



# AGENDA

## 33rd CRC REAL WORLD EMISSIONS WORKSHOP

### *Co-Sponsors*

California Air Resources Board  
Truck and Engine Manufacturers Association  
US Environmental Protection Agency  
South Coast Air Quality Management District  
National Renewable Energy Laboratory

### *Workshop Organizers*

Mike Viola, General Motors (Co-Chair)  
Jim Baustian, BP (Co-Chair)  
Michael Aldridge, US EPA  
Sam Cao, SCAQMD  
Tao Huai, CARB  
Aaron Katzenstein, SCAQMD  
Yusuf Khan, Cummins  
Andrew Kotz, NREL  
Joseph Martin, US EPA  
Rada Purushothaman, Caterpillar  
Matt Thornton, NREL  
Heidi Vreeland, US EPA  
Seungju Yoon, CARB

Renaissance Long Beach Hotel, Long Beach, California  
March 26-29, 2023

The purpose of this workshop is free exchange of ideas, research, data, etc. Please do not record or take photos of presentations. All submitted presentation content will be available to participants in the Workshop Proceedings. Sponsorship of or participation in the workshop by CRC or others does not reflect any endorsement of information.

# Keynote Speakers

## **Jed Mandel**

President

Truck & Engine Manufacturers Association

Jed R. Mandel is President of the Truck and Engine Manufacturers Association, a Chicago-based organization representing the manufacturers of commercial vehicles and of engines used in trucks and buses; farm and construction equipment; lawn, garden and utility equipment; marine; locomotive; and stationary applications. EMA represents the interests of its members to regulators and legislators and provides a forum for the industry to address issues concerning product performance, safety, emissions, test procedures, fuels and lubricants, research and science, and public policy. Mr. Mandel has represented EMA for over 40 years and has been involved in every major regulatory, legislative, and judicial matter affecting engines and emissions since 1977. Mr. Mandel has appeared before Congress, state legislative bodies, and various state and federal agencies, and has served on numerous federal advisory committees. Mr. Mandel was instrumental in negotiating the removal of sulfur from diesel fuel, the historic Tier IV nonroad emission regulations, the first-ever heavy-duty vehicle and engine GHG standards and other rules too numerous to list. Mr. Mandel received his undergraduate degree with honors from the University of Michigan in 1974. He graduated from Northwestern University School of Law in 1977.

## **Chris Tennant**

Coordinating Research Council

Dr. Chris Tennant has been the Executive Director of the Coordinating Research Council (CRC) since 2017. Dr. Tennant started at CRC as the Deputy Director in 2005. During his time at CRC he has been responsible for facilitating the work of all CRC research committees, including the development of major research partnerships and developments such as the Advanced Collaborative Emissions Study (ACES), the Mid-Level Ethanol Blends Program, the formation of the Fuels for Advanced Combustion Engines (FACE) Working Group, and the formation of the Sustainable Mobility Committee (SMC). Before joining CRC, Chris was a Senior Engineer at the National Renewable Energy involved in the startup of the ReFUEL Laboratory, and previously was the Director of Engine Testing Services for Automotive Testing Laboratories. Dr. Tennant received his Ph.D. in Mechanical Engineering from West Virginia University in 1997.

# Workshop Chairs

## Michael Viola

### General Motors

Michael Viola is a Staff Researcher in the Chemical and Materials Systems Laboratory at General Motors Research and Development Center. Mr. Viola has been with GM for 38 years and has held several roles that involved advanced fuels, lubricants and emissions research. He has led and been involved in many projects including working on the first prototype Urea-SCR vehicle at GM. He has won an R&D Magazine, One of the 100 Most Technologically Significant New Products of the Year, for “Ionic Liquid Anti-Wear Additives for Fuel Efficient Engine Lubricants.” He holds 16 patents, has published many peer reviewed journals and papers on fuels, lubricant’s and emissions.

Mr. Viola is the co-chairman of the Emissions Committee and the Real World Working Group and serves as a member of the Advanced Vehicle Fuels and Lubricants (AVFL) Committee and the Fuels for Advanced Combustion Engines (FACE) Working Group within the Coordinating Research Council (CRC). He is a GM representative on the Fuels Working Group and the Electrified Propulsion Working Group within the United States Council for Automotive Research (USCAR). He holds both a Master of Science and Bachelor of Science in Mechanical Engineering from Wayne State University.

## Jim Baustian

### BP

Dr. Jim Baustian is currently Manager of Advanced Fuels Regulatory & Risk for bp Products. Jim’s team provides fuels regulatory implementation, compliance management, and technical impact analyses across bp’s North American fuels businesses.

After completing PhD studies in mechanical engineering at Iowa State University in 1988, Jim joined Amoco Oil Company in refining process development. Subsequent roles for bp in both the US and UK focused on fuel product development, distribution technology, and advanced biofuels. Jim also spent six years outside bp as team lead for HD Performance & Emissions Development at Ricardo, Inc.

# Session Chairs

## **Michael Aldridge**

US Environmental Protection Agency

Dr. Michael Aldridge is a scientist in the Assessment and Standards Division of EPA's Office of Transportation and Air Quality. His work focuses on emissions inventory modeling of mobile sources which includes development of EPA's MOVES model, Nonroad model, and Marine Emissions Tools. Michael holds a B.A. in Physics from New College of Florida and PhD in Materials Science and Engineering from the University of Michigan.

## **Sam Cao**

South Coast Air Quality Management District

Dr. Sam Cao is a Program Supervisor at the Technology Demonstration group at South Coast AQMD. He has a Ph.D. in Chemical and Environmental Engineering University of California, Riverside, specializing in in-use emissions measurement from off-road construction equipment and a MBA from Indiana University. Sam currently manages various low-emissions and zero emission technology demonstration and research projects. Prior to joining South Coast AQMD, he worked at Cummins Inc. in Advanced Emissions Development group for 5 years.

## **Tao Huai**

California Air Resources Board

Dr. Tao Huai is Chief of the Freight Emissions Testing and Research Branch in the Mobile Source Laboratory Division at the California Air Resources Board. Over the past eighteen years, Tao has overseen the development of regulations requiring lower global-warming potential automotive refrigerants, conducted research studies assessing the effectiveness of light- and heavy- duty vehicle advanced emission control technologies, and supported adoption of the ultralow particulate matter standards for the Advanced Clean Car Regulation.

Tao earned a Bachelor of Science degree in Thermal Engineering and a Master of Science degree in Management Science and Engineering from Beijing's Tsinghua University, followed by a Ph.D. in Chemical and Environmental Engineering from the University of California, Riverside. Tao is also an Adjunct Assistant Professor in the Department of Environmental Health Sciences at the University of California, Los Angeles.

# **Aaron Katzenstein**

## **South Coast Air Quality Management District**

Dr. Aaron Katzenstein is the Assistant Deputy Executive Officer of the Technology Advancement Office for Science & Technology Advancement. He is responsible for the Technology Advancement Office which oversees several mobile source incentive programs, technology review, and development and commercialization of clean air technologies.

He began his career at South Coast AQMD in 2003 where he worked in the laboratory prior to his role as the Climate and Energy Supervisor in Planning and Rules. He later became an Acting Planning Manager for Area Sources and most recently was the Laboratory and Source Test Manager. He has been heavily involved in numerous Multiple Air Toxics Exposure Studies, Air Quality Management Plans, policy development, research projects, air quality studies, and technology/infrastructure projects.

Dr. Katzenstein received his undergraduate degree in Chemistry with a minor in Physics from the University of Redlands. He graduated with a M.S. and Ph.D. in Chemistry with a focus on Atmospheric Chemistry from the University of California Irvine where he studied regional and global air quality.

# **Yusuf Khan**

## **Cummins, Inc.**

Dr. Yusuf Khan is a Technical Advisor in the department of Product Compliance & Regulatory Affairs at Cummins Inc. He joined Cummins in 2013 after obtaining his Ph.D. in Chemical & Environmental Engineering from the University of California, Riverside. At Cummins, he is global emissions measurement and test procedures expert supporting global sites. He is the owner of Cummins global emissions post-processing tool, emissions database, and retrieval programs. He is also responsible for ensuring correct implementation of new test procedures at various global test sites. He is currently co-chair of the Truck & Engine Manufacturer Associations - Emissions Measurement & Testing Committee, represents Cummins in European Automobile Manufacturers' Association, SAE Emission Standard Committee, and represents the US for ISO Technical Committee.

# **Andrew Kotz**

## **National Renewable Energy Lab**

Dr. Andrew Kotz is a Senior Research Engineer at the U.S. Department of Energy National Renewable Energy Lab where he is part of the Center for Integrated Mobility Science's Commercial Vehicle Technology team. Andrew received his Ph.D. in Mechanical Engineering from the University of Minnesota where he researched real-world transit bus NOx emissions and vehicle big data. At NREL, Andrew's work focuses on heavy duty electrification, vehicle emissions and big data that help advance energy efficient and renewable transportation.

# **Joseph Martin**

## **US Environmental Protection Agency**

Dr. Joseph Martin is a researcher with the USEPA's Office of Research and Development, in the Surface and Fine Scale Branch of the Center for Environmental Modeling and Measurement. He received an MPH in Environmental Quality and Health from the University of Michigan's School of Public Health and a Ph.D. in Soil Chemistry from Purdue University. At EPA, Joseph's work is centered on characterization of IVOC/SVOC emissions from multiple sources, supporting method development, emissions inventories, and regulatory action.

# **Rada Purushothaman**

## **Caterpillar, Inc.**

Dr. Rada Purushothaman is a Senior Engineering Specialist, Global Engine Development at Caterpillar. Rada joined Caterpillar as an intern in Advanced Materials Technology in 2006. He worked as an engineer for Heat Treatment and Furnace Atmosphere Monitoring Systems. Rada later joined the Engine Emissions Measurement team in 2009 to support the Non-Road Tier IV engine development. His team is responsible for gaseous, particulate and particle emissions measurement for testing and compliance to various global emissions regulations. Rada is currently Chairman of the Truck and Engine Manufacturers Associations' (EMA's) Emissions Measurement and Testing Committee (EMTC) and has been a member of that committee for over 10 years. The EMTC meets regularly with US EPA and CARB to draft and amend emissions test procedures. The EMTC also sponsors and funds projects to improve emissions measurement and testing issues. Rada is also a member in SAE Emissions Standards Committee. Rada's research interests include Particulate and Particle Measurement and Emissions Measurement Uncertainty. He holds a M.S. and Ph.D. from Worcester Polytechnic Institute, Massachusetts in Manufacturing Engineering.

# **Matt Thornton**

## **National Renewable Energy Laboratory**

Dr. Matthew Thornton is a Principal Research Engineer and Strategic Program manager in NREL's Energy Conversion and Storage Systems Center. In this role he leads strategic initiatives across the center as well as the Mechanical and Thermal Engineering Sciences directorate, including the capital investment plan for the Advanced Research on Integrated Energy Systems (AREIS) platform.

Previously Matt was the manager of the Fuels and Combustion Science group in NREL's Center for Integrated Mobility Sciences. The fuels and combustion science group explores the chemical basis of how biofuels, advanced petroleum-based fuels, fuel blends, and natural gas perform in engines and vehicles across all transportation modes as well as in fuel pumps, storage tanks, and distribution systems. Matt was also NREL's PI for the U.S. Department of Energy's Hydrogen Storage Engineering Center of Excellence, advancing materials-based hydrogen storage systems for fuel cell vehicles, he also oversaw NREL's Renewable Fuels and Lubricants Lab, as well as, the vehicle systems analysis team, which conducts technical simulations and analyses of promising vehicle technologies to find cost-competitive solutions that maximize energy savings and minimize emissions.

Beyond NREL, Matt serves as an affiliate professor at Colorado State University and an adjunct professor at the Colorado School of Mines, where he teaches a course he developed on transportation, energy, and the environment. Matt received his Ph.D. in Civil and Environmental Engineering from the Georgia Institute of Technology.

# **Heidi Vreeland**

## **US Environmental Protection Agency**

Dr. Heidi Vreeland is a researcher at the U.S. Environmental Protection Agency in the Office of Research and Development. Her work at EPA includes investigating air quality impacts from combustion source emissions, and managing light-duty and heavy-duty dynamometer research. Heidi holds a M.S. from the Georgia Institute of Technology and Ph.D. from Duke University in Environmental Engineering.

# **Seungju Yoon**

## **California Air Resources Board**

Dr. Seungju Yoon is a manager with California Air Resources Board, Research Division. He oversees on-road and off-road mobile source research programs of mitigating greenhouse gas emissions from mobile air conditioners (MVAC), characterizing in-use vehicle emissions and activity and their impact on air quality, investigating emissions reduction opportunities using laboratory, remote-sensing, and engine and activity data-logging technologies, and understanding non-tailpipe emissions such as brake and tire wear. Seungju holds a master's degree in environmental engineering – air pollution control and a Ph. D degree in civil engineering – transportation systems from the Georgia Institute of Technology. He has over 20 years of experience in transportation and air quality research and policy development.

## Sunday, March 26, 2023

4:30-6:00 PM Registration and Poster Setup in Farrell's Lounge

6:00-7:00 PM Welcome Reception in Dawson and Landmark Patio (3rd Floor Terrace)

## Monday, March 27, 2023

*All sessions take place in Bixby Ballroom, unless otherwise noted*

7:00 AM Registration in Bixby Foyer and Continental Breakfast in Farrell's Lounge

8:00 AM Welcome from the Chairs: Mike Viola, General Motors, & Jim Baustian, BP

8:15 AM **Keynote Address: Jed R. Mandel**

**President, Truck & Engine Manufacturers Association**

### SESSION 1

9:00 AM **In-Use Emissions for Light- and Heavy- Duty Vehicles**

*Introduction by Session Leaders: Matt Thornton, NREL and Tao Huai, CARB*

9:05 AM USE OF REMOTE SENSING DATA TO ASSESS I/M PROGRAM EFFECTIVENESS Jim Lyons Trinity Consultants

9:20 AM INVESTIGATION OF FLEET EMISSIONS USING ENHANCED INSPECTION AND MAINTENANCE METHODS Daisy Thomas 3DATX

9:35 AM INFLUENCE OF SNOWFALL ON CO2 AND NOX EMISSIONS OF WINTER MAINTENANCE VEHICLES Will Northrop University of Minnesota

9:50 AM OVERVIEW OF DIESEL ENGINE MANUFACTURERS' DF VALIDATION RESULTS Precious Ofoegbu California Air Resources Board

10:05 AM **Poster Session and Demonstrations in Farrell's Lounge**

10:40 AM IN-USE EMISSIONS TESTING AND FUEL USAGE PROFILE OF ON-ROAD HEAVY-DUTY VEHICLES – 200 VEHICLE STUDY – NOX EMISSIONS Tom Durbin University of California, Riverside

10:55 AM ANALYSIS AND EVALUATION OF SENSOR-BASED ONBOARD SENSING, ANALYSIS, AND REPORTING (OSAR) FROM SEVERAL CLASS 8 TRUCKS DURING A LONG TERM MEASUREMENT STUDY Kent Johnson University of California Riverside

11:10 AM CHARACTERIZATION OF IN-USE HEAVY-DUTY DIESEL TRUCK EMISSION RATES OVER THE PAST DECADE AND EMISSION CONTROL TECHNOLOGY PERFORMANCE Chelsea Preble UC Berkeley

11:25 AM IMPACT OF LOW AMBIENT TEMPERATURE ON THE TAILPIPE EMISSIONS OF A 2027 HEAVY DUTY LOW NOX ENGINE ON REAL-WORLD DUTY CYCLES Bryan Zavala Southwest Research Institute

11:40 AM EVALUATING THE IMPACT OF CONNECTED VEHICLE TECHNOLOGY ON HEAVY-DUTY VEHICLE EMISSIONS Stanislav Gankov Southwest Research Institute

11:55 AM General Discussion and Open Q & A

12:15 PM **Lunch Break in Pike Ballroom**

### SESSION 2

1:45 PM **Emissions Control Measures**

*Introduction by Session Leader: Seungju Yoon, CARB*

1:50 PM LONG-TERM TRENDS OF IN-USE NOX AND CO2 EMISSIONS FROM HEAVY-DUTY ON-ROAD VEHICLES IN CALIFORNIA Georges Saliba California Air Resources Board

2:05 PM COMPREHENSIVE INTEGRATED SIMULATION FOR ENABLING NEAR ZERO EMISSION VEHICLES Andrea Strzelec University of Wisconsin-Madison

2:20 PM EVALUATION OF EMISSION WARRANTY COST ESTIMATION METHODS FOR THE CALIFORNIA AIR RESOURCES BOARD'S HEAVY-DUTY ENGINE AND VEHICLE OMNIBUS REGULATION Shunsuke Nakao California Air Resources Board

2:35 PM PM EMISSION BENEFITS FROM A NEW U.S. LIGHT-DUTY VEHICLE STANDARD Michael Geller MECA Clean Mobility

2:50 PM General Discussion of Session 2

3:00 PM **Poster Session and Demonstrations in Farrell's Lounge**



# Monday, March 27, 2023

## SESSION 3

3:30 PM	<b>Off Road / Non-Road</b>		
	<i>Introduction by Session Leader: Rada Purushothaman, Caterpillar</i>		
3:35 PM	CARB'S OFF-ROAD IN-USE COMPLIANCE PILOT PROGRAM	Hyun Ji (Julie) Lee	California Air Resources Board
3:50 PM	MODELING SPATIAL VARIABILITY IN LOCOMOTIVE FUEL USE AND EMISSION RATES BASED ON REAL-WORLD MEASUREMENTS	Tongchuan Wei	North Carolina State University.
4:05 PM	DEVELOPMENT OF AN OFF-ROAD EMISSIONS SCREENING PROCEDURE FOR ANALYZING IN-USE EMISSIONS USING A THREE-BIN MOVING AVERAGE WINDOW (3B-MAW) METHOD.	Christian Bartolome	California Air Resources Board
4:20 PM	General Discussion of Session 3		
4:30 PM	Logistics for Dinner Event	Jan Tucker	Coordinating Research Council, Inc.
4:35 PM	<b>END OF DAY</b>		
5:45 PM	Meet in Lobby to Leave for Networking Dinner, Last Bus Leaving at 6:00 PM		

## Tuesday, March 28, 2023

7:00 AM Registration in Bixby Foyer and Continental Breakfast in Farrell's Lounge

8:00 AM Keynote Introduction by Workshop Co-Chair, Mike Viola, General Motors

8:05 AM **Keynote Address: Chris Tennant**  
**Executive Director, Coordinating Research Council**

### SESSION 4

8:50 AM **Electric and Hybrid Vehicles**

*Introduction by Session Leader: Matt Thornton, NREL*

8:55 AM	POTENTIAL EMISSION BENEFITS OF ZERO EMISSION TECHNOLOGY ADOPTION SCENARIOS IN OFF-ROAD EQUIPMENT SECTORS	Junhyeong Park	California Air Resources Board
9:10 AM	CHALLENGES FOR REALGHG REDUCTION UNDER CURRENT TAILPIPE REGULATIONS	Graham T Conway	Southwest Research Institute
9:25 AM	ACTIVITY AND PERFORMANCE FOR HEAVY-DUTY DIESEL AND BATTERY ELECTRIC VEHICLES IN REAL-WORLD OPERATIONS	Tianyi (Jerry) Ma*	University of California, Riverside
9:40 AM	General Discussion of Session 4		
9:50 AM	<b>Poster Session and Demonstrations in Farrell's Lounge</b>		

### SESSION 5

10:15 AM **Improving the Emissions Inventory**

*Introduction by Session Leader: Sam Cao, SCAQMD*

10:20 AM	A TALE OF TWO FLEETS: RSD MEASUREMENTS IN NORTHERN BAJA, MEXICO AND IMPLICATIONS FOR THE BORDER EMISSIONS INVENTORY	John Koupal	Eastern Research Group
10:35 AM	NEXT STEP OF EMFAC DEVELOPMENT: HIGHER SPATIAL RESOLUTION EMISSION INVENTORY	Jiachen Zhang	California Air Resources Board
10:50 AM	APPLICATION OF AUTOMATED LICENSE PLATE READERS (ALPR) FOR FLEET CHARACTERIZATION AND EMISSIONS INVENTORY	Sara Forestieri	California Air Resources Board
11:05 AM	APPLYING REAL-WORLD HEAVY-DUTY EMISSIONS DATA TO INFORMING INVENTORY DEVELOPMENT – DATA ANALYSIS ON PEMS	Mo Chen	California Air Resources Board
11:20 AM	CONTINUED AND EXPANDED REMOTE SENSING MEASUREMENTS OF THE CALIFORNIA VEHICLE FLEET	Alan Stanard	Eastern Research Group
11:35 AM	WHEN AND WHERE SUPER-CLEAN GASOLINE- AND DIESEL-POWERED VEHICLES OUTPERFORM ZEVS ON CRITERIA POLLUTANT EMISSION REDUCTIONS	Gary Yowell	Stillwater Associates
11:50 AM	General Discussion of Session 5		

12:00 PM **Lunch in Pike Ballroom**

**Tuesday, March 15, 2022**

**SESSION 6**

1:30 PM	<b>Emissions Modeling</b> <i>Introduction by Session Leader: Michael Aldridge, US EPA</i>		
1:35 PM	A FINE-SCALE ROADWAY EMISSIONS INVENTORY FOR SAN FRANCISCO BAY AREA USING TELEMATICS-BASED DATA AND EMFAC2021	Yuan Du	Bay Area Air Quality Management District
1:50 PM	EVALUATION OF MODEL PREDICTIONS OF REAL-WORLD EMISSION HOTSPOTS BASED ON MEASURED VEHICLE ACTIVITY AND EMISSIONS	Christina Quaassdorff	Technical University of Madrid / NC State University
2:05 PM	SWITCHING FROM MOVES2014B TO MOVES3: CHANGES IN EMISSION RATES AND IMPLICATIONS ON AIR QUALITY PLANNING	Chaoyi Gu	Texas A&M transportation Institute
2:20 PM	EPA PLANS FOR ELECTRIC VEHICLES MODELING DEVELOPMENT IN MOVES	Tiffany Mo	U.S. EPA Office of Transportation and Air Quality
2:35 PM	PREDICTING HEAVY-DUTY VEHICLE EMISSIONS USING ADVANCED MACHINE LEARNING ALGORITHMS	Abdul Motin Howlader	California Air Resources Board
2:50 PM	General Discussion of Session 6		

**3:00 PM Poster Session and Demonstrations in Farrell's Lounge**

**SESSION 7**

3:30 PM	<b>Air Quality / Effects of COVID-19 on Air Quality</b> <i>Introduction by Session Leader: Heidi Vreeland, US EPA</i>		
3:35 PM	NEW EUROPEAN STANDARDISED METHOD FOR MEASURING PARTICLE AND CARBON DIOXIDE POLLUTION IN THE VEHICLE CABIN	Nick Molden	Emissions Analytics Ltd.
3:50 PM	COVID-19 PANDEMIC EFFECTS ON VEHICLE ACTIVITY AND EMISSIONS	Allison DenBleyker	Eastern Research Group
4:05 PM	USE OF LINEAR REGRESSION TECHNIQUES FOR DEMONSTRATING THE EXCEPTIONAL IMPACT OF THE COVID-19 HEALTH EMERGENCY ON OZONE AIR QUALITY IN THE DISTRICT OF COLUMBIA	Joseph Jakuta	District of Columbia Department of Energy and the Environment
4:20 PM	COVID-19 AND VEHICLE EMISSIONS INSPECTION FRAUD IMPACT	Chris Klaus	NCTCOG
4:35 PM	General Discussion of Session 7		
4:45 PM	<b>END OF DAY</b>		
5:30 PM	<b>Poster Session, Demonstrations, and Evening Reception in Farrell's Lounge</b>		

## Wednesday, March 29, 2023

7:00 AM Registration in Bixby Foyer and Continental Breakfast in Farrell's Lounge

### SESSION 8

#### 8:00 AM Fuel Effects on Emissions

*Introduction by Session Leader: Michael Viola, General Motors*

8:05 AM	EFFECT OF FUEL PROPERTIES ON PM EMISSIONS FROM 4-CYCLE GASOLINE NONROAD ENGINES	Aron Butler	U.S. EPA Office of Transportation and Air Quality
8:20 AM	LOW-CARBON SYNTHETIC FUELS FOR ULTRA-LOW TAILPIPE EMISSIONS IN THE LIGHT-DUTY VEHICLE SECTOR	Alexander Voice	Aramco Americas
8:35 AM	SHORT-TERM FUEL IMPACTS ON TAILPIPE EMISSIONS FROM A 2027 HEAVY-DUTY LOW NOX ENGINE	Chris Sharp	Southwest Research Institute
8:50 AM	General Discussion of Session 8		

### SESSION 9

#### 9:00 AM Brake and Tire Wear

*Introduction by Session Leader: Seungju Yoon, CARB*

9:05 AM	DEVELOPMENT OF NEW BRAKE WEAR EMISSION RATES FOR EPA'S MOVES MODEL	Michael Aldridge	U.S. EPA Office of Transportation and Air Quality
9:20 AM	TRACE METALS AND CHEMICAL COMPOSITION ANALYSIS FROM BRAKE WEAR PARTICULATE MATTER (BWPM) EMISSION AMONG DIFFERENT BRAKING PAD MATERIAL TYPES ON LIGHT-DUTY VEHICLE BRAKING SYSTEMS	Chia-Li Chen	California Air Resources Board
9:35 AM	ELEMENTAL CONTENT OF BRAKE AND TIRE WEAR PM2.5 AND PM10 AT NEAR-ROAD ENVIRONMENTS.	Brenda Lopez*	University of California Riverside
9:50 AM	CHARACTERIZING PARTICLE SIZE DISTRIBUTION AND TOXICITY OF BREAK AND TIRE WEAR EMISSIONS	Molly Haugen	University of Cambridge
10:05 AM	General Discussion of Session 9		
10:15 AM	<b>Poster Session and Demonstrations in Farrell's Lounge</b>		

### SESSION 10

#### 10:45 AM Emissions Measurements Methods

*Introduction by Session Leaders: Tao Huai, CARB and Joe Martin, US EPA*

10:50 AM	PEAQ5 EMISSION CLUSTERING FOR CLASSIFYING HIGH-EMITTING HD TRUCKS	Daniel Phillips	California Air Resources Board
11:05 AM	A COMPREHENSIVE EVALUATION OF ALL THE NEW STATE OF THE ART 1065 COMPLIANT PEMS DESIGNED FOR EMISSIONS AT AND BELOW 0.05 G/HP-HR NOX.	Kent Johnson	University of California, Riverside
11:20 AM	HORIBA TORQUE MATCHING – ELIMINATING THE NEED FOR ON-ROAD EMISSIONS MEASUREMENT	Alex Mason	HORIBA MIRA
11:35 AM	AN IDEA FOR TRADING CARBON AND EMISSIONS USING ON-BOARD MEASUREMENT: UNLOCK THE BENEFIT TO INDUSTRY AND INNOVATION	Kent Johnson	University of California Riverside
11:50 AM	General Discussion of Session 9		

#### 12:00 PM Lunch in Pike Ballroom

**Wednesday, March 29, 2023**

**SESSION 11**

**1:20 PM Particulate Emissions and Measurement**

*Introduction by Session Leader: Yusuf Khan, Cummins, Inc and Heidi Vreeland, US EPA*

1:25 PM	DRIVE CYCLE PM MASS MEASUREMENTS CAPABLE OF RESOLVING GPF-LEVEL EMISSIONS FROM LIGHT-DUTY VEHICLES	Stanislav Bohac	U.S. EPA Office of Transportation and Air Quality
1:40 PM	LUBE OIL EFFECTS ON PARTICLE EMISSIONS FROM A GDI ENGINE OPERATING ON HIGH AND ULTRA-LOW PMI GASOLINE FUEL	Imad Khalek	Southwest Research Institute
1:55 PM	APPARENT TEMPERATURE DEPENDENT REMOVAL EFFICIENCY OF CRANKCASE CONTROL DEVICES	Imad Khalek	Southwest Research Institute
2:10 PM	ASSESSMENT OF CPC-BASED PN-PEMS FOR HEAVY-DUTY CNG ENGINES	Nikhilesh Agarwal	Cummins Inc.
2:25 PM	EVALUATION OF PM AND SUB-23 NM PARTICLE NUMBER EMISSIONS FROM A HEAVY-DUTY DIESEL VEHICLE DURING ON-ROAD OPERATION	Tianyi (Jerry) Ma*	University of California Riverside
2:40 PM	General Discussion of Session 9		

**Closing Remarks from Workshop Chairs**

2:50 PM  
**Jim Baustian, BP**  
**Mike Viola, General Motors**

**3:00 PM END OF WORKSHOP**

## POSTERS

### EMISSIONS CONTROL MEASURES: I/M, OBD, TECHNOLOGIES AND STRATEGIES

INCORPORATING NOX TEST IN ENHANCED I/M – ANALYSIS OF METHODS	Daisy Thomas	3DATX
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### IN-USE HEAVY DUTY

CHARACTERIZING IN-USE STREET SWEEPER ACTIVITY AND EMISSIONS	George Scora	University of California Riverside
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### IN-USE LIGHT DUTY

AN ANALYSIS OF THE BENEFITS OF AN I/M PROGRAMS, PAST, PRESENT, AND FUTURE	Jim Lyons	Trinity Consultants
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ROADSIDE LIGHT-DUTY VEHICLE EMISSIONS IN UTAH VALLEY	Darrell Sonntag	Brigham Young University
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### OFF-ROAD/NON-ROAD

EMISSION TESTING OF COMMERCIAL HARBOR CRAFT (CHC) USING MINI-PEMS	Tianbo Tang	University of California Riverside
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COLLECTION OF AGRICULTURAL EQUIPMENT ACTIVITY DATA	Chas Frederickson*	University of California Riverside
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CARB'S OFF-ROAD LARGE SPARK IGNITION (LSI) ENGINE IN-USE COMPLIANCE PROGRAM	Axel Freund	California Air Resources Board
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### AIR QUALITY

HYPER-LOCAL REAL TIME AIR QUALITY MAP ENABLED BY A NETWORK OF VEHICLES EQUIPPED WITH AIR QUALITY SENSORS	Heejung Jung	University of California Riverside
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FUNDING OPPORTUNITIES OVERVIEW	Chris Klaus	NCTCOG
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### ELECTRIC AND HYBRID VEHICLES

ACTIVITY DATA OF ZERO AND NEAR-ZERO EMISSIONS VEHICLES AND EQUIPMENT	Chas Frederickson*	University of California, Riverside
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EMISSIONS AND PERFORMANCE INVESTIGATIONS OF A CNG PLUG-IN HYBRID ELECTRIC HEAVY-DUTY TRUCK	Tianyi (Jerry) Ma*	University of California, Riverside
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### EMISSIONS MODELING

DIGITAL TWINNING – IMPROVING VEHICLE AND POWERTRAIN DEVELOPMENT AND EFFICIENCY USING VIRTUAL TESTING	Alex Mason	HORIBA MIRA
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DEVELOPMENT, APPLICATION, AND DEMONSTRATION OF A SENSOR-BASED ONBOARD SENSING, ANALYSIS, AND REPORTING (OSAR) FOR EMISSION AND ACTIVITY DATA COLLECTION	Kent Johnson	University of California Riverside
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DATABASE FOR AIR QUALITY AND NOISE ANALYSIS (DANA) TOOL	Chris Dresser	Federal Highway Administration
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FHWA MOVES3 SENSITIVITY ANALYSIS	Chris Dresser	Federal Highway Administration
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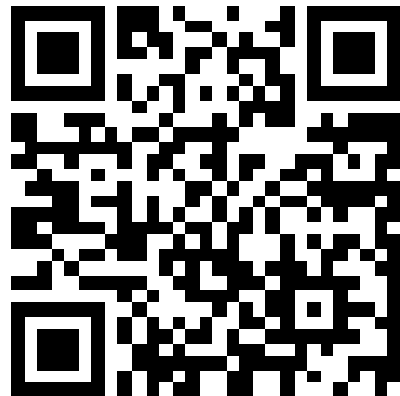
REVS: A NEW APPROACH TO DYNAMIC EMISSIONS MODELLING	Nick Molden	Emissions Analytics Ltd
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EPA PLANS FOR MOVES DEVELOPMENT	Megan Beardsley	U.S. EPA Office of Transportation and Air Quality
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<b>IMPROVING THE EMISSIONS INVENTORY</b>		
CALCULATING THE IMPACT OF NRMM EMISSIONS FROM THE CONSTRUCTION SECTOR IN THE UNITED KINGDOM.	Carl Desouza	Imperial College London
AIR CONDITIONING REFRIGERANT LEAKAGE FOR MODEL YEARS 2021-2023 HEAVY-DUTY VEHICLES CERTIFIED FOR SALE IN CALIFORNIA	Rajvir Nijjar	California Air Resources Board
<b>EMISSIONS MEASUREMENT METHODS</b>		
IN-SITU AND HANDHELD SUB-PPM LASER-BASED SENSORS FOR VEHICULAR EXHAUST MANAGEMENT AND REPORTING	Ritobrata Sur	Indrio Technologies
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