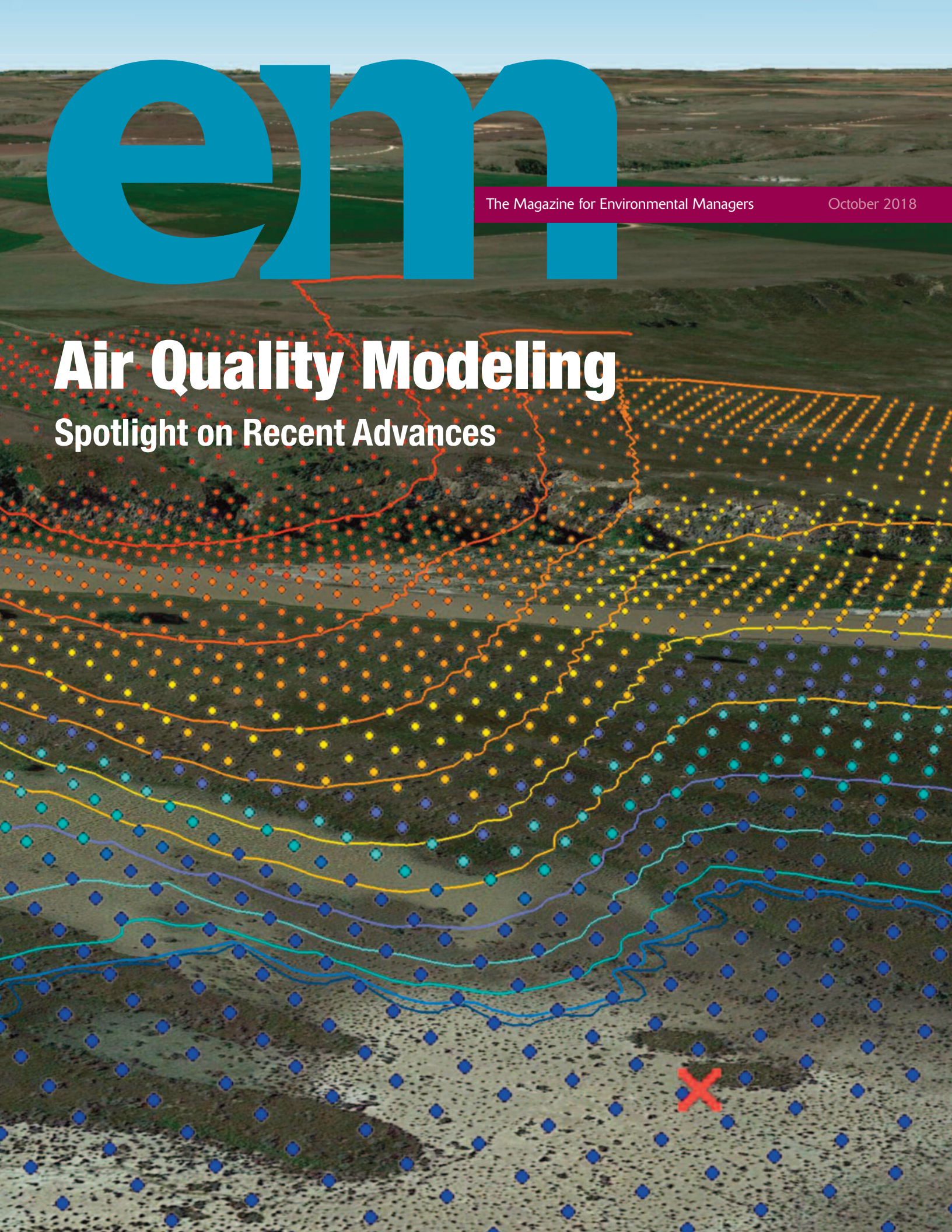
em
The Magazine for Environmental Managers
October 2018

Air Quality Modeling

Spotlight on Recent Advances



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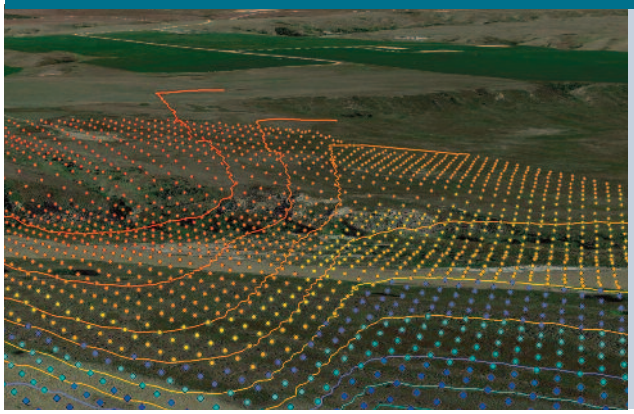
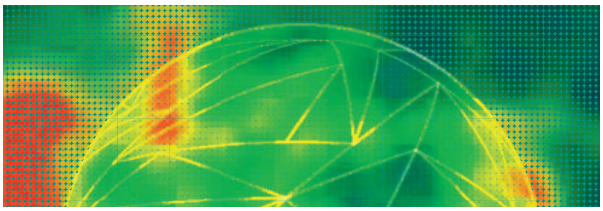


Advances in Air Quality Modeling

by Leiran Biton and Golam Sarwar

The U.S. Environmental Protection Agency (EPA) has completed its modeling guideline updates, but new advances in air quality modeling may spur additional changes. This month's issue of *EM* highlights recent advances in air quality modeling, from dispersion models to next-generation chemical transport models.



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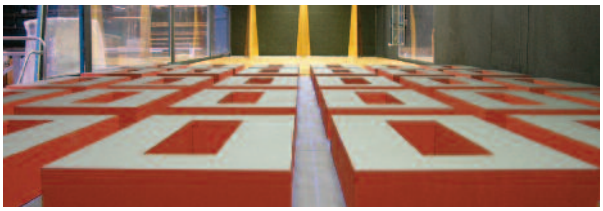

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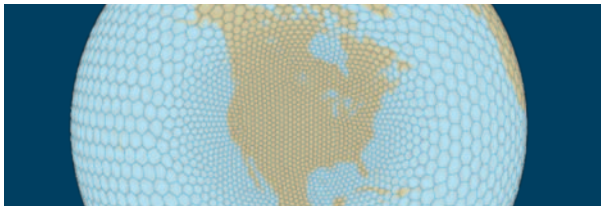

The New Generation of Air Quality Modeling Systems
by Jonathan Pleim, David Wong, Robert Gilliam, Jerry Herwehe, Russell Bullock, Christian Hogrefe, George Pouliot, Limei Ran, Ben Murphy, Daiwen Kang, Wyat Appel, Rohit Mathur, and Elaine Hubal

Advancing Air Quality Forecasting to Protect Human Health
by Daniel Tong and Youhua Tang

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Message from the President:
Building an Online A&WMA Learning Platform
by Chris Nelson

Last Stop: Getting to Know A&WMA's Organizational Members

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Columns

EPA Research Highlights:
Air Sensors 2018: Deliberating Performance Targets Workshop
by Ron Williams, Vasu Kilaru, and Kristen Benedict
A summary of highlights and outcomes from EPA's Air Sensors 2018 Workshop.

Front Cover: Modeling of a hypothetical point source (stack) to show a plume impacting a terrain feature (hill) in the near-field environment.

Credit: Modeling image courtesy of R. Chris Owen (EPA).
Source: Google Earth. 2018.

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Building an Online A&WMA Learning Platform

by Chris Nelson, P.E. » president@awma.org

I spent five years in the mid-2000s reviewing air quality modeling studies for the Minnesota Pollution Control Agency and the science of modeling continues to interest me. I'm excited to read our October issue of *EM* and look forward to additional A&WMA programming that will advance member knowledge on air dispersion modeling. Although I believe that small-scale sensors and other monitoring technology will be a "game changer" for our environmental field, air quality models are still a part of the technical backbone of our work, from State Implementation Plans to project-specific ambient impact analyses. Please enjoy this issue of *EM* and let us know if there are other modeling topics that are important for your organization's success.

Over the past two months, I used this space to lay out ideas for Association work on mentoring and content delivery though modern media. This month, focuses on new learning platforms and their potential application for A&WMA and our members. My hope is that our Association can improve in these areas over the next several years and that improvement will lead to direct member benefits and a more robust A&WMA.

Both our environmental science field and our global economy continue to evolve, often in unpredictable ways. Change is continuous and ongoing learning and professional development has never been more important for individuals. In any profession, people must continue to learn and adapt to new ideas and ways of working. A&WMA has long been a source for member professional development. We will need to adapt too, if we want to be relevant in our marketplace.

In school, my kids use online learning programs to supplement their classroom work. Examples include IXL (https://www.ixl.com/) and Khan Academy (https://www.khanacademy.org/). They lay out topical lessons in a number of areas and can be accessed by anyone with an internet connection. Similarly, websites like Coursera (https://www.coursera.org/) offer advanced learning courses with opportunities to earn certificates and credentials.

Travel budgets are shrinking for nearly everyone and it takes months for some of our state agency colleagues to get approval to travel out of the state. A&WMA already provides high-quality webinar content to meet member needs. I think we could expand our offerings to include on-demand learning on environmental science topics. We may not be able to compete with Silicon Valley startups but, with our core areas of expertise, we could provide real value to our members.

I'll use air dispersion modeling as an example. Some of our members from the consulting world offer high-quality in-person training courses on modeling. Many of these same members support A&WMA by collaborating on webinar content that also enables other members to learn. We could supplement these efforts with online content on air dispersion modeling, available to A&WMA members. Any initial efforts would likely synthesize available Association content and not provide new lessons: past webinars, published articles from *EM* and *JA&WMA*, and conference and workshop proceedings. If organized by topic, a member could improve their knowledge in an organized way and the Association could either develop new programming to fill gaps or partner with other organizations that provide training in a specific area. Members could use A&WMA as a hub for learning and as a gateway to partner organizations.

Any efforts to build an online A&WMA learning platform will start small and build over time. I look forward to working with you to determine what will provide member value and how we can start the development process. **em**

ACE 2019 Technical Program Timeline

November 30, 2018

Abstract Deadline for Professional and Student Platforms, Posters and Panels

January 11, 2019

Notification of Acceptance

January 11, 2019

Student Poster Abstracts Due

February 11, 2019

Author Notification of Presentation Format

March 15, 2019

Drafts Due

April 15, 2019

Final Submissions Due

June 25-28, 2019

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CALL FOR ABSTRACTS

Winds of Change — Environment, Energy & Health

The world is facing numerous challenges with regard to the environment, energy and health that are considered by many as "the global threat of our time". In June 2019, the Air & Waste Management Association (A&WMA) will bring the world's leading experts to Quebec City to develop insights on these important issues and discuss efficacious solutions to bring about needed change.

A&WMA's Annual Conference is recognized as the premier international conference for the latest information on air, climate change, environmental management, resource conservation, and waste with 300+ platform and poster presentations, 35+ panels, and up to 11 concurrent tracks each day.

Abstracts for platform presentations, posters, and panels due November 30.
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- Sustainability and Resource Conservation
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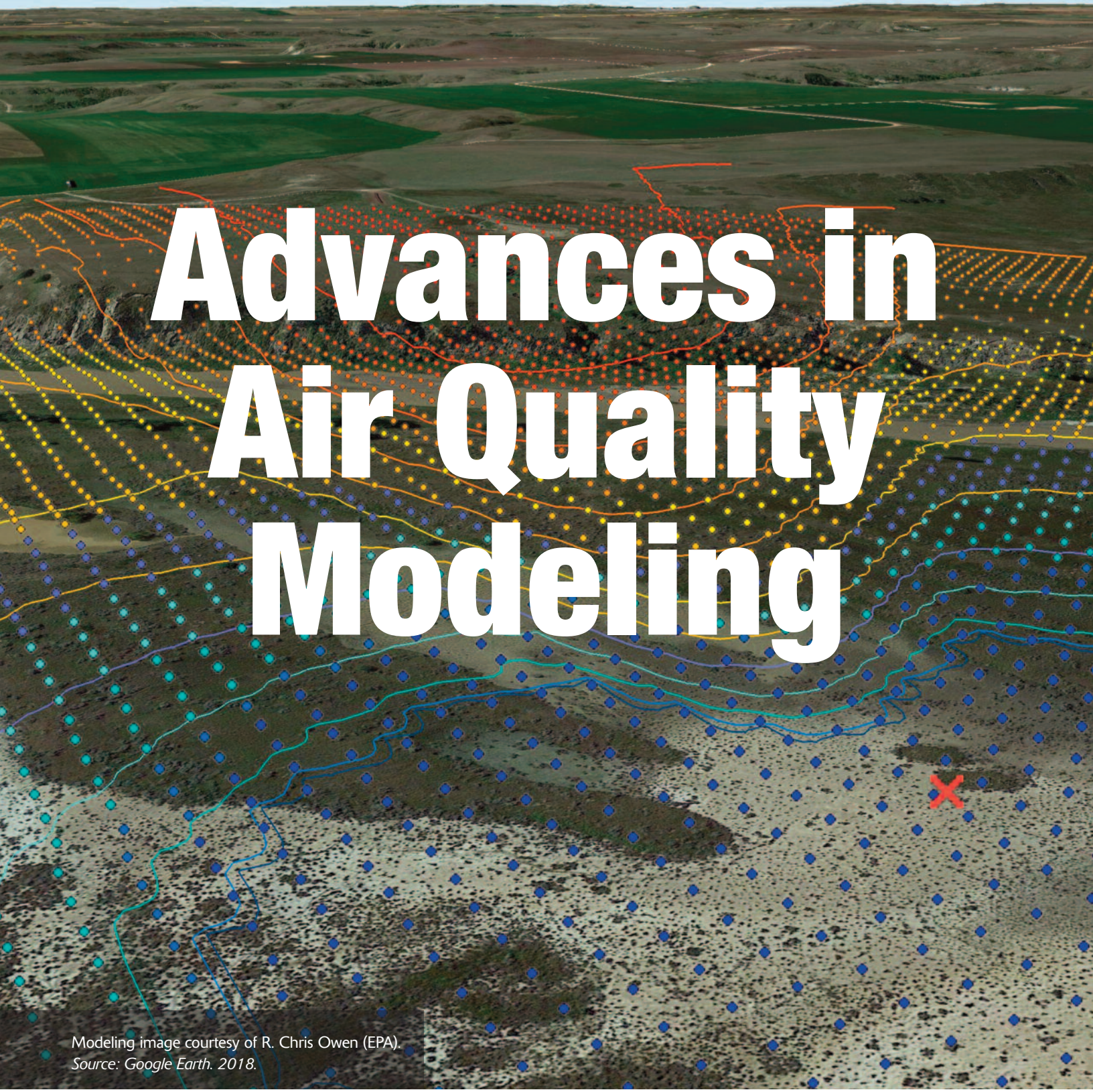
Advances in Air Quality Modeling



Modeling image courtesy of R. Chris Owen (EPA).
Source: Google Earth. 2018.

Spotlighting advances in air quality modeling, from dispersion models to next-generation chemical transport models.

Air quality modeling is of critical importance to inform regulatory and planning activities under the U.S. Clean Air Act (CAA). Due to limitations in spatial and temporal coverage of ambient monitoring networks, air quality models are better able to characterize the ambient impacts of individual sources or demonstrate the adequacy of emissions limits for an existing source. In addition, the impacts of new sources that do not yet exist, and modifications to existing sources that have yet to be constructed, can best be determined through air quality modeling. Therefore, air quality models are relied upon by federal, state, local, and tribal air agencies across a variety of pollutants and CAA programs. For example, dispersion models are used by regulatory agencies to issue permits for new facility operations while ensuring that ambient air quality is protected. Similarly, air quality planners rely on chemical transport models (CTMs) for developing policies to address regional pollutants while still accounting for other factors, such as population growth and economic development.

To effectively serve these purposes, air quality models must continually characterize complex environmental systems that necessitate advances in their science and capabilities. This issue of *EM* is dedicated to better understanding some of the policy-relevant advances in air quality modeling techniques that are currently being developed or proposed.

In the United States, air quality models are applied for regulatory and planning purposes in accordance with the U.S. Environmental Protection Agency's (EPA) *Guideline on Air Quality Models*, published as Appendix W to 40 CFR Part 51. Better known among air modelers as "the *Guideline*," this regulation guides air quality management agencies in using approaches that are based on best practices and demonstrated to be scientifically credible. On January 17, 2017, EPA updated the *Guideline*, *(https://www3.epa.gov/ttn/scram/guidance/guide/appw_17.pdf)* as previewed in *EM*'s October 2016 issue (https://www.awma.org/content.asp?admin=Y–&contentid=240) and detailed in depth in *EM*'s July 2017 issue. (https://www.awma.org/content.asp?admin=Y&contentid=349). Among the most discussed element of the 2017 revision of the *Guideline* is that, for the first time, it addresses the use of models to assess formation of secondary pollutants, such as ozone and secondarily-formed fine particulate matter. As such, tools developed based on information from CTMs are increasingly used to inform permitting of individual sources for the assessment of secondary pollutant formation.

This issue of *EM* is focused on various aspects of the advances in air quality modeling, from science improvements in the American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD), EPA's preferred near-field dispersion model, to planning the next generation of CTMs. The issue dives deep into new thinking about incorporating information from wind tunnels into dispersion models, accounting for moisture in plume rise, use of plume-following models to account for chemical transformation, air quality models for forecasting, and estimating lightning generated oxides of nitrogen.

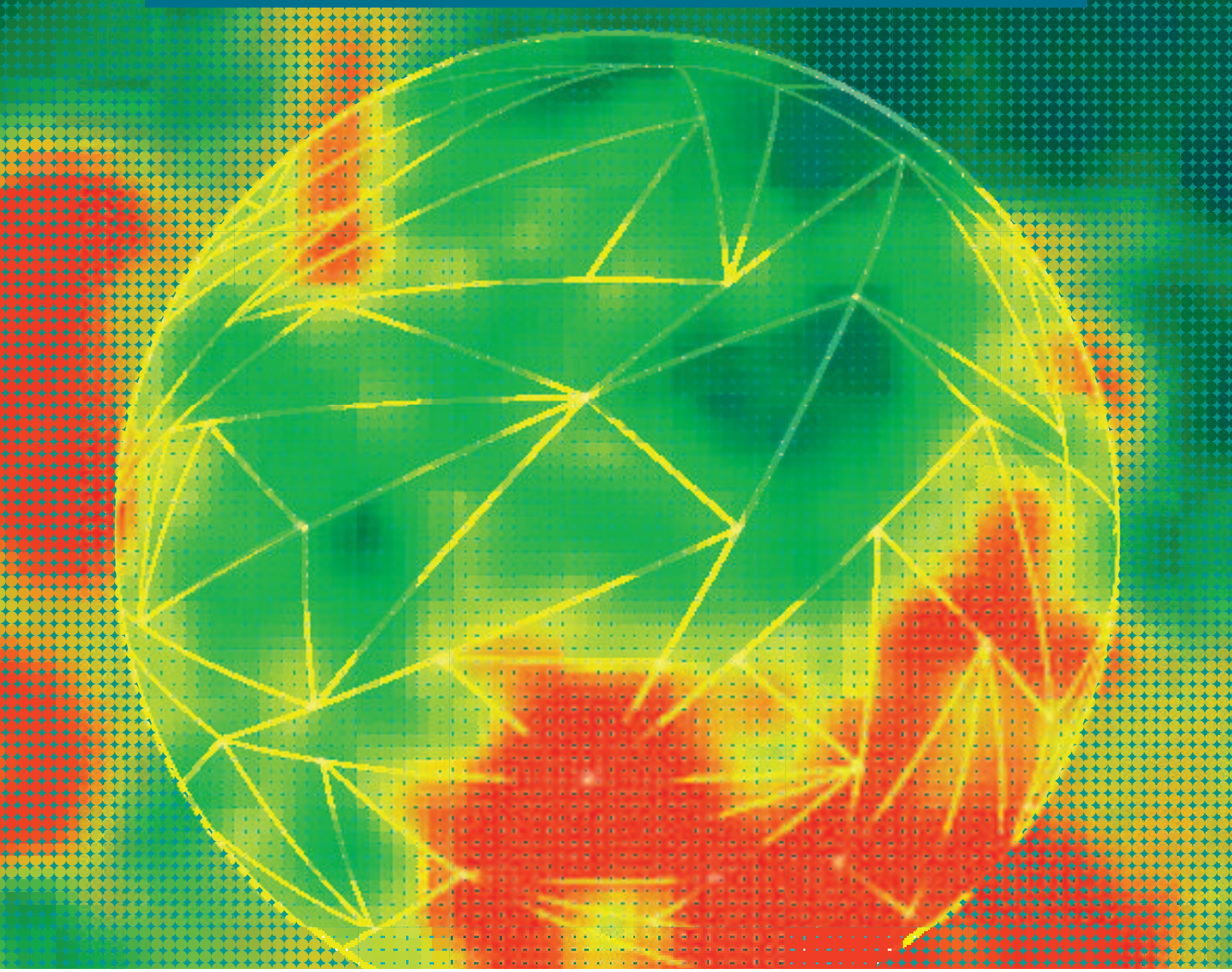
The following articles address these topics:

- "An Overview of the AERMOD Update and Development Plan," by Chris Owen and George Bridgers;
- "Meteorological Wind Tunnels and Dispersion Model Development," by David Heist and Steven Perry;
- "Advances Toward More Accurate Modeling of Moist Plume Rise," by Laura Warren and Robert Paine;
- "SCICHEM: An Alternative Photochemical Model to Calculate Single Source Impacts on Ozone and PM," by Prakash Karamchandani , Ralph Morris, Greg Yarwood, Bart Brashers, Douglas Henn, Ian Sykes, Eladio Knipping, and Naresh Kumar;
- "The New Generation of Air Quality Modeling Systems," by Jonathan Pleim, David Wong, Robert Gilliam, Jerry Herwehe, Russell Bullock, Christian Hogrefe, George Pouliot, Limei Ran, Ben Murphy, Daiwen Kang, Wyat Appel, Rohit Mathur, and Elaine Hubal;
- "Advancing Air Quality Forecasting to Protect Human Health," by Daniel Tong and Youhua Tang; and
- "Lightning NOx Emissions and the Implications for Surface Air Quality over the Contiguous United States," by Daiwen Kang and Kenneth E. Pickering (will appear in next month's issue).

Air quality modeling plays a central and expanding role in informing environmental and public health decision-making. The recent and near-future research and associated scientific advances in air modeling and techniques described in this issue may bolster confidence in air quality modeling for use in environmental decision-making for air quality management agencies, industry, and the public. **em**

Leiran Biton, a physical scientist and air dispersion modeling contact for the U.S. Environmental Protection Agency's (EPA) Region 1 (New England) Office, and **Golam Sarwar, Ph.D.,** a research physical scientist with EPA's National Exposure Research Laboratory (NERL), are both current members of *EM*'s Editorial Advisory Committee. E-mail: **Biton.Leiran@epa.gov; Sarwar.Golam@epa.gov.**

Disclaimer: This article has been subject to technical review by the U.S. Environmental Protection Agency (EPA) and approved for publication. The views expressed by individual authors, however, are their own, and do not necessarily reflect those of EPA. Mention of trade names, products, or services does not convey, and should not be interpreted as conveying, official EPA approval, endorsement, or recommendation.



An Overview of the AERMOD Update and Development Plan

A summary of EPA-identified key areas of improvement to AERMOD based on scientific research related to dispersion modeling.

The U.S. Environmental Protection Agency's (EPA) revision to the *Guideline on Air Quality Modeling*[1] includes enhancements to the formulation and application of the American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD) Modeling System.[2] The final rule was published in the *Federal Register* on January 17, 2017, and the effective date of this action was deferred to May 22, 2017. Following this promulgation, EPA is committed to continue improving the science and performance of its preferred near-field dispersion model to better inform regulatory applications under the U.S. Clean Air Act.

To facilitate future development of AERMOD, EPA has released the AERMOD Development and Update Plan.[3] The plan has four main elements: background on the history of AERMOD development, overview of the current development process, review of the most recent AERMOD updates, and discussion of potential future updates. On this last item, EPA has identified several areas for improvement to AERMOD based on recent scientific research related to dispersion modeling and known issues or limitations in the currently available and/or applicable models for various regulatory needs. These issues are discussed within the plan in the form of white papers and summarized here.

The AERMOD Development and Update Plan

The plan has three overarching goals. First, it is meant to facilitate engagement with the modeling community on AERMOD development. AERMOD was initially developed through a collaborative effort lead by EPA and the American Meteorological Society (AMS), with the contributors from AMS representing both industry and academia and scientific information derived from research and development conducted by groups other than EPA. This development process continued through the proposal and promulgation in 2005 of AERMOD as a preferred model.

EPA has subsequently led the collaboration with the modeling community assisted by annual workshops and conferences. Thus, it is critical for future AERMOD development that there is community input that supports the regulatory process that leads to promulgated scientific updates to AERMOD. This can be facilitated by making EPA's priorities for model development clear and transparent. Through the plan, EPA is formally seeking continual input and feedback on the planned updates to ensure its priorities and associated model updates match community needs.

Second, one of the goals of the plan is to identify gaps in the underlying science or evaluation of specific model updates so that EPA can more fully leverage existing model development and improvement opportunities and foster collaboration opportunities. Third, by laying out its model development process, EPA believes the modeling community can better engage in the process of model updates though focused alternative model approvals. EPA can then leverage the information and data supporting these alternative model approvals to develop regulatory scientific model updates.

Alpha and Beta

Starting with AERMOD version 18081, EPA established "alpha" and "beta" options, which are meant to guide model updates toward meeting the requirements for a preferred model in the *Guideline*. Specifically, alpha options are scientific improvements that reflect developmental or experimental research and are not meant for regulatory application. Instead, alpha options are a mechanism for EPA to provide potential scientific model updates to the modeling community for broad testing and evaluation, but without implying the alpha options are already approved for regulatory application.

Conversely, the beta options have been determined by EPA to have had sufficient review to meet the requirements for

In Next Month's Issue…

Sustainability

The November issue focuses on the complex world of sustainability, with a look at how companies are building their own sustainability strategies and solutions that incorporate aspects such as life-cycle assessment (LCA) and eco-design; corporate social responsibility (CSR); waste, energy, and water footprinting; supply chain sustainability; science-based corporate goals and metrics; and green marketing and communications.

consideration as an alternative model when there is no preferred model (i.e., the requirements applied by EPA for scientific updates to the model). Thus, beta options are potentially available for regulatory applications, though using them requires alternative model approval by the appropriate EPA Regional Office with concurrence from the Model learinghouse.

Section 3.2.2(e) of the *Guideline* states that an alternative model meets EPA's requirements when:

1. The model or technique has received a scientific peer review;
2. The model or technique can be demonstrated to be applicable to the problem on a theoretical basis;
3. The databases that are necessary to perform the analysis are available and adequate;
4. Appropriate performance evaluations of the model or technique have shown that the model or tech nique is not inappropriately biased for regulatory application; and
5. A protocol on met-hods and procedures to be followed has been established.

These are essentially the same criteria EPA uses when considering scientific formulation updates to preferred models, for example the adjusted u* option promulgated with AERMOD version 16216. When model options are identified by EPA as beta options, those options will have met these criteria and potentially be available as a preferred option through the next regulatory action regarding science updates to AERMOD. By following this paradigm, alternative model efforts and work to create beta options can be fully leveraged to bring maximum benefit to the stakeholder community through timely and policy relevant updates to the regulatory version of the model.

EPA White Papers

EPA first released white papers on its priorities for scientific improvements to AERMOD in 2017, prior to the agency's annual Regional, State, and Local Modelers' Workshop. These original white papers have been updated based on progress in EPA's model development and feedback from the public and are now incorporated into the plan. The white papers provide more detail on potential model improvements, including an overview of each issue, a literature review of active research and development, and planned paths forward on these issues. A summary of the current series of white papers is provided below.

Treatment of Low Wind Conditions

To improve model predictions during low wind conditions, EPA promulgated the adjust u* option. The current version of AERMOD also includes an alpha LOW_WIND option designed to aid in further exploring potential improvements in model predictions under these conditions. The alpha LOW_WIND option will allow for adjustments to the following parameters:

- **Minimum σv value.** The default value for the lateral turbulence (σv) in AERMOD is 0.2 m/s, but can be adjusted from 0.01 to 1.0 m/s with this option.
- **Plume meander/Upper limit of FRAN.** The default upper limit for the fraction of the random plume (FRAN) in AERMOD is 1.0, but can be adjusted from 0 (no meander) to 1.0.
- **Minimum wind speed.** The default value in AERMOD is 0.2828 m/s, which is consistent with the model formula tion that relates the minimum wind speed to the minimum σv. While the minimum wind speed can be adjusted from 0.01 to 1.0 m/s under this option, the formulation consistency with σv should be considered in any adjustments.

Saturated Plumes

AERMOD formulations for plume rise are based on an essentially dry plume. Thus, the model does not account for any additional heat released due to condensation within the plume. However, alternate plume rise equations exist that consider additional plume rise due to condensation. EPA is reviewing proposed uses of these alternative plume rise formulations for application to AERMOD.

Downwash Algorithms

A significant amount of experimental work has been done to better characterize various aspects of downwash. This work includes extensive wind-tunnel studies by both EPA and industry stakeholders and large eddy simulations by EPA to develop new databases to examine the formulation of AERMOD's PRIME downwash algorithms. Based on this work, EPA plans to release updates to PRIME as alpha options in the next version of AERMOD for further evaluation by the modeling community.

Nitrogen Dioxide Modeling Techniques

Over the last five years, three new nitrogen dioxide (NO_2)-focused field studies have been conducted to provide data for evaluation and development of NO_2 algorithms in AERMOD and other dispersion models.[4] Additionally, there is currently work to add a new Tier 3 option to AERMOD based on an algorithm currently used in atmospheric dispersion modeling syatems.[5] EPA is using these new field databases to further evaluate the existing NO_2 modeling techniques in AERMOD, and possibly developing new techniques based on information from these studies.

The white papers provide more detail on potential model improvements, including an overview of each issue, a literature review of active research and development, and planned paths forward on these issues.

Mobile Source Modeling

EPA is currently working to integrate the R-LINE model[6] into AERMOD. This will include a new line source option based on the dispersion parameterizations in R-LINE. EPA will release this new line source option in the next release of AERMOD as a beta option.

Overwater Modeling

The Offshore and Coastal Dispersion Model Version 5 (OCD)[7] is currently EPA's preferred model for estimating near-field air pollutant impacts from overwater emission sources. However, OCD does not include the more recent scientific advancements reflected in AERMOD. EPA is considering scientific updates for AERMOD related to platform downwash, shoreline/coastal fumigation, and bettercharacterization of the marine boundary layer. These updates consider leveraging existing models and evaluations (e.g., using the Mesoscale Model Interface Program [MMIF][8] to extract marine boundary layer characteristics from prognostic meteorology), development of new field studies with other federal partners, and applying related research to overwater modeling needs (e.g., applying updates from the current downwash updates to overwater sources).

Additional Research

EPA has identified other areas below that were considered for additional research and development; however, we feel these areas need additional review and further development for consideration in future versions of the plan. They are:

- Theta* calculation, pass through from AERMET, and interactions with other boundary layer characteristics;
- Scientific improvements for special plume rise associated with buoyant line sources; and
- Improvements to existing deposition and depletion algorithms in AERMOD.

Conclusion

EPA seeks to improve the model development process by communicating its plans for model updates in the AERMOD Development and Update Plan. The goal of this effort is to increase feedback on these updates and to leverage collaboration opportunities with the modeling community for future model development. EPA plans to update the plan on approximately an annual basis, based upon the progress of model development, advances in dispersion-related science, and feedback from the community as part of the ongoing model development process. **em**

R. Chris Owen, Ph.D., and **George M. Bridgers** are Physical Scientists, both with the U.S. Environmental Protection Agency, Raleigh, NC. E-mail: **Owen.Chris@epa.gov.**

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8. Mesoscale Model Interface Program (MMIF). See https://www.epa.gov/scram/air-quality-dispersion-modeling-related-model-support-programs#mmif.

Meteorological Wind Tunnels
and Dispersion Model Development

A look at the vital role that wind tunnels play in the development of applied dispersion models.

Air pollution dispersion models are indispensable tools for meeting and maintaining air quality standards. Models can be used to assess control strategies, regulate emissions, and evaluate mitigation options, particularly during the planning and permitting phases of projects. While some of this work can be accomplished through atmospheric monitoring strategies, in many circumstances, estimates of future impacts are needed before a facility is built or before investing in a mitigation strategy. Air dispersion models for routine applications are generally steady-state, Gaussian representations of varying atmospheric conditions and pollution patterns. In practice, the variation over a limited length of time (typically, one hour) is sufficiently well-represented by steady-state conditions to characterize pollutant concentrations for most applications. Though conceptually simple, modern steady-state, dispersion models used in air pollution work[1-3] must incorporate variations in wind speed and direction, surface conditions (from smooth, open fields to urban landscapes), atmospheric stabilities (ranging from stable night-time conditions to sunny daytime situations), source types (e.g., smoke stacks, roadways, industrial sites), and source characteristics (e.g., hot buoyant releases, dense gas releases).

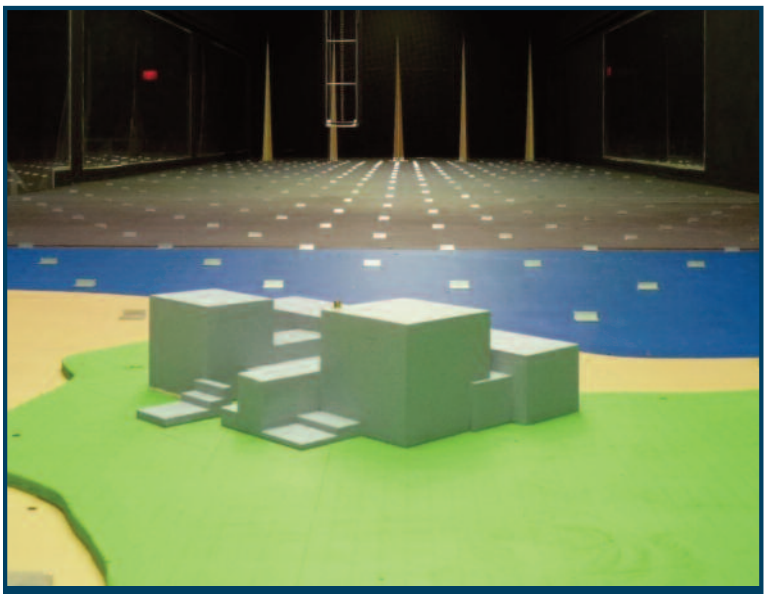


Figure 1. A 1:150 scale model of a coastal nuclear power plant installed in EPA's meteorological wind tunnel. The tall, slender triangular spires in the background and roughness elements visible on the floor of the tunnel initiate, develop and stabilize the simulated atmospheric boundary layer.

Developing dispersion models requires an understanding of the complex flow and dispersion processes inherent in the interaction of pollutant plumes and the atmosphere. Observational methods to advance our understanding of these processes include field measurements and laboratory studies (wind tunnel and water channels). While field studies have the benefit of being performed in the real atmosphere, wind tunnels and other laboratory experiments provide controlled conditions where a more complete characterization of the plume and phenomena affecting the plume can be obtained. This article discusses the vital role that wind tunnels play in the development of applied dispersion models.

What Is a Meteorological Wind Tunnel?

Meteorological wind tunnels are specially designed for modeling the atmospheric boundary layer to study phenomena such as wind loading on buildings and pollutant dispersion. The development of a scaled model of a deep, atmospheric boundary in which to perform experiments distinguishes meteorological wind tunnels from aeronautical tunnels where the goal is usually to provide a uniform approach flow for testing the aerodynamic behavior of objects such as aircraft wings. In a meteorological wind tunnel,[4] a long fetch is required to develop the scaled atmospheric boundary layer after the flow first encounters obstacles (e.g., trip fences, triangular spires) that remove momentum from the lower part of the flow to initiate a vertical profile of wind speed similar to that of the atmosphere (see Figure 1). The floor of the tunnel is covered with small obstacles (roughness elements) to develop the appropriate turbulence levels and bring the flow into equilibrium as it reaches the portion of the tunnel where experiments take place (the test section).

Other distinguishing features of meteorological wind tunnels are their large scale and relatively low wind speeds. The tunnel must be large enough to study a scaled replica of the situation of interest (e.g., a power plant and surrounding topography) at a scale where dispersion phenomena can be measured with a high-fidelity to full-scale conditions. This typically results in wind tunnels with cross sections of several meters square with a fetch of tens of meters (e.g., EPA's wind tunnel is 3.6 m wide, 2.1 m high with a fetch of 18 m).[4] Model scales for dispersion experiments typically range from 1:100 to 1:1000, allowing the experimental design to balance considerations of boundary layer depth, downwind distance to study the plume, and the level of detail required in the model buildings or other objects of study.

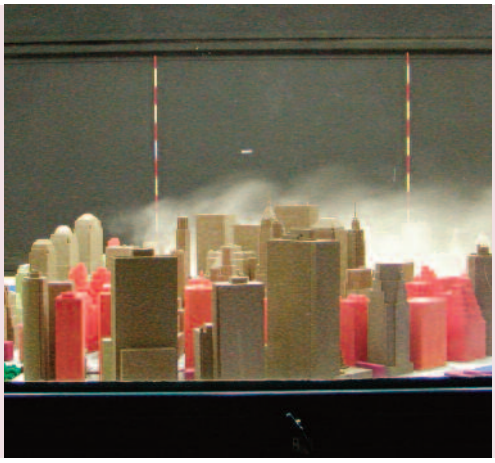
Wind speeds used for dispersion studies, generally less than 8 m/s, are at the lower end of the range used in wind tunnel work. If the experiment includes buoyancy effects (e.g., very hot power plant plumes or dense gas releases), it may be

necessary to maintain a low wind speed to enhance the relative strength of those buoyant forces. Also, to appropriately simulate the stack-to-freestream momentum ratios for point releases, low winds may be required.

Other factors (e.g., Reynolds number independence, approach flow roughness) must be accounted for in each experimental design.[5] Many wind tunnels are designed for neutral atmospheric conditions, but special facilities for stable and convective conditions are also in operation (e.g., the EnFlo wind tunnel in the United Kingdom).[6]

Development of Dispersion Model Algorithms

In addition to characterizing the atmospheric boundary layer approaching a pollutant source, dispersion models must be able to adequately simulate many special features related to the source or its immediate surroundings that can significantly affect the resultant distribution of pollutant concentration. One important example of this is building downwash. The complex flow and turbulence fields surrounding buildings and structures and the associated "downwashing" of nearby pollutant releases has been recognized for years as a situation that



The complex flow and turbulence fields surrounding buildings and the associated "downwashing" of nearby pollutant releases has been recognized for years as a situation that results in some of the highest short-term, ground-level concentrations.

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results in some of the highest short-term, ground-level concentrations.

Since Gaussian plume models are incapable of simulating the complexities of the distorted flow field around a building, the overall influences of the building on the plume must be parameterized. Important parameterizations involving the building wake dimensions, enhancement of turbulence, velocity deficits, and the exchange of pollutants in and out of the wake region have been identified from past wind tunnel studies. These parameters are functions of the surrounding surface conditions, building shape and dimensions, source height and location, and wind direction, all of which can be controlled and simulated with scaled models within a meteorological wind tunnel.

Wind tunnel studies of flow and dispersion around buildings have been performed for decades and each has advanced our understanding of the complex building downwash problem. For example, in the downwash algorithm used in the AERMOD dispersion model,[7] the length of the near-wake zone,[8] the height of the wake,[9] and the streamline deflection around buildings[10] have all been determined from wind tunnel experiments. Recent evaluations of AERMOD against field measurements have highlighted performance issues for long and narrow building shapes. To address this apparent shortcoming and provide the basis for improving the existing parameterization for elongated buildings, Perry et al.[11] reported on an extensive wind tunnel study involving a variety of building shapes, source heights and locations, and wind directions. Analysis of these recent measurements in concert with complementary large eddy simulations[12] resulted in several proposed enhancements to the AERMOD downwash algorithms.[13] As this development work continues to include even more complex flows around industrial and urban building clusters, the need for wind tunnel measurements is even more apparent.

Conclusion

Just as wind tunnels have been instrumental in the development of building downwash algorithms, they have played an equally important role in formulating models for dense gas dispersion, complex terrain, urban landscapes, near-road environments, and industrial sites. Meteorological wind tunnels, with their unique capabilities, remain vital tools for the development and evaluation of air quality models to enhance our ability to maintain air quality standards. **em**

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Characterization of moist plume rise.
Photo credit: Robert Paine.

Advances Toward More Accurate Modeling of Moist Plume Rise

An evaluation of the AERMOIST pre-processor used for modeling moist plume rise.

Most commonly used modeling systems, such as AERMOD (U.S. Environmental Protection Agency's [EPA] preferred short-range model),[1] are "dry" plume models in which it is assumed that plume moisture effects are negligible. In general, these models have not been evaluated for databases involving stacks that utilize pollution control technologies that increase plume moisture (i.e., scrubbed stacks). Model evaluation databases used by EPA to examine AERMOD model performance have generally not considered scrubbed stacks. The dry plume assumption[2] does not consider that, "significant moisture content of the scrubbed plume upon exit leads to important thermodynamic effects during plume rise that are unaccounted for in the usual dry plume rise theories." Accounting for these thermodynamic effects has become more important with the widespread use of pollution controls that inject considerable water vapor into the plume exhaust and increasingly stringent short-term air quality standards (e.g., 1-hr sulfur dioxide [SO_2]).

Most dispersion models do not consider the additional plume rise associated with moisture in plumes. AERMOIST is a source characterization technique that is applicable to most dispersion models, not just AERMOD, because the Briggs plume rise formulation that AERMOIST incorporates is universally applicable. Therefore, its use outside any given model (as a pre-processor) does not render it obsolete when the model itself changes. The AERMOIST formulation, which is based upon an extensively tested moist plume rise model called IBJpluris,[3] has been peer-reviewed and published[4] in open access scientific literature. Recently, EPA has recognized the importance of accounting for moisture in plumes through the release of AERMOD development white papers, one of which addresses saturated plumes.[5]

Formulation of AERMOIST

AERMOIST makes use of a European validated plume rise model called "IBJpluris" that estimates moist plume effects and accurately predicts the final rise of a moist plume.[3,6] Field evaluation results have been reported for the IBJpluris model involving photographic, light detection and ranging (LIDAR), and aircraft measurements through moist plumes emitted by stacks and cooling towers.[6] Another evaluation indicated that IBJpluris accurately represents the impacts of heat of condensation on symmetric chimney plume rise.[7]

Plume rise effects derived using IBJpluris are transferred to "dry models" like AERMOD through a pre-processor (AERMOIST) that runs IBJpluris with a dry plume assumption, as well as with the actual moisture content to obtain the change in the plume rise, and by inference, the difference in the effective buoyancy flux for the moist plume. This difference (expressed as a ratio) is transferred to a dry model by adjusting the hourly input stack temperature to obtain the appropriate adjustment to the buoyancy flux. Ambient temperature and relative humidity, which are used in the computation of the equivalent dry plume temperature, are obtained from the routine meteorological input file.

AERMOIST uses constant stack parameters. However, hourly-varying stack parameters can also be processed with the AERMOIST technique if AERMOIST is first run for multiple stack exhaust conditions over the range of each source's operations. Then, an interpolation procedure determines, on an hourly basis, an appropriate value for the equivalent dry plume hourly stack temperature.

Evaluation of AERMOIST

The IBJpluris plume rise model has been evaluated in numerous model validation studies.[6,7] These model evaluation studies included a variety of source types, such as power plant stacks, cooling towers, and a water tank tested in laboratory conditions.

Of particular interest are the power plant model evaluation studies. For example, a three-day field experiment was performed at the La Coruna power plant in Spain, a 1,400-MW coal-fired power plant with a 356-m stack. A second field experiment was performed for the Castellon

AERMOIST makes use of a European validated plume rise model that estimates moist plume effects and accurately predicts the final rise of a moist plume.

power plant on the east coast of Spain. The Castellon plant operated four oil-fired units at the time of the study with two 150-m stacks. The stack moisture contents of La Coruna and Castellon were approximately 11 percent and 5 percent, respectively.

Plume rise was also examined during a field campaign at the Belchatow power plant in Poland where, at the time of this experiment in 1983–1985, there were six 360-MW units in operation exiting out one 300-m stack and three cooling towers were also in operation. Plume rise information was evaluated for the stack with a stack moisture content of 25 percent. Satisfactory model evaluation results were shown for these power plant model evaluation studies.[6,7]

A model evaluation for AERMOIST used as a pre-processor to AERMOD has also been conducted using two databases involving coal-fired power plants with flue gas desulfurization controls for SO_2 emissions and several monitors in the vicinity. The two databases involve the Gibson Generating Station (Indiana) operated by Duke Energy with four SO_2 monitors within several kilometers of the station, and the Great Plains Synfuels Plant area with five SO_2 monitors in the vicinity of Beulah, North Dakota. An evaluation study for these field databases using low wind options, but not AERMOIST, has been separately published.[8] Additionally, AERMOIST evaluations have been submitted as supporting material to the attainment demonstration for the Indiana, PA, non-attainment area for the 2010 SO_2 NAAQS.[9,10]

The Gibson Generating Station evaluation provided a three-year period of hourly-varying emissions, a network of ambient monitors, wet gas desulfurization controls, and tall stack configuration. The 1-hr SO_2 model impacts for this flat terrain setting were compared to the monitoring data followed by a model-to-model comparison based on the characterization of the source plume (moist vs. dry). The modeling results indicate that the model over-prediction without consideration of plume moisture is reduced on the order of about 10 percent if plume moisture is considered. Better agreement in modeled to monitored concentrations was the result of plume rise increases of as much as 24 percent.

The North Dakota evaluation was conducted using a two-year field study database for a group of sources in both simple and elevated terrain to evaluate model performance for moist versus dry plumes. This group of sources was an ideal candidate given the multi-year period of hourly-varying emissions, a clustered network of ambient monitors, wet gas desulfurization controls, and tall stack configuration. The model-to-model comparison based on the characterization of the source plume (moist vs. dry) demonstrated a 1-hr SO_2 model over-prediction when plume moisture was not considered. This model over-prediction was reduced in a manner similar to that of the Gibson study when plume moisture was considered.

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Future Direction for AERMOIST Development

Based upon comments received from some EPA reviewers for an initial evaluation of an attainment demonstration, the authors are planning specific enhancements to the AERMOIST modeling system. A brief summary of these enhancements and the issue that each will address is provided below.

Discussion of how AERMOIST handles sources with plumes that are not completely saturated. The user documentation will be improved to indicate that AERMOIST automatically adjusts to the plume rise and moisture conditions. The real saturation effect occurs after the plume leaves the stack; it does not need to be saturated inside the stack to be saturated in the ambient environment. In general, the user should err on the low side for stack moisture content if a range is presented, to account for any variation. The use of AERMOIST for emission sources with stack moisture contents lower than approximately 10 percent would result in a minimal effect, and AERMOIST would usually not be applied for these cases.

Representativeness of ambient temperature and relative humidity data. The AERMOIST user documentation will be improved to indicate that its sensitivity to the ambient temperature is low, but the relative humidity is more important. For low-lying airports, there could be a tendency for the relativehumidity readings to be locally high, especially at night with nocturnal drainage flows. AERMOIST users are recommended to avoid the use of low-lying airports and may elect to utilize prognostic meteorological data to obtain elevated relative humidity estimates for use in AERMOIST.

Limiting the magnitude of temperature adjustments. The authors intend to update AERMOIST to have a user-defined maximum adjustment to the stack temperature (default maximum is 50 K) to address theconcern that some stack temperature adjustments are too large. This change would be "conservative" in the sense that the additional plume rise estimate would be limited.

Additional evaluations and a peer-reviewed paper. The authors plan to have discussions with the EPA Office of Air Quality Planning and Standards regarding additional AERMOIST evaluations and a peer-reviewed paper.

Conclusion

The AERMOIST pre-processor provides the capability for dry models like AERMOD to account for additional plume rise with moist plumes using an equivalent plume temperature. EPA has recognized the importance of representing plume moisture in its release of the saturated plume white paper. In their review of AERMOIST, use of a plume temperature adjustment to account for enhanced plume rise was described to be "theoretically plausible." Arguments have been made to incorporate AERMOIST into AERMOD in the future; however, this would restrict its use from other models and would be a very ambitious task as it implements an imbedded model, IBJpluris. Since AERMOD, as well as other models such as the Second Order Closure Integrated Puff Model with Chemistry model (SCICHEM), the Comprehensive Air Quality Model with Extensions (CAMx), and the Community Multiscale Air Quality modeling system (CMAQ) are considered dry models, this treatment should be available as a pre-processor for any model using the Briggs plume rise equations. **em**

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SCICHEM: An Alternative Photochemical Model to Calculate Single Source Impacts on Ozone and Fine Particulate Matter

by Prakash Karamchandani, Ralph Morris, Greg Yarwood, Bart Brashers, Douglas Henn, Ian Sykes, Eladio Knipping, and Naresh Kumar

A demonstration of a photochemical Lagrangian puff model that can be used to calculate the impacts of single sources on secondary pollutants, such as ozone and fine particulate matter. The model, referred to as SCICHEM, includes detailed treatments of atmospheric chemistry that are comparable to those implemented in photochemical grid models traditionally used in regulatory modeling of secondary pollutants.

While photochemical grid models (PGMs) are well established, they are resource-intensive. A newer model—Second-order Closure Integrated puff model with CHEMistry, or SCICHEM—requires significantly fewer computing resources than traditional PGMs and can be used as an alternative photochemical model when resource constraints make it impractical to perform photochemical grid modeling to assess the impacts of single sources on secondary pollutants. Recent revisions to air quality modeling guidelines provide the impetus for developing alternative approaches to single-source modeling.

On January 17, 2017, the U.S. Environmental Protection Agency (EPA) published revisions to the *Guideline on Air Quality Modeling,*[1] also referred to as Appendix W, in the *Federal Register* that was effective May 22, 2017. One update in the revised guideline is to the approach for treating ozone (O_3) and secondary fine particulate matter ($PM_{2.5}$) impacts from proposed new or modified sources under the Prevention of Significant Deterioration (PSD) permitting program. The revised guideline recommends a two-tiered screening approach for permit-related program demonstrations rather than establishing a single preferred model.[1] As detailed in Section 5 of the guideline, both of these tiers involve the use of chemical transport models (CTMs) with state of the science photochemistry.

The recommended approach for Tier 1 demonstrations would utilize CTMs to provide sensitivity estimates (from existing or newly performed modeling) of O_3 or secondary $PM_{2.5}$ responsiveness to precursor emissions. To facilitate this assessment, EPA has published draft guidance for using Modeled Emission Rate Precursors (MERPs) for Tier 1 screening of single-source contributions to ozone and secondary $PM_{2.5}$ by emissions of nitrogen oxides (NOx, the sum of nitric oxide and nitrogen dioxide; i.e., $NO + NO_2$), sulfur dioxide (SO_2) and volatile organic compounds (VOCs).[2]

The recommended Tier 2 approach would directly utilize CTMs to develop quantitative estimates of the impacts of a new or modified source.[3] CTMs include photochemical grid models as well as Lagrangian puff models with the requisite treatment of processes governing the formation of secondary pollutants from their precursors. As stated in the preamble to the 2017 revised guideline, EPA considers that use of photochemical CTMs for such purposes is scientifically appropriate and practical to implement.

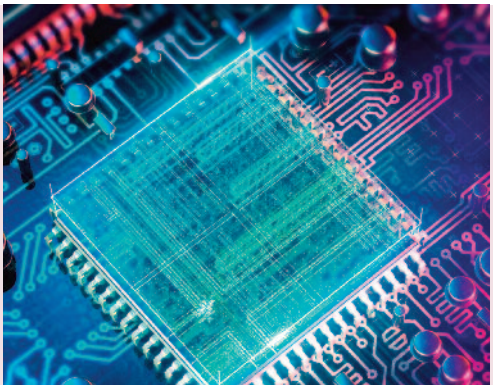
On August 4, 2017, EPA[4] published a memorandum on an alternative model demonstration that justified the use of two specific PGMs for Tier 2 modeling analysis, namely the Community Multi-scale Air Quality (CMAQ)[5] and the Comprehensive Air-quality Model with extensions (CAMx).[6] Below is a similar demonstration of SCICHEM capabilities as an alternative photochemical CTM for Tier 2 single source impact assessments.

SCICHEM Formulation

SCICHEM is an open-source Lagrangian photochemical CTM that has been built by adding chemistry modules from CMAQ and CAMx to the Second-order Closure Integrated PUFF (SCIPUFF) dispersion model. SCIPUFF uses three-dimensional Gaussian puffs to represent the potentially complex three-dimensional, time-dependent plume from one or several sources.[7] The diffusion parameterization is based on second-order turbulence closure theories, which provides a dispersion representation for a wide range of conditions. The model has been applied on local scales up to 50-km range[8] and on continental scales up to 3,000-km range.[9,10] The second-order closure algorithm was demonstrated to provide better model performance than either empirical algorithms, such as the Pasquill-Gifford-Turner (PGT) method, or first-order closure algorithms that use similarity theory to relate dispersion coefficients to micrometeorological variables.[11] The latest version of SCIPUFF that is available in SCICHEM incorporates recently developed enhancements for puff dispersion to accurately capture dispersion in the convective boundary layer.[12]

The current (at the time of preparation of this article) public release of SCICHEM is available on GitHub (https://www.github.com/epri-dev/SCICHEM/releases) as SCICHEM 3.1. The chemistry modules in SCICHEM 3.1 include detailed chemistry modules similar to those used in CAMx and CMAQ. Other recent science updates in SCICHEM 3.1 include a new dry deposition scheme for gas-phase species and an updated inorganic aerosol module. The next version, SCICHEM 3.2, is scheduled for release in fall 2018 and includes science and efficiency updates along with updated pre-processors and post-processors based on feedback from the modeling community.

Lagrangian models, such as SCICHEM, are inherently well-suited to simulating impacts from a single-source because they explicitly simulate the downwind impacts of the "single-source" emissions. SCICHEM represents each plume as a sequence of puffs and calculates source plume impacts in a single model run without having to simulate all other sources. However, unlike PGMs, which include emissions from all sources within the model domain and thus can provide a realistic background chemical environment for a single source assessment, SCICHEM needs information about the background concentrations encountered by the source plume during downwind transport, dispersion and chemical transformation. SCICHEM can use temporally and spatially



The next release, SCICHEM 3.2, will include a processor that can construct background fields using available PGM outputs from previous studies for any domain of interest.

varying background concentrations to more realistically simulate the chemical transformation of pollutants emitted from single sources. The background concentrations for SCICHEM can be generated by running a PGM or using existing PGM outputs if available.

SCICHEM accounts for chemical interactions among puffs that overlap each other, which enables SCICHEM to realistically simulate overlapping plumes from clusters of sources; that is, SCICHEM allows overlapping plumes to compete for available background oxidants and ammonia and thus avoids over-estimating chemical transformation rates due to "double-counting" the influence of the available background. The SCICHEM 3.1 public distribution includes background chemistry fields at state level derived from a PGM simulation of the United States. The next release, SCICHEM 3.2, will

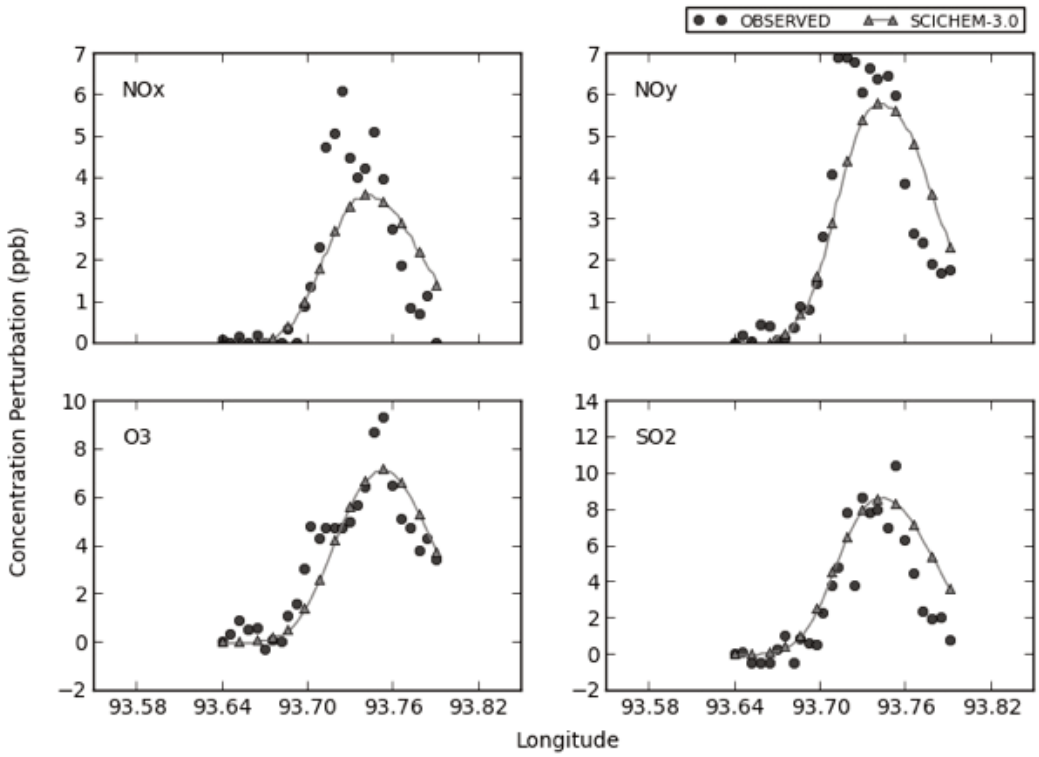


Figure 1. Observed and predicted plume concentration increments (ppb) at 18 km downwind of the Dolet Hills power plant in NW Louisiana on September 8, 2005.[13] The increments are calculated by subtracting background values. Observed background values are the average of the plume measurements at the edges of the plume.

include a processor that can construct background fields using available PGM outputs from previous studies for any domain of interest.

SCICHEM Evaluation

Near-source, in-plume measurement studies by instrumented aircraft provide data that are highly relevant to evaluating model estimates of (near-source) downwind transport and chemical impacts from single- point sources. When initially developed, SCICHEM was extensively evaluated[13] against in-plume aircraft observations of large power plant plumes in Tennessee and demonstrated good agreement with the observed levels of O_3, SO_2, NOx, and NOy (i.e., the sum of all reactive NOx, including NOx and NOx oxidation products).

In a multi-model intercomparison study, the SCICHEM simulation of single-source downwind impacts compared well against field study primary and secondary pollutant measurements (e.g., O_3) for sources in Tennessee and Texas.[14] SCICHEM 3.0 was recently evaluated against other power plant plume measurements of ozone and other gas-phase pollutants.[12,15,16] The model was also successfully evaluated for petrochemical source plumes downwind of the Houston Ship Channel using aircraft measurements of ozone and other reactive pollutants.[17] Examples from these recent evaluation studies are shown in Figure 1 (see Chowdhury et al.[12] for a detailed discussion of model performance) and Figure 2. These studies indicate that SCICHEM estimates of single-source impacts are comparable to in-plume field study measurements and other models and that SCICHEM is not overly biased toward over- or under-estimation tendencies.

SCICHEM 3.2 is currently being evaluated against aircraft measurements of power plant plumes during the 2013 Southeast Nexus (SENEX) field study and the results will be documented in the peer-reviewed literature.

SCICHEM Single-Source Impacts

SCICHEM 3.1 has been extensively tested and applied for single-source applications in four geographical regions of the United States. Annual simulations for the four regions considered a hypothetical new source (i.e., a coal-fired power plant emitting 3,000 ton/yr of NOx). Source impacts on O_3 and secondary $PM_{2.5}$ were calculated and compared with corresponding impacts calculated by the two EPA-preferred PGMs: CMAQ (version 5.0.2) and CAMx (version 6.2). The calculated impacts from the three models were also compared with Tier 1 impact assessments from EPA's Modeled Emission Rate Precursors (MERPs) guidance document[18] for elevated sources emitting comparable amounts of NOx (3,000 ton/yr) in similar geographic areas.

Table 1 compares the daily maximum 8-hr average (MDA8) O_3 increments from SCICHEM 3.1, CMAQ, and CAMx, and the MERPs guidance document. For the maximum MDA8 O_3 impacts, the ranges of values from the three photochemical CTM modeling approaches are generally comparable to the range of impacts reported in the MERPs guidance in the four regions. CAMx predicts lower impacts than CMAQ in all regions. The largest variations are noted in the southeast region, where the CMAQ-predicted impact is nearly a factor of two and a factor of four higher than the impacts predicted by CAMx and SCICHEM, respectively. All three models predict comparable impacts in the northeast region.

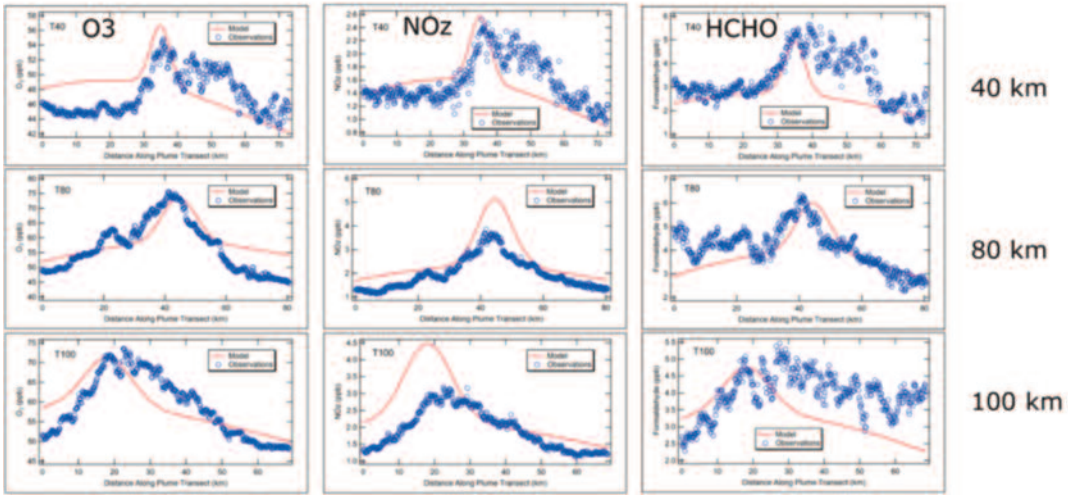


Figure 2. Observed and predicted plume concentrations (ppb) of O_3, NOz, and formaldehyde (HCHO) at 40, 80, and 100 km downwind of the Houston Ship Channel on September 18, 2013.[18]

Table 1. Hypothetical source (3,000 ton/yr NOx emissions) daily maximum 8-hr average ozone impacts (ppb) from several photochemical models in four geographic regions of the United States and qualitative comparison with ranges of values for similar sources and regions reported in the EPA MERPs guidance.[18]

Region	Daily Maximum 8-hr average ΔO_3 (ppb)			
	CMAQ 5.0.2	CAMx 6.2	SCICHEM 3.1	EPA (2016)[1]
Northwest	2.75	1.38	4.10	0.7 – 8
Southwest	3.19	1.91	2.06	2.5 – 8.8
Southeast	21.43	11.89	4.97	2.2 – 10.4
Northeast	5.43	4.36	5.57	3.5 – 6.1

SCICHEM predicts higher impacts than the grid models in the northwest region. In general, SCICHEM does not have a tendency toward over- or under-prediction of impacts predicted by the two PGMs recommended by EPA for Tier 2 demonstrations. The single-source analysis is currently being repeated with SCICHEM 3.2 and will be documented in the peer-reviewed literature.

SCICHEM as an Alternative to PGMs for Single-Source Impacts

The EPA memorandum[4] justifying the use of CMAQ or CAMx for Tier 2 modeling analysis identifies five criteria that need to be satisfied by models used for single-source O_3 and secondary $PM_{2.5}$ assessments. These are: 1) model is peer-reviewed; 2) model is theoretically applicable to single sources; 3) databases are available for model applications; 4) model

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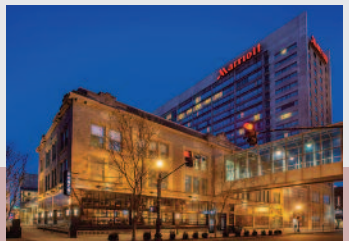

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performance has been previously evaluated; and 5) model has been demonstrated for single-source applications. SCICHEM satisfies all five requirements and can be considered a valid alternative model for such assessments on a case-by-case basis.

Lagrangian models with detailed and explicit photochemistry, such as SCICHEM, are a viable alternative to PGMs for assessing single-source impacts on secondary pollutants. SCICHEM may be a leading candidate model when limitations on available modeling databases, PGM expertise, and computer resources make PGM simulations burdensome or impractical. The ranges of secondary pollutant impacts predicted by the SCICHEM are comparable to CMAQ and CAMx, which provides confidence in SCICHEM's ability to be used for this purpose. **em**

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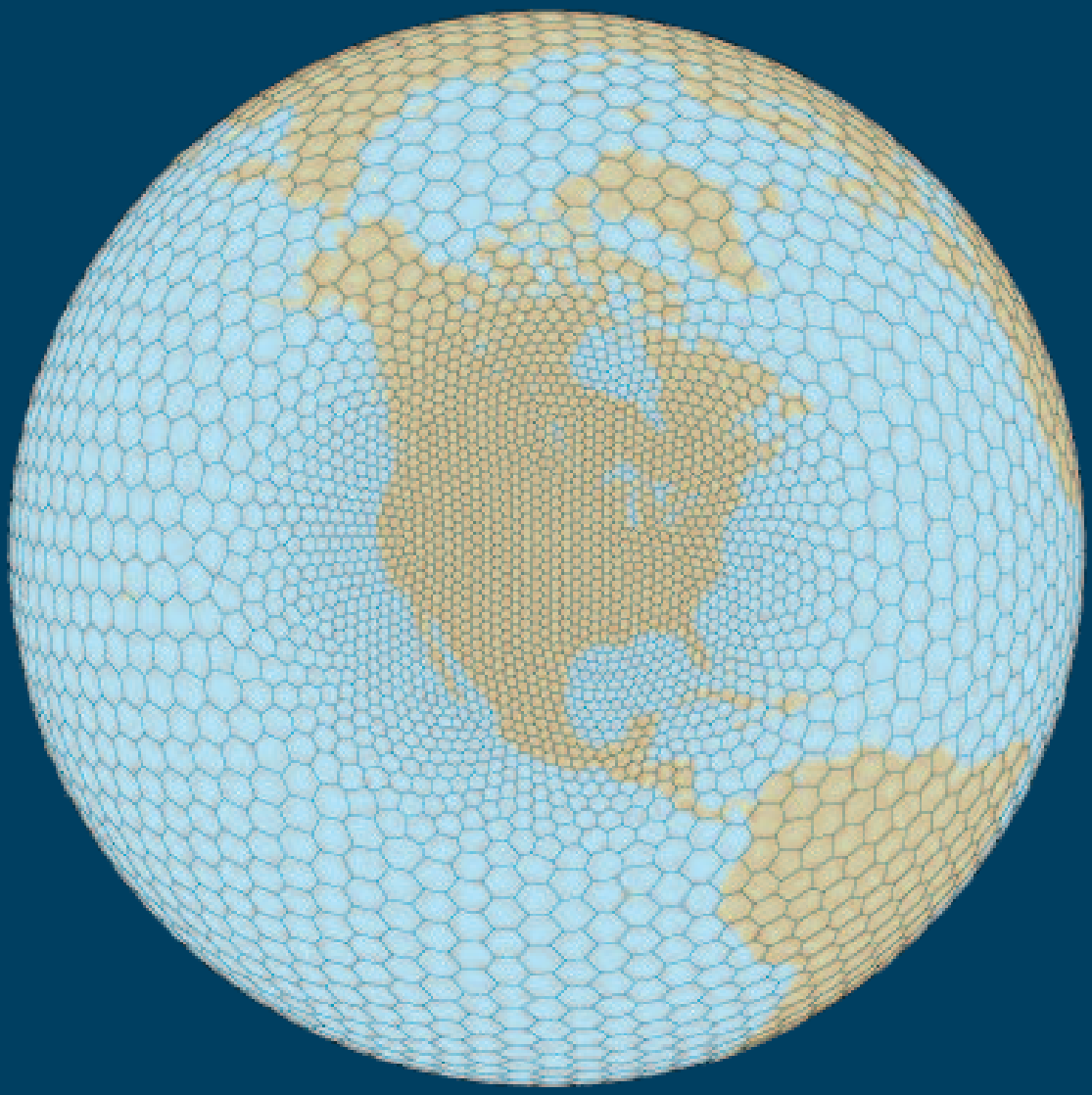

Example of MPAS Voronoi mesh with resolution refinement over North America.
Source: https://mpas-dev.github.io.

The New Generation of Air Quality Modeling Systems

by Jonathan Pleim, David Wong, Robert Gilliam, Jerry Herwehe, Russell Bullock, Christian Hogrefe, George Pouliot, Limei Ran, Ben Murphy, Daiwen Kang, Wyat Appel, Rohit Mathur, and Elaine Hubal

A vision for a new air quality modeling system based on a redesign of the Community Multiscale Air Quality (CMAQ) model coupled to multiple meteorology models, including the global model known as the Model for Prediction Across Scales (MPAS).

The nature of air quality (AQ) degradation in the United States has evolved over the past several decades from intense local smog episodes in cities and industrial areas to widespread increasing background concentrations with less severe but persistent hotspots. While U.S. emissions of pollutants and their precursors have declined significantly in recent decades, other parts of the world have seen substantial growth in air pollutants as their economies and industries have grown rapidly. Pollutants emitted near the Earth's surface can be convectively lofted to the free atmosphere where strong winds efficiently transport them across continents and oceans.

The recognition of the importance of atmospheric-process interactions among global, regional, and local scales inspired international cooperative research efforts such as the Task Force on Hemispheric Transport of Air Pollutants (TF-HTAP) and the third phase of the Air Quality Model Evaluation International Initiative (AQMEII3). Thus, the focus of AQ modeling has shifted over the years from limited area models, which focus on urban areas, to more regional domains and recently to multiscale systems that cover the entire globe. Typically, regional AQ models such as the Community Multiscale Air Quality (CMAQ) model,[1] the Weather Research and Forecasting model with Chemistry (WRF-Chem), Comprehensive Air Quality Model with Extensions (CAMx), and CHIMERE use lateral boundary conditions (LBC) from global AQ models, such as the Goddard Earth Observing System with Chemistry (GEOS-Chem), Model for Ozone and Related Chemical Tracers (MOZART), Atmospheric Model version 3 (AM3), and Composition Integrated Forecasting System (C-IFS).

Recent studies[2] have shown that LBCs derived from different global models have profound effects on simulated regional-scale ozone in the Continental United States (CONUS). It was found that biases inherent in global models propagate into the regional modeling domain. Also, additional uncertainty results from inconsistencies in process representations, chemical species mapping, and grid structures between the global and regional models. Therefore, the CMAQ development group at the U.S. Environmental Protection Agency (EPA) has developed a hemispheric application of the WRF-CMAQ system that has become the preferred practice for supplying LBCs to regional and finer scale WRF-CMAQ applications.[3] While using the same model to scale down from hemispheric minimizes many inconsistencies and sources of error, the multi-scale nesting approach, as shown in Figure 1, still includes spatial and temporal interpolation errors at each step of grid refinement.

A new approach to global to regional and local scale AQ modeling is being developed that takes advantage of recent advances in global meteorology modeling. Until recently, global meteorology and climate models were mostly built on geographic latitude and longitude grids. A serious drawback of such models is that the grid cell size decreases with increasing latitude as grid lines (meridians) converge to singularities at the poles requiring polar filters. Several new approaches to global modeling with unstructured mesh discretization have been recently introduced to avoid these problems including cubed-sphere, icosahedral, hexagonal, Voronoi, or Yin-Yang grid meshes, all of which can represent the Earth's surface with more uniform resolution. Many global climate and meteorology programs are switching from traditional geographic latitude-longitude grid discretization to these new types of unstructured global meshes. For example, the NOAA/NWS recently evaluated five global dynamic cores for potential to serve as the foundation of the Next Generation Global Prediction System (NGGPS) to replace the current Global Forecast System (GFS), which uses a latitude-longitude grid mesh. Four of the five candidate models use unstructured grids, either cubed-sphere or hexagonal-icosahedral meshes.

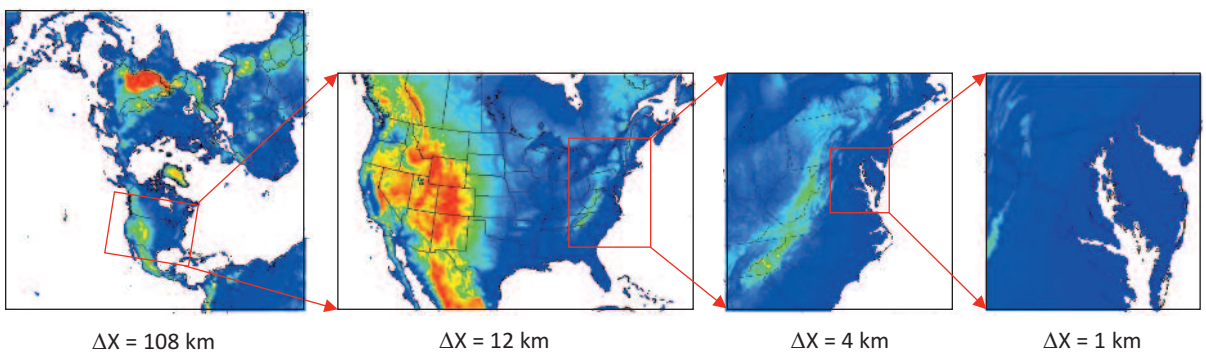

Figure 1. Current approach to multiscale meteorology and air quality modeling. Lateral boundary conditions for the 12-km grid resolution CONUS domain are extracted from a 108-km grid resolution WRF-CMAQ simulation. The 4-km and 1-km grid resolution WRF-CMAQ simulations are sequential 1-way nests. The example domain plots show terrain height. Note that the 12-, 4-, and 1-km domains all show the same terrain color scale, while the 108-km domain shows a larger scale.

The seamless mesh refinement afforded by the Model for Prediction Across Scales (MPAS) that is being developed at the National Center for Atmospheric Research (NCAR) for global meteorology and climate applications[4] is particularly well suited for AQ applications (see illustration on opening page of this article). The ability to have high resolution in a focus area, while representing the rest of the world at lower resolution in a single model simulation with no resolution discontinuities is ideal for AQ modeling.

Vision for New AQ Modeling System

We envision a new system based on a redesigned AQ component that can be coupled to multiple meteorology models, either inline (simultaneous integration) or offline (sequential integration). The MPAS-AQ could use a mesh that is relatively coarse around the globe with a refined higher resolution region in the focus area (e.g., CONUS). In this configuration, the AQ module would not include three-dimensional advection and horizontal diffusion and hence be essentially a one-dimensional model that includes gas, aerosol, and aqueous chemistry, vertical diffusion, emissions, and chemical surface fluxes (i.e., dry deposition, and bi-directional flux). The three-dimensional advection and horizontal diffusion of the chemical scalars would be performed in MPAS in the same way as the meteorological scalars (e.g., water vapor mixing ratio), which assures mass consistency of the chemical concentrations.

Limited-area regional domains will be accommodated in a variety of ways to support fast execution of multiple realizations (e.g., emission control scenarios) while maintaining consistency with the global environment (see Table 1). Since MPAS now supports regional capability, the coupled MPAS-AQ can be run over limited area domains with LBCs derived from a previous global simulation. The advantage of this option would be that the boundary interface would require no interpolation and thus minimal additional error. Furthermore, the regional domain could be much further refined in the interior to achieve high resolution at minimal computational expense. Another regional option would be to run WRF-AQ configurations (similar to the current WRF-CMAQ system) with LBCs provided from a global MPAS-AQ simulation. While this option would require interpolation along the boundaries, there would be the option of on-line or off-line execution.

Progress to Date

The project will be completed in three phases. The first phase, which has been mostly completed, involves the development of a coupled MPAS-CMAQ system, which is considered as an operational prototype of the ultimate new system. This effort includes modifications to MPAS to improve its performance for retrospective AQ applications. Modifications include additional physics options ported from WRF including the ACM2 PBL model, the PX land surface model, and the Pleim surface layer scheme. These surface and boundary layer model components were developed especially for AQ in the WRF-CMAQ system where they are consistently applied for both meteorological and chemical processes.

An updated version of the Kain-Fritsch convective cloud parameterization model that includes the effects of sub-grid clouds on radiation and has a dynamic cloud lifetime has also been added to MPAS. In addition, the four-dimensional data assimilation (FDDA) system that has been used for many years in WRF for long-term retrospective simulations, has been developed for MPAS. Figure 2 shows the reductions in root mean squared error (RMSE) in temperature at 2 m above the surface (T-2m) for the CONUS at sequential stages of MPAS development. The implementation of FDDA effectively eliminates error growth for the one-month simulation while the new physics further reduces the RMSE. There is a further reduction of error for the higher resolution mesh resulting in RMSE for T-2m that's very similar to the RMSE for a 12-km grid resolution WRF simulation using the same physics options.

A prototype of the global MPAS-AQ has been developed by coupling a modified version of CMAQ with MPAS. The AQ component is a 1-dimensional CMAQ (without three-dimensional advection and horizontal diffusion) for which the meteorological input is modified to be passed in through an interface with MPAS. Initial testing and evaluation focused on July 2013 using the 92-km mesh refining to 25 km over CONUS with 50 vertical layers up to 30 km. In addition tometeorological data assimilation from the 1° × 1° National Centers for Environmental Prediction Final (FNL) Operational Global Analysis, ozone concentrations from the FNL analysis were used to replace the model ozone concentrations in all layers above 100 hPa every 6 hours. The FNL ozone provides

Table 1. Air quality model system configurations.

Configuration	Met Model	Boundaries	Coupling	Purpose
Global	MPAS	none	inline	Global to regional AQ
Regional	MPAS	MPAS Global	inline	Regional to local AQ
Regional	WRF	MPAS Global	inline	Regional to local AQ
Regional	WRF	MPAS Global	offline	Regional emission scenerios

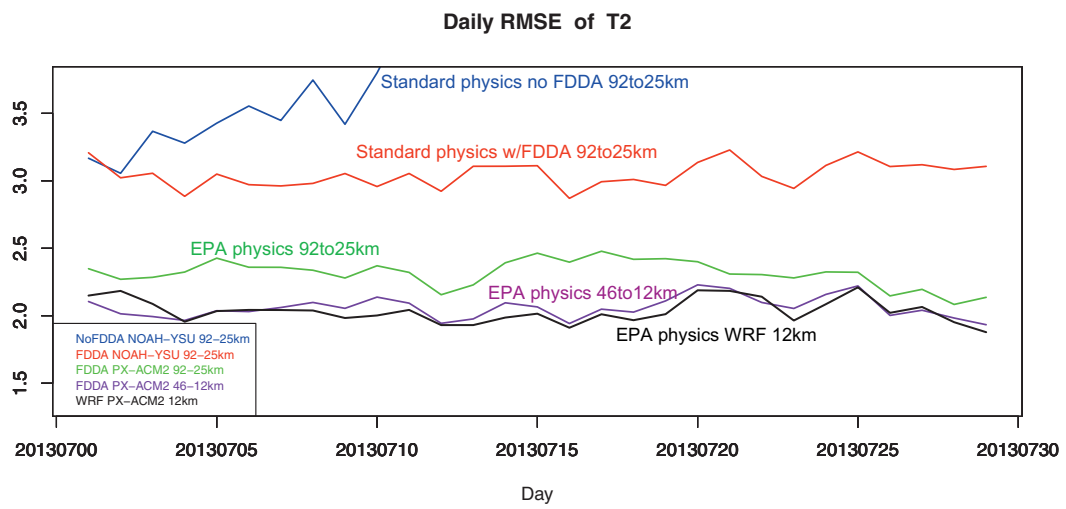

Figure 2. RMSE statistics for 2-m temperature over CONUS compared to observation data for July 2013.

realistic stratospheric concentrations that, over time, will transport downward into the troposphere during stratospheric intrusion events, downdrafts associated with deep convective clouds, and background diffusion. However, the initial one-month simulation is too brief for significant impact of these processes. Thus, model ozone concentrations in high elevation areas are significantly too low in this initial test (see Figure 3).

The second phase of the project involves building on the global MPAS-AQ operational prototype to provide flexible

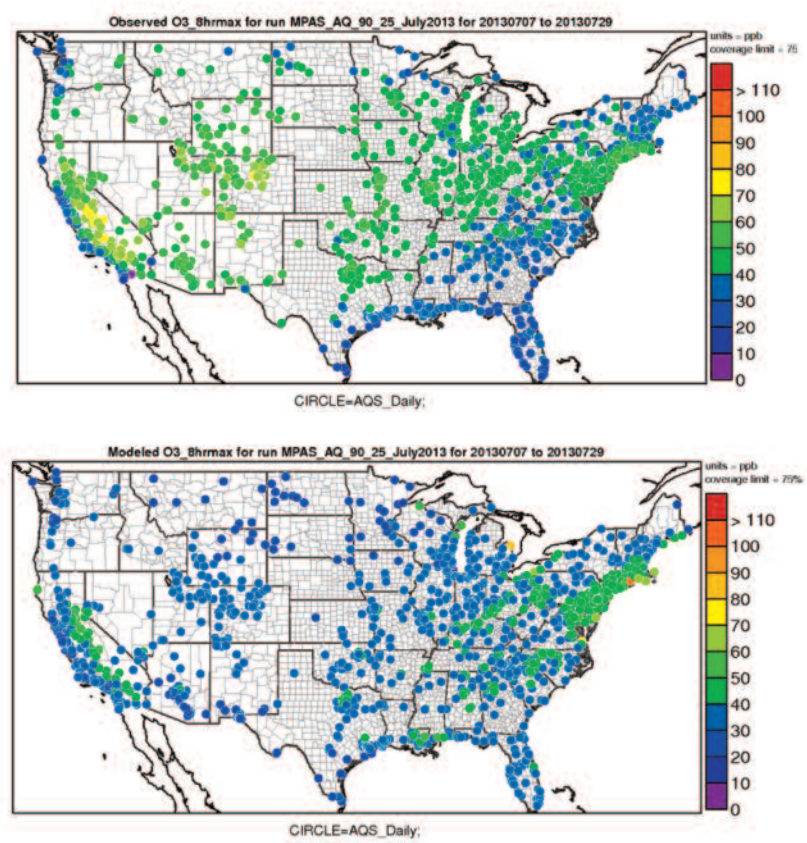

Figure 3. Maximum 8-hr average ozone concentration for July 7–29, 2013. Observations from the Air Quality System (AQS) network on left and MPAS-CMAQ model on right.

options for regional modeling. High resolution regional MPAS-CMAQ simulations, using LBCs from a global simulation, will be evaluated against meteorological and chemical observations, as well as compared to other high-resolution model simulations, particularly WRF-CMAQ. Utilities to derive LBCs from global MPAS-CMAQ simulations for rectangular WRF-CMAQ domains, for either inline or offline execution, will be developed.

The third phase of the project will focus on redesign of the AQ model architecture. While the CMAQ model is under continuous development to include the latest research findings in AQ science processes, the software structure is based on a design from the early 1990s. The goal of this final phase is to implement modern software engineering principles to improve model efficiency, flexibility, and extensibility. The refreshed AQ model would be applied in all global, regional, inline and offline configurations of the new MPAS-AQ. This vanguard AQ modeling system will position the field to address the full range of complex multiscale AQ issues for years to come. **em**

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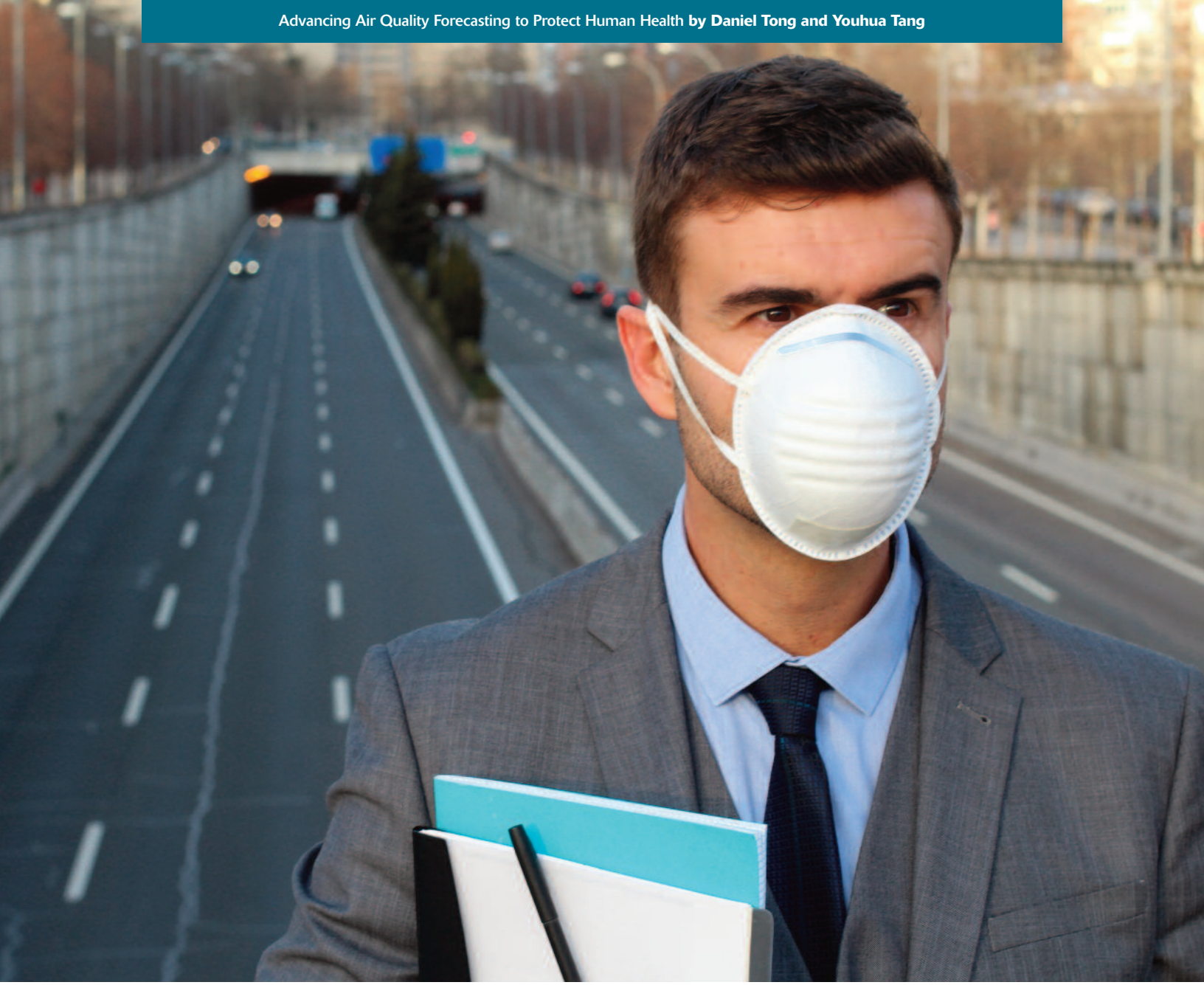

Advancing Air Quality Forecasting

to Protect Human Health

Air quality and public health managers have an important task to protect the public health by alerting the population when forecasts predict the exceedance of national air quality standards, therefore, accurate prediction of the timing, location, and severity of unhealthy air quality episodes is critical.

Air quality forecasting is one of the key tools commonly used by state and local agencies to protect the public from adverse health effects of poor air quality. Exposures to air pollution caused 7 million premature deaths per year, making it the single largest environmental risk today.[1] In the United States, over one third of the population lives in areas not attaining the health-based National Ambient Air Quality Standards (NAAQS) for ozone (O_3) and fine particulate matter ($PM_{2.5}$).[2] Air quality and public health managers have an important task to protect the public health by alerting the population when forecasts predict an exceedance of the NAAQS. During exceedances, action days are issued and, depending on the levels of severity, specific sensitive groups or the entire population are advised to reduce outdoor activities or take other protective measures. Accurate prediction of the timing, location, and severity of unhealthy air quality episodes is, therefore, critical for decision-makers to protect human health.

How Is an Air Quality Warning Issued?

There are several steps involved in the decision-making to issue an air quality warning (see Figure 1). The basic principal of forecasting air quality, similar to that of weather forecasting, is "anchoring and adjustments". First, forecasters gather information of local weather forecasting and pollutant observations to understand the local and regional persistence and possible changes in air quality next day. Next, forecasters consult numerical model guidance, such as the National Air Quality Forecast Capability (NAQFC) operated by the National Oceanic and Atmospheric Administration (NOAA), or the AIRNow map, produced from monitoring and NAQFC prediction by EPA, for next-day air quality forecasts. Putting all the information together, forecasters make necessary adjustments using a variety of methods, including statistical analysis (regression and clustering) and heuristic "expert analysis," to the air quality guidance before producing the officially released air quality advisory. Within forecasters' toolbox, air quality forecasting systems, such as the NAQFC, are a central piece for many states to produce timely air quality advisories.

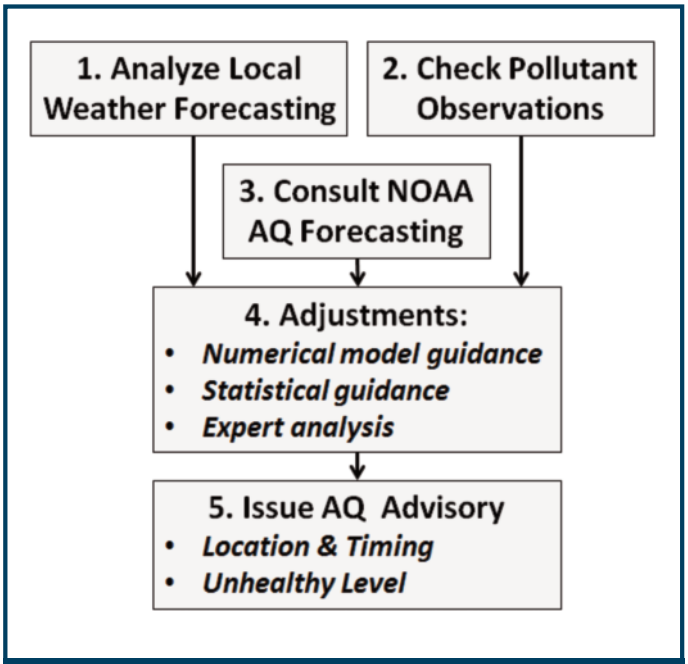

Figure 1. Decision-making process of air quality warning to protect public health.

Recent Advancements in Air Quality Forecasting

A number of advancements have been made to improve the NAQFC system, driven largely by emerging issues caused by drastic socioeconomic and environmental changes. Examples of such changes include economic recession, oil/gas production, rising dust storms and wildfires, and natural disasters such as volcanic eruptions.

Rapid Emission Refresh

An air quality forecasting system has two key inputs: meteorology and emissions. Emissions are often provided by the National Emission Inventories (NEIs). It often takes several years to come up with new NEIs, which become outdated quickly due to rapid changes in emission sources. Consequently, outdated emission data impose large uncertainties on air quality forecasting. To reduce emission time lag, a new technique, called rapid emission refresh, recently emerged to improve time-sensitive modeling applications, such as air quality forecasting. Rapid emission refresh utilizes near-real-time observations from satellites and ground monitors to update either emission data directly, or the parameters used to calculate emissions.

One of the successful stories is to apply this technique to study the air quality impact of the 2008 Great Recession.[3] The Great Recession, kicked off by the bursting of an US$8 trillion housing bubble, was blamed for a loss of 8.4 million jobs, as well as a substantial decrease in air pollutant emissions in the United States.[4,5] The impact is quantified by comparing O_3 concentrations under two model scenarios: business-as-usual (BAU) and recession.

Under the BAU scenario, the emission projection from the Cross-State Air Pollution Rule (CSAPR) is used to estimate the "would-be" NOx emissions level in 2011. In the recession case, the actual NOx trends observed

from ground monitors and the Ozone Monitoring Instrument (OMI) on the Aura satellite are used to obtain "realistic" changes in NOx emissions. The Great Recession was shown to cause a1–2 parts per billion by volume (ppbv) decrease in surface O_3 concentration over the eastern United States, a slight increase (0.5–1 ppbv) over the Rocky Mountain region, and mixed changes in the Pacific West.

Oil and Gas Emissions

Recent rapid increase in unconventional oil and gas production raised concerns about health impacts. For instance, emissions in an oil/gas basin elevated wintertime surface O_3 well above national air quality standards.[6] As the O_3 standards are tightened and oil/gas production continues to increase, it is therefore important to account for the fast changing emissions from oil and gas production. A new method has been developed to project emission inventories using annual energy production data. Model simulations with an NAQFC experimental system suggest that oil/gas emissions could have considerable impacts on air quality with active oil/gas production.

Windblown Dust and Wildfires

As many western states see more frequent droughts, windblown dust storms and wildfires become an increasing concern. In the past three decades, wildfires have increased in number and size across western North America, and the trend will continue in response to further warming.[7] This will, inevitably, lead to substantially higher risk of fire damages to human health and properties. Meanwhile, the frequency of dust storms has increased by 240 percent from the 1990s to 2000s.[8] Rising dust activity imposes myriad effects on the environment and society, including poor air quality, infectious diseases, highway and aviation safety, cropland erosion, and reduced solar energy productivity.

Unlike traditional emission sources, wildfires and dust storms are more difficult to predict. Sophisticated emission models and satellites are often needed to forecast these intermittent events. Over North America there is an interesting phenomenon, called "Tax Day dust storm". Each year, on the day when Americans file their tax returns, one or more large dust storms often sweep across the Southwest.

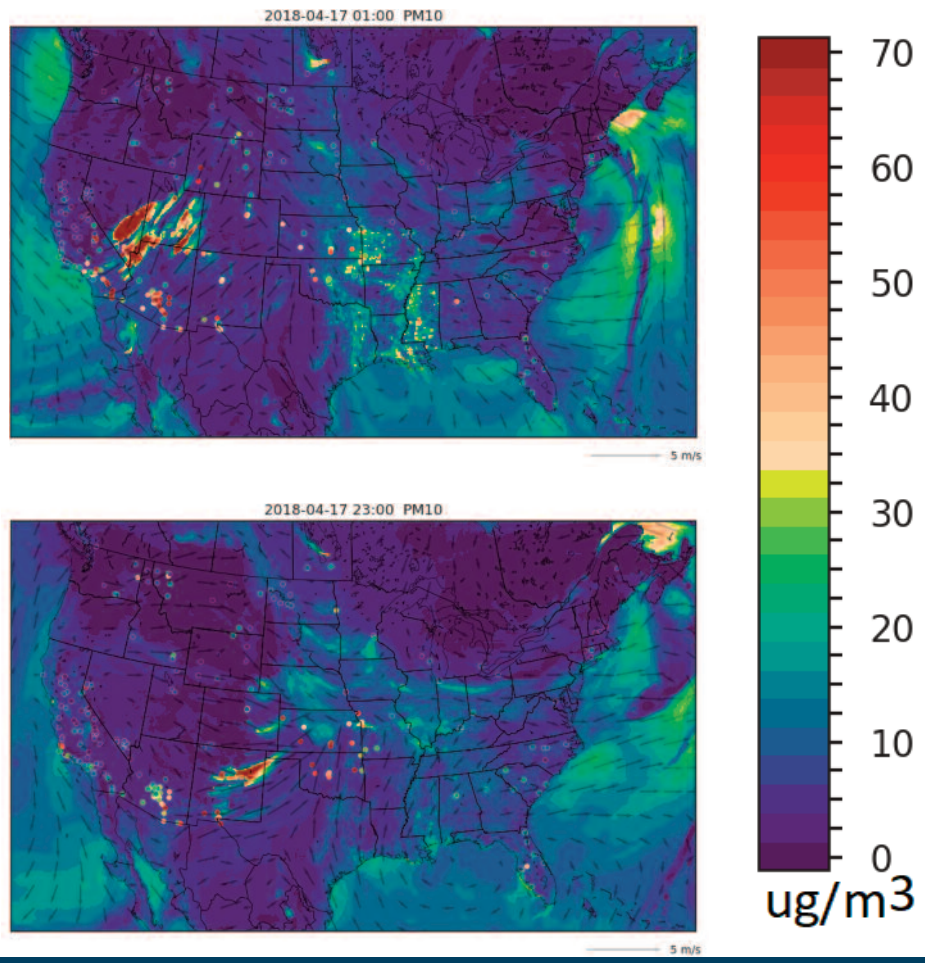

Figure 2. Forecasts of two dust storms (shown in red with high PM_{10} concentrations) during the 2018 Tax Day (April 17, 2018). Courtesy of Barry Baker.

Figure 2 shows the forecast of the "Tax Day" dust storms in 2018. On April 17, 2018–the extended income tax return deadline due to a computer failure at the Internal Revenue Service–two dust storms swept over Nevada, Arizona, Utah, and New Mexico. The forecasts of high winds and reduced visibility caused by dust storms led the Utah Department of Transportation to prohibit high-profile trucks to enter Highway I-80, a precautionary action to prevent fatal accidents during a 2015 dust storm in this region.

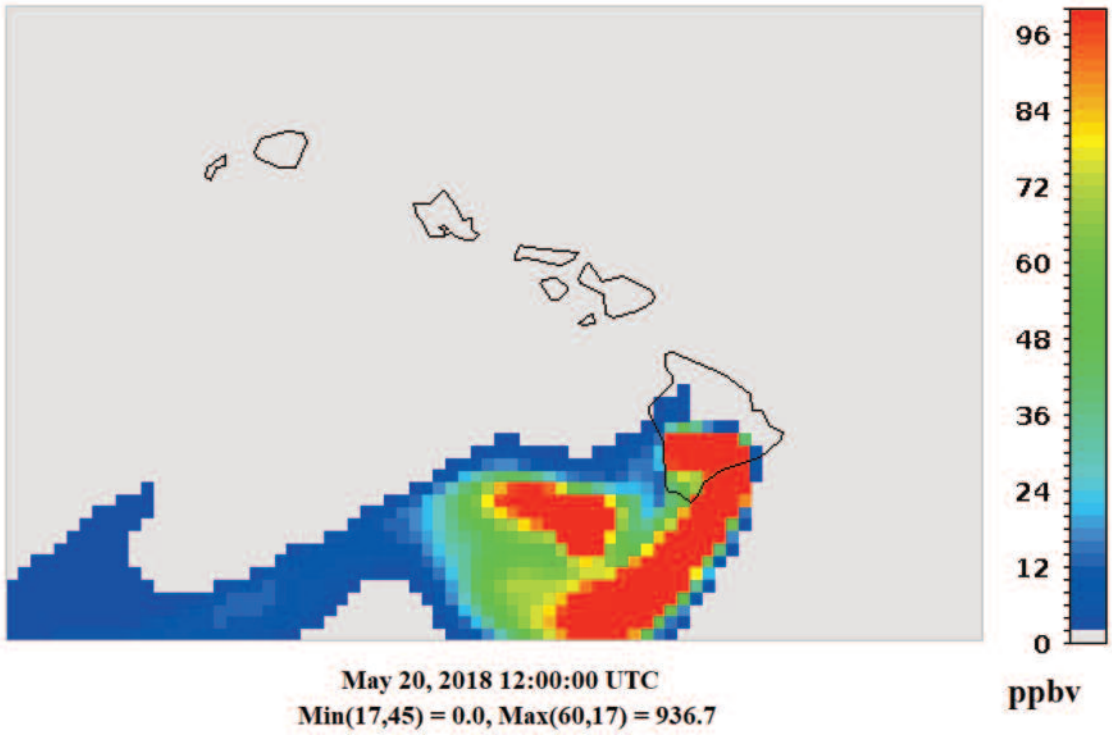

Figure 3. Predicted surface SO_2 concentration over Hawaii from Kilauea volcanic emissions, May 2018.

Volcanic Eruption

The recent eruption of the Kilauea volcano in Hawaii highlights another need for air quality forecasting: providing predictive air quality data for emergency response. At times of natural disasters such as volcanic eruptions, elevated levels of toxic gases and particles can result in severe health stress among the people living in the impacted areas and further downwind. Advanced air quality forecasting systems can be equipped with near-real-time emission estimates to provide critical air quality data to assess population exposure to volcanic smog (vog) and to assist in developing effective evacuation plans, if necessary.

Near-real-time estimates of volcanic emissions can be made from sulfur dioxide (SO_2) and aerosol vertical column density by satellite sensors, such as OMI and Ozone Mapping Profiling Suite (OMPS). The health-based air quality standard for SO_2 is 75 ppbv, which has been frequently exceeded in the areas downwind to the Kilauea volcano during the eruption on May 17, 2018 (see Figure 3).

Chemical Data Assimilation

Similar to weather forecasting, air quality forecasting benefits greatly from assimilating near-real-time observations from ground monitors and satellites. Chemical data assimilation techniques have been developed to improve initial conditions of chemical transport models and yield better prediction by blending the information from a model estimate (referred to as prior or background) and from observations in certain methods.[9] The purpose is to eliminate the accumulated biases in the model system.

One method is direct blending, for instance, using observed chemical mass concentrations to correct the modeled mass concentrations. This approach is relatively straightforward, as they are directly comparable. Since most monitoring data are captured near the surface, this method is usually applied to near-surface field. Another method is indirect guessing, such as comparing satellite retrieved aerosol optical depth (AOD) with modeled AOD to estimate the biases of modeled column mass concentrations and make the corresponding

adjustment. Depending on the quality of observations used in data assimilation, the overall effect of this technique is to reduce the difference between the modeling field and the true field as represented by the observations.

Challenges and Future Directions

Advancements in air quality forecasting allow improved early warning to protect human health. Innovative approaches have been developed to address emerging air quality issues. As emissions from traditional sources decrease, unconventional and intermittent sources become increasingly important at regional and national scales. Assimilating near-real-time data, such as satellite observations, proves an effective measure to improve forecasting performance, calling for further development of emission rapid refresh and chemical data assimilation techniques. **em**

Daniel Tong is a research professor at George Mason University, and a member of NASA Health and Air Quality Applied Science Team. Youhua Tang is an assistant scientist with University of Maryland, College Park. The scientific results and conclusions, as well as any views or opinions expressed herein, are solely those of the authors. E-mail: **qtong@gmu.edu.**

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Catalytic Filter Technology Provides Important Flexibility for Controlling PM, NOx, SOx, O-HAPS

Catalyst-embedded ceramic filters offer a way to remove NOx at lower temperatures, while simultaneously removing PM, SOx, and HCl. The technology also removes organic hazardous air pollutants, THC, dioxins, and mercury.

Applications include the Cement NESHAP; Boiler MACT; incinerator CISWI MACT; Hazardous Waste MACT; glass furnaces; ceramics manufacturing, including fracking proppants, kilns, and thermal oxidizer clean-up.

Typically, PM is removed to ultralow levels (≤5 mg per Nm3, 0.002 grains per dscf); other pollutants are eliminated at levels >90%.

Filter Types: Standard and Catalyst

Standard UltraTemp filters remove PM or PM plus acid gases and metals, including mercury; UltraCat catalyst filters remove those, plus O-HAPS, dioxins and NOx.

Catalyst filters feature the same fibrous construction as the standard version, but have nanobits of catalyst embedded throughout the filter walls. Distribution across the entire wall thickness, as opposed to just a catalyst layer, creates a very large catalytic surface area. The walls that contain the catalyst are about 3/4 inches thick. Ammonia is injected upstream of the filters and reacts with the NOx at the surface of the micronized catalyst to destroy the compound (Figure 1).
An analysis comparing the effectiveness of this nanocatalyst with that of conventional catalysts was summarized in a paper by Schoubye and Jensen of Haldor Topsoe A/S:

"The catalyst particles are micro-porous, and, due to their small size, they catalyze the gas-phase reactions without diffusion restriction (i.e., almost 100% utilization of the catalyst's intrinsic \activity), as opposed to pellet or monolithic catalysts. In industry, conventional catalyst types typically operate with 5-15% catalyst effectiveness in the SCR of NOx by NH3 and with even lower catalyst utilization in dioxin destruction."

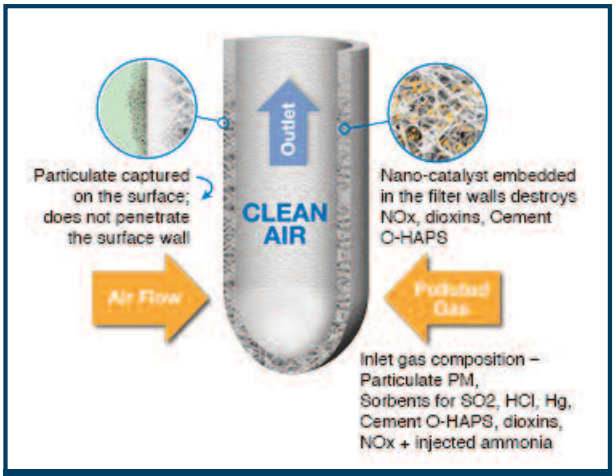

Figure 1. Catalytic filter schematic.

Another remarkable feature is low temperature activation. Substantial NOx removal is initiated at 350°F, with over 90% removal as the temperature exceeds 450°F.

System Design Criteria

Filters are placed in a housing module configured like a reverse pulse jet baghouse. Polluted airstream enters the bottom of the housing. Process PM and reacted acid gas sorbent PM are captured on the filter surfaces, while NOX and injected aqua ammonia are transformed to nitrogen gas and water vapor. O-HAPS (Cement NESHAP) and dioxins are broken down without ammonia additions. Cleaned air passes through the center of the filter tubes and out of the space above (Figures 1-3).

The modular housing design allows filters to be configured for the largest gas flow volumes. The system's modular nature also provides redundancy so a single module can be taken offline while the other modules receive the flow.

Placing multiple plenums in parallel provides redundancy. If one plenum is taken offline for service, others treat the entire flow at a temporarily higher pressure with no change in performance.

Particulate is captured on the face of the filter and does not penetrate the filter. At start-up, the pressure drop is 6" w.g. Over the filter's life, the pressure undergoes a gradual increase, averaging 3% annually. Filter life is generally over 10 years. Conventional reverse pulse jet methods are used for filter cleaning.

Standard Filter: Typical Pollutant Control

Particulate: The typical level of particulate at the outlet of the ceramic filters is ≤ 0.002 grains/dscf (5 mg/Nm^3).

With the exception of mercury, heavy metals are captured at the same rates as other particulate (> 99%).

SO_2, SO_3, HCl, other acid gases: Ceramic filters use dry injection of calcium or sodium-based sorbents for acid gas removal. Injected in the duct upstream of the filter modules, the additional sorbent particulate is captured with its pollutant gas. The reaction of the sorbent with the acid gas creates a solid particle that is captured on the filters alongside the unreacted sorbent and process particulate. The reaction occurs within the duct prior to the filter and on the cake on the filter surface.

The sorbent cake on the filters increases exposure of the SO_2 or HCl, and increases removal rate. For a given removal efficiency, filters require significantly less sorbent than ESPs, which minimizes sorbent costs.

With sorbent injection, SO_2 removal is above 90%. SO_3 and HCl are preferentially removed at higher rates than SO_2. Sorbent injection of

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powdered activated carbon is an option for mercury control. The mercury chemistry and temperature of the application determine the formulation of PAC used and the resulting effectiveness.

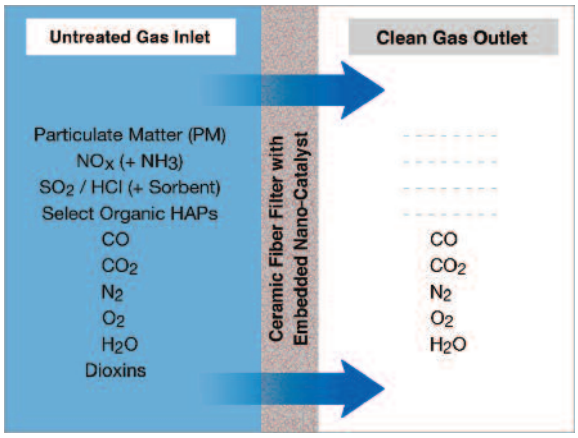

Figure 2. Catalyst filters simultaneously treat multiple pollutants.

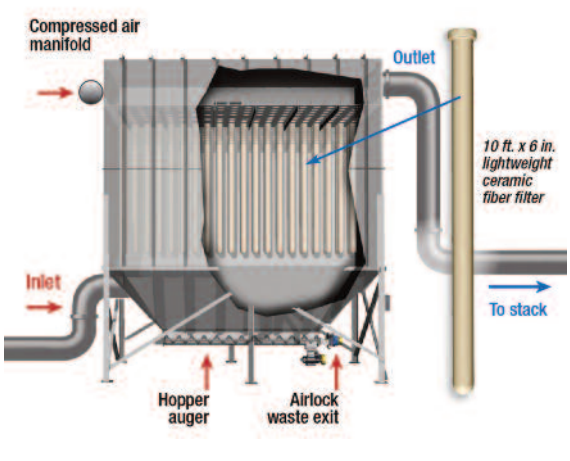

Figure 3. A single housing module containing 3m filter elements.

surface, and gas-phase poisons. A common problem with "honeycomb block" SCR is that the catalyst becomes blinded and poisoned, reducing effectiveness and necessitating replacement. Ceramic catalyst filters address these issues. Particles, including solid-phase metals, are captured on the surface of the filters.

The filter catalyst is distributed throughout the filter walls and is protected inside the filter. This virtually eliminates particulate-type interactions and extends catalyst life. Regarding gas phase, the proprietary catalyst formulation is engineered for extremely low conversion of SO_2 to SO_3 and is virtually immune to HCl.

The reaction of the ammonia and NOx at the micronized catalyst surface is the same as conventional SCR, but benefits from more contact time because the gas mixture doesn't have to diffuse in and out of the block catalyst pores.

Eliminating the diffusion restriction helps reduce the slippage of untreated gases; NOx destruction greater than 90% is common. Ammonia slip is under 10 ppmv.

Cement O-HAP THC: The filters destroy formaldehyde and other O-HAPS. The significant reduction of O-HAPs results in an adjustment of total allowable THC according to NESHAP. This direct approach for O-HAPS reduction is very cost effective compared to PAC injection or thermal oxidation.

Catalytic filters virtually eliminate ammonia slip if SNCR is used in the kiln. Excess ammonia slip is consumed by the filters while acting as a polishing step for NOx removal. This is an important secondary benefit when the filter system is used to collect PM, remove HCl, and/or destroy O-HAPS. Thus the need for a fabric filter baghouse or ESP is eliminated.

Dioxins: Dioxins are destroyed similarly by the catalytic filter.

Operating Temperatures

For PM plus SO /HCl, the range is 300 to 1,200°F.

One important feature of the NOx filters is an operating range that is lower in temperature compared to conventional SCR. Conventional SCR requires 550°F for efficient removal, while the micronized catalyst becomes active at 350°F (Table 1).

O-HAP destruction becomes effective as temperatures approach 400°F and increases rapidly.

Table 1. Temperature ranges by pollutants being removed.

UltraCat Filter	Pollutants	Temp Range
Non-catalytic	PM, SOx, HCl, Hg	300°F - 1,200°F
Catalytic	PM, SOx, HCl, Hg, NOx, O-HAPs, Dioxins	350°F - 750°F

Catalytic Filters for NOx, O-HAP THC, Dioxins

Catalytic filters have the same composition and capabilities as the non-catalytic filters for PM, acid gases and Hg. The difference is the micronized catalyst into the filter walls.

NOx: All catalysts can be compromised by particulate blinding of the catalyst surface, chemical interactions with particulate on the

Proven Solution

Ceramic filters have been used by the U.S. military at munitions destruction facilities for 20 years; hundreds of ceramic filter systems are operating worldwide. With the additional capability of NOx control, ceramic filter systems are the technology of choice for many applications.

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Air Sensors 2018:
Deliberating Performance Targets

by Ron Williams, Vasu Kilaru, and Kristen Benedict

A summary of highlights and outcomes from EPA's Air Sensors 2018 Workshop.

Low-cost, widely available air sensor technologies have the potential to make a dramatic impact on the state of air quality monitoring. While they are not currently as accurate as regulatory-grade monitors—which are certified to meet specific performance and operating standards—they can provide an understanding of local air quality, help identify hot spots, and provide continuous streams of data. This information can empower individuals to make personal decisions, such as choosing to take a different route to work or remaining indoors for exercise. The technology also can help a community work with their local officials to address an air quality issue. Sensor technologies continue to improve at a rapid pace and hold promise for greater air quality monitoring effectiveness and application.

Currently, the value of sensor data collections can be questioned due to the lack of information about how well the sensor technology works.[1] Some of the uncertainties raised include how well the technologies perform under various meteorological conditions, how well they meet basic data quality indicators of performance (e.g., precision, accuracy), and how long the devices perform over time. With many useful applications that do not require regulatory levels of performance, there is still a need to know how much uncertainty is associated with these devices and whether they are adequate for the intended purposes.

To address these and other questions, the U.S. Environmental Protection Agency (EPA) convened a workshop on June 25–26, 2018, in Research Triangle Park, NC, entitled "Air Sensors 2018: Deliberating Performance Targets," to gather information on the state of air quality sensor technologies; learn how they are used to meet a wide range of monitoring needs; and obtain stakeholders' perspectives on non-regulatory performance targets for fine particulate matter and ozone sensor devices. The workshop was conducted in collaboration with the Environmental Council of the States (ECOS), and with the assistance of numerous national and international air quality experts.

Approximately 700 people attended the workshop in-person or via webinar, with diverse representation from sensor manufacturers, and other private entities; community groups/nonprofit organizations; academic institutions; state, local, and tribal air quality agencies; and the federal government.

Workshop Highlights

International colleagues who are actively engaged in developing European and Chinese-based sensor performance standards provided an overview of their efforts and why key decisions on performance targets had been made. Their perspectives on the process to develop performance targets were very valuable in considering how any future U.S.-based approach might be achieved.

State, local, and tribal nation officials provided an overview of their considerations and needs involving low-cost air sensor data. They expressed great interest in using sensor devices to identify pollution hotspots, monitor in new areas, and build community awareness about air quality. As community groups and individuals are already using these devices, they emphasized the need to address performance characteristics of the sensor devices, provide guidance on their use, and develop tools for data management, analysis, and display. While academics expressed similar concerns regarding unknown performance characteristics, they provided multiple examples of purposeful use of sensor data and provided examples of how quality assurance principles might be applied.

Sensor manufacturers provided their perspectives on performance standardization. While not asked to define any process, many indicated that well-defined performance targets by a governmental organization or independent third-party institution would benefit their community and their customer base.

The workshop included presentations on peer reviewed literature findings associated with key data quality performance indicators for fine particulate matter and ozone. In brief, the majority of the findings indicated sensors are often used to address research on the spatial and temporal coverage of pollutants with only a small fraction of reports indicating use of air sensor data for policy decision-making.

The literature reviews also indicated that without a systematic approach to reporting data quality, interpreting published findings is difficult and often the treatment of erroneous data is not discussed, raising concerns on the use of potentially incorrect or bad air quality data.

EPA continues its extensive collaboration with stakeholders to develop non-regulatory air quality sensor performance targets and to evaluate the feasibility of an independent voluntary third-party certification program. The workshop is a major step toward developing consistent performance targets that promote data quality. **em**

More Information

A summary of the main outcomes and findings of the workshop, as well as presentations from the workshop, will be published this fall on EPA's Air Sensor Toolbox website (www.epa.gov/air-sensor-toolbox).

For more general information on the research discussed in this column, contact Ann Brown, U.S. Environmental Protection Agency (EPA), Office of Research and Development, Research Triangle Park, NC; phone: 1-919-541-7818; e-mail: **brown.ann@epa.gov**.

Ronald Williams is an air sensor project lead and **Vasu Kilaru** is a physical scientist and co-lead for the workshop, both with the U.S. Environmental Protection Agency's (EPA) Office of Research and Development, Air and Energy Research Program.
Kristen Benedict is an air sensors policy advisor in EPA's Office of Air and Radiation.

Disclaimer
The views and opinions expressed in this article are those of the author and do not represent the official views of the U.S. Environmental Protection Agency (EPA).

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Getting to Know
A&WMA's Organizational Members

On this page you will find the company profiles of a randomly selected grouping of Organizational Members.

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In 1905, the City of Pittsburgh instituted its first smoke control ordinance and soon after established the Bureau of Smoke Prevention, under the city's Department of Health. It was authorized to collect data and administer the new ordinance. In 1949, Allegheny County passed its first smoke control ordinance and simultaneously established its own smoke control agency, the Bureau of Air Pollution Control. The Bureau of Air Pollution Control has evolved since 1957 into Allegheny County's Air Quality Program, which is still one of five environmental programs administered by the Allegheny County Health Department (ACHD) (www.allegheny-county.us/healthdepartment/index.aspx).

ACHD's Air Program is a delegated local air agency, working closely with the Pennsylvania Department of Environment Protection Agency. The Air Quality Program maintains a staff of approximately 50 and consists of four sections and a special program working together to identify and remedy air quality problems in Allegheny County. Those are:

Monitoring. This section is primarily responsible for the upkeep of ACHD's network of air quality monitoring stations. They are responsible for daily maintenance of equipment, installation of new equipment, verification of monitored data, initial data analysis, and oversight of specialized monitoring studies

Planning and Data Analysis. This section reviews and validates monitored air quality data, analyzing data for trends from sources, model air quality, and develop control strategies. Planning and Data Analysis staff prepare State Implementation Plans (SIPs), detailed plans designed to guide Allegheny County's air quality program activities and insure all air quality standards are reached and maintained.

Permitting. This section issues operating and installation permits to major and minor sources of air pollution within Allegheny County. Industrial sources with the potential to emit air pollutants identified in the U.S. Clean Air Act above a defined level are required to apply for an operating permit. Facility upgrades such as the installation of new equipment or processes require separate installation permits, which after construction are integrated into the facility's operating permit.

Enforcement. This section's main goal is to ensure that facilities are complying with federal, state, and local regulations, as well as conditions in permits and enforcement actions. The section collects information and supplements it with data from sections to take enforcement actions which can include orders to install control equipment, improve processes and implement other actions to limit plant emissions. Part of this group is the emissions inventory team that verifies emissions from permitted sources to determine if facilities are in compliance and set emission fees. When necessary, this section can levy fines against polluters and require other specific actions by plants to correct problems.

Asbestos and Abrasive Blasting Special Program Team. The goal of this team is to reduce public exposure during removal and demolition activities. Our abrasive blasting program reduces dust and contaminants from blasting during paint removal, most significantly on Allegheny County's many bridges. They administer a contractor certification, project permitting and an inspection program.

ACHD has long supported A&WMA. It has been a long-time Organizational Member and was the primary supporter of the 2017 Annual Conference & Exhibition in Pittsburgh. Staff members have served on numerous committees and councils. ACHD finds the professional development, information exchange, and networking opportunities of this organization to be unmatched elsewhere.

Since 1987, Winter Environmental (www.winter-environmental.com) has successfully completed a vast range of environmental projects in virtually every environmentally regulated business sector, including asbestos, lead and mold abatement, dismantling and demolition, nuclear decontamination and decommissioning, soil and groundwater remediation, emergency and disaster response, and other cleanup and site control services. Every project has a critical path and critical components. Fortunately, time management is one of our core strengths. Our vast experience has taught us: how to work smart; how to work efficiently; and how to work together with other trades and disciplines to get the job done right; and, most importantly, how to work safely. Winter Environmental is licensed to work on environmental projects in 24 states.

No project can be called successful if safety is compromised. A well-entrenched culture of "Zero Accidents" has produced one of the best safety records in our industry, with an Experience Modification Rate (EMR) of 0.75; Winter Environmental has recorded zero lost-time injuries in the past five years. We place safety as paramount above all other aspects of the job has resulted in national recognition and accolades, including receiving the industry's coveted STEP (Safety Training and Evaluation Process) award. In addition to the STEP awards, Winter Environmental is recognized annually by other safety-minded esteemed organizations, including the Georgia Department of Labor and the National Demolition Association (NDA), being recognized in 2014 and 2015 with the NDA's Environmental Excellence Award.

Winter Environmental is managed by a highly knowledgeable, experienced, and stable team of executives and senior project managers. Our top four executive officers alone have over 136 years of cumulative experience in the environmental services industry. The average length of industry experience among our project managers and superintendents is 25 years and 23 years, respectively, and their average length of service to Winter Environmental is over 15 years. We deliver stability and security through the long, steadfast, financial resources of The Winter Construction Company, an ENR Top 400 Contractor that has been in business since 1978.

Early on, we chose to invest our capital in achieving the most efficient logistical project support capabilities. Employing the latest in equipment tracking technologies (bar code, GPS, specialized inventory tracking software, etc.), and a full-time logistics management staff. Winter Environmental applies a programmatic approach to the management of equipment and materials purchasing, inventory, dispatch, receiving, maintenance and use. We track expendable supplies on each job site daily. Field personnel statuses are tracked according to skill set, status of certifications and training, grade, current assignment and term, and hours worked or in transit. Projects are then staffed and supplied with the most appropriate and accessible personnel and equipment that can be committed full-term to the job. Every job site is connected, via the internet, to our systems operating platforms. It's simple. Winter Environmental will get the job done by implementing more than three decades of proven, award-winning contracting capability, knowledge, experience, resources, and service that is second to none in the industry. **em**

Send Us Your Information

If you are a current Organizational Member and would like your company profile to be included in a future issue of *EM*, please contact Lisa Bucher, Managing Editor at lbucher@awma.org.

Consider Upgrading to Organizational Membership

Organizational Membership is the perfect solution for companies and organizations with six or more environmental professionals on staff who want to reduce membership costs and increase their participation in A&WMA. For more information, go to www.awma.org/join.

The views expressed are those of the individual organizations and do not necessarily represent an official position of the Association. A&WMA does not endorse any company, product, or service appearing on this page.

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