



2017 Conference

Abstracts and Program

March 30, 2017, Salt Lake City, Utah

10:30 AM Introductory Remarks

Dr. Kerry Kelly, University of Utah, Chemical Engineering

10:35 AM; Oral Presentations, Morning Session

10:35 AM

Residential Wood-burning Emissions in Utah's Valleys

Nancy Daher

Utah is susceptible to elevated levels of fine particulate matter (PM_{2.5}) along the Wasatch Front during winter-time inversions. PM_{2.5} levels often exceed the national ambient air quality standards during winter, with residential wood-burning combustion accounting for about 17% of total primary PM_{2.5} emissions in Utah's PM_{2.5} non-attainment areas. To determine wood-smoke source contribution to PM_{2.5}, a source apportionment analysis was conducted using positive matrix factorization (PMF). 24-hr PM_{2.5} samples were collected at several sites across the Salt Lake, Utah and Cache Valleys during winter. Samples were then analyzed for levoglucosan, a unique tracer for biomass burning. Results showed that wood-smoke contribution to PM_{2.5} varied spatially across all three valleys in Utah, with peak contributions being generally recorded at North Provo. Wood-smoke contribution to PM_{2.5} varied from 21.2% and 2.53 µg/m³ at North Provo to 11.1% and 2.01 µg/m³ at Smithfield, on average during winter. Moreover, while lower percent contributions of wood-smoke to PM_{2.5} were observed at all sites on mandatory no-burn days compared to days with no burning restriction, wood-smoke levels were higher on mandatory ban days relative to days without burning restrictions.

10:55 AM

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

Delbert J Eatough, Brigham Young University, Provo, Utah, email delbert@eatough.net
Paul Cropper, Brigham Young University, Provo, Utah, e-mail paulcropper100@gmail.com
Devon K. Overson, Brigham Young University, Provo, Utah, devonko@gmail.com
Jaron C. Hansen, Brigham Young University, Provo, Utah, e-mail jhansen@chem.byu.edu
Robert A. Cary, Sunset Laboratory Inc., Tigard, Oregon, e-mail r.cary@sunlab.com
Principal Contact: Delbert J. Eatough, Professor of Chemistry Emeritus, Brigham Young University, 1252 Uinta Drive, Provo, Utah 84604, (801) 375-5535. e-mail delbert@eatough.net

Abstract:

A significant need exists to better characterize air pollution and its sources. This especially pertains to fine particulate matter (PM_{2.5}). PM_{2.5} is chemically complex and its sources of emission and secondary production are highly variable. PM_{2.5} complexity is largely due to the organic fraction, which ranges from 10-90% of its total mass. However the organic compounds in PM_{2.5} have generally not been monitored in the field due to limitations in available sampling techniques. An instrument capable of monitoring the organic components of PM in the field and on an hourly averaged basis has been build, automated, and successfully deployed in the field. Emphasis has focused on the measurement of nonvolatile compounds which have been used as markers of organic sources for source apportionment evaluations and which can be volatilized at about 200 C. This instrument uses a filter collection/thermal desorption system integrated with a miniaturized GC-MS to measure hourly averaged concentrations of organic compounds in PM. The instrument's capability for routine monitoring of organic marker compounds for source apportionment analysis was tested in a field sampling campaign conducted on the Brigham Young University campus in Utah Valley, UT during the winter of 2015. Other instruments included in this source apportionment campaign included a Duel Oven OC/EC (Sunset Laboratory), Aethalometer®, nephelometer, Ambient Ion Monitor (URG), FDMS-TEOM, O₃, NO_x and CO monitors. Inclusion of the data from the GC-MS instrument significantly improved the ability to apportion PM sources. A PMF analysis was conducted of a data set (n=248) containing the above outlined conventionally measured species and several organic marker compounds (including levoglucosan), all measured on a 1-hour average basis. Major contributors to fine particulate material were diesel and automobile emissions, wood smoke and secondary ammonium nitrate and secondary organic material. The last three contributors accounted for 91% of the fine particulate material. The value of the hourly average measured organic marker compounds in the PMF analysis will be discussed. The relationship between the various measured organic markers and the resultant source apportionment will be highlighted.

The fine particle light scattering was dominated by the PMF identified sources associated with wood smoke and secondary ammonium nitrate.

11:15 AM

Source Regions and Elemental Composition of PM₁₀ Mineral Dust Originating from the Exposed Lakebed of the Great Salt Lake

Dr. Kevin D. Perry
Department of Atmospheric Sciences
University of Utah

As the water level of the Great Salt Lake (GSL) has decreased to historic lows, it has exposed more than 550 mi² of lakebed. Similar to other receding lakes in arid regions (e.g., the Salton Sea and Owens (dry) Lake), the exposed GSL lakebed has begun to generate dust plumes during high-wind events. These dust plumes significantly reduce local visibility and elevate the PM₁₀ and PM_{2.5} concentrations in communities

along the Wasatch Front. A two-year study is currently underway to learn more about how these dust plumes are generated and to what extent they might impact local air quality. Previous studies of the GSL dust have deployed active or passive air samplers at strategic locations and waited for plumes to arrive. This study takes an alternative approach by collecting soil samples directly from the exposed lakebed and returning them the lab for processing.

An Incremental Sampling Methodology (ISM) approach is used to collect composited soil samples from 40-60 individual samples within 4km x 4km gridded cells on the lakebed. Soil samples are collected from both the surface (i.e., top 1cm) and subsurface (i.e., 1-4cm). Detailed observations of the soil, including surface crust conditions, are also made at each sampling location. The composited soil samples are then dried, sieved, and resuspended in the lab. PM₁₀ samples are collected onto Teflon filters during the resuspension process for subsequent elemental analysis using Inductively-Coupled Plasma Mass Spectrometry (ICP-MS) and Synchrotron X-ray Fluorescence (S-XRF).

To date, soil from ~17% of the GSL lakebed has been sampled and processed in the lab. The sieving analysis showed that the fraction of #200 mesh particles (i.e., $D_p < 75 \mu\text{m}$) in the surface soils varied from > 9% near Goggin Drain to < 1% along the northern shore of Antelope Island and the southern shore of Gilbert Bay. In situ observations of the soil revealed that the dust source regions (i.e., those areas with visible fine particles which are easily dislodged) are concentrated in areas of sparse vegetation and areas that have only recently been exposed to the air by the receding water. The ICP-MS analysis quantified the following 46 elements in each of the resuspended PM₁₀ samples (Ag, Al, As, B, Ba, Be, Ca, Cd, Ce, Co, Cr, Cs, Cu, Dy, Er, Eu, Fe, Gd, Ho, K, La, Li, Lu, Mg, Mn, Mo, Na, Nd, Ni, Pb, Pr, Rb, Sb, Sc, Se, Sm, Sr, Tb, Th, Ti, Tl, U, V, Y, Yb, Zn). The S-XRF analysis, which has not yet been completed, will fill in some of the missing elements (i.e., Br, Cl, P, S, and Si). The ICP-MS analysis conducted so far indicates that the PM₁₀ mass is dominated by evaporates (e.g., Na, Mg, Ca, K). In addition, it revealed significant spatial gradients (i.e., up to a factor of 10) in some of the trace elements.



11:35 AM

Ambient and Laboratory Evaluation of the Plantower PMS Low-Cost Particulate Matter Sensor

K.E. Kelly^{a*}, J. Whitaker^b, T. Sayahi, A. Petty^a, A. Dybwad^c, A. Butterfield^a

^a University of Utah, Department of Chemical Engineering, 3290 MEB, 50 S. Central Campus Dr., Salt Lake City, UT

^b University of Utah, Department of Electrical and Computer Engineering, 2110 MEB, 50 S. Central Campus Dr., Salt Lake City, UT

^c PurpleAir, 15183 Moab Way, Draper, UT

* Corresponding author, kerry.kelly@utah.edu

Abstract

Low-cost, light-scattering-based particulate matter (PM) sensors are becoming more widely available and are being increasingly deployed in ambient and indoor environments because of their low cost and ability to provide high spatial and temporal resolution PM information. Researchers have begun to evaluate some of these sensors under laboratory and environmental conditions. In this study, a low-cost, particulate matter sensor (Plantower PMS 1003/3003) used

by PurpleAir, a local community air-quality network, was evaluated in a controlled wind-tunnel environment and in the ambient environment during two winter seasons and several winter-time inversions. In both the wind-tunnel and in the ambient tests, the individual PMS sensors correlated highly with each other ($R_2 > 0.95$) and correlated well with research-grade, lightscattering instruments. In the ambient tests, the PMS sensor performance correlated well with gravimetric federal reference methods (R_2 of 0.88). Under ambient conditions, this PM sensor appears to correlate better with gravimetric methods than previous studies. However, the PMS's response varies with particle properties to a much greater degree than the research-grade instruments. In addition, the PMS sensors overestimate ambient PM concentrations and begin to exhibit a non-linear response when $PM_{2.5}$ concentrations exceed $40 \mu g/m^3$. These results have important implications for communicating results from low-cost sensor networks. They highlight the utility of these types of sensors as a relative measure of PM as well as concerns about making direct comparisons between low-cost PM measurements and those from a federal equivalent or federal reference method.

11:55 AM

Fluxes of hydrocarbons and carbonyls from snowpack

Seth Lyman, Marc Mansfield

Ozone exceeding EPA standards often forms during multi-day winter inversion episodes in Utah's Uinta Basin. Ozone is formed when oxides of nitrogen, or NO_x , react with volatile organic compounds, or VOC, in the presence of sunlight. According to available emissions inventories, a strong majority of NO_x and greater than 95% of ozone-forming organic compounds emitted into the Uinta Basin atmosphere originate from oil and gas exploration and production activity. Once emitted, nitrogen compounds can be taken up by and chemically processed in the snow into more reactive forms, enhancing ozone formation. Detailed, multi-investigator measurement campaigns carried out from 2012 to 2014 showed that, while this process does occur in the Uintah Basin, the amount of NO_x and other reactive nitrogen compounds released from snow is insignificant compared to inventoried sources. Much less has been done to determine rates of uptake, processing, and release of VOC by snow. We used flux chambers and vertical gradient measurements to investigate snow surface fluxes of methane, non-methane hydrocarbons, alcohols, and carbonyls. We observed significant positive and negative fluxes of VOC from snow surfaces. We expect that VOC are taken up by the snowpack during or after snowfall and are released during melt or sublimation. Average daytime fluxes of individual ($0.04 \text{ mg m}^{-2} \text{ h}^{-1}$) and total ($1.68 \text{ mg m}^{-2} \text{ h}^{-1}$) non-methane hydrocarbons were positive, while average fluxes of methane were very close to zero ($-0.01 \text{ mg m}^{-2} \text{ h}^{-1}$), possibly because methane is less soluble, and therefore less likely to be taken up and released by snow, than many other hydrocarbons. While measured fluxes from snow were low, snow surfaces cover the entire Uinta Basin during most winters and could still be a very significant reservoir of VOC. More work is needed to understand whether and how VOC are chemically processed within the snowpack.

12:15 PM; Poster Session and Box Lunch for Registrants

1:40 PM; Oral Presentations, Afternoon Session

1:40 PM

Familial effects moderate the association between short-term ambient air pollution exposure and risk of suicide

Amanda V. Bakian¹, James A. VanDerslice², Danli Chen³, Chella Palmer¹, W. Brandon Callor⁴, Yue Zhang³, Justin Bergers⁵, Hilary Coon¹

¹Department of Psychiatry, University of Utah, Salt Lake City, Utah, USA

²Division of Public Health, Department of Family and Preventive Medicine, University of Utah, Salt Lake City, Utah, USA

³Division of Epidemiology, Department of Internal Medicine, University of Utah, Salt Lake City, Utah, USA

⁴Utah Department of Health, Office of the Medical Examiner, Utah, USA

⁵Utah Population Database, Huntsman Cancer Institute, University of Utah, Salt Lake City, Utah, USA

Background: Suicide is the tenth leading cause of death in the U.S. and the eighth leading cause in Utah. Suicide's etiology is complex and is likely the result of interactions between adverse life events, co-occurring psychiatric and/or medical conditions, an underlying genetic predisposition, and exposure to environmental factors. Growing evidence suggests the role of short-term ambient air pollution exposure as a risk factor for suicide. In a previous study, we reported a 20% increased risk of suicide following short-term exposure to nitrogen dioxide (NO₂) and a 5% increased risk following short-term exposure to fine particulate matter (PM_{2.5}) among suicide decedents from Salt Lake County, Utah. Important questions remain concerning the underlying factors that increase a person's risk of suicide following short-term exposure to ambient air pollution.

Objectives: 1) Investigate the relationship between suicide risk and short-term exposure to ambient NO₂, ozone (O₃) and PM_{2.5} in a Utah-wide sample of suicide decedents, and 2) Determine how the relationship between suicide risk and short-term exposure to ambient air pollutants is moderated by membership in a high-suicide risk pedigree.

Methods: Information on all suicide decedents in Utah during January 2000-2014 was made available through a long-standing collaboration with the Utah Department of Health's Office of the Medical Examiner (*N* = 5862). Daily exposure to mean NO₂, PM_{2.5}, and O₃ was categorized into quartiles. Suicide decedents were linked to their genealogical information in the Utah Population Database and the familial risk of suicide was estimated using the familial standardized incidence ratio. A bi-directional time-stratified case-crossover design with a 21-day stratum length was used to estimate the odds ratio (OR) of suicide following short-term exposure to mean NO₂, PM_{2.5}, and O₃ with the lowest quartile of exposure serving as the reference. A series of conditional logistic regression models were fit considering exposure to mean NO₂, PM_{2.5}, and O₃ on the day of (lag 0) and each of the five days (lags 1-5) preceding the suicide.

Results: Significantly increased odds of suicide were associated with exposure to the second (OR: 1.130; 95% confidence interval (CI): 1.018-1.254), third (OR: 1.147; 95% CI: 1.030-1.277) and fourth (OR: 1.129; 95% CI: 1.008-1.265) quartiles of mean PM_{2.5} four days preceding the death (lag 4). Similarly, significantly higher odds of suicide were associated with exposure to the third (OR: 1.176; 95% CI: 1.036-1.335) and fourth (OR: 1.264; 95%

CI: 1.093-1.461) quartiles of mean NO₂ on lag 4. Odds ratios associated with exposure to the 4th quartile of PM_{2.5} and NO₂ (lag 4) were 26% and 33% higher, respectively, among decedents from high-suicide risk pedigrees as compared to other decedents (Figure). Null associations were observed between ozone exposure and suicide. **Discussion:** We observed an increased risk of suicide following short-term exposure to ambient air pollution in a Utah-wide sample of suicide decedents. Our finding that decedents belonging to high-suicide risk families may be especially susceptible to short-term ambient air pollution exposure suggests that air pollution interacts with shared genetic or environmental contributors to increase suicide risk among decedents from these families. Figure. Odds of suicide associated with quartile measures of short-term exposure to mean PM_{2.5} (top) and NO₂ (bottom) among suicide decedents belonging to high suicide-risk versus not-high suicide-risk pedigrees on lag 4 (quartile 1 is the reference).

2:00 PM

Genetic and Epigenetic Susceptibility of Airway Inflammation to PM_{2.5} in School Children: New Insights from Quantile Regression

Authors: Yue Zhang^{1,2,3}, Muhammad T. Salam^{4,5}, Kiros Berhane⁴, Sandrah P. Eckel⁴, Edward B. Rappaport⁴, William S. Linn⁴, Rima Habre⁴, Theresa M Bastain⁴, Frank D. Gilliland⁴

Affiliations:

¹ Department of Internal Medicine, University of Utah, Salt Lake City, UT, USA;

² Department of Family and Preventive Medicine, University of Utah, Salt Lake City, UT, USA;

³ Veteran Affairs Salt Lake City Health Care System, Salt Lake City, UT, USA;

⁴ Department of Preventive Medicine, University of Southern California, Los Angeles, CA, USA;

⁵ Department of Psychiatry, Kern Medical, Bakersfield, CA, USA

Correspondence: Yue Zhang, Division of Epidemiology, Department of Internal Medicine, University of Utah, 295 Chipeta Way, Salt Lake City, UT, 84018, E-mail: zhang.yue@hsc.utah.edu.

Running title: Genetic and Epigenetic Variations, PM_{2.5} and FeNO.

Funding

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Abstract

Background: The fractional concentration of exhaled nitric oxide (FeNO) is a biomarker of airway inflammation that has proved to be useful in investigations of genetic and epigenetic airway

susceptibility to ambient air pollutants. For example, susceptibility to airway inflammation from exposure to particulate matter with aerodynamic diameter $\leq 2.5\mu\text{m}$ ($\text{PM}_{2.5}$) varies by haplotypes and promoter region methylation in inducible nitric oxide synthase (iNOS encoded by *NOS2*). We hypothesized that $\text{PM}_{2.5}$ susceptibility associated with these epigenetic and genetic variants may be greater in children with high FeNO from inflamed airways.

Objectives: In this study, we investigated genetic and epigenetic susceptibility to airborne particulate matter by examining whether the joint effects of $\text{PM}_{2.5}$, *NOS2* haplotypes and iNOS promoter methylation significantly vary across the distribution of FeNO in school children.

Methods: The study included 940 school children in the southern California Children's Health Study who provided concurrent buccal samples and FeNO measurements. We used quantile regression to examine susceptibility by estimating the quantile-specific joint effects of $\text{PM}_{2.5}$, *NOS2* haplotype and methylation on FeNO.

Results: We discovered striking differences in susceptibility to $\text{PM}_{2.5}$ in school children. The joint effects of short-term $\text{PM}_{2.5}$ exposure, *NOS2* haplotypes and methylation across the FeNO distribution were significantly larger in the upper tail of the FeNO distribution, with little association in its lower tail, especially among children with asthma and Hispanic white children.

Conclusion: School-aged children with higher FeNO have greater genetic and epigenetic susceptibility to $\text{PM}_{2.5}$, highlighting the importance of investigating effects across the entire distribution of FeNO.

Keywords: exhaled nitric oxide, $\text{PM}_{2.5}$, asthma, inducible nitric oxide synthase, haplotype, methylation.

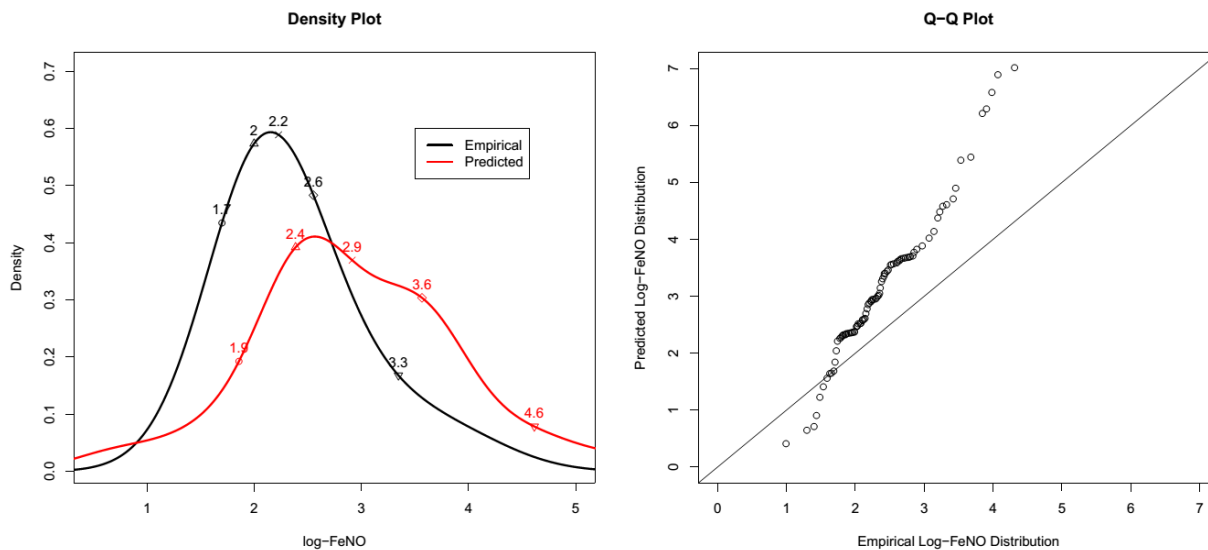


Figure 2: Empirical log-FeNO distribution among children without copy of the haplotype (black line) and its associated predicted distribution among children with two copies of haplotype, $10\mu\text{g}/\text{m}^3$ increases in short-term $\text{PM}_{2.5}$ exposure and 10% decreases in methylation level (Red line). Panel A) shows the density curves of both distributions and selected percentiles (10%, 30%, 50%, 70% and 90%),

respectively. Panel B) is a QQ plot and plotted the quantiles of predicted distribution against those of empirical distribution.

[Editor's Note: There was no "Figure 1" submitted.]

2:20 PM

Cold-air Pool Exchange Processes and their impact on Air Quality in the Salt Lake City Basin

Sebastian W. Hoch¹, Erik T. Crosman¹, Munkhbayar Baasandorj^{1,2}, Alex Jacques¹

¹University of Utah, Salt Lake City, Utah; ²Utah Department of Environmental Quality, Salt Lake City, Utah;

ABSTRACT

The evolution of persistent cold-air pools (PCAPs) and the complex interaction of meteorological processes and air chemistry has been studied during the 2015-2016 The Salt Lake Valley PM_{2.5} Pollution Study and the 2017 Utah Wintertime Fine Particulate Study (UWFPS).

This presentation highlights the role of meteorological processes in modulating PM_{2.5} concentrations and the availability of ozone as oxidant for the formation of Ammonium Nitrate, the dominant particulate pollutant during PCAP conditions along the Wasatch Front. Observations from wind profilers, weather balloons, and aerosol backscatter profilers will be combined with surface observations of PM_{2.5} and ozone to illustrate the role of thermally-driven circulations along the basin sidewalls and through tributary canyons, as well as the influence of lake breezes from the Great Salt Lake.

2:40 PM

Spatiotemporal Patterns of Urban Trace Gases and Pollutants Observed with a Light Rail Vehicle Platform in Salt Lake City, UT

Logan E. Mitchell¹, Erik Crosman¹, Ben Fasoli¹, Luke Leclair-Marzolf¹, Alexander Jacques¹, Daniel Mendoza¹, Judy Ou², John Horel¹, John C. Lin¹, David R. Bowling³, James R. Ehleringer³

¹ Department of Atmospheric Sciences, University of Utah, Salt Lake City, UT 84112

² Huntsman Cancer Institute, University of Utah, Salt Lake City, UT 84112

³ Department of Biology, University of Utah, Salt Lake City, UT & 84112

Urban environments are characterized by both spatial complexity and temporal variability, each of which present challenges for measurement strategies aimed at constraining estimates of greenhouse gas emissions and air quality. To address these challenges we initiated a project in December 2014 to measure trace species (CO₂, CH₄, O₃, and Particulate Matter) by way of a Utah Transit Authority (UTA) light rail vehicle whose route traverses the Salt Lake Valley in Utah on an hourly basis, retracing the same route through commercial, residential, suburban, and rural typologies. Light rail vehicles present

advantages as a measurement platform, including the absence of in-situ fossil fuel emissions, repeated transects across a urban region that provides both spatial and temporal information, and relatively low operating costs. By measuring both air pollutants and greenhouse gases we are able to investigate the common sources of emissions and monitor how they change over time. We also plan to investigate how the spatial distributions of pollutants is related to socioeconomic and demographic characteristics and eventually link our observations directly to health outcomes from air pollution exposure.

3:00 PM; Break

3:30 PM

The Utah PRISMS Infrastructure for Generating Air Quality Exposomes

Julio Facelli, Katherine Sward, for the Utah PRISMS Team

Understanding the effects of the modern environment on pediatric asthma requires generation of a complete picture of the contributing environmental exposures and socio-economic factors. Such an exposome requires integration of data from wearable and stationary sensors, environmental monitors, physiology, medication use and other clinical data. In addition, such an integration would need to have a high spatial-temporal resolution for correlating times and location of exposures to occurrences of conditions and their severities. This would require filling any gaps in the measured data with modeled data along with characterization of any uncertainties.

The Utah PRISMS Federated Integration Architecture is a comprehensive, standards-based, open-source informatics platform that allows sensor data and biomedical data to be integrated in a meaningful manner. We are developing the architecture, data models, processes, hardware and software to acquire, manage, process, and communicate high-resolution clinically relevant exposome information from environmental, physiological, and behavioral sensors and computational models. We envision this infrastructure to support different types of environmental biomedical studies of pediatric asthma and other chronic conditions, and potentially other research. In this presentation, we discuss two main components of the Utah PRISMS infrastructure:

Sensor Common Data Model: Federating or integrating increasingly large, complex and multi-dimensional sensor data requires a thorough human understanding of them. These metadata specifications are designed to support the conduct of research utilizing personalized and environmental sensors. These includes sensors ranging from nano-sensors up to satellites. Sensor measurements may include physical, chemical, and biological species. In addition, these sensors include those that instantaneously (or with a transient storage) measure these species or those that collect physical samples with material transfer for later analysis. Sensors may be deployed in various environments, including personal (i.e. implanted & mobile), immediate (i.e. indoor), and general environment (i.e. external environmental protection agency monitors). The purpose of the data model is to establish a library of instruments; describe and document deployments of sensors; assess quality of data collected by different

instruments within its deployment environments; support harmonization and integration of data collected from various sensors; and guide for structuring and storing sensor output data.

2

Central Big Data Federation/Integration Platform: This is a standards-based, open-access infrastructure that integrates sensor data and mathematically modeled data with biomedical information along with characterizing uncertainties associated with using these data. The platform consists of components that:

1. Discover, characterize, store and version metadata of different sensor data sources
2. Standardize semantics across different sensor data sources using ontology services
3. Store data in a temporal event based model to support different research uses-cases
4. Methods to transform and present data for different use-cases of exposomic studies.

In this symposium, we present initial lessons from the Utah PRISMS Platform that summarizes the interconnected work by diverse expertise including electrical, computer, chemical and industrial engineers, atmospheric and computer scientists, informaticists and pediatric researchers in developing an infrastructure for generating exposomes.

3:50 PM

AQ and U: A Multidisciplinary Approach for Engaging and Informing Citizens About PM_{2.5} Exposure

Miriah Meyer¹, Kerry Kelly², Pierre-Emmanuel Gaillardon³, Ross Whitaker¹, Neal Patwari³, Tony Butterfield²

¹ School of Computing, University of Utah

² Department of Chemical Engineering, University of Utah

³ Department of Electrical and Computer Engineering, University of Utah

The emergence of commodity sensors is changing the way we think about and estimate our personal exposures to potentially harmful air quality events. Through a suite of three synergistic projects at the University of Utah we are working to build networks of these sensors, both indoors and outdoors, to compute real-time, localized estimates of PM_{2.5} levels across Salt Lake City. The tools and products from these projects will be open and accessible to the public. The goal of the first project is to produce a neighborhood-level real-time estimate of PM_{2.5} levels through a combination of innovative sensor technology, state-of-the-art data modeling, and a citizen science outreach effort to engage residents to host and maintain sensors across the city. A second companion project is bringing hands-on air quality education to high schools across Salt Lake City, engaging students through a sensor maker-kit and deployment of student maintained sensors at the schools. The third and complementary project focuses on developing an in-home deployment of sensors that track PM_{2.5} levels throughout a house, providing real-time feedback to empower families, particularly those affected by asthma, to improve air quality in their homes. All three of the projects rely on close collaborations of faculty and students spanning computer science, electrical engineering, and chemical engineering. These projects take a citizen-centric approach both in the way that we deploy and maintain our sensor networks, as well as in the way we design tools for public access.

At the 2017 Air Quality: Science for Solutions conference, we will launch our web portal for these projects, which will be found at AQandU.org.

4:10 PM

What does it matter?

Driver gender, experience, and idling behavior effects on air pollutant emissions

Randal S. Martin, Abdelhaleem Khader, Joe Thomas, Clay Woods

As of 2015, Utah had a total of 1,913,564 licensed drivers, with 51% being male and 49% being female. For comparison, there are approximately 214 million licensed drivers in the United States. Furthermore, about 7% of the total Utah drivers were 20 years old and younger, also nearly equally split between male and female. The Utah Tax Commission reported there were 2,960,987 registered vehicles in the state of Utah for fiscal 2016 – approximately 1 ½ vehicles for each licensed driver. The importance of vehicle emissions to Utah's airsheds is well documented and mobile sources are estimated to contribute roughly 50% of the NO_x, VOC, SO_x, and direct PM emissions. Other investigators (Reiter and Kockelman, 2016) have summarized that up 80% of daily automobile emissions of certain pollutant species can come during the cold start phase. For the past few years, researchers at Utah State University and Weber State University have cooperatively examined automobile emissions, directly measured from a vehicle fleet relative to northern Utah under cold start, hot start, and idle conditions to determine the validity of these estimates to local conditions and the efficacy of anti-idling programs and regulations. The findings indicate that, on average, the tested vehicles showed maximum emissions less than 30 seconds after a cold start, and near maximum reductions after a little more than one minute. Similarly, it was found that restarting (hot starts) a vehicle after a 5-minute shutdown, as opposed to leaving the vehicles idling resulted in an average reductions of 4 times less VOC, 3 times less NO_x, and 10 times less CO being emitted. The USU investigators then decided to examine the relative on-road emissions of NO_x, VOCs, and CO as a function of driver gender and driving experience. A total of 20 drivers, divided equally among male and female and experienced and less experience cohorts, were solicited to drive a single 2001 Dodge Durango along a consistent road path of mixed residential and highway conditions. Although not statistically significant, the results showed that inexperienced (<5 years) female drivers tended to show the lowest pollutant emissions and the most consistency. The older male drivers tended towards highest pollutant emission rates and variability.

4:30 PM

Wintertime PM_{2.5} Pollution in UT: Northern UT Valleys

Dr. Munkbayar Baasandorj

Environmental scientist, ¹Utah Department of Environmental Quality, Salt Lake City, Utah; ²Research Professor, University of Utah, Salt Lake City, Utah,

Contact: mbaasandorj@utah.gov

Valleys along the Wasatch Mountains in northern Utah experience high levels of particulate matter with aerodynamic diameters less than 2.5 micrometers (PM_{2.5}) in winter months. However the chemical aspects of these pollution episodes received little attention in the past. Better scientific understanding of the processes important for the PM_{2.5} formation is needed to develop effective pollution control strategies. Here, I would like to give an overview of the research efforts to improve the scientific

understanding of these pollution episodes, with focus on the pilot study of winter 2015 – 2016 and Utah Winter Fine Particulate Study (UWFPS), which was conducted between January 16, 2017 and February 15, 2017. This presentation will discuss the potential plans for comprehensive analysis and provide a summary of key preliminary findings and their potential policy implications.

12:10p – 1:30p Poster Session during Lunch

2015 Utah Toxics Study

Roman Kuprov
Utah Division of Air Quality

In 2015, as a part of this effort, DAQ designed and conducted a year-long special study aimed at characterizing HAP's distribution and seasonal trends across the Utah and Salt Lake valleys. The study entailed the installation of two additional air toxics monitors in Lindon and West Valley and intensifying the sample collection frequency at the Bountiful NAATS site to one-in-three days. With the exception of formaldehyde, discussed below, the HAPs monitored during the study were observed to be at or below the average national levels.

The analysis of 82 organic and 4 heavy metal species in approximately 300 samples collected over a full year pointed to four species in particular that merit further study. The study identified unusually high formaldehyde concentrations and uncommon seasonal trends at Bountiful. Wintertime observations of the pollutant suggest the potential for a significant source or sources of primary formaldehyde emissions. It is also possible that emissions of formaldehyde precursors might be contributing to the elevated levels of formaldehyde seen at the Bountiful monitor. Sources could include local refineries, painting or paint stripping operations, and/or other unidentified sources.

Two additional species were observed at the Bountiful site. Acetaldehyde showed a strong correlation with formaldehyde concentrations. Another organic compound, methylene chloride, was detected with emission levels significantly above health screening levels. Currently, the source or sources of the methylene chloride emissions are unknown and further investigation is necessary.

Although significantly lower than the health screening level, West Valley PM10 data showed higher lead concentrations than was measured at either Bountiful or the Lindon monitor in Utah County. Possible sources of the elevated lead concentrations could be a residue from former lead smelters that existed in the area, the former Sharon Steel Corporation Superfund site, or current mining operations in the valley. It is also possible that the Rio Tinto/Kennecott tailing ponds could be contributing to the higher lead presence in the area.

A significant decrease (nearly 70%) in benzene concentrations was observed between 2002 and 2016 in West Valley. Benzene is a pollutant that is commonly observed in urban areas and is strongly associated with automobile exhaust. The large reduction in benzene concentrations over the past fourteen years at the West Valley monitor is a very positive development and suggests that cleaner automobile engine technology has been effective in reducing levels of this toxic chemical.

Aerosol Size Distributions at the University of Utah During Winter Inversion Events

Catherine Chachere, Gannet Hallar, Ross Petersen
Department of Atmospheric Science, University of Utah

The Utah Winter Fine Particulate Study (UWFPS) was implemented along the Wasatch Front from January 15 – February 15, 2017. The Hallar Group in the Department of Atmospheric Science at the University of Utah operated aerosol instrumentation to measure the size and number of particles lofted in persistent cold air pool episodes (i.e. “inversions”). The Scanning Mobility Particle Sizer (SMPS) and Aerodynamic Particle Sizer (APS) by TSI, Inc. were run in concert atop the William Browning Building at the University of Utah. This poster will focus on how these two instruments work as well as present the observations collected by them during UWFPS.



An agent-based model for estimating human activity patterns on the Wasatch Front

Albert M. Lund^{1,2}, Nicole B. Burnett^{2,3}, Ramkiran Gouripeddi^{1,2}, Julio C. Facelli^{1,2}

¹Department of Biomedical Informatics, ²Center for Clinical and Translational Sciences, ³Department of Chemistry, University of Utah

A central problem in assessing the impact of air quality on human health is determining the exposure profile of individuals within populations and correlating those profiles with medical outcomes. However, it has been difficult to identify at-risk populations or areas, because public air quality data is reported at geographic resolutions that are larger than needed for assessing localized health effects of pollution, and because accurately tracking human activities and patterns of movement presents both privacy and technical challenges. There are examples of limited sensor deployments and activity tracking in the literature, but fail to capture or estimate the full impact on human health in heterogeneous metropolitan areas or populations, and fail to use a holistic approach that uses both types of data.

A new model based on the work of Amirjamshidi et. al. [1], is under development in our research group. The model is intended to provide a high-resolution spatiotemporal grid that accurately accounts for the distributions of pollution and population in a region. Once fully validated, this model will be used to infer trends in population exposure, and identify classes of people who may be disproportionately affected by poor air quality conditions, both indoor and outdoor. The first component of this model will be presented here; this component is an agent-based simulation that relies on publicly available empirical datasets to model the daytime activity patterns and movements of the entire population of the Wasatch Front, circa 2015. This component relies on machine learning techniques to define a set of activity profiles that describe typical patterns of activity for different demographics. Combined with accurate geographical profiles of household composition, workplaces, and other commonly frequented locations, a functional picture of human activity in the Wasatch Front is elucidated.

[1] G. Amirjamshidi, T. S. Mostafa, A. Misra, and M. J. Roorda, "Integrated model for microsimulating vehicle emissions, pollutant dispersion and population exposure," *Transp. Res. Part D Transp. Environ.*, vol. 18, pp. 16–24, 2013.

Constraining Emissions of Methane in Utah's Uintah Basin with Ground-based Concentration Observations and a Time-Reversed Lagrangian Transport Model (STILT)

Chris Foster, Erik Crosman, Lacey Holland, Derek Mallia, Ben Fasoli, Ryan Bares, John Horel, John Lin

Abstract:

Our team at the University of Utah's Department of Atmospheric Sciences have been carrying out in situ observations at three sites in the Uintah Basin since 2015: a baseline site (Fruitland), in the western portion of the Basin near oil wells (Roosevelt), and in the center of the Basin, near gas wells (Horsepool). To interpret these measurements and relate observed methane variations to emissions, we carried out atmospheric modeling with the Stochastic Time-Inverted Lagrangian Transport (STILT) model driven with wind fields simulated by the Weather Research and Forecasting (WRF) model during the period of 19 April 2015 – 31 May 2015. At Roosevelt, interpretation of the observations necessitated removal of influence from a local source immediately to the southeast of the site that was

not resolved in the emission inventory. At Horsepool, the diurnal cycle of modeled methane concentrations was captured well by the WRF-STILT modeling framework when forced using recent emission inventory estimates (Karion et al. 2013 Ahmadov et al. 2015).

FDDA (nudging) impacts on WRF-CAMx model performance in simulating winter O₃ formation in Uintah Basin

Trang Tran¹, Huy Tran¹, Marc Mansfield¹, Seth Lyman¹

Erik Crosman²

¹ Bingham Research Center, Utah State University, Vernal, UT 84078

² Department of Atmospheric Sciences, University of Utah, Salt Lake City, UT 84112

Principal Contact: Trang Tran, 435-722-1770, trang.tran@usu.edu

Abstract

Newtonian relaxation or nudging has been commonly applied into meteorological model simulations because of its beneficial effects on improvement of model performance, especially for simulation period longer than 48 hours. In this study, we compared WRF-CAMx simulations with and without four-dimensional data assimilation (FDDA or nudging) to examine if nudging approach (i.e., analysis and observation nudging with NAM-12 reanalysis and MADIS+AirNowTech data, respectively) improve model performance in simulating winter O₃ formation in Uintah Basin. Our sensitivity tests were conducted for episode of Jan 16 to Feb 9, 2013. Unlike many of previous studies showing the beneficial effects of nudging to model performance, our primary results showed that observational nudging applied into WRF simulations leading to unrealistically vertical temperature profiles (e.g., too shallow boundary-layers ~ 50m); hence suppressed thermally-driven circulations which then negatively affected CAMx performance in simulating O₃ concentration distribution within Uintah Basin.

Two-year Performance Evaluation of Low-cost Air Quality Sensors

Tofigh Sayahi, Kerry E. Kelly

Department of Chemical Engineering, University of Utah

Abstract

The low-cost, compact size and portability of light-scattering-based particulate matter (PM) sensors have made them attractive for measuring air quality in ambient and indoor environments. Recently, extremely low cost, light-scattering PM sensors (<\$50) have become available. However, this type of sensor needs to be characterized for the conditions of use. In this work, an aerosol chamber as a calibration platform is designed to test the performance of low-cost PM sensors. The test atmosphere is designed for monodisperse polystyrene sphere particles, ammonium nitrate, dust, or sodium chloride particles. The PM sensors, along with a reference sensor, track the particle concentration and changes within laboratory chamber. Comparing the results of PM and reference sensors allows us to evaluate the

performance of PM sensors in terms of different parameters including precision of measurements, limits of detection and linearity of the response.

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

Authors:

Paul M. Cropper^{1,3}, Jaron C. Hansen¹, Devon K. Overson¹, Robert J. Cary², Delbert J. Eatough¹, Judith C. Chow³, John G. Watson³

Affiliations

¹Department of Chemistry and Biochemistry, Brigham Young University, Provo, UT

²Sunset Laboratory, Tigard, OR

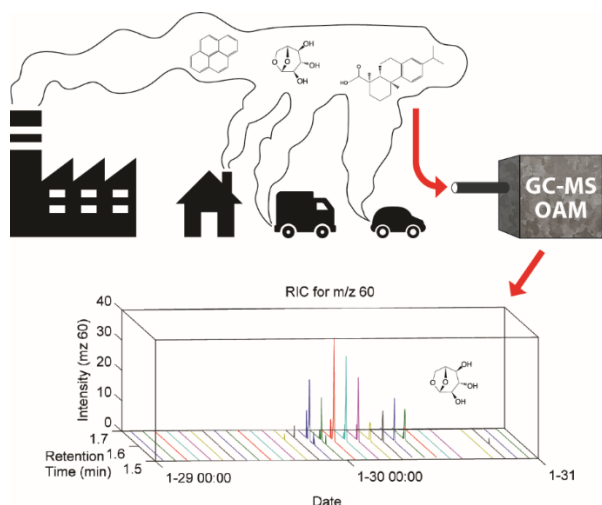
³Division of Atmospheric Sciences, Desert Research Institute, Reno, NV

Correspondence

Paul M. Cropper, Desert Research Institute, 2215 Raggio Parkway, Reno, NV, 89503, Paul.Cropper@dri.edu

Abstract:

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



Efficacy of High-Efficiency Particulate Air Filters in Reducing Respiratory Symptoms During Inversion Season

Danielle Babbel, MD

1. Department of Internal Medicine, University of Utah

Benjamin D. Horne PhD, MPH

1. Intermountain Heart Institute, Intermountain Medical Center

2. Department of Biomedical Informatics, University of Utah

Daniel Mendoza, PhD

1. Department of Atmospheric Sciences, University of Utah

2. Global Change and Sustainability Center, University of Utah

3. Division of Pulmonary Medicine, University of Utah.

Denitza Blagev, MD

1. Division of Pulmonary Medicine, Intermountain Medical Center

2. Division of Pulmonary Medicine, University of Utah

Background: Short-term exposure to high levels of ambient particulate matter air pollution is associated with COPD symptom exacerbation and related hospitalizations. Outdoor air pollution correlates with indoor air pollution levels. High-efficiency particulate air (HEPA) filters are beneficial in removing particulate matter from indoor air and improving health outcomes in patients with asthma. Whether the use of these filters in the homes of patients at risk for COPD can reduce respiratory symptoms during periods of high air pollution remains unknown.

Methods: A randomized, double blind, crossover trial (clinicaltrials.gov NCT02956213) is currently enrolling subjects at risk for COPD. **The purpose of this study is to evaluate whether HEPA filtration reduces respiratory symptoms during inversions in people at risk for COPD.**

Intervention: A stand-alone HEPA filter will be installed in the bedroom of each subject and will run 24/7 during the 12-week trial. Subjects will be randomized to start with sham or filter first, and will cross over halfway through the study

Additionally, subjects will receive a step and sleep counter as well as an indoor/outdoor portable air quality monitor. Spirometry and inflammatory markers (complete blood count, complete metabolic count, erythrocyte sedimentation rate, and C-reactive protein) will also be collected at the start, middle and end of the 12-week trial. Questionnaires regarding respiratory symptoms will be collected at these three time points. In addition, weekly surveys regarding symptoms and exacerbations will be collected during the study period. A long-term follow-up survey will occur 4-6 months after enrollment.

We plan to enroll participants over two years, November through January, during the 2017-2018 and 2018-2019 winter seasons, with a goal of enrolling 80 subjects.

Inclusion criteria:

- Age 40 and older
- History of past tobacco use
- Internet access and wi-fi at home
- Worsening respiratory symptoms during inversions

Exclusion Criteria:

- Already using a HEPA filter at home
- Active smokers in the home

Our primary outcome is reduction in respiratory symptoms as measured using the St. George's Respiratory Questionnaire - COPD (SGRQ-C). Secondary outcomes include symptoms as measured by other respiratory questionnaires, COPD exacerbations and healthcare utilization (hospitalizations, ED visits, etc.). Additional secondary outcomes include changes in median daily step counts, sleep, inflammatory markers, and spirometry. The difference between indoor and outdoor air quality readings with the HEPA filter as well as pre- and post-weights of the filters will be compared to determine whether the filter effectively reduced particulate exposure.

Discussion: This study has important and actionable implications for care of our patients regardless of the outcome. It may reveal a tangible intervention that Wasatch Front residents, especially those at risk for COPD, can use to reduce adverse health outcomes related to poor air quality. Additionally, we may find which outcomes are most sensitive in detecting the effect of air pollution on subjects, informing clinical practice and future studies on air pollution.

How to participate: Prospective participants may contact the research team for eligibility screening at filter@imail.org or (801) 507-4606.

Emissions of organic compounds from a landfarm in the Uintah Basin

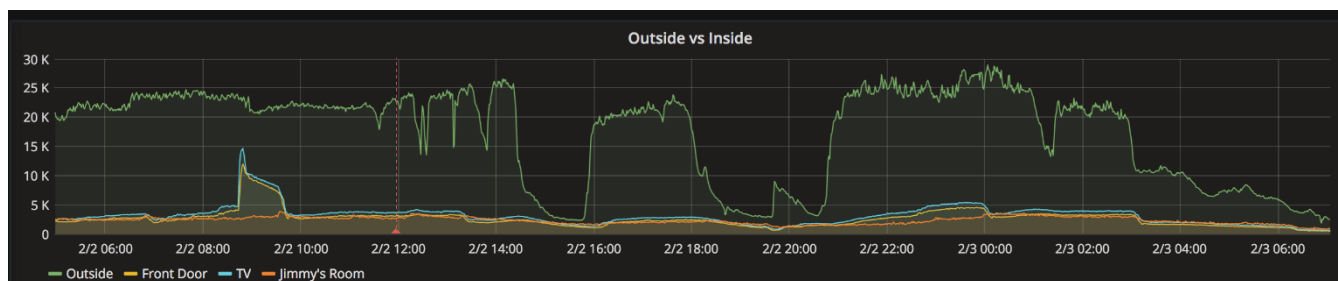
Seth Lyman, Huy Tran, Marc Mansfield, Trevor O'Neil
Utah State University

We measured fluxes of methane, non-methane hydrocarbons, and alcohols at a Uintah Basin landfarm facility during spring and summer in 2014, 2015, and 2016. Landfarms are a type of disposal facility for hydrocarbon solids generated during oil and natural gas exploration and production. At landfarms, solids are spread on soil and periodically tilled in to promote bacterial degradation of hydrocarbons. Because few measurements of hydrocarbon fluxes from landfarms have ever been collected, they are not included in current emissions inventories for the Uintah Basin. We measured fluxes from a remediated landfarm that was not in active use and contained some vegetation and from a landfarm that was actively receiving solid waste. Fluxes from the remediated landfarm were consistently near zero and very similar to background soils in the region. Fluxes from the active landfarm were extremely variable. Methane fluxes were generally low (1.4 ± 1.9 mg m⁻² h⁻¹; mean $\pm$ standard deviation), while fluxes of non-methane hydrocarbons were much higher (198 ± 138 mg m⁻² h⁻¹ for total non-methane hydrocarbons). Alkanes made up more than 75% of the total organic compound flux from the active landfarm. Landfarms in the Uintah Basin commonly cover 1-3 ha. Assuming the fluxes we measured occurred over the area of a 2 ha landfarm, that landfarm would emit 95.0 ± 66.0 kg day⁻¹ of total hydrocarbons. Additional measurements in other seasons, and measurements at additional facilities, are needed to determine the importance of emissions from landfarms relative to emissions from other oil and gas-related sources in the Uintah Basin.

Environmental and Human Factors influencing Residential PM Levels

James Moore

Many people consider air quality to be an exclusively outdoor concern, but environmental effects, human activity, and modern construction techniques can create indoor environments for which Indoor Air Quality (IAQ) can become worse than outside. IAQ is becoming increasingly relevant as the average American now spends 93% of their life indoors where certain pollutant concentrations can be 2 – 5x greater. Monitoring and relating IAQ to human activity is the first step in combating these health complications, for which child-, elderly-, and asthmatic-populations are especially vulnerable. Recent advances in lower-cost sensors make it economically feasible, for the first time, to instrument indoor environments with multiple sensors, providing fine-grained measurements of IAQ within and across homes. We present results from a deployed network of ten sensors that measure PM_{2.5} levels within a private residence, highlighting the effects of human activity as well as a Salt Lake City winter inversion on the IAQ of the home. We are currently working to bring this information to families, clinicians, and citizen scientists in order to better understand respiratory health and provide actionable data to support positive behavior change.



Estimations of VOC emissions from produced-water treatment ponds in Uintah Basin: Evaluation of flux-chamber measurements with inverse-modeling technique

Huy Tran, Seth Lyman, Marc Mansfield, Trevor O'Neil

In this study, we apply an inverse-dispersion modeling technique to validate the flux-chamber measurements of volatile organic compounds (VOCs) emissions from produced-water treatment ponds in the Uintah Basin oil and gas fields. Field measurement campaigns using the flux-chamber technique have been performed to measure VOC emissions from a limited number of produced water ponds in the Basin throughout summers and winters 2015 - 2016. The inverse-modeling technique applies an initial and arbitrary emission rate to estimate pollutant concentrations, and adjusts the emission rate until the estimated pollutant concentrations approximates the concentrations measured by selected evacuated canisters. The results shows significant higher VOC emissions as estimated by the inverse-model than as measured by the flux chamber. This finding in combination with findings in a related study using WATER9 wastewater emission model suggest the flux chamber technique may underestimate VOC emissions due to its limited coverage of the pond and the isolation of the emissions from altering environmental conditions, especially is wind speed. Comparisons of the inverse-model estimations with flux-chamber measurements vary significantly with the complexity in pond facilities and with pond's geometries. Careful treatments should be exercised in applying inverse-modeling for produced-water pond studies.

Formation of Particulate Matter (PM_{2.5}) During Wintertime Inversions in the Salt Lake Valley.

Amy H. I. Hrdina¹, Munkh Bassandorj², Ryan Bares², John Lin², Jennifer G. Murphy^{1*}

¹ Department of Chemistry, University of Toronto, 80 St. George Street, M5S 3H6 Toronto, ON, Canada

² Department of Atmospheric Sciences, University of Utah, 135 S 1460 E, Salt Lake City, UT 84112, USA

During the winter, air quality in Salt Lake City is frequently impacted by inversions that lead to high levels of fine particulate matter. Concentrations of reactive trace gases (HCl, HNO₃, HONO, NH₃, SO₂) and particle phase constituents from particles less than 2.5 microns in diameter (PM_{2.5}) were continuously measured using an online ambient ion monitor ion chromatograph (AIM-IC) within the Salt Lake Valley, Utah, from Jan 17 – Feb 21 2017. A consistent diurnal pattern of

ammonia mixing ratios was observed, with mixing ratios ranging from 0.1 – 5 ppb. Three persistent cold air pool events occurred during the measurement period during which the suppression of vertical mixing led to the buildup of PM_{2.5} in the valley. The total PM_{2.5} level in the valley was as high as 60 µg m⁻³ and was dominated by ammonium nitrate. Falling snow was collected and analyzed by ion chromatography to evaluate the role of scavenging in removing gas and particle phase constituents from the atmosphere. Also, changes in the chemical composition of urban snowpack between snowfall events were used to probe the potential role of snow in surface-atmosphere exchange of ammonia.

Improvements in Wasatch Front Air Quality Modeling

Chris Pennell and Nancy Daher
Utah Division of Air Quality, Salt Lake City, UT*

Utah's frequent winter-time exceedances of the 24-hour PM_{2.5} National Ambient Air Quality Standards (NAAQS) are attributed to strong temperature inversions. These temperature inversions can last several days during persistent high-pressure, low surface-wind conditions. In turn, low-level mixing layers trap pollution near the surface, creating a public-health concern.

Utah's complex topography creates a unique challenge. Air quality models struggle to get adequate performance or show realistic PM_{2.5} composition. During winter-time exceedances, particulate nitrates (PNO₃) often represent the largest portion of PM_{2.5} mass, contributing more than organic carbon. To achieve adequate performance, past PM_{2.5} modeling required disabling vertical advection and adding additional ammonia.

To address the challenges of simulating PM_{2.5} along the Wasatch Front, the Utah Division of Air Quality (UDAQ) has greatly advanced their air quality modeling platform. Currently, we are using the Comprehensive Air Quality Model with Extensions (CAMx), version 6.3. This recent release of CAMx includes UDAQ-funded updates to the CB6 chemistry mechanism, snow-cover treatment, and surface model. We increased the horizontal resolution by nine times and the vertical resolution by three times. Finally, meteorological inputs have improved to better capture near-surface air stability.

For this presentation, we compare differences between our current and past modeling efforts. We also present recent results from modeling the January, 2011 Persistent Cold Air Pool Study (PCAPS) intensive field campaign. Subsequently, we demonstrate a marked improvement in simulating peak PM_{2.5} concentrations, PM_{2.5} composition, and temporal correlation with observations.

** Presenter*

IASA – Indoor Air Quality Sensing and Automation

Kyeong Min

Clean indoor air is important for human health. Using an air purifying system can remove indoor air pollutants, but paradoxically because it increases use of electric power, it in the large scale increases the

generation of air pollutants. To optimize energy consumption and healthful air, we present an indoor air sensing and automation (IASA) system (an "Internet-of-Things" system). The IASA system uses our custom Utah-modified Dylos sensor (UMDS), a gateway device, and a smart thermostat to control the fan in a home's heating and cooling system. When particulate matter goes high, the system uses the fan (and a furnace filter) to remove the pollution from the indoor air. It has been shown that particles less than 2.5 micron are particularly harmful. Our sensors, actuators, and rule-based triggers help reduce these particles in indoor settings. We describe our preliminary system design, deployment results and data analysis. To date, our system has collected 861K air quality data points. This and future data will assist in the development of new models for more intelligent air-purifying automation.



Figure: The graphs show the state of the furnace fan mode and its effects on the small particle (PM2.5) of the indoor air quality. The purple color line graph shows the small particle trend (PM2.5) and the blue color line graph shows the large particle trend (PM10)

Mobile Air Quality Measurements on Light Rail and Helicopter

Alexander A. Jacques, Erik T. Crosman, John D. Horel, Logan Mitchell, Ben Fasoli, Luke Leclair-Marzolf
Department of Atmospheric Sciences, University of Utah

As “Internet of Things” technologies and communications continue to improve, real-time mobile measurements are becoming a relevant resource for surface and near-surface meteorological and air quality observations. In order to help better understand the spatial distribution of ozone and particulate matter in the Salt Lake Valley, two unique mobile platforms were utilized: a public transit light rail car and a television news helicopter. Our deployable systems are described in terms of instrumentation, data logging, and real-time cellular communications protocols. Each unit was designed to utilize power provided by the mobile platform and to require as little maintenance as possible.

Software was developed to communicate with the mobile units in real-time to collect data at routine intervals and made immediately available to users on web products with minimal latency. Light rail car real-time and archived observations of particulate matter and ozone can be found at <http://meso1.chpc.utah.edu/mesotrax>. The helicopter ozone data was collected as part of the 2015 Great Salt Lake Summer Ozone Study (GSLSO3S) and can be found with ozone data from other in-situ and mobile platforms at <http://meso2.chpc.utah.edu/aq>. Examples of interesting case events are displayed using web products from both sources.



Observations and Simulations of a Lake Breeze with High Ozone Concentrations in the Salt Lake Valley

Brian Blaylock, John Horel, Erik Crosman

Urban emissions from the Salt Lake Valley can be transported toward the Great Salt Lake by nocturnal down-valley flows. Pollutants over the lake are concentrated in a shallow boundary layer and may be transported back toward the city in the daytime by lake breezes. During the late afternoon of 18 June 2015, ozone concentrations in the densely populated Salt Lake Valley rapidly increased by ~20 ppb after the passage of a strong lake breeze front. Ozone observations from an enhanced network were available

from state air quality measurement sites, additional fixed locations, and mobile platforms including a news helicopter. The southward progression of the well-defined lake breeze front through the Salt Lake Valley was observed by wind, temperature, and moisture observations available at automated weather stations as well as radial velocity scans from a nearby Terminal Doppler Weather Radar. Strong flow opposing the lake breeze increased convergent frontogenesis and delayed the onset of its passage through the Salt Lake Valley.

The ability of numerical models to simulate the development and progression of lake breeze in the Salt Lake Valley is investigated. Lake breezes on both 17 and 18 June 2015 were simulated using the Weather Research and Forecast model at 1-km horizontal resolution over northern Utah. The model was initialized at 0000 UTC 14 June 2015 using hourly analyses at 3-km resolution from the High Resolution Rapid Refresh model. The underlying surface state was improved by specifying the areal extent and surface temperature of the lake observed during June 2015. An urban canopy parameterization was added as well to better simulate urban effects on wind and heat fluxes. These modifications improved the model simulation particularly for the more typical lake breeze event on 17 June. However, on 18 June weaker than observed opposing southerly flow allowed the development of the simulated lake breeze front to occur too early and its subsequent speed up the valley was too fast. The results of this simulation are compared with the operational HRRR analyses and forecasts available on that day. This study highlights how the timing and intensity of subtle mesoscale features can affect a lake breezes and ozone concentrations within an urban region. Improvements to operational numerical weather models would add skill to air quality forecasts.

Ozone evolution in both time and vertical distribution during Utah winter inversion events.

Ryan Lawton, Johnny Nikoloff, Michael Hess, Jeffrey Page, John E. Sohl
Department of Physics, Weber State University, Ogden, UT

A standard electro-chemical cell ozonesonde has been flown under a tethered balloon (aerostat) during two persistent cold air pool (PCAP) events in 2016 and 2017. These winter inversions are a known health hazard and are especially problematic in urban mountain basins. Ozone is a known precursor molecule in the formation of the particulate matter that is the largest contributor to the health issues associated with winter inversions.

We mapped the vertical and temporal distribution of ozone from ground level to 150 m (500 ft) above ground for two complete PCAP events. The well established diurnal pattern of ozone developing in the morning, peaking in mid-afternoon, then dissipating after sunset was observed. Of interest is the vertical distribution. During a PCAP event the ozone forms first at higher elevations then increases at ground level. Once the sun is higher in the sky the ozone becomes uniform in altitude. With sunset there is no consistent pattern, sometimes the air is uniform, sometimes the ozone will dissipate faster at one altitude or another changing in minutes and with no clear pattern. As the inversion is ending and the air mixes out, the vertical distribution of ozone becomes unstable. Once the mix out is complete the vertical column becomes reasonably uniform, i.e., the ozone concentrations are independent of altitude.

Particulate Matter distribution and formation by size from 0.3 microns to 10 microns during Utah winter inversion events.

Michael Hess, Erik Hall, Jeffrey D. Page, John E. Sohl
Department of Physics, Weber State University, Ogden, UT

A standard clean room particle counter, Met One GT-526, was flown under a tethered balloon (aerostat) during two persistent cold air pool (PCAPs) events during 2016 and 2017. This particle counter has six channels that measure an estimate of the number of particles per liter for particles greater than or equal to 0.3, 0.5, 0.7, 1.0, 2.0, and 5.0 microns in diameter, inclusive. The max particle size readily detected is 10 microns in diameter. Particles smaller than 2.5 microns in diameter are well established as a respiratory health hazard.

We measured the air column from ground to 150 m (500 ft) above ground level. Measurements were made from close to sunrise through the day until approximately sunset. These were measured in southern Salt Lake City, UT, in 2016 and from Ogden, UT, in 2017. Outside of the winter inversions the particle counts were both low in number and fairly uniform in altitude distribution. During the inversion events the grew in number during the day and were mostly uniform in altitude but with occasional layers of some particle sizes but not others. As the inversion mixed out the vertical distribution of particulates was size, time, and altitude dependent. Of special note is that the altitude dependence was unstable during mix out.

These measurements are being compared to simultaneous measurements of ozone with an electro-chemical cell ozonesonde and with a multi-gas sensor called the AtmoSniffer that flew with or near the particle counter. We are also attempting to correlate the particle counts with air motion and possible local sources.

Portable TiO₂ Nanotube Sensor for the Detection of Benzene at Room Temperature

Shruti Hegde ^a, Swomitra Mohanty ^a and Kerry Kelly ^a
^a Department of Chemical Engineering, University of Utah, Utah.

Benzene is one of the few known human carcinogens as identified by the International Agency for Research on Cancer. It is a common indoor and outdoor pollutant, with sources ranging from cigarette smoke to traffic. In 2015, the US Environmental Protection Agency (EPA) implemented a new rule requiring refineries to monitor benzene concentration at their fence-line and to maintain the average benzene concentration below 9 µg/m³. Hence, there is an increasing need to rapidly and inexpensively detect low concentrations of benzene. Metal-oxide based nano-sensors with their high surface-to-volume ratio, high sensitivity and low production cost make for a good choice. Thin films based on titanium dioxide (TiO₂) have previously been shown to respond to benzene (1), however these sensors are run at high temperatures (160-200°C) and require a complex setup for operation. This poster presents the development of TiO₂ nanotube based sensor array that is highly sensitive, and operates at room temperature using portable and simple instrumentation. The response of the sensor coupons to benzene vapor was measured using an amperometric technique. Results on sensing mechanism, stability of the sensor over time, sensor reusability, and detection limit will be presented.

(1) Mabrook M., Hawkins P. (2001) *Sensors and Actuators, B: Chemical* 75, 197-202.

Sex Differences in Ambient Particulate Matter Air Pollution Exposure and Hospital Readmissions among Cardiac Patients in Utah's Medicare Population

Claire L Leiser, MSPH¹; James A Vanderslice, PhD²; Ken R Smith, PhD^{2,3}; Scott Stevenson, MSPH²; Heidi A Hanson, PhD, MS^{1,2}

1. Population Sciences, Huntsman Cancer Institute

2. Department of Family and Preventive Medicine, University of Utah

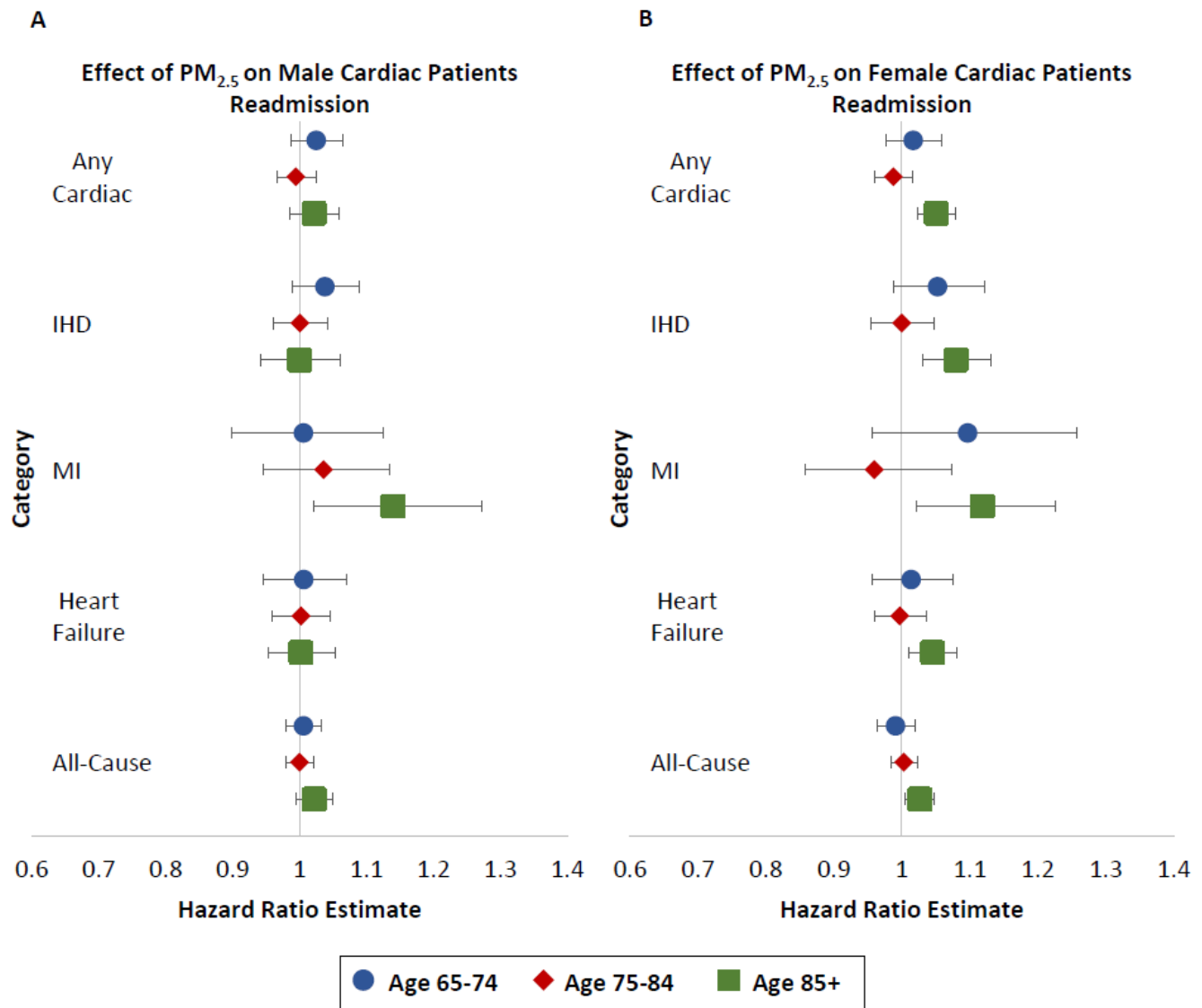
3. Department of Family and Consumer Studies, University of Utah

Particulate matter (PM) air pollution is known to contribute to cardiovascular morbidity and mortality. Short term exposure to fine PM (<2.5 μm in aerodynamic diameter) (PM_{2.5}) is associated with admissions for myocardial infarction, heart failure, and cardiovascular disease. PM_{2.5} is therefore a potential threat to sensitive subpopulations including the elderly. Individuals aged 65 and over also have high rates of hospital readmissions, which are very costly to the healthcare system at an estimated \$17.4 billion per year among Medicare beneficiaries. The effect of PM_{2.5} on length of inpatient stay and readmissions rates could be particularly harmful to elderly population in Utah, where temperature inversions create high concentrations of PM_{2.5} seasonally. Additionally, there are known sex differences in cardiac outcomes and thus potential differences in risk factors. This study uses United States Environmental Protection Agency's (EPA) Air Quality System Data Mart and Centers for Medicare and Medicaid Services data to explore the effects of PM_{2.5} exposure on length of stay during cardiovascular related hospitalizations and subsequent readmissions by age group and sex. Air pollution measures were assigned at the zip code level using inverse distance weighting from ambient air monitors across the Wasatch Front in Utah. Our analyses included 43,454 events for 21,934 individuals during the inversion season (November to March) from 2000-2009. Length of stay was analyzed using Poisson regression. Using EPA's Air Quality Index 24-hour cutoffs for PM_{2.5}, we assigned exposure to "low" and "high" categories. Time to event models were used to analyze the effect of PM_{2.5} on hospital readmissions for heart failure, myocardial infarction (MI), ischemic heart disease (IHD), any heart condition, and all-cause readmission. Analyses were stratified by age group (65-74, 75-84, 85+) and sex.

We found that individuals of both sexes aged 75-84 and 85 or older who were admitted on "high" concentration days had longer length of stay than those admitted on "low" exposure days. These results suggest that these individuals may experience more severe cardiovascular events when exposed to high levels of PM_{2.5}. A 10 μm^3 increase in PM_{2.5} was associated with an 5% - 12% increased risk of cardiac related readmissions among females aged 85 and older who were originally admitted for heart failure (HR=1.05, CI 1.01-1.08), IHD (HR=1.08, CI 1.03-1.13), MI (HR=1.12, CI 1.02-1.23), and any heart condition (HR=1.05, CI 1.02-1.08). A 10 μm^3 increase in PM_{2.5} was associated with a 3% - 14% increased risk of all-cause readmissions for females aged 85 and older who were originally admitted for IHD (HR=1.06, CI 1.02-1.10), MI (HR=1.11, CI 1.01-1.22) and any heart condition (HR=1.03, CI 1.01-1.04). Males aged 85 and older who were admitted for MI were also at higher risk for readmission (HR=1.14, CI 1.02-1.27). Significant results were not found for females of other age groups or males of other age groups and conditions. We did not find increased risk among individuals with respiratory comorbidities.

We found that exposure to PM_{2.5} can increase length of stay and risk of readmission in cardiac Medicare patients across the Wasatch Front.

Figure 1



(Panel A) Effect of PM_{2.5} on readmissions male cardiac patients admitted for any cardiac event, ischemic heart disease, myocardial infarction, heart failure, and all-cause readmission. (Panel B) Effect of PM_{2.5} on readmissions for female cardiac patients admitted for any cardiac event, ischemic heart disease, myocardial infarction, heart failure, and all-cause readmission.

Source Apportionment and Risk Assessment of BTEX for winter 2015 in Roosevelt, Utah

Jerimiah Lamb¹, Seth Lyman³, Roger Coulombe¹, Paul Grossl²

¹*Department of Animal, Dairy, and Veterinary Sciences, Utah State University, Logan, Utah;*

²*Department of Plant, Soils, and Climate, Utah State University, Logan, Utah;*

³*USU-Bingham Research Center, Vernal, Utah*

Deleterious health effects have been associated with some of the Non-Methane Hydrocarbons (NMHC) monitored in Roosevelt, Utah including Benzene, Toluene, Ethylbenzene and Xylene (collectively known as BTEX). This study addressed two points: 1) Source identification using the USEPA's Positive Matrix Factorization (PMF) and NOAA's Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT) model and 2) A human health risk assessment based on ambient concentrations of BTEX collected at the Roosevelt site. Model fit indicates with that the primary contributor to total NMHCs is local oil and gas operations. Assessment of ambient BTEX concentrations are associated with slightly elevated carcinogenic risk.

STATISTICAL ANALYSIS OF WINTER OZONE EXCEEDANCES IN THE UINTAH BASIN

Marc L. Mansfield

Department of Chemistry and Biochemistry

Bingham Research Center

Utah State University Uintah Basin

Vernal, Utah 84078

marc.mansfield@usu.edu

Abstract

Because of the confluence of several factors (persistent multi-day inversions, petroleum production, and snow cover) the Uintah Basin of eastern Utah, USA exhibits high concentrations of winter ozone. A regression analysis is presented that successfully predicts daily ozone concentration with a standard error of about 11 ppb. It also predicts with 90% accuracy whether any given day will exceed the National Ambient Air Quality Standard for ozone, 70 ppb. An analysis is introduced for calculating a "pseudo-lapse rate," a determination of inversion intensity in the absence of sounding data. By combining the model with historical meteorological data it is possible to make long-range forecasts about ozone formation. The odds of observing no exceedances in any given season are 38%. The odds

of only three or fewer exceedances in any given season are 46%. Inter-annual correlations are non-existent or weak: The outcome of any one year has no detectable impact on the outcome of the following year.

Testing a high resolution CO₂, CO, NO_x, and PM_{2.5} emissions inventory against atmospheric observations in Salt Lake City, Utah for health and policy applications

Daniel Mendoza, John Lin, Derek Mallia, Douglas Catharine, Logan Mitchell, Benjamin Fasoli, Ryan Bares, Kevin Gurney, Risa Patarasuk, Darragh O’Keeffe, Yang Song, Jianhua Huang, Erik Crosman, Sebastian Hoch, John Horel, Denitza Blagev, Jeff Sorensen, Susan Rea, James Ehleringer

This presentation discusses the need for robust highly-resolved emissions and concentration data required for planning purposes and policy development aimed at managing pollutant sources. Adverse health effects resulting from urban pollution exposure are dependent on proximity to emission sources and atmospheric mixing, necessitating models with high spatial and temporal resolution. As urban emission sources co-emit carbon dioxide (CO₂) and criteria air pollutants (CAPs) including carbon monoxide (CO), nitrogen oxides (NO_x), and fine particulate matter (PM_{2.5}), efforts to reduce specific pollutants would synergistically reduce others. We present a contemporary (2010-2016) emissions inventory and modeled concentrations for CO₂ and CAPs for Salt Lake County, Utah, and compare emissions transported by a dispersion model against stationary measurement data, systematically quantifying uncertainties.

The emissions inventory for CO₂ is based on the Hestia emissions data inventory that resolves emissions at an hourly, individual building and road segment resolution. The emissions were scaled to specific years using Energy Information Administration (EIA) fuel consumption data. We derived the criteria pollutant inventories by downscaling total county emissions from the 2014 Environmental Protection Agency’s (EPA) National Emissions Inventory (NEI). The gridded CO₂ emissions were compared against CO, NO_x, and PM_{2.5} gridded data to characterize spatial similarities and differences between greenhouse gas and criteria pollutant emissions. Correlations were calculated at multiple scales of aggregation.

The Stochastic Time-Inverted Lagrangian Transport (STILT) dispersion model was used to transport emissions and estimate pollutant concentrations at an hourly resolution. Modeled results were compared against stationary and mobile measurements in the Salt Lake County area. This comparison highlights spatial locations and hours of high variability and uncertainty. Sensitivity to biological fluxes as well as to specific economic sectors was tested by varying their contributions to modeled concentrations and quantifying the resulting variability.

Finally, we present two applications of Hestia. A study focusing on chronic obstructive pulmonary disease (COPD) showed an association between higher levels of pollutant exposure a week prior to an exacerbation when compared to season-long exposure. An analysis using electronic fare collection (EFC) data from the Utah Transit Authority (UTA) resulted in highly detailed transit ridership during poor air quality days. These revealed substantial variability in usage of transit services, and personal vehicle replacement trips with associated emissions.

The AtmoSniffer, a lightweight, flight-ready, multi-sensor, air quality instrument.

Jeffrey Page, John E. Sohl

Department of Physics, Weber State University, Ogden, UT

We are developing a multi-sensor array, called the AtmoSniffer, that is designed to measure particulate matter, ozone, carbon dioxide, carbon monoxide, nitrogen dioxide, sulfur dioxide, and ammonia. It also detects temperature, % relative humidity, and pressure. As a flight optimized device, the AtmoSniffer also has a 9-axis inertial measurement system that can be used as a proxy to measure air turbulence along with a high-altitude rated GPS. The current prototype is 1.47 kg (3.2 lbf) and has a 3 to 4-hour flight time on a 5200 mAh Lipo battery. The prototype has been flown to over 30 km ASL (100,000 ft) on multiple flights simultaneously with a standard ozonesonde and a cleanroom monitor particle detector. All three instruments have been in reasonable agreement. Future plans are to make the system more compact, lighter in weight, and energy efficient. Data taken under free flying high-altitude weather balloons and moored balloons (aerostats) will be presented and compared with both ground-based and flight instruments.

The necessity for a size-based characterization of ultrafine/nano particulate matter (PM_{0.1}) in Utah Valley air

Shoeleh Assemi, Jan.D.Miller

Department of Metallurgical Engineering, University of Utah

Utahns are exposed to particulate matter concentrations twice the EPA limit during the winter. In addition to geographic factors, emissions from human activities, mining and refinery industries can contribute significantly to anthropogenic and natural pollutants such carbon-based emissions, as well as Pb, As, Cd, and Hg, nanoparticles, particularly during the winter inversion.

Previous studies have found that health hazards increase as airborne particulate matter (PM) decreases in size, thought to be due mainly to an increase in the specific surface area and the increased reactivity with the lung alveolar cells. Metallic nanoparticles (e.g V, Cr, Mn, Fe, Ni, Cu, Zn, Cd, Hg and Pb) and organic chemical emissions from combustion sources have been reported to have high toxicity and possible human carcinogenic effects (Cr, As, Cd and Ni). Previous comprehensive epidemiological studies have also related pulmonary and cardiovascular health effects to the air pollution and inversions in Utah Valley. However, the direct effect of nanoparticles has not been documented in detail. Other studies have demonstrated the adverse effect of metallic nanoparticles on the human auto-immune system and arthritis. Recent studies in Europe have demonstrated accumulation of magnetic nanoparticles in the brain, possibly leading to Alzheimer's disease. To the best of our knowledge, studies on the health effects of ultrafine particulate matter (PM_{0.1}/nanoparticles) are still very limited and a study to determine the

composition of PM_{0.1} particles and their potential health effects from exposure to Utah air has not been conducted at all.

Preliminary data will be shown to demonstrate the capabilities to sample and analyze PM_{0.1} (nanoparticles) in Utah air for size, charge and composition. It will be demonstrated how mapping PM_{0.1} in Utah air during cycles of inversion/clean air days, and comparison with the mortality rates, as well as the patient admission data from the University of Utah clinics in Utah Valley, can be used to help identify the sources and contribution of nanoparticles in air pollution to pulmonary and systemic oxidative stress in Utah population.

Toward a Miniaturized Gas Chromatography system; Hao-Chieh Hsieh

Hao-Chieh Hsieh, Ashrafuzzaman Bulbul, Seungbeom Noh, and Hanseup Kim
Department of Electrical & Computer Engineering, University of Utah, SMBB-3100, 36 South Wasatch Drive, Salt Lake City, USA
E-mail: haochieh.hsieh@utah.edu, hanseup.kim@utah.edu
Tel: +1 801 587 9497

Recent literature has increasingly reported on the adverse effects of the worsening air pollution and the resultant demand for distributed air quality monitoring systems. Air pollutants include >100 different chemicals and have been reported to increase the risk of several diseases. Currently, airborne chemicals measured at the community level fail to account for spatial and individual variability in air pollution exposure. For example, there are only <30 stationary stations serving a population of 2.9 million and covering an area of 219,887 km² in the state of Utah. As a consequence, the levels of personal exposure to hazardous air pollutants remain mostly unknown. Therefore, demand for the development of a reliable, small-volume analytical device that is wearable or easily portable is increasing.

To enable personal-level monitoring, the miniaturization of such a gas chromatography (GC) system has been rigorously pursued, particularly by utilizing micro/nano technology. However, in comparison with macro-scale GC systems, such miniaturization efforts have fundamentally caused a reduction in the detection range, mostly resulting in impracticality.

We will present the development of a miniature GC system at the University of Utah, which is setting the state-of-art technology toward a truly wearable air quality monitoring system with a wide detection range.

Trace Gas and Aerosol Measurements in Sevier County

Ryan Thalman – Snow College, Richfield, UT

Seth Lyman, Randy Anderson, Marc Mansfield – Bingham Research Center, USU Uintah Basin

Jaron Hansen – Brigham Young University

Measurements of ozone (O_3), oxides of nitrogen (NO and NO_2), carbon monoxide (CO) and particulate matter (PM_{2.5}) were made in Richfield, UT from December 2015 – February 2017. Richfield lies in Sevier valley, a growing rural area with some smaller scale oil and gas exploration. While the area is currently considered a ‘clean’ area for air quality, future growth and increased oil and gas development may cause that designation to change. A good portion of the local homes still use wood or coal for home heating contributing to particulate matter. In addition Sevier valley part of the I-70 transportation corridor. While isolated PM_{2.5} concentrations greater than $30 \mu g m^{-3}$ are possible throughout the year depending on emissions, these are more common during the winter with increased wood burning and inversions. Ozone in the valley rarely rises above 60 ppbv.

Utah Winter Inversion Optical Air Quality Study

Andrew Petersen, Amanda Williams, John E. Sohl, Stacy Palen,

Department of Physics, Weber State University, Ogden, UT

Northern Utah faces an atmospheric pollution problem for which scientists lack a comprehensive understanding. In an ongoing effort to study the lower atmosphere, Weber State University’s HARBOR team and a joint team of government agencies and universities have been collecting data to track ozone, air particulates, and other atmospheric chemical constituents to learn more about the lower atmosphere, particularly during winter inversions. The data set was collected over a two-year period, in the winter of 2015/2016 in the Salt Lake Valley, and the recent “Utah Winter Fine Particulate Study 2017”, part of a larger scale project under the NOAA. Both studies have produced standalone particulate data in the lower atmosphere progressing both in time and altitude to act as a reliable comparison.

This study focuses on the analysis of digital images to determine a turbidity value for the air over Weber County during the 2015/2016 and 2016/2017 Winter. The data set contains images from two camera systems. A flight camera system, lifted by a low-altitude balloon, collects images to determine the evolution of atmospheric turbidity by both altitude and limited intervals in time. The second system, a stationary “all-sky” camera, takes images for several hours in succession yielding a look at a more continuous evolution of atmospheric turbidity over an extended period. These pictures are analyzed by comparing the optical resolution of selected targets with known air quality measurements, to determine the effectiveness of measuring atmospheric turbidity through imagery. The detailed pollution database, but especially that collected by particle counters, will be used as a calibration standard for the data analyzed through images in both camera systems.

Wind-blown dust modeling using a backward Lagrangian particle dispersion model

Derek V. Mallia^{1*}, Adam Kochanski¹, Chris Pennell², Whitney Oswald², and John C. Lin¹

1 Department of Atmospheric Sciences, University of Utah, Salt Lake City, UT, USA

2 Utah Department of Environmental Quality, Salt Lake City, UT, USA

Air Quality, Science for Solutions

***Corresponding E-mail: Derek.Mallia@utah.edu**

Abstract

Wind-blown dust events can have significant impacts on human activities such as transportation, in addition to degrading air quality for the affected region. As a result, an atmospheric model that simulates wind-blown dust events is needed. Previous studies have developed dust models using either Eulerian or forward-running Lagrangian approaches in order to replicate wind-blown dust events. However, most of these studies either relied upon coarser-scale reanalysis data not suitable for regions of complex terrain or adopted computationally costly methods that are cumbersome for operational forecasting. Presented here is a new dust modeling framework that uses a backward Lagrangian particle dispersion model coupled with a dust emission model, both driven by meteorological data from the Weather Research and Forecasting model (WRF). The modeling framework's performance was tested for two major windblown

dust events during the spring of 2010 across Utah using WRF simulations driven by meteorological reanalyses. Hindcast results for March-April 2010 showed that the modeling system was able to reproduce the duration and magnitude of two significant dust events, while keeping significant false alarms at a minimum. When the dust simulations were driven by WRF forecasts, the model reasonably predicted each dust event 24h in advance. These results suggest that the dust modeling framework has the capability of replicating past dust events, identifying potential source regions of dust, and for short-term forecasting applications. In addition, the modeling framework presented here can be used to project the impacts of decreasing Great Salt Lake levels on dust emissions and its impact on future air quality.

5:00p Closing Remarks for the Science Session

Dr. Randy Martin, Utah State University, Utah Water Research Laboratory

7:00p – 8:15p Community Conversation: Public Forum on Air Quality

Community Conversation open to the public to allow a free flow of ideas between local air quality researchers and the greater community.

The panel members:

Moderator = Judy Fahys, KUER News.

Brock LeBaron (Deputy Directory, Utah Division of Air Quality)

Munkh Baasandorj (Atmospheric Chemist, Utah Division of Air Quality, Univ. of Utah)

Ed Redd (Utah State Legislature, District 4)

Vicki Bennet (Director, Sustainability and Environment at Salt Lake City)

Michelle Hofmann (Medical director of Riverton Hospital's Children's Unit, and the Department Chair of Pediatrics at Riverton Hospital, co-founder of Breathe Utah)

Organizing Committee:

Utah Division of Air Quality, Salt Lake City, UT, Chris Pennell (Committee Chair)

Brigham Young University, Provo, UT, Jaron Hansen (Poster session and registration)

University of Utah, Salt Lake City, UT, Kerry Kelly (Local Organizing Chair)

Utah State University, Logan, UT, Randy Martin (Logan region contact)

Utah State University, Vernal, UT, Seth Lyman (Uintah Basin region contact)

Weber State University, Ogden, UT, John Sohl (Webmaster, registrations, abstracts)