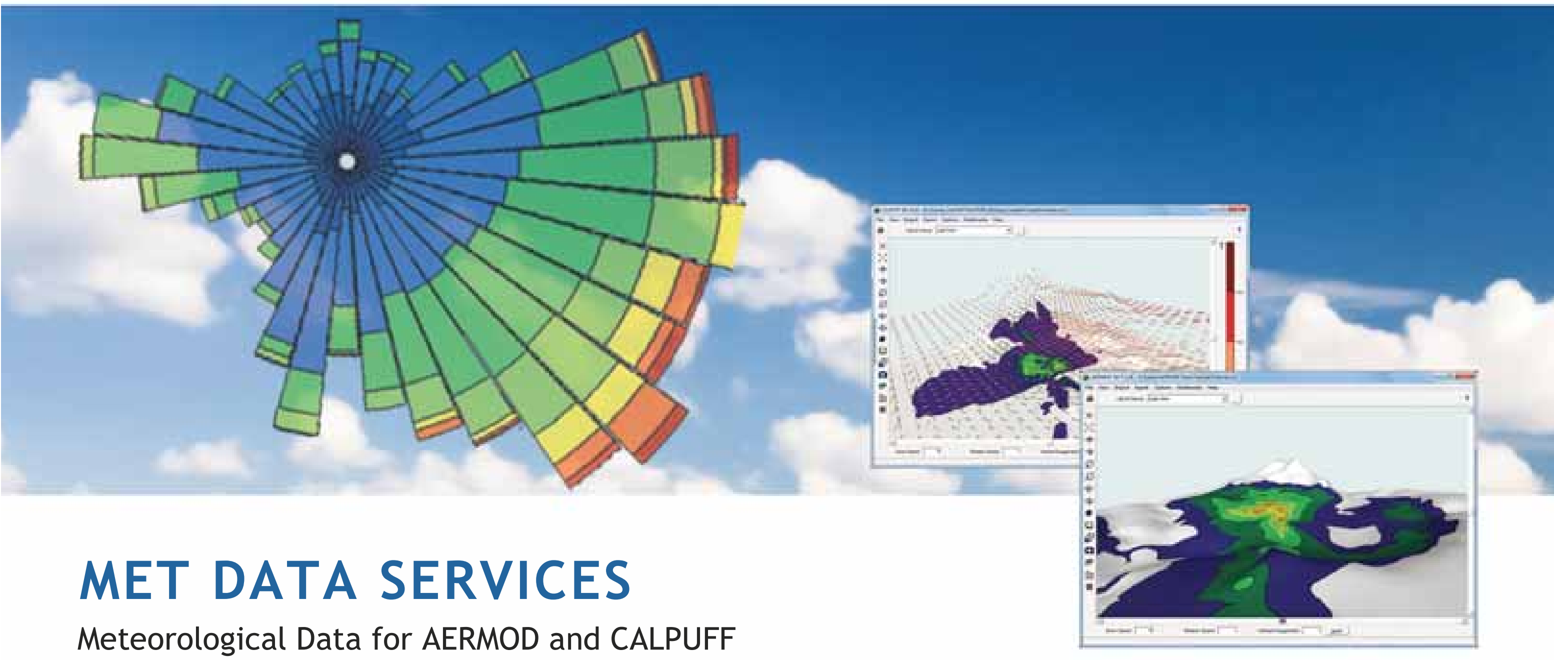

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