FINAL PROGRAM

ATMOSPHERIC OPTICS:
AEROSOLS, VISIBILITY, AND THE RADIATIVE BALANCE

October 5 – 8, 2021 • Bryce Canyon, UT

www.awma.org/visibility

Air & Waste Management Association

FINAL PROGRAM

ABOUT THE CONFERENCE

Established in 1979, 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. Hot topics added for 2021 include sessions on the Regional Haze Rule, satellite and remote sensing, biomass burning and the effects of wildfire, including fire behavior and forecasting, impacts on visibility, radiative balance and health.

GENERAL INFORMATION

REGISTRATION

On site registration and the A&WMA desk will be open in the Ruby's Inn lobby during the following hours.

Monday, Oct. 4: 7:00 am - 5:00 pm

Tuesday, Oct. 5: 7:00 am - 5:00 pm

Wednesday, Oct. 6: 7:00 am - 12:00 pm

Thursday, Oct. 7: 7:00 am - 5:00 pm

Friday, Oct. 8: 7:30 am - 10:30 am

LOCATION & LODGING

Conference Hotel
Ruby's Inn
26 South Main Street
Bryce Canyon City, UT 84764
(866) 866-6616 www.rubysinn.com

REFUND POLICY

If written notice of cancellation is received on or before September 15, 2021 payment will be refunded, less a $100 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.

TRANSPORTATION

There will be a shuttle bus available for $99 each way operated by LD Tours on the following dates:

Sunday, October 3, departing LAS at 4 pm

Saturday, October 9, departing Bryce Canyon at 7 am.

The return bus will load at 6:45 am at the Ruby's Inn lobby.

CONFERENCE COMMITTEE

- Delbert J. Eatough (Chair), Brigham Young University
- Joe Adlhoch, Air Resource Specialists
- Elisabeth Andrews, NOAA
- Pat Brewer, Consultant
- Kip Carrico, New Mexico Institute of Mining and Technology
- Rajan Chakrabarty, Washington University in St. Louis
- Judith Chow, Desert Research Institute
- Jenny Hand, Colorado State University
- Brett Gantt, U.S. EPA
- Philip Hopke, Clarkson University
- Tom Moore, Western States Air Resources Council (WESTAR), Western Regional Air Partnership (WRAP)
- Ralph Morris, Ramboll
- George Schewe, Trinity Consultants
- Bret Schichtel, National Park Service, Air Resources Division
- Kostas Tsigaridis, Columbia University and NASA GISS
- Jay Turner, Washington University in St. Louis
- Rebecca Washenfelder, NOAA
- John Watson, Desert Research Institute

CONTINUING EDUCATION CREDIT OPPORTUNITIES

Conference and course attendees may be eligible for continuing education credits. Attendees should sign the all forms in the sessions rooms and then order a certificate of partcipation from the A&WMA online Store. For more information, please contact Gloria Henning at glhenning@awma.org or 412-904-6021.

CONFERENCE PROCEEDINGS

Conference abstracts will be posted on a secure website along with presenter slides and will be available for viewing and download for a limited time following the conference. Attendees will be notified by email when the proceedings are available.

FINAL PROGRAM

PROFESSIONAL DEVELOPMENT COURSES

Aerosol Data from the Next Generation of Satellites for Air Quality & Climate Research
Monday, October 4 • 8:00 am - 5:00 pm
Manzanita

Instructors: Dr. Pawan Gupta, Senior Scientist, USRA/NASA Marshall Flight Center; Dr. Robert Levy, Research Physical Scientist, NASA Goddard Space Flight Center

Includes lunch.

Back Trajectory Analysis
Monday, October 4 • 8:00 am - 12:00 pm
Pinion

Instructor: Kristi Gebhart, Research Physical Scientist, Cooperative Institute for Research in the Atmosphere

Low Cost Sensors
Monday, October 4 • 8:00 am - 12:00 pm
Sage

Instructor: Dr. Jay Turner, Vice Dean for Education and Professor of Energy, Environmental and Chemical Engineering, Washington University in St. Louis

The Relationship of Visibility to Particle Composition and Sources
Monday, October 4 • 1:00 pm - 5:00 pm
Pinion

Instructor: Dr. Philip K. Hopke, Bayard D. Clarkson Distinguished Professor Emeritus at Clarkson University and Adjunct Professor, Department of Public Health Sciences of the University of Rochester School of Medicine and Dentistry

SPECIAL EVENTS

BRYCE CANYON NATIONAL PARK EXCURSION
Wednesday, October 6

Technical sessions break at noon and all conference attendees are encouraged to spend the afternoon in Bryce Canyon National Park, and enjoy a chat with a Ranger from the National Park Service on Wildfires at Bryce Canyon National Park, followed by hiking in the park.

Hike recommendations include:

- Option 1: IMPROVE site and hiking at Mossy Cave Trail
- Option 2: Queen's Garden/Navajo Combined Loop Hike
- Option 3: Tower Bridge Hike
- Option 4: Bryce Ampitheater Traverse Hike

A box lunch will be available and transportation will be provided to the ampitheater with dedicated shuttles for the conference that will run throughout the afternoon on a 30-minute rotation until 7:00 pm.

Bring good walking shoes and prepare for the weather.

See transportation info on page 11 with full hike details at www.awma.org/visibilityevents.

NIGHT SKY PROGRAM
Thursday, October 7

Gaze at the stars in the breathtakingly clear sky of the Class I protected area of Bryce Canyon through powerful telescopes. NPS Ranger Ben Taylor will be on site to point out major constellations and attractions and provide fascinating details.

Wear your jackets and gloves. See transportation info and details on the Thursday page.

PHOTO CONTEST
Vote for your favorite photo in the categories of Spectacular Visibility, Visibility Impairment and Optical Effects.

Photos will be on display in Red Canyon B. To enter, bring an 8×10 print to the conference to post and check in with Kristi Gebhart at gebhigh@hotmail.com.

Air Resource Specialists, Inc. is sponsoring prizes for photos voted best in class by conference attendees. Winners will be announced at the Thursday lunch.

RAINBOW POINT BUS TOUR
Friday, October 9, 1:30 - 5:30 pm • Cost $50
Busses board at 1:15 pm from the lobby entrance.

This customized 4-hour tour covers 40 miles with stops along many of the park's most scenic viewpoints. In addition to scenic stops at the rim of the Bryce Amphitheater such as Sunset Point and Bryce Point and the southernmost overlooks of Rainbow Point and Yovimpa Point, we will also visit the IMPROVE camera site near Yovimpa Point and the BLM optical measurement site.

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 analysis for filters with our Laboratory-based OCEC analyzer and in ambient monitoring with our Semi-Continuous OCEC aerosol analyzer. Our instrumentation has the ability to easily perform a variety of official analysis methods, such as NIOSH Method 5040, Improve-A, STN, EUSAAR2, as well as others. **www.sunlab.com**

GOLD

DSTech develops uniquely flexible and reliable air quality sensing solutions. The ObservAir is a rugged handheld unit that simultaneously monitors black carbon and up to two gaseous pollutants. Patented technology maintains measurement accuracy in harsh operating conditions, and wireless modules provide real-time data to your phone and PC from nearly anywhere. **www.dstech.io**

Magee Scientific is the originator of the Aethalometer®; the Total Carbon Analyzer; and other instruments for measuring carbonaceous aerosols. Our equipment is rugged, reliable and designed for real-world monitoring applications. Performance may be validated in the field by NIST-traceable standards kits. **www.mageescientific.com**

Sonoma Technology, Inc. (STI) is an employee-owned firm that delivers innovative, science- and technology-based solutions for our clients' environmental needs worldwide. Our services include air quality research, atmospheric measurements, air quality and smoke forecasting, atmospheric modeling and analysis, instrumentation and data system development, software development, decision support systems, and outreach. **www.sonomatech.com**

URG is helping to ensure the air we breathe is the best it can be by creating the Ambient Ion Monitor (AIM) for the time-resolved, direct measurement of gas (hydrogen chloride, nitric acid, nitrous acid, sulfur dioxide, ammonia) and artifact free particulate matter (nitrate, sulfate, nitrite, phosphate, chloride ammonium, sodium, calcium, potassium, magnesium) air pollutants. We specialize in Teflon coated cyclones with various cut-points and flow rates, and stainless steel cyclones for diesel emissions. **www.urgcorp.com**

ABOUT THE AIR & WASTE MANAGEMENT ASSOCIATION

A&WMA is a not-for-profit, nonpartisan professional organization that enhances knowledge and expertise by providing a neutral forum for technology exchange, professional development, networking opportunities, public education, and outreach to more than 5,000 environmental professionals in 65 countries. A&WMA also promotes global environmental responsibility and increases the effectiveness of organizations to make critical decisions that benefit society. For more information, please visit **www.awma.org.**

THANK YOU TO OUR SPONSORS

SILVER

2B Technologies

2B Technologies is dedicated to the development and commercialization of new analytical instruments for atmospheric and environmental measurements. We specialize in miniaturized instruments for measurements of ozone (O3), nitric oxide (NO), nitrogen dioxide (NO2), mercury (Hg), black carbon, PM2.5, and other chemical species in air. **www.twobtech.com.**

Air Resource Specialists

Also sponsoring the photo contest and providing telescopes for the Night Sky Program.

Air Resource Specialists, Inc. (ARS) has nationally recognized expertise in operating air quality, meteorology and visibility monitoring programs and conducting comprehensive special studies. Formed in 1981, ARS has successfully conducted a wide range of projects for federal, state, municipal and tribal agencies, as well as industrial clients. Areas of special expertise include: monitoring for criteria pollutants, volatile organic compounds (VOCs), meteorology and visibility; 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**

TSI

TSI, a world leader in particle measurements, offers a variety of outdoor air quality monitors for real-time, direct-reading results. The DustTrak™ Environmental Monitor measures PM1, PM2.5, respirable, PM10 and total PM size fractions, providing near-reference quality data. In addition, TSI offers a variety of aerosol and dust monitors, and indoor air quality monitors. **www.tsi.com**

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Thank you to our grantors for support of the technical program

Bay Area Air Quality Management District

EPRI | Electric Power Research Institute

EPA

NASA

FINAL PROGRAM

SESSION SCHEDULE - Tuesday, October 5, 2021

7:00 am - 5:00 pm
Registration
Ruby's Inn Lobby

7:00 am
Presenters' Meeting
Red Canyon A

OPENING PLENARY SESSION
Ebenezer's Barn and Grill

8:00 am - 10:20 am

8:00 am — Conference Welcome and Introduction
Delbert Eatough, Conference Chair, Professor of Chemistry, Emeritus, Brigham Young University

8:10 am — Secondary Organic Aerosols and Radiative Effects
Manish Shrivastava, Earth Scientist, Earth Systems Analysis & Modeling, Pacific Northwest National Laboratory (virtual)

8:55 am — Wildfires: Fire Behavior, Forecasting, Impact on Visibility and Radiative Balance
Charles Ichoku, Earth and Atmospheric Sciences, Department of Interdisciplinary Studies, Howard University and Distinguished Scientist of the NOAA Cooperative Science Center in Atmospheric Sciences and Meteorology

9:40 am — Wildfires: Exposure and Health Effects
Michael Jerrett, Professor and Chair of the Department of Environmental Health Sciences, Fielding School of Public Health, ULCA

10:20 - 10:30 am
Networking Break

Panel: Wildfires in the Western United States
10:30 am – 12:20 pm

Chair: Bryce Bird, Director, Utah Division of Air Quality

Wildland and urban interface fires have repeatedly consumed over 10 million acres per year. Communities and major urban centers in the west have been exposed to wildfire smoke that at times exceeds the scale of the air quality index with smoke lingering for weeks to months. Wildfire impacts public health, economic development, management of public lands and compliance with provisions of the Clean Air Act. Air quality regulatory agencies in the western states have been and will be addressing the impacts of smoke to public receptors. The discussion will include:

- Public health policy, communication and health alerts in response to local and regional smoke including air monitoring and modeling of smoke impacting populated areas.
- Interactions with the public, elected officials and land managers to address fire risk and fuel loading through prescribed fire and other fuel management techniques
- Regulatory considerations under the Environmental Protection Agency's exceptional events rule and policy documents that relate to exceptional events justifications for particulate matter and ozone.

Panelists include:

- **Michael Benjamin**, Chief, Air Quality Planning and Science Division, California Air Resources Board (virtual)
- **Jack Broadbent**, Chief Executive Officer, Bay Area Air Quality Management District
- **Mark Boyle,** Idaho Smoke Management Supervisor, Department of Environmental Quality (virtual)
- **Brandon McGuire**, Atmospheric Science Specialist, Montana Department of Environmental Quality

12:30 pm - 1:30 pm
Lunch and Presentation on the Geology of Bryce Canyon
Tiffany Zadi, National Park Service Interpretive Ranger (virtual)
Ebenezer's Barn and Grill

FINAL PROGRAM

SESSION SCHEDULE - Tuesday, October 5

TRACK A Red Canyon A

SESSION 1: VISIBILITY AS AN INDICATOR OF HUMAN HEALTH

Session Chairs: Delbert Eatough, Brigham Young University, Jay Turner, Washington University in St. Louis

1:40 pm
AV#15: **Wildfire Smoke Exposure: Is it Safe to Go Outside?**
Patricia A. Brush, Viki Young, Atena Lunsford, WSP USA, US Energy (virtual)

2:00 pm
AV#130 **Distributed Air Quality Sensing for Wildfire Detection and Monitoring**
Julien Caubel, Troy Cados, Distributed Sensing Technology

2:20 pm
AV #37 : **Bay Area Wildfire Particulate Matter (PM) and Public Health**
Jack P. Broadbent, Bay Area Air Quality Management District

2:40 pm
AV #92 **Wildfires in the Wildland Urban Interface: What Can We Learn from the 2018 Camp Fire?**
Michael Benjamin, California Air Resources Board (virtual)

3:00 pm
AV #85: **Health Effects of Air Pollution and use of Remote Sensing to Estimate PM2.5 Exposures**
Michael Jerrett, UCLA

3:20 pm
AV #79: **Could We Be Underestimating the Health Effects of Particulate Air Pollution?**
William Wilson

TRACK B Manzanita, Pinion, Sage, Bristle Cone

SESSION 2: ATMOSPHERIC NITROGEN: A BRIDGE BETWEEN VISIBILITY, ECOLOGY, AND AIR QUALITY

Session Chairs: Bret Schichtel, National Park Service, Ralph Morris, Ramboll

1:40 pm
AV #91: **Evaluating Ecological Responses of Lichens, Trees, and Herbaceous Plants from Atmospheric Nitrogen and Sulfur Deposition to Federal Lands**
Michael D. Bell (virtual), Emmi Felker-Quinn, US National Park Service Air Resources Division; Christopher M. Clark Jason A. Lynch, US EPA; Linda H. Pardo, Linda H. Geiser, Jeffrey D. Herrick, USDA Forest Service; Jennifer N. Phelan, Research Triangle Institute

2:00 pm
AV #69: **The Nitrogen Story: Emissions, Visibility, Deposition, Ecosystems in Western Class I Areas**
Mike Barna, National Park Service (virtual)

2:20 pm
AV #119: **Assessing the Impact of Agricultural NH3 Emissions on the Excess Nitrogen Deposition in U.S. National Parks**
Gustavo Cuchiara, J.L. Hand, Cooperative Institute for Research in the Atmosphere ,Colorado State University; Barna, M.G., Schichtel, B. A., National Park Service, Air Resources Division

2:40 pm
AV #123 **The Composition and Sources of Organic Nitrogen in Aerosol and Precipitation**
Jeff Collett, Katherine Benedict, Amy Sullivan, Yury Desyaterik, Evelyn Bangs, Colorado State University, Atmospheric Science; Bret Schichtel, National Park Service, Air Resources Division

3:00 pm
AV #124 **A Paradigm Shift in Sulfate-Nitrate-Ammonium Aerosol Formation in the US and its Implications for Air Quality and Reactive Nitrogen Deposition**
Da Pan, Jeffrey L. Collett Jr, Colorado State University, Atmospheric Science; Denise L. Mauzerall, Rui Wang, Xuehui Guo, Mark A. Zondlo, Princeton University, Civil and Environmental Engineering; Melissa Puchalski, Environmental Protection Agency, Office of Air Programs, Atmospheric Science; Bret A. Schichtel, National Park Services Air Resources Division

3:40 pm - 4:00 pm
Networking Break and Exhibition Viewing
Red Canyon B

FINAL PROGRAM

SESSION SCHEDULE - Tuesday, October 5

TRACK A Red Canyon A

SESSION 3: WILDFIRES AND IMPACTS ON VISIBILITY

Session Chairs: Kip Carrico, New Mexico Institute of Mining and Technology, Rebecca Washenfelder, NOAA

4:00 pm
AV #86 **Examining Smoke Impacts from Major California Wildfires in 2017 and 2018 using Modeled Smoke based on BlueSky Framework and Observed Smoke Data from Ground Monitors and Satellites**
Anondo D. Mukherjee, ShihMing Huang, Hilary Hafner, Sonoma Technology; Daniel J. Gorham, Insurance Institute for Business and Home Safety

4:20 pm
AV#94 **Trends in PM and O3 in Response to Recent Increases in Fires in the Western U.S.**
Dan Jaffe, (virtual) School of STEM and Department of Atmospheric Sciences, University of Washington; Udaysankar Nair, Aaron Kaulfus, Department of Atmospheric Sciences, University of Alabama Huntsville

4:40 pm
AV #14 **Comparison of Smoke Aerosol Constituents in Global Fire Emission Datasets and Evaluation of their Potential Utility for Visibility Studies**
Charles Ichoku, Howard University, Xiaohua Pan, Mian Chin, Huisheng Bian, Anton Darmenov, Peter R. Colarco, Luke Ellison, Tom L. Kucsera, Arlindo daSilva, Tomohiro Oda, NASA Goddard Space Flight Center; Jun Wang, Ge Cui, College of Engineering, University of Iowa

5:00 pm
AV #01 **The Formation of Secondary Organic Material from Gaseous Precursors in Wood Smoke**
Delbert Eatough, Jaron C. Hansen, Brigham Young University; Robert A. Carey, Sunset Laboratory, Inc.

5:20 pm
AV #107 **Emission and Evolution of Submicron Organic Aerosol in Wildfire Smoke: Aerosol Mass, Chemical Composition, and Optical Properties**
Lauren Garofalo, Department of Chemistry, Colorado State University, Brett B Palm, Joel A Thornton, Univ. of Washington, Seattle; Teresa L Campos, Xuan Zhang, National Center for Atmospheric Research; Rudra P Pokhrel, Shane M Murphy, Univ. of Wyoming; Sonia M Kreidenweis, Dephine K Farmer, Colorado State University

TRACK B Manzanita, Pinion, Sage, Bristle Cone

SESSION 4: MINERAL DUST AEROSOLS: IMPACTS ON AIR QUALITY AND VISIBILITY

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

4:00 pm
AV #98 **A Global-scale Mineral Dust Equation**
Xuan Liu, R. Turner, Randall V. Martin, Department of Energy, Environmental & Chemical Engineering, Washington University in St. Louis; Bret A. Schichtel, Air Resources Division, National Park Service, Jenny L. Hand, Colorado State University

4:20 pm
AV# 22 **Spatial and Seasonal Variability in Urban and Remote Coarse Aerosol Mass Across the United States**
Jenny Hand, Cooperative Institute for Research in the Atmosphere, Colorado State University, B. A. Schichtel, National Park Service, Air Resources Division, T. E. Gill, Geological Sciences, University of Texas at El Paso

4:40 pm
AV # 27 **Restoration of a Buried Desert Community from Wind Blown Dust and Sand**
Rob Farber, Atmospheric Clarity

5:00 pm
AV # 80 **Owens Lake Dust Control 2021 Update: Lessons Learned and Future Challenges**
Phillip Kiddoo, Great Basin Unified Air Pollution Control District

5:20 pm
AV #93 **USDA Dust Mitigation Handbook - A Resource for Addressing Windblown Dust**
Greg Zwicke, (virtual) Steve Smarik, Mike Wilson, USDA-NRCS, National Air Quality and Atmospheric Change Team; Emile Elias, USDA Southwestern Climate Hub; Dave DuBois, Skye Aney, Brandon Edwards, Nick Webb, New Mexico State University; David Brown, Udall Foundation

5:45 – 7:00 pm
Exhibitor Networking Reception
Red Canyon B

Explore our exhibits, learn about their services, and make connections with all conference attendees!

FINAL PROGRAM

SESSION SCHEDULE - Wednesday, October 6

7:00 am – 12:00 pm
Registration
Lobby

7:00 am
Presenters' Meeting
Red Canyon A

TRACK A Red Canyon A

SESSION 5: PANEL: NASA EARTH SCIENCE CAPABILITIES FOR INVESTIGATING AEROSOL IMPACTS

8:00 am -10:00 am

Session Chairs: Laura Judd, NASA, Helena Chapman, NASA/ Booz Allen Hamilton

NASA's Earth Science Research and Applications Programs have promoted the development and use of observations and tools to enhance decision-making capabilities that affect the health of our planet. This panel will highlight current and future NASA programs and observational systems that assist in better understanding the impact of aerosols in relation to wildfires, air quality, and health. We aim to promote discussion between attendees and our panelist experts to promote the use of current and future NASA capabilities in the broader community.

Panelists include:

- **John Haynes,** Program Manager for NASA's Applied Sciences Health and Air Quality Applications Program
- **Sean Raffuse,** Associate Director – Software and Data, Air Quality Research Center, UC Davis (virtual)
- **Michael Cheeseman**, Dept. of Atmospheric Science, Colorado State University (virtual)
- **Ali Omar,** Lidar Science Branch Head, NASA Langley Research Center
- **Abigail Nastan**, Systems Software Engineer, MAIA Deputy Program Applications Lead, NASA Jet Propulsion Lab

10:00 am – 10:20 am
Networking Break and Exhibition Viewing
Red Canyon B

TRACK B Manzanita, Pinion, Sage, Bristle Cone

SESSION 6: ORGANIC AND LIGHT-ABSORBING CARBON

Session Chairs: Judy Chow, Desert Research Institute and Julien Caubel, Distributed Sensing Technologies

8:00 am
AV #56 **Brownness of Organic Aerosols: Seasonal Variation and Urban-Rural Contrast**
Lung-Wen Antony Chen, University of Nevada, Las Vegas; Xiaoliang Wang, Judith C. Chow, John G. Watson, Desert Research Institute

8:20 am
AV #05 **The Total Carbon Analyzer – A New Instrument for the Characterization of Carbonaceous Aerosols**
Martin Rigler, Aerosol Co., Ljubljana, Slovenia; Anthony D. Hansen, Magee Scientific

8:40 am
AV#78 **In-situ Evaluation of IMPROVE Light Absorption Measurements with Photoacoustic Instruments in Reno, NV**
Bret A. Schichtel, National Park Service, Air Resources Division; W. Patrick Arnott, Palina Bahdanovich, John W. Walker, Sean Colgan, and Heather A. Holmes, University of Nevada Reno; William Malm, Colorado State University; Warren White, Jason Giacomo, Xiaolu Zhang, Josh Grant, and Nicole Hyslop, UC Davis

9:00 am
#AV 129 **Novel Approaches to Correcting for Biases in Filter-based Aerosol Absorption Measurements at a Rural Site**
Joshin Kumar, Theo Paik, Nishit J. Shetty, Rajan K. Chakrabarty, Washington University in St. Louis; Patrick Sheridan, NOAA Global Monitoring Laboratory, Allison Aiken, Manvendra Dubey, Los Alamos National Laboratory

9:20 am
AV#43 **Trends in OM/OC and Organic Composition in IMPROVE and SEARCH networks**
Ann M. Dillner, (virtual) Air Quality Research Center, University of California Davis, Alexandra J. Boris, Satoshi Takahama, Charlotte Burki, Swiss Federal Institute of Technology, Jenny Hand, Colorado State University, Stephanie L. Shaw, EPRI, Eric S. Edgerton, Atmospheric Research & Analysis, Inc., Joann Rice, Melinda Beaver, US EPA

9:40 am
AV #42 **Towards a Single Filter, Single Analytical Method Speciated PM Monitoring Network**
Ann M. Dillner, (virtual) Bruno Debus, Andrew T. Weakley, Air Quality Research Center, University of California, Davis, California Satoshi Takahama, Swiss Federal Institute of Technology

FINAL PROGRAM

SESSION SCHEDULE - Wednesday, October 6

TRACK A Red Canyon A

SESSION 7: AEROSOL AND VISIBILITY TRENDS

Session Chairs: Philip Hopke, Clarkson University, Jay Turner, Washington University in St. Louis

10:20 am
AV#46 **The Changing Composition of Fine Particulate Matter in the Rural United States**
Bret A. Schichtel, A. J. Prenni, K. A. Gebhart, J. C. Vimont, National Park Service, Air Resources Division; J. L. Hand, W. C. Malm, S. Copeland, Cooperative Institute for Research in the Atmosphere, Colorado State University; C. T. Moore, WESTAR-WRAP

10:40 am
AV #38 **Impact of Emissions Reductions on Visibility at Grand Canyon National Park**
Kristi A. Gebhart, National Park Service, Robert J. Farber, Atmospheric Clarity, Warren White, Univ. of CA Davis; Delbert Eatough, Brigham Young University; Mark Green, Desert Research Institute; Jenny Hand, William C. Malm, Colorado State University; Bret A. Schichtel, National Park Service, Air Resources Division

11:00 am
AV #24 **Long-term Trends in Haze in Remote Regions of the United States from 1990 through 2018**
Jenny L. Hand, S. Copeland, W.C. Malm, Cooperative Institute for Research in the Atmosphere, Colorado State University; B. A. Schichtel, A. J. Prenni, National Park Service, Air Resources Division

11:20 am
AV #18 **Strategy for Setting an Urban Visibility Standard**
William C. Malm, Cooperative Institute for Research in the Atmosphere, Colorado State University, A.J. Prenni, M.V. Peters, National Park Service, Air Resources Division

TRACK B Manzanita, Pinion, Sage, Bristle Cone

SESSION 8: US FIELD STUDIES

Session Chairs: Joe Adlhoch, Air Resource Specialists, Rebecca Washenfelder, NOAA

10:20 am
AV#71 **Monitoring Short-term Visibility Impacts at Bryce Canyon National Park for Adaptive Management of the Alton Federal Coal Lease Tract**
Erik Vernon, BLM Utah State Office, Leonard Herr, BLM National Operations Centerr; Bret Schichtel, Debra Miller, National Park Service, Air Resources Division

10:40 am
AV#127 **Visibility Monitoring to Meet Requirements in the Alton Coal Tract EIS**
Christian Kirk, Mark Tigges, Jonathan Furst, Max Abrahamson Air Resource Specialists, Inc.

11:00 am
AV #97 **Attribution of Light Extinction Adjacent to the I-710 Freeway**
Nitish Bhardwaj, Paul M. Cropper, Delbert J. Eatough, Jaron C. Hansen, Brigham Young University

11:20 am
AV #122 **Current Skill and Challenges of the Multi-scale Prediction of Extreme Weather Events in a Rapidly Changing Global Climate**
John Zack, MESO, Inc.

11:40 am
AV #121 **Why is the Weather Extreme— Droughts, Floods, Heat, Cold?**
Rob Farber, Atmospheric Clarity, John Zack, MESO, Inc.

12:00 pm - 7:30 pm
Bryce Canyon National Park Excursion

Busses depart from the Lobby entrance at 12:10, 12:25, and 12:30 pm. Wear your hike gear, grab your lunch and trail map, and head to the ampitheater. Shuttles for the IMPROVE site and Hike 4 (Bryce Ampitheater Traverse) will leave at 1:00 pm. (The IMPROVE shuttle will be dedicated to that group only.)

Dr. Tara. A Olstad, Physical Scientist, Bryce Canyon National Park and Dr. Tom Moore, WESTAR-WRAP will provide an overview at the IMPROVE site.

Those going on Hikes 2 or 3 can stay for the Ranger Chat on Wildfire in Bryce from 1:15 –1:45 pm by Paula Eastman, NPS Interpretive Ranger and then go directly to the trails from the ampitheater.

FINAL PROGRAM

SESSION SCHEDULE - Thursday, October 7

7:00 am – 5:00 pm
Registration
Lobby

7:00 am
Presenters' Meeting
Red Canyon A

TRACK A Red Canyon A

SESSION 9: REGIONAL HAZE RULE PANEL

Session Chairs: Tom Moore, WESTAR, Bret Schichtel, National Park Service

8:00 am - 9:40 am

In this panel, planners and analysts from state air quality control programs have been assembled to share their experience with implementation of the RHR and development of SIPs. The focus is on the use of the monitoring data trends and representations of the revised tracking metric, modeling assessment tools and the distribution of emissions source types – how have these changed since the program tracking and planning formally started in the year 2000 and how they will be used to predict visibility for the 2028 milestone in the second round of planning due in 2021.

Panelists include:

- **Michael Abraczinskas**, Director, Air Quality Division, North Carolina Dept. of Environmental Quality
- **Rhonda Payne**, Air Quality Planner, Regional Haze Project Manager, Montana Dept. of Environmental Quality, Air Quality Bureau (virtual)
- **David Stroh**, North Dakota Dept. of Environmental Quality, Air Quality Division (virtual)
- **Rebekka Fine**, Air Pollution Specialist, California Air Resources Board (virtual)
- **Molly Birnbaum,** Program Manager, Alaska Dept. of Environmental Conservation, Air Quality Division (virtual)

9:40 am – 10:00 am
Networking Break and Exhibition Viewing
Red Canyon B

TRACK B Manzanita, Pinion, Sage, Bristle Cone

SESSION 10: RADIATIVE BALANCE AND MODELING

Session Chairs: John Waston, Desert Research Insitutute, Kostas Tsigaridis, Columbia University, NASA GISS

8:00 am
AV #83 **Role of Biomass Burning Organic Aerosols on Radiative Balance in the Amazon**
Manish Shrivastava, (virtual) Quasi Rasool, Bin Zhao, Ying Liu, John Shilling, Northwest National Laboratory, Atmospheric Schiences and Global Change Division

8:20 am
AV #40 **Contributions to Visibility Impairment in the Mega-Region of China's Guanzhong Basin**
John G. Watson, Jungi Cao, Judith C. Chow, Xioliang Want, Desert Research Institute

8:40 am
AV #84 **Characterization of Black Carbon Aerosol in Palangka Raya**
Muhayatun Santoso, (virtual) Endah Damastuti, Diah Dwiana Lestiani, Syukria Kurniawati, Indah Kusmartini, Djoko Prakoso, Dyah Kumala Sari, National Nuclear Energy Agency of Indonesia (BATAN); Philip K. Hopke, University of Rochester Medical Center; Ahmad Riadi, The Environmental Protection Agency of Palangka Indonesia

9:00 am
AV #108 **Emissions from Fires at the Wildland Urban Interface: Laboratory Measurement of Formaldehyde and Aerosol Properties emitted from Building Materials**
Katherine B. Benedict, James Lee, Kyle Gorkowski, Manvendra Dubey, Los Alamos National Laboratory

FINAL PROGRAM

SESSION SCHEDULE - Thursday, October 7

TRACK A Red Canyon A

SESSION 11: REGIONAL HAZE RULE 1

Session Chairs: Pat Brewer, Consultant, Joe Adlhoch, AIr Resource Specialists

10:00 am
AV #55 **Updates to the Regional Haze Rule Visibility Progress Tracking Metric**
Brett Gantt, Office of Air and Radiation, US EPA (virtual)

10:20 am
AV#26 **Update on Regional Haze Metrics in MANE-VU Region for 2nd Planning Phase**
Sharon Davis, New Jersey Dept. of Environmental Protection (virtual)

10:40 am
AV#59 **WRAP Regional Haze Modeling Overview**
Tom Moore, WESTAR Gail Tonnesen, US EPA, Region 8; Mike Barna, National Park Service, Air Resources Division; Kevin Briggs, Colorado Department Public Health and Environment

11:00 am
AV#60
Source Contributions to Visibility at Western Class I Areas
Pat Brewer, Consultant; Ralph Morris, Ramboll; Tom Moore, WESTAR; Gail Tonnesen, US EPA Region 8; Mike Barna, National Park Service, Air Resources Division

11:20
AV#66 **Historic and Projected Fire Emissions in the Western United States**
Matt Mavko, Air Sciences, Inc.; Tom Moore, WESTAR

11:40
AV#61 **Assessing Progress Toward Regional Haze Visibility Goals Using a US Anthropogenic Emissions Rate of Progress**
Ralph Morris, Ramboll

12:10 pm – 1:30 pm Lunch
Ebenezer's Barn and Grill

Presentation on Bryce Canyon Night Skies
Ben Taylor, National Park Service Interpretive Ranger (virtual)

Announcement of Photo Contest Winners
Kristi Gebhart

TRACK B Manzanita, Pinion, Sage, Bristle Cone

SESSION 12: LIGHT ABSORBING CARBON 1

Session Chair: Philip Hopke, Clarkson University, Rajan Chakrabarty, Washington University in St. Louis

10:00am
AV #74 **Brown Carbon Aerosol Absorption Measured Downwind of Wildfires in the Western U.S.**
Rebecca Washenfelder , (virtual) A. M. Middlebrook, NOAA Chemical Sciences Laboratory; L. Azzarello, York University; A Franchin, National Center for Atmospheric Research

10:20 am
AV #07 Light Absorption Properties of Organic Aerosol from Wood Pyrolysis: Measurement Method Comparison and Radiative Implications
Philip K. Hopke, University of Rochester School of Medicine and Clarkson University; Xinghua Li, Maodong Xiao, Kaiqiang Yang, Zihao Wang, Beihang University; Xuezhe Xu, Jiacheng Zhou, Weijun Zhang , Weixiong Zhao, Chinese Academy of Sciences

10:40 am
AV#39 **Black and Brown Carbon Emissions from Peat Combustion and Their Effects on Light Absorption**
Judith C. Chow, John G. Watson, Mark C. Green, Xiaoliang Wang, L.-W. Antony Chen, Junji Cao, Desert Research Institute

11:00 am
AV #17 **Can a Measure of Filter Absorption Be Used to Estimate Light Absorbing Carbon Concentrations?**
William C. Malm, J. L. Hand, Cooperative Institute for Research in the Atmosphere, Colorado State University; Brett A. Schichtel, National Park Service, Air Resources Division

11:20 am
AV #16 **The Future of Carbonaceous Aerosol Measurements in the IMPROVE Monitoring Program**
B.A. Schichtel, A.J. Prenni, National Park Service, Air Resources Division; William C. Malm, J.L. Hand, Cooperative Institute for Research in the Atmosphere, Colorado State University

11:40 am
AV#109 **Laboratory and Model Synthesis of Brown Carbon Dyes: Humidity-Dependence and Photobleaching**
Kyle Gorkowski, Los Alamos National Laboratory; K.B. Benedict, J. Lee, A.C. Aiken, C. M. Carrico, M. Dubey

FINAL PROGRAM

SESSION SCHEDULE - Thursday, October 7

TRACK A Red Canyon A

SESSION 13: REGIONAL HAZE RULE 2

Session Chairs: Tom Moore, WESTAR, Pat Brewer, Consultant

1:50 pm
AV #62 **Dynamic Air Quality Model Evaluation for Western Class I Areas**
Gail Tonnesen, (virtual) U.S. EPA Region 8; Ralph Morris, Ramboll; Tom Moore, WESTAR; Pat Brewer; Consultant

2:10 pm
AV#63 **WRAP Regional, State, and Sector Source Apportionment**
Mike Barna, (virtual) National Park Service, Air Resources Division; Patricia Brewer, Consultant; Tom Moore, WESTAR; Ralph Morris, Ramboll; Gail Tonnesen, US EPA Region 8

2:30 pm
AV #65 **Colorado Case Study: Applying WRAP Modeling Products to Support Colorado Air Emissions Control Decisions**
Gordon Pierce, Colorado Department of Health and the Environment

2:50 pm
AV #67 **Estimating Fire contributions to Haze at Western Class I Areas**
Tom Moore, WESTAR; Matt Mavko, Air Sciences, Inc.; Ralph Morris, Ramboll; Pat Brewer, Consultant

3:10 pm
AV #68 **Implications of Approaching Goal No US Anthropogenic Visibility Impairment**
Tom Moore, WESTAR

TRACK B Manzanita, Pinion, Sage, Bristle Cone

SESSION 14: LIGHT ABSORBING CARBON 2

Session Chairs: Jenny Hand, Colorado State, Kostas Tsigaridis, Columbia University, NASA GISS

1:50 pm
AV #89 Measuring Light Absorption by Freshly Emitted Organic Aerosols: Optical Artifacts in Traditional Solvent-Extraction-based Methods
Nishit Shetty, Apoorva Pandey, Stephen Baker, Wei Min Hao, Rajan Chakrabarty, Department of Energy, Environmental and Chemical Engineering, Washington University in St. Louis

2:10 pm
AV #88 **Phase Shift Parameter Controls Light Absorption Enhancement for Coated Fractal Aggregates**
Payton Beeler, (virtual) Rajan Chakrabarty, Washington University in St. Louis; William Heinson, NASA Goddard Space Flight Center

2:30 pm
AV #72 **A New Method for Estimating Brown Carbon Light Attenuation from IMPROVE and CSN DRI Model 2015 Carbon Analysis**
Mark C. Green, Judith C. Chow, John Watson, Xioliang Wang, Desert Research Institute; L.-W. Antony Chen, University of Nevada, Las Vegas

2:50 pm
AV #31 **Bounding Aerosol Radiative Forcing of Climate Change**
Nicholas Bellouin, University of Reading, U.K. (virtual)

3:10 pm
AV #110 **Cloud Processing of Black Carbon Particles**
Claudio Mazzoleni, Michigan Technological University

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 email to Delbert Eatough (delbert@eatough.net) indicating the intended material for the manuscript, e.g. the conference presentation number (AV#) related to the manuscript. Submissions to the *Journal* should indicate they are for the Special Issue and should be received by December 15, 2021 to ensure inclusion in the special issue. Publication of the Special Issue is anticipated about a year from the conference.

FINAL PROGRAM

Thursday, October 7

Technical Poster Session 3:40 pm - 5:00 pm Red Canyon A

Session Chair: Delbert Eatough, Brigham Young University

AV #09 **A History of the A&WMA Visibility Specialty Conference**
Delbert J. Eatough, Brigham Young University; Bret Schichtel, National Park Service, Air Resource Division; William Malm, Colorado State University; Marc Pitchford, Desert Research Institute; Peter K. Mueller, TropoChem

AV # 90 **Framework to Estimate the Most Probable Mixing State of Fine Particles over a National Park in Central India**
Krishna Kedia, Ramya Sunder Raman
Indian Institute of Science Education and Research

AV # 12 **Soil and Plant Inorganic Ionic Composition in Relation to Atmospheric Aerosols**
Sabina B. Gulick and Christian M. Carrico, New Mexico Institute of Mining and Technology

AV #48 **Evidence of Organic Sulfur in PM2.5 throughout the United States**
Tracy Dombek, Eric Poitras, Keith E. Levine, RTI International; Yuzhi Chen, Jason D. Surratt, University of North Carolina at Chapel Hill; Jenny Hand, Colorado State University; Bret A. Schichtel, National Park Service, Air Resources Division

AV # 23 **Trends in Remote PM2.5 Residual Mass across the United States: Implications for Aerosol Mass Reconstruction in the IMPROVE network**
J. L. Hand, William C. Malm, Cooperative Institute for Research in the Atmosphere, Colorado State University, A. J. Prenni, B.A. Schichtel, National Park Service, Air Resources Division; J. C. Chow, Desert Research Institute

AV #95 **CASTNET Ozone Response to COVID-19 Related Impacts**
Timothy Sharac, US Environmental Protection Agency

AV #99 **Local and Long-range Impacts of Wildfire Smoke on Air Quality at Fort Collins, CO**
J. L. Hand, D. E. Day, Colorado State University; B. Checkoway, Department of Atmospheric Science, Texas Tech University, A. J. Prenni, B.A. Schichtel, National Park Service, Air Resources Division, M. Tigges, Air Resource Specialists

AV #112 **Optical Properties of Absorbing and Non Absorbing Aerosols**
Rachael Dal Porto, Christopher Cappa, Ningxin Wang, University of California, Davis

AV #113 **Cases of COVID19 and its Correlation with $PM_{2.5}$ in the City of Ayacucho, Peru**
Richard Medina Calderon, Western Texas College; Renato Soca Flores, Christian Cuba Quispe, Universidad Nacional de San Cristobal de Huamanga, Peru

AV #34 **Evaluation of the Second IMPROVE Equation**
J.L. Hand, W.C. Malm, S. Copeland, Colorado State University Anthony J. Prenni, B. A. Schichtel, National Park Services, Air Resources Division

AV #126 **Quantifying Black Carbon Particles in Human Placentae**
Philip K. Hopke, Thomas G. O'Connor, Jessica Brunner, Univ. of Rochester School of Medicine; Amanda Sanko, Yurong Gao, Victoria Dahm, Bhargava Chinni, Tanzy Love, David Q. Rich, Emily Barrett, Richard K. Miller, Carolyn M.Salafia, Ruchit Shah, Placental Analytics, NY Dept. of Health; Jim Zhang, Duke Global Health Institute; Hyagriv Simhan, Magee Women's Hospital

7:30 pm – 10:00 pm Night Sky Program

Don't miss this unique opportunity to see the night skies through powerful telescopes!
Shuttles will depart from the lobby on a rotation of every 20 minutes from 7:30 pm to 9:30 pm. Limit 20 people per trip.

NPS Interpretive Ranger Ben Taylor will provide rotating visual constellation tours.

Thank you to Joe Adlhoch and Mark Tigges, Air Resource Specialists, Bryce Bird, Utah DAQ, and Cameron Pace, Southern Utah University for providing the telescopes.

FINAL PROGRAM

SESSION SCHEDULE — Friday, October 8

7:30 am - 10:30 am
Registration
Lobby

7:00 am
Presenters' Meeting
Red Canyon A

TRACK A Red Canyon A

SESSION 16: SATELLITE AND REMOTE SENSING APPLICATIONS

Session Chairs: Delbert Eatough, Brigham Young University, Brett Gantt, US EPA

8:00 am
AV #25 T**he Dark-Target Aerosol Optical Depth Product: Global Aerosol from MODIS, VIIRS and Geostationary Satellite Imagers**
Robert C. Levy, Shana Mattoo, Yingxi Shi, Virginia R. Sawyer, NASA Goddard Space Flight Center, Pawan Gupta, NASA Marshall Space Flight Center; Lorraine A. Remer, Univ. of Maryland, Baltimore County

8:20 am
AV#128 **Developing a High Resolution Low-cost Sensor Network to Better Understand Local Particulate Matter (PM) Concentrations and Refine Satellite-based Measurements of PM in SC**
Francine Abigail Roberts, Clemson University

8:40 am
AV #29 **Integration of Satellite Observations with Low-Cost Air Quality Monitor: A Data Science Approach to Monitor Air Quality**
Robert C. Levy, NASA Goddard Space Flight Center; P. Gupta, STI, NASA Marshall Space Flight Center; P. Doraiswamy, K. Mills, RTI International; B. Feenstra, O. Pikelnaya, South Coast Air Quality Management District

9:00 am
AV #87 **Future space-based monitoring of aerosol and precursor emissions with TEMPO**
Laura M. Judd, NASA Langley Research Center;
Omar Torres, NASA Goddard Space Flight Center;
Kelly Chance, Xiong Liu, Harvard-Smithsonian Center for Astrophysics

9:20 am
AV #100 **Measuring and Modeling the Relation of Aerosol Optical Depth with Aerosol Scatter, Mass, and Composition to Understand PM2.5 across Multiple Scales**
Randall Martin, Washington University in St. Louis

TRACK B Manzanita, Pinion, Sage, Bristle Cone

SESSION 17: LOW COST SENSORS

Session Chairs: Philip Hopke, Clarkson University, Jay Turner, Washington University in St. Louis

8:00 am
AV#36 **Low-Cost Particulate Matter Sensors for Measuring Wildfire Smoke**
Amara L. Holder, (virtual) Office of Research and Development, U.S. EPA; Lauren Maghran, Anna Mebust, Dena Vallano, Region 9, U.S. EPA; Michael McGown, Robert Elleman, Region 10, U.S. EPA; Kirk Baker, Office of Air Quality Planning and Standards, U.S. EPA

8:20 am
AV #101 **AirNow Fire and Smoke Map Sensor Data Pilot**
Ron Evans, (virtual) Office of Air Quality Planning and Standards, U.S. EPA; Amara Holder, Karoline Barkjohn, Andrea Clements, Office of Research and Development, U.S. EPA; Sim Larkin, U.S. Forest Service, Stuart Illson, University of Washington

8:40 am
AV #03 **Validating Wildfire Smoke Transport Models with a Highly Resolved, Low-Cost Sensor Network**
Kerry Kelly, University of Utah, Chemical Engineering; Wei Xing, Derek Malia, Adam Kochanski, Steve Krueger, Ross Whitaker

9:00 am
AV #35 **Evaluating the PurpleAir Monitor as an Aerosol Light Scattering Instrument**
W. C. Malm, Cooperative Institute for Research in the Atmosphere, Colorado State University; B.A. Schichtel, National Park Service Air Resource Division; P. Sheridan, E. Andrews, J. Ogren, NOAA/ESRL, Global Monitoring Division; W. P. Arnott Department of Physics, University of Nevada

9:20 am
AV #47 **Low-Cost Sensors for Measuring Light Scattering and PM2.5 in National Parks**
W. C. Malm, Colorado State University; Bret A. Schichtel, A. J. Prenni, B. C. Sive, National Park Service Air Resource Division; D. E. Day, P. Sheridan, E. Andrews, NOAA/ESRL, Global Monitoring Division; J. Ouimette, Sonoma Ecology Center

9:40 am – 10:00 am
Networking Break
Red Canyon B

FINAL PROGRAM

TECHNICAL SESSION SCHEDULE - Friday, October 8

TRACK A Red Canyon A

SESSION 18: NEW INSTRUMENTS AND MEASUREMENT TECHNIQUES

Session Chairs: Judy Chow, Desert Research Institute, and Kip Carrico, New Mexico Institute of Mining and Technology

10:00 am
AV #45 **Development of a Humidity-Controlled Single Scattering Albedometer**
Christian M. Carrico, Jared Lam, Sabina Gulick, Jaimy Karacaoglu, New Mexico Institute of Mining and Technology; Tyler Capek, Claudio Mazzoleni, Michigan Technological University; Kyle Gorkowski, James Lee, Allison C. Aiken, Manvendra K. Dubey, Los Alamos National Laboratory; Timothy Onasch and Andrew Freedman, Aerodyne, Inc.

10:20 am
AV #81 **Dispersion Normalized PMF Provides Insights into the Significant Changes in Source Contributions to Atmospheric Particulate Matter after the COVID-19 Outbreak**
Philip K. Hopke, University of Rochester School of Medicine and Dentistry, Qili Dai, Yinchang Feng

10:40 am
AV #51 **Measuring Humidification Effects on Ammonium Sulfate – Nigrosin Mixtures with a Novel Humidity Controlled Albedometer**
Tyler Capek, (virtual) Claudio Mazzoleni, Michigan Technological University; Christian M. Carrico, Jared Lam, New Mexico Institute of Mining and Technology; Kyle Gorkowski, Allison C. Aiken, Manvendra Dubey, Los Alamos National Laboratory; Tim Onasch, Andrew Freedman, Aerodyne, Inc.

11:00 am
AV #52 **High Precision Remote Air Temperature Measurement Using Roto-Vibrational Raman Scattering**
Tyler Capek, (virtual) Jacek Borysow, Claudio Mazzoleni, Michigan Technological University; Massimo Moraldi, Dipartimento di Fisica e Astronomia, Universita' degli Studi di Firenze

1:30 – 5:30 pm
Rainbow Point Bus Tour

Shuttle loads from the lobby at 1:15 pm. Tickets still available!

TRACK B Manzanita, Pinion, Sage, Bristle Cone

SESSION 19: OIL AND GAS FIELD IMPACTS ON OZONE AND PM

Session Chairs: Tom Moore, WESTAR and Naresh Kumar, Desert Research Institute

10:00 am
AV #33 **Wintertime Haze at Dinosaur National Monument**
A.J. Prenni, (virtual) K.A. Gebhart, B.C. Sive, B. A. Schichtel, National Park Service, Air Resources Division; D.E. Day, L. Naimie, J. L. Collett Jr, K.B. Benedict, Department of Atmospheric Science, Colorado State University; Q.M. Chew, E.L. Spencer, Dinosaur National Monument; T. Dombek, RTI International

10:20 am
AV #49 **Visibility Assessment Analysis: The Impacts of Oil and Gas Emissions on Visibility in Class I Areas in the State of Utah**
Trang Tran, Desert Research Institute

10:40 am
Control #53 **Volatile Organic Compound and Ozone Measurements at Carlsbad Caverns National Park: Impacts of Oil and Natural Gas Operation Emissions on Park Air Quality**
Katherine Benedict, Los Alamos National Laboratory; Yong Zhou, Lillain Naimie, Ilana Pollack, Julieta Juncosa Calahorrano, Elana Cope, Emily Fischer, Amy Sullivan, Colorado State University; Barkley C. Sive, Anthony Prenni, Kristi Gebhart, Bret Schichtel, Jeffrey Collett, National Park Service, Air Resources Division

11:10 am
AV #20 **Composition and Concentration of Aerosol in Carlsbad Caverns National Park**
Lillian Naimie, Katherine Benedict, Amy Sullivan, Jeff Collett, Colorado State University, Atmospheric Science; Anthony Prenni, Bret Schichtel, National Park Services Air Resources Division

11:30 am
#AV 125 **Western U.S. Oil and Gas Emissions Quantification for Regional Haze Planning**
John Grant, Amnon Bar-Ilan, Ramboll; Tom Moore, WESTAR

Thank you for attending!

PDF FILES RELATED TO THE 2021 BRYCE CANYON CONFERENCE

The program for the Jackson Hole Conference is found in "12 Bryce Canyon Program.PDF"

PDF files of the Bryce Canyon Presentation are found in "12 Bryce Canyon Proceedings.PDF"

Abstracts from the Bryce Canyon Conference follow.

AV #01 The Formation of Secondary Organic Material from Gaseous Precursors in Wood Smoke

Delbert J. Eatough and Jaron C. Hansen, Brigham Young University, Provo UT
Robert A. Cary, Sunset Laboratory Inc., Tigard OR

The apportionment of the contribution of wood smoke emitted particles has been greatly aided with the development of analytical methods for the quantitative determination of organic marker compounds unique to wood combustion such as levoglucosan. However, these markers have generally been determined in 24-hour samples. We have developed an instrument based on collection of particles on an inert filter, desorption of the organic material in an inert atmosphere with subsequent GC separation and MS detection of the desorbed compounds, the GC-MS Organic Aerosol Monitor (OAM). This instrument has now been used by us in three field studies. An unexpected find in these studies was the determination that in addition to primary wood smoke emitter particles, secondary organic aerosols from the gases present in the wood smoke was also identified. This identification of this secondary material was made possible by the creation of hourly averaged data which allowed the time patterns of black carbon, organic material, and the wood smoke marker compounds to be compared in a PMF analysis. Most of the markers associated with wood smoke (levoglucosan, stearic acid and dehydroabietic acid) are associated with the primary wood smoke emissions, but a fraction of the levoglucosan and stearic acid were associate with the secondary organic material formed from gaseous precursors in wood smoke. The first study in 2015 was located on the BYU campus in Provo Utah. PM2.5 factors identified included identified included Ammonium Nitrate (42%), Diesel Emissions (2.5%), Auto Emissions (2.9%), Ozone Related (2.8%), Wood Smoke (31%) and Wood Smoke Secondary Material (19%, or 61% of the Primary Wood Smoke). The second study in 2016was in West Valley City in the Salt Lake Valley and PM2.5 identified factors included Ammonium Nitrate (57%), Diesel Emissions (12%), Auto Emissions (12%), Smelter Fugitive Emissions (13%), Wood Smoke (1.8%) and Wood Smoke Secondary Material (0.7% or 39% of the Primary Wood Smoke). Wood smoke related material in this study were lower because the sampling site was more removed from the urban areas of the valley. The third study took place in Bountiful UT in 2019. The study was not focused on the identification of secondary particulate material, so a positive identification of the primary wood smoke was made in the PMF analysis and the identification of the secondary wood smoke was more indirect. Primary Wood smoke was 26% of the total PM2.5 and the Wood Smoke Secondary material was 79% of the Primary Wood Smoke. All three studies indicate that the formation of secondary material from the gaseous precursors in wood smoke is about 60% of the primary wood smoke particulate emissions which have been identified in previous studies and that this secondary material is present in an urban area where significant wood smoke burning occurs. There is a need for additional studies to better understand the

contribution of secondary particulate formation to the impacts of both urban and wildfire combustion of wood.

AV #03 Validating Wildfire Smoke Transport Models with a Highly Resolved, Low-Cost Sensor Network
Kerry Kelly, Chemical Engineering, University of Utah, Salt Lake City, UT; Wei Xing; Derek Malia; Adam Kochanski; Steve Krueger; Ross Whitaker

Wildfire smoke poses a significant health and visibility hazard to communities and fire managers. Although many smoke modeling tools exist, accurately simulating smoke production and dispersion is difficult, especially in regions with complex terrain. One of the fundamental problems associated with smoke modeling is the lack of observational data needed for model validation. The limited density of traditional air quality monitoring networks makes validating wildfire smoke transport challenging, particularly over regions where smoke plumes exhibit significant spatiotemporal variability. In this study, we analyze PM2.5 simulations for the Pole Creek Fire, which burned adjacent to the Wasatch Front during the summer of 2018. Here, smoke simulations were generated from a coupled fire-atmosphere model (WRF-SFIRE-CHEM), which can simultaneously render fire growth, fire emissions, smoke dispersion, and fire-atmosphere interaction. These smoke simulations were validated using the University of Utah's AQ&U low-cost sensor network. Initial results from our case study suggest that low-cost sensor can help resolve the spatial heterogeneity of smoke plumes while also serving as a useful data set for validating smoke transport models.

AV #04 Recent advances in understanding secondary organic aerosols and their implications on radiative forcing
Manish Shrivastava, Atmospheric Sciences and Global Change Division, Pacific Northwest National Laboratory, USA; Christopher D. Cappa, Jiwen Fan, Allen H. Goldstein, Alex B. Guenther, Jose L. Jimenez, Chongai Kuang, Alexander Laskin, Scot T. Martin, Nga Lee Ng, Tuukka Petaja, Jeffrey R. Pierce, Philip J. Rasch, Pontus Roldin, John H. Seinfeld, John Shilling, James N. Smith, Joel A. Thornton, Rainer Volkamer, Jian Wang, Douglas R. Worsnop, Rahul A. Zaveri, Alla Zelenyuk, Qi Zhang

Anthropogenic emissions and land-use changes have modified atmospheric aerosol concentrations and size distributions over time. Understanding pre-industrial conditions and changes in organic aerosol due to anthropogenic activities is important because these features 1) influence estimates of aerosol radiative forcing and 2) can confound estimates of the historical response of climate to increases in greenhouse gases (e.g. the 'climate sensitivity'). Secondary organic aerosol (SOA), formed in the atmosphere by oxidation of organic gases, often represents a major fraction of global submicron-sized atmospheric organic aerosol. Over the past decade, significant advances in understanding SOA properties and formation mechanisms have occurred through measurements, yet current climate models typically do not comprehensively include all important processes. This presentation highlights key SOA processes overlooked in climate models that could greatly affect climate forcing estimates. We highlight the importance of processes that influence the growth of SOA particles to sizes relevant for clouds and radiative forcing, including formation of extremely low-volatility organics in the gas-phase; isoprene epoxydiols (IEPOX) multi-phase chemistry; particle-phase oligomerization; and physical properties such as viscosity. We highlight some of the important processes that involve interactions between natural biogenic emissions and anthropogenic emissions such as effects of sulfur and NOx emissions on SOA. Studies that relate the observed evolution of organic aerosol mass and number with knowledge of particle properties such as volatility and viscosity and molecular speciation of gas- and particle-phase precursors are crucial for improving understanding of non-linear SOA-related processes. Continuing efforts are also needed to rank the most influential processes, so that these processes can be

accurately represented in regional and global atmospheric chemistry-climate models. Ultimately, several SOA processes affect global distributions of particle mass, chemical composition, size distribution, optical properties, and are manifested in terms of aerosol-cloud-radiation interactions.

AV #05 The Total Carbon Analyzer – a New Instrument for the Characterization of Carbonaceous Aerosols

Martin Rigler, Aerosol Co., Ljubljana, Slovenia, Anthony D. Hansen, Magee Scientific, Berkeley, CA, USA
Principal Contact: Martin Rigler, Aerosol Co., Kamniška 39A, 1000 Ljubljana, Slovenia (EU). Tel: +386 1 439-1700 E-mail: Martin.Rigler@aerosol.eu

Carbonaceous aerosols often represent a major fraction of PM2.5 mass. They are usually measured by filter sampling for 24 hours followed by thermal-optical analysis for organic carbon (OC) and elemental carbon (EC) fractions. However, although the total carbon (TC) analyses may be consistent, the results for OC and especially EC vary significantly for different thermal protocols. Filter collection followed by laboratory analysis does not yield immediate, real-time data as may be needed to follow extreme events. From a practical perspective, thermal-optical analyzers contain fragile glass tubes and require special high-purity gases. Consequently, these conventional methods are cumbersome for field projects, and problematic for routine use in air-quality monitoring.

The Total Carbon Analyzer collects the aerosol at a flowrate of 16.7 LPM on a quartz-fiber filter mounted between flash heating elements. At the end of the collection period, the sample is instantaneously combusted in a very small flow of filtered ambient air which is used as the analytical carrier gas. This creates a large pulse of CO2 which is detected over baseline and quantified as the Total Carbon content of the sample. The TCA has two parallel flow channels: while one is collecting, the other is analyzing. This provides continuous, real-time data with unattended operation. The chambers are made of stainless steel: the instrument contains no glass, no catalysts, and uses no gas.

Since TC = OC + EC, it follows that OC = TC – EC. "Elemental" Carbon (EC) is related to "Black" Carbon (BC) which is measured in real time by the Aethalometer®. The relationship EC = $b \cdot$BC is used to derive OC in real time by subtraction: OC = TC - $b \cdot$BC. The two instruments (TCA and Aethalometer) may be linked to provide TC, BC, and deduced OC and EC data on a typical 1-hour timebase. The multi-wavelength Aethalometer analysis identifies "Brown" carbon ('BrC') which is associated with emissions from biomass combustion. TCA-Aethalometer results often show that non-light-absorbing OC aerosols from secondary processes may contribute significant PM mass.

The TCA-Aethalometer combination is designed for use in routine monitoring and field applications and has been tested extensively in field campaigns in Europe. The TC, EC (BC) and OC data compare very well with the EC/OC analyses of 24-hour filters. Starting in March 2018, three TCA-Aethalometer combinations have been operated continuously at field sites by two major air-quality agencies in California.

We shall describe the new instrument and show illustrations of the value of real-time TC/EC/OC/BC/BrC data in the context of air-quality monitoring and field projects; and the potential for this instrument to provide a real-time in-field alternative to the conventional method of filter collection followed by thermal-optical analysis in a laboratory. This work was financed in part by the EUROSTARS grant E!8296 TC-BC.

AV #07 Light Absorption Properties of Organic Aerosol from Wood Pyrolysis: Measurement Method Comparison and Radiative Implications

Xinghua Li, *,† Maodong Xiao,† Xuezhe Xu,§ Jiacheng Zhou,§ Kaiqiang Yang,† Zihao Wang,† Weijun Zhang,§ PHILIP K. HOPKE,‡,‖ Weixiong Zhao*,§
†School of Space and Environment, Beihang University, Beijing, 100191, China

§Laboratory of Atmospheric Physico-Chemistry, Anhui Institute of Optics and Fine Mechanics, Chinese Academy of Sciences, Hefei, 230031, Anhui, China
‡Department of Public Health Sciences, University of Rochester School of Medicine and Dentistry, Rochester, NY 14642 USA
‖Center for Air Resources Engineering and Science, Clarkson University, Potsdam, NY 13699 USA

Abstract
Growing evidence indicates that organic aerosol (OA) is a significant absorber of solar radiation. Such absorptive OA is known as "brown carbon" (BrC). However, a formal analytical definition for BrC is currently lacking although several methods have been applied to determine its absorption properties. Imaginary refractive index (*k*OA), a key parameter to describe light-absorption properties of primary OA from various combustion sources, spans 2 orders of magnitude. Measurement methods are an important factor affecting the *k*OA variation. In this work, we isolated organic aerosol from wood pyrolysis by collecting, extracting, and aerosolizing it, and used these samples to compare four methods i.e. extract bulk light absorbance measurement, online and offline filter-based transmission measurements, and optical closure to determine light absorbing properties of OA. The generated aerosol was lognormally distributed, spherical, externally mixed, and nearly pure organic matter. Optical closure was considered as the reference method in this study. The *k*OA values derived by optical closure were 0.031 ± 0.001, 0.0051 ± 0.0002, 0.0012 ± 0.0002 at 365 nm, 532 nm, and 660 nm, respectively. The corresponding mass absorption cross section (MACOA) values were 1.19 ± 0.06, 0.12 ± 0.01, 0.021 ± 0.003 m2g-1, respectively. *k*OA calculated from the extract bulk light absorbance measurement was comparable to that value determined by optical closure. *k*OA and MACOA values obtained by online and offline filter-based transmission measurements were similar and 3.5 to 5.0 times greater than those values determined by optical closure. The Absorption Ångström Exponent (AAE) of organic aerosol determined by four methods were comparable and ranged from 6.1 to 6.8. Size-resolved ratios of MACOA by optical closure to $\alpha/\rho OA$ by extract bulk absorbance were investigated. A clear-sky radiative transfer model implied that using the optical parameters derived from different methods in the full climate model could produce different radiative impacts of POA emissions.

AV #09 A History of the A&WMA Visibility Specialty Conferences

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ABSTRACT
The enactment of the Clean Air Act of 1970 (1970 CAA) resulted in a major shift in the federal government air quality programs, https://www.epa.gov/clean-air-act-overview/evolution-clean-air-act . The Clean Air Act (CAA) became law and the U.S. Environmental Protection Agency was formed in 1970. Congress recognized that visibility is a resource to be valued and preserved, and in the 1977 CAA amendments set forth a national goal that calls for "the prevention of any future, and the remedying of any existing, impairment of visibility in mandatory Class I federal areas which impairment results from manmade air pollution." Class I areas are the 156 national parks and wilderness areas where visibility was deemed an important attribute. In addition, the CAA amendments established the Prevention of Significant Deterioration (PSD) Rule, with the intent of preserving the air quality in Class I areas and in 1999 the Regional Haze Rule (RHR) was created with the goal of reducing haze on the most impaired days to natural conditions. The CCA amendments of 1990 also had a significant effect on visibility.

These amendments did not address visibility directly but were designed to curb four major threats to both the environment and to human health. The mandate to reduce the threat of acid rain resulted in significant reductions in SO_2 emission from oil- and coal-fired power plants. This resulted in significant reduction in particulate sulfate (Malm et al., 2002). To aid in the implementation of the visibility goals and PSD rule, the IMPROVE program was established in 1985 and began speciated aerosol sampling in 1988 and expanded in 2000 to support the RHR. In response to the 1977 CAA Amendments, the Air Pollution Control Association (now A&WMA) held its first Visibility Specialty Conference in Denver CO in 1980. These conferences have been repeated since then about every 3 or 4 years. The relationships among the growth of the IMPROVE monitoring program, the development of the Science, the introduction of the PSD Rule and the introduction of the RHR and these conferences is the subject of this manuscript (now published as an IMPROVE Report).

AV #12 Soil and Plant Inorganic Ionic Composition in Relation to Atmospheric Aerosols

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Aerosols are one of the main contributors to climate forcing and visibility impacts in the atmosphere. However, aerosols show high variability in composition and properties like hygroscopicity. This is particularly the case with smoke from biomass burning, an increasing issue in the southwestern United States. The relative fractions of water-soluble material, mainly inorganic ions, versus carbonaceous content is an important contributor to aerosol hygroscopicity. Plant composition in particular has been shown to be a key driver of these fractions. This study extends that to examine the importance of plant ecozone. Soil composition in particular is questioned as a potential driver of aerosol properties via the plant linkage. It is for this reason that this study examines inorganic ion composition of the soils surrounding select native and invasive plants of the southwest. Samples have been collected from various ecological zones in New Mexico including: the Rio Grande valley bottoms (near Socorro, NM), an alpine site (near Los Alamos, NM), and the salt-lake playas of central New Mexico (near Willard, NM). Methods for soil ion analysis include extracting the ions using a 1:2 mass ratio of soil to RO water followed by injection into an inductively coupled plasma - optical emission spectrometer (ICP-OES) (cations) and an ion chromatograph (IC) (anions). Results to date show much variation in total ion concentrations comparing sites, and even from plant to plant, despite the soils being collected within about a mile of each other. The salt-lake playa samples show overall higher inorganic ion mass concentrations than the Rio Grande valley bottom samples. All samples show high concentrations of calcium and sulfate, with other notable contributors including potassium, magnesium, chloride, and sodium in the soils from both sites. The high concentrations of calcium and sulfate indicate that the soils contain gypsum (CaSO4). A charge balance indicating a deficit of cations in most samples suggests a likely contribution of ammonium, which was not currently analyzable. Continuing work will investigate further sites and species, incorporate plant analysis, and conduct combustion experiments with in-situ measurement of aerosol properties.

AV #13 Wildfires: Fire Behavior, Forecasting, Impact on Visibility and Radiative Balance

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Wildfires and other types of biomass burning are a seasonal phenomenon in different land ecosystems around the world. These fires are estimated to consume biomass containing a total of 2-5 petagrams of carbon globally every year, generating heat energy and emitting smoke plumes that comprise different

species of aerosols and trace gases. These emissions can have adverse effects on visibility, air quality, and climate. Specifically, although less than 5% of global fires occur in North America, recent studies have shown steady and significant increases in burned areas over the last few decades across the continent, especially in the western US. In this presentation, we will discuss how we characterize fires and aerosols from satellite observations in conjunction with other data to continually improve our understanding of fire distribution in space and time, and how fire energetics are quantified and used to analyze emission source strengths and plume injection characteristics that in turn influence smoke dispersion, transport, and impacts. After a brief survey of fire activities and smoke-aerosol emissions and their radiative forcing effects at global and regional scales, we will focus on North American fires, in order to critically examine the impact of wildland fires and prescribed burns on visibility and air quality, as well as the potential for fire and smoke forecasting. Finally, we will see how synergism in coordinating satellite, airborne, and ground-based observations of fires and smoke can yield vital information for addressing current gaps in our knowledge of wildfires and their overall impacts.

AV #14 Comparison of smoke aerosol constituents in global fire emission datasets and evaluation of their potential utility for visibility studies

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ABSTRACT

Aerosols from biomass burning (BB) emissions need to be properly constrained in global and regional models, in order to improve our understanding of their overall environmental impacts. In this study, we compared six BB aerosol emission datasets for 2008 globally as well as in 14 sub-regions. The datasets are: (1) GFED3.1 (Global Fire Emissions Database version 3.1); (2) GFED4s (Global Fire Emissions Database version 4 with small fires); (3) FINN1.5 (Fire INventory from NCAR version 1.5); (4) GFAS1.2 (Global Fire Assimilation System version 1.2); (5) FEER1.0 (Fire Energetics and Emissions Research version 1.0), and (6) QFED2.4 (Quick Fire Emissions Dataset version 2.4). Although biomass burning emissions of aerosols from these datasets showed similar spatial distributions, their global total emission amounts differed by a factor of 3-4, ranging from 13.76 to 51.93 Tg for organic carbon and from 1.65 to 5.54 Tg for black carbon. These differences translate to similar degrees of disagreement when these emissions are used in the forecasting of surface PM2.5 concentrations. We found that the differences between these six BB emission datasets are attributable to the approaches and input data used to derive BB emissions, such
as whether aerosol optical depth (AOD) from satellite observations is used as a constraint, whether the approaches to parameterize the fire activities are based on burned area, active fire count or fire radiative power (FRP), and which set of emission factors was used in deriving them. In this presentation,

we will report the results of the comparison of these BB aerosol emission datasets and evaluate their relative influences in quantifying aerosol distributions and effects on air quality and visibility.

AV #15 Wildfire Smoke Exposure

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Health effects associated with exposure to wildfire smoke are well documented and even those who are healthy are at-risk, if there is enough smoke. In general, wildfire smoke is a hazardous mixture of small particles, gases and water vapor. The primary pollutant related to health effects is particulate matter (PM), specifically the fine particles of <2.5 microns that can travel deep into the lungs and the ultrafine particles of <0.1 microns that are capable of being absorbed directly into the bloodstream, thereby reaching any organ or area of the body. Although, anyone exposed to wildfire smoke is at risk, there are certain groups of people who are at greater risk as a result of pre-disposition for or pre-existing medical conditions. Those populations at greater risk include:

- Young children
- Pregnant women
- Older adults
- Anyone with a respiratory disease
- People with cardiovascular disease
- Diabetics

The key to protecting against and preventing exposure to any hazard is first understanding the potential impact and how to mitigate or control it. This presentation will provide information and important available resources to protect against wildfire smoke exposure by identifying:

- Sensitive populations who are at greater risk
- The potential health effects
- Local Air Quality Index (AQI) information
- Controls to minimize / mitigate exposure
- Available 'real-time' resources related to wildfires.

AV#16 The Future of Carbonaceous Aerosol Measurements in the IMPROVE Monitoring Program

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Abstract

Carbonaceous aerosols are a signification fraction of fine particulate matter, often accounting for more than 50% of the mass in urban and rural environments. In the Interagency Monitoring of Protected Visual Environments (IMPROVE) program, thermal optical reflectance (TOR) is used to determine the

total carbon (TC) concentration, separated into organic carbon (OC) and light absorbing carbon (LAC) fractions. TOR is an operationally defined analysis that cannot be referenced to traceable standards that reflect ambient compositions, so it is challenging to prevent potential instrument drift over long periods. The OC-LAC split can depend on the aerosol composition, which has spatial and long-term trends. These issues can introduce patterns and trends in the data records, complicating assessments of the spatial and temporal patterns of carbonaceous aerosols. In addition, TOR analysis is relatively expensive, and recent decreases in ambient concentrations are challenging the TOR detection limits, particularly for LAC. Due to these issues, two alternative carbonaceous measurements are being explored to supplement or replace TOR analysis in the IMPROVE network. The first is the use of Fourier transform infrared spectroscopy (FTIR), where FTIR spectra are calibrated against a subset of the measured TOR OC and LAC data. The second is a system using TC derived from using a thermal method and filter absorption (fabs) measured using a hybrid integrating plate and sphere (HIPS) system. Estimates of LAC are then derived from the fabs data, and OC is estimated from the difference between TC and LAC. These methods have different benefits and drawbacks. FTIR is cost effective, but being calibrated to TOR, has the same inherent problems as an operationally defined method. TC and fabs measurements are also cost effective and known to produce stable long-term trends. However, fabs is subject to filter loading artifacts and relating TC and fabs to TOR OC and LAC is challenging. This presentation reviews and contrasts these three carbonaceous measurement methods and makes recommendations for monitoring in the IMPROVE network.

AV# 17 Can a Measure of Filter Absorption Be Used to Estimate Light Absorbing Carbon Concentrations?

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In the Interagency Monitoring of Protected Visual Environments (IMPROVE) program, a thermal evolution procedure, referred to as the thermal optical reflectance (TOR) method, is used to determine carbonaceous aerosol concentrations. An aerosol sample that has been collected on a quartz filter is heated, and evolved carbon is characterized as either organic (OC) or light absorbing carbon (LAC). Absorption of aerosols collected on PTFE filters is also measured in the IMPROVE network using a hybrid integrating plate and sphere (HIPS) system, and the data reported are in terms of a filter absorption coefficient, fabs, at 633 nm. Because apportioning thermally evolved carbon to OC and LAC fractions is instrument dependent and cannot be referenced to traceable standards that reflect ambient carbon concentrations, the question must be asked as to whether a more defensible and accurate procedure is plausible. Two candidate measurements, both of which are calibratable with known standards, are total carbon (TC) and fabs. However, because of their very different effects, it is OC and LAC that are of interest. So, can OC and LAC as estimated by TOR analysis be derived from TC and fabs? When the fabs-LAC dataset is averaged over multiple years from 2008 forward, the ratio of fabs, corrected for light absorption by iron (cfabs), to LAC is about 12 and is constant across the continental United States (CONUS). However, on a sample period by sample period basis, the ratio is quite nonlinear, with the ratio decreasing as LAC concentrations increase. To examine how this ratio varies as a function of LAC concentration, the dataset was sorted into ten 10-percentile ranges and then averaged over the 2008–2010 time frame for various regions of CONUS. The slopes of cfabs versus LAC are constant for each percentile across all monitoring locations, with decreasing ratios for percentile ranges above 60%. The

ratios being a function of percentile ranges rather than concentration suggests an underlying physiochemical process, such as aged absorbing aerosols having a lower mass extinction efficiency.

AV# 18 Strategy for Setting an Urban Visibility Standard

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Many national park units in the United States exceed ambient air quality standards set by the Environmental Protection Agency (EPA). Visitors to these protected areas may experience viewsheds impaired by haze as well as health impacts associated with ground-level ozone, particulate matter, and a suite of airborne pollutants. These impacts to park units are in sharp contrast to the importance visitors place upon air resources. Visitors regularly rate clean air and scenic views among the top five important attributes worthy of protection by park managers. Webcams and automated color photography cameras have been routinely operated in many U.S. national parks and other federal lands as far back as 1988, with a general goal of meeting interpretive needs within the public lands system and communicating effects of haze on scenic vistas to the general public, policymakers, and scientists. The purpose of the analysis presented here is to explore the possibility of extracting a quantifiable index from webcam images that reflects human-perceived judgments of visual air quality. Study participants were asked to rate, on a 1 to 7 scale, their perception of the visual air quality; a variety of formats were used, including the use of slides in one case and color photographs in another. Ratings from these different formats are compared, and a variety of image indexes are explored to establish which best represents an individual's perception of visual air quality.

AV #20 Composition and Concentration of Aerosol in Carlsbad Caverns National Park

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The Carlsbad Caverns Air Quality Study (CarCavAQS) was designed to examine the influence of regional sources on fine particle matter, ground level ozone, and nitrogen deposition at Carlsbad Caverns National Park (CAVE); regional sources include urban emissions, oil and gas development, wildfires, biogenic sources, and dust.. Field measurements of aerosols, trace gases, and deposition were conducted from July 25 through September 4, 2019. Here we focus on observations of the composition and concentration of aerosol particles to understand important contributing species and their respective sources. Measurements were made using two PILS (Particle into Liquid Sampler) systems coupled to (1) two ion chromatography systems for quantification of PM2.5 chloride, sulfate, nitrate, nitrite, sodium, ammonium, potassium, magnesium and calcium and (2) a WSOC (Water Soluble Organic Carbon) instrument; a TEOM (Tapered Element Oscillating Microbalance) for PM2.5 mass; URG denuder-filter-pack sampling to measure inorganic gases (HNO3 and NH3) and PM2.5 composition at daily time resolution; and an Aethalometer for online black carbon measurements. Of the inorganic ion species measured on the PILS-IC, sulfate (avg 1.3 μg/m3), ammonium (avg 0.30 μg/m3), Ca2+ (avg 0.22 μg/m3),

and nitrate (avg 0.16 µg/m3) dominated the aerosol mass. The WSOC average concentration was 1.2 µg C/m3. Total PM2.5 mass as measured by the TEOM ranged from 0 to 31.8 µg/m3. The PILS-IC, with its 15-minute time resolution, revealed significant spikes in Ca2+ concentrations, with the largest associated with high wind speeds. The calcium spikes are suspected to be associated with dust transport from local sources. It was also seen that the sulfate was generally neutralized by a combination of calcium and ammonium, and that the anions were balanced by the cations with the exception of points dominated by calcium spikes, which likely contain unmeasured anions (e.g., carbonate). The sum of PILS ion and WSOC concentrations, the latter multiplied by a factor of 1.8 to account for elements other than carbon, were not enough to reach mass closure with the TEOM mass concentrations, suggesting that insoluble species are also an important component of the aerosol at CAVE. Additional analysis of forthcoming IMPROVE data from the study will be presented to further elucidate aerosol concentration and composition. We will also examine the thermodynamic state of inorganic gas-aerosol partitioning using the denuder/filter-pack data.

AV #21 NASA Earth Science Capabilities for Investigating Aerosol Impacts

Co-chairs: Laura Judd*, NASA Langley Research Center, Hampton, VA*
Helena Chapman, *NASA Headquarters and Booz Allen and Hamilton, Washington, DC*
Panelists:
John Haynes*, NASA Headquarters, Washington, DC*
Susan O'Neill, United States Forest Service, Seattle, WA
Michael Cheeseman, *Colorado State University, Fort Collins, CO*
Ali Omar, *NASA Langley Research Center, Hampton, VA*
Abigail Nastan*, NASA Jet Propulsion Lab, Pasadena, CA*

Abstract:
NASA Earth Science Research and Applied Sciences Programs have promoted the development and use of observations and tools to improve the scientific understanding of Earth systems and enhance decision making capabilities that affect the health of our planet. Our panelists all offer a diverse set of expertise and experience with the common goal of highlighting some current NASA programs, datasets, and tools that have been used to better understand the impact of aerosols in relation to (1) wildfires, (2) air quality, and (3) health. John Haynes, Program Manager for NASA's Heath and Air Quality Applications Program, will open this panel by providing an overview of NASA's Earth Science Division including examples of diverse applications and tools developed using NASA Earth observations and sharing pathways for attendees to get involved. Following this presentation, two panelists will offer their expertise in wildfire emissions and smoke research. Susan O'Neill from the United States Forest Service will share her team's work on wildfire smoke forecasting through their participation in the NASA's Health and Air Quality Applied Sciences Team and support of the Wildland Fire Air Quality Response Program. Michael Cheeseman from Colorado State University will discuss the challenges in differentiating surface versus lofted smoke using satellite aerosol measurements motivating a new Moderate Resolution Imaging Spectroradiometer (MODIS) product that can help better identify surface smoke during wildfire events. Ali Omar from NASA LaRC will present the potential of existing and upcoming lidars to provide vertical resolution and discriminate between surface and lofted aerosol layers using LIght Detection and Ranging (LIDAR) techniques from CALIPSO and the upcoming Aerosol-Cloud Convection Precipitation (A-CCP) mission. Finally, Abigail Nastan from NASA JPL will provide an overview of the Multi-Angle Imager of Aerosols (MAIA) satellite which is the first NASA mission dedicated to studying aerosol impacts on human health in partnership with epidemiologists and health organizations. This multidisciplinary panel will facilitate an open discussion between panelist experts

and attendees and enhance awareness about the use of current and future NASA capabilities in the broader community.

AV #22 Spatial and Seasonal Variability in Urban and Remote Coarse Aerosol Mass across the United States

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Coarse aerosol mass (CM = PM10 - PM2.5, mass of particles with diameters between 2.5 and 10 µm) has important environmental and climate impacts, such as influences on air quality, health, visibility, radiative forcing, hydrology, heterogeneous chemistry, biogeochemistry, and ecology. Examining its spatial and temporal variability is important for understanding its sources, evaluating its environmental impacts, and designing potential mitigation efforts. Previous work has demonstrated the significant spatial and temporal variability in CM at remote and rural sites across the United States; however, the variability at urban sites has not been documented over the same spatial and temporal scale. Therefore, CM was computed at over 160 sites from collocated U.S. Environmental Protection Agency (EPA) PM10 and PM2.5 Federal Reference Method (FRM) sites from 2000 through 2019. These data were integrated with remote and rural CM data from over 140 sites from the IMPROVE (Interagency Monitoring of Protected Visual Environments) network to create a continental-scale dataset of daily, monthly, seasonal, and annual mean CM concentrations, as well as regionally aggregated data. These data were used to compare CM seasonality in rural and urban regions, long-term trends in CM concentrations (2000–2019) and regional and seasonal variability in CM contributions to PM10 mass. Annual mean average continental United States (CONUS) urban CM concentrations were over twice that of rural CM concentrations for 2016-2019 (9.3 µg m-3 versus 4.4 µg m-3, respectively). While urban CM concentrations were higher, the CONUS annual mean average contributions of CM to PM10 were similar for both urban and rural sites at ~50%. However, many sites, especially across the West, experienced much higher fractions (> 70%) depending on season. Regional mean CM weekly cycles with lower weekend concentrations were observed at both urban and rural sites throughout most of the country, indicating anthropogenic influence. Trend analyses suggest CM has increased significantly both seasonally and regionally over the 2000-2019 period. The underlying causes for these trends remain an open question.

AV #23 Trends in Remote PM2.5 Residual Mass across the United States: Implications for Aerosol Mass Reconstruction in the IMPROVE network.

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The Interagency Monitoring of Protected Visual Environments (IMPROVE) network collects aerosol samples for gravimetric and composition analysis in support of the Environmental Protection Agency's Regional Haze Rule and for long-term trend studies and model evaluations. Reconstructing PM2.5 mass or extinction from composition measurements requires assumptions of the molecular form of the individual species assumed to compose the bulk of PM2.5 mass. The IMPROVE reconstruction algorithm includes sulfate as ammonium sulfate, nitrate as ammonium nitrate, organic mass calculated with an assumed organic carbon (OC) to organic mass (OM) multiplier (OM/OC) of 1.8, elemental carbon, fine dust assuming common mineral oxides in soil, and sea salt calculated from chloride. Comparisons of reconstructed fine mass (RCFM) to PM2.5 gravimetric fine mass (FM) provide a check on these assumptions as well as help identify possible biases in gravimetric or speciated measurements. Significant changes in aerosol concentration and composition have occurred over time, leading to decreased FM across the United States. However, within the IMPROVE network, annual mean FM and RCFM have decreased at different rates from 2005 through 2019 (-36% versus -45%, respectively), causing the network median residual (FM − RCFM) to increase by 0.29 µg m-3 over the 15-year period. The residual shifted from mostly negative before 2011 to mostly positive after, with a strong summer peak. A multiple linear regression analysis indicated that the increased FM residual was partly due to increased particle-bound water (PBW) in the PM2.5 sample after 2011, associated with increased laboratory relative humidity during weighing. Results also suggested that the OM/OC ratio increased across the network from 2011-2014, unrelated to the influence of PBW. While temporal behavior in the OM/OC ratio was similar across the network and for all seasons, values were highest in the East and during summer. Fine dust also appeared to be underestimated by ~20% during all years. Identifying the source of the trends in the FM residual is essential for accurately estimating contributions by individual species to RCFM and visibility degradation.

AV #24 Long-term Trends in Haze in Remote Regions of the United States from 1990 through 2018.

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The enactment of the Clean Air Act amendments of 1990 resulted in reduced anthropogenic emissions of the precursors to particulate haze, such as sulfur dioxide (SO2) and nitrogen oxides (NOx). The Interagency Monitoring of Protected Visual Environments (IMPROVE) network has tracked trends in haze in remote regions of the United States since the late 1980s. Light extinction (bext) was derived from speciated particulate concentrations measured by the IMPROVE network at nearly 150 sites following the Environmental Protection Agency's Regional Haze Rule guidelines. Trend analyses of the annual 20% most anthropogenically impaired bext indicate strong reductions in haze associated with reduced SO2 and NOx emissions, especially in the eastern United States where the bext values historically were dominated by sulfate particles. Less improvement in visibility conditions occurred in the West, where sulfate contributions were lower. The widespread improvement in visibility across the United States, especially in the East, demonstrates the success of combined regulatory activities that have reduced anthropogenic emissions over the last three decades of the Clean Air Act Amendments. As

emissions from regulated sources continue to decline, the contributions to haze from unregulated sources, such as biomass burning, dust, oil and gas extraction, and international sources, are likely to increase. Reducing haze from these sources will require additional mitigation strategies and resource management plans.

AV #25 The Dark-Target aerosol optical depth product: Global aerosol from MODIS, VIIRS and Geostationary satellite imagers

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The Dark-Target (DT) aerosol algorithm retrieves aerosol optical depth (AOD) and relative aerosol size from observations in visible, near-infrared and shortwave-infrared wavelength regions. Originally developed for Moderate-resolution Imaging Spectrometer (MODIS), the DT algorithm has been successfully ported to Visible-Infrared Imaging Suite (VIIRS). With the combination of MODIS on Terra and Aqua since the early 2000s, VIIRS on Suomi-NPP since 2011 and VIIRS on NOAA-20 since 2018 and on the future JPSS platforms, we expect to eventually have a 30+ year global aerosol dataset from combination of polar-orbiting sensors in low-earth orbit (LEO). More recently, the DT algorithm has been ported to the advanced imagers in geostationary (GEO) orbit, including Advanced Baseline Imager (ABI) on GOES-16/East and GOES-17/West, Advanced Himawari Imager (AHI) on Himawari-8. Aerosol retrievals from GEO sensors allow for sampling of the aerosol diurnal cycle (during daylight), as well as providing characterization of rapidly evolving regional aerosol events (e.g. dust, wildfires, etc.) within the global LEO context. With such a framework, we have a top-down view of the aerosol that impacts visibility as well as radiative balance. In this presentation, we introduce the retrieval algorithm, provide updates on the product and its validation, highlight recent science results, and describe some of the challenges.

AV #26 Update on Regional Haze Metrics in MANE-VU Region for 2nd Planning Phase

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The Mid-Atlantic/Northeast Visibility Union (MANE-VU) coordinates the regional haze planning activities for the Mid-Atlantic and Northeastern states and tribes. Through a coordinated effort, state and tribal members agreed to begin the second phase of regional haze planning efforts with the goal of submitting the second phase Regional Haze State Implementation Plan revisions (RH SIPs) in 2018, ahead of the regulatory revised date of 2021. To date, several states have submitted final RH SIPs to EPA.
During the first phase of regional haze planning, MANE-VU determined that sulfates had the largest impact on visibility impairment. Therefore, the focus of the “Asks” developed by the region targeted reductions in sulfur dioxide (SO2) emissions of up to 90%. Through the planning process, including coordination with federal agencies, the first RH planning phase was extremely successful. Significant reductions of SO2 were achieved, resulting in large reductions of sulfates in the atmosphere, and the MANE-VU states met their 2018

Reasonable Progress Goals. However, during the second RH planning phase, it became clear that these successes resulted in changes in the nature of visibility impairment in the Northeast. The contribution of pollutants to overall light extinction had shifted from sulfate-driven impairment to now seeing greater visibility impairment from nitrates, organic carbon and light absorbing carbon. Most Class I areas are also seeing a greater number of Most Impaired Days now occurring during the winter months than compared to summer as in the first RH Planning Phase. This presentation will provide an evaluation of RH metric trends within the MANE-VU region, summary of the inventory for regional haze precursors, and a general overview of the science behind this shift. Additionally, a discussion regarding the MANE-VU "Asks" to address the changing nature of the Northeast's regional haze will also be provided.

AV # 27 Restoration of a Buried Desert Community from Wind Blown Dust and Sand
Rob Farber, Atmospheric Clarity

This presentation is the latest story of the Dustbusters Research Group's effort to tame wind blown dust in the western Mohave Desert in southern California. This involves implementing several dust mitigation methods developed beginning in 1992. Some of the methods are short term stop gap emergency procedures while others are permanent fixes. In this study we emphasize a mix of semi-permanent and permanent restoration techniques. The outdoor setting is the small Rancho Seco community of 165 acres. The unique attributes of this program are the structures buried with sand scattered throughout the town. We discuss what is needed to remove sand dunes against structures, level the surface having depressions and dunes and re-establishing roads. After the land is reconfigured and compacted we then proceed with hydroseeding. This sophisticated process consists of tackified mulch mixed with a native seed mix of grasses and shrubs. A specialized tanker truck sprays the thin mixture onto the ground using a dye for more uniform coverage. This restoration program is supported by the USDA NRCS EWP (Emergency Watershed Protection) program. The overall administrator and project manager is the Eastern Kern County Resource Conservation District (ECRCD). The actual field program will be conducted beginning in October 2020 and finished in February 2021. This period is the least windy season. Approximately two million water gallons is required. This water will be supplied by a well across the street on the 4000 acre Honda Proving Center. Using these methods, we will have initiated permanent restoration of this community. It will take approximately 5 years for the native vegetation to germinate and reach equilibrium survival. Wood mulch berms surround the community preventing windblown sand from blowing and saltating into Rancho Seco.

AV #29 Integration of satellite observations with low-cost air quality monitors: A data science approach to monitor air quality
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PM2.5, or fine particulate matter, is a category of air pollutant consisting of particles with effective aerodynamic diameter equal to or less than 2.5 microns. These particles have been linked to human

health impacts as well as regional haze, visibility, and climate change issues. Due to cost and space restrictions, the standard monitoring network remains spatially sparse. To increase the spatial resolution of monitoring, previous studies have used satellite data to estimate ground-level PM concentrations, despite these estimates being associated with moderate to large uncertainties when relating a column measure of aerosol (aerosol optical depth or AOD) with surface measurements.
In this paper, we will discuss the role of low-cost PM2.5 sensor and satellite observations in monitoring air quality. We will present results from the field evaluations of the sensor measurements with those obtained from standard measurements. We will also present a framework to integrate low-cost sensor data with NASA satellite observations for real time air quality monitoring. Using one year of ground, satellite and model outputs, machine learning algorithms are developed for CONUS region to provide a high spatial and temporal PM2.5 data sets. Finally, we will highlight lessons learnt and challenges associated with both low-cost sensors and satellite based PM2.5 measurements in the US around the globe.

AV #31 Bounding Aerosol Radiative Forcing of Climate Change
Nicolas Bellouin, Department of Meteorology, University of Reading; The Ringberg 2018 review team

Aerosols interact with radiation and clouds. Substantial progress made over the past 40 years in observing, understanding, and modeling these processes helped quantify the imbalance in the Earth's radiation budget caused by anthropogenic aerosols, called aerosol radiative forcing, but uncertainties remain large. This presentation summarises the outcome of an international workshop and subsequent review paper, which quantify the likely range of aerosol radiative forcing over the industrial era based on multiple lines of evidence, including modelling approaches, theoretical considerations, and observations. Improved understanding of aerosol absorption and the causes of trends in surface radiative fluxes narrow the range of the forcing from aerosol-radiation interactions compared to the latest assessment by the Intergovernmental Panel on Climate Change (IPCC). A robust theoretical foundation and convincing evidence constrain the forcing caused by aerosol-driven increases in liquid cloud droplet number concentration. However, the influence of anthropogenic aerosols on cloud liquid water content and cloud fraction and on mixed-phase and ice clouds remains poorly constrained. Observed changes in surface temperature and radiative fluxes provide additional constraints. These multiple lines of evidence lead to total aerosol radiative forcing ranges that are of similar width to the last IPCC assessment but more clearly based on physical arguments.

AV #33 Wintertime Haze at Dinosaur National Monument
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Abstract
Previous studies in the Uintah Basin have documented ozone concentrations that exceed EPA National Ambient Air Quality Standards (NAAQS) in winter. These high concentrations are driven by high levels of volatile organic compounds (VOCs) from regional oil and gas development, coupled with temperature inversions and enhanced photochemistry from persistent snow cover. Although wintertime ozone events have been studied extensively in this region, little work has been done to characterize wintertime haze. To this end, an 18-month study was conducted at Dinosaur National Monument (DINO), located near the edge of the Uintah Basin, from November 2018 through April 2020. During the first twelve months of the study, haze was characterized using an IMPROVE sampler, a nephelometer, and a web camera. A number of haze events were observed, with hourly light scattering routinely exceeding 100 Mm-1. These events were dominated by ammonium nitrate at high humidities and often coincided with elevated ozone levels. From April through October 2019, relatively clean conditions were observed, with average aerosol light scattering of ~12 Mm-1. During this period, ammonium nitrate concentrations decreased by more than an order of magnitude compared to winter, and contributions from coarse mass and soil increased. Measurements of ammonia, nitric acid, NOx, and a suite of VOCs were added to the monitoring site in November 2019 to better characterize aerosol precursors and sources. Results will be presented for the entire study period, with a focus on the enhanced measurements during the final six months of the study.

AV #34 Evaluation of the Second IMPROVE Equation

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The Interagency Monitoring of Protected Visual Environments (IMPROVE) network provides the primary method for visibility monitoring at Class I areas throughout the United States. Monitoring is conducted by collecting PM2.5 and PM10 samples every third day at over 150 sites nationwide, with PM2.5 samples being analyzed for chemical composition. Using these data, light extinction is reconstructed using the second IMPROVE equation. Reconstructed extinction values are then used to calculate haze levels and estimate visibility. In addition to calculated light extinction from IMPROVE, the National Park Service directly measures light scattering 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 scattering from the nephelometers and reconstructed scattering from the IMPROVE equation should be equivalent. During its development, the second IMPROVE equation was shown to accurately estimate light scattering for a broad array of aerosol compositions and loadings. However, the relationship between measured and reconstructed light scattering has changed over time, corresponding to systematic changes in the chemical and physical properties of the aerosol. One important implication of this is that trends based on calculated light scattering from IMPROVE measurements generally overestimate decreasing trends in measured light scattering. Reasons for the discrepancy between measured and reconstructed scattering and proposed changes to the IMPROVE equation to minimize these differences will be presented.

AV #35 Evaluating the PurpleAir monitor as an aerosol light scattering instrument

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Abstract

The Plantower PMS5003 sensors (PA-PMS) used in the PurpleAir (PA) monitor PA-II-SD configuration are equivalent to cell-reciprocal nephelometers using a 657 nm perpendicularly polarized light source that integrates light scattering from 18 to 166 degrees. Yearlong field data at the National Oceanic and Atmospheric Administration's (NOAA) Mauna Loa Observatory (MLO) and Boulder Table Mountain (BOS) sites show that the 1 h average of the PA-PMS first size channel, labeled ">0.3 μm" ("CH1") is highly correlated with submicrometer aerosol scattering coefficients at the 550 nm and 700 nm wavelengths measured by the TSI 3563 integrating nephelometer, from 0.4 Mm-1 to 500 Mm-1. This corresponds to an hourly average submicrometer aerosol mass concentration of approximately 0.2 to 200 μg m-3. A physical-optical model of the PA-PMS is developed to estimate light intensity from the scattered polarized light source on the photodiode, accounting for angular truncation as a function of particle size. It is shown that CH1 is linearly proportional to the model-predicted intensity of the light scattered by particles in the PA-PMS laser to its photodiode over 4 orders of magnitude. This is consistent with CH1 being a measure of the scattering coefficient and not the particle number concentration or particulate matter concentration. Field data at BOS confirm the model prediction that the ratio of CH1 to the scattering coefficient would be highest for aerosols with median scattering diameters <0.3 μm. The PA-PMS detects aerosols smaller than 0.3 μm diameter in proportion to their contribution to the scattering coefficient. The model predicts that the PA-PMS response to particles >0.3 μm decreases relative to an ideal nephelometer by about 75% for particle diameters ≥1.0 μm. This is a result of using a laser that is polarized, the angular truncation of the scattered light, and particle loss in the instrument before reaching the laser. The results of this study indicate that the PA-PMS is not an optical particle counter and that its six size fractions are not an accurate representation of particle size distribution.

AV #36 Low-Cost Particulate Matter Sensors for Measuring Wildfire Smoke

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Wildfire smoke is a major source of ambient air pollution that can result in degraded visibility across large portions of the U.S. as well as localized severe visibility impacts. Low-cost particulate matter (PM) sensors are increasingly being used by local air quality agencies and the public to monitor wildfire smoke impacts. However, many of these sensors have not been evaluated at the high smoke concentrations frequently encountered near wildfires. We collocated three low-cost PM/air quality sensor systems

(Aeroqual - AQY1, PurpleAir - PAII-SD, Sensevere - RAMP) with reference PM monitors near three wildfires in the western U.S. and one prescribed fire in the eastern U.S. (max PM = 295 µg/m3). The sensors were moderately - highly correlated with the reference monitor (hourly averaged r2 = 0.52-0.95). All sensors overpredicted PM2.5 concentrations, with an average normalized mean bias of 41%, 62%, and 40% for AQY1, PAII-SD, and the RAMP respectively.
Calibration factors for individual fires varied, likely due to the different concentration ranges observed at each fire rather than the variation in smoke optical properties. By combining all datasets, a smoke specific calibration factor was developed that reduced the normalized root mean square error to less than 35%. The calibration factors varied among sensors, demonstrating the impact of the physical configuration of each sensor and the sensor-specific algorithm used to translate particle size and count information into PM concentrations. These results suggest the low-cost sensors tested here (PM2.5 < 300 µg/m3) can fill in the large spatial gaps in monitoring networks near wildfires with errors of less than 10 µg/m3 in the hourly PM2.5 concentrations when using a sensor specific smoke calibration factor.
This abstract was reviewed by EPA and approved for publication, it may not necessarily reflect official Agency policy. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

#AV 37 Bay Area Wildfire Particulate Matter (PM) and Public Health
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California experienced some of the deadliest and most destructive wildfires in its history over the last several years. Studies show that climate change is not only causing higher temperatures and longer dry periods, but also lengthening the fire season and increasing the risk of catastrophic wildfires throughout the state. Regional weather patterns and atmospheric conditions influence fire behavior and affect the transport of smoke to local communities, entire regions or even nearby states. The sheer devastation, size and magnitude of the 2017 North Bay Fires in Napa and Sonoma Counties, 2018 Camp Fire in Butte County and 2019 Kincade Fire in Sonoma County are a reminder that wildfires are the new normal and wildfire smoke has no boundaries. In the Bay Area, impacts from these fires have the potential to eliminate positive gains made from progressive regulatory actions over the last decade to reduce particulate matter (PM), with grave consequences for public health.

Acknowledging the new reality of increased wildfires across the state and the surmounting concerns of wildfire smoke impacts prompted significant actions by the Bay Area Air Quality Management District (Air District) to prioritize new wildfire program initiatives and affect changes to programs, policies and regulations as well as public health protections. The Air District developed the *Wildfire Air Quality Response Program,* a multi-faceted program to ensure health protective measures and strategies are in place. New legislation, Assembly Bill 836 (AB836) *Wildfire Smoke Clean Air Center Incentive Program for Vulnerable Communities,* was initiated to fund ventilation retrofits to provide improved air filtration to vulnerable populations. The Air District embarked on regulatory amendments which prohibit burning year-round when air quality is forecast to exceed the 24-hour National Ambient Air Quality Standard for PM2.5 and align with statewide efforts to prevent larger, more destructive wildfires. Partnerships were formed with local county health officers and emergency responders to help create a regional alliance to improve wildfire preparedness and coordination. Air District efforts targeted advancing communications across the nine Bay Area counties with local and state partners to develop consistent public health guidance and messaging on wildfire smoke health impacts. Through these partnerships, the Air District is

building community resources and access to air quality data, forecasts and current air quality information during wildfires, and exploring grant funding opportunities to establish a network of Clean Air Centers within the region and across the state.

As climate change will inevitably promote larger and more catastrophic wildfires, the Air District is committed to shine a continued spotlight on health and PM with the help of leading health experts and scientists to move the public health needle and identify health-focused guidelines based on the latest science and set targets beyond PM attainment standards already in effect.

AV# 38 Impact of emissions reductions on visibility at Grand Canyon National Park

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Visibility impairment, particularly at the iconic southwestern U.S. national parks was an early and persistent concern that helped motivate parts of the Clean Air Act and its 1977 and 1990 amendments. Grand Canyon National Park (GCNP), Arizona, in particular, was the site of many air quality studies. These included monitoring airborne particulate concentrations as part of air quality networks as early as 1967, when measurements were made as part of the National Air Surveillance Network (NASN), and later the National Park Service Fine Particle Network, 1979-1987, and Interagency Monitoring of Protected Visual Environments (IMPROVE), 1988 to present. In addition, there were many special studies conducted at GCNP, dating back at least to the 1980s focused on visibility, fine particle characteristics, economics, meteorology, perception, and source apportionment. During the past few decades, concentrations of particulate matter, especially sulfate, at GCNP have declined dramatically as emissions in the region have declined, primarily due to effective regulations. We review some of the early studies, examine trends in concentrations and regional emissions in association with transport patterns to tell this success story.

AV #39 Black and Brown Carbon Emissions from Peat Combustion and Their Effects on Light Absorption

Judith C Chow, Desert Research Institute, Reno, NV; John G. Watson; Mark C. Green; Xiaoliang Wang; L.-W. Antony Chen; Junji Cao

Smoke from laboratory chamber burning of peat fuels from Russia, Siberia, U.S.A. (Alaska and Florida), and Malaysia representing boreal, temperate, subtropical, and tropical regions was sampled before and after passing through a potential aerosol mass-oxidation flow reactor (PAM-OFR) to simulate intermediate-aged (~2 days) and well-aged (~7 days) source profiles. Species abundances in PM2.5 between aged and fresh profiles varied by several orders of magnitude with two distinguishable clusters, centered around 0.1% for reactive and ionic species and centered around 10 % for carbon. Organic carbon (OC) accounted for 58–85 % of PM2.5 mass in fresh profiles with low EC abundances (0.67–4.4 %). OC abundances decreased by 20–33 % for well-aged profiles, with reductions of 3–14 % for the volatile OC fractions (e.g., OC1 and OC2, thermally evolved at 140 and 280 °C). Ratios of organic matter (OM) to OC abundances increased by 12–19% from intermediate- to well-aged smoke. Ammonia (NH_3) to PM2.5 ratios decreased after intermediate aging. Light-absorbing black carbon (BC) and brown carbon (BrC) dominated the light absorption, as smoldering dominated emissions during the entire burning cycle. Profile aging with the PAM-OFR showed both increases and decreases in the BrC

absorption among the different peat profiles and burning conditions. A sufficient aging time (~one week) is needed to allow gas-to-particle partitioning of semi-volatilized species, gas-phase oxidation, and particle volatilization to achieve representative source profiles for regional-scale source apportionment.

AV #40 Contributions to Visibility Impairment in the Mega-Region of China's Guanzhong Basin
John G. Watson, Desert Research Institute, Reno, NV; Junji Cao; Judith C. Chow; Xiaoliang Wang

The Guanzhong Basin is located inland from the Chinese capital and coastal areas within which the Xi'an megacity is located. Long-term records of airport visual range show increasing impairment after the 1990s, with only a recent plateauing and indication of a decrease. The poorest visibility is encountered during winter, although there are haze events in spring owing to Asian dust events. Long-term chemical composition measurements show the usual contributions from organic and elemental carbon, minerals, sulfate, nitrate, and ammonium, with enhancements during winter owing to higher relative humidities. Wintertime experiences prolonged high-pressure systems punctuated by unstable precipitation events that sometimes include snow. A shallow surface layer forms at night that couples to an upper-level inversion after sunrise, allowing pollutants accumulated aloft to mix to the surface. Sluggish nighttime winds aloft allow pollutants such as ammonia from distant agricultural operations to mix with urban pollutants, sometimes serving as a reactor to create secondary sulfates and nitrates, and possibly some secondary organic compounds. Although current air quality management strategies have focused on urban emissions, and PM2.5 levels that cause visual impairment are on a downward trend, future management efforts must consider reducing emissions from a variety of sources in the larger region of the entire Basin. Tactics developed for this region would probably be effective in other areas of the world with similar emissions, topography, and meteorology.

AV #42 Towards a Single Filter, Single Analytical Method Speciated PM Monitoring Network
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Understanding the composition of fine particulate matter (PM2.5) is crucial to assessing the impact of atmospheric aerosols on visibility as well as human health and climate change. The Interagency Monitoring of PROtected Visual Environment network (IMPROVE) and the Chemical Speciation Network (CSN) collect PM2.5 on three filter types which are analyzed by five analytical methods to capture the bulk chemical composition of each 24-hour sample. In these routine monitoring networks, Polytetrafluoroethylene (PTFE) filters are analyzed by gravimetry, X-ray fluorescence, and hybrid integrating plate and sphere (HIPS) to measure mass, elements, and light absorption, respectively. Nylon filters are analyzed by ion chromatography to measure inorganic ions and quartz filters are analyzed by thermal optical reflectance for organic (OC) and elemental carbon (EC). Given that most of the major components of PM have vibrational modes in the mid-infrared, we assess the capability for Fourier transform infrared (FT-IR) spectra of PTFE filter samples along with multivariate calibration to provide a fast, inexpensive, and non-destructive means of quantifying most of the compositional data obtained by US national monitoring networks.

To demonstrate the one filter, one measurement concept, FT-IR spectra from one year of PM2.5 PTFE filter samples collecting in IMPROVE are used to develop and test the concept. A small subset of the approximately 160 sites in the network, that span the compositional range within the network, is used to develop multivariate calibrations for OC, EC, sulfate, nitrate, soil elements, light absorption and gravimetric mass. The calibrations are used to predict all samples at the remaining sites. OC, PM2.5 mass, sulfate, aluminum, silica and calcium are all predicted with high R2 relative to routine IMPROVE data (R2 > 0.97) and low relative error (≤ 12 %). EC and HIPS are reliably quantified as well (R2 > 0.91) with relative error ranging from 25 % to 30 %. Finally, nitrate calibration shows satisfactory predictions (R2 > 0.88) but is characterized by a large relative error (≈ 65 %) caused by nitrate volatilization off the Teflon filters. A better understanding of nitrate concentrations on PTFE filters may be able to be obtained using laboratory standards rather than ambient data from nylon filters. This method could be used to provide speciated data in the US Federal Reference Method (FRM) monitoring network that collects PM2.5 PTFE filter samples at over 700 sites for compliance with the National Ambient Air Quality Standards for mass but currently obtains no speciation data. In addition, this work suggests that FT-IR could be explored for measuring multiple components on PTFE filters in international monitoring networks such as the Speciation Surface PARTiculate mAtter Network (SPARTAN).

AV #43 OM**/OC and Organic Composition in IMPROVE, SEARCH and FRM networks**

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The relative contribution of organic matter (OM) to atmospheric aerosol is increasing due to regulations that have successfully reduced ammonium sulfate concentrations, especially in the Southeastern US. Estimation of OM in routine monitoring networks typically involves multiplying the measured organic carbon (OC) by a static OM/OC value such as 1.8 for rural sites and 1.4 for urban sites. However, researchers have shown that OM/OC varies by region, site, season and sample. OM/OC provides insight into the level of oxygenation and sources of the carbonaceous fraction. In this work, we present trends in estimates of functional groups and OM/OC using from Fourier Transform infrared (FT-IR) spectroscopy. FT-IR is a non-destructive, information-dense analytical method that can be applied to routinely collected Teflon filter aerosol samples. Organic functional groups, aliphatic CH, unsaturatued CH, alcohol OH, amines, carboxylic acids, oxalates and non-acid/non-oxalate carbonyls, are measured by calibrating to laboratory standards using partial least squares regression and used to estimate OM/OC. The Federal Reference Method (FRM) network is a mass only network that collects Teflon filter samples at ~700 sites in the US. Samples from six FRM sites in 2013, show that OM/OC and functional group composition varies by site and season. Eight years of functional group and OM/OC data obtained from samples at two urban rural pairs in the Southeastern Aerosol Research and Characterization (SEARCH) network are presented. We show that the FT-IR OM/OC values are consistent (no trend) over the eight-year period. However, the trends in the composition of OM/OC show decreasing concentrations of more

oxygenated functional groups, carboxylic acid and oxalates, and increasing less oxygenated functional groups, alcohol OH and non-acid carbonyl. The OM/OC trends based on FT-IR are different than those obtained using regression analysis of routine IMPROVE data for samples in the Southeastern US. This result is in line with a separate study comparing FT-IR OM/OC ratios – calibrated to be consistent with collocated thermal optical OC – against the regression analysis method for select sites in the Interagency Monitoring of PROtected Visual Environment network (IMPROVE) for 2011 and 2013. This parallel study supports the SEARCH results that the OM/OC is not varying while the regression analysis of IMPROVE data during these years shows increasing OM/OC, especially in summer. The differences in the OM/OC trends are likely due to differences in the methods not due to differences in networks, as the 2011/2013 comparison uses the same network, sites and years.

AV #45 Development of a Humidity-Controlled Single Scattering Albedometer

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Significant uncertainties remain with aerosol light extinction properties, their relative humidity (RH) dependence, and the resulting impacts on atmospheric radiative transfer. In a multi-institution collaboration, we have developed a controlled-RH single scattering albedometer. The instrument simultaneously measures *in-situ* aerosol light extinction and scattering using a cavity-attenuated phase shift-single scattering albedo PM monitor (CAPS-PMSSA, Aerodyne, Inc.), a relatively new, commercially available instrument. The CAPS-PMSSA allows estimation of aerosol light absorption by difference and provides a direct quantification of aerosol single scattering albedo (SSA). The CAPS-PMSSA is built into a controlled-RH system allowing measurement of humidity-dependent optical properties including absorption and SSA. The hygroscopic response of these parameters has been under-reported, largely due to artefacts with current techniques (e.g. volatilization of water from heating via photoacoustic methods). The humidity-controlled single scattering albedometer's design and performance will be discussed as well as laboratory testing. System development included overcoming problems with mirror purge-flow humidification, minimizing instrument heating, and achieving control and measurement of cell RH. We tested the system with several pure single component aerosols including ammonium sulfate, absorbing compounds such as nigrosine, and levoglucosan, an organic considered a biomass smoke tracer. The design, development, and characteristics of the instrument will be discussed here and additional experiments with mixtures of light scattering and absorbing compounds will be discussed in a companion paper.

AV #46 The Changing Composition of Fine Particulate Matter in the Rural United States

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Over the past 30 years, there have been dramatic shifts in fine particulate matter (PM2.5) emissions and their precursors, changing the composition and levels of ambient PM2.5. Many of these trends are reflected in the daily speciated PM2.5 samples collected in the Interagency Monitoring of Protected Visual Environments (IMPROVE) program, which has operated uninterrupted throughout the rural United States since 1988. PM2.5, measured at eastern U.S. IMPROVE sites, is now about half of what it was in the 1990s. This change is primarily the result of decreasing particulate sulfate brought on by steep declines in SO2 emissions. Prior to 2007, there was a near-linear decrease in sulfate with decreasing emissions. However, since then, the apparent response of sulfate concentrations to decreasing SO2 has slowed, particularly in the winter. This is potentially due to increased availability of oxidant and more efficient SO2 oxidation leading to a greater fraction of the SO2 being converted to sulfate. The reductions in sulfate appear to have also caused commensurate reductions in sulfate-processed, biogenic secondary organic aerosols. Much of the decreased SO2 emissions were initially driven by regulations and then later accelerated by a switch from coal- to natural-gas-powered electrical generation. However, the development of oil and gas resources has led to the industrialization of once-rural landscapes, increasing the impact of local emissions on the air quality in surrounding areas. Many of these change in PM2.5 composition have also occurred in the intermountain western United States, but the response in ambient PM2.5 is more subtle due to lower anthropogenic emissions. Instead, the changes in PM2.5 composition appear to be driven by external and more-natural forces. This includes increases in spring sulfate concentrations in the first decade of the 2000s, potentially due to international transport, as well as increased wildfires contributing to the background of carbonaceous aerosols and spatially and temporally varying PM2.5 episodes. Over the last decade, there has also been an earlier onset of the spring dust season in the Southwest, presumably due to increased surface winds and decreased precipitation, which were associated with a shift in the Pacific Decadal Oscillation. In this presentation, these and other changes in the PM2.5 composition over the past few decades and their potential causes will explore.

AV #47 Low-Cost Sensors for Measuring Light Scattering and $PM_{2.5}$ in National Parks

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The National Park Service (NPS) has the responsibility of protecting air quality related values, including visibility, and human health from elevated fine particulate matter ($PM_{2.5}$) in national parks. High $PM_{2.5}$ levels occur due to anthropogenic and natural emissions that generally cause elevated concentrations over regional scales and multi-daytime periods in remote areas. $PM_{2.5}$ episodes over transient and extended periods also occur, due to, for example, windblown dust and smoke from prescribed and wildfires. To inform and protect visitors and develop mitigationstrategies, there is a need for $PM_{2.5}$ monitoring. Monitoring in national parks has typically been done using 24-h particle samplers and optical monitors, including nephelometers, to measure light scattering. This monitoring is limiting in that 24-h PM monitoring cannot provide real-timeinformation and nephelometer deployment is restricted due to costs. The NPS has begun to examine the potential use of the PurpleAir (PA) low-cost continuous sensor and an alternative monitoring instrument. A field study has begun in a rural setting in Fort Collins, Colorado, where four PAs are collocated with three nephelometers; a TEOM measuring $PM_{2.5}$; and a portable optical particle counter (POPS) measuring particle diameters between ~0.13 to 3.0 μm. One of the PAs is heated to keep relative humidity (RH) below 50% while the other three are in ambient conditions. One nephelometer is from Optec has no particulate size cut, and a second ismade by AirPhoton with a variable size cut. Both nephelometers are at ambient conditions. Thelast nephelometer, which is located in a temperature-controlled shelter and measures light scattering from fine particles, is from Radiance Research. This configuration allows for the evaluation of the PAs to measure the particle size distribution, $PM_{2.5}$, light scattering, as well thesensitivity of these sensors to changes in RH. Initial results are promising in that PA counts greater than 0.3 μm are highly correlated with the hourly light scattering ($r > 0.96$) where light scattering ranged from 2 to 70 Mm^{-1}. The ambient PA sensors have also been found to be relatively insensitive to RH and coarse particles.

AV #48 Evidence of Organic Sulfur in $PM_{2.5}$ throughout the United States

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For more than 30 years, fine particulate matter ($PM_{2.5}$) has been characterized as part of the Interagency Monitoring of Protected Visual Environments (IMPROVE) network. $PM_{2.5}$ can be emitted directly or formed through condensing of gases and gas-phase reactions between sulfur oxides, nitrogen oxides and volatile organic compounds (VOCs) released through combustion offossil fuels. Atmospheric oxidation of biogenic emissions of VOCs (or BVOCs) result in certainoxidation products that participate in acid-driven particle-phase (multiphase) reactions, yielding organic sulfur (OS) formation.

This study shows evidence of water-soluble OS compounds in IMPROVE extracts. Nearly 18,000 IMPROVE $PM_{2.5}$ samples collected in 2016 were analyzed for sulfate (SO_4^{2-}) by Ion Chromatography (IC) and were also analyzed by Inductively Coupled Plasma-Optical EmissionSpectroscopy (ICP-OES) for total

particulate sulfur (TPS). Routinely, IMPROVE network TPS measurements are obtained via X-ray Fluorescence (XRF) from Teflon filters. Historical comparisons between these TPS values with total inorganic sulfur (as measured as sulfate by IC)indicates geospatial and temporal disparity between values, with higher TPS suggesting OS not accounted for by IC. To alleviate potential biases introduced between collection and measurement methods, all extracts previously analyzed for SO_4^{2-} were analyzed for TPS by ICP-OES.

The aim of this study was to evaluate differences between water soluble TPS measured by ICP-OES and SO_4^{2-} measured by IC in IMPROVE $PM_{2.5}$ extracts. Differences in TPS, would be indicative of the presence of water-soluble OS compounds. A second goal was to assess differences for seasonal and geographic variability. A subset of samples were also analyzed using hydrophilic liquid interaction chromatography (HILIC) coupled to electrospray ionizationhigh-resolution quadrupole time-of-flight mass spectrometry (HILIC/ESI-HR-QTOFMS) in order to measure the presence of known OS compounds, especially those derived from BVOCs such as isoprene.

TPS (ICP-OES) and SO_4^{2-} (IC) data were highly correlated across the IMPROVE network. Linear regression results suggested near perfect agreement for samples collected during winter (December, January, February) and spring (March, April, May) and to a lesser extent during summer (June, July, August) and fall (September, October, November) suggesting the presence of OS in the warmer months. In addition to observed seasonal differences, geographic variationswere observed. Some of the greatest differences between TPS (ICP-OES) and SO_4^{2-} (IC) occurred for sites located in the southeastern and midwestern United States (U.S.). These differences were evident during summer and fall periods, peaking in the summer. Sites located along the U.S. West Coast and in the Northeast also exhibited some elevated differences during summer sampling periods. The smallest differences were observed at sites located in the Great Plains with subtle seasonal differences. Sites along the U.S./Canadian border also showed distinguishable differences. Overall, the increased TPS measured by ICP-OES are indicative thatwater-soluble OS is present in IMPROVE network samples. HILIC/ESI-HR-QTOFMS analysesof a subset of winter and summer samples showed that BVOC-derived OS compounds were present mostly in summer samples, likely providing an explanation for the difference between TPS (ICP-OES) and SO_4^{2-} (IC) during warm months.

AV #49 Visibility assessment analysis: the impacts of oil and gas emissions on visibilityin Class I areas in the State of Utah.

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The Bureau of Land Management Utah State Office (BLM) have been conducted the Air Resource Management Strategy (ARMS) photochemical modeling analysis to inform and support BLM's air management strategy. The most updated ARMS study (2017 ARMS) performed photochemical simulations for base year 2011 and future year 2025 to evaluate impacts of BLM oil and gas development activities in the State of Utah on air quality. This paperpresents visibility assesment analysis at Class I Areas. Visibility impacts were calculated for oil and gas and mining emissions on BLM lands as well as for cumulative emissions sources. The approach used the incremental concentrations as quantified by the Comprehensive Air Quality Model with Extensions Particulate Source Apportionment

Technology (CAMx-PSAT) tool simulation of oil and gas and mining activities within each BLM planning area. Changes in light extinction from model concentration increments due to emissions from oil and gas and other activity emissions were calculated for each day at grid cells that intersect Class I areas within themodeling domain. The Federal Land Managers'Air Quality Related Values Work Group (FLAG2010) procedures were used in the incremental BLM planning area-specific visibility assessmentanalysis.

AV #51 Measuring Humidification Effects on Ammonium Sulfate – Nigrosin Mixtureswith a Novel Humidity Controlled Albedometer

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Water can have a significant influence on the optical properties of atmospheric particles by altering their ability to scatter and absorb sunlight. Water can condense on these particles, increasing their size and altering their overall morphology. Some absorbing particles can be hydrophobic; however, hydrophilic coatings on these particles can lead to water uptake and enhancements in both absorption and scattering. Accurate assessment of these enhancements is key for determining the particles' impact on the climate. We have developed a cavity attenuatedphase-shift albedometer (RH-CAPS-SSA), operating at 450 nm, integrated with a humidifier to study humidification effects on the optical properties of atmospheric particles. We have characterized the optical properties and hygroscopicity of two benchmark aerosol, ammonium sulfate, and nigrosin. Ammonium sulfate (AS) is a hygroscopic aerosol that scatters strongly in the visible spectrum. Nigrosin ink is used as a proxy for strongly absorbing and weakly hygroscopic atmospheric particles, providing a reproducible model particle to study and better understand the fundamental behaviors of more complex absorbing atmospheric particles such asblack and brown carbon. Mixtures of nigrosin and AS can lead to a particle that is more hygroscopic than pure nigrosin and more absorbing than pure AS. We compare the measured enhancements of pure aerosol and mixtures to models incorporating Mie theory and κ-Köhler theory with an eye on characterizing the performance of the RH-CAPS-SSA and developing a model for characterizing humidified atmospheric aerosol mixtures. Enhancements in absorptionwere observed for each sample containing nigrosin when relative humidity was increased. For example, absorption enhancement as high as 1.12±0.02 in pure nigrosin, which compared favorably to the Mie estimate of 1.15±0.08. As relative humidity increased, we also observed increasing single scattering albedo (SSA) in each of the samples containing nigrosin.

AV #52 High Precision Remote Air Temperature Measurement Using Roto-Vibrational Raman Scattering

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Relative humidity greatly affects aerosol optical properties and atmospheric visibility. To estimate the relative humidity around an aerosol one needs to measure the nearby water vapor concentration and the temperature without disturbing the environmental conditions. In turbulentenvironments, the temperature can vary across small spatial and temporal scales. Often, it is critical to measure temperature non-invasively to minimize the measurements influence on the surrounding environment. For most LIDAR applications temperature is typically inferred from pure rotational Raman (PRR). However, Mie scattering due to aerosol or cloud droplets can cause leakage of elastically scattered light through optical filters. Temperature information can also be obtained from Vibro-Rotational Raman (VRR) of signals corresponding to low and highrotational levels, like in PRR. VRR has the advantage of being farther spectrally from elastic scattering than PRR and, therefore, is less sensitive to biases resulting from elastic scattering.

Additionally, VRR scattering by major atmospheric constituents, such as N2 and O2, are spectrally separated, making for simpler analysis in post-processing. We measured VRR spectra of atmospheric O2 and N2 using a multi-pass configuration that consists of two-concave mirrors to pass a 10 W 532nm laser through a shared focal point 40 times. A 500 mm imaging spectrograph was used to record the VRR spectrum after the light had passed through a long-passfilter with an optical density of 6 at 532 nm. Molecules populate the rotational states of the VRR spectrum based on Maxwell-Boltzmann statistics, which means that temperature can be inferred from the spectrum without ad-hoc calibrations. However, temperature cannot be accurately determined from VRR using the simple rigid rotor model of atmospheric molecules. We show that for molecular oxygen and nitrogen, a non-rigidity correction can easily be applied to improve the accuracy of the measurement. We show that temperature can be inferred remotely from VRR spectra with 1% accuracy on an absolute scale and precision less than 1K. We believethis technique can be used to measure temperature profiles in heavily polluted environments, or to remotely quantify temperatures in the immediate vicinity of wildfires, for example, to study the effect of humidification on atmospheric aerosols.

AV #53 Volatile Organic Compound and Ozone Measurements at Carlsbad Caverns NationalPark: Impacts of Oil and Natural Gas Operation Emissions on Park Air Quality

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Carlsbad Caverns National Park (CAVE) has recently experienced elevated ozone levels that exceed the EPA's National Ambient Air Quality Standards (NAAQS) 70 ppb standard (10 8-hourexceedances in 2018,

8 in 2019), while there were no ozone NAAQS exceedances from 2013 through 2017. The Carlsbad Caverns Air Quality Study (CarCavAQS) was designed to examine the influence of regional sources, including urban emissions, increased oil and gas development, wildfires and other biogenic sources on the park and provide key insight into our understanding ofthe elevated ozone levels. The special study was conducted from 25 July through 4 September 2019, with a comprehensive suite of gaseous and particulate measurements made at the CAVE Biology Building. Volatile organic compounds (VOCs) were measured using a continuous real- time gas chromatographic (GC) system and a quadrupole proton-transfer reaction mass spectrometer (PTR-MS). Whole air samples were also collected in canisters around the region toaid in characterizing air mass transport from the source regions to the park. A signature of elevatednonmethane hydrocarbon mixing ratios was observed throughout the entire study period. Moreover, the C_2-C_5 alkane mixing ratios were approximately an order of magnitude greater thanregional background levels. Light alkane mixing ratios at CAVE were similar to various other sites influenced by oil and gas emissions, and the i-pentane to n-pentane ratio clearly demonstrates the widespread impact from oil and gas production emissions throughout the region. Results from the CarCavAQS study will be presented, with an emphasis on VOC and ozone distributions.

AV #55 Updates to the Regional Haze Rule Visibility Progress Tracking Metric

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Abstract

In the 2017 update to the Regional Haze Rule, the selection of days used to track visibility progress was adjusted from the 20% haziest to the 20% most anthropogenically impaired. Thischange was necessitated by the observation that wildfire smoke and dust events were increasingly impacting the 20% haziest days and obscuring visibility improvements from anthropogenic emissions reductions. Compared to the 20% haziest days, the 20% most anthropogenically impaired days have a substantially different seasonality, chemical composition, and natural conditions estimate at many sites across the western U.S. Since 2017,the EPA has provided technical guidance related to ambient data analysis and photochemical modeling to aid States in their implementation plans for the second planning period. In this presentation, we'll summarize these different guidance documents and discuss lessons learned regarding how the change to the tracking of visibility affected the baseline 2000-2004 period, recent years, 2028 projections, and the 2064 endpoint at natural conditions. Finally, we'll explore how the impairment framework can be utilized to account for seasonality in the naturalconditions and unique natural emissions like sulfur dioxide from the volcanoes in Hawaii.

AV #56 Brownness of Organic Aerosols: Seasonal Variation and Urban-Rural Contrast

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Carbonaceous material (CM) plays an important role in aerosol visibility, climate, and health effects. Black (BC) and brown carbon (BrC) are subsets of CM that absorb lights particularly in the visible region, while the two differ in the spectral dependence of light absorption. The brownness of organic aerosol (OA) depends on how it partitions between the light-absorbing BrCand non-light-absorbing white carbon (WtC), which reflects the sources and aging process in the atmosphere. A novel thermal/optical analyzer (TOA, DRI Model 2015, Magee Scientific, Berkeley, CA, USA) quantifies thermal carbon fractions while simultaneously monitoring filter reflectance and transmittance at 7 wavelengths (405 – 980 nm), offering an opportunity to measure CM light absorption along with conventional total carbon (TC), elemental carbon (EC),and organic carbon (OC) concentrations. An empirical method was developed to quantify BC, BrC, and WtC from applying DRI Model 2015 to one-year (2016) Interagency Monitoring of Protected Visual Environments (IMPROVE) $PM_{2.5}$ samples. This method includes a loading correction scheme and a spectral mass balance procedure accounting for distinct BC and BrC optical absorption profiles, which were derived from subsets of BC or BrC-dominated samples. The resulting network average BC, BrC and WtC are 0.11, 0.19, and 0.84 μg m^{-3}, respectively. EC measured by the conventional TOA is 0.12 μg m^{-3}, and the overall r^2 between EC and BC is 0.75. The IMPROVE urban sites showed significantly higher BC concentrations (0.47 – 0.80 μg m^{-3}) than rural sites (0.01 – 0.30 μg m^{-3}) as well as higher BrC/OC ratios (i.e., organic brownness), with the highest (0.42) and lowest (0.05) annual average brownness found at City ofDetroit and Organ Pipe National Monument in Arizona, respectively. Network-average OA lightabsorptions at 405 nm are 28% and 50% those for BC over urban and rural areas, respectively. Larger organic fractions of light absorption occur in winter, partially due to higher organic brownness. While in winter organic brownness exhibited a dramatic regional/urban-rural contrast, it diminished to uniformly low values in summer, consistent with effective BrC photobleaching over the mid-latitudes. An empirical relationship between BC, ambient temperature, and organic brownness is established, which can facilitate the incorporation of organic aerosol absorptivity into climate and visibility models that currently assume either zero or static organic light absorption efficiencies.

AV #57 The Use of Measured Data and Modeled Air Quality Results in DevelopingRegional Haze State Implementation Plans

Session #9 - Chairs: Bret Schichtel, NPS-ARD and Tom Moore, WESTAR-WRAP

Panelists include:

- Rhonda Payne, Air Quality Planner, Regional Haze Project Manager, Montana Dept. of EnvironmentalQuality, Air Quality Bureau
- David Stroh, North Dakota Dept. of Environmental Quality, Air Quality Division
- Rebekka Fine, Air Pollution Specialist, California Air Resources Board
- Michael Abraczinskas, Director, Air Quality Division, North Carolina Dept. of Environmental Quality
- Molly Birnbaum, Program Manager, Alaska Dept. of Environmental Conservation, Air Quality Division

The 1977 Clean Air Act (CAA) amendments set the national goal of remedying existing and preventing future anthropogenic sources of visibility impairment in the 156 visibility-protected Class I areas (CIA) across the country. The strategy employed in the 1999 Regional Haze Rule (RHR) is to reduce the haze causing emissions,such that visibility gradually returns through anthropogenic emissions reduction programs to reach estimates of natural levels by 2064, as soon as the emissions controls are able to be implemented under CAA evaluation criteria. States are required to submit Implementation Plans (SIPs) every 10 years using the 2000-04 monitoring data as a "baseline" and analyze the trends in haze since then for each CIA in their jurisdiction. In addition, the States are to analyze and implement emissions control commitments in their SIPs at a reasonableprogress rate toward improving visibility each decadal planning period. Not all emission sources causing impairment are regulated by states. A large fraction can come from natural sources, e.g. wildfires; international sources; and from sources regulated by the federal government. All 50 states are expected to dostatewide emission control analyses to evaluate their sources' impacts at downwind CIA, even if a state does not have a CIA in its jurisdiction. We are now completing the second planning period; those of SIPs were due by July 31, 2021.

Two important components of the SIPs are the integration of the measured tracking of progress in reducing observed haze species causing impairment and the regional chemical transport modeling assessments used to test emissions control strategies and project future visibility conditions – all these analyses are subject to requirements found in various EPA guidance documents. The haze metric used to track progress is derived from IMPROVE speciated particulate matter data. This metric changed in the 2017 RHR promulgation from requiring planning to improve the average of the 20% haziest days in a year to plan for improving the 20% most anthropogenically-impaired days, then averaged into a 5-year metric. The existing monitoring data werere-processed back through 2000. Anthropogenic impaired is the haze from human activity above the estimated but unknowable natural levels. The change was done to be more consistent with the language and intent of the CAA and, with the natural haze estimated, produces a visibility metric with trends that are more responsive to species changes assumed to be caused by anthropogenic emissions. The chemical transport models are used to simulate current haze levels and their causes; assess future visibility in the CIA and evaluate the response of predicted haze levels to projected changes in emissions due to implementation of already-adopted or proposed regulatory actions; estimated changes in human populations and economic activities; and emission reduction options that do not have to include the visibility effects. The development ofSIPs is complicated by the use of a single monitoring site to represent visibility over large CIAs; the difficulty in simulating aerosol in remote locations in complex terrain from natural and anthropogenic sources; and the requirements for CTM simulations to match measured aerosols and predict the future.

In this panel, planners and analysts from state air quality control programs have been assembled to share theirexperience with implementation of the RHR and development of SIPs. The focus is on the use of the monitoring data trends and representations of the revised tracking metric, modeling assessment tools and the distribution of emissions source types – how have these changed since the program tracking and planning formally started in the year 2000 and how they will be used to predict visibility for the 2028 milestone in thesecond round of planning due in 2021.

AV # 59 Regional Haze Modeling for the Western United States

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The Western Regional Air Partnership and Western Air Quality Study (WRAP-WAQS) 2014 modeling platform is the latest of series of regional modeling efforts supporting western air quality planning and management. The Weather Research and Forecasting (WRF) meteorological model, the Sparse Matrix Operator Kerner Emissions (SMOKE) model and the Comprehensive Air Quality Model with Extensions (CAMx) were used for the 2014 base year. The Goddard Earth Observing System global chemical model (GEOS-Chem) provided global boundary conditions for 2014 as inputs to the regional CAMx model. Model performance was evaluated compared to ambient air quality measurements in 2014. A Representative Baseline model run used emissions updated to account for emissions changes and variation between 2014and 2018. Emissions were projected from the Representative Baseline to the future year 2028. The WRAP Technical Support System website displays those model results that specifically address the requirements for regional haze state implementation plans due to EPA in 2021. Visibility projected by 2028 for Class I areas in the western U.S. was compared to EPA assumptions for a uniform rate of visibility progress between 2000-2004 IMPROVE observations and estimated natural visibility conditions in 2064 for western Class I areas. Contributions from U.S. anthropogenic, international anthropogenic, natural and fire emissions to visibility conditions at western Class I areas were estimated using the CAMx Particle Source Apportionment Tool (PSAT) for the Representative Baseline and 2028 future year model runs. For the 2028 model run, PSAT also defined the U.S. anthropogenic contributions to ammonium sulfate and ammonium nitrate from specific western states and emission sectors. These model results allow states to prioritize which emissions reductions strategies might be most effective inimproving visibility at western Class I areas. Additional model results (including current and future year ozone concentrations, model performance, and source contributions) and the CAMx modeling files are available by request from the Intermountain West Data Warehouse for other western air quality planning and analysis applications. As a separate assessment of the relative importance of emissions sectors, back trajectory analyses were used to calculate geographic areas of influence and weighted emission potential for visibility impacts in 2028. These analysesare also available from the WRAP Technical Support System and the Intermountain West Data Warehouse.

AV #60 Source Contributions to Visibility at Western Class I Areas Defined using IMPROVEData and Photochemical Source Apportionment Model

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In the second Regional Haze state implementation planning period, states are required to demonstrate progress by 2028 toward the national goal of no manmade visibility impairment. EPA guidance defines a visibility impairment tracking metric and statistical methods using IMPROVE measurements of carbon and crustal materials to separate contributions from episodicextreme natural events (e.g., wildfire or dust) from routine natural and anthropogenic contributions. Ammonium sulfate and ammonium nitrate are assigned primarily to anthropogenicemissions with smaller contributions from routine natural sources. This statistical approach doesnot separate contributions from U.S. and international anthropogenic emissions. Since states do not have authority to reduce international emissions, better understanding of U.S. anthropogenic contributions to visibility is needed. The CAMx photochemical grid model was run for the 2014 base year, representative baseline period (2014-2018), and a future year (2028) with emissions defined using a combination of western state and EPA projection data. Natural, fire, and international anthropogenic emissions were held constant at Representative Baseline levels for the 2028 model runs. The CAMx Particle Source Apportionment tool (PSAT) was applied for the Representative Baseline and 2028 model scenarios to define international anthropogenic, natural, fire, and U.S. anthropogenic emission contributions and the fraction of total haze attributable to U.S. anthropogenic emissions. At many western Class I areas, total US plus international anthropogenic contributions as defined by source apportionment modeling was similar to anthropogenic impairment defined by EPA statistical methods. Source contributions varied greatly across the western states with highest international loadings near the US borders and lowest contributions in the interior. In general, light extinction due to ammonium sulfate was dominated by international anthropogenic contributions while light extinction due to ammonium nitrate was dominated by U.S. anthropogenic contributions. At several sites, particularly those in California, the Pacific Northwest, and the Rocky Mountains, source apportionment indicates that fires (either wildfire or wildland prescribed fire) contributed significantly to haze (as evidenced by elevated light extinction due to carbon) even on those daysdefined as most impaired due to anthropogenic emissions. For coarse mass and fine soil, CAMx underestimated natural windblown dust and assigned most of modeled coarse mass and fine soil to anthropogenic contributions. Different days are selected as most impaired days using source apportionment compared to EPA methods.

AV #61 Assessing Progress Toward Regional Haze Visibility Goals using a United States Anthropogenic Emissions Rate of Progress

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Abstract

There are 156 Federally mandated Class I Areas (CIAs) that are offered special visibility protection with most of them being in the western U.S. Section 7491 of the Clean Air Act (CAA) has a national goal to remedy any existing visibility impairment at CIAs that is caused by manmade air pollution. The regional haze rule addresses this national goal by requiring states to show they are making progress toward natural conditions by 2064 for the 20% Most Impaired Days (MID) and have no worsening in visibility for the 20% clearest days. The second round of RH state implementation plans are to show progress toward natural conditions in 2028. EPA has developed the IMPROVE 20% MID visibility metric that assumes visibility extinction due to ammonium sulfate and nitrate is anthropogenic in origin and screens out days with high fire and windblown dust impacts using, respectively, carbon and crustal material

extinction as proxies. The Uniform Rate of Progress (URP) Glidepath is used to determine whether a CIA is on a path toward natural conditions in 2064 by drawing a straight line (in deciview) from a 2000-2004 IMPROVE MID Baseline to natural conditions in 2064. Photochemical modeling is used to estimate visibility in 2028 that is compared to the URP Glidepath at 2028 to see whether the CIA is on a path to natural visibility conditions in 2064 (i.e., on or below the URP Glidepath).
This paper discusses an alternative approach for showing progress toward no manmade impairment at CIAs by using modeling results to generate a U.S. Anthropogenic Emissions Rate of Progress (RoP). The CAMx photochemical grid model was run for a current year (RepBase2 representing 2014-2018), the 2028 future year (2028OTBa2) and a 2002 past year (2002 Hindcast). The CAMx Particulate Source Apportionment (PSAT) tool was used to isolate the contributions of U.S. anthropogenic, international anthropogenic, fires and natural sources to PM concentrations and visibility extinction at CIAs. A RoP trend line is drawn from the 2002 Hindcast simulation total visibility (in deciview) to visibility in 2064 with no visibility contributions from U.S. anthropogenic emissions, where the CAMx 2028 PSAT results are used for the no U.S. anthropogenic visibility contributions 2064 end-point. The CAMx total visibility results for 2016 (RepBase2) and 2028 are then compared with the RoP trend line to determine whether visibility at CIAs are on a path toward no U.S. anthropogenic emission contributions by 2064. The U.S. anthropogenic RoP approach has several advantages over the URP Glidepath because it does not rely on uncertain and unknown parameters (e.g., IMPROVE MID, natural conditions, and emissions from fires and international sources) and focuses on what we know best and is available to control (i.e., U.S. anthropogenic emissions).

AV #62 WRAP Dynamic Air Quality Model Evaluation

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As part of the Western Regional Air Partnership – Western Air Quality Study (WRAP-WAQS) 2014 modeling study, a dynamic model evaluation was conducted to test the model's ability to project changes in ambient aerosol visibility extinction at IMPROVE monitoring sites in response to changes in U.S. anthropogenic emissions. The CAMx photochemical grid model was initially run with 2014 meteorology, emissions, and GEOS-Chem global model boundary conditions for the purposes of conducting an operational model performance evaluation that compared the modeling results to IMPROVE aerosol observations. Additional model runs representing U.S. anthropogenic emissions for 2002 (2002 Hindcast), the current period 2014 to 2018 (Representative Baseline), and a future year (2028) used the same boundary conditions and naturalemissions as defined for 2014. Fire emissions representing the period 2014-2018 (Representative Baseline) were used for 2002, Representative Baseline, and 2028 model runs. 2002 U.S. Anthropogenic emissions were back cast from the 2014 National Emissions Inventory (NEI) usingscaling factors based on EPA's NEI trends for most sectors, with exceptions that California Air Resources Board provided 2014 to 2002 scaling factors for California and western states supplied 2002 emissions for electric generating units (EGU), oil and gas point sources, and other non-EGU point sources. Representative Baseline and 2028 emission scenarios used a combination of western states' inventories for point, oil and gas, and on-road mobile emissions and EPA emissionprojections for other sectors (e.g. nonroad, nonpoint, residential wood combustion.) The dynamic model evaluation applied the future year projection methods defined by Environmental Protection Agency guidance to project 2014-2018 visibility from 2002 Hindcast and Representative

Baseline model runs. Projected 2014-2018 aerosol light extinction closely matched IMPROVE observed light extinction. This confirmation increases confidence that the CAMx model and EPA projection methods can produce credible 2028 visibility projections. Backward projections of 2002 visibility from Representative Baseline had larger discrepancies from 2000-2004 IMPROVEobservations than forward projections from 2002 to Representative Baseline. This is likely due to using Representative Baseline levels of fire and international emissions for the 2002 model run that differed from the emissions that contributed to 2000-2004 IMPROVE observations. A future dynamic model evaluation may want to back cast natural, fire and international emissions as well as U.S. anthropogenic emissions.

AV #63 Western Regional, State, and Emissions Source Sector Apportionment for Regional Haze

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As part of the Western Regional Air Partnership regional haze analyses for western Class I areas, the CAMx photochemical with the Particle Source Apportionment tool (PSAT) was applied at a regional level to separate U.S. anthropogenic contributions from those of fire, natural, and international anthropogenic contributions for a current period (2014-2018, Representative Baseline) and a future year, 2028, for 7 aerosol species (ammonium nitrate, ammonium sulfate, organic mass from carbon, elemental carbon, fine source, coarse mass, and sea salt). For the futureyear 2028, PSAT was applied to further define U.S. anthropogenic contributions to ammonium sulfate and ammonium nitrate aerosols at western Class I areas due to 13 western states and the remaining U.S. combined. State contributions were further sub divided into five anthropogenic source categories (electric generating units, oil and gas, remaining point sources, on-road + non- road mobile, and remaining anthropogenic sources). For each Class I area, these results identify which source sectors in that state and surrounding states are projected to have the greatest contributions in 2028 to visibility impairment due ammonium sulfate and ammonium nitrate.
Regionally, U.S. anthropogenic emissions are generally the largest source contribution to ammonium nitrate, while international anthropogenic emissions can have larger contributions than U.S. anthropogenic emissions for ammonium sulfate. State and source sector attribution is site- specific. At many Class I areas mobile emissions and oil and gas emissions are significant contributors to ammonium nitrate, while electric generating units and remaining point sources aremore important source categories for ammonium sulfate.

AV# 66 Historic and Projected Fire Emissions in the Western United States

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Fire is a major source of emissions that contribute to regional haze. As part of the Western Regional Air

Partnership - Western Air Quality Study 2014 modeling platform, emissions inventories for wildfire, wildland prescribed fire, and agricultural fire were developed for the2014 base year, a five-year (2014-2018) representative baseline, and separate future fire scenarios for wildfire and wildland prescribed fire to support air quality planning and the Regional Haze SIP updates.

Development of the Base Year fire emissions inventories relied primarily on the National Fire Emissions Inventory for 2014. Adjustments were made to improve the consistency of metadataneeded for modeling purposes, and events totaling 6% of the acreage in the WRAP region that had been classified as "urban" were reevaluated, resulting in a 9% drop in total prescribed burning emissions.

To develop the representative baseline (RepBase) and Future Fire Scenarios (FFS), a novel approach was considered. Wildfire activity across the United States can vary greatly from year toyear across three primary degrees of freedom: space, time, and magnitude. Therefore, building asingle-year, composite inventory dataset that captures "average" wildfire activity over a five-yearbaseline period is difficult: assessing average total acres burned across the domain is straightforward, but not so for the timing, location, and size of the constituent events. Using the concept of self-organized criticality, we developed a probabilistic approach to determine distributions of fire events by size, start date, and location for each ecoregion in the United States. We then sampled these distributions to build simulated wildfire activity datasets for the RepBase and FFS inventories using different assumptions about overall levels of fire activity. Prescribed and agricultural fire events were carried through from the 2014 Base Year to RepBase. An additional scenario for FFS was created by amplifying prescribed fire events basedon projected percent increases in burning across four federal land management agencies by region.

Application of the probabilistic approach to developing fire inventories led to some unexpectedresults and invited interesting questions to consider for how scenario-based fire inventories are developed in the future. A key characteristic when comparing across the baseline and future scenarios was that an overall increase in wildfire activity across the domain did not result in an increase in emissions in all areas, whether looking by state or by ecoregion. A consideration forapplying this approach again would be to select "representative" levels of activity on an ecoregion basis instead of a regional total, since interannual variation can lead some areas to experience much fewer fires even when the overall total is high. In addition, scaling future wildfire activity using climate modeling results for mid-century conditions resulted in overall modest increases, which seem out of step with the reality of actual levels of activity since 2018. Part of our methodology involved sampling the wildfire activity probability distributions to build100 simulated fire years for each ecoregion. Interestingly, the *maximum* simulated years in the ecoregions for which we saw unprecedented burning in 2020 far under-predicted actual acreages.

AV367 Estimating Fire Contributions to Haze at Western Class I Areas

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Fires are major sources of emissions that contribute to regional haze, particularly in the western United States. For the second regional haze planning period, the Environmental Protection Agency (EPA)

defined a visibility tracking metric that is intended to focus on days that have thehighest fractional contribution assumed to be from anthropogenic emissions. The IMPROVE monitoring data record for Class I Federal areas is used to assign chemical aerosol species to episodic extreme events (elevated carbon or crustal materials, attributed to fire or dust) versus assumed routine natural or anthropogenic source contributions. However, evidence from the Western Regional Air Partnership (WRAP) air quality and source apportionment modeling indicates that fires can be major contributors to total haze at western Class I areas on the days that are tracked as most impaired for the purpose of demonstrating visibility progress. IMPROVE monitoring data for several western Class I areas also indicate elevated carbon likelyattributable to fire on most impaired days throughout the 2000-2018 Regional Haze program tracking period.

The CAMx regional photochemical model was applied to project air quality for a 2014 base year,a representative baseline period (2014-2018) and future year (2028) emissions. 2014 meteorology was used for all model scenarios. Visibility progress by 2028 at each Class I Federal area is calculated for Regional Haze planning purposes. Fire emissions representative of the 2014-2018 period were held constant for the 2028 model scenarios that tested the benefits of reducing U.S anthropogenic emissions in 2028. The Particle Source apportionment tool (PSAT) was applied with CAMx to define contributions from U.S. anthropogenic, international anthropogenic, natural, and fire emissions for the representative baseline and future years. The PSAT results demonstrated that fire activity in the western U.S. impacts days that are tracked as most impaired. The presence of fire, as well as international and natural emissions, makes it more difficult to demonstrate using model results the visibility benefits due to reducing emissions from U.S. anthropogenic sources.

To evaluate future fire contributions to haze, two separate 2028 sensitivity modeling runs tested alternative fire activity assumptions for western ecoregions for wildfire and for wildland prescribed fire. For this future (non-specific) year fire sensitivity, no other changes were made to2028 modeling emissions inputs. 2014 base year meteorology was retained as future year meteorological variability is difficult to forecast. Impacts of the future fire activity varied geographically, temporally, and in magnitude compared to the 2028 scenario. Implications of changing fire prevalence will be discussed in this presentation.

AV #70 Panel Discussion - Wildfires in the Western United States

Chair: Bryce C. Bird, Air Quality Division Director, Utah Department of Environmental QualityPanelists include:

- Jack Broadbent, Chief Executive Officer, Bay Area Air Quality Management District,San Francisco, CA
- Michael Benjamin, Chief, Air Quality Planning and Science Division, California AirResources Board, Sacramento, CA
- Mark Boyle, Idaho Smoke Management Supervisor, Department of EnvironmentalQuality, Coeur d'Alene, ID
- Katie Alexander, Air Quality Meteorologist, Meteorological Services & SmokeForecasting, Montana, Department of Environmental Quality, Helena, MT

Wildland and urban interface fires have repeatedly consumed over 10 million acres per year. Communities and major urban centers in the west have been exposed to wildfire smoke that attimes exceeds the scale of the air quality index with smoke lingering for weeks to months.
Wildfire impacts public health, economic development, management of public lands and compliance

with provisions of the Clean Air Act. Air quality regulatory agencies in the westernstates have been and will be addressing the impacts of smoke to public receptors.
The discussion will include:

- Public health policy, communication and health alerts in response to local and regionalsmoke including air monitoring and modeling of smoke impacting populated areas.
- Interactions with the public, elected officials and land managers to address fire risk andfuel loading through prescribed fire and other fuel management techniques
- Regulatory considerations under the Environmental Protection Agency's exceptionalevents rule and policy documents that relate to exceptional events justifications for particulate matter and ozone.

AV #71 Monitoring short-term visibility impacts at Bryce Canyon National Park for adaptive management of the Alton Federal Coal Lease Tract

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Abstract

On August 28, 2018, the Bureau of Land Management Utah State Office (BLM) approved the Alton Coal Tract for a competitive lease sale. To address potential air quality-related impacts to Bryce Canyon National Park from the mining of the Alton Coal Lease Tract the BLM, National Park Service (NPS), and other advisory agencies developed an adaptive management strategy. There are three elements to the adaptive management strategy: 1) conduct targeted air monitoringof air pollutants and air quality related values (i.e. visibility) at Bryce Canyon National Park and the town of Alton, 2) identify episodic spikes in the monitoring data and degradations to visibilityor air quality trends that can be attributed to mine operations at the Federal Lease Tract, and 3) if monitored air quality degradation can be attributed to such mining activities, implement additionalenvironmental protections and mitigation measures. This presentation discusses the development and implementation of the monitoring strategy and provides a preliminary review of data collectedto date.

AV# 72 A new method for estimating brown carbon light attenuation fromIMPROVE and CSN DRI Model 2015 carbon analysis

Mark C. Green, Desert Research Institute, Reno, Nevada, USA Judith C. Chow, Desert Research Institute, Reno, Nevada, USA John G. Watson, Desert Research Institute, Reno, Nevada, USAXiaoliang Wang, Desert Research Institute, Reno, Nevada, USAL.-W. Antony Chen, University of Nevada, Las Vegas

A new method for estimating brown carbon light attenuation from IMPROVE and CSN DRI Model 2015 carbon analysis Mark C. Green, Judith C. Chow, John G. Watson, Xiaoliang Wnag,Antony ChenChow et al., (2018) developed and applied a method to IMPROVE and CSN datato apportion light absorption through the filter separately to brown carbon (BrC) and black carbon (BC) at each of seven wavelengths utilized by the DRI Model 2015 carbon analyzer. Themethod involved fitting a curve to the light attenuation measured at seven wavelengths from 405-980 nm. An aerosol absorption coefficient (AAE) is calculated. It was assumed that the AAE ofBC is unity and any deviation above unity is attributed to BrC. A limitation is that for a majorityof CSN samples and many IMPROVE samples, the AAE was less

than 1, leading to no attenuation due to BrC. Here we remove the assumption of AAE=1 for BC and calculate the BC AAE based upon two wavelengths (980 nm and 808 nm) where BrC light attenuation is negligible (assumed zero). Using the AAE calculated AAE for BC allows determination of BC attenuation at each wavelength. Any remaining attenuation is then assigned to BrC. We also applied filter loading corrections to account for reduced sensitivity of attenuation as BC lading increases. Applying filter loading corrections to the Chow (2018) method increased the attenuation due to BrC at 405 nm from 3.6% to 10.7% for the CSN network and from 19.0% to 25.3% for the IMPROVE network. Using the new method determining the BC AAE from the 980 and 808 nm measurements increased the filter loading corrected BrC attenuation at 405 nm to 20.3% for CSN and 35.7% for IMPROVE.

AV #74 Brown Carbon Aerosol Absorption Measured Downwind of Wildfires in theWestern U.S.

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Marginally classified as black carbon (graphitic-like aerosol that absorbs broadly across the ultraviolet and visible spectral regions) or brown carbon (organic aerosol that absorbs strongly in the ultraviolet and near-visible spectral regions). The lifetime and chemical aging of brown carbonfrom wildfires are important, but poorly known. We sampled wildfires in the Western U.S. during August 2019 on the NOAA Twin Otter aircraft as part of the Fire Influence on Regionalto Global Environments and Air Quality (FIREX-AQ) field campaign. We measured brown carbon absorption using a particle-into-liquid sampler coupled to a liquid waveguide capillary cell, and aerosol composition using a high-resolution aerosol mass spectrometer. We use thesemeasurements to examine the absorption Angstrom exponent and lifetime of brown carbon absorption as a function of wildfire plume age.

AV #78 In-situ Evaluation of IMPROVE light absorption measurements withphotoacoustic instruments in Reno NV

Bret A. Schichtel, National Park Service, Air Resources Division, Denver, CO (presenting author)
W. Patrick Arnott, Palina Bahdanovich, John W. Walker, Sean Colgan, and Heather A. Holmes, Atmospheric Science Program and Dept of Physics, University of Nevada Reno, Reno, Nevada
William Malm, Cooperative Institute for Research in the Atmosphere, Colorado State University,Fort Collins, Colorado
Warren White, Jason Giacomo, Xiaolu Zhang, Josh Grant, and Nicole Hyslop, University ofCalifornia at Davis, Davis, California

Abstract

The Interagency Monitoring of PROtected Visual Environments (IMPROVE) program provides stewardship of visibility in National Parks and Wilderness Areas. Aerosol light absorption can contribute significantly to visibility reduction and is determined with forward and backward lightscattering measurements of aerosol collected on PTFE filters using a hybrid integrating plate andsphere (HIPS) method with a 633 nm light source. Light absorption is also derived from light absorbing carbon (LAC) measured on quartz filters using a thermal optical reflectance (TOR) method. An IMPROVE sampler collecting 24-hr PM2.5 samples on quartz and PTFE filters every-day was established on the roof of the Physics building at the University of Nevada Reno to compare and evaluate the HIPS filter light absorption (fabs) and TOR LAC measurements against an in-situ light absorption (babs) method. In-situ measurements were made with custom photoacoustic instruments operating at 405 nm, 532 nm, 635

nm, 660 hm, 870 nm, and 1047 nm.All but the 1047 nm instrument were also equipped with a reciprocal nephelometer, which measured aerosol light scattering. Reno is impacted from local mobile and other sources. It has clear air quality days when storms move the urban aerosol out, sometimes replaced with windblown dust from distant sources, and is susceptible to smoke from wildland fires and residential wood combustion. This diversity of sources of absorbing aerosols make Reno a goodlocation for the aerosol light absorption intercomparison experiment. This presentation will describe the experiment and show preliminary results for the intercomparison from January through November 2020. This period experienced clean days as well as poor air quality due to urban aerosol, a strong dust storm on February 8th with Honey Lake CA as the aerosol source region, wildfire smoke from California, and the sudden reduction in societal activity caused by the global viral COVID-19 pandemic. The spectral response of the Babs measurements shifted on day dominated by wildfire smoke compared to other days. However, the underlying relationship between the fabs and in-situ absorption was stable throughout the entire time period at Babs < 5 Mm^{-1}. At higher babs there was evidence of filter loading artifacts causing the fabsto be low. The TOR LAC concentrations did not show evidence of a filter loading artifact, butthe LAC to Babs increased with increasing babs.

AV #79 Could We Be Underestimating the Health Effects of Particulate Pollution?
William E. Wilson

There are two basic reasons why current estimates of the association of cardiovascular mortality (CVM) with PM2.5 are too low. 1. We are not adequately accounting forthe delayed effects of PM2.5. In a previous study of the effect of socioeconomic status (SES) onthe CVM/PM2.5 association, we used Zip Code level mortality data to divide Phoenix into 3 areas with low, middle, and high SES populations and investigated the association out to 5 lag days. We found strong associations at lag days 1, 3 and 5 for low SES; lag days 2 and 5 for middle SES, but no strong associations for high SES. Since it appeared that it might be taking longer for people in the middle SES to die than those in the low SES, we extended our analysis out to lag day 11. For high SES, we found additional strong associations at lag days 8,9,10, and 11; for middle 7 and 8; and for low 10. The low SES association at 10 is due to the small size tail of PM10 which is found in PM2.5. In the middle and high SES, the associations due to fine and coarse particles overlap in the lag day region greater than 5. By looking only at deaths in the first few days after exposure, we miss the deaths of members of the high SES population and the deaths due to particles in the small size tail of the coarse mode. 2. We treat PM2.5 as asingle pollutant with a uniform composition rather than as a mixture whose composition may vary from day to day and city to city. PM2.5 does not have a true association with CVM. It has an apparent association only because it is confounded by all of its many components, as well asother pollutants with which it is correlated. (If pollutant A is non-causal but is corralled with a pollutant B that is causal, A will appear to have an association. The strength of the association is proportional to R^2 of the correlation between A and B.) Phosphorous, Mercury, Elemental Carbon, Cobalt, Sulfur, and Organic Carbon have strong associations with CVM on multiple lag days. Nine other elements have weaker associations. When PM2.5 is included in a multi- pollutant model with its chemical components, the PM2.5 contribution goes to zero. When the associations with CVM of the chemical components found in PM2.5 are added, the contribution of PM2.5 to CVM is much higher. There is no consensus on how to add up the effects of multiple lag days or multiple pollutants. However, the health effects of PM2.5 could be as much as 10 times greater than the current estimate.

AV #89 Owens Lake 2020 Dust Control Update: Lessons Learned and Future Challenges
Phillip L. Kiddoo, Air Pollution Control Officer, Great Basin Unified Air Pollution Control District

On August 7, 1987, the Environmental Protection Agency (EPA) designated the Owens Valley Planning Area (OVPA) as one of the regions in California in violation of the National Ambient Air Quality Standard (NAAQS) for particulate matter less than 10 microns in diameter (PM10) and designated the OVPA as a "serious non-attainment area". PM10 is a criteria pollutant regulated by thefederal Clean Air Act, 42 U.S.C. Section 7401 et seq., as amended (CAA). Under the NAAQS adopted pursuant to the CAA, PM10 levels may not exceed an average concentration of 150 micrograms per cubic meter ($\mu g/m^3$) during a 24-hour period more than one time per calendar year averaged over three years.

The serious non-attainment designation for PM_{10} in the OVPA is strictly attributed to air pollution from Owens Lake located in Inyo County, California, caused as a direct result of the drying of the lake due to water diversions by City of Los Angeles Department of Water and Power (City). By 1913the completion of the Los Angeles Aqueduct had diverted, in entirety, the sole tributary of Owen Lake, the Owens River, over 200 miles south, providing water and power to the residents of Los Angeles. The exposed Owens Lakebed is comprised primarily of dry saline soils and crusts that are the source of wind-borne dust pollution during wind events where elevated concentrations of PM10 prior to any dust mitigation, exceeded the NAAQS up to approximately one-third of the days per yearand up to100 times the standard on the largest exceedance days.

The Great Basin Unified Air Pollution Control District (District) is a unified district as provided by Division 26, Part 3, Chapter 3 of the California Health and Safety Code and consists of all of Inyo, Mono and Alpine counties. The District has regulatory authority over air quality issues in the OVPAwhere Owens Lake is situated. California Health and Safety Code Section 42316, (CHSC 42316) enacted by the California Legislature in 1983, provides in part that the District has authority to require the City to undertake reasonable measures at Owens Lake in order to address the impacts of its activities that cause or contribute to violations of air quality standards.

To bring the OVAP into attainment for the federal air quality standard, the District, under authority of CHSC 42310, submitted to EPA its 1998 State Implementation Plan (SIP) that was approved the following year with an attainment deadline of December 31, 2001 that was extended five years. A series of subsequent SIPs were approved by the District Governing Board in 2003 and again in 2008 due to a failure to attain issued by EPA in 2007. After years of litigation between the District and City over supplemental control requirement determinations, in 2014 the California Superior Court ruled in favor of the District. With a court endorsed 2014 Stipulated Judgment, 3.62 mi^2 of additional dust control mitigation was required to be constructed by the City with a December 31, 2017 deadlineto achieve attainment of the NAAQS. On April 13, 2016, a final 2016 SIP was presented to the District Governing Board for proposed adoption requiring the City to construct, operate and maintain dust controls on an area totaling 48.6 mi^2. From 2000 through the 2017-18 budget year, the price tag to control PM10 emissions at Owens Lake is projected to surpass $2,100,000,000 (2.1B) dollars. Today, cost projections for ongoing operations and maintenance with purchasing of water from othersources to offset the 60,000 - 95,000-acre feet of water used on Owens Lake for dust mitigation, is anadditional $75,000,000 annually. Countless lessons have been learned and future challenges remain.

AV #81 Dispersion Normalized PMF Provides Insights into the Significant Changes in Source Contributions to Atmospheric Particulate Matter after the COVID-19 Outbreak.

Qili Dai, Yinchang Feng, Philip K. Hopke

Abstract
An effective source apportionment tool, factor analysis, utilizes the covariance of compositional variables to separate sources of ambient pollutants like particulate matter (PM). In addition to the variations in source emission rates, meteorology provides another important source of variation through transport and dilution. Conventional positive matrix factorization (PMF) loses information in the observation data due to variations in dilution. To reduce the influence of dilution, dispersion normalized PMF (DN-PMF) is proposed to incorporate the ventilation coefficient into the PMF analysis. This approach has been applied to hourly speciated particulate data measured at a suburban location in a field campaign that included the COVID-19 outbreak. Compared to standard PMF, the results from DN-PMF increased the morning peaks of coal combustion, and traffic rush hour peak of traffic emissions, lowered the daytime peak of soil and aged sea salt and a point source of waste incinerator. It is provided more subtlety defined source directionality. DN-PMF enhanced the local influence of coal combustion, traffic emissions and incinerator, and highlighted the regional transport nature of soil and aged sea salt. The enhanced emission patterns indicated that the DN-PMF is a useful addition to current source apportionment methods. This work also highlights the significant changes in source contributionsafter the outbreak of COVID-19. During this unprecedented pandemic, secondary inorganic aerosol (SIA) was the predominant source of $PM_{2.5}$, with averaged mass contribution of 50.5% that formed via gaseous precursors mostly emission from coal combustion, followed by firework emissions (32.0%), primary emission of coal combustion (13.3%), primary traffic emissions (2.1%), soil and aged sea salt (1.2%) and incinerator (0.9%). The traffic contribution has decreased dramatically (70%) compared to other sources. Soil and aged sea salt contributions decreased by 68%, also likely related to decreased traffic volume.

#AV #83 Role of biomass burning organic aerosols on radiative balance in the Amazon

Manish Shrivistava, Atmospheric Sciences and Global Change Division, Pacific NorthwestNational Laboratory, USA; Quazi Rasool; Bin Zhao; Ying Liu; John Shilling

Biomass burning is a globally important source of aerosols and affects Earth's radiative balance and clouds. Here we present a modeling study showing how biomass burning affects radiative balance over the Amazon. We use the Weather Research and Forecasting Model coupled to chemistry (WRF-Chem) to investigate emissions, plume rise, atmospheric chemistry and SOA formation and aerosol-radiation-cloud interactions over the Amazon. We evaluate our model simulations with the Green Ocean Amazon (GoAmazon2014/5) field campaign datasets and other observations over the Amazon. Preliminary results show that biomass burning emissions oftrace gases and aerosols undergo plume rise by upto 4 km altitudes and significantly perturb atmospheric chemistry, SOA formation and aerosol-radiation-cloud interactions over the Amazon rainforest. Our results have important implications for understanding role of biomass burning in the Earth's radiative balance.

AV #84 Characterization of black carbon aerosol in Palangka Raya,central Kalimantan, Indonesia

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Black Carbon (BC) aerosol has been identified as one of factors that significantly affected theair quality and atmospheric light absorption due to its unique physical properties. It is the second most important contributor to global warming after Carbon Dioxide (CO2) and is considered a short-lived climate pollutant. To quantify its contribution to air pollution, we hadcontinuously measurement of BC in PM2.5 aerosols in Palangka Raya, Central Kalimantan, Indonesia, since 2011 to 2018. The BC concentrations were found in the range of 0.03 – 7.74 ug/m3, with the average concentration was 1.15 ug/m3. The highest BC concentration were found during the massive forest fires episode on September-October 2015. During this forest fires episode, either the PM2.5 or PM10 concentrations were significantly increasing, almost reach 400 ug/m3 and 800 $\mu g/m^3$ respectively and had reduce the visibility in the city until 50m.In this paper were also discussed the seasonal variations of the BC in Palangka Raya. Other than reflectometer, the measurement of BC was also carried out using seven multi-wavelength absorption black carbon MABI to distinguish the sources of the BC observed which may leadto more effective mitigation on reducing the BC emissions especially in Palangka Raya.

AV #85 Health Effects of Air Pollution and Use of Remote Sensing to Estimate PM2.5Exposures

Michael Jerrett, UCLA

A primary limitation of epidemiological studies of the health effects of exposures to PM2.5 air pollution is the lack of direct measures of exposures. The studies therefore require estimates ofexposure. These estimates of exposure have historically relied on ground-based air pollution monitoring. However, because ground-based monitoring is limited in its coverage, there have been growing efforts to use remote sensing or satellite-based estimates in exposure assessment. This presentation will briefly present results from several efforts to use remote sensing to improve estimates of PM2.5 exposure in epidemiological studies. The findings suggest that theuse of remote sensing can contribute to estimates of exposure assessment, but that exposure assessment models that appropriately includes ground-based information from monitoring networks provide superior estimates. Robust exposure estimates can be obtained using models that integrate empirical geographic data, including ground-based monitored data, satellite-basedpollution estimates, and measures of traffic, land use and land cover. In general estimates of adverse health effects from air pollution are larger when exposure is based on integrated empirical geographic models than when exposure is based on remote sensing or satellite-based air pollution estimates alone.

AV #86 Examining Smoke Impacts from Major California Wildfires in 2017 and 2018using Modeled Smoke based on BlueSky Framework and Observed Smoke Data from Ground Monitors and Satellites

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The 2017 and 2018 California wildfire seasons were unprecedented in their number of casualties, amount of property damage, and total fire size. In addition, the smoke impacts from the major wildfires during these seasons caused record-poor air quality and severely reduced visibility in downwind areas. In this study, we model the emissions and transport of fine aerosols from four major wildfires—the

Tubbs Fire in October 2017, the Thomas Fire in December 2017, and the Camp Fire and the Woolsey Fire in November 2018—using satellite fire detections, the NationalOceanic and Atmospheric Administration's (NOAA) High Resolution Rapid Refresh (HRRR) meteorological data, and the BlueSky Smoke Modeling Framework, which includes the HYSPLIT dispersion model. The relationship between modeled concentrations of particulate matter 2.5 micrometers and smaller in diameter (PM2.5) and measured PM2.5 concentrations at regulatory monitoring stations across California are quantified using hourly, daily, and other time-integrated statistical metrics to determine correlation. The spatial extent of modeled smoke dispersion is compared with satellite-based datasets, including imagery and aerosol optical depth.The results from these analyses are used to characterize the air quality impacts of these major wildfires and evaluate the performance of the BlueSky-based smoke modeling approach.

AV #87 Future space-based monitoring of aerosol and precursor emissions with TEMPO

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Omar Torres, NASA Goddard Space Flight Center
Kelly Chance, Harvard-Smithsonian Center for Astrophysics
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In 2022, NASA will launch its first geostationary air quality monitoring satellite capable of monitoring air qualityover greater North America every hour in the daytime. The TEMPO (Tropospheric Emissions: Monitoring of Pollution) instrument measures high spectral and spatial resolution ultraviolet-visible light from which key pollutants can be detected. Products from this mission include column densities of key precursors for particulate matter and ozone (e.g., NO_2, HCHO, SO_2) as well as retrieved products of aerosol optical depth, aerosol layer height, and single scattering albedo. This presentation will give an overview and status update onthe TEMPO mission including its place as part of a developing global air quality observations constellation.
Some highlights will include background information on products produced using TEMPO data as well as preparative measurements collected over strong emissions sources (e.g., cities and wildfires). The goal of thispresentation is to inform end-users about these future observations at unprecedented spatial and temporal resolution for their use in science and applications related to air quality.

AV #88 Phase Shift Parameter Controls Light Absorption Enhancement for Coated FractalAggregates
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The mass absorption cross-section (MAC) of black carbon (BC) aggregates is an important parameter in many climate models. Failure to account for the complex morphology and mixing state of BC aggregates will result in significant underestimation of their MAC, and ultimately errors in global radiative forcing calculations. Consensus holds that organic compounds can coat the surface of BC aggregates and alter their morphology towards an increase in phase shift parameter. However, the detailed evolution pathway of MAC during the coating-induced BC restructuring remains understudied till date. Here, we perform computer simulation to comprehensively probe the MAC enhancement factor ($E_{MAC,BC}$) for coated BC aggregates with changing phase shift parameter and amount of coating. Three aggregation

models: diffusion- limited cluster-cluster aggregation, percolation, and simple cubic lattice stacking, were adopted togenerate aggregates mimicking the real-world BC in the freshly-emitted, partially-collapsed, and fully-collapsed states, respectively. The simulated aggregates were subsequently coated with non-refractory organics, and their optical properties were calculated with the Amsterdam discrete dipole approximation. Our results show that the amount of coating determines the magnitude of $E_{MAC,\,BC}$ per a universal scaling relationship. Finally, we find that the phase shift parameter determines whether $E_{MAC,\,BC}$ is positive or negative (i.e., increased or decreased absorption) over the atmospheric lifetime of BC aggregates and determines whether core-shell model overestimatesor underestimates light absorption by coated BC aggregates.

AV# 89 Measuring Light Absorption by Freshly Emitted Organic Aerosols: Optical Artifacts in Traditional Solvent-Extraction-based Methods

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Recent studies have shown that organic aerosol (OA) could have a non-trivial role in atmospheric light absorption at shorter visible wavelengths. Good estimates of OA light absorption are therefore necessary to better estimate radiative forcing due to these aerosols in climate models. One of the common techniques used to measure OA light absorption is the solvent extraction technique from filter samples which involves the use of a spectrophotometerto measure bulk absorbance by the solvent-soluble organic fraction of particulate matter.

Measured solvent phase absorbance is subsequently converted to particle-phase absorption coefficient using scaling factors. The conventional view is to apply a correction factor of 2 to absorption coefficients obtained from solvent-extracted OA based on Mie calculations. The appropriate scaling factors are a function of biases due to incomplete extraction of OC by solvents and size-dependent absorption properties of OA. The range for these biases along withtheir potential dependence on burn conditions is an unexplored area of research.

Here, we performed a comprehensive laboratory study involving three solvents (water, methanol,and acetone) to investigate the bias in absorption coefficients obtained from solvent extraction- based photometry techniques as compared to in-situ particle phase absorption for freshly emitted OA from biomass burning. We correlated the bias with OC/TC mass ratio and single scattering albedo (SSA) and observed that the conventionally used correction factor of 2 for water and methanol-extracted OA might not be extensible to all systems and suggest caution while using such correction factors to estimate particle-phase OA absorption coefficients. Furthermore, a linearcorrelation between SSA and OC/TC ratio was also established. Finally, from the spectroscopic data, we analyzed the differences in Absorption Ångström Exponents (AAÅEE) obtained from solution- and particulate-phase measurements. We noted that AAÅEE from solvent phase measurements could deviate significantly from their OA counterparts.

AV #90 Framework to Estimate the Most Probable Mixing State of Fine Particles over a NationalPark in Central India

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Aerosol light scattering coefficient (β_{scat}) is a function of its chemical composition, size distribution and mixing state. Two methods of β_{scat} reconstruction (IMPROVE algorithm and Miecalculations) were used for reconciliation between measurements of model derived β_{scat} derived from the chemical and physical properties of measured $PM_{2.5}$.

β_{scat} estimates obtained from the IMPROVE algorithm (Malm, 2000a; Canada, 2004) derived using the aerosol chemical composition overestimated the measurements by a factor of ~4.This suggested that size distribution and the external mixing state assumption of the algorithm need to be reevaluated for the study region.

Mie calculations enable estimation of aerosol optical properties using both its chemical composition and size distribution and allow accounting for possible mixing states. A framework to estimate the most probable mixing state for a given aerosol size distribution and chemical composition using a Mie model (Bond, 2006) has been described.

The Mie model requires the following inputs:

- Size distribution parameters (count median diameter and geometric standard deviation)
- Complex refractive index of particle core and shell
- Reconstructed using chemical composition based on method described in Stelson,1990
- Species can be assigned to core or shell based on their typical occurrence Eg: ECis assigned to core
- Particle coating

o Determines fractional increase in particle diameter due to coating

Extinction efficiency of the aerosol is calculated by the methodology based on Mie theory (Bohrenand Huffman, 1983). The model provides the following output:

- Forward and backward scattering light scattering efficiency ($\beta_{scat,fw}$, $\beta_{scat,bw}$)
- Light absorption efficiency (β_{abs})
- Single scatter albedo (ω)
- Asymmetry parameter (g)

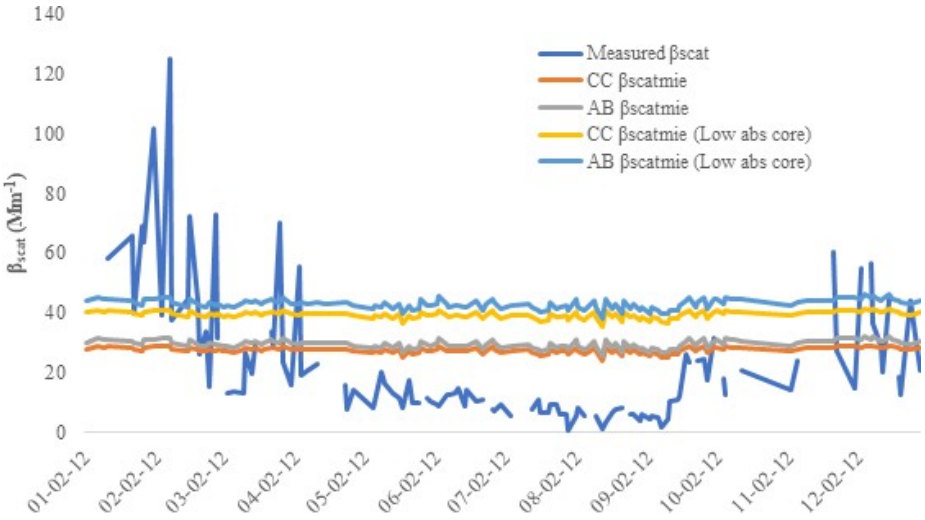

Fig. 1: Comparison of measured and modelled β_{scat} for two size distributions, Clean Continental(CC) and Average Background (AB)

Model estimated β_{scat} was of the same order of magnitude as measured β_{scat} however, without accounting for the mixing state (i.e. no core-shell model considered) the trends (i.e. peaksand troughs) could not be captured by the model in this scenario (Fig. 1). Furthermore, the estimates were sensitive to assumed core absorbance values and the effect of this was also studied.

To demonstrate the effect of accounting for mixing state, two β_{scat} scenarios were considered, a winter high and a monsoon low. The particle diameter was increased for winter anddecreased for monsoon by a factor of 2 and 0.2, respectively which resulted in estimates very closeto the measurements.

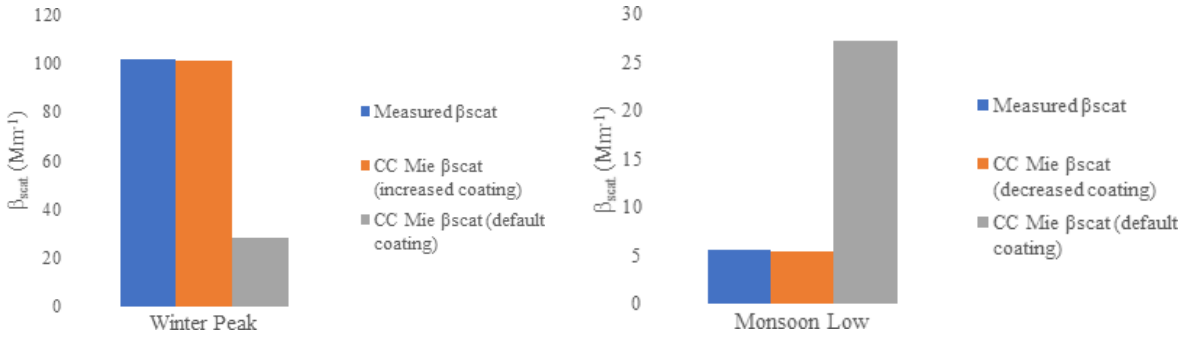

Fig 2: Comparison between measured and modelled β_{scat} for (a) winter high with increased and (b) monsoon low scenarios with decreased coating parameter

Due to the absence of size distribution measurements in this study, the Mie calculations lack accuracy. However, with assumed/ proxy size distribution, a combination of this framework with PMF apportioned β_{scat} results demonstrate the ability of this approach in estimating source- specific probable mixing state of fine aerosols.

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AV #90 Evaluating Ecological Responses of Lichens, Trees, and Herbaceous Plants from Atmospheric Nitrogenand Sulfur Deposition to Federal Lands

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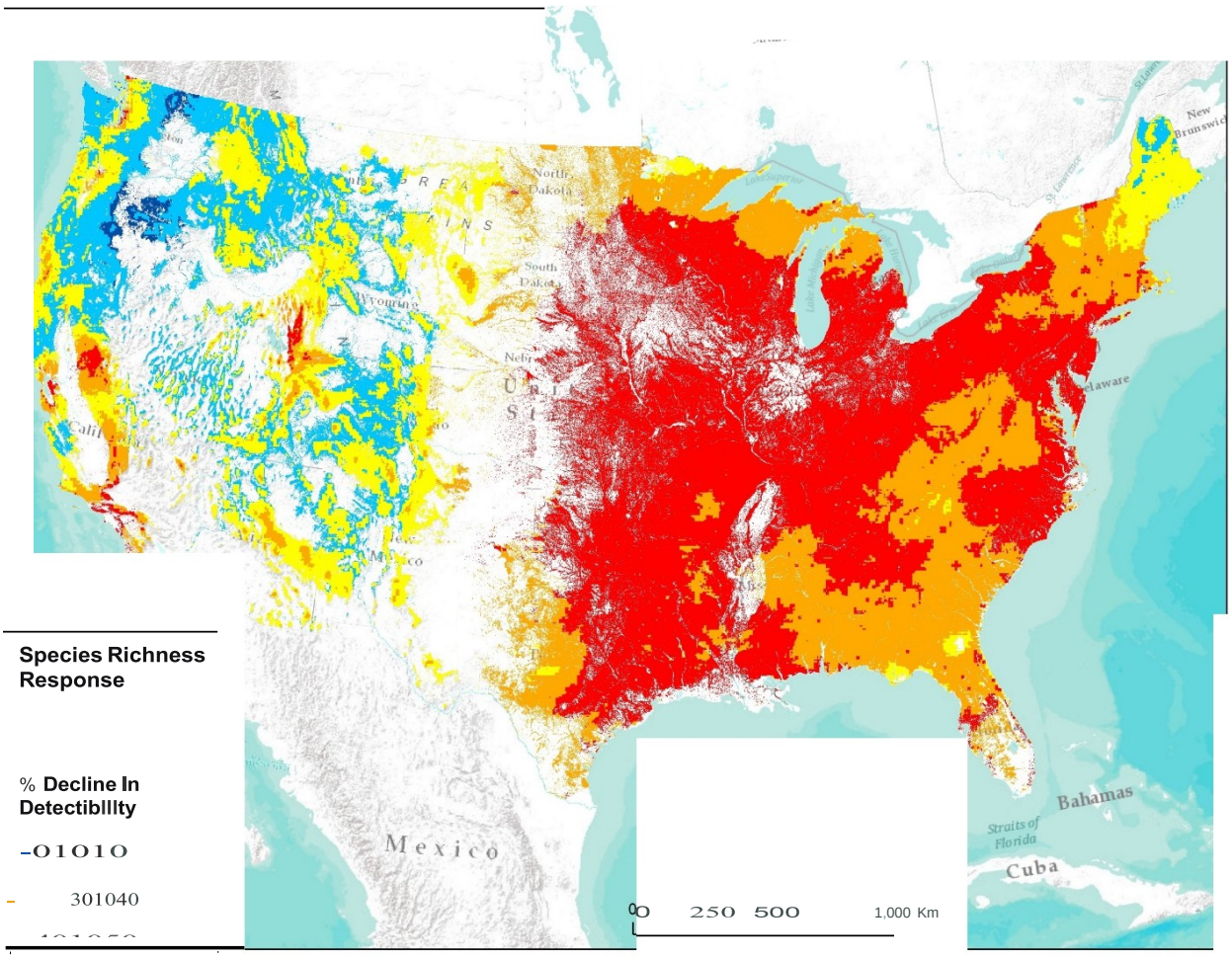
Anthropogenic nitrogen and sulfur pollution are deposited to remote federal lands where they can cause harm to sensitive ecosystem components. The level of deposition below which harm does not occur is called a critical load. US federal agencies have used critical loads to manage ecosystems for over a decade. Recent critical load research has emphasized national- and regional-scale datasets to prepare models of biotic responses to N and S deposition. National-scale critical loads now include species- and community-level responses for epiphytic macrolichens and trees, and regional-scale responses for herbaceous plants. The datasets differ in the response parameters selected but all are widely applicable to forested ecosystems. By synthesizing predictions, managers and regulatory authorities can use current deposition to identify resources at risk and support decision-making to meet legal responsibilities for natural resource protection. This analysis explores a variety of ways of applying species and community specific responses to federal lands.
These new critical loads have a higher level of certainty across a broader geographic area allowing for a refined analysis at a local level. Individual tree, herb, and lichen species have unique response curves for growth, survival, or probability of detection that can be related to species lists for a given site or modeled species distribution ranges. When compared to current deposition the range of responses for individual species can be used to direct management and policy action. Lichen and herb community level critical loads account for climate and other limiting environmental influences, so the responses are mapped on the forest cover in the National Land Cover Database to only apply the critical load to proper ecosystem types. Combining overlapping critical loads gives decision-makers a range of response levels from which they can make informed decisions based on perceived risk. Through this analysis we have identified where additional data collection is needed in order to improve the applicability of critical loads and where alternate analyses using a reduced range of sites are needed to account for variability in environmental/geographic factors.



AV #92 Wildfires in the Wildland Urban Interface: What can we learn from the 2018 Camp Fire?

Michael Benjamin, *California Air Resource Board*

With the increasing frequency of large catastrophic wildfires in California in recent years, there are greater opportunities for these fires to affect communities located within the wildland urban interface (WUI). Fires that occur within the WUI are unique in that they not only burn natural forest lands but can move through entire communities, burning any structures and motor vehicles in their path. While particulate matter emissions from wildfires are generally the biggest health concern, wildfires that burn structures and vehicles can also emit a range of harmful and toxic substances. The 2018 Camp Fire, which burned through Butte County, destroying nearly 19,000 buildings and much of the town of Paradise, was unique in the devastation it caused both in the loss of life and in the number of structures that were destroyed. Findings from a recent California Air Resource Board (CARB) study, which compared air quality impacts from the Camp Fire and three other large wildfires that occurred in 2018 (Carr Fire, Mendocino Complex Fire, and the Ferguson Fire), but burned many fewer structures than the Camp Fire, will be presented. Although regions impacted by the four wildfires all showed elevated PM2.5 levels, only the Camp Fire saw significant increases in both lead and zinc, pointing to emission signatures unique to burning structures.

AV #93 USDA Dust Mitigation Handbook - A Resource for Addressing Windblown Dust

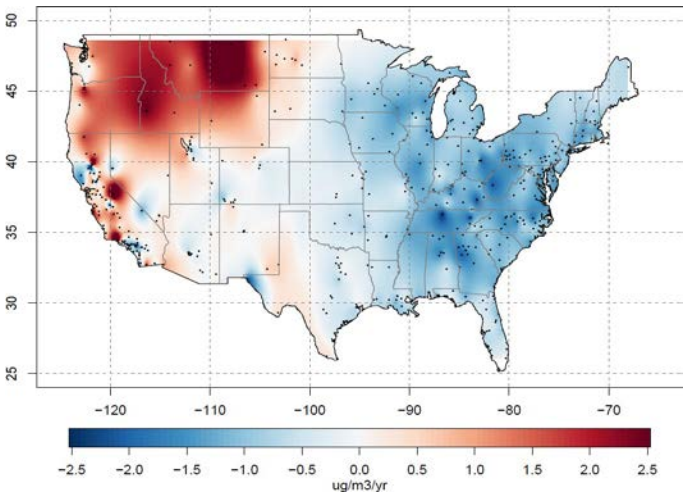
Greg Zwicke, USDA-NRCS, National Air Quality and Atmospheric Change Team, Fort Collins,CO; Steve Smarik, USDA-NRCS (retired); Emile Elias, USDA Southwestern Climate Hub; Dave DuBois, New Mexico State University; Skye Aney, New Mexico State University; Mike Wilson, USDA-NRCS; Brandon Edwards, New Mexico State University; Nick Webb, New Mexico State University; David Brown, Udall Foundation

The USDA Natural Resources Conservation Service (NRCS) and the USDA Southwestern and Southern Plains Climate Hubs have developed the USDA Dust Mitigation Handbook, a resourcefor addressing dust on rangeland, agricultural land, and natural areas. The Dust Mitigation Handbook was authored by a team of NRCS and Agricultural Research Service (ARS) scientistsin 2018-2019 and is designed to be a "one-stop shop" for resource managers for identifying specific conservation practices to mitigate windblown dust emissions.

AV #94 Trends in PM and O3 in response to recent increases in fires in the Western U.S.

Dan Jaffe, School of STEM and Department of Atmospheric Sciences, University of Washington, Udaysankar Nair, Department of Atmospheric Sciences, University of Alabama Huntsville Aaron Kaulfus, Department of Atmospheric Sciences, University of Alabama Huntsville

Between 1960-2000 wildfires burned about 1.5 million hectare per year. But since 2000, the annual area burned has nearly doubled, with most of this increase accounted for by large fires inthe Western U.S. The resulting emissions have exposed millions to very poor air quality for extended periods of times. In this analysis, we examine how fires have impacted the policy relevant air quality metrics for both PM**2.5** and O3. While smoke may impact a community on arelatively small number of days per year, this is still important from both a health and policy perspective, given that the both the PM and O3 standards look at just a few of the highest days ineach year. (98th percentile for PM**2.5** and 4th highest for O3). Our analysis shows that for many cities in the western U.S. the increase in fires has offset the reduction in emissions from anthropogenic sources. For O3 the story is similar albeit a bit more complicated as a secondary pollutant. While fire emissions generate O3 precursors, there is a large degree of variability thatis not well understood. We apply a machine learning method to examine the relationship between O3 and other meteorological factors and this allows us to better understand the influence of smoke on urban O3. In this presentation, we will provide an overview of these methods, with an emphasis on how both PM**2.5** and O3 concentrations have been influenced by the



dramatic increase in fires in the recent decade. Trend in annual 98th percentile $PM_{2.5}$ for 2006-2018.

AV #95 CASTNET Ozone Response to COVID-19 Related Impacts

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ABSTRACT

The Clean Air Status and Trends Network (CASTNET) is a long-term monitoring network designed to measure acidic pollutants and ambient ozone (O_3) concentrations in rural areas across the United States.CASTNET is managed collaboratively by the U.S. Environmental Protection Agency – Clean Air Markets Division (EPA), the National Park Service – Air Resources Division (NPS), and the Bureau of Land Management – Wyoming State Office (BLM-WSO). In addition to EPA, NPS, and BLM-WSO, numerous other participants provide site operator support and grant land access including North American tribes, other federal agencies, States, private landowners, and universities.

On March 13, 2020 the White House issued a national emergency concerning the COVID-19 outbreak and subsequently US state governors began issuing stay-at-home orders beginning with California on March 19, 2020 followed up by an additional 12 states issuing similar stay-at-home orders by March 23,2020. By April 3, 2020, all but five US states have issued state-wide or partial-state stay-at-home orders.

We hypothesize that the stay-at-home orders likely reduced mobile, commercial, and industrial ozone-precursor emissions sufficiently to detect changes in regional air quality. To test this hypothesis, we compare hourly and daily maximum eight-hour average (DMA8) ozone values from 2020 against annualweekly averaged values from 2015-2019 from 75 CASTNET sites with more than 5 years of monitoring data.

Beginning the week of the declaration of the national emergency, March 9th, through May 17th, preliminary CASTNET ozone data show average relative percent differences of -9.2% in the 90th percentile 1-hour ozone values and a -7.4% in the average 1-hour ozone value. We also observe that theaverage number of ozone exceedances of the 2015 ozone NAAQS measured during this same time period is 33.8 exceedances per year between 2015-2019, while in 2020 there have only been 7 exceedances.

We compare the CASTNET ozone data with meteorological datasets from CASTNET and the National Atmospheric Deposition Program (when present) to determine meteorological impacts on ozone formation. We also examine satellite measurements to infer changes in the magnitude and spatial extent of ozone precursors including NO_2. Lastly, we analyze mobility changes based on Google community mobility reports, inferring that changes in mobility patterns suggest reduced emissions fromthe transportation sector.

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AV 397 Attribution of Light Extinction by $PM_{2.5}$ Adjacent to the I-710 Harbor Freeway in Long Beach, CA

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During August and September 2012, a study was conducted to determine the sources of $PM_{2.5}$ adjacent to the I-710 Long Beach Freeway. The sampling site is located immediately east of thefreeway and just south of the northbound Long Beach Avenue exit. The site is directly affected by the emissions from heavy diesel traffic originating from two major container ports about 10 km south of the sampling site. Hourly average data were obtained for particulate species including $PM_{2.5}$, black carbon and UV absorbing carbon, EC, fine particulate nonvolatile and semi-volatile organic material (NVOM and SVOM), sulfate, nitrate, chloride, ammonium ion and Na ion, and for related factors including O_3, CO, NO_X, SO_2, and total traffic flow on the I- 710. A total of 520 hourly averaged data sets with 15 measured variables were analyzed by EPA-PMF v5.0. The data were best described by a 10-factor solution. The results of the PMF analysis were combined with nephelometer light scattering, corrected for coarse particle scattering and estimated aerosol water content in a multi linear regression analysis to identify visibility degradation sources. The effect of relative humidity on water content was estimated from the aerosol nitrate and sulfate content and the relative humidity, using a previously described protocol to average the hysteresis effects on the data for pure ammonium nitrate. The result of the multi-linear analysis of the data indicated that light scattering adjacent to the freeway during the study is significantly affected by aerosol water (28%), the PMF identified NVOM, SVOM factor (32%) the PMF identified Nitrate – NVOM factor (17%) and the PMF identified Port 1 (the major of two Port associated factors identified by PMF) factor (11%). Thevarious traffic relate factors were responsible for a total of 17% of the light scattering and of thattotal the Port 1 factor was responsible for 64%. The PMF analysis will be briefly reviewed and the results of the extinction budget analysis presented.

AV #98 A Global-scale Mineral Dust Equation

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Mineral dust is the most abundant global aerosol by mass. A robust method to estimate mineraldust mass in ambient particulate matter (PM) is essential, as the dust fraction cannot be directlymeasured but is needed to

understand dust impacts on visibility, the climate system, biogeochemistry, and human health. In this study, a global-scale dust equation is developed that builds on the widely used Interagency Monitoring of Protected Visual Environments (IMPROVE) network's "soil" formula that is based on five measured elements (Al, Si, Ca, Fe, and Ti). We incorporate K, Mg, and Na into the equation using the mineral-to-aluminum (MAL) mass ratio of $(K_2O+MgO+Na_2O)/Al_2O_3$ and apply a correction factor (CF) to account for other missing compounds. We obtain region-specific MAL and CF by investigating the variation in dust composition across desert regions. To calculate reference dust mass for equation evaluation, we use total-mineral-mass (summing all the oxides of dust) and residual-mass (subtracting non-dust species from total PM) approaches. For desert dust in source regions, the global equation has a small normalized mean bias (NMB within ±1%) while the IMPROVE equation has an NMB of -6−10%. For $PM_{2.5}$ with high dust content from the U.S. IMPROVE Network, the global equation estimates the dust mass well (NMB within ±5%) at most sites. For desert dust transported to non-source regions, the global equation still performswell (NMB within ±2%). The global equation can also represent paved road, unpaved road, and agricultural soil dust well (NMB within ±5%). This global-scale dust equation provides a promising approach for characterizing mineral dust of different types from various regions, which can help future studies assess the measured dust contribution to aerosols more accuratelyand better understand the dust impacts. More accurate representation of ground-based dust measurements can also benefit the development of atmospheric models and satellite remote sensing algorithms.

AV #99 Local and long-range impacts of wildfire smoke on air quality at Fort Collins, CO

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During the summer and fall of 2020, wildfire smoke caused some of the highest $PM_{2.5}$ concentrations in Fort Collins, CO, in recent years. Smoke from local and distant (i.e., California) fires influenced air quality in Fort Collins during this period, at times concurrently. Aerosol optical properties were measured as part of a nephelometer comparison study at a site inwestern Fort Collins where instruments were operated parallel at low and ambient relative humidity. Initial results indicate that ambient aerosol extinction (b_{ext}) regularly exceeded 500 Mm^{-1} during periods with smoke impacts and hourly $PM_{2.5}$ measurements exceeded 140 $\mu g/m^3$. Aerosol composition was determined from filters collected by the IMPROVE (Interagency Monitoring of Protected Visual Environments) network that operated 24-hr samplers two out of three days. Preliminary results suggest organic carbon and elemental carbon concentrations in excess of 30 and 2 $\mu g/m^3$, respectively, during peak events. We compare aerosol optical, chemical, and hygroscopic properties during periods influenced by local and long-range smoke and place these results in the context of regional climatology.

AV #100 Measuring and Modeling the Relation of Aerosol Optical Depth with Aerosol Scatter,Mass, and Composition to Understand $PM_{2.5}$ across Multiple Scales

Randall Martin, Washington University in Saint Louis

Atmospheric visibility is at the intersection of the relation of satellite aerosol optical depth (AOD) retrievals with fine particulate matter (PM2.5). Modeling the relationship of aerosol opticswith mass using a chemical transport model is being applied to learn about the distribution of PM2.5 from global toward local scales. Collocated measurements of AOD, aerosol scatter, aerosol mass, and aerosol composition are needed to evaluate and improve the ability of a modelto represent these complex relationships. Connections between a national visibility network (IMPROVE) and a global aerosol network (SPARTAN) extend visibility information from national to global scales. Sensitivity simulations with the GEOS-Chem model provide information on the sources of ambient fine particulate matter contributions that affect visibility and human health. These capabilities offer information about the effects of COVID-19 lockdowns on air quality. This presentation will connect atmospheric visibility with satellite and ground-based measurements of atmospheric aerosols with implications for air quality across multiple scales.

AV #101 AirNow Fire and Smoke Map Sensor Data Pilot

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Amara Holder, Karoline Barkjohn, Andrea Clements. Office of Research and Development, U.S. EPA, Research Triangle Park, NC
Sim Larkin. U.S. Forest Service, Seattle WA
Stuart Illson, University of Washington, Seattle WA

In recent years, data from particulate matter (PM) sensors have become a valuable tool for broadening our understanding of air quality impacts from wildfire smoke and demonstrating the localized nature of smoke plumes. In 2020, EPA, in conjunction with state, tribal and local air monitoring agencies and the US Forest Service, initiated the Sensor Data Pilot on the AirNow Fire and Smoke map. This pilot displayed publicly available PurpleAir sensor data side-by-side with data from the permanent and temporary ambient air quality monitors. Because PM sensor data are often biased compared to federal reference method monitors, a correction equation was developed from a long-term sensor collocation across geographically diverse areas, spanning a wide range of PM concentrations. This correction was improved to include extremely high concentrations and validated with smoke-impacted collocations during the 2020 fire season. Datacleaning and quality control steps were developed to quality assure the sensor data that is displayed on the map. This presentation will provide an overview of the AirNow Fire and Smokemap and describe the research behind the sensor data processing that has enabled the addition of thousands of new air quality observations helping communities monitor smoke impacting their area.

This abstract was reviewed by EPA and approved for publication; it may not necessarily reflectofficial Agency policy. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

AV #107 Emission and Evolution of Submicron Organic Aerosol in Wildfire Smoke:Aerosol Mass, Chemical Composition, and Optical Properties

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Delphine K Farmer, Department of Chemistry, Colorado State University, Fort Collins, CO

The intensity and frequency of wildfires in the western US, and associated visibility, health, and climate effects, is increasing. However, wildfire smoke remains poorly characterized, especially regarding aerosol emissions, composition, and optical properties, as well as transformations to that aerosol during atmospheric oxidative aging. The Western Wildfire Experiment: Cloud Chemistry, Aerosol Absorption, and Nitrogen (WE-CAN) aircraft-based study targeted emissions and near-field evolution (<6 hours since emission) of smoke from wildfires during summer 2019. In this work, we focus on the emissions and evolution of organic aerosol (OA), measured by high-resolution aerosol mass spectrometry. For the timescales sampled during WE- CAN, we find that while OA mass concentration does not change, after normalizing for dilution, the chemical composition of the OA does change, becoming more oxidized with age. This result that net OA mass concentration change is zero with clear indication of chemical processing implies that dilution-driven evaporation nearly equals oxidation-drive condensation for wildfire smoke OA. Indeed, modeling secondary organic aerosol (SOA) formation from directly emitted gas precursors, co-measured by chemical ionization mass spectrometry, shows that, downwind ofthe first transect, oxidation of gas emissions to form SOA only accounts for a small component (<5%) of the total organic aerosol, compared to SOA formed from evaporated semi-volatile species that are oxidized to lower-volatility species and re-condense (~30%) to the primary OA(~66%). Brown carbon absorption shows similar dilution-driven loss and secondary formation, and the role of nitrophenolic compounds in aerosol absorption is investigated.
Integration of the field campaign results and a chamber study of catechol oxidation by NO_3 to form nitrocatechol shows that nitrocatechol formation has a disproportionally large effect on aerosol absorption, with nitrocatechol representing only 4 ± 2% of total OA mass but accountingfor 29 ± 15% of aerosol absorption at 405nm. With the rich dataset generated in WE-CAN, we explore the role of dilution and oxidation in the evolution of the chemical and optical properties of smoke aerosol from fires in the western US.

AV #108 Emissions from Fires at the Wildland Urban Interface: Laboratory Measurement of Formaldehyde and Aerosol Properties emitted from Building Materials

Authors: K.B. Benedict, J. Lee, K. Gorkowski, M. K. Dubey, A.C. Aiken

Emissions from burning urban fuels including home building materials and plastics has not received much attention, yet are likely to release greater amounts of toxics into the atmosphere. Fires regularly occur in populated areas and are spreading across the wildland urban interface (WUI) threatening neighborhoods with increasing severity due to drought and land use changes. In order characterize the toxicity of urban fires we report on laboratory measurements aerosol and trace gas emissions from burning of targeted building materials. Emissions from plywood, melamine particle board, pressure treated lumber, and MDF, all with known composition are quantified and contrasted with traditional natural hardwood fuels. We report significant emission of formaldehyde, a toxic EPA regulated gas, fromplywood in an open wood-stove burner.

We also measure the size distribution, soot and metal content of the smoke aerosols and interpret it using the composition of the fuel and the combustion phase. Our gas phase analysis focuses on formaldehyde (HCHO), CO, and CO_2 while aerosol are characterized for their optical properties, organic, inorganic , and black carbon content, and size distribution. While our preliminary analysis did not detect a significant presence of metals in smoke this issue will be explored further with our soot particle aerosol mass spectrometer. Finally, smoke emissions from urban and naturalfuels will be contrasted to better attribute their toxicity.

AV #109 Laboratory and Model Synthesis of Brown Carbon Dyes: Humidity-Dependence andPhotobleaching

Authors: Kyle Gorkowski, K.B. Benedict, J. Lee, A.C. Aiken, C M Carrico, M. Dubey

Non-refractory light absorbing molecules can photochemically oxidize to become more hygroscopic and less absorbing on a per molecule basis. This dynamic process occurs during aerosol transport in the atmosphere and is particularly important during the aging of biomass- burning plumes. We will discuss both laboratory measurements and modeling comparisons forthis process using brown carbon mimics (photobleaching, hygroscopicity, and light scattering).
We preformed aging experiments on mono-disperse surrogate brown carbon aerosol using an Aerodyne oxidation flow reactor. The humidity-dependent optical absorption was measured at 450 nm using a newly developed humidity-controlled single scattering albedometer. We observed a decrease in absorption and increase of single scatter albedo as the days of equivalent OH exposure was increased (1 to 10 days). We interpret our observations using an integrated modeling framework that combines thermodynamics and optical modeling. Specifically, we useda binary activity thermodynamics model to simulate water uptake. We predicted the complex- refractive index from the molecular structures using a newly developed molecular-optical model.We then combined these two steps in a hygroscopic-Mie model to compare our simulation to theobserved humidity-dependent optical absorption.
Our synthesis combines the multiple processes by which brown carbon undergoes photo- bleaching in the atmosphere that will be developed into a simplified parameterization for use inair quality models.

AV #110 Cloud Processing of Black Carbon Particles

Claudio Mazzoleni, Michigan Technological University; Janarjan Bhandari; Will Cantrell;Raymond Shaw; Shreya Joshi; Ian Helman; Swarup China; Tyler Capek; Barbara Scarnato

Atmospheric light-absorbing aerosols such as black carbon containing particles, significantly impact Earth's radiation budget through direct radiative forcing (i.e., light absorption and scattering), indirect effects by interactions with clouds, and semi-direct effects by altering atmospheric dynamics. Black carbon particles, when freshly emitted, are typically fractal-like aggregates of nanometer-sized monomers. During atmospheric transport, black carbon containing particles undergo several transformations due, for example, to oxidation, condensation, and cloud processes. These processes affect the morphology and mixing state of these particles. Morphological changes of black carbon and mixing with other aerosol material affect the particles' scattering and absorption cross-sections and therefore, their direct and semi-direct radiative forcing. These changes also affect the particles' ability to act as ice crystals or water droplets' nuclei in the atmosphere. We studied how the morphology of freshly emitted black carbon particles changes after water condensation and evaporation of water. The experiments were carried out in the turbulent cloud chamber at Michigan Technological University.

In this presentation, we show that the activation of these particles to water droplets results in significant compaction of the black carbon particle aggregates with implications for their direct, semi-direct, and indirect effects on climate. Ongoing research activities are aimed atexpanding this research to include the effects of cloud processing on black carbon particles that have been previously internally mixed with other materials.

AV #112 Optical Properties of Absorbing and Non Absorbing Aerosols

Rachael Dal Porto*, Christopher Cappa*
*Civil and Environmental Engineering, University of California, Davis

Climate change is leading to an increase in wildfires on the U. S. west coast, both in terms of severity and frequency. Biomass burning emits aerosols that absorb solar radiation and are composed of black and brown carbon as well as other organic and inorganic components. Post-emission chemical processing and mixing with other air masses, including coastal emissions from regions such as the Bay Areas, transform the chemical and physical properties of particlesin smoke plumes and can alter the efficiency with which they absorb solar radiation. A key uncertainty in the climate impacts of light absorbing aerosols relates to how they interact with water and, in particular, how particle-phase water alters their absorption. We will report on measurements and analysis of the optical properties of both internal and external mixtures of particles composed of both absorbing and non-absorbing compounds, using a modified CAPS PMSSA, with a particular focus on the impact of humidity on particle light absorption for these mixtures.

AV #113 Cases of COVID19 infections and its correlation with Particle Matter in thecity of Ayacucho, Peru

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The Moderate Resolution Imaging Spectroradiometer (MODIS) datasets in conjunction with ground- based data were used for particle matter (PM) estimation in the city of Ayacucho, Peru. We compared the concentrations of PM2.5 and PM10 recorded in March and April 2019 (pre-pandemic period) with the concentrations recorded from March and April 2020 (pandemic period) in the city of Ayacucho, Peru. A significant decrease in the concentration of PM2.5 and PM10 during the pandemic period when popula- tion movement was strongly restricted.
Subsequently, we correlated PM2.5 and PM10 concentrations with the number of COVID-19 infections on the months of pre-pandemic and during the pandemic days. It was found a strong correlation of PM2.5and PM10 concentrations with COVID-19 infections, suggesting that SARS-CoV-2 might circulate at- tached to the concentration of these particles. However, these results may reflect other factors, such as so-cio-economic impacts that could explain the dynamics of infection in Ayacucho, Peru. Further analysis done with principal components was needed to better understand the dynamics of the SARS-CoV-2 pandemic.

AV #119 Assessing the impact of agricultural NH_3 emissions on theexcess nitrogen deposition in U.S. national parks

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In recent years, successful regulation of nitrogen oxide (NOx) emissions that impact reactive nitrogen (Nr) deposition across the United States has led to increased attention to ammonia(NH_3) emissions, which contribute to Nr deposited in sensitive ecosystems, including many national parks and wilderness areas. NH_3 is a primary trace gas emitted into the atmosphere from a variety of biological, industrial, and combustion processes. Agriculture activities are the largestsource of NH_3, and it is estimated that in the United States it accounts for ~80% of NH_3 emissions.Although NH_3 is not a regulated National Ambient Air Quality Standard (NAAQS) pollutant, $NH_3$is important for particulate matter formation and the fate of other NAAQS pollutants and is therefore included in the National Emission Inventory (NEI) in three main sectors (livestock waste,fertilizer application, and agriculture field burning). To better understand the links between agricultural NH_3 emissions and the excess Nr deposition, the Comprehensive Air Quality Model with Extensions (CAMx) was used to simulate Nr deposition in selected U.S. national parks and wilderness areas. Environmental Protection Agency (EPA) 2016 modeling platform emission andmeteorology inputs were used to evaluate simulated trace gases and particulates against routine monitoring data, including from the Interagency Monitoring of Protected Visual Environments (IMPROVE), Clean Air Status and Trends Network (CASTNET), and Ammonia Monitoring Network (AMoN), and wet nitrogen deposition estimates from the National Atmospheric Deposition Program (NADP). The evaluated model was then used to quantify the contributions ofagricultural NH_3 emissions to the Nr deposition as well as the individual contributions from livestock, fertilizer applications, and field burning activities. NH_3 processes of reemission (bidirectional flux) versus deposition are also discussed.

AV #121 Why is the weather extreme, droughts, floods, heat, cold?
Rob Farber and John Zack

The earth is warming since 1850. Totally due to increasing fossil fuel combustion. Before 1850, CO2 was 250 ppm for at least 650,000 years. Now CO2 is 420 ppm and steadily increasing. CO2 traps the outgong solr radiation, like a blanket. The oceans absorb 90% of the increasing heat, thus the oceans are warming. High pressure dominates areas with warmerthan normal temperatures. The atmospheric temperature profile becomes more unstable. The **Hemispherical pattern changes from zonal to ridges and troughs as the atmosphere tries to dissipate the extra heat.** High pressure sinks heat to the earth's surface, low pressure dissipates heat to the upper atmosphere. These patterns remain stagnant for long temporal periods, strengthening over time. Thus the western US experiences drought and the east floods. The Pacific Ocean high pressure strengthens and expands while the east receives ever more precipitation from more and stronger hurricanes, tornadoes, storms and increasing precipitation from the warming Gulf of Mexico. The summer pattern is increasing heat everywhere.Lots of current meteorological pattern examples will be shown and discussed. These patterns will cover the winter and summer. By the end ofthis 20 min discussion, the audience should have a reasonable understanding about the title above.

AV #122 Current Skill and Challenges of the Multi-scale Prediction of ExtremeWeather Events in a Rapidly Changing Global Climate
John W Zack, Ph.D,MESO, Inc., john@meso.com

Simulations from physics-based global climate models as well as recent observational data and anecdotal evidence all indicate that the global climate is rapidly changing in a direction that will be characterized not only by significant changes in the typical ("normal") global patterns of temperature and moisture but also by an increase in the variability of virtually all weather parameters over muchof the earth, especially in the middle-latitude and polar regions. This increase in variability is also likely to be associated with the more frequent occurrence of (what were previously considered to be) extreme weather events and an increase inamplitude of the parameter anomalies that define the extreme events (i.e., the eventsare likely to be more extreme). In an increasing number of cases the events will be able to be characterized as "never before observed in recorded weather history".

The likely higher frequency and more extreme nature of future weather anomalies will almost certainly increase the interest, demand and probably the critical needfor predictions of these events on multiple look-ahead time frames ranging from a year or season-ahead to hours ahead. A broad range of tools has been developed and is being used to operationally predict such events. However significant prediction challenges are emerging because of the "never seen before" nature of some of the events. This characteristic poses a daunting challenge to statistical or machine learning models that are trained with historical observations since these events are not in the training sample. Physics-based models do not encounter as significant of a barrier in predicting "never seen before" events since presumably the future laws of atmospheric/earth physics will be the same as the present ones. However, even these models have empirical components, which may cause issues in the prediction of extreme events and they also rely on input data to define the state of the atmosphere, water bodies and surface of the earth at the start of a forecast. Assumptions about the nature of the sparsely observed components of this system that we commonly make today may not be valid in the future.

This presentation will (1) review the evidence and arguments for anticipating increased weather variability and a higher frequency and amplitude weather anomalies in the near future climate; (2) a review of the methods (physics-basedand machine learning/statistical) used to predict different types of extreme weather events today and their current skill; and (3) the challenges and research needs to maximize the predictability of the more frequent and more extreme future events.

AV # 123 The Composition and Sources of Organic Nitrogen in Aerosol and Precipitation

Jeff Collett, Colorado State University, Atmospheric Science Katherine Benedict, Colorado State University, Atmospheric Science[1]Amy Sullivan, Colorado State University, Atmospheric Science Evelyn Bangs, Colorado State University, Atmospheric Science[2] Yury Desyaterik, Colorado State University, Atmospheric Science[3] Bret Schichtel, National Park Services, Air Resources Division

Studies around the globe have found organic nitrogen to comprise a significant portion of total atmospheric reactive nitrogen, while amines have been found to be important contributors to newparticle formation. Organic nitrogen (ON) species are emitted from a wide range of anthropogenic and biogenic sources. Some species form in the atmosphere via chemical reaction of biogenic and anthropogenic precursors (e.g., addition of nitrogen oxides during oxidation of monoterpenes). Despite the importance of ON, its abundance is not routinely measured, and its composition remains largely undetermined. Here we summarize a series of investigations to better understand ON composition and sources and to improve approaches for routine ON

monitoring in atmospheric samples. Important methodological advances include development of a method for measuring amines in atmospheric particulate matter and evaluation of methods (filtration, freezing) for preserving ON in wet deposition samples. The new amine method, whichcan separate and quantify 18 different amines, was applied along with liquid chromatography with electrospray ionization mass spectrometry (LC/ESI-MS) and protein analysis to characterizeON composition in aerosol samples from Grand Teton and Rocky Mountain National Parks. ON typically contributed 15-30% of water-soluble nitrogen in collected PM2.5. Higher concentrations were observed during wildfire smoke impact. ON contributions in precipitation samples ranged from 12-25%. The largest measured contributors to PM2.5 water-soluble ON (WSON) were amines and nitrogen-containing compounds measured by positive mode LC/ESI- MS, including indicators of primary biological aerosol particles. The majority of PM2.5 WSON remained unspeciated. Measurements of amine size distributions were made in winter and summer in Fort Collins, Colorado. Methylamine, dimethylamine, and trimethylamine were all observed mainly in submicron particles where they contributed, along with ammonium, to balancing anionic species including nitrate, sulfate, and oxalate.

AV #124 A Paradigm Shift in Sulfate-Nitrate-Ammonium Aerosol Formation in the US and itsImplications for Air Quality and Reactive Nitrogen Deposition

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Denise L. Mauzerall, Princeton University, Civil and Environmental Engineering/Public andInternational Affairs
Rui Wang, Princeton University, Civil and Environmental Engineering Xuehui Guo, Princeton University, Civil and Environmental Engineering Melissa Puchalski, Environmental Protection Agency, Office of Air Programs
Jeffrey L. Collett Jr, Colorado State University, Atmospheric Science
Bret A. Schichtel, National Park Services Air Resources Division
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Sulfur dioxide emissions have decreased by 90% in the US in the last two decades, leading to a paradigm shift in sulfate-nitrate-ammonium (SNA) aerosol formation. At the same time, there isa large discrepancy between scientific findings and regulatory policies in the US regarding the effectiveness of ammonia (NH_3) reduction, another critical precursor of SNA aerosol, on $PM_{2.5}$ control. To quantify the impact of the paradigm shift and resolve the discrepancy, we integratedobservations from multiple air quality monitoring networks (Clean Air Status and Trends Network (CASTNET), the Interagency Monitoring of Protected Visual Environments (IMPROVE) network, the US Environmental Protection Agency $PM_{2.5}$ Chemical Speciation Monitoring Network (CSN), and the Ammonia Monitoring Network (AMoN)) and conducted aerosol thermodynamic analyses to estimate secondary inorganic aerosol (SIA) mass changes inresponse to precursor concentration perturbations. We show aerosol pH has increased by about
0.3 to 0.6 unit across the US from 2011 to 2019, driven mostly by the decrease in sulfate concentrations (50 – 70% on average in the five visibility Regional Planning Organizations (RPOs)). Consequently, annual mean SIA concentration has become insensitive to NH_3 perturbations across the US. Only in the northeastern and southeastern US in winter, SIA concentration still responds to NH_3 changes. With the long-term observational evidence of decreasing SIA sensitivity to NH_3 availability, our results indicate NH_3 emission regulation is unnecessary in the US for air quality purposes, consistent with existing policies.

Meanwhile, the annual mean molar fraction of NH_3 in total ammonium ($NH_4^T = NH_3 + NH_4^+$) has increased from 30 – 40% to 60 – 70% on average in the five RPOs in the US from 2011 to 2019. Therefore, the

importance of NH_3 dry deposition is expected to increase significantly, and the paradigm shift in SNA aerosol formation could lead to dramatic changes in the spatiotemporal pattern of reactive nitrogen (N_r) deposition in the US. Using IASI satellite NH_3 observations, we identified 11 (26) national parks in the contiguous US that are within 100 (200)km of an NH_3 emission or concentration hotspot and are subject to potential impacts on their N_r deposition. More NH_3 flux observations are needed to quantify the impacts of NH_3 hotspots on downwind ecosystems and assess if NH_3 reduction is needed in those areas to mitigate excess N_r deposition.

AV #125 Western U.S. Oil and Gas Emissions Quantification for Regional Haze Planning

John Grant, Amnon Bar-Ilan, Tom Moore

On-shore oil and gas emission inventories are a key component for regional haze planning in the Western U.S. and are rapidly evolving based on changes to exploration and production techniques; regulatory environments; and oil and gas emission measurement studies. Based on recent top-down studies, regulatory oil and gas emission inventories may underestimate emissions from sources either not included or accurately characterized in bottom-up emission inventories. State and local agency programs to compile oil and gas emission inventories vary substantially, leading to regional oil and gas emission inventories that do not have uniform currency or quality. As part of a multi-phase Western U.S.states oil and gas emissions project, baseline 2014-2016 period and future forecast year inventories were developed and control strategies available to control oil and gas emissions evaluated. The 2014- 2016 baseline inventory was improved substantially with state agency-provided emission inventories and as well as targeted operator surveys, developed by Ramboll and distributed to and collected from operators by state agencies. The targeted survey effort provided important updates to wellsite exploration and production activity inputs and emission factors for key emission source categories and organic gases speciation profiles. Recognizing the uncertainty in potential future emissions from oil and gas sources, emission inventories for three scenarios were developed to capture a range of potential future scenarios: 1) Continuation of Historical-Trends, 2) Decline in Vertical Wells, and 3) Increased Horizontal Wells. For the Continuation of Historical-Trends scenario, the emission inventory was disaggregated by mineral designation for use in identifying emission contributions by mineral estate ownership. The control strategy analysis provided a menu of additional reasonable control strategies available to control emissions from oil and gas sources for use in agency decision-making towards identifying controls necessary to make reasonable progress toward natural visibility conditions at Class I areas in accordance with 40 CFR Section 308 (d)(1)(i)(A) of EPA's Regional Haze Rule. Analyses undertaken in this project were performed by Ramboll in accordance with the workplan created by and under the guidance of the Western Regional Air Partnership (WRAP) Oil and Gas Work Group (OGWG).

AV #126 Quantifying Black Carbon Particles in Human Placentae

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There have been many reports concerning associations between ambient particulate matter and reduced birth weight, but the mechanisms by which inhalation impacts fetal growth are poorly understood. Bove et al. (Nature Communications 3866, 2019) reported observing black carbon (BC) particles in the human placenta. The translocation of ambient particles from the lungs to maternal blood to the placenta may be an important pathway for a toxicant that impairs placental development and by extension, fetal growth. We evaluated placental tissue obtained from womenliving in close proximity to major sources of pollution, specifically heavily trafficked highways, and airports, in three cities: Brooklyn (n=9), Rochester (n=5), NY, and Pittsburgh, PA (n=13).
Five areas on each sample slide were examined using two-photon laser microscope (Olympus FVMPE-RS) to image the sample and collect the data. BC particles were identified by the relatively uniform emission across the 4 employed detection channels. Industrial carbon black particles were used to test and characterize the response of the microscope to known BC-like particles. From the obtained 3-dimensional microscopic images, the number of particles per unitvolume of each sample were estimated using Imaris image analysis software. Results indicated particles in the maternal blood space, villus tissue, and fetal blood, suggesting that BC particles can translocate from mother into placenta and into the fetal circulation. We have explored the relationships between the volume concentrations and exposure to ambient BC particles as estimated as the distance to the nearest major known source. These preliminary results demonstrate a promising analytical approach to the estimation of pregnant women's exposure toBC particles and their placental translocation during pregnancy.

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AV #127 Visibility Monitoring to Meet Requirements in the Alton Coal Tract EIS

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Abstract
Monitoring to meet the requirement in the Alton Coal Tract EIS has been ongoing since Decemberof 2019. The Optec NGN2a nephelometer, the instrument of choice in the National Park Service'sVisibility Program for almost 30 years, was paired with the Droplet Measurement Technologies Photoacoustic Extinctiometer (PAX) at two remote, limited-access locations and powered off-grid.The NGN2a measures light scattering at 530 nm, within visual range of the human eye. The PAXsimultaneous measures light scattering and light absorption at 870 nm, suitable for large particlesand black carbon particles, respectively. This presentation is an overview of the monitoring program.

AV #128 Developing a high-resolution low-cost sensor network to better understand local particulate matter (PM) concentrations and refine satellite-based measurements of PM inSouth Carolina

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Currently, our research group is developing a high-resolution low-cost sensor (LCS) networkto monitor air

quality and improve satellite-based measurements of particulate
matter (PM) in South Carolina (SC). We have built an internet-of-things sensor pack, which we call *Intelligent Air*, for use in monitoring ambient PM in remote locations. The sensor pack is builtaround a Sensirion SPS30 PM sensor and is capable of unattended field deployment for many months. In our initial deployment, over the latter half of 2019, sensor performance was found
to have an average R^2 = 0.75 for 24-hour measurements of $PM_{2.5}$ when compared with federal equivalence methods. This value was obtained in hot and humid environments, when the central 99% of data was retained and the data completeness for the 24-hour interval was 75%or greater. There are currently 14 SC Department of Health and Environmental Control (SC DHEC) sites dedicated to monitoring particulate matter in SC for the National Ambient Air Quality Standards, but the use of a dense LCS network and satellite-based retrievals would significantly improve the amount of air quality information available to remote locations and diverse communities. This talk will describe the *Intelligent Air* sensor pack and its initial deployment and discuss strategies for subsequent deployments to improve satellite-based retrievals of aerosol optical depth that are used to infer ground-level PM.

AV #129 Novel approaches to correcting for biases in filter-basedaerosol absorption measurements at a rural site

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Abstract:
Measurement of absorption of solar radiation by aerosols is vital for assessing direct radiativeforcing, which affects local and global climate (IPCC AR5, 2013). Low-cost and simple-to- operate filter-based instruments, such as Particle Soot Absorption Photometer (PSAP) that collect aerosols on a filter and measure the attenuation of light transmittance through the filterare widely used to infer aerosol light absorption. However, filter-based absorption measurements are subject to unquantifiable artifacts associated with the presence of the filter medium and the complex interactions between the filter fibers and accumulated aerosols (Virkkula et al., 2015). Various correction algorithms (e.g., Virkkula et al., 2010 and Muller et al. 2014) have been introduced to correct for the filter-based absorption coefficient measurements toward predicting the particle-phase absorption coefficient (B_{abs}).
Unfortunately, no correction algorithms have been proven to predict absorption coefficientswith a high degree of accuracy (<5% Error) from filter-based absorption monitoring instruments.
In this study, we have analyzed three months of high-resolution ambient absorption data collected in parallel by a PSAP and 3-wavelength photoacoustic spectrometer; both instruments were operated at the Department of Energy's Southern Great Plains (SGP) userfacility at Oklahoma. We implemented the following algorithms to predict B_{abs} values fromPSAP data and estimate their accuracy – (1) the Virkkula (2010) correction algorithm, (2) Revised Virkkula algorithm with updated coefficients, and (3) a Random Forest Regression(RFR) machine learning algorithm. We observe that the RFR algorithm outperforms the predictions of both the Virkkula (2010)

and revised Virkkula algorithms.
To further test the potential of the proposed machine learning model, we trained and testedthe RFR algorithm on a laboratory-generated dataset of burn chamber experiments. The model predicted particle-phase B_{abs} values using the total number concentration, geometricmean diameter, geometric standard deviation, uncorrected Tricolor Absorption Photometer(TAP) based B_{abs}, and nephelometer B_{scat} as input variables. We observed that the RFR algorithm correctly predicted the particle-phase B_{abs} within 5% of the reference B_{abs}.

AV #130 Distributed air quality sensing for wildfire detection and monitoring
Authors: Julien Caubel and Troy Cados

We developed the ObservAir, a modular air quality sensor that is easily deployed in remote, wireless networks to detect and monitor wildfires in real-time. The ObservAir is centered around an aerosol absorption photometer that measures ambient black carbon (BC) concentrations. In this study, sensors were also outfitted with optional carbon monoxide (CO) and nitrogen dioxide (NO_2) modules. All threemonitored pollutants are products of incomplete combustion, and are therefore strongly correlated towildfires, vehicle traffic, and other combustion-driven pollution sources.
Five ObservAir units were collocated with a reference BC instrument in the field for two weeks, and demonstrated close agreement to the reference measurements. The integral CO and NO_2 modules were calibrated in the lab. Following validation, the sensors were deployed to monitoring sites in the northern San Francisco Bay Area. One sensor was deployed at an upwind site near the Bay to monitor background pollutant concentrations, and the rest were located at urban sites in densely populated neighborhoods or rural sites largely surrounded by open vegetation. All ObservAir units were deployed outdoors in weatherproof enclosures outfitted with active ventilation. The ObservAir also implements patented hardware features and software algorithms that promote measurement accuracy when environmental conditions fluctuate. Air quality data was collected over WiFi using a custom web dashboard that providesreal-time air pollution alerts and notifies users of sensor errors and maintenance requirements (e.g., whenthe aerosol filter requires replacement).
The demonstration network was operated for several weeks. Using the data collected, we investigatelocal air quality trends, and evaluate localized wildfire impacts in both urban and rural settings. The dataset illustrates that distributed networks of wireless air quality sensors can help to detect wildfires more rapidly, and provide highly resolved, accurate assessments of health and environmental impacts in real-time.