FINAL PROGRAM

ATMOSPHERIC OPTICS:
AEROSOLS, VISIBILITY, AND THE RADIATIVE BALANCE

September 27-30, 2016 • Snow King Hotel, Jackson Hole, WY

http://visibility.awma.org

Five courses on
Monday, Sept. 26, 2016

Air & Waste Management Association

FINAL PROGRAM

ABOUT THE CONFERENCE

This international conference will provide a technical forum on advances in the scientific understanding of the effects of aerosols on urban, regional, continental, and global-scale haze and the radiative balance. The conference will take a multipronged approach and address scientific topics (e.g., related to measurements, modeling, etc.) as well as regulatory and policy issues. There will be sessions on black and brown carbon, as recent research has shown the importance of these particles for radiative forcing. In addition, there will be sessions related to the synergistic and increasing concerns of the effects of atmospheric nitrogen and carbonaceous material on haze, climate change, and nitrogen deposition on ecosystems. Conference learning will be enhanced with a half day excursion and hikes in Grand Teton National Park and a Night Sky Program.

GENERAL INFORMATION

REGISTRATION

Register online at http://visibility.awma.org or complete the registration form and bring it with you on site during the following hours:

Monday, Sept. 26	7:00 am - 5:00 pm
Tuesday, Sept. 27	7:00 am - 5:00 pm
Wednesday, Sept. 28	7:00 am - 12:00 pm
Thursday, Sept. 29	7:00 am - 5:00 pm
Friday, Sept. 30	7:30 am - 10:30 am

Your registration will not be processed without payment.

REFUND POLICY

If written notice of cancellation is received on or before September 19, 2016 payment will be refunded, less a $75 cancellation fee. Substitutions may be made at any time; payment for any difference is due at the time of substitution. This refund policy applies to all occurrences, including weather-related events and other natural disasters. In the unlikely occurrence of event cancellation, the Association is not liable for any expenses incurred by the registrant other than the full refund of registration fee(s) paid.

CONTINUING EDUCATION CREDIT OPPORTUNITIES

Conference and course attendees may be eligible for continuing education credits. For more information, please contact Gloria Henning at glhenning@awma.org or 412-904-6021.

CONFERENCE PROCEEDINGS

Conference abstracts will be posted on the A&WMA website prior to the start of the conference. Following the conference, presentations will also be posted. Attendees will be notified by e-mail when the proceedings are available.

CONFERENCE COMMITTEE

- Delbert J. Eatough (Chair), Brigham Young University
- Joe Adlhoch, Air Resource Specialists
- Elisabeth Andrews, University of Colorado, Boulder
- Junji Cao, Chinese Academy of Sciences, Beijing
- Kip Carrico, New Mexico Institute of Mining and Technology
- Rajan Chakrabarty, Washington University St. Louis
- Zhen (Stephen) Cheng, Shanghai Jiaotong University, China
- Judith Chow, Desert Research Institute
- Jenny Hand, Colorado State University
- Nicole Hyslop, University of California, Davis
- Philip Hopke, Clarkson University
- Mukesh Khare, Indian Institute of Technology, Delhi, India
- Byeong-Kyu Lee, University of Ulsan, Korea
- Taehyoung Lee, Hankuk University of Foreign Studies, Korea
- Shun Cheng (Frank) Lee, Hong Kong Polytechnic University
- William Malm, CIRA-Colorado State University
- Chuck McDade, University of California, Davis
- Tom Moore, WESTAR-WRAP
- Shamsh Pervez, Pt. Ravishankar Shukla University, India
- Luis Alonso Díaz Robles, University of Santiago, Chile
- Bret Schichtel, National Park Service, Air Resources Division
- Ivar Tombach, Consultant
- Kostas Tsigaridis, Columbia University and NASA GISS
- Jay Turner, Washington University St. Louis
- Ricky Tropp, Desert Research Institut
- Rebecca Washenfelder, NOAA
- John Watson, Desert Research Institute
- Chung-Shin (Jonathan) Yuan, National Sun Yatsen University, Taiwan
- Qi Zhang, University of California Davis

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GENERAL INFORMATION

LOCATION & LODGING

Conference Hotel
Snow King Resort
400 East Snow King Avenue
Jackson Hole, WY 83001
1-800-522-KING; www.snowking.com

Additional Accommodations

Painted Buffalo Inn
400 West Broadway, Jackson, WY 83001
307-733-4340;

Rawhide Motel
75 S Milward St, Jackson, WY 83001
307-733-1216; www.rawhidemotel.com

TRANSPORTATION

The Snow King Hotel will provide guests with complimentary transportation to and from the Jackson Hole airport upon request.

The Jackson Hole Shuttle, http://www.jhshuttle.com/, has 24-hr shuttle service from the Jackson Hole Airport to the town of Jackson.

PRESENTER'S BREAKFAST

Presenters and Session Chairs will meet for a continental breakfast on the day of their session in the Jackson Room to review program details. Presenters should bring their presentations on a memory stick/USB to this meeting.

JOURNAL SPECIAL ISSUE

A special Issue of the *Journal of the Air & Waste Management Association (JA&WMA)* dedicated to the material presented at this conference will be published. Anyone who presented at the conference may submit a manuscript for consideration. All submissions will undergo the usual peer review process before being accepted. If anyone would like to submit please send an e-mail to Delbert Eatough indicating the intended material for the manuscript, e.g. the conference control number related to the manuscript. Submissions to the *Journal* should indicate they are for the Special Issue and should be received by December 15, 2016 to insure inclusion in the special issue. Publication of the Special Issue is anticipated about a year from the conference.

SPECIAL EVENTS

GRAND TETON NATIONAL PARK EXCURSION

On Wednesday, September 28, the conference will take a field trip to the Grand Teton National Park Class I area, participate in one of four options for the afternoon, and then rejoin for a special National Park Service Fireside and a Night Sky program.

Option 1: Webcam Visibility and Wet Deposition Site and Heron Pond and Swan Lake Hike

Option 2: Bradley Lake/Taggart Lake/Beaver Creek Loop

Option 3: Jenny Lake

Option 4: Historical Tour

Space on tours is nearly full. If you haven't signed up for a tour, come to the registration area on site to see if space is still available.

At 5:30 pm, the Park Service will treat us with a Fireside about the Park in the outdoor amphitheater next to the Colter Bay Visitor Center.

For complete detals, visit the website at http://visibility.awma.org.

NIGHT SKY PROGRAM

From 6:30-8:00 PM you will be free to have dinner on your own. Buses will take groups to several locations for dinner, and return to the Night Sky Program site, just north of the Colter Bay Visitor Center. The night sky program will begin at 8:00 PM, and buses at the site will return on a staggered schedule as they are full to the Snow King Hotel.

PHOTO CONTEST

Conference participants are invited to participate in the Visibility Photo Contest. Don't forget to vote for your favorite!

Photos will be on display in the Timberline Foyer. To enter, email a digital copy of the photo to Kristi.gebhart@colostate.edu and bring an 8×10 print to the conference to post.

Air Resource Specialists, Inc. is sponsoring prizes for photos voted best in class by conference attendees. Winners will be announced at the Thursday luncheon by Kristi Gebhart and Anna Lee Farber.

FINAL PROGRAM

THANK YOU TO OUR SPONSORS

PLATINUM

Sunset Laboratory has been leading the way for Organic/Elemental Carbon Aerosol (OCEC) measurements since 1984. We remain the market leader in OCEC instrumentation and filter analysis with our Laboratory-based OCEC analyzer and in ambient monitoring with our Semi-Continuous OCEC aerosol analyzer. Our OCEC analyzers are found throughout the world at many universities, commercial labs, meteorological stations, and government agencies. **www.sunlab.com**

GOLD

Advance your aerosol research with unique instruments from Aerosol Devices Inc.: SPOT SAMPLER™ – revolutionizing the science of airborne particle collection for chemical or biological analysis. MAGIC CPC™ – NEW! The world's first tippable, self-sustaining, compact, quiet, water-based condensation particle counter. **www.aerosoldevices.com**

Air Resource Specialists, Inc. (ARS) has nationally recognized expertise in operating air quality, meteorology and visibility monitoring programs as well as conducting comprehensive special studies. Formed in 1981, ARS has successfully conducted a wide range of projects for federal, state, municipal, and tribal agencies, and industrial clients. Areas of special expertise include: criteria pollutant, meteorology, and visibility monitoring; data analysis; research, audit, and instrument services; air quality and visibility modeling; and environmental compliance services. Our staff of scientists, field specialists, data analysts, and support personnel, operate over 100 monitoring sites nationwide, including large and small networks in urban, rural, and remote locations. **www.air-resource.com**

ARA Instruments is a manufacturer of innovative ambient air monitoring equipment. We specialize in portable, battery-powered particulate samplers for air pollution research. We also offer flow calibration instruments and accessories for routine air monitoring. Our goal is to help our customers make important air quality decisions by providing affordable, versatile, reliable, and accurate equipment. **www.arainstruments.com**

Magee Scientific is the originator of the Aethalometer®, the most widely used instrument for real-time measurement of Black Carbon aerosols. Various models offer analysis at 7 optical wavelengths from UV to IR, with time resolutions to 1 second. The Optical Transmissometer measures the BC content of previously-collected filter samples. **www.mageesci.com**

Sponsor Table Diagram on Page 21

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GOLD, CON'T.

Met One Instruments, Inc. is an expanding company that provides solutions to the environmental monitoring market. Our expertise includes meteorological sensors and systems, particulate monitoring, datalogging and software solutions. Utilizing modern technology, innovative design, and years of experience, we satisfy the needs of our customers for ambient and indoor monitoring. **www.metone.com**

Ambient Ion Monitor (AIM): Continuous direct measurement of particles and gases (nitrate, sulfate, ammonium, nitric acid, ammonia and other gases/particles found in PM2.5). Our speciation monitors for PM10, 2.5, 1 include Medium Volume Particle Sampler & Annular Denuder System. Selection of: Teflon coated cyclones; stainless steel cyclones/diesel emissions. **www.urgcorp.com**

SILVER

Ambilabs is a full services provider and integrator of air, environmental, and process monitoring solutions. We distribute, install, and train on a broad range of gas and particulate monitoring instrumentation. Our experienced staff provide expertise, engineering, software, instrumentation, systems and solutions for obtaining valid, accurate, and precise air quality data.
www.ambilabs.com

The National Atmospheric Deposition Program (NADP) provides fundamental measurements of pollution in precipitation (wet deposition) and estimates of pollutant dry deposition. These measurements support informed decisions based upon the flow of pollutants into different ecosystem types. The NADP is composed of five networks measuring different chemical components. Special attention is given here to the Total Deposition Science Committee (TDEP), with its mission to improving the science behind wet, dry, and total atmospheric deposition of multiple chemical species. **http://nadp.isws.illinois.edu**

Thank you to the following for financial support for the Technical Program:

- U.S. Environmental Protection Agency EPA
- U.S. Department of Energy
- U.S. National Science Foundation
- U.S. National Park Service
- Electric Power Research Institute
- California Air Resources Board
- South Coast Air Quality Management District

PRELIMINARY PROGRAM

PROFESSIONAL DEVELOPMENT COURSES

HALF DAY COURSES

Half Day Course registration includes refreshment breaks, and a copy of the course manual. Lunch will be on your own with options available at the venue.

APPLICATION OF TIME SERIES METHODS TO AIR QUALITY DATA

Monday, September 26, 2016
8:00 am – 12:00 pm
Timberline 2

Instructor: *Philip K. Hopke, Center for Air Resources Engineering and Science, Clarkson University*

This course will provide an introduction to time series analyses of air quality data. Such analyses can be used to understand the underlying causative factors for collected data or to use existing data to forecast future behavior. There are a wide variety of available tools and their applicability and limitations of the various methods will be presented. Examples of the application of various methods will be provided.

CONTEMPORARY AEROSOL OPTICS

Monday, September 26, 2016
1:00 pm - 5:00 pm
Timberline 2

Instructors: *Hans Moosmüller, Desert Research Institute, Reno NV; Rajan Chakrabarty, Washington University in St. Louis, St. Louis, MO; and Rebecca Washenfelder, National Oceanic & Atmospheric Administration, Boulder, CO*

This course will outline the importance of aerosol optics for estimating visibility impairment and radiative forcing of climate, identifying the relevant optical parameters that are needed for understanding and modeling. This will be followed by a general discussion of aerosol physics before focusing on contemporary measurement and characterization techniques of aerosol optical properties. Computational electromagnetic techniques discussed will include both exact calculation methods and useful approximations while the discussion on experimental techniques will include state-of-the-art in situ, filter-based, and remote sensing techniques and instruments for quantification of aerosol scattering, absorption, and extinction coefficients, phase functions and asymmetry parameters.

FULL DAY COURSES

Full day courses will include refreshement breaks, lunch, and a copy of the course manual.

AIR QUALITY MODELING

Monday, September 26, 2016
8:00 am - 5:00 pm
Summit 2

Instructors: *Mukesh Khare, Civil Engineering Department, Indian Institute of Technology, Delhi, India; and S. M. Shiva Nagendra, Civil Engineering Department, Indian Institute of Technology, Madras, India*

Visibility is a dynamic and complex local/urban phenomena. Fine particles and gaseous air pollution affect visibility in the ambient environment by creating haze through complex dispersion mechanisms. This course has been designed to give attendees a basic understanding of fundamental principles of contaminant dispersion including meteorological parameters affecting pollutant dispersion, principle of Gaussian plume theory, types of air quality models and their uses and techniques of model validation and verification and adjustments. Participants shall also be taught as to how visibility acts as a surrogate for air pollution impact on the environment followed by the theory of visibility prediction models using air quality relationship on

PRELIMINARY PROGRAM

PROFESSIONAL DEVELOPMENT COURSES

THE PRACTICAL USE OF SATELLITE OBSERVATIONS FOR VISIBILITY AND AIR QUALITY ANALYSIS

Monday, September 26, 2016
8:00 am - 5:00 pm
Timberline 3

Instructors: *Pawan Gupta, NASA Goddard Space Flight Center, Greenbelt, MD; and Sean Raffuse, Crocker Nuclear Laboratory, University of California, Davis, CA*

This course is in collaboration with NASA's Applied Remote Sensing Training Program (ARSET), http://arset.gsfc.nasa.gov/airquality. The course will provide an overview of satellite data and its application in visibility and air quality data analysis. The focus will be on understanding what present satellite measurements can and can't provide and how to use them. In addition to an overview of satellite data and terminology, we will explore common and achievable uses for satellite data in air quality analysis (e.g., events, trends, long-range transport, spatial context) through a series of case studies.

REGIONAL HAZE RULE: SCIENCE, MODIFICATIONS, AND STATE IMPLEMENTATION PLAN REQUIREMENTS

Monday, September 26, 2016
8:00 am - 5:00 pm
Timberline 1

Instructors: *Bret Schichtel, NPS-ARD, Fort Collins, CO; and Tom Moore, WESTAR/WRAP, Fort Collins, CO*

EPA is currently reviewing the requirements of the Regional Haze Rule (RHR), with any changes to be completed in 2016. It is anticipated that the haze metrics used to track progress, estimate natural visibility goals and planning requirements will be modified resulting in new RHR guidance documents and potentially RHR changes. These changes will impact the requirements for the next round of the RHR State Implementation Plans (SIPs) currently due in 2018.

This course will review the visibility and aerosol science and regulations underpinning the RHR. Issues raised by States and others on the current RHR SIP requirements will be discussed and how revisions to these requirements address these issues. With this background, detailed descriptions of the RHR SIP requirements will be presented and discussed along with examples of different elements of a SIP.

SESSION SCHEDULE - TUESDAY, SEPTEMBER 27, 2016

7:00 am - 5:00 pm
Conference Registration
Grand Teton Mezzanine

7:00 am - 8:00 am
Continental Breakfast
Grand Teton Mezzanine

7:00 am - 8:00 am
Presenter's Breakfast
Jackson Room

OPENING PLENARY SESSION

Grand Room

8:00 am – 9:40 am

Welcome
Delbert J. Eatough, Conference Chair

Introduction of Plenary Speakers: *Rajan Chakrabarty and William Malm*

The many cloudy faces of black carbon in the climate system
Bjørn Samset, *Senior Researcher, Center for International Climate and Energy Research - Oslo (CICERO)*

Aerosol water: now you see it now you don't
Ann Marie Carlton, Associate Professor, Department of Chemistry, University of California, Irvine

9:40 am – 10:00 am
Networking Break
Timberline Foyer

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SESSION SCHEDULE - Tuesday, September 27, 2016

TRACK A

SESSION 1: VISIBILITY AS AN INDICATOR OF HUMAN HEALTH EFFECTS

Grand Room

Session Chairs: Delbert Eatough, Brigham Young University; Phillip Hopke, Clarkson University

10:00 am
Control #1
A 1960's Copper Smelter Strike and Increased Visibility: Natural Experiment of Reduced Sulfate Particle Pollution on Regional Mortality
C. Arden Pope III: Brigham Young University

10:20 am
Control #44
Using Visibility to Examine Health Effects in Epidemiologic Studies: An Historical Perspective
Bart Ostro: University of California -Davis

10:40 am
Control #3
Municipal Solid Waste Burning: Discoloring the Taj Mahal and Human Health Impacts in Agra
Raj M. Lal, Lina Luo, Armistead G. Russell: Georgia Institute of Technology; Ajay S. Nagpure, Anu Ramaswami: University of Minnesota; Sachchida N. Tripathi: Indian Institute of Technology – Kanpur; Michael H. Bergin: Duke University

11:00 am
Control #114
Blending Output from Forest Fire Smoke Models with Measured $PM_{2.5}$ Concentration Can Improve their Utility for Exposure Assessment in Epidemiologic Research and Public Health Surveillance
Jiayun Yao: British Columbia Center for Disease Control; Saran B. Henderson, University of British Columbia

11:20 am
Control #67
Development of a Visibility Forecasting Product using the GEM-MACH Air Quality Model – a Pilot Project for the Lower Fraser Valley of British Columbia
Rita So, Andrew Teakles, Jonathan Baik, Keith Jones, Roxanne Vingarzan: Environment and Climate Change Canada

11:40 am
Control #72
Citizen Science and NexGen Visibility Measurement
Shawn Dolan: Virtual Technology LLC and Sustainable Sky's Org

TRACK B

SESSION 2: SATELLITE AND REMOTE SENSING APPLICATIONS TO HAZE/AEROSOL MONITORING

Teton Room

Session Chairs: Rajan Chakrabarty, Washington State University in St. Louis and Katie Kaku, CSRA

10:00 am
Control #64
Assessing the Limitations of Surface-level Aerosol Mass Calculations from Aerosol Optical Depth and Lidar Observations During the $SEAC^4RS$ Campaign
Katie C. Kaku: CSRA; Jeffery S. Reid: Naval Research Laboratory; Robert E. Holz, Ralph E. Kuehn: University of Wisconsin; Jianglong Zhang: University of North Dakota; Eric S. Edgerton: Atmospheric Research & Analysis, Inc.; Brent N. Holben, Anne M. Thompson: NASA; Shi Kuangi, University of Alabama Huntsville

10:20 am
Control #84
A Global Time Series of Aerosol Optical Depth, Derived from MODIS and VIIRS Observations
Falguni Patadia: MSU/GSFC/613; Robert C. Levy: GSFC/613; Shana Mattoo: SSAI/GSFC/613

10:40 am
Control #66
A Laboratory Experiment for the Statistical Evaluation of Aerosol Retrieval (STEAR) Algorithms
Gregory L. Schuster, Luke D. Ziemba, Andreas J. Beyersdorf, Bruce E. Anderson, Michael A. Shook, Richard H. Moore: NASA LaRC; Reed Espinosa, Adriana Rocha-Lima, Jose V. Martins: UMBC; Oleg Dubovik, Fabrice Ducos, David Fuertes, Tatsiana Lapyonok, Yevgeny Derimian: U. de Lille 1

11:00 am
Control #101
Study on Aerosol Optical properties and Radiative Effect in Cloudy Weather in the Guangzhou Region
DENG Tao, DENG XueJiao, TAN Haobo, LI Fei: China Meteorological Administration

11:20 am
Control #106
TwilightSat: A New Concept for Optical Satellite Remote Sensing of Atmospheric Aerosols
Hans Moosmüller, Michealene Iaukea-Lum: Desert Research Institute; Jeffrey C. LaCombe, Eric Wang: University of Nevada Reno

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SESSION SCHEDULE - Tuesday, September 27, 2016

12:00 pm - 1:30 pm (Grand View Ballroom)
Lunch Presentation on The Night Sky Program at Grand Teton National Park
Robert Hoyle, Lead Park Ranger/Interpretation

TRACK A

SESSION 3: HUMAN PERCEPTION OF VISIBILITY
Grand Room

Session Chair: Ivar Tombach, Consultant

1:30 pm
Control #93
Study of Carbonaceous Fractions Associated with Indoor PM2.5/ PM10 during Asian Cultural and Ritual Burning Practices
Yasmeen Pervez: CSIT; Shippi Dewangan, Shamsh Pervez: Pt. Ravishankar Shukla University; Rajan Chakrabarty: Washington University in St. Louis; John G. Watson, Judith C.Chow: Desert Research Institute

1:50 pm
Control #27
Preserving Treasured Views – The National Park Service Visual Resource Inventory
Mark Meyer, Melanie Peters, John Vimont: National Park Service; Robert Sullivan: Argonne National Laboratory

2:10 pm
Control #79
Reconciliation of Urban Visibility Preference Studies: Implications for an Urban Visibility Standard
Bret A. Schichtel: National Park Service; William C. Malm, Dustin Schmidt, Jenny Hand: Colorado State University

2:30 pm
Control #51
A Review of Seven Visibility Preference Studies as they Relate to Various Visibility Metrics
William C. Malm: Colorado State University; Bret A. Schichtel: National Park Service

2:50 pm
Control #86
Urban Visibility Standards and Trends in Fort Collins, Colorado
Cassie Archuleta: City of Fort Collins Environmental Services Department; Bret Schichtel: Cooperative Institute for Research in the Atmosphere; Joe Adlhoch, Emily Vanden Hoek: Air Resource Specialists; Gregory Harshfield, Gordon Pierce: Colorado Department of Health and Environment

3:30 pm - 3:50 pm
Networking Break
Timberline Foyer

TRACK B

SESSION 4: AEROSOL AND VISIBILITY MODELING AT LOCAL, REGIONAL, AND GLOBAL SCALES
Teton Room

Session Chair: Tom Moore, WESTAR

1:30 pm
Control #58
Calculating Single Source Visibility Impacts Using a Reactive Puff Model
Eladio Knipping, Naresh Kumar: Electric Power Research Institute; Prakash Karamchandani, Lynsey Parker, Greg Yarwood: Ramboll Environ

1:50 pm
Control #115
Single Source Visibility Assessment using CAMx
Marco A. Rodriguez, Chao-Jung Chien, Caitlin Shaw, Courtney Taylor: AECOM

2:10 pm
Control #30
$PM_{2.5}$ Pollution in Households Involved with Solid Fuel Burning Practices: Application of Receptor Models for Source Apportionment
Shamsh Pervez, Jeevan Matawle: Pt. Ravishankar Shukla Univ.

2:30 pm
Control #2
Application of Global High-resolution Emission Inventories of Air Pollutants from Combustion Sources
Shu Tao, Huizhong Shen, Qirui Zhong: Peking University

2:50 pm
Control #45
Assessment of Regional Air Quality Resulting from Emission Control in the Pearl Delta River Region in China
Nan Wang, X.J. Deng, T. Deng, C.Q. Yin: Guangdong Provincial Key Laboratory of Regional Numerical Weather Prediction; X.P. Lyu: The Hong Kong Polytechnic University; Y. Li: Hong Kong University of Science and Technology

3:10 pm
Control #116
Evaluation of Revised Uniform Rate of Progress (URP) Procedures to Assess Reasonable Progress Goals (RPGs) for the Second Regional Haze Rule Implementation Period of 2018-2028
Ralph Morris, Ramboll Environ; Zac Adelman, UNC Chapel Hill; Tom Moore, WESTAR

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SESSION SCHEDULE - Tuesday, September 27, 2016

TRACK A

SESSION 5: PANEL: EVOLVING ISSUES IN AIR QUALITY RELATED TO A CHANGING CLIMATE

Grand Room

Session Chair: Kip Carrico, New Mexico Institute of Mining and Technology

3:50 pm - 5:30 pm

Panelists:

- **Kip Carrico** - New Mexico Institute of Mining and Technology
- **Jenny Hand** - Colorado State University
- **Sean M. Raffuse** - University of California, Davis
- **Sarah Suda-Petters** - North Carolina State University
- **Gannet Hallar** - University of Utah and DRI Storm Peak Laboratory
- **Hans Moosmüller** - Desert Research Institute

The magnitude and pace of anthropogenic climate change have profound implications for related air quality problems. Aerosols (and some trace gas species) are well-known as climate drivers, directly via backscatter and absorption of radiation and indirectly via cloud impacts. Among the most impacted air quality parameters are ozone and aerosol concentrations. Whereas anthropogenic emissions of greenhouse gases are just beginning to be addressed, emission reductions in aerosols and their precursors have been remarkably successful in the US over the last 50 years. Thus perturbed natural sources of aerosols have become more important in urban and, in particular, rural areas. Trends related to this include the growing importance of primary and secondary carbonaceous aerosols as well as an upward trend in mineral dust species observed in the Western US over two decades. The panel will address the following related questions:

- *Warming and extreme weather: what are the expected changes and how will it impact air quality?*
- *A warming climate: what does this mean for visibility and regional haze?*
- *What trends are emerging with 'perturbed natural sources' of PM including windblown dust and biomass burning smoke?*
- *What are the feedback processes involving inter-connected changes in air quality and climate?*
- *What are the current research needs to further reduce uncertainties in aerosol-climate interactions?*

TRACK B

SESSION 6: ATMOSPHERIC NITROGEN — A BRIDGE BETWEEN VISIBILITY, ECOLOGICAL, AND AGRICULTURAL ISSUES

Teton Room

Session Chairs: Bret Schichtel, National Park Service; Richard Poirot, Consultant

3:50 pm
Control #33
Back Trajectory Insights on Sources of Nitrogen at Rocky Mountain National Park, CO
Kristi A. Gebhart, Jim Cheatham, Kristi Morris, John Vimont: National Park Service

4:10 pm
Control #50
Modeled Source Apportionment of Reactive Nitrogen in the Greater Yellowstone Area
Tammy M. Thompson: Colorado State University; Michael G. Barna, Bret A. Schichtel: National Park Service; C. Thomas Moore: Western States Air Resources Council (WESTAR)

4:30 pm
Control #95
The Increasing Importance of Deposition of Reduced Nitrogen in the United States
Jeffrey L. Collett, Jr., Yi Li, Bret A. Schichtel: Colorado State University; John T. Walker, Donna B. Schwede, Xi Chen, Melissa A. Puchalski: US EPA; Christopher M.B. Lehmann, David Gay: University of Illinois Urbana-Champaign

4:50 pm
Control #77
NADP's Total Deposition Science Committee (TDEP): Advancing the Use of Measurement and Modeling Data for Spatial Interpolation of Total Atmospheric Deposition
Greg Beachley, Donna Schwede, Gary Lear, John T. Walker, Melissa Puchalski: US EPA; Christopher M. Rogers: Amec Foster Wheeler; Kristi Morris: National Park Service

5:10 pm
Control #117
The Cache Valley Ammonia Super Volcano
Randal S. Martin: Utah State University; Munkh Baasandorj: Utah Division of Air Quality

5:30 - 6:30 pm
Exhibitor Networking Reception
Timberline Foyer

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SESSION SCHEDULE - Wednesday, September 28, 2016

7:00 am - 12:00 pm
Registration
Grand Teton Mezzanine

7:00 am - 8:00 am
Continental Breakfast
Grand Teton Mezzanine

7:00 am - 8:00 am
Presenter's Breakfast
Jackson Room

TRACK A

SESSION 7: PANEL: REGIONAL PERSPECTIVES ON THE SECOND PLANNING PERIOD FOR REGIONAL HAZE STATE IMPLEMENTATION PLANS

8:00 am - 9:40 am

Grand Room

Session Chair: Tom Moore, *WESTAR-WRAP*

Panelists:

- **Theresa Pella**, *Central States Air Resource Agencies (CenSARA)*
- **Joseph Jakuta,** *Ozone Transport Commission (OTC)*
- **Rob Kaleel,** *Lake Michigan Air Directors Consortium (LADCO)*
- **Arthur Marin**, *Northeast States for Coordinated Air Use Management (NESCAUM)*
- **Mary Uhl**, *Western States Air Resources Council (WESTAR)*

The panelists will discuss the results to date of efforts to improve visibility at Class I areas. They will also discuss existing and potential future challenges, such as whether EPA's transport rule requirements are more effective than the Regional Haze rule's best available retrofit technology (BART) provisions. Also to be addressed will be ongoing legal actions and potential future legal challenges. Some panelists will be able to share technical work that is underway or will be initiated in the near future. Depending on the Class I area, ongoing and planned future reductions in Sulfur Dioxide and Nitrogen Oxide emissions are and will be largely responsible for visibility improvements. Still, achieving long-term goals necessitates a multi-pollutant approach.

Members of the Panel will present information on the impacts of key aerosol components of haze, including sulfates, nitrates, elemental carbon, organic carbon, and crustal materials such as dust/soil. The panel will also discuss EPA's draft reasonable progress guidance and how those provisions may ultimately influence state and regional technical work for the next round of Regional Haze SIPs.

TRACK B

SESSION 8A: AEROSOL-OPTICAL RELATIONSHIPS

Teton Room

Session Chair: Ivar Tombach, Consultant

8:00 am
Control #52
The Application of a Fast Fourier Transform Index to Webcam Images for Quantitative Characterization of Haze
William C. Malm: Colorado State University; Scott Cismoski: Air Resource Specialists; Melanie Ransmeier, Bret A. Schichtel: National Park Service

8:20 am
Control #4
Effect of PM2.5 Chemical Constituents on Atmospheric Visibility Impairment in Delhi City, India
Isha Khanna, Mukesh Khare: Indian Institute of Technology; Prashant Gargava: Central Pollution Control Board; Anwar Ali Khan: Environment Department Uttar Pradesh

8:40 am
Control #57
Effects of Local Emissions on Urban Visibility Measured with a Mobile Airship Monitoring Platform
P K. Hopke: Clarkson University; J. Hovoka, N. Kuzelova, J. Bendl, M. Klan, C. Leoni: Charles University; O. F. Bischof: TSI Inc.;

9:00 am
Control #69
Dual Wavelength Integrating Nephelometer to Determine Source Influences on Particle Concentration Measurements
Herbert Schloesser: Ambilabs LLC

9:20 am
Control #6
Visibility in Dusty Environment: Experiment and Theory
Speaker to be announced

9:40 am to 10:00 am
Networking Break
Timberline Foyer

FINAL PROGRAM

SESSION SCHEDULE - Wednesday, September 28, 2016

TRACK A

SESSION 9A: REGIONAL HAZE RULE
Grand Room

Session Chairs: Joe Adlhoch, Air Resource Specialists; Bret Schichtel, National Park Service

10:00 am
Control #73
Potential Alternative to the Regional Haze Rule Visibility Progress Tracking Metric
Brett Gantt, Neil Frank, Melinda Beaver: US EPA

10:20 am
Control #74
Comparison of Tracking Progress Metrics under the Regional Haze Rule using Default and Impairment Based Approach
Scott A. Copeland: CIRA; Brett Gantt, Neil Frank, Melinda Beaver: US EPA; Bret A. Schichtel, John Vimont: National Park Service

10:40 am
Control #78
The Dependence of the Distribution in Natural Haze on Haze Levels and the Contributions from Anthropogenic Sources
Bret A. Schichtel, Kristi A. Gebhart, John Vimont: National Park Service; Scott Copeland, William C. Malm: Colorado State University; Neil Frank, Tom Moore: WESTAR

11:00 am
Control #55
A Conceptual Approach to Address Anthropogenic/Non-Anthropogenic Emission Sources to Help Develop a More Accurate Regional Haze Program Glidepath
Theresa Pella: CenSARA; Cassie Archuleta: City of Fort Collins Environmental Services Department; Uarporn Nopmongcol, Ralph Morris: Ramboll Environ; Emily Vanden Hoek, Joe Adlhoch: Air Resource Specialists

11:20 am
Control #88
Visibility Improvements Past and Future in the Southeastern United States
Sheila Holman: North Carolina Department of Environment and

12:15 pm - 6:30 pm Grand Teton National Park Excursion

8:00 pm - 10:00 pm Night Sky Program

Busses depart from the Lobby entrance

TRACK B

SESSION 8B: AEROSOL-OPTICAL RELATIONSHIPS CON'T
Teton Room

Session Chair: Kip Carrico, New Mexico Institute of Mining and Technology

10:00 am
Control #63
On the Implications of Aerosol Liquid Water and Phase Separation for Modeled Organic Aerosol Mass
Havala O. T. Pye, Ben N. Murphy: US EPA; Aikaterini Bougiatioti, Hongyu Guo, Athanasios Nenes, Nga L. Ng, Rodney Weber, Lu Xu: Georgia Institute of Technology; Ann Marie Carlton, Khoi Nguyen: Rutgers University; Weiwei Hu, Jose L. Jimenez: University of Colorado at Boulder

10:20 am
Control #53
Estimating Temporal Trends in Biogenically Formed Secondary Organic Aerosols Resulting From Reduction in Atmospheric Aerosol Water Content Across the Continental United States
William C. Malm and J.L. Hand: Colorado State University; Bret Schichtel: National Park Service

10:40 am
Control #60
The Hygroscopicity of Organic Compounds as a Function of Carbon Chain Length, Carboxyl, Hydroperoxide, and Carbonyl Functional Groups
Sarah Suda Petters, Markus D. Petters: North Carolina State University; Ezra J. T. Levin, Sonia M. Kreidenweis: Colorado State University; Demetrios Pagonis, Megan S. Claflin, Paul J. Ziemann: University of Colorado at Boulder

11:00 am
Control #8
Role of RH, Temperature, and $PM_{2.5}$ in the Changes in Ambient Visibility, Busan, Korea
Gee-Hyeong Park: Busan Institute of Health and Environment; Byeong-Kyu Lee: University of Ulsan

11:20 am
Control #28
Mass Extinction Efficiency and Hygroscopicity of PM2.5 in Major Chinese Cities
Zhen Cheng, Yujie He, Naiqiang Yan: Shanghai Jiao Tong University; Yungang Wang: GAGO Inc.; Xin Ma: China Meteorological Monitoring Center; Jingkun Jiang: Tsinghua University; Xiaoliang Wang: Desert Research Institute; Li Sheng, Jiangkai Hu: China Meteoro

11:40 am
Control #20
An Examination of the Current IMPROVE Algorithm
A.J. Prenni, B.A. Schichtel: National Park Service; J.L. Hand, W.C. Malm: Colorado State University

FINAL PROGRAM

SESSION SCHEDULE - Thursday, September 29, 2016

7:00 am - 5:00 pm
Registration
Grand Teton Mezzanine

7:00 am - 8:00 am
Continental Breakfast
Grand Teton Mezzanine

7:00 am - 8:00 am
Presenter's Breakfast
Jackson Room

TRACK A

SESSION 10: PANEL: AIR QUALITY ISSUES IN THE WESTAR REGION

Grand Room

Session Chairs: Mary Uhl, Tom Moore, WESTAR

8:00 am - 9:40 am

Panelists:

- **Nancy Vehr,** *Air Quality Division Administrator, Wyoming*
- **Bryce Bird,** *Division of Air Quality Director, Utah*
- **Gordon Pierce,** *Program Manager, Colorado Department of Public Health and Environment*
- **Stephen Coe,** *Air Resources Management Bureau, State of Montana*

The panel presentation will focus on air quality issues in four WESTAR member states close to the conference location: Wyoming, Utah, Montana, and Colorado. All four states willl address how they have each addressed visibility and potential degradation associated with winter ozone episodes, smoke, and energy development including oil and gas mining as well as from a rural perspective. Two of the states - Utah and Colorado - will also address these issues from an urban perspective. The presentation will highlight the similarities or differences in how states have addressed these issues as a result of the state's specific policy perspective or other unique circumstances.

9:40 am to 10:00 am
Networking Break
Timberline Foyer

TRACK B

SESSION 11: NEW INSTRUMENTS AND MEASUREMENT TECHNIQUES

Teton Room

Session Chairs: Ann Dillner, University of California, Davis; Jaron Hansen, Brigham Young University

8:00 am
Control #5
Development of the GC-MS Organic Aerosol Monitor (GC-MS OAM) For In-field Detection of Particulate Organic Compounds
Paul M. Cropper, Delbert J. Eatough, Jaron C. Hansen: Brigham Young University; Robert A. Cary: Sunset Laboratory

8:20 am
Control #7
Use of a GC-MS Monitor for In-Field Detection of Fine Particulate Organic Compounds in Source Apportionment
Delbert J Eatough, Paul Cropper, Jaron C. Hansen: Brigham Young University; Robert A. Cary: Sunset Laboratory Inc.

8:40 am
Control #11
Advanced Detection Methods for Thermal/Optical Analysis of IMPROVE Samples
John G. Watson, Judith C. Chow, Gustavo M. Riggio, Xiaoliang Wang, Paul M. Cropper, Devon K. Overson: Desert Research Institute; L.-W Antony Chen: University of Nevada

9:00 am
Control #36
A Non-destructive, Inexpensive Method for Predicting TOR OC and EC in the IMPROVE and CSN networks using Infrared Spectra
Ann M. Dillner, Andrew T. Weakley: University of California Davis; Giulia Ruggeri, Matteo Reggente, Satoshi Takahama: Swiss Federal Institute of Technology Lausanne (EPFL)

9:20 am
Control #92
Optical Characterization of Filtered Aerosols Using Broadband Illumination: An Enhanced Measurement System for the IMPROVE Air Quality Network
Keith J. Bein, Nicholas J. Spada, Charles E. McDade, Warren H. White: University of California–Davis

FINAL PROGRAM

SESSION SCHEDULE - Thursday, September 29, 2016

TRACK A

SESSION 9B: REGIONAL HAZE RULE CON'T.
Grand Room

Session Chairs: Joe Adlhoch, Air Resource Specialists; Bret Schichtel, National Park Service

10:00 am
Control #34
The Role of "Margin of Error" In Regional Haze Determinations
Gale F Hoffnagle: TRC Environmental Corporation

10:20 am
Control #65
Source Attribution for Visibility Planning using a Regional Photochemical Model
Patricia F. Brewer: National Park Service; Gail Tonnessen: US EPA; Tom Moore: Western States Air Resources Council

10:40 am
Control #68
The Uniform Rate of Progress and Setting a Reasonable Progress Goal in Western U.S. Class I federal areas
Gail Tonnesen: US EPA; Tom Moore: WESTAR; Patricia F. Brewer: National Park Service

11:00 am
Control #42
Assessment of the Contributions to Visibility Impairment in the Western United States and the Potential Effects of New Guidance for Tracking Visibility Progress
Ralph Morris: Ramboll Environ US Corporation; Tom Moore: WESTAR

11:20 am
Control #54
Using NAAPS Smoke to Estimate National Regional Haze Contributions in the Western U.S.
Neil Frank: US EPA (retired); Rudy Husar, Washington Universty; Doug Westphal, Naval Research Laboratory

12:00 pm - 1:30 pm (Grand View Ballroom)

Photo Contest Winners
Kristi Gebhart and Anna Lee Farber

Lunch Presentation
Current Resource Issues at Grand Teton
Sue Consolo-Murphy, Chief of the Division of Science and Resource Management, Grand Teton National Park

TRACK B

SESSION 12: SECONDARY ORGANIC AEROSOLS
Teton Room

Session Chair: Phillip Hopke, Clarkson University

10:00am
Control #14
Drying-Induced Evaporation of Secondary Organic Aerosols during Summer
Christopher J. Hennigan, Marwa M. H. El-Sayed, Dziedzorm Amenumey: University of Maryland

10:20 am
Control #12
More Complete Analysis of IMPROVE Samples for Visibility and Source Apportionment Studies
Judith C. Chow, John G. Watson, Xiaoliang Wang, Paul M. Cropper: Desert Research Institute

10:40 am
Control #37
Organic Functional Group and OM/OC Measurements at Select IMPROVE Sites using Infrared Spectra: Organosulfates and Amines
Ann M. Dillner, Mohammed Kamruzzaman: University of California Davis; Satoshi Takahama: Swiss Federal Institute of Technology Lausanne (EPFL)

11:00 am
Control #23
Carbonaceous Aerosols and their Light Absorption Ability at an Urban Site of Delhi: Implications for Local Air Quality and Climate
Zainab Arub, Annada Padhi, Shilpi Samiksha, Ramya Sunder, Gazala Habib, Gaurav Singh, India Institute of Technology

11:20 am
Control #96
Improving Understanding of the Southeastern U.S. Biomass Burning Contribution to SOA
Stephanie L. Shaw, Eladio M. Knipping: Electric Power Research Institute; Karsten Baumann, Eric S. Edgerton: Atmospheric Research & Analysis; Charlie L. Blanchard, George M. Hidy: Envair; John J. Jansen: Southern Company Services; Aikaterini Bougiatioti, Athanasios Nenes, Rodney J. Weber, Jenny P.S. Wong: Georgia Institute of Technology

11:40 am
Control #46
Projections of Anthropogenic Secondary Organic Aerosols Over China Under RCP Scenarios
Changqin Yin: Institute of Tropical and Marine Meteorology; Tijian Wang, Bingliang Zhuang: Nanjing University; Xuejiao Deng, Tao Deng, Nan Wang: Institute of Tropical and Marine Meteorology

FINAL PROGRAM

SESSION SCHEDULE - Thursday, September 29, 2016

TRACK A

SESSION 13: POTENTIAL IMPACTS OF EMISSIONS FROM OIL AND GAS FIELDS ON AIR QUALITY AND VISIBILITY

Grand Room

Session Chair: Tom Moore, WESTAR

1:30 pm
Control #35
Upper Green River Basin, WY, Oilfield Disposal Pond Emission Study
Cara Keslar, Adam Deppe: Wyoming DEQ; Richard Bowers, Ann Smith: GSI Environmental Inc.

1:50 pm
Control #80
Statistical Analysis of Winter Ozone Events in the Uinta Basin, Utah
Marc L. Mansfield: Utah State University

2:10 pm
Control #85
Using Modeling Technique to Quantify Background Ozone Concentration in the Uintah Basin, Utah
Huy Tran, Trang Tran, Marc L. Mansfield: Utah State University

2:30 pm
Control #49
Modeled Representation of Visibility Impacts due to Emissions Associated with Oil and Gas
Tammy M. Thompson: Colorado State University; Michael G. Barna, Bret A. Schichtel: National Park Service; C. Thomas Moore: Western States Air Resources Council (WESTAR)

2:50 pm
Control #22
An Overview of the Bakken Air Quality Study
A.J. Prenni, B.C. Sive, K.A. Gebhart, B.A. Schichtel: National Park Service; D.E. Day, A.R. Evanoski-Cole, A. Hecobian, Y. Zhou, J.L. Hand, A.P. Sullivan, Y. Li, M.I. Schurman, Y. Desyaterik, W.C. Malm, J.L. Collett Jr: Colorado State University

3:10 pm
Control #61
Aerosol Light Scattering Measurements in the Bakken Oil Fields
Derek E. Day, Jenny L. Hand, Ashley Evanoski, Jeff L. Collet Jr.: Colorado State University; Kristi A. Gebhart, Anthony J. Prenni, Bret Schichtel: National Park Service

TRACK B

SESSION 14: MINERAL DUST AEROSOLS: IMPACTS ON AIR QUALITY AND VISIBILITY

Teton Room

Session Chairs: Rob Farber, Atmospheric Clarity; Jenny Hand, Colorado State University

1:30 pm
Control #17
Spatial and Seasonal Patterns in Mineral Dust Concentrations at Remote Sites Across the United States
J. L. Hand: Colorado State University; B. A. Schichtel: National Park Service; W. H. White, N. P. Hyslop: University of California-Davis; T. E. Gill: University of Texas at El Paso

1:50 pm
Control #87
The Impact of African Dust on the Annual Average $PM_{2.5}$ Concentrations at the Maximum Concentration $PM_{2.5}$ Monitoring Site in the Houston Texas Region, 2009-2015
David W. Sullivan: The University of Texas at Austin; James H. Price, Kasey Savanich: Texas Commission on Environmental Quality; Richard J. Tropp: Desert Research Institute

2:10 pm
Control #108
Optical Properties of Suspended Mineral Dusts from Desert Source Regions
Johann P. Engelbrecht, Hans Moosmüller: Desert Research Institute; R. K. M. Jayanty: RTI International; Gary Casuccio: RJ Lee Group, Inc.

2:30 pm
Control #25
Taming the Wind Blown Dust in the Western Mojave Desert
Rob Farber, Atmospheric Clarity

2:50 pm
Control #62
Fine Particle Generation from Fugitive Dust Sources
Julie Schuder and Chatten Cowherd, Jr.: AV Dust Control Group

3:10 pm
Control #26
Assessing the Impact of Precipitation on PM Coarse (PM10-2.5)
Yousaf Hameed: Clark County Department of Air Quality

3:30 pm - 3:50 pm
Networking Break
Grand Teton Mezzanine

FINAL PROGRAM

Thursday, September 29, 2016

Technical Poster Session 3:50 pm - 5:50 pm (Grand Room)

Session Chairs: Delbert Eatough, Brigham Young Uninversity and Alfred Lawrence, Isabella Thoburn College, India

VISIBILITY AS AN INDICATOR OF HUMAN HEALTH EFFECTS (Topic Area A)

Control #125

Measuring and Reporting Visual Air Quality Management Progress in the Canadian Lower Fraser Valley, BC

Julie E. Saxton, D. Laurie Bates-Frymel: Metro Vancouver; Markus Kellerhals, BC Ministry of Environment

Control #127

Indoor Air Quality Assessment and Health Impact in Context with the Living Standards in Urban & Rural Lucknow Homes

Alfred Lawrence and Tahmeena Khan
Department of Chemistry, Isabella Thoburn College, Lucknow, India

HUMAN PERCEPTION OF VISIBILITY (Topic Area B)

Control #56

Using Dark Sky Images Captured with a Standard Digital Camera to Quantify Visual Air Quality and the Night Sky Viewing Experience at Bryce Canyon National Park

Scott Cismoski: Air Resource Specialists; William C. Malm: Colorado State University; Bret A. Schichtel: National Park Service

AEROSOL AND VISIBILITY MODELING AT LOCAL, REGIONAL, AND GLOBAL SCALES (Topic Area C)

Control #129

Source apportionment of biogenic contributions to ozone formation over the United States

Rui Zhang and Daniel Cohan: Rice University; Alex Cohan: Lake Michigan Air Directors Consortium (LADCO; and Arastoo Pour-Biazzar: The National Space Science Technology Center, University of Alabama in Huntsville

SATELLITE AND REMOTE SENSING APPLICATIONS TO HAZE/AEROSOL MONITORING (Topic Area D)

Control #123

Aerosol Optical Parameters Detection from LIDARS and Applications to an Ultraviolet and Visible Radiative Transfer Model

Richard Medina: NOAA Center for Atmospheric Sciences, Howard University

ATMOSPHERIC NITROGEN (Topic Area E)

Control #21

Enhanced Concentrations of Reactive Nitrogen Species During the Hewlett Gulch and High Park Fires in Colorado

A.J. Prenni, B.A. Schichtel: National Park Service; K.B. Benedict, A.P. Sullivan, J.L. Collett Jr.: Colorado State University; C.M. Carrico: New Mexico Institute of Mining and Technology

Control #128

Innovative Approach to Selectively Measure Nitrogen Dioxide from Industrial Processes Over a Wide Linear Dynamic Range

Dr. Charles A. Odame-Ankrah, Carlyn, L.F. McGeean, Charles, E. Grimm, Shaun, W. Hayward; Brodie, D. Bigger; and Brian, W. Rosentreter, Global Analyzer Systems Ltd.

AEROSOL-OPTICAL RELATIONSHIPS (Topic Area F)

Control #39

Ambient Aerosol Extinction in Great Smoky Mountains National Park

Timothy D. Gordon, Gavin R. McMeeking, Ping Chen: Handix Scientific; Jim Renfro, Anthony J. Prenni: National Park Service

NEW INSTRUMENTS AND MEASUREMENT TECHNIQUES (Topic Area G)

Control #38

Nitrogen Oxides Measurements Using Direct Optical and Chemiluminescence Techniques

Caroline Allen, Christian M. Carrico: New Mexico Institute of Mining and Technology; Peter Anderson: 2B Technologies

Control #118

A "MAGIC" Water Condensation Particle Counter

Gregory S. Lewis, Steve Spielman, Arantzazu Eiguren Fernandez, and Susanne V. Hering: Aerosol Dynamics Inc.; Patricia B. Keady, Aerosol Devices Inc.

Control #119

A Universal Spot Sampler for High-Efficiency, Concentrated Collection of Aerosol Particles on a Solid Substrate and in Liquids

Patricia B. Keady, Christopher Hare: Aerosol Devices, Inc.; Arantzazu Eiguren Fernandez, Gregory S. Lewis and Susanne V. Hering: Aerosol Dynamics Inc.

Thursday, September 29, 2016

Technical Poster Session 3:50 pm - 5:50 pm (Grand Room)

SECONDARY ORGANIC AEROSOLS (Topic Area H)

Control #124

Urban Heat Island (Uhi) Influence on Secondary Pollutant Formation at a Tropical Humid Environment

Gsnvksn Swamy, Dr. S.M. Shiva Nagendra, Indian Institute of Technology; Dr. Uwe Shlink: Helmholtz Centre for Environmental Research, Leipzig, Germany

POTENTIAL IMPACTS OF EMISSIONS FROM OIL AND GAS FIELDS ON AIR QUALITY AND VISIBILITY (Topic Area I)

Control #40

Upper Green River Basin, WY, Historical Analysis of Pollutant Concentrations

Leif Paulson, Adam Deppe, Cara Keslar: Wyoming DEQ

Control #83

FDDA (Nudging) Impacts on WRF-CAMx Model Performance in Simulating Winter O_3 Formation in Uintah Basin

Trang Tran, Huy Tran: Utah State University; Erik Crosman: University of Utah

Control #120

Novel Lab Method to Detect Methane or CO_2 Leakage from Damaged Cement in Unconventional Oil and Gas Wells

Raili Taylor and John McLennan: Dept. of Chemical Engineering and Energy and Geoscience Institute (EGI), University of Utah; Jake Tuttle: Chemical Engineering Dept., University of Utah; Randy Neilsen: Dept. of Mining Engineering, University of Utah

Poster Diagram on Page 22

MINERAL DUST AEROSOLS: IMPACTS ON AIR QUALITY AND VISIBILITY (Topic Area J)

Control #32

Back Trajectory and Meteorological Factors in Spring Dust Trends in the Southwestern U.S.

Kristi A. Gebhart, Bret A. Schichtel: National Park Service; Jenny L. Hand: Colorado State University; Warren H. White, Nicole P. Hyslop: University of California; Thomas E. Gill: University of Texas

AEROSOL FIELD STUDIES AND MONITORING NETWORKS (Topic Area K)

Control #76

US EPA Applications of the Monitor for AeRosols and Gases in Ambient air (MARGA) to Measure Ambient Gaseous and Particulate Pollutants and Dry Deposition Fluxes

Gregory Beachley, John T. Walker: US EPA; Ian Rumsey: College of Charleston; Ashley Evanoski-Cole: Colorado State University

Control #59

Source apportionment studies of particulate matter in China

S.C. Lee and Y. GAO: The Hong Kong Polytechnic University

Control #89

Behavior Of Atmospheric Pollutants In Closed Valleys

Carmen Zapata, Natalia Cano, Mauricio Ramirez, José Fernando Jimenez: Universidad Nacional de Colombia

Control #29

Characteristics of Absorbing Aerosols During Winter Foggy Period over the National Capital Region of Delhi: Impact of Planetary Boundary Layer Dynamics and Solar Radiation Flux

Philip K. Hopke: Clarkson University; S. Tyagi, A. Mishra: Gautam Buddha University; S. Tiwari: Indian Institute of Tropical Meteorology; S. Singh: CSIR-National Physical Laboratory; S.D. Attrie: India Meteorological Department

Technical Poster Session, con't. 3:50 pm - 5:50 pm (Grand Room)

Session Chairs: Delbert Eatough, Brigham Young Uninversity and Alfred Lawrence, Isabella Thoburn College, India

AEROSOL FIELD STUDIES, CON'T.

Control #121

The Southeastern Aerosol Research and Characterization Network 1992-2016

Stephanie L. Shaw: Electric Power Research Institute; Eric S. Edgerton: Atmospheric Research & Analysis; John J. Jansen: Southern Company Services

Control #122

Spatial Variability and Speciation of PM2.5 in New Delhi, India

Pallavi Pant: University of Massachusetts-Amherst; Sarath K. Guttikunda: Desert Research Institute; Shamsh Pervez: Pt. Ravishankar Shukla University, Raipur, Chhattisgarh, (India); Richard E. Peltier: University of Massachusetts-Amherst

TRENDS IN VISIBILITY (Topic Area L)

Control #126

Addressing Challenges in Analyzing and Projecting Emissions Trends

Susan S.G. Wierman, Julie McDill, Susan McCusker: Mid-Atlantic Regional Air Management Association, Inc. (MARAMA)

LIGHT ABSORBING CARBON (Topic Area M)

Control #107

Optical Properties of Emissions from Laboratory Peat Combustion

Hans Moosmüller, Madhu Gyawali, Reddy L. N. Yatavelli, Adam C. Watts, V. Samburova, X. Wang, A. Y. Khlystov: Desert Research Institute; R. K. Chakrabarty: WUSTL; L.–W. A. Chen: UNLV; I. Arnold: University of Arizona, Tucson

Control #90

The Impacts of Diesel Emission Control Strategies on Elemental Carbon Concentrations in the South Coast Air Basin

Payam Pakbin, Aaron Katzenstein, Scott Epstein, Phil Fine: South Coast Air Quality Management District; Yue Lin, Ph.D student at University of California – Riverside; Michela Vicariotto, Ph.D. student at University of California – Irvine

Control #105

Aerosol Optics, Radiative Forcing, and Climate Change

Hans Moosmüller: Desert Research Institute

Control #47

Physicochemical Characteristics of the Black Carbon Aerosol and its Radiative Impact in a Polluted Urban Area of China

Q.Y. Wang, R.J. Huang, J.J. Cao: Chinese Academy of Sciences

Control #43

Effects of Black Carbon Mixing State on Aerosol-climate Interaction in China Using a Source-oriented WRF/Chem Model

Hongliang Zhang: Louisiana State University

Control #109

Coefficients of an Analytical Aerosol Forcing Equation Determined with a Monte-Carlo Radiation Model

Hans Moosmüller, Chul E. Chung: Desert Research Institute; Taufiq Hassan: Hankuk University of Foreign Studies

FINAL PROGRAM

TECHNICAL SESSION SCHEDULE - Friday, September 30, 2016

7:00 am 10:30 am
Registration
Grand Teton Mezzanine

7:00 am - 8:00 am
Continental Breakfast
Grand Teton Mezzanine

7:00 am - 8:00 am
Presenter's Breakfast
Jackson Room

TRACK A

SESSION 15: AEROSOL FIELD STUDIES AND MONITORING NETWORKS

Grand Room

Session Chair: Ricky Tropp, Desert Research Institute, and Dr. Jamson Masih, Wilson College, Mumbai, India

8:00 am
Control #13
Wintertime PM2.5 Pollution in UT: What Can Measurements at Ground Level and Higher Elevation Tell Us?
Munkbayar Baasandorj: Utah Department of Environmental Quality and University of Utah; Sebastian W. Hoch, John C. Lin, Ryan Bares, Fasoli Ben: University of Utah; Randy Martin: Utah State University; John Sohl: Weber State University; Dylan B. Millet: University of Minnesota

8:20 am
Control #18
Temporal Trends in the Difference Between Gravimetric and Reconstructed Fine Mass at Rural and Urban Sites across the United States
J. L. Hand, W. C. Malm: Colorado State University; A. J. Prenni, B. A. Schichtel: National Park Service; W. H. White: University of California; D.A. Ridley, C. L. Heald: Massachusetts Institute of Technology

8:40 am
Control #24
Positive Matrix Factorization and Data Quality Assessment of EPA's PM2.5 Chemical Speciation Network (CSN) Derived from Six Collocated CSN Sites for the Period 2010 - 2013
Richard J. Tropp: Desert Research Institute; L.-W. Antony Chen: University of Nevada Las Vegas

9:00 am
Control #15
Chemical and Morphological Characteristics of Fine Particulate Matter Emitted from an Open Municipal Solid Waste (MSW) Disposal Site in India
Anju Elizbath Peter, S.M. Shiva Nagendra: Indian Institute of Technology

9:20 am
Control #19
Personal Exposure Measurements of PM Concentrations at a Central Business District in Chennai City
Jyothi S Menon, Shiva Nagendra S M: Indian Institute of Technology

9:40 am
Control #97
Concentration of Particulate Matter and Polycyclic Aromatic Hydrocarbons at Northern Central part of India
Jamson Masih: Wilson College; Ajay Taneja: Dr. B.R. Ambedkar University

TRACK B

SESSION 16A: LIGHT ABSORBING CARBON

Teton Room

Session Chair: Rebecca Washenfelder, NOAA

8:00 am
Control #71
Contribution of Different Chemical Species to Brown Carbon Aerosol in Biomass Burning Emissions
Andrey Khlystov, Vera Samburova, Jessica Connolly, Chiranjivi Bhattarai, Deep Sengupta, Adam Watts, and Hans Moosmüller: Desert Research Institute

8:20 am
Control #113
Light absorbing carbonaceous aerosols from cookstoves in India
Apoorva Pandey, Sameer Patel, Pratim Biswas, Rajan Chakrabarty: Washington University in St. Louis; Shamsh Pervez: Pt. Ravishankar Shukla University, Chhattisgar; Judith Chow, John Watson: Desert Research Institute

8:40 am
Control #94
Brown Carbon Absorption in the Red and Near Infrared Spectral Region
Chul E. Chung: Desert Research Institute; András Hoffer, Ádám Tóth, András Gelencsér: MTA-PE Air Chemistry Research Group

9:00 am
Control #75
A Decade of Backscatter-Corrected Transmittance Measurements by IMPROVE
Warren H. White, Krystyna Trzepla, Nicole P. Hyslop: University of California; Jenny L. Hand: Colorado State University; Bret A. Schichtel: National Park Service

9:20 am
Control #41
Multispectral BC Comparison to Continuous Mass Measurement of Wide-Ranging Aerosols
David Gobeli, Seung-Ho Hong: Met One Instruments, Inc.; George Allen: NESCAUM

10:00 am - 10:20 am
Networking Break
Timberline Foyer

TECHNICAL SESSION SCHEDULE - Friday, September 30, 2016

TRACK A

SESSION 17: TRENDS IN VISIBILITY
Grand Room

Session Chairs: Jenny Hand, Colorado State University; Rebecca Washenfelder, NOAA

10:20 am
Control #91
Long-Term Visibility Trends in Megacities in China, India and the U.S. during 1944-2016
Yungang Wang: GAGO Inc.

10:40 am
Control #16
Observed Historical Trends in Atmospheric Haze Interpreted with a Global Chemical Transport Model
Chi Li, Brian L. Boys, Aaron van Donkelaar: Dalhousie University; Randall V. Martin: Dalhousie University and Harvard-Smithsonian Center for Astrophysics; Sacha Ruzzante: Dalhousie University and Queen's University

11:00 am
Control #98
Recent Developments in Improved Understanding of San Joaquin Valley's Impact on Grand Canyon Visibility Since 1980
Rob Farber, Atmospheric Clarity

11:20 am
Control #82
The Effect of Atmospheric Sulfate Reductions on Diffuse Radiation and Photosynthesis
Rebecca A. Washenfelder: University of Colorado and NOAA; Gretchen Keppel-Aleks: University of Michigan

11:40 am
Control #102
Aerosol Concentration, Composition and Optical Effects During Valley Cold Pool Occurrences
Mark C. Green: Desert Research Institute

TRACK B

SESSION 16B: LIGHT ABSORBING CARBON, CON'T
Teton Room

Session Chairs: Rajan Chakrabarty, Washington University in St. Louis

10:20 am
Control #112
Intensive optical properties of fresh and aged brown carbon aerosols from biomass burning in the Arctic Tundra
Benjamin J. Sumlin, Rajan K. Chakrabarty: Washington University in St. Louis

10:40 am
Control #111
A Two-Component 'Ångström Exponent' analysis of Aethalometer Data
Anthony D. A. Hansen: Magee Scientific Co.

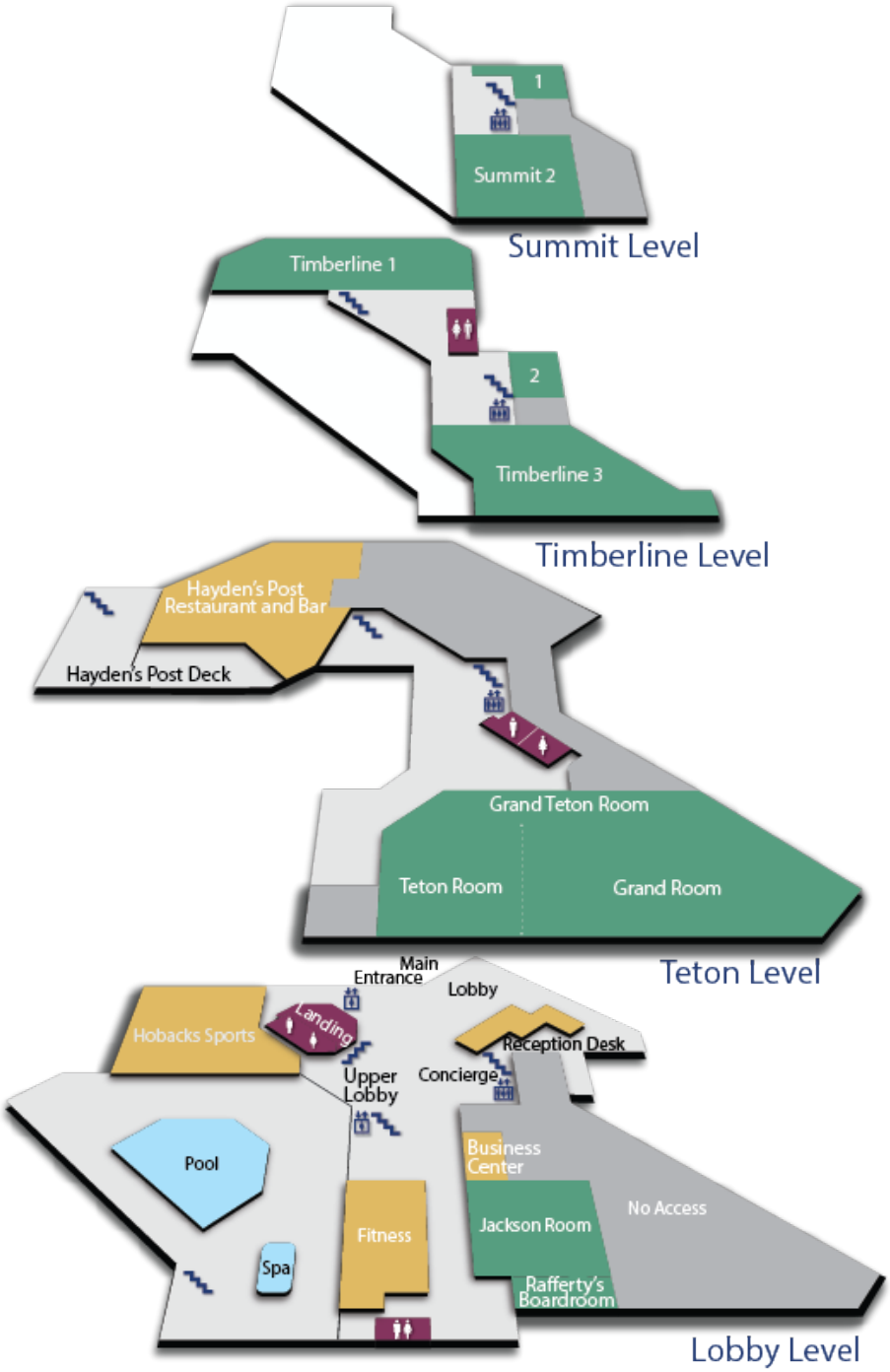
11:00 am
Control #110
Fractal Scaling and Radiative Properties of Coated Soot Aggregates: Implications for Direct Forcing
William Heinson, Rajan Chakrabarty: Washington University in St. Louis

11:20 am
Control #100
Representing the Black Carbon Aging Process in the Two-way Coupled WRF-CMAQ Modeling System
Jia Xing, Jiandong Wang, Shuxiao Wang, Bin Zhao, Jiming Hao: Tsinghua University; Jonathan E. Pleim, David C. Wong, Rohit Mathur, Christian Hogrefe: US EPA

11:40 am
Control #48
Sensitivity of BC Concentrations and Climate Impact to Aging and Scavenging Processes in the OsloCTM2
Marianne T. Lund: Center for International Climate and Environmental Research – Oslo (CICERO; Terje Berntsen: University of Oslo and Center for International Climate and Environmental Research – Oslo (CICERO)

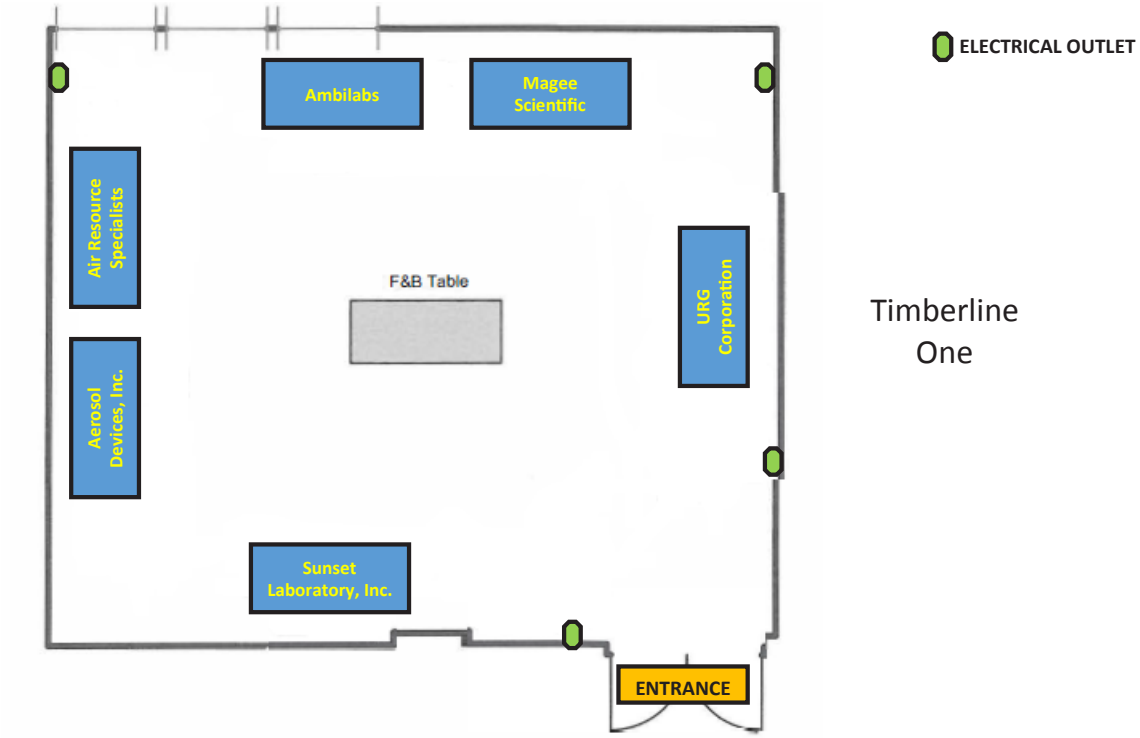
12:00 pm
Control #10
Quantifying enhancement in aerosol radiative forcing during 'extreme aerosol days' in summer at Delhi National Capital Region, India
Arun Srivastava, Sumant Kumar: Jawaharlal Nehru University; Sagnik Dey: IIT Delhi

SNOW KING HOTEL FLOOR PLAN



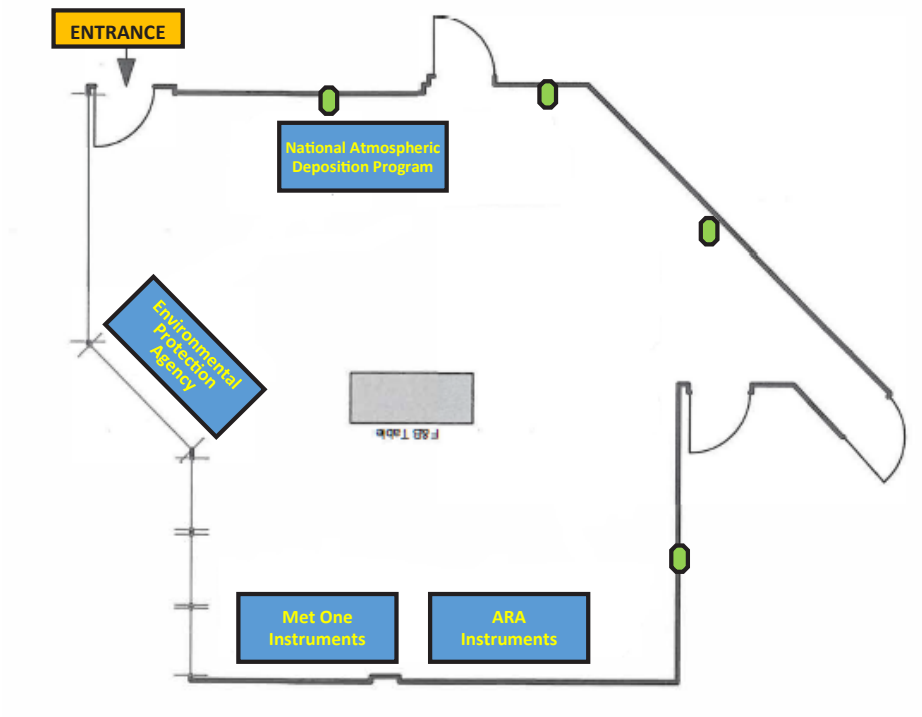
FINAL PROGRAM

SPONSOR TABLE DIAGRAM



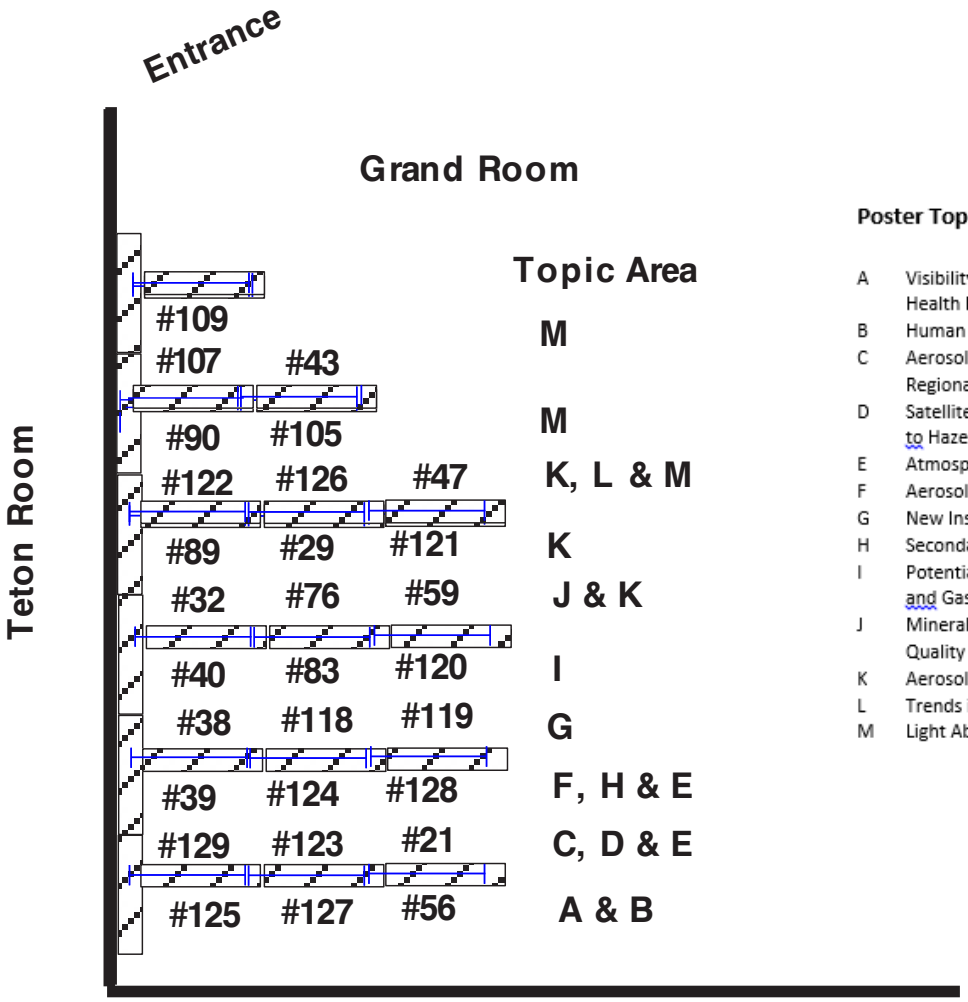
Timberline One

Timberline Three



FINAL PROGRAM

TECHNICAL POSTER DIAGRAM



Poster Topic Areas

A	Visibility as an Indicator of Human Health Effects
B	Human Perception of Visibility
C	Aerosol and Visibility Modeling At Local, Regional, and Global Scales
D	Satellite and Remote Sensing Applications to Haze/Aerosol Monitoring
E	Atmospheric Nitrogen
F	Aerosol-Optical Relationships
G	New Instruments and Measurement Techniques
H	Secondary Organic Aerosols
I	Potential Impacts of Emissions from Oil and Gas Fields on Air Quality Visibility
J	Mineral Dust Aerosols: Impacts on Air Quality and Visibility
K	Aerosol Field Studies and Monitoring Networks
L	Trends in Visibility
M	Light Absorbing Carbon

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Abstracts for the 2016 Jackson Hole Conference Presentations

Both the Abstracts for a Given Session and the Associated Poster Sessions are Given Under the Session Number

Track A

Session 1. Visibility as an Indicator of Human health Effects

Control Number 1

A 1960's Copper Smelter Strike and Increased Visibility: Natural Experiment of Reduced Sulfate Particle Pollution on Regional Mortality

C. Arden Pope III, PhD. Brigham Young University, Provo, UT

Abstract

This study retrospectively explored a natural experiment associated with a historical copper smelter strike that occurred in the Southwest United States from July 15, 1967 through the beginning of April 1968. In the 1960s, copper smelters accounted for approximately 90% of all sulfate emissions in the four Southwest states of New Mexico, Arizona, Utah, and Nevada. Over the 8 1/2-month strike period, an approximately 60% decrease in concentrations of suspended sulfate particles resulted in regional improvement in visibility. This strike provided a unique and interesting natural experiment to explore the mortality effects of air pollution. Monthly mortality counts for 1960-1975 were collected and analyzed using Poisson regression models. The strike-related estimated percent decrease in mortality was approximately 2.5% (95% CI: 1.1%-4.0%). The effect estimates were reasonably stable and robust to controlling for time trends, mortality trends in other areas of the U.S., and nation-wide monthly mortality counts for influenza/pneumonia, cardiovascular, and other respiratory deaths. There is no evidence that lagged effects of the reductions in pollution lasted substantially longer than one month. These results provide evidence that reductions in ambient sulfate particulate matter and related air pollutants not only result in improved visibility but can also contribute to improved human health and reduced mortality.

Control Number 44

Using Visibility to Examine Health Effects in Epidemiologic Studies: An Historical Perspective

Bart Ostro, University of California -Davis

In the last two decades, hundreds of studies have reported associations between ambient fine particles (PM2.5) and a wide range of health effects. These studies were able to use existing daily or every third day measures of PM2.5. However, a PM10 standard was created in California in 1983 and in 1987 the U.S. EPA revised its ambient standard for particulate matter by replacing the TSP standard with a new standard for particles less than 10 microns (PM10). Unfortunately, these standards were developed at a time when there were few available epidemiologic studies using PM10. In addition, during the review of these standards, there was heightened awareness and concern regarding exposure to the smaller-sized fine particles. Thus, there was a need to provide additional evidence regarding the potential effects of PM2.5. To obtain the statistical power to detect an effect of acute exposure, daily measures of PM2.5 were often needed for most epidemiologic studies. In addition, there were few countries outside the U.S. that had any data on PM2.5. As a result, alternative methods of measuring exposure to fine particles were needed, prompting methodologies that would foster the use of airport visibility as a surrogate measure. Careful

consideration of airport markers used to measure visibility was necessary to ensure reasonable accuracy in predicting PM2.5. Ultimately, studies examining the effects of visibility-based PM2.5 on both mortality and morbidity were conducted both in the U.S. and in Thailand, among other countries. In the U.S., these studies demonstrated associations of daily changes in PM2.5 with increases in premature mortality, hospitalization, respiratory symptoms, work loss and restrictions in activity. Ultimately these studies provided input for the development and promulgation of ambient standards for PM10 and PM2.5. Some of these studies were used by the U.S. EPA in their Regulatory Impact Analyses to generate quantitative estimates of the health and economic impacts of exposure to PM10 or PM2.5. In addition, the studies were used by the World Health Organization and other international institutions to generate estimates of the burden of disease associated with air pollution. This talk with review some of the methods used in this approach, discuss issues of quality control and indicate some of the major epidemiologic findings.

Control Number 3

Municipal Solid Waste Burning: Discoloring the Taj Mahal and Human Health Impacts in Agra

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Abstract

The Taj Mahal – an iconic World Heritage monument built of white marble – has become discolored with time, due, in part, to high levels of particulate matter (PM) soiling its surface. Such discoloration has required extensive and costly treatment and despite previous interventions to reduce pollution in its vicinity, the haze and darkening persists. PM responsible for the soiling has been attributed to a variety of sources including industrial emissions, vehicular exhaust and biomass burning, but the contribution of the emissions from the burning of open municipal solid waste (MSW) may also play an important role. A recent source apportionment study at the Taj Mahal showed biomass burning emissions, which would include MSW emissions, accounted for nearly 40% of organic matter (OM) – a component of PM – deposition to its surface; dung cake burning, used extensively for cooking in the region, was the suggested culprit and banned within the city limits, although the burning of MSW, a ubiquitous practice in the area, may play a more important role in local air quality. Using spatially detailed emission estimates and air quality modeling, we find that open MSW burning leads to about 150 (130) mg m-2 yr-1 of PM being deposited to the surface of the Taj Mahal compared to about 12 (3.2) mg m-2 yr-1 from dung cake burning. Those two sources, combined, also lead to an estimated 713 (377-1050) premature mortalities in Agra each year, dominated by waste burning in socioeconomically lower status neighborhoods. An effective waste management strategy would reduce soiling of the Taj Mahal, improve human health, and have additional aesthetic benefits.

Control Number 114

Blending output from forest fire smoke models with measured PM2.5 concentration can improve their utility for exposure assessment in epidemiologic research and public health surveillance

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Saran B Henderson, Senior Scientist, Environmental Health Services, BCCDC Assistant Professor, School of Population and Public Health, University of British Columbia

Particulate matter 2.5 (PM2.5) generated from wild forest fire is strongly linked to numerous adverse health outcomes, including respiratory diseases and increased mortality risk. Due to the unpredictable nature of wildfire, it is extremely difficult to evaluate wildfire PM2.5 exposures for the use in epidemiologic studies. While methods for assessing or predicting the exposures include direct air quality measurements, empirical models, and deterministic models, each have certain strengths and limitations. The purpose of our research is to blend wildfire PM2.5 exposure output from different available methods and evaluate if this method is more predictive of respiratory health outcomes. Among 15 models including 4 single metrics and 11 hybrid metrics, a hybrid model created from blending output from an empirical model with measured PM2.5 was the best model for predicting asthma-specific health indicators with the smallest Quasilikehood under the Independence Model Criterion. All hybrids models where measured PM2.5 was added performed better than other models where measured PM2.5 was not added. Hence, we conclude that the blending method is feasible for improving exposure assessment in epidemiologic studies compared to current available methods.

Control Number 67

Development of a Visibility Forecasting Product using the GEM-MACH Air Quality Model – a Pilot Project for the Lower Fraser Valley of British Columbia

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Andrew Teakles, Meteorological Service of Canada, Environment and Climate Change Canada, Halifax,NS,
Jonathan Baik, Meteorological Service of Canada, Environment and Climate Change Canada, Vancouver, BC
Keith Jones, Meteorological Service of Canada, Environment and Climate Change Canada, Vancouver, BC
Roxanne Vingarzan, Meteorological Service of Canada, Environment and Climate Change Canada, Vancouver, BC

Abstract

In the Lower Fraser Valley (LFV) of British Columbia, the clarity of a visual scene, a common indicator of air quality conditions, plays an important role in the quality of life for residents, and can affect the local economy through impacts on tourism, property values, and business investment. To address the growing concerns of visibility degradation, regional, provincial and federal government agencies involved in air quality management have established the British Columbia Visibility Coordinating Committee (BCVCC). As part of a visual air quality pilot project, led by the BCVCC, the LFV has a dedicated multi-instrumented visibility monitoring network, which includes optical point measurements, visibility-related aerosol speciation measurements, and digital camera imagery. In addition, a Visual Air Quality Rating (VAQR) was developed for the LFV based on perception studies, where daylight hours are categorized as “excellent”, “good”, “fair”, “poor” and “very poor”. Given the desire to manage and raise awareness of visual air quality conditions in the LFV, the development of a visibility forecasting product would be beneficial to local and regional governments and the tourism industry alike. The objective of this project is to develop and assess the feasibility of implementing a visibility forecasting product using the current operational air quality chemical transport model, GEM-MACH (Global Environmental Multi-scale – Modelling Air quality and CHemistry), for the LFV. Currently, GEM-MACH provides 48-hr forecasts twice daily (at 0000 UTC and 1200 UTC) over North America and is used to provide guidance for the production of air quality forecasts for Canadians, including hourly $PM_{2.5}$, PM_{10}, and NO_2 at surface level. As the effects of particulate

composition, particle size distribution, and hygroscopic growth on visibility have been studied in some detail, hourly visibility forecasts, in terms of total light extinction, were estimated using these GEM-MACH air quality forecasts for the same duration and frequency. Additional post-processing models, which include air quality and meteorological predictors exogenous to the GEM-MACH forecasts, were developed, using various statistical methods including Multiple Linear Regression, Random Forest, and Kalman Filtering. The forecast accuracy of the developed product was assessed by comparing the forecasts with hourly and 24-hr observations from the monitoring network. In addition, the developed product was also assessed in its predictive ability to forecast VAQR. Initial results indicate that the raw forecasts had generally good agreement with the observations, although some overestimation occurred during the night time, especially for the western part of the LFV. The application of statistical post-processing techniques enhanced the overall forecast accuracy, which may be associated with the inclusion of additional air quality and meteorological variables as predictors. With respect to the predictive ability for VAQR, the product had reasonable forecast accuracy, but generally had difficulties in distinguishing between "excellent" and "good", and between "poor" and "very poor" visibility conditions.

Control Number 72

Citizen Science and NexGen Visibility Measurement.

Shawn Dolan, Virtual Technology LLC, and Sustainable Sky's Org

The paper will cover the emergence of NexGen Citizen Science Smart Phone based visibility measurement devices. The smart phone has become common place in the population and freeware "apps" like Spot the Smoke for SustainableSkys.org have enabled citizens ability to measure multiple environmental conditions. The paper will focus on the freeware sensation Spot the Smoke and its phenomenal growth in the conservation sector. The app allows any smart phone or tablet mobile device to record images and report visibility impairment. The freeware App records the weather and sun positions, as well as, the bearing and view angle of the image captured. The App then transposes the image onto a "Google" Map of the area to enable scaling and impact assessment. Providing the public, regulator and regulated with an ability to capture imagery of pollutant sources of all types and visibility impairments as viewed in real-time. The paper is a case study of the growth of the Spot the Smoke app and its role in combatting wood smoke issues, large source issues, mobile source concerns and fugitive source identification.

Session Associated Poster Presentations

Control Number 125

Measuring and Reporting Visual Air Quality Management Progress in the Canadian Lower Fraser Valley, BC

Julie E. Saxton, D. Laurie Bates-Frymel, Metro Vancouver, Burnaby, BC, Markus Kellerhals, BC Ministry of Environment, Victoria, BC

Abstract

The BC Visibility Coordinating Committee (BCVCC) was established in 2006 as a collaborative initiative between Environment Canada, Health Canada, BC Ministry of Environment, Metro Vancouver, the Fraser Valley Regional District (FVRD) and the City of Kelowna to take action on impaired visual air quality in BC. A pilot project was initiated by the BCVCC in 2010 to create a visual air quality management program in the Canadian Lower Fraser Valley in the southwestern part of the Province of BC and produce a visual air quality management framework that may provide a model for developing visual air quality management programs elsewhere in BC and Canada.

One of the key features of the pilot project was to develop monitoring and reporting capability to allow progress on visual air quality management and the effectiveness of actions to be assessed. Instrumentation, including cameras to capture visual air quality conditions and air quality monitors to record scattering and absorption parameters, has been installed at several locations in the Lower Fraser Valley. This visual air quality monitoring network has allowed the development of a perception-based index, known as the Visual Air Quality Rating (VAQR), using photographic records of visual air quality alongside air quality and meteorological data collected at five sites.

The primary intended function of the VAQR is a communication tool to report visual air quality in a clear and concise way. The VAQR categorizes visual air quality as ‘Excellent’, ‘Good’, ‘Fair’, ‘Poor’ or ‘Very Poor’ and is currently reported for four locations within the Lower Fraser Valley. It was important for the credibility of this index that these categories represented the visual air quality people were experiencing at any given time. Extensive in-house and public testing were undertaken to determine the reliability of the calculated VAQR. Public testing indicated a slightly negative bias in the rating of visual air quality by the public compared to the VAQR. However, a large majority of residents found the VAQR easy to understand and supported making it publicly available. Based on the results of the testing, minor changes were made to the VAQR and additional validation undertaken prior to its launch in August 20

A secondary use of the VAQR is to inform the development of a Visibility Goal by the BCVCC and provide a semi-quantitative means of defining visual air quality impairment for reporting by local air quality agencies. VAQR statistics have been described and compiled for 2012 and 2013 to establish the baseline against which future progress on visual air quality management performance on Metro Vancouver's goal to "Improve visual air quality"[1]can be tracked.

Control Number 127

Indoor air quality Assessment and health impact in context with the living standards in Urban & Rural Lucknow homes

Alfred Lawrence and Tahmeena Khan
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Abstract
The study was conducted to assess the indoor air quality and health impact in urban and rural houses of Lucknow from November 2014 to October 2015. Five urban and five rural houses were selected for monitoring. Assessment was for SO2, NO2, CO, CO2, NH3, H2S, RSPM (PM10&PM2.5) seasonally throughout the year. RSPM concentrations were found to be higher than WHO standards at all monitoring sites being highest in winter season at rural sites having valuesPM10(218±42 μg/m3) and PM2.5 (92± 17μg/m3). CO2 (458±26 ppm), CO (1.1±0.4ppm), NO2(0.14±0.02ppm) and SO2(0.18±0.05ppm) were also found to be higher in winter season due to increased consumption of wood, coal for cooking and combating cold conditions. Though gaseous pollutants had lowest concentration in rainy season owing to wash out effect but still NH3(0.121.±0.02ppm) and H2S (0.07±0.05ppm) had highest values at rural sites due to poor sanitary conditions and cattle excreta. Concentration of SO2(0.26±0.04ppm), NO2(0.038±0.07ppm), CO(0.32±0.1ppm), CO2 (387±26ppm), PM10(164±36μg/m3) & PM2.5(81±12 μg/m3) were highest in summer season at urban city and attributed to vehicular emission, use of heavy diesel generators due to scanty electricity supply, frequent dust storms and infiltration. A questionnaire survey was done to obtain overall picture of the household. According to seasonal trend of pollutant concentration and questionnaire survey results, health related issues reported by the people were sorted seasonally, categorizing the prevalence of different symptoms in specific seasons. Symptoms of congestion, headache and nausea were prevalent in winter season due to exposure of RSPM and CO2. Crude fuel, poor sanitary conditions and inadequate ventilation were major suspects for increased pollution in rural areas. Among urban dwellers COAD, headache and complaints of bronchial asthma were more prevalent. Survey results also revealed that literacy rate was low for rural population. Educational status influenced the living standard of people in different areas. Rural population mostly used crude fuel whereas use of LPG and electric heater were more prevalent among urban population as the literacy rate was much higher and they were more sensitive towards good indoor air quality. Indoor activity and house characteristic correlation with the assessment data showed that infiltration, smoking and use of mosquito repellents, deodorants etc. were mainly responsible for poor IAQ in urban houses. Poor drainage system, rearing cattle inside house premise and uses of chullahs for cooking were the main culprits in rural households. Health Risk Assessment of particulate matter exposure showed that that health problems related with particulate matter were more prevalent in the occupants. The authors recommend awareness programs for the exposed

population especially in rural areas to discuss hazard associated with poor IAQ.

Keywords: *IAQ, urban, rural, living standard, COAD*

Session 3. Human Perceptions of Visibility

Control Number 93

Study of Carbonaceous Fractions associated with Indoor PM2.5/PM10 during Asian Cultural and Ritual Burning Practices

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ABSTRACT

The study was carried out to evaluate the seasonal and annual trend of thermal fractions (organic and elemental carbon) associated to different cultural/ritual-indoor aerosol carbonaceous matter compared to residential-indoors and ambient-outdoors. Thermal speciation of carbonaceous fractions (SCFs: OC1, OC2, OC3, OC4, OP, EC1, EC2, EC3) associated to cultural/ritual-indoors and indoor/outdoor relationship were also taken into account in four different types of cultural/ritual centers: 1) Marriage Places (MP), 2) Muslim Holy Shrines (MHS), 3) Buddhist Temples (BT), and 4) Hindu Temples (HT). Longitudinally measured 360 PM2.5/PM10 samples throughout the year 2012-13, onto quartz fiber filters, were analyzed for organic (OC) and elemental carbon (EC) along with eight SCFs using thermal/optical reflectance/transmittance method. SCFs were determined in selected samples, representing all selected cultural/ritual-indoors, to address the source markers associated to biomass burning (BB) emissions; observed during cultural/ritual performances. Results have shown significantly higher levels of BB markers' SCFs in cultural/ritual-indoors compared those reported for residential-indoors and ambient-outdoors. Three to eight-fold higher carbonaceous aerosols was found in cultural/ritual-indoors compared to those determined in residential-indoors and ambient-outdoors. OC/EC ratio was found 2-fold higher in MHS and MP indoors compared to those found in other selected indoor and outdoor sites. Similarly, higher degree of seasonal variability with higher occurrence of aerosol fractions and associated OC and EC in winter is observed in both MHS and MP due to higher activity pattern.

Keywords: Thermally speciated carbonaceous aerosols, Indoor PM2.5/PM10, Cultural/ritual practices, Indoor/outdoor ratio, Secondary organic aerosols, Source contribution

Control Number 27

Preserving Treasured Views – The National Park Service Visual Resource Inventory

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The U.S. Department of the Interior (USDI) National Park Service (NPS) was created 100 years ago through the Organic Act of 1916. The new agency's mission as managers of national parks and monuments was clearly stated. "… to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations." To protect clean, clear air and spectacular scenery now and for future generations, the NPS focuses on clearing haze that impairs scenic views and addressing physical intrusions that detract from important views. NPS views range from iconic vistas to historic places where the agency preserves cultural and historic settings.

In response to concerns arising from potential scenic impacts from the development of physical infrastructure from renewable energy, electric transmission, and other types of development on lands and waters near its units, the NPS, has developed a new visual resource inventory (VRI) system to facilitate the understanding and management of scenic resources.

The inventory system uses formal design qualities such as form, line, color, and texture to describe and assess *scenic quality*, and incorporates viewer sensitivity in what is ultimately a judgement-based quantitative ranking of relative scenic value. In these respects the NPS VRI system is similar to other U.S. federal agency VRI systems, such as the USDI Bureau of Land Management VRI, and the U.S. Department of Agriculture Forest Service Scenery Management System. However, the NPS VRI differs from other federal agency approaches in order to address the NPS mission of preserving scenic resources for the enjoyment of current and future generations while other federal agencies are charged with multiple-use mandates for the lands under their management. One primary difference is that the NPS inventory unit of analysis is a predetermined view from a specified viewpoint, rather than a polygon based on physiographic properties, e.g. a valley floor or a mountain range. The view-based inventory unit was chosen because NPS is concerned with specific landscape areas as they would be seen from the visitor's perspective. Also, because historic and cultural resources are essential to the scenic experience of NPS visitors, the NPS VRI scenic inventory includes an assessment of *view importance* which is a measure of the non-scenic values of the view. View importance incorporates historic and cultural elements and values, as well as the value of both the viewpoint and viewed landscape to NPS interpretive goals and visitor experience. Scenic quality and view importance combine to create a scenic inventory value that identifies the overall visual value of the view to NPS and its visitors.

The NPS VRI system includes an online database for storing inventory data for NPS units, and an associated geographic information system, for semi-automated production of inventory maps. The database generates a variety of reports and spatial products for inventory data. The VRI allows the NPS to apply a systematic approach to understanding and communicating the value of scenic views so that they can be actively managed and planned for alongside other important resources.

Control Number 79

Reconciliation of Urban Visibility Preference Studies: Implications for an Urban Visibility Standard

Bret A. Schichtel[1], William C. Malm[2], Dustin Schmidt[2], and Jenny Hand[2]

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Visibility in urban settings is protected by the particulate matter (PM) secondary National Ambient Air Quality Standard (NAAQS). The secondary standard is currently set equal to the 24-hr fine PM ($PM_{2.5}$) primary standard of 35 $\mu g/m^3$. This $PM_{2.5}$ level was found to be protective of urban visibility based on the results of five North American urban preference studies, where visibility was acceptable to half of the people in the studies at haze levels between 19 DV and 28 DV, depending on the urban setting. EPA showed that the primary PM standard resulted in haze levels less than 28 DV in most urban centers. A source of uncertainty in setting the secondary standard was the broad range in the preference study results. In the work, we show that the range in acceptable levels of haze in the same five preference studies is significantly reduced if scene-dependent haze metrics that integrate the effects of light extinction along the sight paths between the observers and landscape features are used. The metric with the least variability was based on the contrast of the more distant major land scape feature in a scene. At contrast levels of -0.03 to -0.045, half of all participants in the studies deemed the visibility as unacceptable. These contrast levels are near the threshold of the human eye; consequently, when these more distant landscape features were no longer visible, i.e. at the visual range, the haze level was unacceptable. Based on this finding the acceptability of urban visibility throughout the United States was explored by relating $PM_{2.5}$ concentrations to visual range and comparing this to characteristic sight path lengths to distant landscape features derived for each urban center. It was found that at the current primary standard the visual range was less than these characteristic sight path lengths at most urban centers, thus the visibility would not be considered acceptable.

Control Number 51

A review of seven visibility preference studies as they relate to various visibility metrics

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Bret A. Schichtel
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ABSTRACT

Five visibility preference studies were carried out in urban settings, four in the United States and one in Beijing, China. A sixth study focused on the validity of the preference study approach to identify levels of acceptable visibility, and a seventh study was carried out in a nonurban setting. In all studies, groups of individuals were shown slides or computer-projected scenes under a variety of visual air quality (VAQ) conditions and asked to judge whether or not each image would meet either an urban or nonurban visibility standard. In addition to determining the amount of haze deemed to be acceptable, respondents were also asked to make VAQ judgments of the various scenes. The specific definition of "acceptable" was largely left to the individual respondent, allowing each to identify his own preferences.

The studies clearly showed that when preference ratings were compared to universal visibility metrics such as atmospheric extinction, visual range, or deciview, there was not a single indicator that represented acceptable levels of VAQ for the varied urban settings investigated. Characteristics and distances to landscape features apparently determine the sensitivity of visibility preference levels to general measures of atmospheric clarity. Recent studies have introduced new scene-dependent visibility metrics such as equivalent and average scene contrasts, edge detection algorithms such as the Sobel and fast Fourier transform indexes, and just noticeable difference metrics based on the human visual system. Here, various scene-specific VAQ indexes and their applicability for use in quantifying visibility preference levels as well as judgments of VAQ will be explored.

Control Number 86

Urban Visibility Standards and Trends in Fort Collins, Colorado

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Bret Schichtel, Cooperative Institute for Research in the Atmosphere, Fort Collins, Colorado, Joe Adlhoch, Air Resource Specialists, Fort Collins, Colorado,
Emily Vanden Hoek, Air Resource Specialists, Fort Collins, Colorado,
Gregory Harshfield, Colorado Department of Health and Environment, Denver, Colorado,
Gordon Pierce, Colorado Department of Health and Environment, Denver, Colorado,

Abstract

Visual qualities of the atmosphere are some of the more obvious indicators of air quality to the general public. The Denver area has long experienced haze episodes that have come to be known as the "brown cloud." Denver's location at the foot of the Rocky Mountains makes the area prone to temperature inversions in which warm air traps cooler air near the ground, causing air pollutants to build up because of the limited atmospheric mixing, resulting in haze episodes. In 1989, in response to concerns about the Denver "brown cloud," the state of Colorado adopted an urban visibility standard for the Denver area in 1995, and this standard has also been used by the City of Fort Collins.

Visibility is reduced, or haze increased, by the absorption and scattering of light by particles and gases in the atmosphere. Light extinction in Fort Collins (and Denver) has been measured continuously since 1993 using a transmissometer and nephelometer. A transmissometer measures total light extinction along a sight path (the Fort Collins site path is 2 km), and an ambient nephelometer draws air into a chamber and measures only the scattering component of light extinction. While the nephelometer does not measure total extinction, it can be calibrated in the field using a gas with known scattering properties, and has fewer uncertainties than transmissometer measurements. Trends since 1993, including comparisons between transmissometer and nephelometer data, will be presented along with approximations of total extinction using the more robust nephelometer measurements as opposed to transmissometer measurements.

Additionally, the local applicability of the Denver visibility standard for Fort Collins will be discussed. The current standard was developed based on a visibility preference study undertaken in Denver, Colorado during the summer of 1989. The study consisted of group of people evaluating a collection of slides representing a range of visibility conditions for a Denver vista. A visibility standard (76 Mm^{-1}) was proposed at the level of extinction where half of the study group judged the image as having an acceptable amount of haze, and half judged the image as unacceptable. Because the standard was developed using images and measurements in downtown Denver, a method will be explored which offers a metric more specific to the judgment of Fort Collins residents for Fort Collins views. Specifically, the metric will be determined based on contrast for the most prominent visible object, which in Fort Collins, includes our coveted mountain views.

Session Associated Poster Presentation

Control Number 56

Using dark sky images captured at Bryce Canyon National Park to quantify visual air quality and the night sky viewing experience

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A digital SLR camera has been operating in Bryce Canyon National Park since September 2013, capturing night sky images of the light dome (sky region) over the Alton coal mine and St. George, Utah, southwest of the Park. The images capture the direct light from the dome, as well as light scattered by haze and clouds in the dome.

Research by the authors into using daytime webcam images from Great Smoky Mountains and Grand Canyon National Parks to determine visual air quality is currently underway using techniques such as equivalent (EQ) and average contrast (CR), Sobel (SOB) and fast Fourier transform (FFT) to develop air quality indexes.

Night sky images may also be used to determine visual air quality, but using different techniques to develop air quality indexes. In particular, characterizing the light dome on moonless, cloud free nights and comparing those data to concurrent measures of the atmospheric extinction coefficient demonstrate a relationship between the two. Since most nights are not cloud free, analysis of the entire moonless image set provides a measure of how much light is coming from the dome and affecting the night sky viewing experience.

Control Number 129

Quantifying enhancement in aerosol radiative forcing during 'extreme aerosol days' in summer at Delhi National Capital Region, India

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Abstract

Changes in aerosol characteristics (spectral aerosol optical depth, AOD and composition) are examined during the transition from 'relatively clean' to 'extreme' aerosol days in the summer of 2012 at Delhi National Capital Region (NCR), India. AOD smaller than 0.54 (i.e. 12-year mean AOD −1σ) represents 'relatively clean' days in Delhi during the summer. 'Extreme' days are defined by the condition when AOD 0.5 exceeds 12-year mean AOD +1 standard deviation (σ). Mean (±1σ) AOD increases to 1.2 ± 0.12 along with a decrease of Angstrom Exponent from 0.54 ±0.09 to 0.22 ±0.12 during the 'extreme' days. Aerosol composition is inferred by fixing the number concentrations of various individual species through iterative tweaking when simulated (following Mie theory) AOD spectrum matches with the measured one. Contribution of coarse mode dust to aerosol mass increased from 76.8% (relatively clean) to 96.8% (extreme events), while the corresponding contributions to AOD0.5 increased from 35.0% to 70.8%. Spectrally increasing single scattering albedo (SSA) and CALIPSO aerosol sub-type information support the dominant presence of dust during the 'extreme' aerosol days. Aerosol direct radiative forcing (ADRF) at the top-of-the-atmosphere increases from 21.2 Wm^{-2} (relatively clean) to 56.6 Wm^{-2} (extreme), while the corresponding change in surface ADRF is from −99.5 Wm^{-2} to −153.5 Wm^{-2}. Coarse mode dust contributes 60.3% of the observed surface ADRF during the 'extreme' days. On the contrary, 0.4% mass fraction of black carbon (BC) translates into 13.1% contribution to AOD0.5 and 33.5% to surface ADRF during the 'extreme' days. The atmospheric heating rate increased by 75.1% from 1.7 K/day to 2.96 K/day during the 'extreme' days.

Session 5. Panel: Evolving Issues in Air Quality Related to a Changing Climate

Session Chair: Kip Carrico, New Mexico Institute of Mining and Technology

Panelists:
Kip Carrico - New Mexico Institute of Mining and Technology
Jenny Hand - Colorado State University
Sean M. Raffuse - University of California, Davis
Sarah Suda-Petters - North Carolina State University
Gannet Hallar - University of Utah and DRI Storm Peak Laboratory
Hans Moosmüller - Desert Research Institute

The magnitude and pace of anthropogenic climate change have profound implications for related air quality problems. Aerosols (and some trace gas species) are well-known as climate drivers, directly via backscatter and absorption of radiation and indirectly via cloud impacts. Among the most impacted air quality parameters are ozone and aerosol concentrations. Whereas anthropogenic emissions of greenhouse gases are just beginning to be addressed, emission reductions in aerosols and their precursors have been remarkably successful in the US over the last 50 years. Thus perturbed natural sources of aerosols have become more important in urban and, in particular, rural areas. Trends related to this include the growing importance of primary and secondary carbonaceous aerosols as well as an upward trend in mineral dust species observed in the Western US over two decades. The panel will address the following related questions:
Warming and extreme weather: what are the expected changes and how will it impact air quality?
A warming climate: what does this mean for visibility and regional haze?
What trends are emerging with 'perturbed natural sources' of PM including windblown dust and biomass burning smoke?
What are the feedback processes involving inter-connected changes in air quality and climate?
What are the current research needs to further reduce uncertainties in aerosol-climate interactions?

Session 7, Panel: Regional Perspectives on the Second Planning Period for Regional Haze State Implementation Plans

Session Chair: Tom Moore, *WESTAR-WRAP*

Panelists:
Theresa Pella, *Central States Air Resource Agencies (CenSARA)*
Joseph Jakuta, *Ozone Transport Commission (OTC)*
Rob Kaleel, *Lake Michigan Air Directors Consortium (LADCO)*
Arthur Marin, *Northeast States for Coordinated Air Use Management (NESCAUM)*
Mary Uhl, *Western States Air Resources Council (WESTAR)*

The panelists will discuss the results to date of efforts to improve visibility at Class I areas. They will also discuss existing and potential future challenges, such as whether EPA's transport rule requirements are more effective than the Regional Haze rule's best available retrofit technology (BART) provisions. Also to be addressed will be ongoing legal actions and potential future legal challenges. Some panelists will be able to share technical work that is underway or will be initiated in the near future. Depending on the Class I area, ongoing and planned future reductions in Sulfur Dioxide and Nitrogen Oxide emissions are and will be largely responsible for visibility improvements. Still, achieving long-term goals necessitates a multi-pollutant approach.
Members of the Panel will present information on the impacts of key aerosol components of haze, including sulfates, nitrates, elemental carbon, organic carbon, and crustal materials such as dust/soil. The panel will also discuss EPA's draft reasonable progress guidance and how those provisions may ultimately influence state and regional technical work for the next round of Regional Haze SIPs.

Session 9A. Regional Haze Rule

Control Number 73

Potential Alternative to the Regional Haze Rule Visibility Progress Tracking Metric

Brett Gantt, Neil Frank, EPA, Melinda Beaver, EPA, Research Triangle Park, NC

Abstract

For many Class I areas in the Western U.S., the frequency and magnitude of wildfires and dust storms can have a large impact on the more prominent of the two metrics used to track visibility changes under the requirements of the Environmental Protection Agency's Regional Haze Rule. At some Interagency Monitoring of Protected Visual Environments (IMPROVE) sites, visibility degradation on the haziest days has occurred over the last 15 years despite widespread emission reductions from stationary and mobile sources. To better track visibility changes associated with anthropogenic pollution sources rather than uncontrollable natural sources, we have been exploring a new metric which tracks visibility changes on days that are the "most impaired" rather than the "haziest." Specifically, this new metric estimates the anthropogenic and natural fractions of the daily light extinction budget and calculates impairment as the anthropogenic extinction relative to that of natural extinction, so that the 20% "most impaired" days can be identified. The daily values of the total light extinction on these days are averaged to get the value of the new metric. This new metric divides the light extinction from natural sources into a relatively constant background contribution and an episodic contribution likely associated with smoke from wildfires or dust storms on a site-by-site basis.

Applying this new metric to the 2000-2014 period of IMPROVE measurements across all Class I areas in the U.S. results in a substantial change in the visibility trend for sites in the Northern Rockies and Southwest U.S., and little change in much of the Eastern U.S. and Southern California. When compared to a glidepath of steady visibility improvement between baseline period (2000-2004) and natural conditions in 2064, many sites in Northern Rockies and Southwest U.S. have switched from being above to being below the glidepath for the recent 2010-2014 period. The seasonality of days selected as the 20% most impaired at the latter sites is different than that of the 20% haziest days, with many more winter and spring days selected instead of the summer and fall periods which dominate the 20% haziest days at most sites. In addition to tracking visibility changes, the new metric enables the characterization of the anthropogenic and natural fractions of components in the daily extinction budget at each site. Nationally, sulfate and nitrate make up the majority of the anthropogenic extinction during the 2010-2014 period. Natural extinction is largely made up of organic carbon mass in the Eastern U.S. and a combination of organic carbon mass, dust components, and sea-salt in the Western U.S.

Control Number 74

Comparison of Tracking Progress Metrics under the Regional Haze Rule using Default and Impairment Based Approach

Scott A. Copeland[1], Brett Gantt[2], Neil Frank[2], Melinda Beaver[2], Bret A. Schichtel[3], John Vimont[3]

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[2]Enivronmental Protection Agency, 109 T.W. Alexander Drive, Research Triangle Park, NC, 27711
[3]National Park Service, Air Resources Division, Lakewood, CO 80235

Abstract

EPA's 2016 Regional Haze Rule revision provides a conceptual framework to track progress towards the national goal of no manmade visibility impairment by selecting a different set of days from each sample year compared to the days selected under the 2003 Guidance for Tracking Progress Under the Regional Haze Rule. In the new formulation, "most impaired" days are selected based on a simple algorithm based only on the monitoring data, the default natural conditions estimates, and a somewhat arbitrary definition of episodic events of dust and smoke. Selection of a metric based on these different days is meant to limit the effect of variations in haze from natural sources which have considerable influence on the default metric.

Significant differences exist between trends derived from the default metric and the impairment based approach. Changes in trends and composition are generally small for eastern US IMPROVE sites. Western US IMPROVE sites which had large increases or decreases in haze using the default metric, now often show steady declines in haze, and compositions much less influenced by carbon and dust species. Some sites in the desert southwest show modest degradation in visibility using the impairment metric. Sites in Southern California show considerable improvement with either metric.

Seasonal distributions of haziest days and most impaired days can be very different across the IMPROVE network. Haziest days tend to occur most frequently in summer months, where most-impaired days are spread out across the year

Control Number 78

The Dependence of the Distribution in Natural Haze on Haze Levels and the Contributions from Anthropogenic Sources

Bret A. Schichtel[1], Scott Copeland[2], Neil Frank[3], Kristi A. Gebhart[1], William C. Malm[2], Tom Moore[4], and John Vimont[1]

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[2]CIRA, Colorado State University, Fort Collins, CO 80523
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[4]U.S. Environmental Protection Agency, Region 8, Denver, CO
[5]Western States Air Resources Council (WESTAR), Fort Collins, CO 80523

The Regional Haze Rule (RHR) established the goal of returning visibility on the 20% most impaired days to natural conditions by 2064, while the visibility on the 20% least impaired days should not diminish. Impaired visibility was defined as any humanly perceptible change in visibility (light extinction, visual range, contrast, coloration) from that which would have existed under natural conditions. Consequently, impaired visibility is the anthropogenic contributions to haze. However, in the RHR guidance documents, the most impaired days were defined as the 5-year average of the 20% worst haze days measured at an Interagency Monitoring of Protected Visual Environments (IMPROVE) monitoring site, without regard to whether this haze was natural or human caused, and a constant natural haze level was defined for each class I area. Implicit in these definitions was the assumption that the 5-year average natural haze levels were relatively constant from one 5-year period to the next, allowing for the tracking of the trends in impaired visibility. However, due to large episodic wildfires and dust storms, impairment from natural haze can vary significantly and obscure trends in human caused visibility impairment. The impact of natural haze episodes

on the RHR tracking metric, defined as either the 20% haziest or the 20% most human impaired haze days, was explored using natural haze levels derived from the 2008 WESTJUMP modeling results. The analysis focused on IMPROVE sites in the western United States, where the most detailed modeling information was available. It was found that the distribution of natural haze levels on the 20% haziest days was broad with a long tail due to smoke and dust episodes. However, on the 20% most human impaired days the distribution of natural haze levels was narrower. Consequently, variation in natural haze levels should have a smaller impact on tracking haze trends in the most human impaired days compared to the haziest days.

Control Number 55

A Conceptual Approach to Address Anthropogenic/Non-Anthropogenic Emission Sources to Help Develop a More Accurate Regional Haze Program Glidepath

Theresa Pella, CenSARA, Oklahoma City, Oklahoma, Cassie Archuleta, City of Fort Collins Environmental Services Department, Fort Collins, Colorado, Uarporn Nopmongcol, Ramboll Environ, Novato, California, Ralph Morris, Ramboll Environ, Novato, California, Emily Vanden Hoek, Air Resource Specialists, Fort Collins, Colorado, Joe Adlhoch, Air Resource Specialists, Fort Collins, Colorado

Abstract

In 1999, the EPA promulgated the Regional Haze Rule (RHR), which included requirements for states to develop State Implementation Plans (SIPs) which provide for the protection of visibility in Federal Class I Areas (CIAs). These SIPs are intended to establish goals which provide for "reasonable progress" towards achieving "natural" visibility conditions by the year 2064. To implement the requirements of the RHR, the EPA formed 5 Regional Planning Organizations (RPOs) that consist of states, tribes, federal agencies and local agencies. The Central States Regional Air Partnership (CENRAP) RPO was affiliated with the Central States Air Resource Agencies Association (CenSARA) and performed the technical analysis needed to develop the initial RHR SIPs for the central states.

The long-term 60-year implementation period for RHR goals, with periodic SIP updates due every 10 years, provides an opportunity to review and appropriately revise future planning goals. In fact, the EPA has recently released proposed revisions to the RHR for public review. Final revisions are expected prior to the September 2016 Visibility Conference and will be incorporated into this presentation.

As specified in the RHR, "natural conditions" represent the visibility conditions that would be experienced in the absence of human-caused impairment. In developing the reasonable progress goals in the initial RHR SIPs, the CENRAP and others found that "reasonable progress" targets based on the RHR recommended methods in some cases are unattainable due to several factors, including:

- Some impairment is caused by uncontrollable sources such as international transport of emissions.
- Human-caused impairment is an ambiguous concept, as human activity can affect emissions from sources such as windblown dust and wildfires, and human activity profoundly affects all natural systems and their emissions.
- Current aerosol measurements include large natural episodic events such as wildfires, dust transport and volcanic activity. "Natural conditions" cannot appropriately represent these types of episodic events as they are highly variable from year to year.

In an effort to address these short-comings of the RHR, CenSARA developed the following preliminary methodology:

- Visibility attribution results from recent photochemical grid modeling (PGM), developed through WESTAR for use by the WRAP states, were used to represent aerosol extinction contributions from a number of source categories and source regions for the CenSARA regional haze monitoring sites for the year 2008.
- Using the modeled source categories, modeled aerosol extinction was divided into contributions from "controllable" and "uncontrollable" sources.
- The "controllable" and "uncontrollable" components of IMPROVE measured extinction were then determined using relative contributions of "controllable" and "uncontrollable" emissions to modeled extinction.
- The "uncontrollable" portion of the 2008 aerosol measurements was used to represent an RHR 2064 end goal by eliminating anthropogenic emissions that can reasonably be controlled by states. In cases where extreme natural events were attributed to "uncontrollable" emissions, large outliers of total carbon (related to fire impacts), and soil and coarse mass (related to dust storms) were replaced with median values.

The methods developed by CenSARA effectively define a planning goal for 2064, using the best available estimate of what conditions might look like if all emissions subject to U.S. controls were eliminated. While this does not explicitly reflect the RHR goal of "natural conditions", it does offer a more realistic planning goal for CenSARA States for purposes of determining "reasonable" progress

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Control Number 88

Visibility Improvements Past and Future in the Southeastern United States

Sheila Holman, North Carolina Department of Environment and Natural Resources and
Patricia F. Brewer, National Park Service

The Regional Haze Rule requires states to submit implementation plans that demonstrate progress in improving visibility in Class I national parks and wilderness areas. The first state plans were due to the Environmental Protection Agency in December 2007, implementing long-term emission reduction strategies through 2018. Technical analyses for regional haze planning in North Carolina and nine other southeastern states were conducted through the Regional Planning Organization for the Southeast. Visibility at the five Class I areas in North Carolina (Great Smoky Mountains National Park; Joyce Kilmer, Linville Gorge, and Shining Rock Wilderness Areas, and Swanquarter Wildlife Refuge) is impaired primarily by ammonium sulfate. Coal fired electric generating facilities and coal fired industrial boilers were the major contributors to ammonium sulfate in both the 2002 base year and the 2018 projection year.

In 2002, the North Carolina legislature passed the Clean Smokestack Act that required reductions of sulfur dioxide and nitrogen oxides emissions from electric utilities in North Carolina. By 2015, EGU emissions of sulfur dioxide and nitrogen oxide had been reduced by 94% and 76%, respectively, compared to 2002 emissions. In negotiations to permit a single new coal fired unit at Cliffside power plant, Duke Energy agreed to permanently retire four smaller and older coal fired generating units in North Carolina. Other coal fired units are being converted to natural gas.

In 2007, North Carolina Department of Environment and Natural Resources (DENR) evaluated industrial sources within the Area of Influence of each Class I area. These Areas of Influence accounted for emissions in upwind source areas as a function of distance from the Class I area and frequency that winds passed over the source area (residence time). Sources with contribution

greater than 1% of total contribution to visibility impairment at the Class I areas were further evaluated for four factors: cost, existing air emission controls, remaining useful life, and non-air environmental impacts. In 2007 three industrial facilities were evaluated, however controls were determined not to be cost effective. Since then, one of the sources has committed to convert the boilers from coal to natural gas.

The second round of state plans are due in 2018, however EPA is proposing to extend the due date to 2021 to allow states additional time to develop plans that consider implications of multiple pollutant standards. DENR is again expecting to focus on coal-fired industrial sources of sulfur dioxide. Technical methods to prioritize and evaluate controls will be discussed and compared to EPA' newly released guidance for evaluating reasonable progress.

Session 10. Panel Air Quality Issues in the WESTAR Region

Session Chairs: Mary Uhl, Tom Moore, WESTAR

Panelists:
Nancy Vehr, *Air Quality Division Administrator, Wyoming*
Bryce Bird, *Division of Air Quality Director, Utah*
Gordon Pierce, *Program Manager, Colorado Department of Public Health and Environment*
Stephen Coe, *Air Resources Management Bureau, State of Montana*

The panel presentation will focus on air quality issues in four WESTAR member states close to the conference location: Wyoming, Utah, Montana, and Colorado. All four states willl address how they have each addressed visibility and potential degradation associated with winter ozone episodes, smoke, and energy development including oil and gas mining as well as from a rural perspective. Two of the states - Utah and Colorado - will also address these issues from an urban perspective. The presentation will highlight the similarities or differences in how states have addressed these issues as a result of the state's specific policy perspective or other unique circumstances.

Session 9B. Regional Haze Rule

Control Number 34

The Role of "Margin of Error" In Regional Haze Determinations

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Abstract

Because of the judicial notice of the concept of the "margin of error" in the Montana BART litigation, the issue has come to the forefront of regional haze analysis. The courts have been sensitized to this issue because they require experts to explain the error in their calculations. Instead of assuming that the air quality dispersion model provides bright line answers of deciviews, the courts are understanding the concept that the FLAG writers outlined at the very beginning of their efforts, i. e. that the model was only a screening tool. EPA has continued its path of modeling with an old version of CALPUFF and has said nothing about the margin of error in its model results.

This paper reviews the status of the margin of error presentations in 2016, including the comments on the Utah BART state implementation plan which was denied by EPA. The margin of error is determined by all the studies that have been done comparing CALPUFF (and its different versions) to measured data. The margin of error falls into two categories: 1) transport and diffusion error and 2) c\atmospheric chemistry error. Each will be explored with the data. The results are that transport, and diffusion error is at least 70% too high and that atmospheric chemistry error can be up to an order of magnitude too high.

Control Number 65

Source Attribution for Visibility Planning using a Regional Photochemical Model

Patricia F. Brewer, National Park Service, Gail Tonnessen, Environmental Protection Agency Region 8,
Tom Moore, Western States Air Resources Council

The Regional Haze Rule implements the Clean Air Act's national goal to prevent future and remedy existing visibility impairment due to manmade air pollution in Class I national parks and wilderness areas. States are required to define long-term emission reduction strategies to improve visibility on the most impaired (worst 20% average of total daily impairment) days and to prevent degradation of visibility on the least impaired (best 20% average of total daily impairment) days. States are to submit plans every 10 years that demonstrate reasonable progress toward achieving natural background visibility conditions by 2064.

Over the past two decades state and federal requirements have substantially reduced anthropogenic emissions of sulfur dioxide, nitrogen oxides, and fine particulate matter, primarily from fossil fuel combustion, that contribute to visibility impairment. However in many western Class I areas, visibility is also degraded by natural emissions from wildfire and dust events and by international emissions of both natural and anthropogenic origin that are transported to the US. As a result, visibility in many western Class I areas has not improved on the worst days by an amount comparable to the reductions in US anthropogenic emissions.

In 2016, EPA will propose revised methods for tracking visibility progress using the IMPROVE monitoring data. Statistical analyses are proposed to separate episodic contributions from wildfire or dust events and routine contributions from natural emission sources such as vegetation and soil. The remaining pollutant contributions are attributed to anthropogenic emissions. The days with highest light extinction attributed to anthropogenic sources are considered the most impaired days. The revised monitoring metric under EPA's proposal will be the average 20% of the most impaired days (attributed to anthropogenic emissions), not the 20% worst days as used for the first 2008-18 planning period.

Monitoring data alone are not sufficient to define the contributions of controllable U.S. anthropogenic emissions or specific source categories. Emissions inventories and regional photochemical modeling tools are also needed to estimate contributions of U.S. anthropogenic sources from natural and international emissions and to evaluate the effectiveness of emission reduction strategies to improve visibility. The West-wide Jumpstart Air Quality Modeling Study[1] (WestJumpAQMS) applied 2008 emissions inventories and the Particle Source Apportionment Tool (PSAT) in the CAMx regional photochemical model to attribute contributions to light extinction at western Class I areas from U.S. anthropogenic emissions, wildland fire, natural biogenic sources, and sources outside the continental U.S. The PSAT source apportionment analyses projected that international transport was the largest contributor to ammonium sulfate at many Class I areas in the West and that ammonium nitrate was primarily from U.S. anthropogenic sources. As a result, CAMx predicted larger estimates of U.S. impairment in winter when nitrate concentrations were highest and lower levels of impairment in other seasons when sulfate was the more dominant contributor.

[1] Available from: http://www.wrapair2.org/WestJumpAQMS.aspx

This caused a shift in the seasonal distribution of the most impaired days in CAMx compared to the 20% most impaired days based on the IMPROVE data. Specific examples for Class I areas in the western U.S. for the 2008 WestJump and 2011 Western Air Quality Study[2] will be discussed.

Control Number 68

The Uniform Rate of Progress and Setting a Reasonable Progress Goal in Western U.S. Class I federal areas

Gail Tonnesen, Environmental Protection Agency Region 8, Tom Moore, WESTAR-WRAP, Patricia F. Brewer, National Park Service

The Clean Air Act established a goal of preventing future and remedying existing visibility impairment conditions at Class I areas, and the 1999 Regional Haze Rule (RHR) requires states to determine the uniform rate of progress (URP) able to be achieved through a 2018 projection, and the expected date to reach estimated natural visibility conditions on the 20 percent most impaired days. The URP has the nominal target year of 2064 to reach natural conditions and states can adopt an alternative target year to achieve natural conditions. The URP is determined by estimating visibility impairment in deciviews in the baseline period, as a 5-year average of the 20% worst impairment days in each year from 2000 to 2004, and drawing a straight line to zero impairment in 2064. States are also required to identify a Long Term Strategy (LTS) of emission reduction measures needed to make reasonable progress towards natural visibility conditions and to use photochemical modeling to estimate a reasonable progress goal (RPG) as reduced impairment in deciviews that will result from the LTS. States must then compare the RPG for the 20 percent most impaired days to the URP line for the each Class I area. If the RPG is above the URP line, the state has an additional obligation to demonstrate that there are no additional emission reduction measures that would be reasonable to include in the LTS.

The URP is defined by an analysis of IMPROVE monitoring data, but the RPG is determined by photochemical model simulations, and this raises the questions of whether the model RPG is evaluated on a consistent basis as the URP and what effects model bias or error might have on the comparison of the RPG to the URP. Here, we compare new estimates of the URP at four western U.S. Class I areas based on an analysis of impairment using IMPROVE data to a CAMx model estimate of the URP for U.S. anthropogenic emissions. We use a CAMx baseline simulation for 2011 and we use CAMx PSAT to estimate the total U.S. anthropogenic contribution to impairment in 2011. The CAMx URP is defined by drawing a straight line from the CAMx 2011 baseline to zero U.S. impairment in 2064. We compare the CAMx URP to the IMPROVE data URP and use this as an estimate of how the maximum potential model visibility benefit compares to the visibility benefits that are expected to be achieved based on the analysis of impairment in the IMPROVE data. Additionally, we compare relative contributions of each $PM_{2.5}$ species to the IMPROVE URP and the CAMx URP. We find that at the Lassen Class I area, the model URP is flatter than the IMPROVE URP, and this indicates that CAMx model simulations will fail to demonstrate achievement of visibility goals at this site unless a model relative response approach is used to adjust the model projections of visibility benefits. At other Class I areas, the slope of the model URP is similar to the IMPROVE data URP, but the relative contribution of sulfate and nitrate differs in the model and in the IMPROVE data. We conclude that additional research is needed both to improve model performance and to develop relative response approaches for adjusting the model estimates of the RPG so that it can be compared to the IMPROVE data URP on a consistent basis.

Control Number 42

[2] http://views.cira.colostate.edu/tsdw

Assessment of the Contributions to Visibility Impairment in the Western United States and the Potential Effects of New Guidance for Tracking Visibility Progress

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Tom Moore, WRAP Air Quality Program Manager, Western States Air Resources Council (WESTAR), CSU/CIRA,1375 Campus Delivery, Fort Collins, CO, 80523-1375

Abstract

Over the last several years the Western Regional Air Partnership (WRAP) has conducted several regional air quality modeling studies of the western U.S. to improve our understanding of regional source-receptor relationships related to ozone, particulate matter, visibility and sulfur and nitrogen deposition. In 2015, WRAP developed a new 2011 Photochemical Grid Model (PGM) modeling platform that was used to estimate current (2011) and future (nominally 2025) year air quality and air quality related value (AQRV, i.e., visibility and deposition) levels in the western U.S. The 2011 PGM modeling platform used a 36 km resolution domain covering the continental U.S. (CONUS), a western U.S. (WESTUS) domain with a 12 km grid resolution and a finer scale (4 km) resolution domain covering several of the intermountain west states (i.e., CO, UT, WY and northern NM and AZ). This paper focuses on the WRAP PGM visibility modeling results including the source regions and categories that contribute to visibility impairment at Class I areas in the western U.S. and the projected changes in visibility between 2011 and 2025.

The Regional Haze Rule (RHR) requires states to analyze their progress toward natural visibility conditions at Class I areas and has established a 2000-2004 baseline period and procedures for assessing the Uniform Rate of Progress (URP) toward natural conditions in 2064. Several milestone years have been established to track this progress with 2018 being the first milestone year that URP was evaluated in the initial RHR visibility State Implementation Plans (SIPs) that were due in 2007. The URP progress was evaluated for the worst and best 20 percent visibility days (W20% and B20%) that were identified using observed IMPROVE particulate matter (PM) measurement data. In the western U.S., however, the W20% days at some Class I areas were frequently associated with emissions from wildfires or regional dust storms. The W20% days visibility metric is inconsistent with the language in the RHR to reduce visibility degradation at Class I areas for the most impaired days, which is interpreted to mean emissions due to man-made sources in the U.S. Thus, EPA and others are evaluating alternative visibility metrics to the W20% and B20% days for calculating URP and has released guidelines and is expected to release guidance on the revised procedures in 2016. The effects of these revised procedures on how PGMs are used for demonstrating URP is evaluated along with how such new visibility metrics change visibility source-receptor relationships for western U.S. Class I areas. The contributions of various source sectors (e.g., wildfires, oil and gas, on-road mobile, electrical generating units, etc.) and source regions to visibility impairment for the most impaired days visibility metrics are calculated and compared. The effects of these changes in procedures for calculating visibility URP using current and future year PGM modeling results are discussed.

Control Number 54

Anthropogenic Impairment using NAAPS Smoke and Dust

Neil Frank, Raleigh, NC, Rudy Husar, Washington University, St. Louis MO, Doug Westphal, Naval Research Laboratory, Monterey, CA, *Venkatesh* Rao, OAQPS/U.S. EPA, RTP, NC, Brett Gantt, OAQPS/U.S. EPA, RTP, NC.

Abstract

Derivation of daily visibility impairment attributed to anthropogenic emissions requires estimates of the daily contribution from natural sources. Such data are important in order to judge improvement in visibility resulting from reductions in anthropogenic emissions. A recognized uncertainty in establishing impairment trends is the daily natural contribution from smoke and dust which can represent a large contribution to aerosol-based light extinction particularly in the western U.S. These large and variable contributions from natural sources can frequently dominate the overall contributions from all emission sources and make it difficult to discern improvements in anthropogenic impairment of visibility.

In this paper, modeled smoke and dust from the Navy Aerosol Analysis and Prediction System (NAAPS) Global Aerosol Model are retrieved from DataFed.Net to establish estimates of the routine and episodic contributions at IMPROVE locations. Monthly median values of the satellite based NAAPS smoke and dust estimates over a multi-year period are first calibrated to surface measurements of carbonaceous aerosols, coarse mass and calculated fine soil. These values are used to provide the routine contributions from fire and dust events. The estimated typical light extinction from carbon and dust are then used to establish their daily episodic components. The paper compares the spatial and temporal patterns of the NAAPS-based estimates with natural contributions provided by the US EPA. The implications for estimating natural conditions and tracking improvement in visibility impairment are discussed.

Session 13. Potential Impacts of Emissions from Oil and Gas Fields on Air Quality and Visibility

Upper Green River Basin, WY, Oilfield Disposal Pond Emission Study

Cara Keslar, Wyoming DEQ, Cheyenne, Wyoming, Richard Bowers, GSI Environmental Inc., Austin, Texas, Ann Smith, GSI Environmental Inc., Austin, Texas, Adam Deppe, Wyoming DEQ, Cheyenne, Wyoming,

Abstract

Since 2005, the Wyoming Department of Environmental Quality (WDEQ) has recorded wintertime exceedances of the 8-hour National Ambient Air Quality Standard (NAAQS) for ozone in the Upper Green River Basin (UGRB), causing Sublette County and portions of Sweetwater and Lincoln Counties to be designated as non-attainment areas for the 8-hour ozone NAAQS. Volatile organic compounds such as benzene, toluene, xylene, and aldehydes serve as key pre-cursors to ozone formation.

A recent study has been conducted to characterize key VOC emissions from open-air oilfield waste disposal impoundments under summer and winter conditions at two commercial oilfield waste disposal facilities in the UGRB. A variety of impoundment types were investigated, including ponds receiving tank bottoms, produced water and flow back water, intermediate evaporation or storage ponds, and ponds containing only fresh water (for experimental controls). For each pond, two distinct air emissions characterization methods—flux chambers and open path FTIR—were deployed, allowing for a comparison of direct vs. indirect VOC emissions measurements in conjunction with traditional canister air sampling. Concurrent, site-specific meteorological data were collected to support related emissions and air dispersion modeling. The two emissions measurement approaches exhibited good agreement when distinct wind speed effects were taken into account.

Observations from the field studies conducted in the summer of 2015 and the winter of 2016 in the UGRB yielded the development and calibration of a simple, water concentration and meteorologically-based calculation model to predict year-round VOC emissions without the need to conduct site specific air monitoring. The model incorporates concurrent and co-located air and water samples, meteorological conditions influenced by pond geometry, and the presence of open water, oil sheen or ice to determine

accurate emissions under a variety of conditions. This public domain model can be used by interested stakeholders to facilitate the development of annual air emissions inventories, air permits, or for other applications based simply on site-specific water sampling results and meteorological data. Initial results indicate consistent agreement between the model predictions and field observations.

Control Number 80

Statistical Analysis of Winter Ozone Events in the Uinta Basin, Utah

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In 2013, we published a quadratic regression model aimed at predicting the daily winter ozone concentration in the Uinta Basin [Mansfield and Hall, Air Qual Atmos Health, 6: 687-699]. The model employed, as independent variables: (1) a quantity we call the pseudo-lapse rate (derived from a surface temperature-altitude correlation to characterize the strength of thermal inversions), (2) snow depth, (3) solar angle, (4) temperature, and (5) the number of consecutive days under inversion conditions. The input "training" data set consisted of all winter ozone data available at the time of the study, covering 239 days over three winter seasons, two of which were high ozone seasons. The resulting model was able to predict actual concentrations with a 10-ppb standard error. Based on the model, we predicted that 44% of winter seasons in the Uinta Basin would comply with the former NAAQS of 75 ppb ozone. We also found that the number of NAAQS exceedances' in one season is not correlated with the number in the following season, i.e., multi-year trends are not expected.

Winter 2016 has provided a new avenue of study. Because of the global decline in fossil fuel demand, drilling of new oil and gas wells in the Basin has almost completely ceased, and oil and gas production rates have also declined. Furthermore, inversions during Winter 2016 often had higher relative humidity and warmer temperatures than are typical, yet the season saw a number of exceedences of the new NAAQS of 70 ppb. With the close of Winter 2016 we now have a total of seven consecutive seasons of winter ozone data, including several years that produced no high ozone. In other words, we now have available a much larger training set that lets us examine the influence of a more varied meteorology, and the impact of variability in fossil fuel production.

A new regression model will be presented that includes, in addition to the five independent variables listed above, atmospheric H_2O concentration and several markers of oil and gas industrial activity, including the number of new wells drilled in a season, and monthly production data of oil and natural gas.

A common human fallacy is to see non-randomness in sequences that are essentially random, e.g., a gambler that believes he is in a winning streak. With that in mind, I have examined over 60 years of climate data in the Uinta Basin, extending the search for multi-year correlations mentioned above. These results will also be presented.

Control Number 85

Using Modeling Technique to Quantify Background Ozone Concentration in the Uintah Basin, Utah

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Abstract

To accurately quantify contributions of local anthropogenic emissions to the ozone pollution by modeling source apportionment technique, background ozone concentrations must be adequately accounted for. The

Uintah Basin, Utah, is well-known for its winter (December through March) ozone pollution phenomenon. Historical data show that daytime ozone was frequently above 100 ppb during high ozone winters, but reached as low as 25 ppb during ozone none-polluted winters. During summer, daytime ozone frequently stayed above 60 ppb. To quantify background ozone concentration, in this study we adopted a two-step approach: first, the GEOS-Chem, a global 3-D chemical model driven by assimilated meteorological observations from the Goddard Earth Observing System (GEOS) of the NASA Data Assimilation Office, is performed to account for possible influxes of ozone and its precursors from outside the Basin. Second, a high resolution (1.3 km) Weather Research and Forecasting meteorological mode coupled with the Community Multi-scale Air Quality chemistry model (WRF-CMAQ) is performed with employing GEOS-Chem outputs as its lateral boundary conditions. WRF-CMAQ simulations performed with and without local anthropogenic emissions are compared to quantify background ozone concentrations. We pick winter 2012 when observed ozone were low to do simulations for quantifying background concentrations, which are then applied for simulating high ozone pollution episodes in winter 2013 and evaluating model's performances. Outcomes of this study is a set of seasonal ozone background concentrations for future air quality modeling studies in the Uintah Basin.

Control Number 49

Modeled Representation of Visibility Impacts due to Emissions Associated with Oil and Gas

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We evaluate the model estimated impact of emissions from oil and gas (O&G) activities on visibility, focusing on National Parks (NPs) in the Western US. We use a regional photochemical modeling platform representing a best estimation of emissions and meteorology in the year 2011. This platform includes fine spatial (12km by 12km) and temporal (hourly) detail of inputs and includes the most current estimation of emissions associated with O&G activities in the Western US. The O&G emissions inventory was developed and evaluated for model performance by the Intermountain West Data Warehouse –Western Air Quality Study (IWDW-WAQS). By running the model both with and without emissions associated with O&G and comparing the model output of these two runs, we can estimate the modeled impact of O&G emissions on all air quality metrics including visibility. We show how O&G impacts on visibility change between the highest and lowest impaired days and seasons, and we evaluate the relative impact of the different species that make up fine Particulate Matter (PM). We also explore emissions modeling assumptions related to primary PM speciation. Findings suggest that O&G impacts on visibility are mostly localized in the Western US meaning that O&G operations have the largest impact on visibility in NPs that are located close to O&G basins. However, O&G impacts on visibility are widespread in Texas and Oklahoma mostly related to the formation of nitrate during winter months. At eleven class II national parks, which are not subject to the Regional Haze Rule requirements, the O&G production activity contributed more than 0.5 DV to the average 20% worst haze days. Finally, relative to the Federal Land Managers' Air Quality Related Values Group (FLAG) criteria, there are six National Park Service units with greater than 1 deciview (DV) modeled change in visibility due to O&G emissions on more than 50 days of the 2011 modeling year, and 17 NPs where O&G caused more than 0.5 DV of haze on at least 50 days a year.

Control Number 22

An overview of the Bakken Air Quality Study

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Abstract

The Williston Basin covers several hundred thousand square kilometers in parts of North Dakota, Montana, South Dakota, Saskatchewan, and Manitoba. In the Bakken and Three Forks formations within the Williston Basin, it is estimated that there are more than 7 billion barrels of recoverable oil, making it the largest tight oil play in the United States. Despite these vast deposits, it is only in the past decade that horizontal drilling and hydraulic fracturing methods have allowed for cost-efficient extraction of these resources, which has led to exponential growth of oil production in the region over the past decade. Along with this development has come an increase in associated emissions to the atmosphere. Combined with decreasing emissions from power plants, new emissions sources related to oil and gas activities are playing an increasingly important role in regional air quality. Along with these new emissions, haze levels have increased or remained unchanged for some sites in the region since 2000, counter to national trends, and increases in wintertime sulfate and nitrate have been observed. Concern about potential impacts of these emissions on federal lands in the region prompted the National Park Service to sponsor the Bakken Air Quality Study over two winters in 2013-2014. Measurements were conducted at five sites: the north and south units of Theodore Roosevelt National Park, Fort Union Trading Post National Historic Site, Knife River National Historic Site, and Medicine Lake National Wildlife Refuge. Additional data were collected from long-term monitoring networks in the region. Here we provide an overview of the study and present some initial results aimed at better understanding the impact of local oil and gas emissions on regional air quality. Data from the study suggest that while power plants are still an important emissions source in the region, emissions from oil and gas activities are impacting ambient concentrations of nitrogen oxides and black carbon and may dominate recent observed trends in pollutant concentrations at federal lands in the region. Measurements of volatile organic compounds also definitively show that oil and gas emissions were present in almost every air mass sampled over a period of more than four months.

Control Number 61

Aerosol Light Scattering Measurements in the Bakken Oil Fields

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Abstract

The Bakken Formation covers an area of approximately 200,000 square miles in North Dakota, Montana, and southern Canada. Estimates of oil reserves within the formation vary, however, recent predictions suggest as much as 7.4 billion barrels of oil will ultimately be recovered. The recent advances in oil and gas

extraction techniques such as horizontal drilling and hydraulic fracturing have allowed economic recovery of these resources and have led to an increase in production in the Bakken region from a few million barrels per month in 2000 to well over 35 million barrels per month in 2015. The rapid and extensive development has outpaced infrastructure, therefore, since 2008 25-40 percent of natural gas extracted from these wells has been flared. Gas flaring produces particulate matter in the form of black carbon; however, gas flaring is only one aspect of the oil and gas extraction processes which contributes to emissions and ultimately to reductions in air quality. Other emissions include nitrogen oxides (NOx), volatile organic compounds (VOCs), and particulate matter (PM2.5) mostly produced by the heavy duty diesel engines powering drilling rigs, trucks, pumps, and the myriad other equipment used to extract and transport the fossil fuel products. Although emissions from any given source are small, the cumulative impact from all sources throughout the basin can be significant from a local and regional air quality perspective. Since there are three Class I areas within the Bakken region (Theodore Roosevelt National Park (THRO), Medicine Lake (MELA) and Lostwood National Wildlife Refuges (LOST) where visibility is a protected air quality attribute, any impact of oil and gas development is a concern to federal land managers. To assess whether there has been a significant impact to regional air quality, a suite of measurements was made during the winter months of 2013 and 2014 at THRO, MELA, and Fort Union trading post. In this work, we use aerosol light scattering measurements (bsp) from nephelometers and surface wind direction from portable meteorological stations to show that aerosol light scattering coefficients were a factor of 1.8 higher at MELA and a factor of 2.0 higher at THRO when the wind was from the east (where oil field activity is high) than from the west (where there is little oil field activity). Further analyses using back trajectories from the 14 nearest IMPROVE sites show that oil and gas activity has a regional impact on fine particulate concentrations.

Session Associated Poster Presentation

Control Number 40

Upper Green River Basin, WY, Historical Analysis of Pollutant Concentrations

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Abstract

Since 2005, the Wyoming Department of Environmental Quality (WDEQ) has recorded wintertime exceedances of the 8-hour National Ambient Air Quality Standard (NAAQS) for ozone in the Upper Green River Basin (UGRB). In July 2012, the U.S. Environmental Protection Agency designated all of Sublette County and portions of Lincoln and Sweetwater counties as an ozone nonattainment area for the 8-hour ozone NAAQS, collectively known as the UGRB Ozone Nonattainment Designation Area.

In response to these elevated concentrations, first observed in the winters of 2005 and 2006, the WDEQ started the Upper Green Winter Ozone Study (UGWOS) campaign in January 2007. The goal of the UGWOS was to study and evaluate spatial and temporal variability in meteorology, ozone, and ozone precursors. Since 2007, multiple locations in the UGRB have been established, both permanent and seasonal, to monitor and observe meteorology and pollutant trends during the winter ozone season, as emissions are reduced, and control strategies are implemented.

As ten years of data has been collected in the UGRB since the first UGWOS campaign, the WDEQ has commenced a study to analyze pollutant changes in the UGRB since 2007. The goal of this study is to evaluate historical pollutant concentrations, especially VOCs such as benzene, toluene, xylene, and aldehydes that serve as key precursors to ozone formation. This will include analyzing pollutant trends and comparing pollutant ratios (e.g., VOCs to NO_x), with the understanding that significant changes in metrological conditions, oil and gas development, and control strategy regulations have occurred in the

UGRB between 2007 and current.

Control Number 83

FDDA (nudging) impacts on WRF-CAMx model performance in simulating winter O_3 formation in Uintah Basin

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Abstract

Newtonian relaxation or nudging has been commonly applied into meteorological model simulations because of its beneficial effects on improvement of model performance, especially for simulation period longer than 48 hours. In this study, we compared WRF-CAMx simulations with and without four-dimensional data assimilation (FDDA or nudging) to examine if nudging approach (i.e., analysis and observation nudging with NAM-12 reanalysis and MADIS+AirNowTech data, respectively) improve model performance in simulating winter O_3 formation in Uinta Basin. Our sensitivity tests were conducted for episode of Jan 16 to Feb 9, 2013. Unlike many of previous studies showing the beneficial effects of nudging to model performance, our primarily results showed that observational nudging applied into WRF simulations leading to unrealistically vertical temperature profiles (e.g., too shallow boundary-layers ~ 50m); hence suppressed thermally-driven circulations which then negatively affected CAMx performance in simulating O_3 concentration distribution within Uintah Basin.

Control Number 120

Novel Lab Method to Detect Methane or CO_2 Leakage from Damaged Cement in Unconventional Oil and Gas Wells

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Abstract

Subsurface fluid leakage is a primary concern from unconventional oil and gas development as well as carbon sequestration and gas storage wells. During the past thirty years, methane leakage from said wells has received significant attention from industry, government and the public because of environmental and human health concerns. Recent studies have increased not only public awareness but also concern because methane is a powerful greenhouse gas and a known precursor to the formation of ozone, an air pollutant that is regulated.

In a typical well steel casing is installed and the annular space between this casing and the drilled rock is filled with cement. Ideally, this cement provides a hydraulic seal in the casing- rock annulus. If this cement becomes damaged it can allow fugitive methane or CO_2 emissions to aquifers or to the surface. Current emission estimates from surface facilities, cemented annuli and the surrounding rock are thought to be somewhere between 1 and 11% of the actually produced gas. Methane leakage can be

viewed as short-, medium- and long-term. Proper cement system design and good operational practices can easily mitigate short-term leakage that is often the result of wrong cement weights.

Since medium-term leakage has received significant attention from industry the assumption of this research is that proper cementing techniques will mitigate this type of leakage. Long-term leakage usually relates to wellbore integrity issues and can occur weeks to years after initiation of production – substantial leakage may also occur after a well has been plugged and abandoned. Controlling or preventing long-term leakage has not been prioritized by industry because their commercial interest is with production or with developing products and services that mitigate short- and medium-term leakage. However, more research has been directed toward long-term leakage recently because of concern with atmospheric methane and CO_2, and the costs associated with remediating a leaky well.

Mechanisms accelerating cement seal degradation include pressure cycling from hydraulic fracturing and other well operations. It is currently uncertain if conventional cementing can prevent this kind of leakage. This research presents a novel method to detect leakage along the length of a wellbore at the lab scale from pressure cycling. Pressure is applied in a cyclic manner to pseudo casing and permeability along the length of the cement is monitored. This method can detect not only the time that the cement becomes damaged but also the location. CT images are also taken before and after to visualize damage. It is hoped that in better understanding how cement damage occurs that methods can be developed to prevent damage in future wells and repair damage in current wells.

Session 15. Aerosol Field Studies and Monitoring Networks

Control Number 13

Wintertime $PM_{2.5}$ Pollution in UT: What Can Measurements at Ground Level and Higher Elevation Tell Us?

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Valleys along the Wasatch Mountains in northern Utah (Cache, Salt Lake and Utah) experience high levels of particulate matter with aerodynamic diameters less than 2.5 micrometers ($PM_{2.5}$) in winter months. These pollution episodes are closely associated with Persistent Cold Air Pool (PCAP) events, which have been a focus of several recent studies, and are typically dominated by secondary species, in particular ammonium nitrate. However, the chemical aspects of these pollution episodes received somewhat little attention compared to the meteorological phenomena. The Salt Lake Valley Winter $PM_{2.5}$ study was conducted

between December 2015 and February 2016 to improve the scientific understanding of these pollution episodes, especially the chemical processes governing the PM formation. During this study, rooftop observations of a suite of chemical and meteorological parameters relevant to PM formation were made at the University of Utah site located ~ 150 m above the valley floor. The measurements included PM mass, chemical composition and size distribution, trace gases and radical measurements (notably O_3 and N_2O_5). Mobile and aerostat measurements of PM and related species were also made to explore their vertical and spatial variability. This presentation will give an overview of the results focusing on the chemical and meteorological conditions that lead to the PM pollution episodes. Further, I will compare chemical conditions at the bottom of the valley and higher elevations, explore the time evolution of the aerosol layer during these pollution episodes and highlight the importance of the coupling between the nighttime and morning chemistry, and dynamical processes that yield elevated PM levels near surface.

Control Number 18

Temporal trends in the difference between gravimetric and reconstructed fine mass at rural and urban sites across the United States

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Abstract

Characterizing the speciated composition of atmospheric aerosols is essential for estimating contributions from individual species to visibility degradation and to $PM_{2.5}$ total mass concentration. Reconstructing $PM_{2.5}$ mass requires assumptions of the molecular form of the individual species assumed to compose the bulk of $PM_{2.5}$ mass. Typically, the species include sulfate as fully neutralized ammonium sulfate, nitrate as ammonium nitrate, an organic carbon multiplier to convert organic carbon to particulate organic mass (a typical value of 1.8), and dust concentrations assuming common oxides of soil. Comparisons of reconstructed fine mass (RCFM) to gravimetric $PM_{2.5}$ mass (FM) also provides a quality assurance check and informs on possible biases in gravimetric or speciated measurements. The difference between FM and RCFM can be explored temporally and spatially to understand the robustness of the reconstruction or biases that may vary regionally or seasonally. Data from the rural Interagency Monitoring of Protected Visual Environments (IMPROVE) network and the Environmental Protection Agency's urban Chemical Speciation Network (CSN) are ideal for this type of analysis given the consistent analysis methodologies used over time. We calculated linear trends in the difference between FM and RCFM at rural and urban sites across the United States since 2005. Results suggest that RCFM has decreased at a faster rate across both urban and rural sites relative to FM. This divergence in trends varies both regionally and seasonally and suggests that the RCFM algorithm may be missing species contributions or that potential biases in the FM measurement have changed over time. However, given that the trend in the difference was observed using data from both networks, analytical or measurement biases are less likely responsible, although perhaps not negligible. Using multi-linear regression techniques, we investigate possible changes in assumptions used to reconstruct fine mass, including changes in the organic carbon multiplier. Resolving the increased discrepancy between measured and reconstructed fine mass concentrations is essential for accurately estimating contributions by individual species to FM and visibility degradation.

Control Number 24

Positive Matrix Factorization and Data Quality Assessment of EPA's $PM_{2.5}$ Chemical Speciation Network (CSN) Derived from Six Collocated CSN Sites for the Period 2010 - 2013

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The U.S. Environmental Protection Agency (EPA) established the $PM_{2.5}$ Chemical Speciation Network (CSN) in 2000 to supplement its $PM_{2.5}$ Federal Reference Method (FRM) monitoring program established in 1998. EPA recently completed a review of the CSN with the goal of reducing base costs and providing a percentage of funds to upgrade the network. This assessment builds upon two alternate studies conducted by DRI. One that performed a large-scale overview of CSN sample and blank data for the period 2010 through 2013 contained in EPA's Air Quality System (AQS) annual summary files. The second looked at CSN data quality derived from AQS retrievals obtained from six collocated CSN sites (each with a primary-collocated sampler pair) in 2013. The current assessment examines data derived from AQS retrievals obtained from the six collocated CSN sites for the period 2010 - 2013. The six collocated sites are: California Avenue (Bakersfield), CA; Rubidoux (Riverside), CA; Roxbury (Boston), MA; New Brunswick, NJ; G.T. Craig (Cleveland), OH; and Deer Park (Houston), TX. The period 2010 - 2013 was chosen because it was the most recent period for which there were consistent sampling and analysis methods used. In addition, a complete set of speciation parameters in four major categories ($PM_{2.5}$ mass, elements by x-ray fluorescence [XRF], anions and cations by ion chromatography [IC], and organic carbon [OC] and elemental carbon [EC] by thermo-optical carbon analysis using the IMPROVE_A protocol) were available for the period but not later since EPA discontinued measuring $PM_{2.5}$ speciation mass at most CSN sites in October, 2014, replacing it with the $PM_{2.5}$ mass obtained from collocated FRM samplers.

The data quality assessment looks at the degree of correlation and relative percent error between the primary and collocated samplers for major constituents (i.e., $PM_{2.5}$ mass, ions, OC and EC, and select XRF elements). The twelve select XRF elements are those which EPA's National Air and Radiation Exposure Laboratory (NAREL) typically included in its annual performance evaluation laboratory intercomparisons of CSN analytical laboratories. They include: aluminum, bromine, calcium, chlorine, copper, iron, lead, potassium, silicon, sulfur, titanium and zinc. Four additional XRF elements are also examined because of potential interest for health risk assessments (arsenic and cadmium) or their past use as source-receptor tracer elements (selenium and vanadium).

Matched sets of complete speciation data for the primary and collocated samplers at each of the collocated CSN sites were compiled for receptor model analysis with the Positive Matrix Factorization (PMF). The primary and collocated data sets were analyzed separately to see what differences, if any, were obtained and to assess to what extent CSN data quality is adequate for performing source apportionment, as well as for control strategy development.

Control Number 15

Chemical and morphological characteristics of fine particulate matter emitted from an open municipal solid waste (MSW) disposal site in India

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Abstract

Municipal solid waste (MSW) management is a challenging task in many urban areas of the developing countries. Open dumping of MSW and deliberate burning of MSW for volume reduction or recovery of resources are common at MSW disposal sites in developed countries. As a result, a large amount of toxic pollutants released into the ambient environment and affecting regional and local air quality including visibility impairment.
This paper aims to study the seasonal distribution of water-soluble inorganic ions and morphological characteristics of fine particulate matter (PM2.5) monitored near an open MSW dumpsite in Chennai city, India. The 24 hour PM2.5 Sampling was done for 14 days in both winter (January- February 2015) and summer (March-May 2015) seasons. A total of 28 PM2.5 samples collected were analyzed for chemical and morphological characteristics. The PM2.5 mean mass concentration showed maximum during winter (61.17±24.90 μg/m3) and minimum during summer (27.95 ± 13.91 μg/m3) periods. The ionic composition of PM2.5 samples showed the dominance of SO42- ions in both seasons. During winter and summer seasons, the other predominant ionic species followed the order of NH4+ > NO3- > Cl- >Ca2+ > K+ >Na+ >Mg2+ > F-; NH4+ >Ca2+ > NO3- >Na+ > Cl- > K+ > Mg2+ >F-, respectively. The ion balance (expressed the mean anion – cation ratio of PM2.5) indicated that PM2.5 particles were alkaline in nature in both seasons. The presence of SO42- , NH4+, NO3- , Cl- and K+ were mainly contributed by activities at the dumpsite mainly organic decomposition, burning of garbage and plastic, movement of heavy duty vehicles at the dumpsite. In addition, Cl- and SO42- also contributed from the marine sources. The crustal sources also contribute Ca2and Mg2+ ions. The analysis of elemental composition indicated the presence of mineral particles (Si, Al, Ca, Fe, Na, and Mg) in both the seasons. However, sulfur- rich particles (Sulfur with minor amount of K and Ca) were dominant in the winter season.
Further, the increasing PM2.5 concentration at dump site cause visibility impairment at local and regional scales (The Hindu, 2014). The visibility measured at the study area was found to be in winter (5.41±0.5 Km) and in Summer (7.8± 2.15 Km) indicated the influence of PM concentration in deterioration of visibility at the local scale during the winter season

Control Number 19

Personal exposure measurements of PM concentrations at a Central Business District in Chennai city

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Abstract

Within the urban area, the variations in land uses combined with the micro-meteorological conditions can result in local space-time variation of air pollutant concentrations which leads to air pollution hotspots. At these hotspots the individuals may experience highest level of air pollutants exposure in a short period of time. The elevated pollutant concentrations particularly, the fine PM concentrations in urban hotspots can cause serious health implications and visibility impairment.
In the present study, personal exposure measurements were carried out at a major central business district of an urban area. The PM monitoring campaign was carried out by carrying an environmental dust monitor (Grimm 1.109) in a backpack and walking through the major roads of the study area. About 40 minutes monitoring was carried out at the study area during three different time periods i.e., morning (8AM –9AM), afternoon (12.30PM-1.30PM) and evening (4PM-5PM), covering both the peak and lean hour traffic. In order to understand the spatial variation of PM concentration, a GPS system was also carried along with the instrument. The PM concentrations were found to vary both spatially and temporally. The mean PM2.5 concentrations were found to be 47.36±35.64, 57.55±88.21 and 54.03±46.82 μg/m3 during morning, afternoon and evening on the weekends. In the weekend, commercial area become more active towards the afternoon resulting in higher concentrations. During weekdays, the mean PM2.5 concentrations were found to be 77.38±247.6, 51.92±50.16 and 54.09±26.92 μg/m3 in morning, afternoon and evening, respectively.

The higher PM2.5 concentrations was correlated with the morning peak hour traffic during weekdays. The contribution of vehicular exhaust to the ambient PM2.5 is indicated by the higher PM2.5/PM10 ratio during the weekdays (0.51) as compared to the weekends (0.4).
Further, the size segregated analysis of the PM collected using an eight stage Andersen Cascade impactor was also carried out at this site. The 24-hour average PM10 and PM2.5 concentration was found to be 188 µg/m3 and 37.6 µg/m3, respectively. In addition, the visibility at the study area was estimated using the empirical relationship developed by considering the meteorological parameters and ambient PM2.5 concentration.

Control Number 27

Preserving Treasured Views – The National Park Service Visual Resource Inventory

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The U.S. Department of the Interior (USDI) National Park Service (NPS) was created 100 years ago through the Organic Act of 1916. The new agency's mission as managers of national parks and monuments was clearly stated. "… to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations." To protect clean, clear air and spectacular scenery now and for future generations, the NPS focuses on clearing haze that impairs scenic views and addressing physical intrusions that detract from important views. NPS views range from iconic vistas to historic places where the agency preserves cultural and historic settings.

In response to concerns arising from potential scenic impacts from the development of physical infrastructure from renewable energy, electric transmission, and other types of development on lands and waters near its units, the NPS, has developed a new visual resource inventory (VRI) system to facilitate the understanding and management of scenic resources.

The inventory system uses formal design qualities such as form, line, color, and texture to describe and assess *scenic quality*, and incorporates viewer sensitivity in what is ultimately a judgement-based quantitative ranking of relative scenic value. In these respects, the NPS VRI system is similar to other U.S. federal agency VRI systems, such as the USDI Bureau of Land Management VRI, and the U.S. Department of Agriculture Forest Service Scenery Management System. However, the NPS VRI differs from other federal agency approaches in order to address the NPS mission of preserving scenic resources for the enjoyment of current and future generations while other federal agencies are charged with multiple-use mandates for the lands under their management. One primary difference is that the NPS inventory unit of analysis is a predetermined view from a specified viewpoint, rather than a polygon based on physiographic properties, e.g. a valley floor or a mountain range. The view-based inventory unit was chosen because NPS is concerned with specific landscape areas as they would be seen from the visitor’s perspective. Also, because historic and cultural resources are essential to the scenic experience of NPS visitors, the NPS VRI scenic inventory includes an assessment of *view importance* which is a measure of the non-scenic values of the view. View importance incorporates historic and cultural elements and values, as well as the value of both the viewpoint and viewed landscape to NPS interpretive goals and visitor experience. Scenic quality and view importance combine to create a scenic inventory value that identifies the overall visual value of the view to NPS and its visitors.

The NPS VRI system includes an online database for storing inventory data for NPS units, and an associated geographic information system, for semi-automated production of inventory maps. The database generates a variety of reports and spatial products for inventory data. The VRI allows the NPS to apply a systematic

approach to understanding and communicating the value of scenic views so that they can be actively managed and planned for alongside other important resources.

Session Associated Poster Presentations

Control Number 76

US EPA applications of the Monitor for AeRosols and GAses in ambient air (MARGA) to measure ambient gaseous and particulate pollutants and dry deposition fluxes

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The US EPA has been deploying Monitor for AeRosols and GAses in ambient air (MARGA) analyzers as part of numerous research-orientated intensive sampling campaigns since 2012 which have included cooperation with universities and other government agencies. The MARGA is a semi-continuous, multipollutant analyzer that samples soluble gases (HNO_3, HONO, SO_2, and NH_3) and particles (NO_3^-, SO_4^{-2}, NH_4^+, Ca^{+2}, Mg^{+2}, K^+, Na^+) via an absorption medium and quantifies their concentrations via on-line ion chromatography on an hourly basis.

The analyzer can be deployed in a conventional setup with a single sampling 'box' (containing a wet, rotating, denuder for gases and a steam jet aerosol collection device for particles) or in a 'gradient mode' setup in which two sampling boxes are installed at different heights allowing for measurement of an hourly averaged concentration gradient.

EPA research efforts using the conventional MARGA setup have focused on the assessment of integrated measurement techniques such as the CASTNET filter pack for effects due to shorter time-scale phenomena (i.e. meteorology, diurnal variation) to provide more information on pollutant transport, potential reservoirs, and source apportionment. MARGA measurements are also compared with co-located measurements of other pollutants (e.g. O_3, NO_y).

The gradient mode setup allows the measurement of hourly concentration gradients to be coupled with micro-meteorological measurements to provide direct measurements of deposition fluxes and velocities. The system performance was characterized in terms of analytical accuracy and chemical gradient detection limits to estimate the uncertainties of the flux measurement and these were found to be sufficiently precise for flux gradient applications (Rumsey and Walker, 2016). Results from this study were taken over a short grass surface, the MARGA systems are currently being deployed on a tall tower over a forest canopy at the Coweeta Hydrologic Laboratory in western NC and over a coastal marshland site in Charleston, SC to expand the research to different types of ecosystems.

This improved information on pollutant speciation and deposition will help to develop more complete N and S deposition budgets and will help to develop algorithms in regulatory models such as the Community Multiscale Air Quality (CMAQ) model for use in assessing ecosystem exposure and vulnerability to excess deposition.

Control Number 59

Source apportionment studies of particulate matter in China

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Many source identification models are used in the world, such as, diffusion model, receptor model and satellite method. Because of limited database in China and Hong Kong area, the statistics calculation theory model was popular used in the areas. Seven Chinese cities were selected for the source apportionment studies review and the cities are located in northern, eastern, southern, western and central China. Based on simulated PMF model, there are 6 sources of $PM_{2.5}$ are commonly observed, which including soil/fugitive dust, coal combustion, industrial emission, vehicle emission, biomass burning and secondary aerosol. The contribution of each source is varied in different cities, because of varied anthropogenic activities, but in general, the secondary formation aerosol the fraction is over 30% on average to $PM_{2.5}$ mass. But in many major cities, which surrounded many industries, the contribution on industrial emission has relative high contribution, such as Beijing and Nanjing cities. The amount of coal consumption in Xi'an and Wuhan cities are relatively high, increased contribution on coal combustion emission. In Hong Kong, traffic emission and secondary aerosol has comparative contribution to fine particulate matters, which due to the high traffic loading. While, in recent stage, many issues related with $PM_{2.5}$ is still unclear. The characteristics of fine particulate matters need to have further discussion. In addition, the uncertainty on single model simulation remains high, and multi-model combination model can reduce its uncertainty and more accurate source profiles can be identified in China. The accurate source profiles are provide useful information for Chinese government build effective and efficient air pollution control program in China.

Keywords: PMF, source identification, secondary aerosol

Control Number 89

Behavior Of Atmospheric Pollutants In Closed Valleys.

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Abstract

Valle de Aburrá (Colombia) is a valley located in the Andes Mountain range, characterized by being a geographically narrow valley, besides, for having thermal inversion problems. The environmental authority has established an air quality monitoring network with 22 permanent stations, distributed along 9 of the 10 municipalities conforming the valley. There is also a mobile station whose location depends on the interest of the environmental authority.

The concentrations of total particulate matter (TPM), particulate matter less than 10 μm, PM10, particulate matter less than 2.5 μm, PM2.5, particulate matter less than 1 μm, PM1, Sulphur dioxide, SO2, nitrogen dioxide, NO2, carbon monoxide, CO, and ozone, O3 in the air are monitored.
Thus, in this research they will be approached in detail the atmospheric pollution problems present in closed valleys due to physicochemical and meteorological phenomena, taking as out case study the Valle de Aburrá (Colombia) and the contingency plans that have been taken in this respect.
The Air Quality Network has mainly focused on the atmospheric pollution associated to particulate matter and the gases which were previously described, but it has not been sufficiently analyzed the pollution attributed to microorganisms associated to the particulate matter itself, such particles with biological origin that are suspended in the atmosphere are called bioaerosols, which are considered to be allergens and are ubiquitous in the environment; for this reason people are daily exposed to a wide variety of microorganisms which can produce adverse effects on human health.

That is how the Air Quality Network highlights the need of carrying out studies in the Valley concerning bioaerosols, which can contribute to the epidemiological monitoring, by assessment and quantification, of the allergen type microorganisms present in the air that can affect health.

Control Number 29

Characteristics of absorbing aerosols during winter foggy period over the National Capital Region of Delhi: Impact of planetary boundary layer dynamics and solar radiation flux

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Abstract

Severe air pollution in northern India coupled with the formation of secondary pollutants results in severe fog conditions during the winter. Black carbon (BC) and particulate matter ($PM_{2.5}$) play a vital role within the planetary boundary layer (PBL) to degrade atmospheric visibility. These species were continuously monitored during the winter of 2014 in the National Capital Region (NCR) of Delhi. The average BC concentration was 8.0 ± 3.1 μg/ m^3 with the January mean (11.1 ± 5.4 μg/ m^3) approximately two times higher than February (5.9 ± 2.1 μg/ m^3). The average $PM_{2.5}$ concentrations was 137 ± 67 μg/ m^3 with monthly area-average maximum and minima in December and February, respectively. Higher concentrations of BC at 1000 (8.5 μg/m^3) and 2200 local standard time (9.7 μg/m^3) were consistently observed and assigned to morning and evening rush-hour traffic across Delhi. Daily average solar fluxes, varied between 17.9 and 220.7 W/m^2 and had a negative correlation (r = -0.5) with BC during fog episodes. Ventilation coefficient (VC) reduced from 'no fog' to fog phase over Palam Airport (PLM) (0.49) times and Hindon Air Force Base (HND) (0.28) times and from fog to prolonged fog (> 14 hr) phase over PLM (0.35) times and HND (0.41) times, respectively, indicating high pollution over the Delhi NCR. Ground measurements showed that daily mean AOD_{500} nm varied between 0.32 and 1.18 with mean AOD_{500} nm being highest during the prolonged fog (> 14 hr) episodes (0.98 ± 0.08) consistent with variations in $PM_{2.5}$ and BC. Angstrom exponent (α) and Angstrom turbidity coefficient (β) were found to be greater than 1 and 0.2, respectively, during fog showing the dominance of fine mode particles in the atmosphere.

Control Number 121

The Southeastern Aerosol Research and Characterization Network 1992-2016

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Abstract

The Southeastern Aerosol Research and Characterization (SEARCH) air quality monitoring

network is a long-term, comprehensive, multi-pollutant effort addressing scientific and regulatory questions on ozone and its precursors, particulate matter (PM) mass and composition, mercury speciation and deposition, wet deposition of acidity and nutrients and atmospheric visibility. SEARCH was conceived in the early 1990s as part of the Southern Oxidants Study SCION network, and was expanded significantly in the late 1990s and early 2000s. The eight-site network of urban-rural pairs evolved to provide a comprehensive suite of measured meteorological, gaseous, and particulate phase chemicals. The data and sites have been used to create and test novel and improved measurement techniques; and individual sites have served as platforms for long-term investigations of health effects as well as short-term research campaigns to address key science questions through a number of monitoring intensives.

SEARCH network monitoring activities at the 5 current sites will cease by the end of 2016, with closure dates at various times. The Birmingham, AL, site was shut July 1, 2016, with Yorkville, AL, and Pensacola (Outlying Field), FL, shutting October 1, 2016. Jefferson Street (Atlanta), GA, and Centreville, AL, will be shutting January 1, 2017. Although plans have been made for much of the monitoring equipment, anyone with an interest in obtaining any devices should contact John Jansen at jjjansen@southernco.com. This poster will describe the remaining monitoring plans, plan for site closures, and upcoming activities. The physical filter archives created over the course of the network from mid-1998 to present will continue to be maintained for some time, and selected studies will be performed with them. Collaborations with external researchers on the use of the archive are encouraged.

Additionally, the full database of SEARCH results though the end of operations will continue to be made publically available once complete at http://www.atmospheric-research.com/public/index.html, and we encourage its continued use by the research community. To date, SEARCH data have been the basis of approximately 270 peer-reviewed scientific publications and have been used to constrain and evaluate local, regional, continental and global-scale atmospheric models, assess atmospheric chemical and physical processes at resolution from hourly to decadal time scales, perform source attribution, evaluate new instrumentation, assess the impact of upcoming regulations, and support investigations of human health impacts of air quality.
The authors are grateful for the long-standing support from Southern Company and EPRI as well as the many collaborators that have made the SEARCH network a unique experience. We look forward to continued collaborations in the future

Control Number 122

Spatial Variability and Speciation of PM2.5 in New Delhi, India

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Delhi is among the most polluted cities in the world and in recent years, both the government and judicial efforts have aimed to reduce air pollution in the city despite a lack of consensus in source contribution understanding. A number of PM source apportionment studies, as well as emission inventory analyses, have been conducted in the city, but there are significant discrepancies in estimation of several sources (e.g. dust). The aim of this study was to assess spatial variability of PM2.5 and its components in the National Capital Territory (NCT) region.

PM2.5 monitoring was conducted across 16 sites in the Delhi NCT region in September 2015. Twenty-four hour samples were collected each day at a central site (IIT Delhi) for the entire period, while at 15 other locations, samples were collected for one or two days. Co-located low-volume samplers (AirMetrics, Springfield, OR) were used for PM2.5 collection on pre-baked 47 mm quartz and PFTE filters at a flow rate of 5 liters per minute. Teflon filters were weighed using a microbalance and analyzed for elements (Na-U) using energy dispersive X-ray fluorescence (ED-XRF) and calibrations were performed using thin film standards. A punch from each quartz fiber filter was analyzed using thermography for measurements of organic and elemental carbon (OC and EC) fractions using a Sunset OC/EC Analyzer in offline mode using the NIOSH 5040 protocol.

There was significant spatial variability observed in PM2.5 concentrations and chemical components of PM across Delhi, and unsurprisingly, concentrations tend to be higher closer to pollution hotspots, and areas near specific sources. This is particularly relevant in Delhi, since population density is very high, and people often live in close proximity of pollution sources, especially roads and industrial units. Average 24h PM2.5 concentration was observed to be 58.5 ± 23.8 μg/m3. Moderate correlation between BC and PM2.5 at the central site indicates some variability in the sources for the pollutants. Two sets of elements were found to be strongly correlated; those typically associated with soil/mineral dust including Si, Al, Fe and Ca, as well as a distinct group of elements comprised of Cu, Ni, Zn and Pb. Several elements were also enriched across a majority of the sites. In terms of carbon, average OC/EC ratio was observed to be 3.06 ± 2.97 at the central site while across the sites, the average ratio value was 3.49 ± 3.38, broadly corresponding to previous studies from India.

Coefficient of divergence (CoD) was calculated for PM2.5 as well as individual chemical components to estimate the spatial variability of various pollutants. Values ranged between 0.15 and 0.51 for PM2.5, while for other pollutants, all CoD values were greater than 0.2, indicating spatial heterogeneity.

Session 17. Trends in Visibility

Control Number 91

Long-Term Visibility Trends in Megacities in China, India and the U.S. during 1944-2016

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Abstract

The fine particulate matter ($PM_{2.5}$) pollution has been serious in megacities in both China and India due to the rapidly expanding economic and industrial developments. Atmospheric visibility is a highly relevant factor indicating the level of ambient air quality because it reflects the combined influences of atmospheric pollutants and synoptic processes. It is inversely related to the optical extinction coefficient caused by gas and particle phased. A number of studies have reported that the visibility reduction in Chinese and Indian megacities resulted largely from the high concentration of aerosol particles, especially $PM_{2.5}$. Coal combustion, automobile exhaust, industry, and certain natural factors (e.g. sand and dust storms, fog, and sea salt aerosols) were the major particle emission sources. In this study, visibility trends for several representative megacities (five from each country with population > 5 million) in China, India and the U.S. will be evaluated during 1944-2016 on the basis of the U.S. National Climatic Data Center (NCDC) database using four measurement approached: (1) the days per year of daily visibility < 10 km (bad visibility days), (2) the days per year of daily visibility ≥ 20 km (very good visibility days), (3) the annual average visibility, and (4) the dry extinction coefficient. The annual and seasonal change trends of visibility for each city will be analyzed using a linear regression model. In addition, the effects of various environment policies on atmospheric visibility will be highlighted using the environment control and treatment variables. The results show that decreasing visibility corresponds to greater industrialization and particulate concentrations.

Moving pollution sources from the coastal to inland locations only moves the decreasing visibility elsewhere. This work offers a great opportunity to comprehend the visibility variation in the two largest developing countries and the most developed country worldwide over the last seven decades.

Control Number 16

Observed Historical Trends in Atmospheric Haze Interpreted with a Global Chemical Transport Model

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Abstract

Atmospheric aerosols are associated with various acute effects on air quality, climate change and human health. Information on long-term aerosol trends is needed to evaluate historical emission inventories, to guide mitigation actions, and to project future changes. Horizontal visibility (Vis) from worldwide meteorological stations and airports is mainly determined by the optical extinction (bext) of the atmospheric boundary layer and has been recognized as a proxy of aerosol burden. Decadal Vis data from thousands of global stations provide a valuable source to study trends in atmospheric haze. However, the interpretation of Vis data and their trends might be limited by insufficient data processing or poor data quality.

To improve the quality of historical Vis observations worldwide, we filter global Vis data and construct a monthly inverse visibility (1/Vis) dataset for trend analysis. The data screening includes removal of relatively clean cases with high uncertainty, and change point detection to identify and separate methodological discontinuities such as the introduction of instrumentation. Spatially coherent trends of the screened 1/Vis data exhibit consistency with the trends of collocated atmospheric extinction (bext) over the US for 1989-1996 (-1.6% yr-1, 95% confidence.

Control Number 98

Recent Developments in Improved Understanding of San Joaquin Valley's Impact on Grand Canyon Visibility Since 1980

Rob Farber

At the 2012 Whitefish Visibility Specialty Conference we presented a paper on "California's Urban Impact on Grand Canyon Since 1980." We examine the urban impacts from both the Los Angeles area and the San Joaquin Valley (SJV). It appeared that the SJV's Grand Canyon impact was under represented based on the strength of its emission source. With recently required research data, this paper explains why the SJV has a smaller aerosol signal at the Grand Canyon than one might expect. As our tracer we used measured ambient sulfate concentrations in the Grand Canyon. We performed extensive ATAD back trajectories end point analyses for several areas including the SJV. During the spring SJV impacts the Grand Canyon 15 days/month, during the summer, 10 days/ month. The SJV is geographically large and landlocked. However, marine air does enter from the coastal passes into the SJV creating a summer stably stratified atmosphere with a mixing height about 800 m. The High Sierra forms a nearly 4000 m formidable barrier to pollutant transport. Winds in the boundary layer in the SJV are light northerly flow of 8-15 km/hour. The flow over and out of this exit Tehachapi pass is complex. During the past year, in a CEC and EPRI sponsor research program, transport winds have been modeled daily. We've been exercising a state of the art high resolution WRF model with added vertical data to more accurately monitor the wind flow through

this region. This paper will explain this l complex diurnal flow pattern through this pass and its implications for long range pollutant transport. The knowledge gained in this ongoing field program has important information addressing long range pollutant transport for the many other land locked valleys in the western US

Control Number 82

. **The Effect of Atmospheric Sulfate Reductions on Diffuse Radiation and Photosynthesis**

Rebecca A. Washenfelder, University of Colorado and NOAA, Boulder, CO
Gretchen Keppel-Aleks, University of Michigan, Ann Arbon, MI

Abstract

Between 1995 and 2013, SO_2 emissions in the United States declined by over 70%, leading to reduced sulfate aerosol mass loading. Over the eastern U.S., the MISR satellite measured AOD reductions of -3.0 ± 0.6% yr^{-1} during 2001-2013. Experimental observations have shown that plant photosynthesis is more efficient using scattered light than direct light, because more leaf surfaces are illuminated. We use two methods to examine the impact of decreased SO_2 emissions on photosynthesis. First, we use a historically accurate SO_2 emissions inventory in the Community Earth System Model (CESM), and determine that diffuse light decreased by almost 0.6% per year during 1995-2013, leading to small declines in gross primary production. Second, we use published relationships between diffuse light and gross primary production, together with satellite land cover maps, to calculate the expected change in gross primary production over the same period. Our results suggest that anthropogenic aerosol trends have a small impact on carbon uptake in temperate forests due to scattered light, and should be fully considered along with other impacts of changing SO_2 emissions.

Control Number 102

Aerosol concentration, composition, and optical effects during valley cold pool occurrences

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Abstract

Wintertime $PM_{2.5}$ (suspended particulate matter with aerodynamic diameters <2.5 μm) levels are frequently elevated in many western U.S. valleys. These valleys experience strong temperature inversions, frequently enhanced by the presence of snow cover, and are described as “valley cold pools”. Cold pool stagnation allows a gradual buildup of pollutants over a period of several days. Green, et al. (2015) studied the relationship between wintertime $PM_{2.5}$ concentration and atmospheric stability (defined by heat deficit) for five western US cities (Salt Lake City, Reno, Missoula, Spokane and Boise) located in valleys with periods of snow cover. They found that during snow cover conditions, stability increased and $PM_{2.5}$ values increased over non-snow cover conditions. Only a portion of the $PM_{2.5}$ increase could be attributed to increased stability. $PM_{2.5}$ was increased additionally due to enhanced formation and retention of particulate phase ammonium nitrate during snow cover conditions. Green et al. also found that without controlling for year-to-year variations in atmospheric stability (heat deficit), no long-term trends in wintertime $PM_{2.5}$ levels were statistically significant. After controlling for yearly average wintertime heat deficit, highly statistically significant, strongly decreasing trends in winter average $PM_{2.5}$ were found for the study period of January 2000- December 2013. The analysis presented here describes the optical effects (measured and reconstructed light extinction, as available) for these cities during winter conditions stratified by snow cover and snow free conditions. Two more years were added to the data set and long-term trends in $PM_{2.5}$ and reconstructed light extinction are also evaluated.

Reference: Green, M.C., Chow, J.C., Watson, J.G., Dick, K., Inouye, D., 2015: Effects of snow cover and atmospheric stability on winter $PM_{2.5}$ concentrations in western US valleys. *J. Appl. Meteor. Climatol*., **54,** 6, 1191-1201.

Session Associated Poster Presentation

Control Number 128

Innovative Approach to Selectively Measure Nitrogen Dioxide from Industrial Processes Over a Wide Linear Dynamic Range:

Dr. Charles A. Odame-Ankrah, Carlyn, L.F. McGeean, Charles, E. Grimm, Brian, W. Rosentreter, Shaun, W. Hayward; Brodie, D. Bigger Global Analyzer Systems Ltd, Calgary.

Abstract

Heavy pollution immediately and adversely impacts human health, visibility, plants, animals, etc. As the world moves towards accurate measurements of criteria pollutants such as nitrogen dioxide (NO2), simpler, cost effective and robust approaches are needed. An example of such an approach is to make existing heated molybdenum chemiluminescence NOx analyzers selective and specific in the indirect measurement of NO2 especially emissions from industrial processes. Industrial processes may contribute a significant level of NOx every day to the global nitrogen oxides burden and hence, there are regulatory frameworks in place to ensure compliance due to their known health effects. To ensure better regulatory compliance, overestimation or underestimation of any the regulated species, such as NO2 may have legal and health consequences. For the past few decades, most existing NOx analyzers use a heated molybdenum catalyst to convert NO2 to nitric oxide (NO). The NO is titrated with excess ozone to produce an equivalent amount of excited state NO2. The excited NO2 gives off photons in a process called chemiluminescence and it is detected and quantified. Although the molybdenum converters are robust, they are non-selective and are known to have reduced efficiency under certain process conditions i.e., ammonia interference. Alternatively, photolytic NO2 converters have been demonstrated to be selective for NO2 conversion to NO and detected using the same chemiluminescence technique. One major drawback to currently known photolytic NO2 converters is their limited linear dynamic range. This drawback may impact the application of photolytic converters in such analyzers for high source measurements such process stacks and especially to accurately account for NO2 during plant upset conditions. A novel approach for the conversion of NO2 to NO using ultraviolet light has been developed and proven through laboratory and field testing. This technology has been specifically designed for application in chemiluminescent NOx analyzers that are typically used for ambient and Continuous Emissions Monitoring applications as a direct replacement for the commonly used heated Molybdenum converters. In this presentation, preliminary field results from a plant site deployment are presented. The results are compared to existing heated molybdenum systems. The photolysis device has been tested as a direct replacement of 'heated converters' at reduced pressure (200 mmHg) from 0.03 parts per million (ppm) up to 37.30 ppm at a linear conversion efficiency of 98%. This novel converter only slightly lost conversion efficiency at 37.30 ppm (~94% efficiency) surpassing the performance range of any known photolytic converters at this time. The converter can also be used as a standalone system without any significant decrease in conversion efficiency due to recombination reactions. The advantages, drawbacks, and future applications are discussed.

Track B

Session2 Satellite and Remote Sensing Applications to Haze/Aerosol Monitoring

Control Number 64

Assessing the limitations of surface-level aerosol mass calculations from aerosol optical depth and lidar observations during the SEAC^{4}RS campaign

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Abstract

There has been continued optimism in the scientific community that satellite systems can be used to enhance the monitoring of particulate matter (PM) for air quality applications. Scientists have tried to correlate retrieved aerosol optical thickness (AOT) from satellite sensors to surface particulate matter. However, such regressions have mixed results when systematically reviewed, with regression coefficients rarely above 0.5. Adding space-based lidar observations only marginally improves the aerosol predictive capabilities. The assimilation of satellite AOT data into global aerosol models at operational centers is now commonplace and while AOT assimilation clearly improves AOT model analyses and forecasts, preliminary assessments of the impact of AOT assimilation on $PM_{2.5}$ forecasting are quite mixed.

We will explore the limitations of using AOT measurements to predict ground-level $PM_{2.5}$ mass concentrations using data collected during the SEAC^{4}RS campaign in the southeast United States (SEUS) during the summer of 2013. First we will explore the correlation between AOT measurements and surface-based $PM_{2.5}$ mass concentration measurements at multiple sites in the SEUS and examine how adding local knowledge of the aerosol chemistry and size distribution improves the relationship. Moving on to the SEAC^{4}RS High Spectral Resolution Lidar (HSRL) ground site ground site at the University of Alabama in Huntsville, we will add knowledge of the vertical atmosphere, including mixed layer and entrainment layer heights, free troposphere AOT, and relative humidity to see how this can improve the correlation between AOT and $PM_{2.5}$.

Finally, we will evaluate the limits of the AOT-$PM_{2.5}$ relationship through exploration of the impacts of poorly defined aerosol physical and optical properties, as well as the uncertainties in the state of the atmosphere in the vertical. To achieve this we will present the result of error propagation through a two dimensional model of several case studies during the Huntsville HSRL deployment. The results will establish the limitations of utilizing AOT to estimate $PM_{2.5}$ aerosol concentrations without better knowledge of the aerosol properties and the state of the atmosphere in the vertical.

Control Number 84

A global time series of aerosol optical depth, derived from MODIS and VIIRS Observations

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Abstract

For more than a decade, NASA's Moderate resolution Imaging Spectroradiometer (MODIS) sensors, on NASA's Terra and Aqua satellites, have provided quantitative information about aerosol optical depth (AOD) over land and ocean. Although validated for both MODIS sensors, there remain some puzzling

differences. At the same time, this period is still too short to create an aerosol climate data record (CDR) and rigorously detect aerosol trends. The Visible Infrared Imaging Radiometer Suite (VIIRS) was launched on the Suomi-NPP (SNPP) satellite in late 2011, with additional copies planned for future satellites. Can we homogenize the Terra/Aqua MODIS aerosol data record, and then continue with VIIRS to create a consistent CDR across decades? By using consistent radiative transfer assumptions and applying consistent thresholds for cloud masking and other pixel filtering, we have ported the MODIS "dark-target" (DT) retrieval algorithm to VIIRS on SNPP. We have run this DT retrieval on global VIIRS data between March 2012 and Dec 2015 and have compared the results with the routine MODIS Collection 6 products, as well as NOAA's operational VIIRS Environmental Data Record. Over land, use of the DT algorithm clearly reduced the discrepancy between VIIRS and MODIS -derived AOD. However, although global offsets are near zero, some regional biases remain, especially in cloud fields and over brighter surface targets. As examples of obstacles for a joint MODISa-VIIRS aerosol CDR, we discuss issues of calibration, instrument spatial resolution, and cloud masking based on shifted wavelength bands. Finally, we discuss planned improvements to the aerosol retrieval algorithm, and show some examples of how the satellite aerosol products are being used for visibility and air quality studies

Control Number 66

A Laboratory Experiment for the Statistical Evaluation of Aerosol Retrieval (STEAR) Algorithms

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Richard H. Moore, NASA LaRC; Hampton, VA,

Abstract

We have developed a method for validating aerosol retrieval algorithms by mimicking atmospheric extinction and radiance measurements in a laboratory experiment with real aerosols. This enables radiometric retrievals that utilize the same sampling volumes, relative humidities, and particle size ranges as observed by other in situ instrumentation in the experiment. We utilize three Cavity Attenuated Phase Shift (CAPS) monitors for extinction and UMBC's three-wavelength Polarized Imaging Nephelometer (PI-Neph) for angular scattering measurements. We subsample the PI-Neph radiance measurements to angles that correspond to Aerosol Robotic Network (AERONET) almucantar scans with solar zenith angles ranging from 50^0 to 77^0. These measurements are then used as input to the Generalized Retrieval of Aerosol and Surface Properties (GRASP) algorithm, which retrieves size distributions, complex refractive indices, single-scatter albedos (SSA), and lidar ratios for the in-situ samples.

We tested 285 aerosol samples in our experiment; the PI-Neph provided quality radiances for 232 of those samples, and the GRASP retrieval code provided retrievals with residuals R < 10% for 93-100 of those samples, depending upon the simulated solar zenith angle. The samples that we tested include Arizona Test

Dust, Arginotec NX, Senagal clay, Israel clay, Montmorillonite, Hematite, Goethite, volcanic ash, ammonium nitrate, ammonium sulfate, and fullerene soot. Samples were alternately dried or humidified, and size distributions were limited to diameters of 1.0 or 2.5 _m by using a cyclone. The SSA at 532 nm for these samples ranged from 0.59 to 1.00 when computed with CAPS extinction and PSAP absorption measurements. The GRASP retrieval provided SSAs that are highly correlated with thein situ SSAs, and the correlation coefficients ranged from 0.955 to 0.976, depending upon the simulated solar zenith angle. The GRASP SSAs exhibited an average absolute bias of +0.023_0:01 with respect to extinction and absorption measurements for the entire dataset. Similarly, bistatic lidar ratios at 532 nm (_sca = 173_) computed from the extinction & PI-Neph scattering measurements ranged from 21 to 144 sr; the correlations of GRASP bistatic lidar ratios with these direct measurements ranged from 0.488 to 0.735, and monotonically increased with the simulated solar zenith angles. The GRASP bistatic lidar ratio retrievals exhibited average positive relative biases of 6-10% and average absolute biases of 4.0-6.6 sr with respect to the direct measurements (again, depending upon the simulated solar zenith angle).

Control Number 101

Study on Aerosol Optical properties and Radiative Effect in Cloudy Weather in the Guangzhou Region

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Abstract: Currently, Guangzhou region was facing the problem of severe air pollution. Large amount of aerosols in the polluted air dramatically attenuated solar radiation. This study investigated the vertical optical properties of aerosols and inverted the height of boundary layer in the Guangzhou region using the lidar. Simultaneously, evaluated the impact of different types of clouds on aerosol radiation effects using the SBDART. The results showed that the height of the boundary layer and the surface visibility changed consistently, the average height of the boundary layer on the hazy days was only 61% of that on clear days. At the height of 2km or lower, the aerosol extinction coefficient profile distribution decreased linearly along with height on clear days, but the haze days saw an exponential decrease. When there was haze, the changing of heating rate of atmosphere caused by the aerosol decreased from 3.72K/d to 0.9K/d below the height of 2km, and the attenuation of net radiation flux at the ground surface was 97.7 W/m^2, and the attenuation amplitude was 11.4%; when there were high clouds, the attenuation was 125.2 W/m^2 and the attenuation amplitude was 14.6%; where there were medium cloud, the attenuation was 286.4 W/m^2 and the attenuation amplitude was 33.4%. Aerosol affected mainly shortwave radiation and affected long wave radiation very slightly.

Control Number 106

Study on Aerosol Optical properties and Radiative Effect in Cloudy Weather in the Guangzhou Region

DENG Tao[a] , DENG XueJiao[a], TAN Haobo[a], LI Fei[a],

[a] Institute of Tropical and Marine Meteorology, Guangzhou, China Meteorological Administration, Guangzhou 510080, China

Abstract:

Currently, Guangzhou region was facing the problem of severe air pollution. Large amount of aerosols in the polluted air dramatically attenuated solar radiation. This study investigated the vertical optical properties of aerosols and inverted the height of boundary layer in the Guangzhou region using the lidar. Simultaneously, evaluated the impact of different types of clouds on aerosol radiation effects using the SBDART. The results showed that the height of the boundary layer and the surface visibility changed consistently, the average height of the boundary layer on the hazy days was only 61% of that on clear days. At the height of 2km or lower, the aerosol extinction coefficient profile distribution decreased linearly along with height on clear days, but the haze days saw an exponential decrease. When there was haze, the changing of heating rate of atmosphere caused by the aerosol decreased from 3.72K/d to 0.9K/d below the height of 2km, and the attenuation of net radiation flux at the ground surface was 97.7 W/m^2, and the attenuation amplitude was 11.4%; when there were high clouds, the attenuation was 125.2 W/m^2 and the attenuation amplitude was 14.6%; where there were medium cloud, the attenuation was 286.4 W/m^2 and the attenuation amplitude was 33.4%. Aerosol affected mainly shortwave radiation and affected long wave radiation very slightly.

Sessions Associated Poster Presentation

Control Number 123

Aerosol Optical Parameters Detection from LIDARS and Applications to an Ultraviolet and Visible Radiative Transfer Model

Abstract

In-situ measurements of aerosol composition as well as other atmospheric optical parameters provide valuable information for climate and atmospheric radiation processes. Remote sensing instrumentation plays a significant role in the detection of these parameters as well as atmospheric mathematical models to describe the change of properties of particulate in the atmosphere.

Nowadays the use of lasers for particle detection and ranging has become obligatory in almost all atmospheric research centers in the world. These systems in conjunction with mathematical models provide us with detailed information of aerosol properties like vertical profile distribution, polarization and size characterization. In this sense, LIDARs (Light Detection and Ranging), for example, are pulsed laser transmission and receiving systems that were created for long range detection and to show their products in both spatial and temporal dimensions.

The LIDARs operating in the NOAA Center for Atmospheric Sciences (NCAS) at Howard University, Beltsville Campus, Maryland are in-situ instruments that provide a variety of measurements, including, but not limited to aerosol backscattering coefficients, water vapor mixing ratios, nitrogen concentrations and cloud heights. These products are compared with Satellite information for specific days providing a full detail of the atmospheric composition of aerosols and water vapor for the region.

Additionally, the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) satellite - Level 2 Clouds and Aerosol Data Products v3.01 are obtained from the Atmospheric Science Data Center for specific days and compared with ground base measurements from the LIDARs at Howard University Beltsville Campus (HUBC) site. Data from CALIPSO are organized by latitude and longitude as well as vertical and temporal resolution.

On the other side, the Tropospheric Ultraviolet and Visible (TUV) radiative transfer model (Madronich, et al., 2002) calculates spectral irradiances, spectral actinic flux, photo-dissociation coefficients (J-values), and biologically effective irradiance (dose rates, doses). The model can be used for both free and cloudy specific days at specific time of the day and wavelengths. However, the outputs are at specific fixed altitude. In this work, the TUV model uses vertical profile data from the ground-based LIDARs in Beltsville and from satellite to calculate irradiances at different altitudes creating in this way vertical profiles of radiation.

In conclusion, the analysis of aerosol data and the relevance of using Light Detection and Ranging (LIDAR) in Atmospheric Sciences are described. Also, calculation of aerosol backscattering profiles from Raman LIDAR data and comparison with Ceilometers and the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) are also presented. Finally, these optical parameters are used as inputs in a radiative transfer model to calculate a profile of irradiances at Howard University, Beltsville Campus in Beltsville, Maryland**.**

Session 4. Aerosol and Visibility Modeling at Local, Regional and Global Scales

Control Number 58

Calculating Single Source Visibility Impacts Using a Reactive Puff Model

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Lynsey Parker, Ramboll Environ, Novato, CA,
Greg Yarwood, Ramboll Environ, Novato, CA,
Naresh Kumar, Electric Power Research Institute, Palo Alto, CA

This paper describes the use of a puff model with chemistry to conduct visibility impact analysis of power plant emissions on downwind Class I areas. The model, SCICHEM, is a state-of-the-science, non-steady-state Lagrangian puff model with complete chemistry treatment, including gas-phase chemistry, aerosol chemistry, and cloud chemistry modules that are based on those used in the U.S. EPA Community Multiscale Air Quality (CMAQ) model. The model represents a continuous plume by a series of Gaussian puffs governed by ordinary differential equations; puff transport is determined by atmospheric turbulence in addition to the mean winds and the terms representing puff interactions handle nonlinearities introduced by turbulent effects and concentration variations. SCICHEM can calculate the short-range and long-range impacts of individual sources and source complexes on downwind concentrations of primary and secondary pollutants, including ozone and fine particulate matter ($PM_{2.5}$). A post-processor provided with the model is used to perform Class I analyses for Prevention of Significant Deterioration (PSD) permit applications, and Class II analyses for PSD permits or Minor New Source Review, including changes in background visibility extinction due to the source. The model is publicly available and has been extensively tested with measurements from field studies of power plant plumes. The model is applied for hypothetical sources in 4 different regions in the U.S. with nearby Class I areas and the visibility impacts are calculated and compared with impacts calculated using regional photochemical grid models.

Control Number 115

Single Source Visibility Assessment using CAMx

Marco A. Rodriguez, Chao-Jung Chien, Caitlin Shaw, Courtney Taylor: AECOM

(No abstract in proceedings)

Control Number 30

$PM_{2.5}$ pollution in households involved with solid fuel burning practices: Application of receptor models for source apportionment

Shamsh Pervez, Jeevan Matawle, School of Studies in Chemistry, Pt. Ravishankar Shukla University, Raipur-492010, Chattisgarh,

Abstract

USEPA's UNMIX, positive matrix factorization (PMF) and Effective Variance- Chemical mass balance (EV-CMB) receptor models were applied to chemically speciated profiles of 125 indoor PM2.5 measurements, sampled longitudinally during 2012-2013 in low-income group households of central India which uses solid fuels for cooking practices. Three step source apportionment studies were carried out to generate more confident source characterization. Firstly, UNMIX6.0 extracted initial number of source-factors, which were used to execute PMF5.0 to extract source-factor profiles in second step. Finally factor analog locally derived source profiles were supplemented to EV-CMB8.2 with indoor receptor PM2.5 chemical profile to evaluate source contribution estimates (SCEs). The results of combined use of three receptor models clearly describe that UNMIX and PMF are useful tool to extract types of source categories within small receptor dataset and EV-CMB can pick those locally derived source profiles for source apportionment which are analog to PMF extracted source-categories. The source apportionment results have also shown three fold higher relative contribution of solid fuel burning emissions to indoor PM2.5 compared to those measurements reported for normal households with LPG stoves. The previous reported influential source marker species were found to be comparatively similar to those extracted from PMF fingerprint plots. The comparison between PMF and CMB SCEs results were also found qualitatively similar. The performance fit measures of all three receptor models were cross verified and validated and support each other to gain confidence in source apportionment results.

Practical Implications: Total nineteen locally derived source profiles (included different indoor as well as outdoor sources) which consists of thirty-two (elemental, ionic and thermally speciated carbon fractions) chemical species were applied to test their applicability in chemical mass balance (CMB) model execution for source apportionment. The UNMIX and PMF results were supplemented to CMB solution to obtain accuracy in SCEs. The latest model parameters (factor fingerprint plot for PMF and MPIN matrix of EV-CMB) were used to evaluate source markers, selection of measured source profiles on executing EV-CMB and validation of source apportionment results.

Control Number 2

Application of Global High-resolution Emission Inventories of Air Pollutants from Combustion Sources

Shu Tao, Huizhong Shen, Qirui Zhong, Peking University, Beijing, China

Abstract

Based on an newly compiled global energy consumption data product and a number of emission factor database, a series of global emission inventories were compiled for major air pollutants including primary particulate matter (TSP, PM_{10}, $PM_{2.5}$, BC, OC), secondary aerosol precursors (SO_2, NOx, and VOC, etc.), and toxic substances (polycyclic aromatic hydrocarbons, Hg, etc.) from all combustion sources, both anthropogenic and natural. Emissions from major non-combustion sources were included. The most important feature in the inventories is its high resolutions in terms of spatial (0.1 degree), temporal (monthly or daily for residential, wildfires, and open field burning for crop residues), and sectorial (81 activities). A spatial-for-time substitution method was developed for modeling the temporal variation of residential energy use. Sub-national data-based disaggregation was applied to reduce spatial bias in energy use within large countries. The detailed source (sector) resolution can provide valuable information for formulating appropriate abatement strategy. The emission factors were from both published references and field survey in rural China, and the latter were conducted to provide scarce first-hand data for developing countries.

The inventories were used to model atmospheric transport of various pollutants and formation of secondary aerosols. Several examples of the application are as follows. Based on the results of the transport modeling, inhalation exposure to benzo(a)pyrene and the exposure associated lung-cancer morbidity were evaluated. It was found that the risk are doubled due to variation in genetic susceptibility of the global population. It was found that solid fuel combustion in residential sector contribute more than half of the overall risk. Similarly, health risk of inhalation exposure to ambient $PM_{2.5}$ was assessed on global scale and millions of people are affected. It was also found that both emission density and meteorological parameters affect the air pollution

and the influence of emission are mainly long-term (annual) based, while meteorological conditions affect short-term (daily) variation of the exposure. This is particularly true for heavily polluted episodes. By using the emission inventories, influence of urbanization on air quality and human health in China was simulated. It was revealed that the energy mix of hundreds of millions of rural-to-urban migrants in China is different from those of permanent urban residents, causing significant impact emission of pollutants. Due to changes in both emissions and locations, there is significant implication of Chinese urbanization on emission, exposure, and health.

Control Number 45

Assessment of regional air quality resulting from emission control in the Pearl Delta River region in China

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Abstract: The Pearl River Delta (PRD) in China has been suffering from air quality issues and the government has implemented a series of strategies in controlling emissions. In an attempt to provide scientific support for improving air quality, the paper investigates the concerning past-to-present air quality data and assesses air quality resulting from emission control. Statistical data revealed that energy consumption doubled from 2004 to 20014 and vehicle usage increased significantly from 2006 to 2014. Due to the effect of control efforts, primary emission of SO_2, NO_x and $PM_{2.5}$ decreased resulting in ambient concentrations of SO_2, NO_2 and PM_{10} decreased by 66%, 20% and 24%, respectively. However, O_3 increased 19% because of the increase of VOC emission. A chemical transport model, the Community Multi-scale Air Quality, was employed to evaluate the responses of nitrate, ammonium, SOA, $PM_{2.5}$ and O_3 to changes in NO_x, VOC and NH_3 emissions. Three scenarios, a baseline scenario, a CAP scenario (control strength followed as past tendency), and a REF scenario (strict control referred to latest policy and plans), were conducted to investigate the responses and mechanisms. NO_x controlling scenarios showed that NO_x, nitrate and $PM_{2.5}$ reduced by 1.8%, 0.7% and 0.2% under CAP and reduced by 7.2%, 1.8% and 0.3% under REF, respectively. The results indicated that reducing NO_x emission caused the increase of atmospheric oxidizability, which might result in a compensation of $PM_{2.5}$ due to the increase of nitrate or sulfate. NH_3 controlling scenarios showed that nitrate was sensitive to NH_3 emission in PRD, with nitrate decreased by 0 - 10.6% and 0 - 48% under CAP and REF, respectively. Since controlling NH_3 emissions not only reduced ammonium but also significantly reduced nitrate, the implement of NH_3 controlling strategy was highly suggested. The VOC scenarios revealed that though SOA was not the major component of $PM_{2.5}$, controlling VOC emission might take effect in southwestern PRD where photochemical pollution usually occurred. Last but not least, the responses of O_3 indicated that the PRD was generally VOC-sensitive, while the regime turned to NO_x-sensitive in the afternoon, therefore controlling VOC emission could reduce the overall O_3 and controlling NO_x emission in the afternoon could reduce peak O_3.
Keyword: Emission control, Air quality in PRD, WRF/CMAQ, Scenario analysis

Control Number 116

Evaluation of Revised Uniform Rate of Progress (URP) procedures to Assess Reasonable Progress Goals (RPGs) for the Second Regional Haze Rule Implementation Period of 2018-2028

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Abstract

The goal of the Regional Haze Rule (RHR) is to achieve the national visibility goal from the Clean Air Act (defined in the RHR as natural visibility conditions) at Class I federal areas by a planning target year of 2064. The RHR requires states to demonstrate that they are making reasonable progress toward natural conditions over several implementation periods. The first implementation period was 2000-2018 and required states to submit State Implementation Plans to demonstrate how they would achieve their state-identified Reasonable Progress Goals (RPGs) toward natural conditions for the most and least impaired visibility days between the 2000-2004 baseline and the 2018 future year. EPA defined the most impaired days as the worst 20 percent average (W20%) visibility days at a Class I area using the IMPROVE measurements and visibility equation. A nominal Uniform Rate of Progress (URP) was constructed by EPA drawing a visibility line (in deciviews) between the 2000-2004 baseline and 2064 natural conditions estimates. The nominal target for the first RPG was the value of URP visibility line for the year 2018. Using EPA guidance, photochemical grid model (PGM) results were then used to project visibility at each Class I area from the 2000-2004 baseline to 2018 and if the projected 2018 visibility was on or below the 2018 value on the URP line then the RPG was achieved; if not the expected year to reach natural conditions was changed to a later year in the SIP.
In the western U.S., however, the W20% days at many Class I areas were frequently associated with emissions from international transport, and regional wildfires and dust storms. On July 8, 2016, EPA published new draft guidance that redefined the most impaired days metric to minimize the influence of wildfires and windblown dust events. This paper compares visibility projections at several Western U.S. Class I areas using recent PGM modeling results and the new EPA guidance for the most impaired days metric with those for the W20% days metric used in the previous implementation period. We assess whether the new guidance procedures really limit the influence of wildfires and windblown dust impacts in making RPG projections. We also present alternative approaches for calculating RPGs.

Session 6. Atmospheric Nitrogen – A Bridge Between Visibility, Ecological and Agricultural Issues

Control Number 33

Back Trajectory Insights on Sources of Nitrogen at Rocky Mountain National Park, CO

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Abstract

During April 2013, there were unusually high levels of Nitrogen wet deposition at two National Acid Deposition National Trends Network (NADP/NTN) sites in Rocky Mountain National Park, Colorado. Both sites, Beaver Meadows, and Loch Vale, have long records of observations dating to the 1980s, making it possible to examine annual and seasonal trends in concentrations, deposition, and meteorology to better understand the conditions that existed during various levels deposition. Hourly meteorological measurements from three sites in the area were also included in the analyses.

Hourly five-day long ensemble back trajectories were generated for Beaver Meadows and Loch Vale for 1980-2015 to examine the transport pathways under various sets of conditions including, all times, Aprils only, hours with and without precipitation, various levels of Nitrogen deposition and combinations of these.

In addition to the standard statistical and graphical analyses of back trajectories, a new technique was developed to better visualize differences in transport under different conditions. This is to generate a map of how unusual it was to receive air masses from upwind areas as compared to average conditions. This allows easy visualization of areas that contribute in both common and unusual ways during various conditions and uses an easy-to-understand metric, the Z score, for how unusual that transport was. The Z score is the number of standard deviations from the mean transport condition.

Results show that April and July have the greatest precipitation at these sites, with April more likely to have synoptic scale storms and July more likely to have convective storms. Only about 7% of hours at Beaver Meadows and 12% at the higher elevation, Loch Vale, have precipitation. Though the predominant wind direction at both sites is northwesterly, when precipitation occurs, there is more likely to be transport from the east than the west. This is evident from both the 10-m tower meteorological data at nearby Longs Peak and from the back trajectory analyses. April 2013 had unusually frequent transport from eastern Colorado, even compared to the April average. Other Aprils with higher-than-average Nitrogen deposition also tended to have higher than average transport from the east, while Aprils with lower average deposition had more transport from other areas, usually to the west and south. Some analyses were completed for both 2008-2015 when there are higher resolution meteorological data available and for 1980-2015 with lower resolution, but a longer time period. Results were consistent with both sets of trajectories.

Control Number 50

Sensitivity of Modeled Source Apportionment of Agricultural Ammonia to Bi-Directional Flux

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We use two Regional Photochemical Models with consistent input data in order to estimate the sensitivity of modeled source apportionment of ammonia emissions from agricultural activities in the US to the inclusion of the representation of the bi-directional flux of ammonia in the model. The Comprehensive Air quality Model with extensions (CAMx) is used with the Particle Source Apportionment Technology (PSAT) in order to estimate the individual contribution of ammonia from 27 agricultural regions in the U.S. to regional haze in National Parks in the Western U.S. Because CAMx does not currently include representation of the bi-directional flux of ammonia between air and surfaces, we also use the Community Model of Air Quality (CMAQ) with bi-directional flux parameterization for ammonia (NH3). Flux studies show that NH3 deposited on a surface can be re-emitted once a compensation point is reached, thus potentially changing the location of final impact. Only models with bi-directional flux would capture re-emission. We focus our evaluation on the Grand Teton National Park (GTNP), utilizing data from a major National Park Service measurement campaign that occurred during 2011 and included hourly measurements of ammonia at four sites in and around the park. We select two major agricultural regions in the U.S. (defined for the CAMx PSAT study), one adjacent to the GTNP (the Snake River Valley in southern Idaho) and one further away from GTNP (the Central Valley of California). By running the bi-directional flux CMAQ model without the emissions of agricultural NH3 from these two regions one-by-one and comparing the modeled representation of regional haze from each of these sensitivity runs to the model run with all emissions, we can estimate the CMAQ modeled source apportionment of Agricultural NH3, from these two regions, including bi-di. We compare the CMAQ results to the CAMx PSAT model estimated contribution from these two regions finding that the bi-directional flux model extends the influence of agricultural emissions.

Control Number 95

The Increasing Importance of Deposition of Reduced Nitrogen in the United States

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Abstract

Rapid development of agricultural activities and fossil fuel combustion in the United States led to a great increase of reactive nitrogen emissions in the second half of the twentieth century. These emissions have been linked to excess nitrogen deposition in natural ecosystems through dry and wet deposition pathways. U.S. efforts to reduce NO_x emissions since the 1970s have substantially reduced nitrate deposition, as evidenced by decreasing trends in long-term wet deposition data. These decreases in nitrate deposition, along with increases in deposition of wet ammonium deposition, have altered the balance between oxidized and reduced nitrogen deposition. Across most of the U.S., wet deposition has evolved from a nitrate dominated situation in the 1980s to an ammonium dominated situation in recent years. Because ammonia has not been a regulated air pollutant in the U.S., its historical measurement has not been common. Recent measurement efforts, however, provide a more comprehensive look at ammonia concentrations across several regions of the U.S. These data, along with more routine measurements of gas phase nitric acid and fine particle ammonium and nitrate, permit new insight into the balance of oxidized and reduced nitrogen in the total (wet + dry) U.S. inorganic reactive nitrogen deposition budget. Utilizing two years of N-containing gas and fine particle observations from 37 monitoring sites across the U.S. and scaling the ammonia dry deposition velocity to the modeled nitric acid deposition velocity, we estimate that reduced nitrogen contributes, on average, approximately 65 percent of the total inorganic N deposition budget. Dry ammonia deposition plays an especially key role in N deposition compared with other N deposition pathways, contributing from 19% to 65% in different regions. A bidirectional treatment of ammonia surface-atmosphere exchange decreases the estimated contributions of ammonia dry deposition, but the broad conclusion regarding the overall importance of reduced N remains unchanged. With reduced N species now dominating the wet and dry reactive N deposition budgets in much of the country, the U.S. will need to consider ways to reduce ammonia emissions if it is to continue progress toward reducing N deposition to sustainable levels defined by ecosystem critical loads. Reductions in ammonia emissions also can contribute to regional reductions in fine particle concentrations offering additional benefits for visibility and human health.

Control Number 77

NADP's Total Deposition Science Committee (TDEP): Advancing the use of measurement and modeling data for spatial interpolation of total atmospheric deposition.

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Abstract

The Total Deposition Science Committee (TDEP) was chartered by the National Atmospheric Deposition Program (NADP) in 2011 as a science advisory group with the mission of improving estimates of atmospheric deposition. The committee holds biannual meetings and acts as a forum for the exchange of information on current and emerging issues in the science of measuring and modeling wet and dry atmospheric deposition processes of nitrogen, sulfur, and mercury species.

The committee includes members from federal and state agencies, universities, industries, and research groups and encourages participation from a broad range of stakeholders all with a common interest in improving the understanding of atmospheric deposition.

Thus far, TDEP has worked to identify gaps in the field of deposition science and advocated for research to address those gaps. The committee was a direct contributor to the hybrid method for estimating total deposition (Schwede and Lear, 2014) utilizing monitoring and modeled data to produce annual gridded deposition maps for nitrogen and sulfur species (http://nadp.isws.illinois.edu/committees/tdep/tdepmaps/). Additionally, results from measuring dry deposition fluxes within a forest canopy, estimating the spatial variability of NH_3, and measuring wet, organic nitrogen will be used to make further improvements to the hybrid method.

To foster further collaboration, the group has identified and prioritized a list of key research areas for reducing uncertainties in total deposition. TDEP is enlisting volunteers from both within and outside of the committee to champion those fields, i.e., providing background research, staying abreast of emerging technologies, and consulting with experts to better disseminate knowledge and communication. Future plans include hosting periodic webinars and producing a white paper as an intermediate step toward a review article discussing the state of the science.

Control Number 117

The Cache Valley Ammonia Super Volcano

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Abstract

Ammonia (NH3) is the principal basic gas in the atmosphere. In abundance, its deposition can affect the nutrient and ionic balances of ecosystems and its presence in the atmosphere can photochemically contribute to the formation of secondary particulate matter (e.g. PM2.5). In the PM2.5 non-attainment areas along the Wasatch Front, essentially the Salt Lake City area, as well as the Cache Valley, which straddles the Utah-Idaho border, the largest mass fraction of the particulate matter is most often ammonium nitrate (NH4NO3). In December of 1983, the National Atmospheric Deposition Program (NADP) established a National Trends Network (NTN) monitoring location in the south-central area of the Cache Valley (UT01) and the data have consistently shown, on an annual basis, an isolated island in northern Utah of ammonium (NH4+) wet deposition which is among the highest in the nation.

Denuder measurements at the Logan, UT regulatory site in 2003-04 (Zhu, 2005), found winter and summer NH3 concentrations averaged 9.2 ± 2.3 and 3.7 ± 0.4 µg/m3, respectively. Additionally, modeling studies suggested local atmospheric NH3 was in excess by approximately a factor of two in regard to probable PM2.5 formation.

In the winter and summer of 2006 (Moore, 2007), an array of 25 Ogawa passive samplers was deployed throughout the Cache Valley for three different five-to-seven-day sample periods during each season. The winter and summer valley wide NH3 concentrations averaged 28.1±5.1 and 22.9±5.2 µg/m3, respectively.

Additionally, contour mapping of the spatial concentrations showed approximate correlation to the location and strength of known, primarily agricultural, sources.

The UT01 location was updated in 2011 to be a part of the NADP's Ammonia Monitoring Network (AMoN), wherein atmospheric NH3 is monitored via 2-week integrated, passive sampling. In support of the above measurements, the AMoN data has once again consistently indicated that the Cache Valley location had among the highest gas-phase NH3 measurements in the USA. UT01's annual average NH3 concentrations for 2012, 2013, and 2014 were 15.0 ± 1.7, 18.7 ± 1.9, and 15.8 ± 2.3 μg/m3, respectively.

More recently, during January and February of 2016, a slightly smaller version of the passive array study was repeated in the Cache Valley, parallel to a study along the Wasatch Front, wherein 10 samplers were deployed at many of the same locations as the 2006 study for

seven, weeklong periods. The spatial concentration contours from this study were found to be very similar to the previous study. However, the valley wide average NH3 concentrations were found to be significantly greater with an overall average of 106 ± 22.7 μg/m3, roughly four times larger than the earlier study. For comparison, the Wasatch Front NH3 concentrations averaged 14.2 ± 2.0 μg/m3.

Session Associated Poster Presentations

Control Number 21

Enhanced concentrations of reactive nitrogen species during the Hewlett Gulch and High Park Fires in Colorado

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Abstract

During the summer of 2012 the Hewlett Gulch and High Park fires burned nearly 400 km^2 northwest of Fort Collins, Colorado. These fires both came within 20 km of the Department of Atmospheric Science at Colorado State University, allowing for extensive measurements of smoke-impacted air masses over the course of several weeks. In total, smoke plumes were observed at the measurement site for approximately 125 hours. During this time, measurements were made of multiple reactive nitrogen compounds, including NH_3, NO_x, HNO_3, NO_3^-, NH_4^+, and an additional, unspeciated reactive nitrogen component. Concurrently, measurements of CO, levoglucosan and $PM_{2.5}$ served to indicate the presence of smoke at the monitoring site. Significant enhancements were observed for all of the reactive nitrogen species measured in the plumes, except for NH_4^+, which likely did not show enhancements due to the fresh nature of the plume. Excess mixing ratios for NH_3 and NO_x relative to excess mixing ratios of CO in the smoke plumes, $\Delta NH_3/\Delta CO$ and $\Delta NO_x/\Delta CO$, were determined to be 0.027 ppb ppb^{-1} and 0.006 ppb ppb^{-1}, respectively. These ratios suggest that smoldering combustion was the dominant source of smoke during our plume interceptions based on previous literature results. We will also briefly summarize observations from relevant laboratory and field measurements of reactive nitrogen species during previous studies by our research group.

Control Number 128

Innovative Approach to Selectively Measure Nitrogen Dioxide from Industrial Processes Over a Wide Linear Dynamic Range

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Abstract

Heavy pollution immediately and adversely impacts human health, visibility, plants, animals, etc. As the world moves towards accurate measurements of criteria pollutants such as nitrogen dioxide (NO2), simpler, cost effective and robust approaches are needed. An example of such an approach is to make existing heated molybdenum chemiluminescence NOx analyzers selective and specific in the indirect measurement of NO2 especially emissions from industrial processes. Industrial processes may contribute a significant level of NOx every day to the global nitrogen oxides burden and hence, there are regulatory frameworks in place to ensure compliance due to their known health effects. To ensure better regulatory compliance, overestimation or underestimation of any the regulated species, such as NO2 may have legal and health consequences. For the past few decades, most existing NOx analyzers use a heated molybdenum catalyst to convert NO2 to nitric oxide (NO). The NO is titrated with excess ozone to produce an equivalent amount of excited state NO2. The excited NO2 gives off photons in a process called chemiluminescence and it is detected and quantified. Although the molybdenum converters are robust, they are non-selective and are known to have reduced efficiency under certain process conditions i.e., ammonia interference. Alternatively, photolytic NO2 converters have been demonstrated to be selective for NO2 conversion to NO and detected using the same chemiluminescence technique. One major drawback to currently known photolytic NO2 converters is their limited linear dynamic range. This drawback may impact the application of photolytic converters in such analyzers for high source measurements such process stacks and especially to accurately account for NO2 during plant upset conditions. A novel approach for the conversion of NO2 to NO using ultraviolet light has been developed and proven through laboratory and field testing. This technology has been specifically designed for application in chemiluminescent NOx analyzers that are typically used for ambient and Continuous Emissions Monitoring applications as a direct replacement for the commonly used heated Molybdenum converters. In this presentation, preliminary field results from a plant site deployment are presented. The results are compared to existing heated molybdenum systems. The photolysis device has been tested as a direct replacement of 'heated converters' at reduced pressure (200 mmHg) from 0.03 parts per million (ppm) up to 37.30 ppm at a linear conversion efficiency of 98%. This novel converter only slightly lost conversion efficiency at 37.30 ppm (~94% efficiency) surpassing the performance range of any known photolytic converters at this time. The converter can also be used as a standalone system without any significant decrease in conversion efficiency due to recombination reactions. The advantages, drawbacks, and future applications are discussed.

Session 8A. Aerosol – Optical Relationships

Control Number 52

The application of a fast Fourier transform index to Webcam images for quantitative characterization of haze

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Webcam images typically are used to represent the visual appearance of some scene for purposes of communicating visibility and weather conditions or to just represent the visual appearance of a geographic region of a country. Images from several national parks are used in combination with a measurement of atmospheric scattering to represent the effects of haze on a scenic resource or to compare a current level of haze to what might be expected at other times. The extraction of a quantifiable index from webcam images that reflect the effects of haze on a scene allows these images to be used to quantify the distribution of

visibility conditions associated with a given scene and how fundamental atmospheric variables, such as the atmospheric extinction coefficient, change over time and space.

Equivalent (EQ) and average contrast (CR), Sobel (SOB), and fast Fourier transform (FFT) indexes computed from webcam images collected over a 10-year period at Great Smoky Mountains and Grand Canyon national parks are compared to concurrent measures of the atmospheric scattering coefficient. Contrast indexes are highly dependent on time of day, while the FFT and Sobel indexes are very dependent on image resolution. It is shown that when image resolution is held constant over time, the FFT index correlates with atmospheric extinction better than other indexes for all times of day and meteorological conditions. The analysis also suggests that webcam images can be used to quantify the effects of haze on a scenic resource as well as to track basic atmospheric optical variables.

Control Number 4

Effect of $PM_{2.5}$ Chemical Constituents on Atmospheric Visibility Impairment in Delhi City, India

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Abstract

Visibility impairment has become a highly prevalent phenomenon in developing countries including India due to exponential growth and development in all sectors. It has resulted into increase in atmospheric pollutant concentrations which frequently violates the National Ambient Air Quality Standards (NAAQS), particularly the ambient $PM_{2.5}$. Visibility impairment is primarily caused due to extinction of light by scattering and/or absorption by fine particles. Hence, it seems imperative to investigate causes of reduced visibility for effective implementation of emission reduction strategies. The objectives of this study are twofold, *one*, to assess the relationship between $PM_{2.5}$ and visibility; *two*, to assess the causes of visibility impairment by relating light extinction coefficients (b_{ext}) to $PM_{2.5}$ chemical composition. In the present study, the relationship between $PM_{2.5}$ and visibility has been analyzed at a sampling site located at a curbside along a National Highway in Delhi city, India. $PM_{2.5}$ has been sampled during summer (May 2014) and winter (January 2014) seasons in 12-hour cycles using standard $PM_{2.5}$ sampler. The mean $PM_{2.5}$ mass concentrations have been observed to be 293.1±36.7 $\mu g/m^3$ and 60.5±21.4 $\mu g/m^3$ during winter and summer seasons, respectively, exceeding the NAAQS of 60 $\mu g/m^3$. Further, the chemical constituents of $PM_{2.5}$ (water-soluble ionic species - SO_4^{2-}, NO_3^-, Cl^-, NH_4^+ and carbonaceous species – organic carbon, elemental carbon) have been analyzed to study their impact on visibility impairment by reconstructing b_{ext}. $PM_{2.5}$ and its chemical constituents (SO_4^{2-} and NO_3^-) show negative correlation with visibility during the summer and winter seasons. The exponential fits are obtained relating $PM_{2.5}$ and visibility in both seasons. However, correlation of visibility with SO_4^{2-} and NO_3^- has been observed to fit power profile. Further, b_{ext} has been reconstructed using the revised IMPROVE algorithm given by Pitchford et al. (2007). The results of apportionment of b_{ext} show that organic matter has been the largest contributor to b_{ext} in both the seasons (34% in summer, 32% in winter) which may be attributed to combustion sources. In summer season, it is followed by elemental carbon (~27%) and ammonium sulfate [$(NH_4)_2SO_4$] (~23%), with minor contributions from ammonium nitrate (NH_4NO_3) (~9%) and fine soil (~7%). However, in winter, major contributions are from ammonium nitrate (~24%), elemental carbon (~24%) and ammonium sulfate (~18%); and minor contributions are from fine soil (~2%). Higher elemental carbon in both seasons may be attributed to traffic sources; while lower concentrations of nitrate during summer, may be attributed to volatility because of higher atmospheric temperatures.

Control Number 57

Effects of local emissions on urban visibility measured with a mobile airship monitoring platform

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An unmanned aerial vehicle (UAV) was used to provide mobile monitoring of particle number concentrations in the Kladno District of Svermov, Czech Republic during the winter of 2015-16. This area has shown high concentrations of PM and PAHs coming from local building heating systems that burn coal. In winter, these emissions are not well dispersed leading to degraded local visibility. To further explore the plumes coming from these systems, a lighter-than-air airship was deployed to measure particle number concentrations (PNC) with a condensation particle counter (CPC; TSI Nanoscan 3910), and size distributions using an OPC (TSI OPS 3330). Videos collected during the flight permits the linking of the particle concentrations with the local visibility. In addition, measurements were made by pedestrians carrying a backpack system consisting of a DRX 8533 and a P-Trak 8525 to provide near ground concentrations. This study demonstrates the utility of such mobile monitoring systems to explore the substantial inhomogeneities in the local particle concentrations as the airship moves in and out of specific plumes as well as providing information on the average concentrations over this local region at ground level. Videos were obtained on a number of the flights so the observed visibility can be related to the measured PNCs.

Control Number 69

Dual wavelength integrating Nephelometer to determine source influences on particle concentration measurements.

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Integrating Nephelometers are well proven scientific tools in the measurement of aerosol optical properties. Together with absorption measurements they allow the determination of the single scattering albedo and help in determining global warming issues. Extensive studies have been performed to generate a mass closure for optical measurements, where the scattering coefficient will be corrected with the growth factor for different particle contributions. Measuring the dry scattering coefficient eliminates the need for growth factor corrections and allows to determine a scattering coefficient close to the particle mass.

Multi-wavelength nephelometry enables the determination of the scattering Ångström exponent. Since this factor is inversely related to particle size, it creates additional possibilities in utilizing nephelometer data. The time series of the scattering coefficient represents the measured particle concentration and the corresponding Ångström exponent shows basically the average (mode) diameter of the measured particle distribution. This information is delivered in real time and adds the ability of identifying different aerosol groups, or size fractions quickly, making it ideal for moving platforms like cars, trains, planes or unmanned aerial vehicles.

Using this method at a fixed measurement station allows e.g., to identify a ground level influence of a long-range transport of a special aerosol, not normally measured at that site, as example a “Sahara dust event” at a site in Atlanta will be shown.
Wildfires and prescribed burning can influence the total PM measurement and if the values exceed the daily limiting values, the additional information provided by the nephelometer could allow regulatory agencies to deduct that event from the regular measured daily PM values as possible “exceptional event” since the source could be outside the site’s jurisdiction. A burn event influence on PM measurement will be shown,

where close by short term Black Carbon data are being used to determine in addition the single scattering albedo of the smoke aerosol.

For routine monitoring applications, a changing Ångström exponent would indicate changes in the aerosol mix, site pattern could be generated by averaging the aerosol measurement over time and a significant deviation from that pattern could be used to automatically alert the user. With the stored measurement data, a detailed evaluation could subsequently be performed. With several stations utilizing this method, a geographical area could improve source apportionment studies as special aerosol characteristics of a given source could now be selectively targeted.

Control Number 6

Visibility in dusty environment: experiment and theory

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The performance of electro-optical sensor in conditions of low visibility dusty atmosphere is altered due to optical extinction and back scattering caused by the aerosol medium. As a result, false positive and negative alarms are caused. One way to avoid this difficulty is to test the electro-optical sensor performance under controlled dusty environment in aerosol chambers. The goal of the present study is to characterize the best practice of using aerosol chamber with varying dusty visibility conditions, followed by theoretical analysis. The presentation will provide a detailed description of the experimental setup and a comparison of experimental results and theory.

Measurements were carried on in an in-house designed 70 m^3 aerosol chamber discharged with various dust types, including "Arizona dust" and local desert dust. The medium was characterized with real-time measurements of visibility and particle size distribution. The low-visibility dusty atmosphere is presented using mass extinction coefficient, which is a measure of the interaction between the aerosol particles composing the environment and the radiation passing through it. This value can be obtained experimentally from the measured visibility inside the chamber (based on LED radiation extinction) and dust concentration, using Koschmieder equation. Theoretical mass extinction coefficients for the examined dusts were calculated using the measured size distribution and models for light scattering through aerosol medium. Assuming dust particles to be spherical, Mie theory was used to calculate mass extinction coefficient. Since dust particles have little to do with the geometric shape of any symmetry, Mie theory is not an exact solution. T- Matrix Computation allows computing light scattering for nonspherical particles, characterized by particles ellipsoidity.

It was found that mass extinction coefficient values are in reverse relation to particle size distribution; higher mass extinction coefficient values were obtained for dust batches with smaller particles and vice versa. The extent of inaccuracy assuming spherical particle (Mie model) was tested using T- Matrix method calculations of extinction cross section for ellipsoidic particles. A variation of ± 20% was found in the calculated values of extinction cross section for ellipsoidic particles relative to that of a spherical particle. A comparison of the calculated and measured mass extinction coefficients has shown a similarity in the general behavior and tendency of both measured and calculated mass extinction coefficients, although higher values were obtained for the measured coefficients. This can be explained mainly by the inherent difficulty of characterizing the dusty environment within the chamber. To improve the fit between measurements and calculations, one has to enable spatial measurement of real-time size particles distribution, concentration and visibility inside the chamber. In addition, exact calculation based on T-method model will improve the agreement of calculated and measured values.

Session Associated Poster Presentation

Control Number 39

Ambient Aerosol Extinction in Great Smoky Mountains National Park

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Abstract

Light scattering and extinction are fundamental properties of visibility. To quantify extinction the IMPROVE (Interagency Monitoring of Protected Visual Environments) program, which is tasked with monitoring visibility in U.S. National Parks and Wilderness Areas, relies primarily on reconstructions from speciated aerosol (filter) measurements and humidification growth factors (among other parameters). Under many atmospheric conditions reconstructed extinctions compare favorably with measurements; however, at high relative humidities (RH) aerosol-induced light extinction is very sensitive to RH perturbations, and technical challenges (e.g., inlet losses and truncation errors) have thwarted previous efforts to quantify it (extinction) with closed-path instruments. Thus under such conditions not only are the uncertainty bounds large for the humidification growth factors used to reconstruct extinction (and therefore visibility), but also it has not even been possible to provide robust in situ measurements for comparing these reconstructions against.

The Open-Path Cavity Ringdown Spectrometer (OPCRDS) was designed to overcome the RH limitations of previous extinction instruments. The OPCRDS was recently deployed in the Great Smoky Mountains National Park (GSM), where the high RH and high photochemical activity typical in summer provided an opportunity to explore the upper limits of the aerosol hygroscopicity (f(RH)) curve and the accuracy of the IMPROVE extinction reconstruction algorithm. True ambient extinction measured by the OPCRDS and dry extinction measured by a traditional closed-cell extinction monitor were used to investigate the hygroscopicity of aerosol at GSM and the importance of coarse-mode particles to light extinction. In addition, extinction obtained with the OPCRDS was used to validate the reconstructed extinction currently reported by IMPROVE. We also discuss the broader implications of these data for radiative transfer simulations in remote sensing and climate forcing research.

Session 8B. Aerosol – Optical Relationships

Control Number 63

On the implications of aerosol liquid water and phase separation for modeled organic aerosol mass

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Abstract

Current chemical transport models assume that organic aerosol (OA)-forming compounds partition mostly to a water-poor, organic-rich phase in accordance with their vapor pressures. However, in the southeast United States, a significant fraction of ambient organic compounds are water soluble. In this work, this

potential discrepancy is investigated by examining how separation between the organic and inorganic phases as well as water uptake to the organic phase affects a chemical transport model's estimation of the importance of water solubility for organic aerosol formation.

The CMAQ model reproduces SEARCH, IMPROVE, and CSN network observations of organic carbon (OC) within 20% in the eastern US. However, a factor of 1.7 overestimate in primary organic aerosol (POA) compensates for 40% underestimates in secondary organic aerosol. After updates, the Community Multiscale Air Quality (CMAQ) model adequately represents intensive organic aerosol properties such as OM/OC and □ during the 2013 Southern Oxidant and Aerosol Study (SOAS) at the Centreville (CTR), AL site. Despite indications that OM/OC may not be a good indicator of hygroscopicity, we find that parametrizing □$_{org}$ based on OM/OC can reproduce the observed □$_{org}$ of 0.15 at SOAS-CTR. Aerosol liquid water associated with organics peaks 1-2 hours earlier in the model than observations but reproduces the observed diurnal pattern with daytime concentrations being lower than nighttime concentrations.

Based on model-predicted OM/OC, the organic and inorganic phases are likely mixed throughout most of the Eastern US except in urban areas where POA concentrations are high, and OM/OC is low. This implies that aerosol liquid water should contribute to the partitioning medium for semi volatile organics. Including water (either associated with the inorganic ions or organic molecules) in the partitioning medium of OA leads to overestimates in OC at night and reasonable performance during the daytime at SOAS-CTR.

Control Number 53

Estimating Temporal Trends in Biogenically Formed Secondary Organic Aerosols Resulting From Reduction in Atmospheric Aerosol Water Content Across the Continental United States.

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Particulate organic carbon (POM) aerosols make between 30-40% of PM2.5 in the Eastern United States (U.S.) and more than 50% in parts of the Western U.S. Therefore, understanding the fate and origin of the PM2.5 POM aerosol is essential to mitigating its contribution to visibility, health, and climate forcing. To some degree apportionment of POM in the form of secondary organic aerosols (SOA) to an emission source is an ill-defined problem in that volatile organic carbon (VOC) gases may have their origin in biogenic emissions while the oxidation of that VOC and formation of SOA particles may be dependent of anthropogenic emissions from a variety of sources. A recent analysis has suggested that atmospheric aerosol water, in the form of water absorbed by hygroscopic aerosols, such as sulfates and nitrates, is the dominant pathway for the formation of SOA in parts of the Eastern United States. Therefore, as aerosols, such as sulfates, and associated aerosol water decrease over time it is expected that a concurrent decrease in SOA should occur.

In this analysis trends in POM over time, collected over a 16 year time period in the IMPROVE monitoring program, are explored. It is shown that particulate organic mass (POM) is decreasing in almost all parts the U.S. and in all seasons of the year. The decrease in POM over time has its origins in changing emissions from wild and prescribed fire and reductions in mobile and industrial sources and possible in reductions in atmospheric aerosol water. An approximation of temporal trends in biogenically derived SOA across the

U.S. is developed by accounting for the fraction of POM that is biogenic and addressing how anthropogenic POM has changed over time and across the U.S. The analysis suggests that in much of the Eastern U.S. a significant portion of the decrease in summer-time POM aerosol is associated with fire and vegetative emissions. A concurrent reduction in sulfate aerosol is consistent with the hypothesis that reducing aerosol water results in reductions in biogenically derived SOA/

Control Number 60

The Hygroscopicity of Organic Compounds as a Function of Carbon Chain Length, Carboxyl, Hydroperoxide, and Carbonyl Functional Groups

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Visibility and cloud albedo are influenced by aerosol hygroscopic water uptake and aerosol cloud condensation nuclei (CCN) activity, respectively. The hygroscopic properties of complex organic mixtures in the atmosphere vary widely and remain challenging to predict. Here we present a study of the hygroscopicity of organic compounds in which the molecular structure was systematically varied to establish relationships between structure and hygroscopicity. Organic molecules varying in carbon chain length, and the number of carboxyl, hydroperoxide, and carbonyl functional groups were synthesized and analyzed using High Performance Liquid Chromatography coupled with a Cloud Condensation Nuclei detector (HPLC-CCN). Results show that hygroscopicity tends to decrease with increasing carbon chain length and increase with the number of carboxyl groups, consistent with previous experimental results. The addition of carbonyl groups also increased hygroscopicity, consistent with heretofore unvalidated functional group model predictions. Measurements of the activation diameter at different supersaturations showed deviations from the -3/2 slope in log-log space predicted by Köhler theory, thus confirming the role of solubility in limiting CCN activation properties for weakly functionalized organic molecules. This work builds on the growing understanding of organic aerosol hygroscopicity as a function of molecular composition. We anticipate that results will constrain models that seek to predict the hygroscopicity of ambient organic aerosols from molecular structure.

Control Number 8

Role of RH, temperature, and $PM_{2.5}$ in the changes in ambient visibility, Busan, Korea

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Abstract

Visibility impairment in urban atmosphere is closely associated with concentrations of air pollutants, particularly fine particle such as $PM_{2.5}$, from anthropogenic and natural sources and meteorological factors such as temperature, relative humidity (RH), wind speed and precipitation. In this study, we investigated the role of RH, ambient temperature and $PM_{2.5}$ in the changes of ambient visibility from Busan, a metropolitan

city, in Korea. A long-term ambient visibility (6 years: 2010-2015) was measured from an urban area by a Visibility Sensor Model 6230A (Belfort instrument, USA) which is using an infrared forward scatter visibility sensor.

The $PM_{2.5}$ concentrations and two meteorological parameters (RH and ambient temperature) were negatively correlated with the measured ambient visibility. Although RH itself does not significantly influence atmospheric visibility, high humidity levels substantially increased water absorption of hygroscopic particles such as sulfates, which then increased the light scattering cross section of fine particles resulting in reducing visibility. High ambient temperature accelerated photochemical reactions to form secondary fine aerosols such as $PM_{2.5}$, which can scatter sun light effectively reducing ambient visibility.

Control Number 28

Mass Extinction Efficiency and Hygroscopicity of $PM_{2.5}$ in Major Chinese Cities

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Abstract

The rapid industrialization and urbanization in China is astonishing. The associated ambient $PM_{2.5}$ pollution problem has drawn substantial international attentions. The current literature mainly focuses on the mass concentration, chemical composition, and sources of $PM_{2.5}$. The mass extinction efficiency (MEE) and hygroscopicity (f_{RH}) of $PM_{2.5}$ can be directly introduced to study the impacts of atmospheric visibility degradation and climate change. The sparse research papers in this area only report results from pilot studies that are lack of spatial and temporal variability. In this paper, hourly average ambient $PM_{2.5}$ concentration, relative humidity and atmospheric visibility data for 24 major Chinese cities during September 2013 to October 2014 were collected from the China national air quality and meteorological monitoring networks. The visibility data were converted into light extinction coefficient to estimate the annual average MEE and f_{RH} of $PM_{2.5}$ in these cities. The results show a strong relationship between these two parameters and the $PM_{2.5}$ chemical composition. Nationwide, the contributions of dry and wet $PM_{2.5}$, and gases to light extinction are 44%, 53%, and 3%, respectively. The MEE of dry $PM_{2.5}$ is 3.60 ± 0.65 m^2/g ranging from 2.36 to 5.07 m^2/g. The MEE is strongly linked to the different emission profiles and no spatial trend was observed.

Control Number 20

An examination of the current IMPROVE algorithm

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Abstract

The IMPROVE Network provides the primary method for visibility monitoring at Class I Areas throughout the United States. Monitoring is conducted by collecting $PM_{2.5}$ and PM_{10} samples every third day at over 150 sites nationwide, with $PM_{2.5}$ samples being analyzed for chemical composition. Using these data, light extinction is estimated using the IMPROVE Equation. Reconstructed extinction values are then used to calculate haze levels and estimate visibility. In addition to calculated light scattering from IMPROVE, the National Park Service directly measures aspects of visibility through optical measurements at a subset of IMPROVE sites using Optec NGN-2 integrating nephelometers. The optical measurements serve as a quality assurance check for IMPROVE, in that measured and reconstructed (from IMPROVE data) scattering should be equivalent. The nephelometer data were used to help develop the original IMPROVE algorithm in 1994. More recently, the nephelometer data were used to evaluate the performance of the IMPROVE algorithm, and in 2007 a revised IMPROVE algorithm was established. Overall, the revised IMPROVE algorithm has been shown to accurately estimate light scattering from a broad array of aerosol compositions and loadings, and it is currently used to determine visibility conditions at Class I Areas around the country. Periodically revisiting this equation is needed, as some of the relationships have been empirically derived and may change with changing atmospheric composition. In this presentation, we will discuss observed discrepancies between measured light scattering and reconstructed light scattering from the original and revised IMPROVE Equations. Preliminary results suggest that the relationship between measured and reconstructed light scattering has changed over time, possibly corresponding to systematic changes in the chemical and/or physical properties of the aerosol. We will present possible reasons for these changes and discuss their implications. One important implication is that trends based on calculated light scattering from IMPROVE measurements generally overestimate decreasing trends in measured light scattering.

Session 11. New Instruments and Measurement Techniques

Control Number 5

Development of the GC-MS Organic Aerosol Monitor (GC-MS OAM) For In-field Detection of Particulate Organic Compounds

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ABSTRACT

Particulate matter (PM) is among the most harmful air pollutants to human health, but due to its complex chemical composition is poorly characterized. A large fraction of PM is composed of organic compounds, but these compounds are not regularly monitored due to limitations in current sampling techniques. The Organic Aerosol Monitor (GC-MS OAM) combines a collection device with thermal desorption, gas chromatography and mass spectrometry to quantitatively measure the carbonaceous components of PM on an hourly averaged basis. The GC-MS OAM is fully automated and has been successfully deployed in the field. It uses a chemically deactivated filter for collection followed by thermal desorption and GC-MS analysis. Laboratory tests show that detection limits range from 0.2 to 3 ng for many atmospherically relevant compounds. The GC-MS OAM was deployed in the field for semi-continuous measurement of the organic markers, levoglucosan, mannosan, galactosan, dehydroabietic acid, and polycyclic aromatic hydrocarbons (PAHs) from January to March 2015. The concentrations and diurnal patterns of these organic

marker compounds will be compared to the concentrations and diurnal patterns of other indicators of primary emissions, e.g. BC and CO. Results illustrate the significance of this monitoring technique to characterize the organic component of PM and identify sources of pollution

Control Number 7

Use of a GC-MS Monitor for In-Field Detection of Fine Particulate Organic Compounds in Source Apportionment.

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Abstract:

A significant need exists to better characterize air pollution and its sources. This especially pertains to fine particulate matter ($PM_{2.5}$). $PM_{2.5}$ is chemically complex and its sources of emission and secondary production are highly variable. $PM_{2.5}$ complexity is largely due to the organic fraction, which ranges from 10-90% of its total mass. However, the organic compounds in $PM_{2.5}$ have generally not been monitored in the field due to limitations in available sampling techniques. An instrument capable of monitoring the organic components of PM in the field and on an hourly averaged basis has been build, automated, and successfully deployed in the field. Emphasis has focused on the measurement of nonvolatile compounds which have been used as markers of organic sources for source apportionment evaluations and which can be volatilized at about 200 C. This instrument uses a filter collection/thermal desorption system integrated with a miniaturized GC-MS to measure hourly averaged concentrations of organic compounds in PM. The instrument's capability for routine monitoring of organic marker compounds for source apportionment analysis was tested in a field sampling campaign conducted on the Brigham Young University campus in Utah Valley, UT during the winter of 2015. Other instruments included in this source apportionment campaign included a Duel Oven OC/EC (Sunset Laboratory), Aethalometer©, nephelometer, Ambient Ion Monitor (URG), FDMS-TEOM, O_3, NO_x and CO monitors. Inclusion of the data from the GC-MS instrument significantly improved the ability to apportion PM sources. A PMF analysis was conducted of a data set (n=287) containing the above outlined conventionally measured species and several organic marker compounds (including levoglucosan), all measured on a 1-hour average basis. The value of the hourly average measured organic marker compounds in the PMF analysis will be discussed. The relationship between the various measured organic markers and the resultant source apportionment will be highlighted. The fine particle light scattering was dominated by the PMF identified sources associated with wood smoke and secondary ammonium nitrate.

Control Number 13

Wintertime $PM_{2.5}$ Pollution in UT: What Can Measurements at Ground Level and Higher Elevation Tell Us?

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Administration, Boulder, Colorado, [2]Cooperative Institute for Research in Environmental Sciences, University of Colorado, Boulder, CO, Steve Brown, *[1]Chemical Sciences Division, Earth System Research Laboratory, National Oceanic and Atmospheric Administration, Boulder, Colorado, [2]Department of Chemistry and Biochemistry, University of Colorado, Boulder, CO,*

Valleys along the Wasatch Mountains in northern Utah (Cache, Salt Lake and Utah) experience high levels of particulate matter with aerodynamic diameters less than 2.5 micrometers ($PM_{2.5}$) in winter months. These pollution episodes are closely associated with Persistent Cold Air Pool (PCAP) events, which have been a focus of several recent studies, and are typically dominated by secondary species, in particular ammonium nitrate. However, the chemical aspects of these pollution episodes received somewhat little attention compared to the meteorological phenomena. The Salt Lake Valley Winter $PM_{2.5}$ study was conducted between December 2015 and February 2016 to improve the scientific understanding of these pollution episodes, especially the chemical processes governing the PM formation. During this study, rooftop observations of a suite of chemical and meteorological parameters relevant to PM formation were made at the University of Utah site located ~ 150 m above the valley floor. The measurements included PM mass, chemical composition and size distribution, trace gases and radical measurements (notably O_3 and N_2O_5). Mobile and aerostat measurements of PM and related species were also made to explore their vertical and spatial variability. This presentation will give an overview of the results focusing on the chemical and meteorological conditions that lead to the PM pollution episodes. Further, I will compare chemical conditions at the bottom of the valley and higher elevations, explore the time evolution of the aerosol layer during these pollution episodes and highlight the importance of the coupling between the nighttime and morning chemistry, and dynamical processes that yield elevated PM levels near surface.

Control Number 36

A Non-destructive, Inexpensive Method for Predicting TOR OC and EC in the IMPROVE and CSN networks using Infrared Spectra

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Giulia Ruggeri, Matteo Reggente, S Satoshi Takahama, Swiss Federal Institute of Technology Lausanne (EPFL), Lausanne, Switzerland,

Abstract

The Interagency Monitoring of Protected Visual Environments (IMPROVE) network and the Chemical Speciation Network (CSN) are speciation particulate matter monitoring networks in the U.S. IMPROVE is located primarily in Class 1 visibility areas and CSN is located in urban and suburban areas for which visibility is becoming increasingly important. Carbonaceous aerosol, which can be 50% or more of the particulate matter mass, is measured in both networks using thermal optical reflectance (TOR) on quartz filter samples. We have developed a less expensive, non-destructive method using Fourier transform-infrared spectroscopy (FT-IR) and partial least squares regression to predict TOR organic (OC) and elemental carbon (EC).

Infrared spectra are obtained from PTFE filters that are routinely collected in parallel with the quartz filters in both monitoring networks. Using two-thirds of samples collected at seven IMPROVE sites in 2011, FT-IR can reproduce TOR OC and EC with good accuracy and precision on par with collocated TOR measurements. Using the 2011 calibrations and samples collected at 17 sites in 2013, we show that FT-IR can measure OC and EC in different years and at different sites than the samples used in the calibration. For two sites (Fresno, CA and South Korea IMPROVE sites) that likely have different aerosol composition than

the primarily rural US sites used in the calibration, making separate calibrations with these sites or adding these sites to the 2011 calibration improved the prediction of TOR OC and EC. Using a sparse calibration method, we show that TOR OC is predicted using a suite of organic functional groups and that EC is predicted using a few organic functional groups and C-C stretch in ring-structured compounds.

We developed TOR OC and EC calibrations for the CSN network using samples collected at 10 sites during 2013. Although the aerosol mass is generally higher in urban areas than in rural areas, samplers used in CSN have lower flowrates and larger filters causing the mass interrogated by the FT-IR beam to be on average ~5 times less in CSN than in IMPROVE. For OC, the predictions results are very similar to IMPROVE and for the EC the relative error is similar to IMPROVE but the R^2 drops from 0.96 to 0.85. Using processed FT-IR spectra, we determine that organic carbon functional groups are used to predict TOR OC and that organic and elemental carbon functional groups and a factor related to pyrolyzed carbon are used to predict EC. Processed spectra also enable us to use the CSN calibrations to predict TOR OC and EC on Federal Reference Method (FRM) samples located throughout the US. The FRM network is used to determine compliance with EPA National Ambient Air Quality Standards for PM2.5 but does not have speciation measurements.

The next steps in this work are to develop network-wide calibrations for IMPROVE and CSN to inexpensively and non-destructively predict TOR OC and EC for a larger number of sites and periods. Together with the capability for FT-IR spectra to provide estimates of organic functional group abundance, organic matter (OM) and OM/OC, and identify sources, the work described in this talk highlights the value of FT-IR integration into measurement networks.

Control Number 92

Optical Characterization of Filtered Aerosols Using Broadband Illumination: An Enhanced Measurement System for the IMPROVE Air Quality Network

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Abstract

Light absorption by aerosols is a critical factor in the global radiative budget. The complicated morphology and composition of real-world, mixed aerosols cause severe challenges for model predictions, including high uncertainty. Recent developments in both hardware and measurement techniques have fostered greater understanding of aerosol optics. However, more ambient measurements are necessary to improve and validate large-scale models.

The IMPROVE network is a large data producer, generating comprehensive chemical speciation of non-urban aerosols. The optical characterization is conducted using a single-wavelength He(Ne) laser in the hybrid integrating-plate/sphere (HIPS) orientation. This setup has produced a relatively consistent absorption value for IMPROVE samples, which can be directly compared to other important chemical concentrations including elemental carbon and mineral species. The development of more informative optical measurements through the use of additional wavelengths will aid in understanding the relationships between wavelength dependents

and chemical composition. To meet these goals, a new broadband instrument has been constructed and is being optimized for use on the 25 mm PTFE filters utilized by the IMPROVE network.

The new broadband instrument, BITS (**B**roadband **I**ntegrating **T**ransmittance/Reflectance **S**pectrometer), incorporates a deuterium/tungsten-halogen light source with a steady output spanning near-ultraviolet, visible, and near-infra red regions (specifically 190 to 1700 nm). The source introduction system collimates and focuses light over the entire sample deposit, which immediately follows a 3.3-inch Spectralon-coated integrating sphere. Detection is carried out with a back-thinned, charge coupled device (BT-CCD) spectrometer in 2,048 channels with 3.2 nm resolution. Data acquisition and exploration is carried out with LabVIEW software using current best practices. Ongoing work involves developing calibration, data processing, and quality control procedures using established IMPROVE samples and the HIPS measurement technique for benchmarking.

Session Associated Poster Presentation

Control Number 38

Nitrogen Oxides Measurements Using Direct Optical and Chemiluminescence Techniques

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Ambient nitrogen oxides (NO_x) are important to atmospheric photochemistry, human health, and atmospheric light attenuation. In 2010, the EPA set a primary hourly standard for NO_2 of 100 ppb, and required states to implement new NO_2 monitoring stations. The stringent standard and known limitations with traditional methods has led to interest in new NO_x measurement techniques in the low-ppb range. Here we used two techniques to measure NO_x: light absorption of NO_2 at 405 nm (2B Technologies Model 405 $NO/NO_2/NO_x$ Monitor) and a traditional chemiluminescence monitor (Thermo Electron Corporation Model 42C $NO\text{-}NO_2\text{-}NO_x$ Analyzer). The method of chemiluminescence uses the reaction of NO and O_3 to produce excited NO_2, which then emits measurable radiation. NO_2 is measured as the difference between measurements made by passing air though a high temperature molybdenum converter to measure NO_x (= $NO + NO_2$) and bypassing the converter to measure NO. A principal drawback to this method is the error introduced by calculating NO_2 from the difference between two measurements, especially when the NO concentration is much higher than NO_2. Furthermore, since other species such as nitrous acid, PAN, and organic nitrates are converted to NO as well, a positive interference results in the measurement of NO_2. Light absorption by NO_2 at 405 nm is advantageous because there is little to no overlap of other airborne species absorbing light at this wavelength. The absorption method relies on a comparison of visible light intensities with and without NO_2 present. The Beer-Lambert Law is then used to calculate the concentrations of NO_2 from measured intensities. The concentration of NO is found by measuring the intensity of light before and after adding excess O_3 to convert the NO into NO_2. The concentration of total NO_x is found by summing the concentrations of the two species. In this analysis we characterize detection limits, determine any interferences, and examine ambient and laboratory measurements. The absorption method is compared to the more traditional method of chemiluminescence for indoor and ambient air. Results explored here include the sensitivity and noise of the absorption instrument as well as an examination of the possible interfering N-species of atmospheric relevance including nitric acid and ammonia. Testing to date shows an LDL (2σ) of approximately 4ppb ($t = 5$ min) for both NO and NO_2. The data showed that average NO_2 levels in sparely populated Socorro, NM are well below both the annual standard of 53 ppb as well as the hourly standard.

Control Number 118

A "MAGIC" Water Condensation Particle Counter

Gregory S. Lewis, Steve Spielman, Arantzazu Eiguren Fernandez, and Susanne V. Hering,,Aerosol Dynamics Inc., CA, Patricia B. Keady, Aerosol Devices Inc., CO

Abstract

A miniature, water-based condensation particle counter has been developed for portable monitoring of particle number concentrations. This instrument uses a new temperature moderated laminar flow condensation method with a self-sustaining wick. It operates in any orientation and can function for extended periods without addition of working fluids.

Called MAGIC, for moderated aerosol growth with internal water cycling, this portable WCPC, this counter operates from a combination of the water vapor recovered from the sampled airstream, and from that recovered internally. There are no water reservoirs, yet it is capable of days to weeks of unattended operation. It may be tipped or shaken without affecting the measurement.

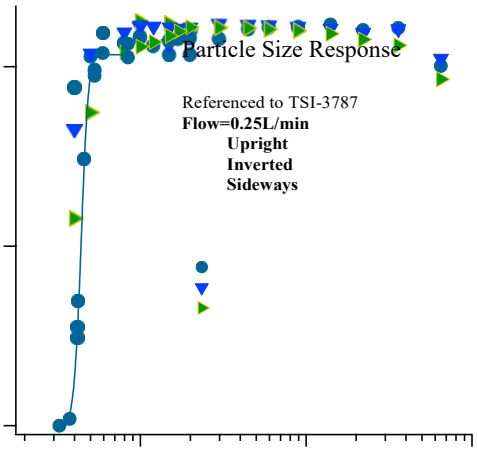
The sustained operation is achieved through MAGIC's three-stage design, with a single wetted wick throughout. As described by Hering et al, (2014), the first stage is a "conditioner" and is generally operated with slightly cooled walls to regulate the temperature and relative humidity of the flow. The second stage, referred to as the "initiator", is relatively short with walls that are warmer than that of the conditioner. This initiator stage provides the water vapor that creates the super-saturation to initiate droplet growth. The third stage, called the "moderator", has cool walls similar to the first stage. This third stage captures the water vapor released by the initiator stage without significant change to the saturation profiles. The stages are lined with single wick that provides wetted surfaces throughout. Once the wick is wet, instrument operation is sustained through a combination of water vapor removed from the sampled air flow and internal capture of added water vapor. Calibration data are shown in Figure 1, where the reference is the TSI Model 3787 general purpose water-based condensation particle counter. The test aerosol is ammonium sulfate. MAGIC was operated with a temperature of 5°C, 45°C and 5°C, for the conditioner, initiator and moderator, respectively. The detection efficiency is 50% at 4.5 nm, and plateaus at 90%.

For two weeks of unattended operation, and without addition of water, the portable WCPC was compared to the TSI-3787 ultrafine WCPC while sampling ambient air. During the first 48 hours of this period the correlation between the portable WCPC gives $R2>0.99$, with regression slope of 0.95. Over the entire two-week period the correlation decreases to $R2=0.97$, with regression slopes of 0.89.

Support from the National Institutes of Health, grants ES019081 and ES014997 is gratefully acknowledged.

Reference: Hering, S.V., Spielman, S.R. Lewis G.S. (2014) Aerosol Science and Technology 48:401-408.

Figure 1. Calibration of the MAGIC CPC With ammonium sulfate aerosol, as compared to a TSI 3767 WCPC.



Control Number 119

A Universal Spot Sampler for High-Efficiency, Concentrated Collection of Aerosol Particles on a Solid Substrate and in Liquids

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Christopher Hare and Patricia B. Keady, Aerosol Devices Inc., CO

Abstract

A Universal Spot Sampler is a new approach to aerosol particle sampling using the proven technology of laminar-flow water condensation particle growth, similar to that used in popular water condensation particle counters. Rather than counting the number concentration of the particles, the instrument collects water-encapsulated particles using soft, bounceless impaction onto a dry solid substrate or into a small volume of liquid. The particle samples are inherently pre-concentrated allowing small volume extraction for improved detection/quantification sensitivity using on-line or off-line chemical or biological analysis. The enabling technology is a patented, three-stage, moderated laminar-flow condensation growth tube which enlarges particles into ~3µm droplets at moderate temperatures. The sampler is a fully integrated portable instrument. An aerosol sample flow of 1.5 L/min stream enters a cool wet-walled region to pre- condition the aerosol temperature and relative humidity, followed by a warm activation section that increases the relative humidity to values above 140%. The supersaturated water vapor initiates condensational growth of particles. The 50% activation particle size is ~5-8nm depending on particle chemistry. A cool, moderating third stage follows allowing droplet growth to continue while reducing the exit flow temperature and water vapor content to below ambient conditions. Droplets are collected via gentle impingement into a small volume of liquid, or soft impaction onto a variety of solid substrates.

To characterize the chemical composition of ambient particles with time-resolution of minutes to hours, the particles are deposited as 1-mm, dry "spots" into a 33-well collection disk. A stepper motor rotates the disk to a new sample well at user-selectable intervals. The instrument is field deployable for up to two weeks of unattended operation. Back in the laboratory, the 'ready-to-analyze' collection disk is placed in an autosampler for automated solvent addition, mixing, and injection into a chemical analyzer (e.g., IC or HPLC). Each sample well is 5.6mm in diameter and can hold up to 75µL of extraction solvent. Alternatively, liquid samples can be user configured for direct on-line analysis with liquid chromatography to quantify water-soluble inorganics and organics, or ion chromatography for anions, cations and carbohydrates. This presentation shows performance validation data for a new commercial version of the Spot Sampler, as well as data examples from various field applications.

Figure 1. Schematic of the moderated, three-condensation growth particle collector.

Figure 2. Temperature, saturation ratio, and droplet stage size in the moderated method (Hering et al, 2014).

Reference: Hering, S.V., Spielman, S.R. Lewis G.S. (2014) Aerosol Science and Technology:401-408.

Session 12. Secondary Organic Aerosols

Control Number 14

Drying-Induced Evaporation of Secondary Organic Aerosols during Summer

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Abstract

Aerosol liquid water plays a critical role in the scattering of light by atmospheric particles. Aerosol liquid water can also facilitate the formation of secondary organic aerosol (SOA) from a variety of VOCs. This aqueous-phase processing is thought to be especially important in the formation of SOA from isoprene. However, many aspects of this process are unknown at present, including the contribution of aqueous organic uptake to the total SOA budget, as well as the relative contributions of reversible and irreversible uptake processes to SOA formed in aerosol water.

Ambient measurements were conducted in Baltimore, MD to characterize the effects of particle drying on SOA concentrations during the summertime. On-line measurements of particulate water-soluble organic carbon ($WSOC_p$), a surrogate for SOA, were alternated between an unperturbed ambient channel and a "dried" channel maintained at ~35% relative humidity (RH). $WSOC_p$ concentrations measured through the dried channel were systematically lower than the ambient $WSOC_p$ concentrations: the average mass ratio between the two measurements was 0.85, showing that significant evaporation of the organic aerosol occurred due to drying. The average amount of evaporated water-soluble organic matter (WSOM = WSOC × 1.95) was 0.6 µg m^{-3}; however, the maximum evaporated WSOM concentration exceeded 5.0 µg m^{-3}, demonstrating the importance of this phenomenon. The systematic difference between ambient and dry channels indicates a significant and persistent source of aqueous SOA formed through reversible uptake processes.

Although this new measurement method has only been deployed in Maryland thus far, we expect that this phenomenon will be important across the entire eastern U.S., and likely beyond. These results have important implications for our understanding of SOA formation facilitated by particle-bound water. The results also suggest that many common aerosol measurement techniques are unable to measure this aqueous SOA or its effects. For example, the f(RH) method, HTDMA method, and the inlet of widely used aerosol

mass spectrometers all implement some degree of sample drying, and thus, do not fully measure reversible aqueous SOA. The EPA's Federal Reference and Federal Equivalent Methods for measuring $PM_{2.5}$ are also subject to this bias. These measurement artifacts have implications for interpreting measurements of air quality made from remote sensing platforms, which are not subject to such an effect. The results also suggest problems with many prior modeling studies, if any of the above measurement methods were employed for model evaluation.

Control Number 12

More Complete Analysis of IMPROVE Samples for Visibility and Source Apportionment Studies

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IMPROVE acquires $PM_{2.5}$ samples on Teflon-membrane, quartz-fiber, and Nylon filters. Much more chemical information can be obtained from these samples that would assist understanding of optical properties and aerosol sources, especially the origins of secondary organic aerosols (SOA). In addition to non-destructive mass and elemental analyses on Teflon membranes, filter transmittance in the ultraviolet (UV), visible (VIS), and infrared (IR) parts of the spectrum provides indicators of optical properties, functional groups, and sources. Rare earth elements can be quantified after acid extraction by Inductively-coupled Plasma Mass Spectrometry. In addition to thermal/optical carbon fractions from the quartz-fiber filter, more than 100 non-polar and compounds can be quantified by Thermal Desorption Gas Chromatography/Mass Spectrometry without solvent extraction. In-Situ Derivatization Thermal Desorption Mass Spectrometry has been perfected for more than 80 polar compounds, several of which are light absorbing and many of which constitute SOA. In addition to inorganic anions from the Nylon filter water extract, the recently available ion chromatographic (IC) technology allows for quantification of acetate and formate. This modern technology also allows for cation analysis simultaneous with anion analysis, providing soluble potassium as an indicator of biomass burning and soluble calcium as an Asian dust indicator. UV-VIS-IR transmittance through the extraction solution provides optical properties specific to the soluble $PM_{2.5}$ fraction. Short-chain carboxylic acids, anhydro sugars, polyols, and saccharides, including levoglucosan, are also quantifiable by IC with appropriate eluents, columns, and detectors.

Control Number 37

Organic functional group and OM/OC measurements at select IMPROVE sites using Infrared Spectra: Organosulfates and amines

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Satoshi Takahama, Swiss Federal Institute of Technology Lausanne (EPFL}

Abstract

The Interagency Monitoring of Protected Visual Environments (IMPROVE) is a speciation particulate matter monitoring network in the U.S. located primarily in Class 1 visibility areas. Organic carbon (OC) is measured using thermal optical reflectance (TOR) on quartz filter samples and an organic matter (OM) to

OC ratio (OM/OC) of 1.8 is assumed to account for the hetero atoms attached to the carbon including oxygen, hydrogen, sulfur and nitrogen. In previous work, we developed a method using Fourier transform-infrared spectroscopy (FT-IR) and partial least squares (PLS) regression to measure the four largest organic functional groups, aliphatic C-H, alcohol/sugar OH, carbonyl and carboxylic acid OH. These functional groups are summed to estimate OM and the carbon from the functional groups is summed to estimate OC. With this method, OM/OC can be estimates for each sample rather than relying on one assumed value for all samples. More recently, we have adopted a range of strategies for PLS model development to better estimate OC from functional group measurements (as evaluated by comparison to TOR OC).

We have expanded our suite of functional groups to include organosulfates and amines. Amines are ubiquitous in the atmosphere and come from car exhaust, animal husbandry, biomass burning and vegetation among other sources. Calibration standards for amines are produced by atomizing four amino acids and one amine to create standards over a range amine functional group mass in the range of infrared absorption observed in atmospheric samples. Spectra from the standards in the wavenumber range of amine absorption are used in a partial least squares (PLS) regression to obtain a calibration for amine functional groups. The calibration is applied to samples collected throughout 2013 at 17 IMPROVE sites. Urban sites showed the highest amine concentrations due to traffic and Fresno, CA an urban site surrounded by cattle and other agriculture, had the highest amine concentration of any site due to traffic and animal husbandry. The lowest amine concentrations were found at rural sites that did not experience prescribed or forest fires in 2013. Samples collected during the Rim Fire near Yosemite National Park had the highest individual amine concentrations of all the samples. Rural sites in the Southeast and Kansas that have prescribed fires during the January to March and high biogenic emissions in the summer, had higher amine concentrations than other rural sites. The OM/OC is higher when the amine functional group is included but for most samples, the increase is small.

Organ sulfates are tracers for secondary organic aerosol (SOA) in regions with high sulfate. In the FT-IR spectrum, organo sulfates absorb in two regions where other functional groups including bisulfate and carbonate absorb. Standards of organo sulfate, ammonium bisulfate and calcium carbonate were produced in the laboratory and used in a PLS calibration for the organo sulfate functional group (C-O-SO3). Organ sulfate concentrations are higher in the east and Midwest, consistent with trends in inorganic sulfate concentrations that are also higher than in the west. Changes to OM/OC ratios when organo sulfate is added will be discussed.

Control Number 23

Chemical and Optical Characterization of Water-Soluble Organic Carbon and its Relation to Secondary Aerosol Formation

Priyanka Takhar, Gaurav Singh, Annada Padhi, Gazala Habib

The light absorbing species of atmospheric particulate matter are gaining considerable interest in recent years owing to their significant role in regional as well as global climate change. Although several studies have evaluated their impact on atmospheric environment, uncertainties associated with the regional scenario are still large and demand further assessment. One of the possible sources of uncertainty could be attributed to poor characterization of organic aerosols including its water-soluble fraction in the atmospheric particulate matter. Therefore, this study will present the seasonal variation (May 2015 to May 2016) in atmospheric concentration of $PM_{2.5}$, water soluble organic carbon and its chemical components, and related light absorbance to investigate the role of WSOC in local air quality degradation

Control Number 96

Improving Understanding of the Southeastern U.S. Biomass Burning Contribution to SOA

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Abstract

Biomass burning is an important source of primary and secondary pollutants that can impact air quality and influence public health and climate. In addition to criteria pollutants and CO_2, emission plumes also include ammonia, brown carbon and reactive oxygen species. It is particularly difficult to accurately quantify the biomass burning contribution to secondary PM due to the complex formation processes of the secondary organic aerosol (SOA) portion that often dominates the mass. Additionally, because no direct measure of SOA exists, characteristic chemical tracers must be used. These challenges are compounded by the fact that emission rates are a function of fuel composition, wild vs. prescribed burns, and numerous other conditions. Other major uncertainties include the lifetimes of the tracers used to estimate biomass burning contributions to ambient PM.

The characteristic tracer(s) used include combustion tracers (e.g., BC, K and CO) along with cellulose pyrolysis products (e.g., levoglucosan, other anhydrosugars, simple sugars). Several laboratory and field studies have suggested these sugars have limited chemical lifetimes that can range from 15 to >24 hours, depending on ambient conditions. The atmospheric stability of other organic markers is less well-known. Chemical loss of the tracers at a rate faster than that of the remaining SOA would imply a less than a full accounting of SOA attributed to this source, and vice versa. Therefore, identification of biomass burning SOA tracers that remain stable for multi-day periods is needed for accurate assessment of biomass burning impacts.

The southeastern U.S. landscape is characterized by a fire-dependent forest ecosystem, and therefore is subject to a substantial amount of prescribed biomass burns, with a more limited number of agricultural burns. Detection of prescribed burning can be particularly difficult because (1) many events occur under high forest canopies and are thus not detectable by satellite remote sensing, and (2) many occur at military installations, which are not regularly recorded in inventories. Therefore, additional tracers are particularly important in this region, where the sources are poorly constrained and photochemical oxidation can occur at high rates in multiple seasons.

This study incorporates two separate approaches to constrain the contribution of biomass burning to carbonaceous PM. The first approach uses indirect tracer methods based on bulk particle measurements (e.g. total organic carbon (OC) and non-soil K) to estimate the amount of OC from biomass burning over a decadal time frame. While uncertainty exists in this approach, it avoids the dependence upon specific individual organic molecular tracers. The second approach builds on prior work in the Eastern Mediterranean. It was demonstrated that biomass burning plumes aged beyond a day retain a characteristic signature in the form of a Positive Matrix Factorization factor from aerosol mass spectrometry (AMS) measurements. This factor is a hybrid between traditional AMS factors for fresh emissions and a highly aged factor referred to as “Oxygenated Organic Aerosol”. This new factor implies a considerable fraction of the background OOA may originate from biomass burning. The chemical composition of the new factor is being identified and will be applied to samples taken in the Southeastern U.S. The results from these two approaches will be presented, along with an overview of prior assessements of biomass burning emissions and contribution to SOA in the region.

Control Number 46

Projections of anthropogenic secondary organic aerosols over China under RCP scenarios

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Abstract

Secondary organic aerosol (SOA) is one of the abundant fine particles in the atmosphere, and may become the most important fine particles in the future because of the reduction of sulfate and nitrate. In this paper, a regional climate model RegCM-CHEM is used to assess SOA over China in present days and in the future.

First of all, A SOA module called volatile basis set (VBS) is implemented in RegCM-CHEM. With the anthropogenic and biomass burning emission inventory from MEIC and an off-line biogenic emission from MEGAN-MACC, the simulation is conducted for year 2005, using the modified RegCM-CHEM. The results indicate that Year-averaged anthropogenic SOA (ASOA) is distributed mainly in Sichuan Basin, Hubei, Hunan, Guizhou and Guangxi provinces, and biogenic SOA (BSOA) is distributed mainly in Yunnan, Guizhou, Hunan, Jiangxi, Guangxi and Guangdong provinces; SOA are distributed mainly over North China in Summer, and over South China in Winter; The ASOA concentration is higher in Autumn and Winter than Spring and Summer, as for BSOA, the concentration is higher in Summer and Autumn; The total SOA surface concentrations are 5.50, 4.31, 4.05 and 5.95 μg m^{-3} in Winter, Spring, Summer, and Autumn, respectively; Aromatic and α-pinene VOCs are the main contributors to ASOA and BSOA; The results of process analysis suggest that chemical reactions, dry deposition and vertical turbulence are the three most important processes of SOA generation.

Secondly, four pathways of anthropogenic emission and boundary conditions from IPCC RCP scenarios are adopted to project the future SOA over China. Under the future RCP45 climate scenarios, the increased temperature and water vapor lead to increased ozone concentration in the north part of Yangzi River, and decreased ozone will decrease in the south part. According to the change of ozone, surface SOA concentration will increase in the north part of Yangzi River and decrease in the south part. Averaged surface ASOA concentration will decrease by 2.6% and BSOA will decrease by 1.5%. Though the domain averaged values are small, the future climate has larger impact on SOA in regional scale. Under RCP26, RCP45, RCP60 and RCP85 emission scenarios, ASOA surface concentrations will decrease by 80%, 60%, 40% and 45% and BSOA will decrease by 21%, 22%, 11% and 12%, respectively. Under RCP26 emission scenarios, the reduction of POA emission decrease the SOA concentration by 6%, and the reduction of NO_X emission decrease the SOA concentration by 2% and 11% for ASOA and BSOA. The production and the use of solvent is the biggest contributor to SOA concentration change in the future.

Above all, the modified regional climate model has a good performance in SOA modeling, especially in OC seasonality. In China, ASOA has a larger contribution than BSOA. Regardless of biogenic emission change, SOA will increase in the north part of Yangzi River, and decrease in the south part, because of the temperature and water vapor change in future. SOA will decrease, mainly because of the reduction of anthropogenic VOCs.

Session Associated Poster Presentation

Control Number 124

Session 14. Mineral Dust Aerosols & Impacts on Air Quality and Visibility

Control Number 17

Temporal and seasonal patterns in mineral dust concentrations at remote sites across the United States

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Abstract

Mineral dust is a significant source of particulate matter in the global atmosphere. Dust can impact air quality, visibility, and health and has important direct and indirect climate impacts. The spatial and temporal variability of fine ($PM_{2.5}$) mineral dust at rural and remote sites in the United States was characterized using data from the Interagency Monitoring of Protected Visual Environments (IMPROVE) network. The IMPROVE network currently operates about 165 sites across the United States where speciated $PM_{2.5}$ aerosol composition is measured. Elemental species as determined from X-ray fluorescence (XRF) were used to compute mineral dust concentrations by summing the oxides of elements typically associated with soil. Annual, seasonal, and monthly means were computed for 2011 through 2014 to investigate the spatial and temporal variability in fine dust across the United States. Regions with significant dust concentrations include the Southwest in spring where fine dust contributed 50% or greater to reconstructed fine mass. In regions of the Central, Midsouth, and Southeast fine dust contributed 20-30% of $PM_{2.5}$ mass during summer. The spatial and seasonal variability in the oxides assumed to compose dust was also investigated and suggested that the oxide fractions can vary significantly during the year depending on region, perhaps suggesting different seasonal sources.

Temporal trends in dust concentrations since 2000 were computed using Theil linear regression analysis. Trend analyses revealed regions and seasons with significantly increased dust concentrations, especially the Southwest during spring months, the Central United States during summer and fall, and the Southeast in summer—all regions that are associated with significant contributions of dust to $PM_{2.5}$ mass. Positive trends in dust concentrations contrasted with significant negative trends in other major aerosol species over the same time periods.

There are several important implications of increased atmospheric dust concentrations. High levels of dust can contribute negatively to health effects, contribute to visibility degradation, and to direct and indirect climate effects. It can also affect snow melt timing and water availability in the West by shortening seasonal snow coverage and has important ecological impacts such ecosystem dynamics and the removal and transport of topsoil. As dust becomes a larger fraction of $PM_{2.5}$ mass, understanding the magnitude and causes of increased dust concentrations is important for designing strategies to reduce particulate matter in the atmosphere, to improve visibility, for resource management decisions, and to better understand the climate impacts of dust.

Control Number 87

The Impact of African Dust on the Annual Average $PM_{2.5}$ Concentrations at the Maximum Concentration $PM_{2.5}$ Monitoring Site in the Houston Texas Region, 2009-2014

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Abstract

The Clinton Drive $PM_{2.5}$ monitor located at the edge of a neighborhood on the north side of the Houston Ship Channel has historically had the highest annual average mass concentration of all the $PM_{2.5}$ monitors in

the central, northern, southern, and eastern areas of Texas. The Texas Commission on Environmental Quality led a cooperative, non-regulatory effort to reduce $PM_{2.5}$ concentrations in the area, resulting in reducing the three-year average concentrations from a high of 15.8 $\mu g/m^3$ for 2007 to 11.8, 11.6, and 11.6 $\mu g/m^3$ 2013, 2014, and 2015, respectively. International transport affecting this area comes from smoke from Mexico and Central America and dust from Africa.

The data analyses reported here relied largely on the use of the Environmental Protection Agency's PMF 5.0 software tool. Clinton Drive speciation data from 2009 through 2014 were used.

Control Number 108

Optical Properties of Suspended Mineral Dusts from Desert Source Regions

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Abstract
On a global scale, mineral dust aerosol has the largest mass emission rate, average column mass burden, and average optical depth of all aerosol types, with its single scattering albedo (SSA) determining the sign (heating or cooling) and influencing the magnitude of its radiative forcing. Previously, we had suspended surface soil samples from ten desert sites and characterized their optical properties, especially SSA at two visible wavelengths, concluding that mineral dust SSA was controlled by iron content (Moosmüller et al.; 2012). Here we have extended this work to 65 samples, including sample locations in Africa, Arabian Peninsula, Asia, North and South America, and Australia (Engelbrecht et al., 2016).
A sieved fraction of each sample was suspended in an entrainment facility, from which the airborne particulate matter (PM) was sampled and analyzed. Instruments integrated into the entrainment facility included PM filter samplers, a beta attenuation gauge for the continuous measurement of PM mass fractions, an aerodynamic particle size (APS) analyzer, and a three- wavelength (405, 532, 781 nm) photoacoustic instrument with integrating reciprocal nephelometer for monitoring aerosol absorption and scattering coefficients of suspended PM2.5. Filter sample media included PTFE membrane and quartz fiber filters for chemical analysis (71 species), and nucleopore filters for individual particle analysis by scanning electron microscopy (SEM). Sieved fractions were also analyzed by X-ray diffraction for their mineral content and further mineralogically characterized by optical microscopy.
We will be presenting results on the optical measurements, showing the relationship between PM optical properties including SSA at different wavelengths and chemical as well as mineralogical properties of the entrained dust samples.
References
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Engelbrecht, J. P., Moosmüller , H., Pincock, S., Jayanty, P. K. M., Lersch, T., and Casuccio, G. S.: Technical Note: Mineralogical, Chemical, Morphological, and Optical Interrelationships of Mineral Dust, Atmos. Chem. Phys. Discuss., doi:10.5194/acp-2016-5286, 2016.

Control Number 25

Taming the Wind-Blown Dust in the Western Mojave Desert

R.J. Farber, Consultant

The western Mojave Desert is an ideal setting for windblown dust. The desert has been disturbed by many sources including farming, construction, brush fires, off-road vehicles, and more recently solar farms and

wind parks. The desert experienced a severe drought from 1986- 1992. PM10 24-hour concentrations exceeded 700 ug/m3. Visibilities were often reduced to zero in blowing dust and sand. The Dustbusters Task Force was created at the request of the LA County Board of Supervisors in 1991. In 1992,, using USDA Emergency Watershed Protection funding, 2500 acres of the worse eroded soils were seeded with native vegetation. Miracle March 1992 rains doused the soils and germinated the seeds. The Dustbuster Research Group (DRG) was formed in 1992 to develop cost-effective methods for stabilizing eroding soils and restoring the desert to its native habitat. This research group is a multi-agency multi-disciplinary with easily 20 members. These methods are currently being successfully implemented in newly developing solar farms.

This presentation will focus on short term measures for stabilizing unstable soils. We will also discuss techniques for restoring disturbed land to its native undisturbed look and ecological habitat. We are continually developing and implementing improved techniques for dust mitigation and restoration. These approaches are necessary because the southwestern US is drying out and becoming increasingly disturbed.

Control Number 62

Fine Particle Generation from Fugitive Dust Sources

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ABSTRACT

Fugitive dust sources contribute fine particles to the atmosphere that can contribute to degradation of visibility. This include sources that involve mechanical disturbance to unpaved surfaces such as roadways and ravel routes for off-road recreational vehicles. Also included are sources associated with wind erosion of unstable ground surfaces under high wind conditions where dust generation is driven by saltation that sandblasts the ground surface. Wind erosion sources are particularly significant in desert environments where (a) land development is in progress as in the case of new solar farms, or (b) active farmland has recently been abandoned, typically because of water shortage. Damaging sand storms in the Desert Southwest have become more frequent as a result of the extended drought and the continuation of land development that destroys the protective features of natural desert soil including crusting and native vegetation.

This paper summarizes historical and recent field testing to determine the intensity and particle size distributions of dust plumes from fugitive dust sources. This includes the generation of particles in the respiratory size range that creates health risks and limits visibility during and immediately following high wind events. A review of test methods is presented for development of predictive emission factor equations both for sources involving mechanical disturbances activities and for sources associated with wind erosion. This includes methods involving stationary and mobile test platforms. Of particular interest is the consistency of the particle size distribution within the PM10 size range, as a function of broad source category. This result demonstrates the consistency of the underlying physical mechanisms for fine particle generation.

The paper will also provide a brief review of newly explored control measures for wind erosion that use natural materials for trapping saltating sand, thereby limiting damage to land areas further downwind. Included are crosswind berms constructed of landscaping waste or soil that has been stabilized on the upwind face. Traditional chemical stabilizers are generally cost-prohibitive for the large land areas affected and also leave potentially damaging chemical residues. Also, traditional measures that attempt to protect large areas from damage by wind erosion have often proven ineffective because such areas can be readily covered with sand during a high-wind event.

Control Number 26

Assessing the Impact of Precipitation on PM Coarse ($PM_{10-2.5}$)

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Abstract

Precipitation has a clear effect on particulate matter (PM) emissions and re-entrainment in Clark County, Nevada, but the relationship of $PM_{2.5}$ to PM Coarse ($PM_{10-2.5}$) surrounding precipitation events is not well documented or understood. This abstract outlines a method to better understand fine particulate/aerosol and $PM_{10-2.5}$ response, including mass concentration and visibility, before and after precipitation events in Clark County, Nevada.

The relationship between $PM_{2.5}$ and related aerosols and how they impact visibility is fairly well understood. PM_{10}, particularly in the United States Desert Southwest and Clark County, Nevada, is known to negatively affect visibility during high-wind days. $PM_{2.5}$ NAAQS exceedances tend to be anthropogenic in nature, often resulting from human activities (such as wood burning or fireworks) and weather patterns (such as inversions), many of which are conducive to $PM_{2.5}$ and related aerosol buildup. PM_{10} NAAQS exceedances, particularly in the United States Desert Southwest, are often caused by natural events including high winds, and these events may also impair visibility. Both $PM_{2.5}$ and PM_{10} have been evaluated in terms of how precipitation affects these pollutants, both in terms of NAAQS exceedances and visibility. However, $PM_{10-2.5}$, a regulated pollutant, has not had the same level of independent scrutiny and documentation related to precipitation in the Desert Southwest.

As part of the National Core (NCore) Multipollutant Monitoring Network, agencies, including Clark County, are required to measure $PM_{10-2.5}$ in accordance with federal regulation 40 CFR 58.
Using information from this site, we will plot $PM_{2.5}$, PM_{10}, and $PM_{10-2.5}$ trends before and after precipitation, looking closely at elevated PM and visibility events and giving particular attention to the $PM_{10-2.5}$ fraction. We will examine if $PM_{10-2.5}$ can serve as a surrogate for PM_{10} or $PM_{2.5}$ (and related aerosol). Assessment of the datasets and their relationship will be presented, and we will outline any known health-based effects of $PM_{10-2.5}$ with regard to levels of concern.

Lastly, PM measurement issues will be considered. We will investigate advantages between with continuous and filter-based measurements, outline how Clark County is measuring $PM_{10-2.5}$ and related aerosols (as applicable), and discuss what implications these measurements have on the data.

Session Associated Poster Presentation

Control Number 32

Back Trajectory and Meteorological Factors in Spring Dust Trends in the Southwestern U.S.

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Abstract

It has recently been observed that fine soil (<2.5 μm diameter) concentrations measured in the Interagency Monitoring of PROtected Visual Environments (IMPROVE) network in the southwestern United States

have increased during March, while remaining relatively stable during other months of the year. Fine soil concentrations at these mostly rural and remote sites in this region typically peak during the spring and early summer and so this March increase is interpreted as an earlier onset of the dust season. The rate of increase has been approximately 5% per year over the time period of 1995-2014 and is consistent with an approximately two weeks earlier beginning of the season. The March increase in fine soil is ubiquitous over a large four-state region and so is unlikely to be due to unique local sources or small-scale meteorological fluctuations. This increase in spring dust has implications for ecosystems, human health, the hydrologic cycle and visibility.

The temporal trends in March fine soil concentrations are correlated with the Pacific Decadal Oscillation (PDO) which, like the more familiar El Nino and La Nina, is related to sea surface temperatures in the Pacific Ocean, though with a longer periodicity. The PDO is believed to influence the position of storm tracks around the world. To further investigate the details of how the PDO influences meteorology and ultimately fine soil concentrations, hourly Automated Surface Observing System (ASOS) and Remote Automated Weather Station (RAWS) meteorological data were examined for the southwestern U.S. and back trajectories were generated for the IMPROVE sites in Colorado, Utah, Arizona, and New Mexico for 1995-2014. The surface based meteorological data were examined for trends in wind speed, wind direction, temperature, precipitation, and humidity. The back trajectory endpoints, which track transport patterns, were grouped by the known dust source regions that they traversed and then the meteorology associated with the endpoints in each source region were examined for number of endpoints (indicating transport direction), wind speed, temperature, precipitation, humidity, solar radiation, mixing depth, and transport height. The most significant finding was that the later years were drier than the earlier years as indicated by both lower average relative humidity and lower amounts of and less frequent precipitation Also, wind speeds were slightly higher during the later years. Little differences were found in wind direction, temperature, height of transport, mixing heights, number of endpoints in a source region (indicating transport direction) or how often the trajectory was below the mixing height while over a source region

Control Number124

URBAN HEAT ISLAND (UHI) INFLUENCE ON SECONDARY POLLUTANT FORMATION AT A TROPICAL HUMID ENVIRONMENT

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Abstract

The combined urbanization (change in land use) and increase in vehicular emissions enhanced the urban heat island (UHI) effect in many cities in the developed countries. The urban warming (UHI) enhances heat stress related diseases and ozone (O3) levels due to photochemical reaction. Even though UHI intensity depends on wind speed, wind direction and solar flux, the thermodynamic properties of surface materials, intensify of the temperature profiles at local scale. This mechanism modifies the atmospheric boundary layer (ABL) structure and mixing height in a local scale. The change in mixing height at local scale will further influence the local air quality. In the present work, an attempt has been made to understand the interrelationship between air pollution and UHI intensity at an urban area in Chennai city.

The characteristics of ambient temperature profiles associated with the land cover changes in the different microenvironments of Chennai city have been simulated using Envi-Met model. The model results showed

significance of wind velocity on UHI intensity i.e. lower the wind speed higher the UHI effect. Further, Richardson number has been estimated to study the diurnal variation of the mixing height. The estimated lowest mixing height at residential area was found to be 60 m at middle of the night. Height ozone (O3) concentrations were also observed during that period. The measured ozone (O3) concentrations during that period also showed increase in levels. The simulated surface air temperatures (2.5 m above the ground) showed 1.5±0.5 and 2.25±0.5oC difference between the urban background site with commercial and residential sites.

Session 16A. Light Absorbing Carbon.

Control Number 71

Contribution of Different Chemical Species to Brown Carbon Aerosol in Biomass Burning Emissions

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Abstract

Brown carbon (BrC) has been shown to be an important contributor to light absorption by atmospheric aerosols in the blue and near-ultraviolet (UV) part of the spectrum. A significant portion of BrC emissions in the atmosphere has been associated with biomass-burning during wildfires, such as forest and peat fires. Although BrC is a recognized radiative forcing agent, there is still little known about this atmospheric organic fraction. No attempt has been made so far to quantitatively analyze the contribution of individual organic species and different compound classes, including HUmic LIke Substances (HULIS), polycyclic aromatic hydrocarbons (PAHs), and other water-soluble and non-water-soluble organic species, both primary and secondary, to light absorption.

We will report optical properties and chemical composition of fresh and aged biomass burning emissions measured during laboratory combustion of fuels from five different locations around the world (boreal forest and peat land, Siberia, Russia; extra tropical forest, Oregon, USA; tropical forest and peat, Brazil; coastal swamp peat, Florida, USA; mixed conifer forest, Sierra Nevada mountains USA), covering the main wildfire-prone areas of the globe. Aging of biomass burning emissions was done using the potential aerosol mass reactor (PAM, Aerodyne Research Inc.). Aerosol optical properties were measured with a three-wave photoacoustic instrument that provides information on wavelength dependence of light absorption by biomass burning aerosols. For chemical characterization, emissions were collected on filters and XAD cartridges. Collected samples were extracted separately with (a) water and (b) dichloromethane followed by acetone. The extracts were analyzed using gas chromatography mass spectrometry (GC-MS; Varian 4000 Ion Trap and Scion Triple Quad MS/MS), ultra-high-performance liquid chromatography coupled to evaporative light scattering detector (Waters UPLC-ELSD), and Total Organic Carbon analyzer (TOC; Shimadzu TOC-VCSH). Hundreds of individual compounds were quantified. Absorption spectra of the extracts and the most prominent compounds were recorded between 190 and 900 nm with a UV/VIS spectrophotometer (PerkinElmer, Lambda 650). Spectra and concentrations of individual compounds were then combined to estimate their contribution to the total light absorption by the extracts.

Control Number 113

Light absorbing carbonaceous aerosols from cookstoves in India

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Abstract

Solid biomass fuels are the primary source of cooking energy in India. Combustion of solid biomass in traditional cookstoves is the largest of carbonaceous aerosols emissions in the region. The atmospheric effects of carbonaceous aerosols emissions over the Indian subcontinent are multifold: they have been linked to surface dimming, weakening of Indian monsoon, and melting of the Himalayan glacier. However, there is a high level of uncertainty in the magnitude of the aerosol direct forcing over this region due to the underlying uncertainties and discrepancies in inputs to the climate models. One important step towards reconciling observational data on aerosol atmospheric impacts with outputs from climate models is improving our understanding of emissions source characteristics. Findings from a few previous studies indicate that there may be significant differences between the magnitude and composition of in-field particulate emissions from biomass cookstoves, and those measured in laboratory studies. Therefore, the first objective of this field study was to develop particulate emission factors from in-field operation of a traditional stove using common solid biomass fuels. Further, the absorption characteristics of these emissions, particularly the role of light absorbing Organic Carbon (LAOC), are not well established. We aimed to address this gap by estimating wavelength dependent Mass Absorption Cross-sections (MAC) of the emitted aerosols and their organic components.

Our field study was conducted in Raipur, Chhattisgarh (a central Indian state) in December 2015. Common types of biomass fuel — fuelwood, agricultural residue and cow dung — from different regions of India were used in a traditional mud stove, to prepare typical meals in a household kitchen. Emissions were sampled with an eight-armed probe at a height of ~1m from the stove, and analyzed by a portable mobility particle sizer, optical ultra-fine particle counter and a continuous gas analyzer. Two Harvard sharp impactors and Minivols, placed at a horizontal distance of ~ 1m from the stove were used to collect particle samples on Teflon and quartz fiber filters. These filter samples were collected during the ignition, steady flaming and smoldering phases of the combustion cycle. The Teflon filters sampled were used for gravimetric analysis and UV-vis spectrophotometry on the filter deposits and their extracts in water and acetone. Thermo-optical (IMPROVE-TOR) analysis on the quartz filters yielded the total carbon and elemental/organic fractions. Emission factors ($PM_{2.5}$, EC, OC and CO) were calculated using the carbon balance method, using measured fuel carbon contents. Filter transmission spectra were used to calculate the total aerosol MAC, with appropriate corrections for filter measurement artifacts. The total MAC was apportioned to Black Carbon and LAOC using the two-component deconvolution scheme. The total contribution of LAOC to aerosol light absorption was estimated by integrating its spectrally varying absorption coefficient with solar irradiance in the 300-900 nm wavelength range.

Control Number 94

Brown carbon absorption in the red and near infrared spectral region

András Hoffer, Ádám Tóth, András Gelencsér, MTA-PE Air Chemistry Research Group, Hungary, Chul E. Chung, Desert Research Institute, USA

Abstract

Black carbon aerosols have been conventionally assumed to be the only light-absorbing carbonaceous particles in the red and near-infrared spectral regions of solar radiation in the atmosphere. Here we report that contrary to the conventional belief tar balls (a specific type of organic aerosol particles from biomass burning) do absorb red and near infrared radiation significantly. Tar balls were produced in a laboratory experiment and their chemical and optical properties were measured. The absorption of these particles in the range between 470 and 950 nm was measured with an aethalometer, which is widely used to measure aerosol absorption in the field. We find that the absorption coefficient of tar balls at 880 nm exceeds 10% of that at 470 nm. This substantial absorption of red and infrared light is also evident from a relatively low Angström coefficient (and a significant mass absorption coefficient) of tar balls between 470 and 950 nm. Retrievals of

aerosol column optical properties from a global network of surface stations over vast tropical areas dominated by biomass burning suggest that tar balls are the predominant light-absorbing species of organic aerosols. Our results also infer that the role of BC (including Diesel soot) in global climate forcing has likely been overestimated at the expense of brown carbon (BrC) from biomass burning.

Control Number 75

A Decade of Backscatter-Corrected Transmittance Measurements by IMPROVE

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ABSTRACT

Light absorption by aerosol particles can affect atmospheric visibility and climate and is not easily measured directly nor easily predicted from chemical composition. The IMPROVE (Interagency Monitoring of PROtected Visual Environments) network monitors the attenuation of light by $PM_{2.5}$ samples routinely collected on PTFE (polytetrafluoroethylene) filters throughout the United States. Filter-based absorption measurements more conventionally employ optically thick quartz- or glass-fiber collection media, for which a substantial calibration literature offers algorithms to correct for particle scattering and filter loading effects. PTFE membranes are optically thinner and less homogeneous than the fiber media, but they avoid interference from adsorbed organic gases that is associated with quartz and glass fiber media. IMPROVE's measurement system is a hybrid of integrating sphere and integrating plate that records the light backscattered as well as transmitted by each filter. A theory-based model has now been developed for the system's optics and shown to account satisfactorily for particle scattering effects as well as production variations in filter optics. Tests based on historical analyses of field blanks and recent reanalyses of archived samples establish that the current system has operated with a stable calibration since 2003. This paper introduces calibrated absorption data based on the new model, data which provide a consistent historical record of sample optics to support IMPROVE's chemical characterizations of the sampled aerosol.

The newly calibrated IMPROVE absorption values correlate strongly with the refractory carbon fraction reported by thermal-optical analysis as "elemental" (EC). EC is sometimes treated as the only significant light absorber in $PM_{2.5}$, but the general decline observed between 2005 and 2014 in IMPROVE EC was not accompanied by a comparable decline in IMPROVE absorption. Absorption also exhibits a distinct association with Fe concentrations from XRF analysis. Iron concentrations at rural and remote IMPROVE sites are attributable mainly to mineral dusts and have generally held steady or risen since 2003 (Hand et al., this conference). An increased relative contribution by mineral dusts can explain some, but not all, of the observed difference between recent absorption and EC trends; additional effects may be attributable to trends in the character of carbonaceous emissions.

Control Number 41

Multispectral BC Comparison to Continuous Mass Measurement of Wide-Ranging Aerosols

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The responses of a new filter-based carbon measurement instrument is compared to continuous PM measured with beta attenuation and a near-IR nephelometer at ten discrete wavelengths ranging from 375 nm to 950 nm when challenged with a variety of artificially generated and naturally occurring aerosols. All monitors were configured to sample $PM_{2.5}$. A Met One Instruments, Inc., BC-1054 multispectral carbon monitor was collocated with a Magee Scientific, Inc. AE21 Aethalometer®, Met One Instruments BAM-1022 beta attenuation mass monitor, and a Met One Instruments E-Sampler at an air quality monitoring site in Elizabeth NJ located adjacent to a turnpike toll booth and previously used by Met One Instruments for US-EPA equivalency designation testing. Additional ambient air quality monitoring was conducted in Grants Pass OR. In addition to the ambient air quality monitoring all monitors were set up to sample from a test chamber into which controlled levels of diesel exhaust, wood smoke, cigarette smoke or incense smoke were introduced.

The BC-1054 multispectral carbon monitor automatically measures the absorption of aerosols collected onto glass fiber filter tape at 375, 430, 470, 525, 565, 590, 660, 700, 880 and 950 nm with one-minute time resolution. The Magee Scientific AE21 Aethalometer automatically monitors the absorption of aerosols collected onto quartz filter tape at 370 and 880 nm. Absorption data from both monitors was corrected for filter loading with a post processing algorithm on a one-hour time scale, employing the "binned" algorithm first developed by Park.

The results of the tests reveal broad agreement between the BC-1054 and AE21 results for both the near-UV and near-IR illumination wavelengths for both raw uncorrected hourly data and filter-loading corrected data. The results also indicate that for ambient aerosols, black carbon levels as determined by near-IR 880 nm illumination were typically on the order of 5% or less of ambient mass concentrations as determined by the BAM-1022 continuous beta gauge on the hourly time frame. Further, ambient black carbon levels at 880 nm did not significantly deviate from black carbon levels at 375 nm, indicating that insignificant amounts of the PM were comprised of organic compounds possessing electronic transitions in the near-ultraviolet. Absorption measurements made from samples collected from a diesel generator indicate that sampled particulate matter is mainly black carbon.

Comparison of mass concentrations as determined by the beta attenuation mass measurements and light-scatter based nephelometry measurements to black carbon measurements made by both the BC-1054 and Aethalometer demonstrates good correlation during the measurement campaigns in both Elizabeth NJ and Grants Pass OR. Finally, comparison of beta attenuation mass measurements and light-scatter based measurements to black carbon measurements demonstrate excellent correlation for artificially generated aerosols comprised of diesel exhaust, incense, and cigarette smoke.

Session Associated Poster Presentations

Control Number 107

Optical Properties of Emissions from Laboratory Peat Combustion

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Abstract

Globally, organic soils and peats may store as much as 600 Gt of terrestrial carbon, representing 20 – 30% of the planet's terrestrial organic carbon mass. This is approximately the same carbon mass as that contained

in Earth's atmosphere, despite peatlands occupying only 3% of its surface. Effects of increasing fire frequency and size in these ecosystems are of global concern due to the potential for enormous carbon release into the atmosphere with significant implications for the global carbon cycle and radiative forcing. Combustion of peat mostly takes place in the low temperature, smoldering phase of a fire. It consumes carbon that may have accumulated over a period of hundreds to thousands of years. In comparison, combustion of aboveground biomass fuels releases carbon that has accumulated much more recently, generally over a period of years or decades.

Here, we present the aerosol optical properties from the controlled laboratory combustion of peat soil samples from three regions, Siberia (Russia) and Alaska and Florida (USA). Aerosol absorption and scattering coefficients measured using a three-wavelengths photoacoustic instrument were analyzed for single scattering albedo (SSA) and absorption Ångström coefficient (AAC) and compared with previously reported values for other common wild land fuels. The mean organic mass-normalized absorption cross-section (MAC) of peat samples was found to be quite low, ranging from as low as 0.001 m2g-1 at 781 nm to as high as 0.32 at 405 nm; however, combustion emissions from all peat samples depicted large AAC. While SSA values (0.9-1.0 at 405 nm) were similar to those from other wildland fuels, AAC values, (4.5-7.2 range at 405-870 nm) were substantially higher for emissions from peat combustion. These results have important implications for radiative forcing, actinic fluxes driving photochemistry, and optical source apportionment. Three fuel moisture levels were used in this work to enable us to determine whether peat sources or fuel moisture content were more important for the optical characteristics of combustion emissions. Results showed that SSA and AAC vary with moisture content—higher moisture content results in higher SSA values and lower spectral dependence of AAC. Florida lake peat (at 10% moisture level) exhibited the highest AAC value (~7.2).

Control Number 90

The Impacts of Diesel Emission Control Strategies on Elemental Carbon Concentrations in the South Coast Air Basin

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South Coast Air Quality Management District (SCAQMD) has been conducting comprehensive elemental carbon (EC) measurements at $PM_{2.5}$ speciation sites in the South Coast Air Basin (SoCAB) for more than a decade. Long-term monitoring of speciated aerosols provides the opportunity to study the changes in carbonaceous aerosols over time and assess the success of regulatory efforts, such as stringent statewide regulations and a myriad of incentive programs, in reducing diesel emissions. EC in atmospheric particulate matter (PM) originates from a broad range of sources, most notably fossil fuel combustion and biomass burning in urban locations. EC emissions in urban environments are used in environmental health and air quality studies as a surrogate to monitor diesel PM exposure.

Diesel exhaust is considered a toxic air contaminant in California. The most recent Multiple Air Toxics Exposure Study (MATES IV) conducted by the SCAQMD showed that diesel PM accounted for 68% of the total cancer risk from air toxics in the Basin. In addition, diesel PM was found to be the largest source of elemental carbon in the Basin, even though the diesel PM exposure declined by approximately 70% between the MATES III (2005) and the MATES IV (2012) studies. We attribute the observed declining trends in EC concentrations to the reduction in vehicular emissions due to numerous stringent regulations and incentive programs (i.e. Carl Moyer Program, School Bus Program, Proposition 1B-Goods Movement Program, etc.) that target diesel emissions (primarily $PM_{2.5}$ and NOx) by introduction of advanced technologies with lower

emission rates, retrofitting engines with emission control systems, replacing existing engines with newer technology engines, and placing restrictions on the operation of existing equipment.

Long-term changes in the motor vehicle fleet emissions impact their relative contribution to EC emissions. The regulations addressing diesel PM do not have a substantial impact on light-duty vehicle emissions. Consequently, the decrease in the ratio of EC to $PM_{2.5}$ concentrations throughout the past decade indicates that the decline in EC has outpaced the decline in total fine particulate mass, primarily due to significant reductions in diesel emissions. The relative contribution of heavy-duty and light-duty vehicles can be assessed by emission ratios of EC/CO, which are very different depending on the types of emission sources. For example, EC/CO emission ratios are known to be much higher for diesel engines as compared to ratios for gasoline vehicles. Therefore, the EC/CO correlation ($\Delta EC/\Delta CO$) is a suitable parameter for detecting changes in the strength of EC emissions and examining the relative contribution of different sources to total EC emissions.

The goal of the current study is to assess the effects of air quality regulations and the effectiveness of incentive programs that target Diesel PM, $PM_{2.5}$ and NOx, using EC emissions. This study helps identify and evaluate emission mitigation measures that can lower emissions at reasonable cost and the societal imperative of reducing human health effects arising from these emissions.

Control Number 105

Aerosol Optics, Radiative Forcing, and Climate Change

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Abstract
The common perception of climate change is dominated by the greenhouse effect due to gases such as carbon dioxide. Aerosols influence the earth's direct radiative forcing and climate largely through modifying the planetary albedo, which is the whiteness of the planet as seen from space. If aerosols are whiter than the underlying scene, they increase the planetary albedo, have a negative radiative forcing and cause cooling (more solar energy is scattered back into space); otherwise if they appear darker, they decrease the planetary albedo, have a positive radiative forcing and cause heating (more solar energy is retained by earth). In addition, aerosols can continue to cause radiative forcing after deposition. In particular, dark aerosols can strongly decrease surface albedo after deposition on high-albedo surfaces such as snow and ice.
The dominant aerosol optical property that determines radiative forcing is the aerosol single scattering albedo (SSA) integrated over the solar spectrum with an additional contribution from the asymmetry parameter or hemispherical backscatter ratio (Chýlek and Wong, 1995). The SSA is the ratio of scattering to extinction coefficient, with the extinction coefficient being the sum of scattering and absorption coefficient. The ambient aerosols with the most uncertainty in their SSA spectra are carbonaceous aerosols emitted by combustion processes and entrained mineral dust.

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Chýlek, P., and J. Wong (1995). Effect of Absorbing Aerosol on Global Radiation Budget. *Geophys. Res. Lett.*, **22**, 929-931.

Control Number 47

Physicochemical characteristics of the black carbon aerosol and its radiative impact in a polluted urban area of China

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Abstract

Black carbon (BC) aerosol plays an important role in the Earth's radiative balance. An intensive measurement campaign was conducted at Xi'an, China during winter to investigate the sources and physicochemical characteristics of refractory BC (rBC) and its direct radiative forcing at the surface. The average mass concentration of rBC was 8.0 ± 7.1 μg m^{-3}, with high values in the morning and at night and lower values in the afternoon. Receptor modeling showed that motor vehicle traffic was the largest contributor to the rBC aerosol, accounting for 46.0 ± 25.1% of the total rBC, followed by coal burning (33.9 ± 23.8%) and biomass burning (20.1 ± 7.9%).

The rBC mass-size distribution for the ensemble of all samples was mono-modal and lognormal, and it had a mass median diameter (MMD) of 207 nm, which presumably was the result of the mixed emissions from the traffic, coal burning, biomass burning, and possibly other sources. The MMD for rBC from coal burning was 215 nm, which was ~26 nm larger than the MMD for the traffic source samples (189 nm). This difference can be attributed to the combined effects of the fuel types burned, combustion conditions, transport, and aging. The results reported here are the first to document larger rBC particles in ambient air from coal burning compared with those from traffic sources from China. Furthermore, the number fraction of thickly coated rBC (f_{BC}) was much larger for the coal burning sample group (50.3 ± 7.7%) compared with the traffic source group (36.9 ± 7.2%). The contributions of organics, sulfate, and nitrate to the coatings on rBC from coal burning were estimated to be 44.0%, 32.3%, and 23.7%, respectively. In comparison, the contributions to the coatings of traffic rBC were organics = 63.2%, sulfate = 10.3%, and nitrate = 26.5%. These differences among the coatings from the two sources can be attributed to the complex processes involved in the formation of the rBC particles as well as those involved in the aging processes (condensation, coagulation, and photochemical oxidation, etc) that alter the particles' size, composition, and mixing state after emission. These observations also imply that the rBC particles from coal burning will more readily act as cloud condensation nuclei than those from the traffic sources because the former have more hygroscopic (water-soluble ion) coatings.

The Tropospheric Ultraviolet and Visible (TUV) radiation model indicated that the mean daytime value for the clear-sky direct radiative forcing (DRF) caused by rBC varied from -116.8 to -10.3 W m^{-2} and averaged -47.7 ± 28.9 W m^{-2}. Furthermore, rBC contributed 45.7% to the total surface atmospheric aerosol forcing of -100.5 ± 46.1 W m^{-2}. The mean daytime values for the total aerosol and rBC surface DRF during pollution periods (-107.4 and -49.3 W m^{-2}, respectively) were much higher than those during non-pollution periods (-59.3 W m^{-2} for total aerosol and -37.8 W m^{-2} for rBC), which was simply due to the larger particulate loadings during pollution periods.

Control Number 43

Effects of black carbon mixing state on aerosol-climate interaction in China using a source-oriented WRF/Chem model

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Abstract

Black carbon (BC) has profound impacts on air quality and climate change due to its contribution to total particulate matter mass and its absorption of solar radiation. Recent studies have shown that the mixing state of BC plays an important role in its ability of absorbing radiation. The coating of secondary aerosols greatly enhances the extinction coefficients of BC and improves its chance of being cloud condensation nuclei (CCN). Without consideration of BC mixing state in current models is leading to an

under-prediction in effects of aerosols on climate. China is experiencing severe air pollution with high levels of BC concentration and fast BC aging processes. The effects of aerosols in China on regional and global climate will not be well understood if BC mixing state is not considered.

In this study, a source oriented WRF/Chem model (SOWC) that explicitly tracks the mixing state of particles emitted from different sources in the simulation of atmospheric chemistry is applied to a severe polluted month in 2013 in China. The SOWC model realistically calculates the optical properties of light absorbing particles and secondary products when particle mixing state is important. The ability of the model to reproduce meteorological parameters, gas and particulate pollutant concentrations, particle optical coefficients, and cloud optical thickness will be evaluated. Then, the effects of BC mixing state on climate will be quantified.

Control Number 109

Coefficients of an Analytical Aerosol Forcing Equation Determined with a Monte-Carlo Radiation Model

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Abstract

Simple analytical equations for global-average aerosol radiative forcing are useful to understand how aerosol forcing depends on key atmosphere, surface and aerosol parameters (Chýlek and Wong, 1995). The surface and atmosphere parameters in these analytical equations are the globally uniform atmospheric transmittance and surface albedo and have so far been estimated from simplified observations under untested assumptions. In the present study, we take the state- of-the-art analytical equation and modify it to be a function of the single scattering albedo and the asymmetry parameter. Then we determine the surface and atmosphere parameter values of this equation using the output from the global MACR (Monte-Carlo Aerosol Cloud Radiation) model, as well as testing the validity of the equation. The MACR model incorporated spatio- temporally varying observations for surface albedo, cloud optical depth, water vapor, stratosphere column ozone, etc., instead of assuming as in the analytical equation that the atmosphere and surface parameters are globally uniform and should thus be viewed as providing realistic radiation simulations.

The modified analytical equation needs globally uniform aerosol parameters that consist of aerosol optical depth, single scattering albedo, and asymmetry parameter. The MACR model is run here with the same globally uniform aerosol parameters. The MACR model is also run without cloud to test the cloud effect. In both cloudy and cloud-free runs, the equation fits in the model output well. This means the equation is an excellent approximation for the atmospheric radiation. On the other hand, the determined parameter values are realistic for the cloud-free runs but not realistic for the cloudy runs. The global atmospheric transmittance, one of the determined parameters, is found to be around 0.74 in case of the cloud-free conditions and around 1.03 with cloud. The surface albedo, another determined parameter, is found to be around 0.18 and 0.28 in case of cloud-free and cloudy-sky conditions respectively. Because the cloudy-sky runs yield unrealistic parameter values, we conclude that the equation is more adequate for cloud-free conditions.

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Chýlek, P., and J. Wong (1995). Effect of Absorbing Aerosol on Global Radiation Budget. *Geophys. Res. Lett.*, **22**, 929-931.

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Control Number 112

Intensive optical properties of fresh and aged brown carbon aerosols from biomass burning in the Arctic Tundra

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Abstract

Organic aerosol (OA) is known to constitute a large portion of total tropospheric particulate matter, and the characterization of sources and fates of OA in the atmosphere is crucial to our understanding of the relationship between human activity and global climate. Boreal forest fires have been shown to be the largest contributor to OA emissions in the Arctic region and contribute between 46 and 72% of all carbon emissions in a given year. These ecosystems serve as a carbon sink, holding up to one-third of the planet's terrestrial organic carbon (OC), primarily in peatlands, moss, and litter. Accumulation in this biomass has been occurring over hundreds to thousands of years and plays an important role in regulating the planetary carbon cycle and climate. During the past several decades, an increase in wildfires has released substantial amounts of particulate matter and greenhouse gasses. In particular, emissions from low-temperature smoldering fires have contributed to changes in the quantity of seasonal snow cover, ice and permafrost, and vegetation productivity in the Arctic Tundra, which has seen a rise in surface air temperatures at approximately twice the global rate.

Brown carbon (BrC) aerosols are light-absorbing OC aerosols emitted from long-lasting smoldering phases of wildfires. The aerosol emission mechanism during smoldering is distinct from flaming emissions, and BrC aerosol particles have different physical, chemical, and optical properties than black carbon aerosols. BrC aerosols have been shown to absorb short-wavelength solar radiation due to a significant wavelength-dependence in the imaginary part of the index of refraction which increases towards the shorter visible and UV wavelengths. There is a large uncertainty in the intensive optical properties of brown carbon, and these properties undergo changes as a function of atmospheric residence time. As residence time increases, particulates are subject to chemical and physical changes that affect radiative properties.

To investigate the changes in physicochemical properties across long atmospheric residence times, a Potential Aerosol Mass (PAM) reactor has found wide use in recent years to simulate atmospheric oxidation processes on timescales from one to several days. For this study, peat samples were collected from different regions of Alaska, combusted in the smoldering phase at the *Washington University Biomass Combustion Chamber* to generate BrC aerosols, and were "aged" to different timescales using a PAM reactor under the combined influence of OH, O_3, and UV light. This talk will provide a comprehensive comparison of the measured intensive optical properties such as single-scattering albedo, hemispherical backscatter fraction, and asymmetry parameter of both fresh and aged BrC aerosols in the 375 – 1047 nm (UV-Vis-IR) spectrum from burning of Alaskan peat lands.

Control Number 111

A Two-Component 'Ångström Exponent' analysis of Aethalometer Data

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Abstract

Over the spectral range from the near-infrared to the near-ultraviolet, the optical absorption of atmospheric aerosols collected on a filter has been described by a two-component model (for example, Chen, Chow et al., 2015) which combines absorption due to "Black" material (wavelength dependence of absorption proportional to λ^{-1}), with that due to "Brown" material whose absorption over this range is approximated by a wavelength dependence of $\lambda^{-\alpha}$.

Data is reported by the Aethalometer at seven wavelengths from 370 nm to 950 nm. This may be fit to the above model to separate the two components, both in terms of the magnitude of their contributions, as well as the Ångström Exponent (**α**) of the second component. The separation suggests a source apportionment of "Black Carbon", typically associated with high-temperature combustion processes such as diesel emissions; versus that of "Brown Carbon", typically associated with low-temperature combustion of biomass-like materials.

This presentation will show the results of this analysis applied to two air-sampling scenarios. The first scenario was a rural town in wintertime, impacted by emissions from residential wood combustion but asserting that its PM exceedances were due to diesel traffic. The second scenario was a rural location impacted by summertime forest-fire emissions. In both cases, the Ångström Exponent analysis of Aethalometer data is compared to co-located measurements of PM2.5 mass; and, in one case, periodic analyses of levoglucosan as a tracer for biomass combustion.

The results show that there is a clear relation between PM2.5 mass and the "Brown" and "Black" Carbon components of optical absorption derived from the Aethalometer data. The results also suggest that under conditions of total dominance of biomass-burning emissions, an identifiable "Black" carbon component is associated with the "Brown" carbon analysis, representing co-emissions from a high-temperature portion of the combustion process. However, the frequency distribution of the ratio of these two components of biomass smoke suggest that it may be possible to separate 'flaming' from 'smoldering' combustion emissions.

These results have significance for the analysis of multi-wavelength optical absorption data; the source apportionment of combustion-derived aerosol components; and inputs to models of the radiative effects of these emissions.

Reference: "Multi-wavelength optical measurement to enhance thermal/optical analysis for carbonaceous aerosol" L.-W. A. Chen, J. C. Chow, et al., AMT, 8, 451–461, (2015)
Control Number 110

Fractal Scaling and Radiative Properties of Coated Soot Aggregates: Implications for Direct Forcing

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Abstract

Soot Aggregates (SAs) in the atmosphere significantly influence the earth's radiation balance and climate, visibility, and public health. They are formed from high-temperature, incomplete combustion of fossil and biomass fuels via diffusion-limited aggregation of spherical monomers. Real-world combustion sources, such as wildfires and engines, operate in fuel-rich conditions and co-emit large amounts of gas-phase organic compounds along with SAs. These compounds, either upon cooling or after undergoing atmospheric processing, get deposited on the aggregate surfaces as layers of external coating.

Recent studies have shown SAs can contain significant amounts of surface coatings of organic compounds which obfuscate their native fractal morphology and make them visually appear as "near-spherical". Depending on the amount of coating mass, the morphologies of SAs are currently parameterized using mass fractal dimension (D_f) values in the range of $1.8 \leq D_f \leq 3.0$. We performed detailed three-dimensional

morphological characterization of simulated surface coated aggregates that mimic atmospheric SAs. Our results show that D_f remains invariant at 1.8 with increasing coating mass. We also found coating to affect only the fractal prefactor, an understudied parameter which controls the aggregate shape anisotropy and local packing fraction of monomers. Based on our results, we provide revised scaling relationships to enable better representation of SA morphologies in climate models.

There has been a recent surge in interest to investigate the role of coating on enhancement of light absorption by SAs. Several recent field and laboratory studies have reported an absorption enhancement of up to a factor of three due to the presence of organic coating on SAs. To accurately determine this phenomenon, we calculated the optical properties of our simulated coated SAs using the discrete dipole approximation (DDA) algorithm. DDA is optimal for coated SAs since it can easily model irregular geometries with no extra cost in computational time or accuracy. Concurrent with previous experimental findings, our results show an enhancement in light absorption by coated SAs up to a factor of three. More surprisingly, however, is that the aerosol scattering cross-showed an increase of an order of magnitude compared to the absorption cross-section. This enhancement leads to an increased single scattering albedo for coated SAs in comparison to nascent SAs of equivalent size. We infer that coated SAs could lead to enhanced cooling effects than what has been previously thought. Our results could potentially lead to a revision of how coated SAs are currently modeled in climate models and upending our views on their role in enhanced warming amplification.

Control Number 100

Representing the black carbon aging process in the two-way coupled WRF-CMAQ modeling system

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Abstract:

As one of harmful pollutants in the atmosphere, aerosol also acts as an important climate forcing species influencing the atmosphere and ecosystem through the interaction with climate system. However, current atmospheric models have significant deficiency in reproducing the mixing state and aging process of black carbon aerosols, thus fail to make accurate representation of the optical properties of black carbon aerosols. Therefore, reducing the uncertainties of the radiative forcing associated with sources, morphography and aging process of black carbon aerosols is crucial to successful evaluation of the aerosol climate effects.

To date, only a few models explicitly resolved the mixing state of BC particles by simulating the relative aging process. *Riemer et al.* (2009) reported a stochastic particle-resolved model PartMC-MOSAIC, which resolves the composition of each particle, hence, tracts the mixing state of particles. The aerosol model MADRID-BC (*Oshima et al.*, 2009) simulated the mixing state of particles with two-dimensional aerosol sections and applied in WRF-CHEM model (*Matsui et al.*, 2013). However, these two methods are computationally expensive and cannot be directly used in modal models.

Therefore, we developed a new module in two-way coupled WRF-CAMQ modeling system. Fresh BC and aged BC (with coating) were represented as separated species. The freshly emitted BC was considered as external mixing. It would transfer to aged BC by condensation and coagulation. Parameters, such as the detailed reaction rate refers to the smoke chamber experiments in recent references. Core-shell Mie theory was employed to calculate the scattering and absorption cross section. The newly developed WRF-CMAQ/BC-AGING system (Two-way WRF-CMAQ model with BC mixing state module) was validated through comparison with the observed carbonaceous aerosol aging data. Aging rates of black carbon under different circumstances, as well as impacts on the aerosol radiative effects from the aging process were evaluated. Preliminary results suggested that newly developed black carbon aging module significantly improves the model performance in the simulation of mixing states and radiative properties of black carbon. Additionally, the WRF-CMAQ/BC-AGING system will be used to simulate a campaign conducted in Beijing, March 2015. Species composition of single particle from Soot Particle Aerosol Mass Spectrometer (SP-AMS) and single particle albedo (SSA) from photo-acoustic spectroscopy will be used to further validate the modeling results.

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Riemer, N., West, M., Zaveri, R.A., and Easter, R.C. (2009), Simulating the evolution of soot mixing state with a particle-resolved aerosol model, Journal of Geophysical Research-Atmospheres, 114, doi:10.1029/2008jd011073.

Control Number 48

Sensitivity of BC concentrations and climate impact to aging and scavenging processes in the OsloCTM2

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The potentially strong climate warming of black carbon (BC) aerosols, combined with the short atmospheric residence time and harmful health impacts, has made BC reductions an attractive climate mitigation measure. However, accurately representing the distribution of BC in global atmospheric models remains challenging. In particular, several studies show an underestimation of the magnitude, and failure to capture the seasonal cycle, of Arctic BC surface concentrations and an overestimation of high-altitude BC concentrations over remote regions compared to measurements. Because the impact of the aerosols on radiation and temperature depends strongly on altitude, such discrepancies lead to uncertainties in the net climate impact of BC. While overestimating high-altitude concentrations can result in an overestimation of the BC radiative forcing (RF), too low surface concentrations may lead to an underestimation of the temperature response. This in turn poses significant challenges for the design and evaluation of effective BC mitigation measures.

We use the chemistry-transport model OsloCTM2 with the microphysical aerosol parameterization M7 (OsloCTM2-M7) and investigate the sensitivity of modeled BC to a range of parameters controlling the concentrations and remote vertical distributions of BC. Furthermore, we quantify the impact of changes in the concentrations on the consequent RF and surface temperature response.

We find that shorter aging timescales or increasing scavenging efficiency can improve the representation of remote vertical BC profiles compared to measurements, in line with previous studies. However, this is typically at the expense of an exacerbated model performance in the Arctic. Relative to the baseline simulation, our sensitivity experiments results in changes in the global-mean RF and surface temperature response of up to 40% and 30%, respectively.

Averaged over the Arctic, the changes are larger. In particular, several sensitivity experiments reduce the Arctic BC surface concentrations significantly, resulting in up to 80% percent lower Arctic surface temperature responses.

Control Number 10

Quantifying enhancement in aerosol radiative forcing during 'extreme aerosol days in summer at Delhi National Capital Region, India

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Abstract

Changes in aerosol characteristics (spectral aerosol optical depth, AOD and composition) are examined during the transition from 'relatively clean' to 'extreme' aerosol days in the summer of 2012 at Delhi National Capital Region (NCR), India. AOD smaller than 0.54 (i.e. 12-year mean AOD −1σ) represents 'relatively clean' days in Delhi during the summer. 'Extreme' days are defined by the condition when AOD 0.5 exceeds 12-year mean AOD +1 standard deviation (σ). Mean (±1σ) AOD increases to 1.2 ± 0.12 along with a decrease of Angstrom Exponent from 0.54 ±0.09 to 0.22 ±0.12 during the 'extreme' days. Aerosol composition is inferred by fixing the number concentrations of various individual species through iterative tweaking when simulated (following Mie theory) AOD spectrum matches with the measured one. Contribution of coarse mode dust to aerosol mass increased from 76.8% (relatively clean) to 96.8% (extreme events), while the corresponding contributions to AOD0.5 increased from 35.0% to 70.8%. Spectrally increasing single

scattering albedo (SSA) and CALIPSO aerosol sub-type information support the dominant presence of dust during the 'extreme' aerosol days. Aerosol direct radiative forcing (ADRF) at the top-of-the-atmosphere increases from 21.2 Wm^{-2} (relatively clean) to 56.6 Wm^{-2} (extreme), while the corresponding change in surface ADRF is from −99.5 Wm^{-2} to −153.5 Wm^{-2}. Coarse mode dust contributes 60.3% of the observed surface ADRF during the 'extreme' days. On the contrary, 0.4% mass fraction of black carbon (BC) translates into 13.1% contribution to AOD0.5 and 33.5% to surface ADRF during the 'extreme' days. The atmospheric heating rate increased by 75.1% from 1.7 K/day to 2.96 K/day during the 'extreme' days