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The DEARS Data Analysis Workshops: Summary of Findings and Discussions

Office of Research and Development
National Exposure Research Laboratory

The DEARS Data Analysis Workshops

Summary of Findings and Discussions

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Notice

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The DEARS Data Analysis Workshops

Summary of Findings and Discussions

Organizational Sponsor

U.S. Environmental Protection Agency, Office of Research and Development (ORD)

Chair: Ron Williams, (ORD)
Steering Committee: Val Garcia (ORD), Karen Wesson (OAQPS), Jennifer-Richmond Bryant (NCEA), Rich Cook (OTAQ)

1. Background

The Detroit Exposure and Aerosol Research Study (DEARS) was a three-year study conducted by the U.S. Environmental Protection Agency through the Office of Research and Development's National Exposure Research Laboratory (EPA/ORD/NERL). Field data collections were completed in 2007 and validation of the primary datasets was completed in late 2008. The study's primary goal was to investigate the relationship of select air pollutant concentrations and their sources measured at community air monitoring stations in comparison to those measured in various neighborhoods in Wayne County, Michigan. Six primary data analysis objectives were components of the original study design (www.epa.gov/dears). These original data analysis objectives were to: (1) characterize spatial and temporal relationships between pollutants, (2) determine human exposure factors, (3) determine environmental exposure factors, (4) develop enhanced human exposure models, (5) establish source contributions, and (6) investigate multi-pollutant (particulate matter/gases/semi-volatiles) relationships.

The study was designed to significantly contribute to our understanding of how well air quality information collected at community monitors accurately reflects what neighborhoods and the individuals living in these neighborhoods are exposed to every day. It would provide needed information on defining what factors affect an individual's exposure to various particulate matter and air toxic sources. Exposure-related data from the DEARS can be divided into five main parts: (1) personal monitoring, (2) residential indoor monitoring, (3) residential outdoor monitoring, (4) monitoring performed at a central community site, and (5) survey information related to environmental and human exposure factors. The personal and residential monitoring involved a total of 145 participants over a three-year period of data collection. A total of nearly 36,000 individual 24-hr based exposure measurements involving particulate matter, criteria pollutant gases and other air pollutants of interest were obtained during the field measurements.

NERL and its collaborators have been actively analyzing data to support the six original data analysis objectives. A detailed summary of the six objectives, progress to date, ongoing analyses, and current data summarization products was recently developed and made available on the DEARS website (www.epa.gov/dears/findings.html). This summary was useful in assisting the NERL in determining the overall progress being made on the study as a whole as well as gaining a perspective on study areas showing potential for unanticipated research benefits

to ORD and its stakeholders. These stakeholders include among others, the National Center for Exposure Assessment (NCEA), the Office of Air Quality, Planning and Standards (OAQPS), the Office of Transportation and Air Quality (OTAQ), US EPA Region 5, and the National Health and Environmental Effects Research Laboratory (NHEERL). NERL has been actively sharing DEARS data with both internal and external collaborators in pursuit of the study objectives. Significant progress had been made on data analyses during the 2008-2010 calendar periods and information updating key collaborating institutions of these analyses would be beneficial to all parties. A workshop setting was proposed where DEARS progress-to-date could be shared and where potential new uses of exposure data to meet critical EPA needs could be explored.

1.1 Overall Goal

The goal of the effort was to develop a multi-institutional review of critical exposure-related data gaps and determine the potential value of the DEARS in meeting those needs.

1.2 Specific Objectives

The DEARS Principal Investigator had a charge to:

- Develop a multi-institutional steering group interested in exposure-related research to guide overall workshop development and summarization,
- Establish workgroups responsible for identifying exposure-related data gaps in four primary research areas: (1) measurement assessment and uncertainty, (2) human exposure modeling, (3) atmospheric and environmental modeling, and (4) health and epidemiology,
- Plan, schedule and conduct a series of developmental meetings to accomplish the objectives above, ultimately resulting in one or more workshops each involving a report-out of findings-to-date, and
- Develop a summary (report) on the workshops and the ability of DEARS to meet the identified exposure-related data needs.

1.3 Approach

Senior scientists from the Office of Air Quality Planning and Standards (Karen Wesson/OAQPS), the National Center for Exposure Assessment (Jennifer Richmond-Bryant/ NCEA), the Office of Transportation and Air Quality (Rich Cook/OTAQ), and the Atmospheric Modeling and Analysis Division (Val Garcia/NERL) were contacted by the DEARS Principal Investigator (Ron Williams/NERL) and invited to participate on the Steering Committee. The Steering Committee had the responsibility of examining the four draft exposure research areas of potential mutual interest proposed by NERL. These research areas were:

(1) exposure assessment and uncertainty,
(2) human exposure modeling,
(3) atmospheric and environmental modeling, and
(4) health and epidemiology.

To facilitate this effort, the Steering Committee developed strawman exposure data gap questions within each of the four areas (Attachment1). The Steering Committee recruited other Agency staff members who could provide expertise on the data gap issues and act as Workgroup members. To the greatest extent possible, multi-institutional Workgroup member rosters were developed for each of the four research areas being examined. A total of 23 Workgroup members were invited to participate in discussions concerning one or more research areas. A listing of the Steering Committee and invited Workgroup members is provided (Attachment 2).

A series of meetings involving the Steering Committee and the various Workgroups were held between August 19th and September 29th, 2010. During this time, "champions", or individuals who would summarize individual Workgroup discussions, were named. These individuals had the responsibility of reporting back to the Steering Committee what exposure-related data gaps existed within each research area and then summarizing these findings in a common slide presentation format. A report-out by these champions was then presented to the Steering Committee and the other Workgroups to gain input from all involved.

Slide sets meeting the Steering Committee's approval were developed in anticipation of an invitation-only workshop event to be sponsored by the NERL (Part 1). The Acting Director of the NERL's Human Exposure and Atmospheric Sciences Division (Roy Fortmann) made personal contact with all invitees who he believed would benefit from the workshop discussion as well as provide valuable input to NERL on the role exposure science must play in advancing the Agency's goals. This event was held on October 19th, 2010 on the EPA-RTP campus. The agenda for this event is provided (Attachment 3) as well as the list of invited attendees (Attachment 4). This event had the goal of providing a summary of the purpose of the DEARS Data Analysis Workshops, defining the charge given to the Steering Committee and Workgroups, reporting on the DEARS overall study progress to date (Attachment 5) and providing a report out on each of the four research areas. In particular, the champion of each research area had the responsibility to report on exposure data gap issues of importance to the Agency. The individual presentations associated with these reports are provided (Attachments 6-9). In addition, a "Common Needs" summary was reported (Attachment 10). This summary reviewed information obtained from all of the research area discussions. In doing so, it provided a simple tabular means of determining what exposure data gaps were viewed as essential across the four research areas.

The last segment of the Part 1 workshop event focused on encouraging all present to engage in future discussions concerning how the DEARS data might have the potential to meet the agreed upon data gaps. The ensuing November 2010 discussions held between the study's Principal Investigator (Ron Williams), the Steering Committee, and all Part 1 invitees provided information ultimately reported out during a November 30th workshop event (Part 2). The agenda, summary presentations associated with each of the four critical research areas, DEARS publication plan, and evaluation of the usefulness of the DEARS to potentially meet specific exposure data gaps associated with this event are included as Attachments 11-14.

2. Steering Committee and Workgroups Pre-Part 1 Workshop Discussions

The draft exposure research areas and strawman data gaps (Attachment 1) provided by NERL to facilitate the discussions with the Steering Committee proved to be invaluable. Further discussions indicated that the strawman data gaps should be refined by each of the subsequently-developed Workgroups rather than the Steering Committee itself. This decision ultimately resulted in very focused and highly productive meetings concerning each of the four research areas. Partial summaries of these discussions are reported below.

2.1 Exposure Assessment and Uncertainty Workgroup:

This Workgroup considered what air pollutants were of interest to their respective organizations. Particulate matter (PM) and its component species were of high interest as well as the multi-pollutant environment consisting of PM, air toxics, criteria pollutant gases and semi-volatiles. Workgroup members were interested not only in data gap questions pertaining to pollutant concentrations but also in how pollutants related to one another in time and space (spatial/temporal). The degree of error involved in obtaining pollutant measurements was discussed as well as issues related to understanding source impacts. Concerning source impacts, Workgroup members raised questions as to how one might summarize source characterizations using surrogates or select species as identifying tools. The value of non-ambient pollutant measurements (e.g., personal, residential) were issues deemed worthy of examination.

2.2 Human Exposure Modeling Workgroup:

These individuals examined a series of draft questions concerning what pollutant data was viewed as critical for development or evaluation of select models (e.g., PMSHEDS). This group was asked to provide feedback on needed or perceived data needs ranging from PM (various size fraction), VOCs and air toxics. Draft questions included issues involving human activity and environmental exposure factors. Of particular interest to the steering committee were the inputs needed to help advance the Exposure Model for Individuals (EMI), which NERL plans to use in ongoing near-road field studies. The modelers comprising this workgroup believed that a more systematic approach was needed to determine the state of the science for this given area rather than examining the draft questions. Therefore, the majority of the discussions this group held focused on defining what they collectively felt was the current state-of-the-science pertaining to advancing human exposure modeling.

2.3 Atmospheric and Environmental Modeling Workgroup:

This Workgroup considered what exposure data was needed to advance current models (like CMAQ). Specific components of their discussion indicated that multi-pollutant issues were viewed as critical and that those involved in modeling needed extensive spatial/temporal exposure datasets. This included draft questions involving meteorology and the need for micro-scale source information. Two key discussions points included the need for data collections involving both high frequency and high quality data. In addition, this workgroup decided that a potentially beneficial approach concerning the subject matter was not a direct examination of the draft questions, but rather an extensive discussion on what exposure monitoring data was needed

to support CMAQ and other model development.

2.4 Health and Epidemiology Workgroup:

Members were initially asked to consider draft questions pertaining to what critical needs exist following the most recent NOx/SOx, PM, and O_3 Integrated Science Assessments (ISAs). The role of multi-pollutant exposure issues was raised as well as how important it is to understand exposures related to non-ambient spatial settings. Questions related to the PM_{coarse} ($PM_{10-2.5}$) size fraction were proposed, including whether there exists sufficient interest on the role of various non-ambient PM_{coarse} sources (e.g., residential indoor) to warrant further discussion. Draft questions pertaining to the value of volatile organic compounds (VOCs) were examined as well as the value of exposure data of time durations significantly smaller than the normal 24-hr based metrics often encountered.

Information obtained during deliberations of each Workgroup was then presented to the Steering Committee for feedback. The goal of the Steering Committee during this review was not to change the summary from the respective Workgroup, but help each group gain a perspective on the findings of all other groups and areas of collective agreement. An approach (style) of presentation was formalized and each Workgroup was asked to develop a slide set to be used for the October 19th meeting (Part 1 event).

3. Part 1- Workshop Event

An invitation only Workshop reporting event (Part 1) was held on October 19, 2010 on the EPA-RTP campus. Following introductions and other housekeeping activities, the DEARS Principal Investigator (Ron Williams) and select DEARS team members (Janet Burke and Gary Norris) provided a detailed description of the current progress of the study (Attachment 5). This was viewed by the Steering Committee as an essential part of the Workshop activities because it would inform all participants about the extensive exposure data collected in the DEARS as well as progress associated with the six primary (original) data analysis objectives. The latter was viewed as being extremely helpful in helping Workgroup members understand what data findings were already available as well as the focus of current or near-future planned analysis activities. The DEARS Data Analysis Progress presentation was divided into a series of sub-sections. Each sub-section provided information on one of the six data analysis objectives, including: (1) data analysis progress during the 2008-2010 time periods, (2) select results associated with one or more components, and (3) tabular and/or graphical examples of findings highlighting results of interest to Workshop invitees. Examples of information provided during this component of the Part 1 event included a thorough discussion of the DEARS study design, the types of pollutants measured and their frequency, and the types of human activity/environmental exposure factor survey materials obtained.

DEARS Objective #1 highlights provided a discussion of current exposure assessment collaborations, the spatial and temporal variability of select exposure measures and the observed heterogeneity of many of the pollutants with respect to their relationship with a central

community monitor. Progress reported for DEARS objectives #2 and #3 included findings relating the impact of indoor sources on total personal exposures to PM and the role of exposure factors on observed residential air exchange rates in the DEARS homes. Proximity effects from localized line sources (near-roadway and stationary mobile source emissions) were described. The impact of ambient versus non-ambient source effects and their role in personal exposures were discussed. The DEARS survey materials and real-time personal PM monitoring appears to have value in examining these issues.

Human exposure modeling progress (DEARS objective #4) detailed work investigating meteorological impact on PM spatial relationships and expected DEARS inputs for the planned EMI-NEXUS model. The ongoing collaborative work involving NERL and OAQPS researchers and the CMAQ model was reported. In brief, this effort will utilize validated DEARS outdoor exposure data as a means to compare CMAQ modeling output associated with the 2005 Detroit airshed. The comparability of National Air Toxics Assessment (NATA) modeled VOC results with actual DEARS measures have been performed and provided to OAQPS. These findings indicate that modeled human exposures to benzene might be underestimating total air exposures to this pollutant due to non-ambient source impacts.

Significant progress has been made on obtaining detailed speciation data needed to support source allocation distributions for the DEARS airshed (Objective #5). Findings associated with source impacts on the central community monitoring site were reported. A key component of the ongoing work is trying to understand the impact of biomass-related sources on the airshed. Data from various marker species (e.g., potassium, levoglucosan, polynuclear aromatic hydrocarbons) have been obtained using extensive laboratory analyses. These inorganic and organic molecular markers are being examined for their spatial and temporal variability with respect to the airshed. The acceptability of various markers to be used in source assessment activities represents a key component of this effort as it has broad value to not only the DEARS but the source apportionment community as a whole.

DEARS objective #6 (multi-pollutant relationships), represented an area of high interest across all of the Workgroups. Progress to date indicated that the survey information and exposure monitoring data obtained in the DEARS (e.g., PM, VOC, criteria pollutant gases, questionnaires) had great potential for providing advances in this research area. Findings indicated that use of canonical correlations as well as mixed modeling analyses had already elucidated the role human and environmental exposure factors play on total personal exposures to numerous pollutant groups. As such, data analyses indicated that non-ambient NO_2 and VOC sources severely limited the agreement between total personal exposures to these pollutants and ambient-based measurement systems (i.e., central community monitoring). It was reported that analyses examining the spatial relationships between various multi-pollutant groupings with other select measures (e.g., VOCs, outdoor elemental carbon, NO_2) are ongoing and the initial results were described.

An additional objective of the DEARS data analyses reported on during the Workshop Part 1 event was the epidemiological investigation of select environmental exposures and health outcomes associated with a companion study performed by the University of Michigan (Dr. Rob Brook). This collaborative effort has already provided unique findings including the role of PM

of non-ambient origin on select cardiovascular outcomes and the observance of heart rate changes following personal exposures to fine particulate matter. Speciation data has provided the means to examine the multi-pollutant environment associated with some personal exposure scenarios. Personal NO_2 exposures would appear to be more highly associated with reduced brachial artery diameters as compared to select elements (iron, potassium) and their influence on blood pressure changes. The DEARS exposure datasets and the companion health outcome data have the potential to examine a wide range of epidemiological research issues.

Each of the four Workgroups provided short summaries of their consensus findings on data gaps (Attachments 6-9). The Exposure Assessment and Uncertainty Workgroup indicated that monitoring data on lead (Pb) was of the highest priority due to an upcoming Pb ISA (draft in 2011). The second greatest exposure-related need was the need for summarized and interpreted information pertaining to the multi-pollutant environment. The Human Exposure Modeling Workgroup indicated that a number of critical exposure data gaps existed. These included single and multi-pollutant concentrations and relationships, the impact of source(s) on human exposures, detailed human and environmental exposure factors, data sets containing widely varying temporal and spatial scales, and obtaining the determinants for PMSHEDS and potentially other models supporting the national air quality standards. In similar fashion, the Environmental and Atmospheric Modeling Workgroup identified data gaps associated with spatially dense and high temporal frequency collections of PM and other pollutants. In essence, this group was identifying the need for saturation-style collections in a given location and that there was a need for this monitoring to be extended over long temporal periods. High quality meteorology data was identified as being highly valued. This included the need for micro-scale data collections to capture key topographical features. Data gaps associated with identifying local emission sources was reported as well as technically challenging efforts to provide data on nitrogen cycling, free radical production and biogenic contributions to local and regional air sheds. The Health and Epidemiology Workgroup identified several research areas of interest. These included the need for more integrated exposure and health outcome research beyond cardiovascular and respiratory effects, and mortality. This Workgroup indicated that focused human exposure panel studies involving select subpopulations were needed and that the multi-pollutant environment should be incorporated in development of future study designs. High quality exposure data were viewed as being critical in helping to advance epidemiological research

One of the key products the steering committee produced and reported at the Part 1 event was a "Common Needs" document (Attachment 10). It quickly became apparent as the individual slide sets were being reviewed for the Part 1 event that a pattern of commonality often existed between a given exposure data need (e.g., O_3 & PM and multi-pollutant measures) and the four independent Workgroups. To facilitate discussion, a collective total of twenty exposure data gaps were identified and a tabular format used to list individual Workgroup recommendations for such data. Results of the Common Needs table were shared at the Part 1 event and indicated that the greatest number of identified needs were in the exposure assessment and uncertainty area (needs in 16/20 critical data gaps).

The Part 1 event was closed out by inviting all attendees to participant in an evaluation of the ability of DEARS data to meet some of the exposure gaps being reported. This discussion would

take place in scheduled meetings involving the Steering committee, the various Workgroups, and all interested parties, in early November 2010.

4. Part 2- Workshop Event

The final DEARS data analysis workshop event (Part 2) was conducted on November 30, 2010. These deliberations examined the DEARS study design and its reported (ongoing and planned) data analysis objectives with each of the data gaps identified during the Part 1 effort. In doing so, we would determine the extent to which DEARS data: (1) had already provided some benefit, (2) was expected to provide benefit based upon its planned data analysis scheme and available data, (3) could provide benefit but not currently targeted due to resource management, or (4) did not have the ability to be of benefit due to the lack of the specific exposure data requirements. To facilitate this effort, a summary slide set (Attachment 12) was developed that reiterated the critical data needs of the various working groups. In additional, the DEARS publication plan (Attachment 13), a constantly evolving strategy first developed in 2007, was revised to highlight the latest efforts of NERL researchers and collaborators with respect to peer review publication status. All attachments were either presented or made available at the Part 2 event.

5. Common Needs

The primary document provided to Part 2 attendees was a revised "Common Needs" document (Attachment 14). This document now contained new information pertaining to: (1) the degree of agreement between the various subcommittee working groups on each individual data gap, (2) specific outputs determined to be needed (publications, databases, models), (3) the date by which the needed outputs were required to make an impact on the science, (4) the extent to which DEARS data might be of value in meeting the specific outputs, (5) specific descriptions of the outputs the DEARS might be able to provide, and (6) the current progress pertaining to the original six DEARS data analysis objectives and specific publications, models or databases identified as being needed. The Steering Committee and all subcommittee working groups were unable to agree upon a priority of critical data needs. However, a simple listing of the number of groups identifying a given data need did provide a pseudo-ranking of the collective thought. In particular, data needs associated with the following areas were viewed as highly important by all groups:

1. high frequency spatial and temporal measurement data (publications and a database useful for modeling),
2. multi-pollutant measures and establishment of spatial/temporal relationships between and among these co-pollutants (publications and a database for modeling),
3. regional and local emission source identification (including indoor settings) and the determination of key species making up each source (publications and a database for modeling),
4. measurement data of short time resolution (publications and a database for modeling), and
5. air toxic measurement and relationship data pertaining to hazardous air pollutants (HAPs) including but not limited to VOCs. The association of these HAPs with health effects represents an area of immediate need (publications and a database for modeling).

While the remaining 15 data gaps did not receive unanimous recommendations as key research areas, this should not be taken as a downplaying of their importance to specific Workgroup members or the needs of the Agency as a whole. For example, only two groups of the four groups reported the need for Pb data (publications and/or a database) involving human exposures to be available by the summer of 2011. This time frame was needed to meet the Pb ISA publication inclusion criteria. Therefore, each of the research data gaps needs to be viewed accordingly. In this light, the overall workshop summary document (Attachment 13) might best serve as a review of data needs as they relate to important timelines rather than just specific data needs.

A review of the current DEARS data analysis progress (pertaining to its original six exposure data analysis areas and the additional collaborative epidemiological efforts) indicates progress supporting fourteen of the twenty identified data gap needs. Much of this progress relates to the development of databases which have been used to support peer review journal article development. Examples of DEARS benefits to the state-of-the-science include publications pertaining to the multi-pollutant environment, PMcoarse exposure assessment, the impact of various source settings on personal exposure assessment, and the association of PM and gaseous co-pollutant species on observed human health outcomes. There are, however, areas where the DEARS will provide little or no benefit to the reported data gaps. These include needs associated with extensive meteorological monitoring, high frequency (short-time duration) pollutant monitoring, nitrogen cycling, and data needs from long duration monitoring at a consistent location.

No study, including the DEARS can be expected to meet all needs, especially when many of those needs were not a part of its original study design. Even so, this workshop pointed out the value of conducting intensive, high impact exposure monitoring efforts like the DEARS to meet a variety of unforeseen exposure-related needs. Part 2 workshop attendees were thanked for their overall contributions in developing all of the materials for both events. They were invited to continue independent discussions following the conclusion of the workshop event with the DEARS Principal Investigator on opportunities for collaborations associated with targeted data gap needs. While NERL has been consistently releasing DEARS data to all collaborators as needs have been established, it is adjusting its database management priorities to target public release of the DEARS data within the 2011-2012 time frame.

6. Workshop Conclusions

The information obtained by NERL during the Workshop events has provided the means to examine planned data analyses and the development of other key research products for their overall value to the Agency. This will allow for the establishment of a more refined DEARS publication plan. It has also provided keen insight as to specific data analysis questions which should be incorporated into such efforts. This has the potential for enabling future data analyses to target not only a given research area, but specifically focus on exposure science-related issues of high relevance to those involved in rule making or supporting risk assessments. In addition, the Workshops have provided the means to effectively describe the original purpose and potential

value of DEARS to the Agency. This has resulted in enhanced communication between the NERL and those interested in developing new collaborative research efforts involving the DEARS. It is anticipated that a number of additional collaborations involving data analyses and targeted peer-review manuscript development will be established as a result of this communication. One additional aspect of this communication will be the development of a summary report (this document) detailing the Workshop events and summary findings. As such, NERL and non-NERL participants alike will have documentation pertaining to the identified exposure data gaps and the common needs identified by the various Workgroups. This information will be of value to each of them as they conduct their own future research planning activities.

Draft Research Questions

DEARS Workgroup
meeting August 31st, 2010

Assessment and Uncertainty

- What pollutants are of greatest interest to your organization?
- Is there a need to establish pollutant relationships (temporal and spatial)? If so, what are your interests?
- Are there methodological considerations regarding uncertainty (data collection/analysis) that your organization is concerned about?

Assessment and Uncertainty

- Are concerned about the impact of non-ambient sources of pollutants and the uncertainty of using just ambient-based measures for risk assessment? If so, what pollutants and their non-ambient sources concern you?
- What data do you feel is currently lacking in the published literature concerning pollutant concentrations, pollutant sources and their impact upon human exposures. Where are you having to use assumptions in your research?

Assessment and Uncertainty

- What multi-pollutant uncertainties confront your organization? What combinations are of greatest interest?
- Concerning pollutant sources, what information is needed to confront science areas of greatest interest? Are you interested in non-traditional source categories (residential indoor sources, local, non-NEI sources)?

Assessment and Uncertainty

• Are there specific source categories that you feel deserve special Agency attention at this time (near-roadway, airports, power plants)? If so, within this category, what represents the greatest unknown (e.g., general pollutant concentrations and gradients, impact on surrounding neighborhoods, spatial/temporal variability)?

Assessment and Uncertainty

- Is there a need within your organization for information on environmental and human exposure factors? If so, what are they and how would such information be useful to you?
- How would access to actual measurement data be useful to you in moving specific research areas forward in your organization?

Health and Epidemiology

- What critical data needs exist following the most recent ISAs for NOx/SOx, O3, and review for PM. Is there a real need to understand epi implications of PM size fractions, PM constituents, PM sources? Are there other pollutant classes that need to be addressed (e.g., VOCs, SVOCs,carbonyls, carbon)?
- Is it important to understand the impact of non-ambient pollutants (or sources) or just the ambient upon human health?

Health and Epidemiology

- What multi-pollutant mixtures are of concern? Are there still underlying issues of surrogacy or confounding with certain pollutants and PM and resulting health effects?
- Are there location (urban,suburban,rural) specific effects that need to be explored?

Health and Epidemiology

- PMcoarse would appear to be a relativelyheterogeneous mass in some airsheds. Ambient monitoring would appear to be a very poorsurrogate for total PMcoarse exposures. Is there an interest in trying to establish PMcoarse health effects at this time?
- Is there an interest in trying to establish some marker of ambient PMcoarse (fresh) versus PMcoarse mass being retained within residences (resuspended)? Does it really matter?

Health and Epidemiology

- Would you expect to see any impact of VOC or SVOC (PAH) exposures upon certain cardiovascular endpoints?
- Do source categorized epi findings (regional vs mobile vs industrial, etc) provide value to issues you are dealing with?
- Are epi outcomes associated with daily measures all that we need to be concerned about or should finer resolution (hourly) be investigated? If so, how could findings related to shorter time domains support existing 24-hr based standards?

Environmental and Atmospheric Modeling

- What measurement data inputs are needed to support new or improved CMAQ modules? Is there any particular time domain or spatial scale that is particularly needed?
- Are there specific CMAQ modules or output in need of evaluation versus actual physical measurements?

Environmental and Atmospheric Modeling

- What further integration of CMAQ and the SHEDS (Stochastic Human Exposure and Dose Simulation) is needed?
- Are there other (non-CMAQ) models of interest needing evaluation?
- If you could design a field study meeting your most critical data measurement need, what would that study involve (location, duration, time resolution, grid resolution, pollutant selection)

Environmental and Atmospheric Modeling

- What multipollutant mixtures are of the highest interest?
- Is there potential to use micro-scale source information (eg., presence of local gas station, freeway distances) relative to neighborhood-based pollutant measurements in existing or future models? If so, what type of data would be needed?

Environmental and Atmospheric Modeling

- Is there environmental factor information (meteorology, seasonality, etc) on a neighborhood scale that would benefit current or future modeling efforts? If so, what inputs would be needed?
- How small do we go relative to grid size? Is there information available that would indicate grids below 1 km might be needed with respect to risk assessments in certain localities? If so, what pollutants?

Human Exposure Modeling

- Where do we stand relative to air toxics modeling? What inputs are needed and at what spatial and temporal domains?
- What pollutant information is needed to develop a PMcoarse model?

Human Exposure Modeling

- What would appear to be the most critical human exposure factors needed as inputs to updating the PM-SHEDS? Is there the potential for developing SHEDS-VOC or some other variant?
- Are there other human exposure models that need evaluation using physical data (PNEM?). Who would be the stakeholder?

Human Exposure Modeling

- Is there a need to collect actual GPS-based time/location information as an input into human exposure models? Would coincidental exposure measurements also be needed (at what timedomain)? If so, which pollutants are the most critical at this time?
- How do we enhance the integration of human exposure models and atmospheric models? Whydo such attempts provide value to risk assessment? What type of data is needed to move some epidemiologists away from using only ambient-based monitoring data instead of integrated human exposure/air quality models in their studies.

Human Exposure Modeling

- Indoor air often contains concentrations of certain pollutants well above ambient levels (e.g.,VOCs, carbonyls). Are there critical data analyses needed to support indoor air quality models in such instances? If so, for what pollutants?
- What inputs are needed to further develop/evaluate models like the EMI (exposure model for individuals)? What utility do such models provide to end users? How can they be applied to risk assessment or basic epi research?

Attachment 2-Data Analysis Workshop Part 1 Workgroup Members

Detroit Exposure and Aerosol Research Study (DEARS)

Data Analysis Workshop-Part 1

Workshop Responsibility	Workgroup Members
Workshop Steering Committee	Ron Williams (NERL), Val Garcia (NERL), Karen Wesson (OAQPS), Jennifer Richmond-Bryant (NCEA), Rich Cook (OTAQ)
Exposure Assessment and Uncertainty	Steve McDow* (NCEA); Jennifer Richmond-Bryant (NCEA); Quingyu Meng (NCEA), Gary Norris (NERL), Alan Vette (NERL)
Human Exposure Modeling	Janet Burke* (NERL), Michael Breen (NERL), Stephen Graham (NCEA), Tom Long (NCEA), Mark Morris (OAQPS), Lindsay Stanek (NCEA)
Environmental and Atmospheric Modeling	Karen Wesson*(OAQPS), Deborah Luecken (NERL), Wyatt Appel (NERL), Val Garcia (NERL-AMAD), Brian Eder (NERL)
Health and Epidemiology	Lisa Baxter* (NERL), Ron Williams (NERL), Joe Pinto (NCEA), George Bollweg (Region 5), Motria Caudill (Region 5), Tom Luben (NCEA), Rich Cook (OTAQ), Morta Fuoco (Region 5)

* denotes discussion champion

Attachment 3-Data Analysis Workshop Part 1 Agenda

Detroit Exposure and Aerosol Research Study (DEARS)

Data Analysis Workshop-Part 1

EPA- RTP Campus-room C112

October 19, 2010

1:00-4:30 pm

Agenda

Welcome and introductions	Tim Watkins (NHEERL Acting Division Director)
Workshop overview	Tim Watkins (NHEERL)
DEARS background and results to date	Ron Williams/Janet Burke/Gary Norris (NERL)
Break (10 min)	
Workgroup charge and member introductions	Ron Williams (NERL)
Common research data gaps	Ron Williams (NERL)
Uncertainty and assessment	Steve McDow (NCEA)
Human exposure modeling	Janet Burke (NERL)
Break (10 min)	
Atmospheric modeling	Karen Wesson (OAQPS)
Health and epidemiology	Lisa Baxter (NERL)
Part 2 and next steps	Tim Watkins (NHEERL)
Adjournment	Tim Watkins (NHEERL)

Attachment 4-Data Analysis Workshop Part 1 Invited Attendee List

NERL Participant
Wyatt Appel
Tim Barzyk
Lisa Baxter
Sarah Bereznicki
Michael Breen
Janet Burke
Fred Dimmick
Rachelle Duval
Brian Eder
Roy Fortmann
Val Garcia
Andrew Geller
BJ George
Davyda Hammond
Kristin Isaccs
Kasey Kolvacik
David Kryak
Deborah Luecken
Gary Norris
John Offenberg
David Olson
Linda Sheldon
Alan Vette
Jon Sobus
Don Whitaker
Ron Williams

NCEA Participant
Jennifer Richmond-Bryant
Stephen Graham
Tom Long
Tom Luben
Steve McDow
Quingyu Meng
Mark Morris
Joe Pinto
Lindsay Stanek

NHEERL Participant
Lucas Neas
Tim Watkins

OAQPS Participant
Karen Wesson

OTAQ Participant
Rich Cook

Region 5 Participant
George Bollweg
Motria Caudill
Marta Fuoco

OAR/ORIA Invitee
Laura Kolb

ACE Interim Program Director Invitee
Dan Costa

Attachment 5-DEARS Study Objectives Progress Report Presentation

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2010 DEARS Research Update

DEARS Workshop - Part 1 October 19, 2010

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EPA's Exposure Research

- Provide the link between source/regulatory monitoring and health outcomes
- Goal: Evaluate/model the relationship between PM at ambient sites and personal exposure

•Outdoor sources
•Indoor sources
•Personal sources
•Physical factors
•Environmental factors

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Exposure Research Focus

- Determine the relationships between PM, and select air toxics measured at the community, residential outdoor, residential indoor, and personal scale,
- Determine the chemical and physical factors that influence these relationships,
- Determine the human factors that influences these relationships,
- Develop and improve human exposure models,
- Perform source apportionment using pollutant and exposure factor data inputs, and
- Determine the relationships between PM and criteria pollutant gases as potential confounders or surrogates of exposure

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The DEARS

- Detroit Exposure and Aerosol Research Study
  - Multi-pollutant design
  - Multi-seasonal in scope
  - Fully powered (1200 participant days)
  - Randomized participant recruitment
  - Integrated exposure and survey data collection
  - Varied housing stock
  - Varied monitoring settings
  - Varied spatial monitoring (census areas)

1

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DEARS Monitoring Design

- 3 year field study initiated in July 2004 and completed on February 25, 2007
- Randomized household purposeful study design
- Non-smoking with no health or vocational exclusion
- Each year (winter/summer) had ~ 40 enrollees
- Households were monitored for 5 days in winter and 5 days in summer (~1200 total sampling days)
- ~ 36,000 individual 24-hr environmental records
- Concurrent monitoring at:
  - Central community site
  - Residential outdoors and indoors
  - Personal

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Detroit Was Selected Because…

- Was an non-attainment area for $PM_{2.5}$
- Projected non-attainment status after sulfur reductions in 2010
- Large number of industrial point sources
- Heavy mobile source impact including diesel
- Potential for pollutant spatial variability
- Possibility of summer and winter season variability
- Historic Speciation Trends Network site and National Air Toxics Network Site data
- State and local interest
- Existing community partnerships

EPA United States Environmental Protection Agency

Was Detroit a Good Choice?

We believed…	Data is showing…
PM2.5 concentrations > 15 μg/m³	Some means above annual standard
Local impact of industrial sources	CRUISER data shows this potential
Mobile source impact of certain areas	Southfield freeway has obvious impacts from nearby roadway
Spatial variability of pollutants might exist	VOC, NO_2, PAH, elemental variability observed
Seasonal effects might exist for some pollutants	Acrolein, nitrate, sulfate, VOC, ozone, PAH seasonality
Historical data would be useful	Provided means to cross-check
MDEQ and others would be interested	Multiple collaborators and partners have been established
Local community groups might participate	Local groups formally involved in recruiting

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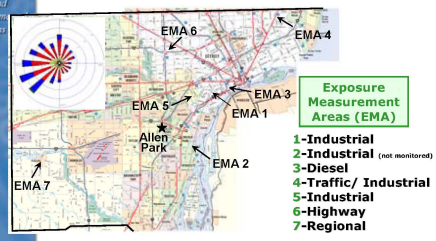
DEARS Study Sites

(Emphasis on Proximity to Sources)



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DEARS Measurements

Parameter	Personal	Indoor	Outdoor	Ambient
$PM_{2.5}$ (mass, elements)	X	X	X	X
PM_{coarse} (mass, elements)	--	X	X	X
EC-OC ($PM_{2.5}$)	--	X	X	X
EC ($PM_{2.5}$)	X	X	X	X
Nitrate	--	X	X	X
$O_3/NO_2/SO_2$	X	--	-NO_2	X
Aldehydes	X	X	X	X
VOCs	X	X	X	X
SVOCs	--	X	X	X
PAHs	--	X	X	X
Air Exchange Rate	--	X	--	--

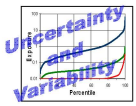
EPA United States Environmental Protection Agency

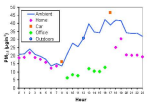
DEARS Data Attempted to Capture Ongoing Personal Exposure, Local and Regional Air Quality

Methods Development

Exposure Measurements

Personal Activity Data





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Use of Novel Passive or Active Samplers

- 25VOCs (aromatics/HCs (9) + halogenated HCs (16))
- 3 carbonyls
- Continuous $PM_{2.5}$
- O_3, NO_2, SO_2

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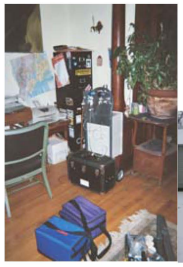
Indoor & Outdoor Monitoring



- Matched to personal and ambient instrumentation

3

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Central Community Site Monitoring

•Community-based monitoring at Allen Park, an MDEQ air site central to the study area

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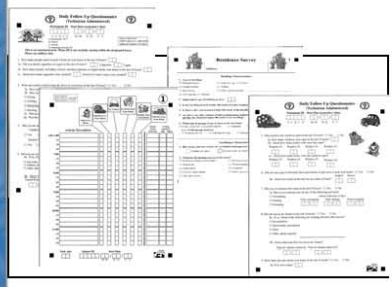
Environmental and Human Factor Surveys



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Data Calendar of Events

- Completion of field data collection (March 2007)
- Recovery of final season of raw data from contractor (July 2007)
- Primary DEARS datasets released to collaborators in late 2008 (ongoing).
- Completion of season 6 XRF laboratory analyses (Fall 2009)
- Organic markers laboratory analyses (select samples from select seasons) anticipated to be completed in 2010
- APM 159 completed (September 2010)

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DEARS Data Analysis Objectives

Six primary objectives:

1. Determine associations between concentrations at central site with those from outdoor and personal monitoring
2. Determine the factors affecting the mass concentration relationships described above
3. Identify human activity factors influencing personal exposures
4. Improve and evaluate models used to estimate residential and personal exposures
5. Investigate and apply source apportionment models to determine contributions from specific sources
6. Determine the associations between ambient measurement of criteria pollutant gases (like ozone) with personal exposures to these gases, PM constituents and other air toxics.

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Data Analysis Phases

The DEARS data analysis plan had a four tiered analysis structure. These are:

1. Performing descriptive statistics, searching for anomalies as a means to validate individual datasets, and establishing the relationships between various spatial measurements
2. Use of various modeling approaches to integrate factors and ancillary data influencing the relationships established above
3. Data from 1 and 2 above will be integrated into PM and air toxics human exposure modeling development.
4. Data from 1 and 2 above, along with original data will be used to perform source apportionment modeling

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Progress/Results Format

1. Progress of overall effort
2. Results
3. Examples of findings

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Objective 1 Progress

- Validation and examination of raw data for outliers
- Data release (ongoing) to all stakeholders/collaborators since 2008 (State of Michigan, SEMCOG, U of Michigan, Region 5, NERL-HEASD, OAQPS, OTAQ, NERL-AMAD, NCEA, EOHSI, NHEERL. Specific datasets released to meet needs.
- Public release scheduled for FY12

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Objective 1 Progress

- Williams et al. Study design publication with univariate analyses of PM, gases, demographics and recruiting components
- Thornburg et al. Publication of coarse PM spatial and temporal relationships
- Rodes et al. Publication of PM2.5 Spatial and temporal relationships
- George et al. Publication of community versus outdoor PM2.5 relationships manuscript
- Wheeler et al. Publication of DEARS and WOEAS PM relationships

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Objective 1 Progress

- Vette et al. Pending draft of VOC spatial and temporal relationships (Winter 2010).
- Philips et al. Publication of DEARS recruitment/retention strategy.
- Stevens et al. Community and outdoor elemental components relationships. Pending journal review.
- Niu et al. Publication of XRF vs ICP-MS sample analysis considerations.
- Johnson et al. Publication of article describing indoor/outdoor relationships in the MICA with DEARS input

Objective 1 Results

- Incredibly rich database, high quality and quantity
- Multiple users
- Meets the Integrated, multidisciplinary model
- Both spatial and temporal variability observed. A primary component of the study design and the reason for selecting Detroit
- $PM_{2.5}$ mass spatially homogenous outdoors with respect to mass concentration

Objective 1 Results

- PM coarse mass heterogeneous across study neighborhood. Noted seasonality in relationships between monitoring sites
- Community NO_2 monitors poor surrogate for personal exposures. Many indoor sources
- Indoor VOC sources significantly impact community versus personal relationship
- With exceptions, $PM_{2.5}$ outdoor elemental and organic component mass highly variable by season and location

Objective 1 Results

- Coarse spatial and temporal variability of PM composition being determined using highly sensitive ICP-MS methods
- Development of methods needed to detect organic markers in low volume samples have been developed.
- Biomass markers needed for source apportionment have been quantified.

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Variability of PM and Exposure Factors

Metric	Days	Season	Min ($\mu g/m^3$)	Max ($\mu g/m^3$)	Mean ($\mu g/m^3$)	Std Dev ($\mu g/m^3$)	Median ($\mu g/m^3$)	99% ($\mu g/m^3$)
Personal $PM_{2.5}$	874	1-6	-0.5	255.8	20.3	20.9	15.6	113.6
Indoor $PM_{2.5}$	973	1-6	-1.3	297.8	18.7	20.1	14.0	91.2
Outdoor $PM_{2.5}$	1347	1-6	-1.1	85.6	16.3	9.7	14.5	43.4
Ambient $PM_{2.5}$	189	1-6	2.8	66.4	16.9	10.6	14.0	63.0
$PM_{2.5}$ personal exposure factor	788	1-5	-0.01	4.09	0.7	0.29	0.68	1.56
$PM_{2.5}$ residential infiltration factor	855	1-5	0.16	6.45	0.7	0.33	0.70	1.48
PFT air exchange (h^{-1})	916	1-6	0.1	17.0	1.5	1.5	1.0	7.5

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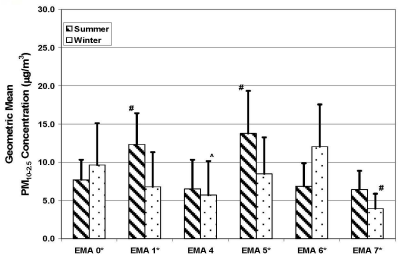
Spatial and Temporal PM Coarse Variability



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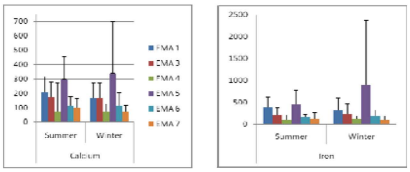
Spatial and Temporal Elemental Variability



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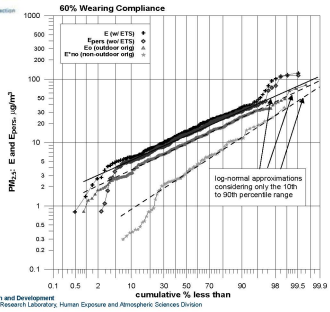
Distribution of Personal PM2.5 Exposures



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Impact of Housing Stock and Age on Air Exchange Rate

	AER (hr^{-1})							
	N	Mean	Std	P5	P25	P50	P75	P95
Home Age								
<=35yrs	32	1.517	1.652	0.259	0.451	0.744	2.368	4.422
36-70yrs	178	1.534	1.694	0.257	0.582	1.063	1.918	3.683
71-100yrs	100	1.591	1.119	0.366	0.590	1.226	2.497	3.592
>100yrs	9	1.701	1.678	0.155	0.547	1.219	1.723	5.221

	AER (hr^{-1})							
	N	Mean	Std	P5	P25	P50	P75	P95
Exposure Monitoring Area								
1	66	2.227	1.497	0.575	1.026	1.844	3.121	5.221
3	42	1.583	1.413	0.374	0.695	1.146	2.266	4.119
4	69	1.629	2.261	0.278	0.568	0.979	1.849	4.244
5	44	1.281	0.899	0.285	0.568	0.954	1.726	3.355
6	83	1.199	0.871	0.257	0.471	0.986	1.789	2.853
7	19	0.908	1.014	0.194	0.366	0.552	0.926	4.422

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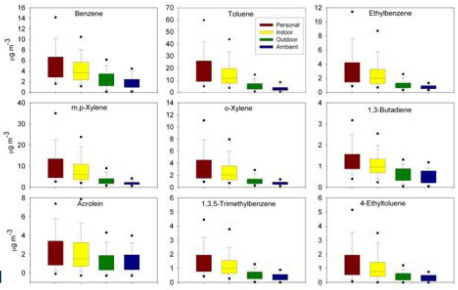
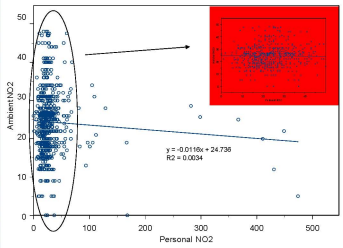
VOC Results – Summer '04 → Winter '06



Personal and Ambient NO_2 Mass Concentration Relationships (ppb)



$PM_{2.5}$ Spatial Composition Comparison (P-Values)

Comparison of outdoor sites with ambient monitor (summer/winter)

Element	EMA 1	EMA 3	EMA 4	EMA 5	EMA 6	EMA 7
Calcium	< 0.01 / < 0.01	< 0.01 / < 0.01	< 0.01 / < 0.01	< 0.01 / < 0.01	0.14 / 0.92	< 0.01 / < 0.01
Potassium	< 0.01 / 0.07	0.49 / 0.15	0.39 / 0.48	<0.01 / 0.01	0.11 / 0.46	0.16 / 0.38
Manganese	< 0.01 / < 0.01	< 0.01 / < 0.01	0.02 / 0.09	< 0.01 / < 0.01	< 0.01 / 0.83	0.09 / 0.02
Iron	< 0.01 / < 0.01	0.02 / < 0.01	< 0.01 / < 0.01	< 0.01 / < 0.01	0.01 / 0.16	< 0.01 / < 0.01
Zinc	< 0.01 / 0.01	0.02 / < 0.01	0.53 / 0.97	< 0.01 / < 0.01	0.04 / 0.58	< 0.01 / 0.05
Lead	< 0.01 / < 0.01	< 0.01 / < 0.01	0.66 / 0.68	< 0.01 / < 0.01	0.32 / 0.73	0.01 / 0.48

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Progress/Results-Objectives #2 and 3 (factors impacting relationships)

1. Progress of overall effort
2. Results
3. Examples of findings

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Objective 2 &3 Progress

- Williams et al. Draft manuscript describing the impact of human and environmental factors on SO_2, NO_2 and O_3 relationships
- Meng et al. Draft manuscript exploring NO_2 of ambient origin impact on exposure
- Brook, Williams et al. Publication of effects of short term PM exposures and observable human health effects (0-4 hrs significant)
- Brook, Williams et al. Publication of PM measures of ambient and non-ambient exposures versus observable human health effects. Non-ambient sources impacted outcomes

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Objective 2 &3 Progress

- Williams et al. Draft manuscript describing PM components and gases and their impact upon health effect linkages
- Brook, Williams et al. Submission linking personal temperatures to alterations in blood pressure
- Hammond, et al. Analyses defining short-term $PM_{2.5}$ exposure sources. Will be linked to health effects
- Lawless et al. Draft manuscript on personal monitoring compliance and why knowledge of ETS exposures are critical in reducing measurement uncertainty

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Objective 2 & 3 Progress

- Isaacs, Burke et al. Completed report defining factors influencing residential air exchange. Being converted to manuscript.
- Alion, Burke et al. WA to produce report on residential infiltration parameters for PM species and air toxics (2010). Subsequently will be converted to manuscript.
- Baxter et al. Publication of diesel impacting residences near the Ambassador Bridge
- Barzyk et al. Publication of methods to assess near road impacts and preliminary findings.

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Objective 2 & 3 Progress

Current progress:

- George, Palma et al. Submission of DEARS VOCs and NATA modeling comparison
- George, Whitaker et al. Publication of comparison of outdoor $PM_{2.5}$ to ambient monitor and impact of meteorological factors
- Thornburg, Williams et al. Draft of participant compliance and impact on data quality for multiple pollutants
- Whitaker et al. Completion of secondary field and laboratory work needed to further evaluate carbonyl methodological considerations impacting DEARS data

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Objective 2 & 3- Results

- **Diesel emission marker impacted homes close to the Ambassador Bridge**
  - Barzyk et al. Publication of methods to assess near road impacts and preliminary findings.
  - Baxter et al. Publication of diesel impacting residences near the Ambassador Bridge
- **DEARS provided good agreement for benzene spatiality versus NATA models.**
  - George, Palma et al. Submission comparing NATA model predictions for benzene to DEARS measurements. Meteorological factors shown to impact both $PM_{2.5}$ and PM coarse spatiality across the DEARS areas.
- **Residential air exchange rate distributions strongly influenced by temperature and air conditioning presence**

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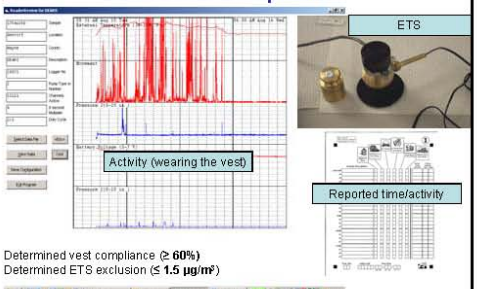
Objective 2 & 3- Results

- ETS impacted PM, NO_2 and VOC measures
- Indoor appliances impacted NO_2 measures resulting in poor relationship between community and personal levels. Community levels of SO_2 and O_3 reasonable surrogates for personal exposures.
- Indoor VOCs impacted VOC measures. Community monitors often poor surrogate for personal
- Both PM of ambient origin and PM of non-ambient origin had **significant** impacts on health
- Chronic impact (short duration) impact of PM exposures determined. Different health effects versus use of 24-hr based data

Personal Compliance



Determined vest compliance (≥ **60%**)
Determined ETS exclusion (≤ **1.5 µg/m³**)

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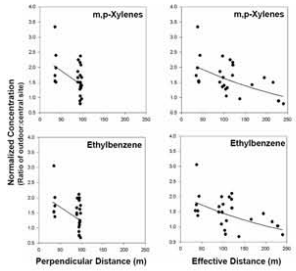
Effective Distance to Roadway (Southfield Fwy.)



- Concentrations (24-hour) decreased to urban background levels at ~ 250 m

Barzyk et al. 2009

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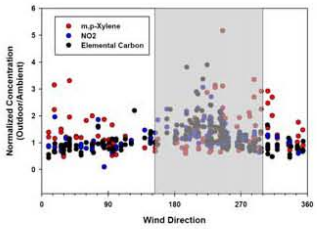
Homes Near the Ambassador Bridge-Source Impact



- Concentrations elevated and more variable when winds are from the Bridge

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Progress/Results-Objective 4 (human exposure modeling)

1. Progress of overall effort
2. Results
3. Examples of findings

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Objective 4-Progress

- Hammond, Burke et al. DEARS PM coarse mass and components data being targeted as planned inputs to SHEDS. Laboratory data currently being pursued
- Hammond et al. MIE and human exposure data analyses nearing completion. Planned input for SHEDS and article preparation on indoor and personal sources

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Objective 4-Progress

- Burke et al. DEARS residential indoor/outdoor data being used to evaluate SHEDS modeled exposures to multiple air pollutants
- Breen et al. Using DEARS data to further evaluate residential air exchange model in EMI
- Breen et al. Using DEARS data to further evaluate EMI before developing EMI-based exposure metrics for NEXUS

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Objective 4-Progress

- George, et al. DEARS data used in evaluation of NATA modeled results. Article in review.
- Wesson et al (OAQPS). 2005 DEARS PM and select air toxics data used to evaluate 2005 CMAQ output at 4 km and 1 km grid size resolution for Detroit area. All data sets developed.
- Appel & Leucken et al (AMAD). Direct input of select 2005 air toxics data into CMAQ model evaluation tool

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Objective 4- Results

- Analyses for multiple modeling areas are currently ongoing
- DEARS providing data for improving SHEDS inputs and evaluating model output
- DEARS data being used for evaluating EMI for use in NEXUS modeling
- DEARS being used as important evaluation dataset for OAQPS and AMAD air quality modeling for Detroit

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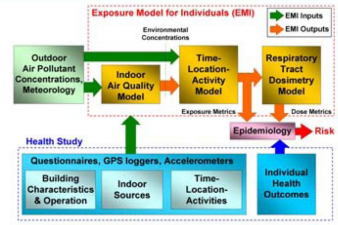
Conceptual EMI



EMI Web site: www.epa.gov/heasd/emi

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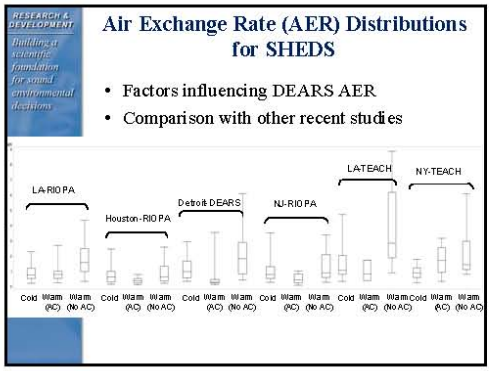
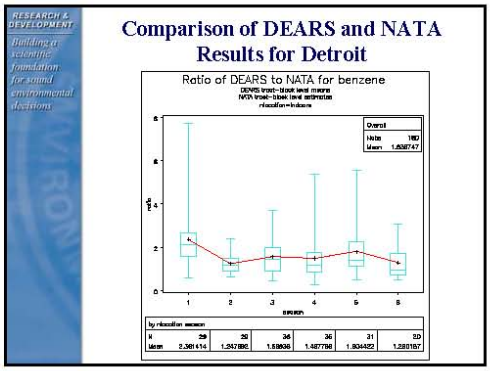
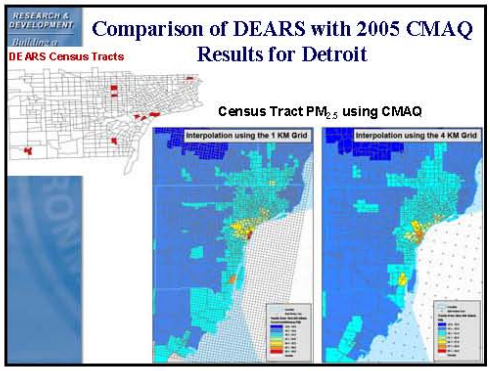

RESEARCH & DEVELOPMENT
Building a scientific foundation for sound environmental decisions
Air Exchange Rate (AER) Distributions for SHEDS
• Factors influencing DEARS AER
• Comparison with other recent studies
LA-RIO PA
Houston-RIO PA
Detroit-DEARS
NJ-RIO PA
LA-TEACH
NY-TEACH
Cold
Warm (AC)
Warm (No AC)


RESEARCH & DEVELOPMENT
Building a scientific foundation for sound environmental decisions
Comparison of DEARS and NATA Results for Detroit
Ratio of DEARS to NATA for benzene
Overall
Mean 1.626747


RESEARCH & DEVELOPMENT
Building a scientific foundation for sound environmental decisions
Comparison of DEARS with 2005 CMAQ Results for Detroit
DEARS Census Tracts
Census Tract PM2.5 using CMAQ
Interpolation using the 1 KM Grid
Interpolation using the 4 KM Grid

RESEARCH & DEVELOPMENT
Building a scientific foundation for sound environmental decisions
Progress/Results-Objective 5 (source impacts)
1. Progress of overall effort
2. Results
3. Examples of findings

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Objective 5 Progress

Current progress:

- Completion of initial Allen Park source apportionment. Determination of appropriate data and models for use in the DEARS.
- Completion of laboratory analyses associated with select residential samples (2010).
- Organic markers analyzed and applied in source apportionment modeling, improving understanding of motor vehicle and biomass sources (on-going).
- Ongoing determination of concentration impact on data quality, determination of marker selection for inclusion in future (integrated) source apportionment associated with EMA spatial comparison.

Objective 5 Progress

Current progress:

- Baxter et al. published impact of near road sources from the Ambassador Bridge.
- Duval et al. Submission of PM sources spatiality variability.
- Stockburger et al. Implementation of levoglucosan method. Was needed to validate biomass contribution to Detroit airshed.
- McDow et al. Selection and observations associated with organic markers for source apportionment in the DEARS. Source factor analyses have been completed
- Vette et al. Determination of the impact of sources and environmental factors upon multipollutant spatial and temporal variability

Objective 5- Results

- High biomass source contribution (K signature) that agrees with other researcher's findings from Detroit. Multiple externals have now found similar impact. This is a very complicated issue.
- Substantial spatial variability observed for organic species (especially PAHs) on some days, other days are fairly uniform. Spatial variability appears to be related to patterns of abundance (i.e.. diagnostic species ratios)

Objective 5- Results

- Integration of both elemental and organic markers needed to improve source characterization in Detroit. Multiple sources having similar profiles complicate the source apportionment process.
- Multiple indoor sources exist. Cooking a major contribution to total PM exposures.

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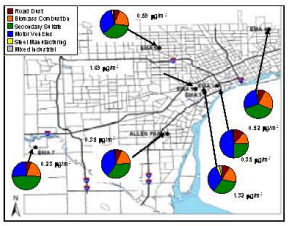
Spatial Variability of $PM_{2.5}$ Sources in the DEARS



CMB average source contributions (in %) for DEARS Season 3 (Summer 2005) and 4 (Winter 2006). Values in µg/m³ represent sum of mixed industrial and steel manufacturing contributions.

Reference: Duvall et al., Determining Spatial Variability in $PM_{2.5}$ Source Impacts across Detroit, MI. In preparation.

Summary

- Localized PM sources (motor vehicles, road dust, steel manufacturing, and mixed industrial) vary in each of the residential outdoor samples.
- Personal exposures can vary depending on the proximity to different PM sources.
- Impacts of local sources in Detroit airshed may not be well characterized by Allen Park monitoring location

P-values for the Non-parametric One-way Wilcoxon Score Test Comparing Variability of Sources in DEARS Ambient and Residential Outdoor Samples

Source	All EMAs*	EMA1	EMA3	EMA4	EMA5#	EMA6	EMA7
Road Dust	**< 0.01**	**< 0.01**	**< 0.01**	0.16	**< 0.01**	0.24	0.14
Biomass Burning	**0.04**	0.44	0.73	0.06	0.36	0.81	0.79
Secondary Sulfate	0.17	0.72	0.94	0.26	0.37	0.54	0.20
Motor Vehicles	**< 0.01**	0.77	0.11	**0.02**	0.97	0.80	**< 0.01**
Steel Manufacturing	**< 0.01**	**< 0.01**	0.09	0.20	**< 0.01**	0.38	0.54
Mixed Industrial	**< 0.01**	**< 0.01**	**0.05**	**0.05**	**< 0.01**	0.99	0.93

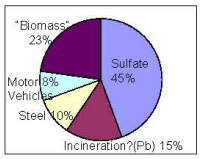
p-values in bold are significant
* Not compared to Allen Park
\# Seasons 3 and 4 only

Summary:

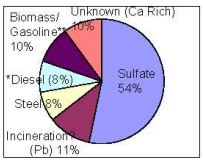
- Across all EMAs, local sources of PM (road dust, motor vehicles, steel manufacturing, mixed industrial) were spatially different
- In comparing residential outdoor source contributions to those estimated in Allen park, spatial differences also observed for local sources of PM

PRELIMINARY PMF RESULTS – ALLEN PARK Seaons 2 + 3

XRF, OC & EC Data Only



GCMS, XRF, OC & EC



*EC + hopanes
**PAHs + K + Hopanes

Without PAHs and hopanes:

- **abundant factor has K and OC, consistent with biomass, but high mass contribution unexpected**

With PAHs and hopanes:

- **Most PAHs + some K and hopanes make a "gasoline + biomass factor"**
- **Most but not all hopanes associated with the EC rich factor → separate diesel & gasoline factors**
- **Hypothesis: Biomass overestimated, motor vehicles underestimated without PAHs + hopanes**

LEVOGLUCOSAN

- Real need to understand biomass source contribution
- Both elemental markers (like K) and organic markers like levoglucosan are needed
- Elemental and organic biomass markers support findings indicative of substantial biomass source contributions across the DEARS study area

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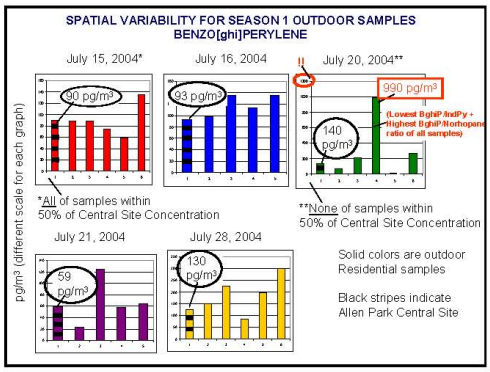
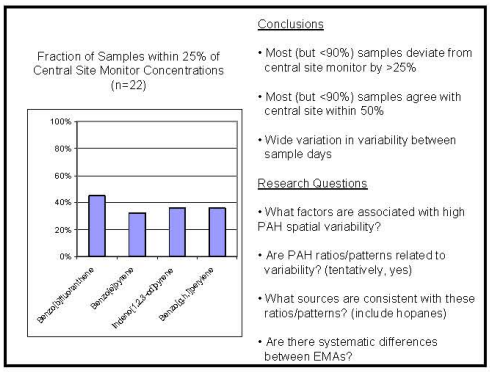


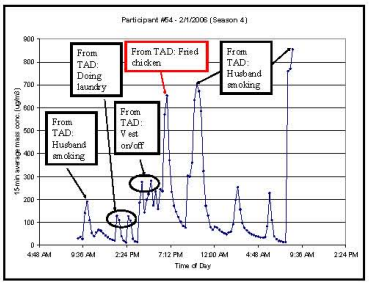


Cooking Results by Type

Type	Count	Percentage (of total cooking peaks)
WA (water)	51	16%
TO (toast)	8	3%
FG (fry/grill)	180	59%
BO (boiling)	42	14%
BB (bake/broil)	25	8%

Max value within a peak: Season 4 – 11,633 and 11,570 [both FG, same participant (051), different days, breakfast]

Example of Indoor Source Impact



Progress/Results-Objective 6 (multipollutant relationships)

1. Progress of overall effort
2. Results
3. Examples of findings

Objective 6 Progress

Current progress:

- Canonical correlation analyses of select VOC data and human/environmental factors completed by EOHSI. Used as input in George et al manuscript and input into planned Vette et al. manuscript
- Vette et al., completion of VOC and copollutant APM report. Basis for planned manuscript
- Williams et al. Completion of mixed model evaluation of factors influencing NO_2, $S0_2$ and O3 relationships. Draft manuscript developed

Objective 6 Progress

Current progress:

- Meng, Pinto et al (NCEA). Modeling of PM and criteria gas copollutants and human/environmental factors. AAAR presentation developed into draft manuscript.
- Multipollutant impact upon health outcomes. Draft manuscript completed by Williams, Brook, et al.

Objective 6-Results

- Significant indoor and personal exposure factors influencing NO_2 spatial relationships.
- Significant NO_2 spatiality observed in various neighborhoods-suspected near road influence
- ETS a major confounder of personal NO_2 and VOC data.
- NO_2 was detected in a high percentage. Detection limits impacted some personal O_3 and SO_2 measures

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Variability of Criteria Gas Concentrations

Metric	Days	Seasons	Min (ppb)	Max (ppb)	Mean (ppb)	STD (ppb)	Median (ppb)	99% (ppb)
Personal O_3	936	1-6	-5.4	43.2	2.1	3.3	1.0	15.0
Ambient O_3	199	1-6	3.0	53.0	25.0	11.5	24.0	52.0
Personal NO_2	891	1-6	-3.0	474.0	29.9	37.4	23.1	188.0
Outdoor NO_2	989	3-6	-1.0	65.0	20.3	9.7	20.0	48.0
Ambient NO_2	198	1-6	0.0	48.0	23.9	8.2	23.1	47.5
Personal SO_2	928	1-6	-4.0	12.4	0.5	1.7	0.0	6.0
Ambient SO_2	195	1-6	-2.2	14.0	2.8	2.8	2.0	14.0

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Examples of Exposure Survey Variables

- season
- air exchange
- time spent in activities
- outdoor temperatures
- ets influence
- use of fans
- use of air conditioning
- presence of open windows
- cleaning episodes
- cooking episodes
- age of home
- proximity to roadways
- attached garages
- cooking fuel type
- use of clothes dryers
- volume of home
- use of candles
- use of incense

80+ variables examined for effect

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Impact of Human and Environmental Factors on Personal NO_2 Exposures

Summer			
Factor	Yes	No	P value
Air conditioning	28.1±26.9	23.4±9.2	0.08
Candles burned	25.8±9.2	25.1±20.3	0.86
Travel by auto	23.4±26.9	29.8±30.4	0.03
Central AC in home	28.1±15.8	23.4±8.7	<0.01
Doors opened	23.5±10.2	27.2±32.9	0.17
ETS exposure believed to have occurred	20.3±9.9	26.1±26.1	0.22
Cooking fuel type	20.5±33.1	26.1±20.4	0.07
Furnace pilot light	23.1±21.8	27.3±23.3	0.09
Use of gas fireplace	10.4±3.4	23.4±23.7	0.04
Use of gas appliance	24.3±19.6	28.3±37.5	0.24
Window AC used	26.5±21.3	19.9±9.9	<0.01
Windows opened	24.6±26.9	26.7±21.6	0.47
Kitchen exhaust fan operated	25.2±28.5	24.9±20.3	0.84

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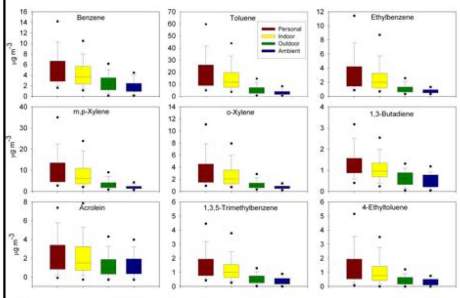
Indoor VOC Sources Impact Personal Exposures



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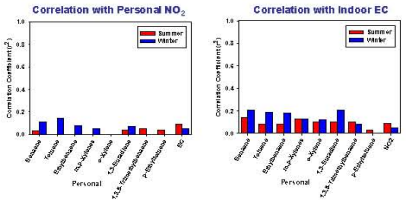
Multipollutant Comparisons



- Indoor EC and personal NO_2 weakly correlated
- Personal MSATs poorly correlated with personal NO_2; slightly better with indoor EC
- Little seasonal difference observed

Progress/Results-Source to Effects

1. Integration of Cardiovascular Health Study
2. Results
3. Examples of findings

In Home Health Data Collections

Health Measures

4 hour fast prior to measures and reduced physical activities. Resting state obtained prior to starting.

Systolic blood pressure (SBP)- Omron 780 monitor
Diastolic blood pressure (DBP)- Omron 780 monitor
Heart rate (HR)- Omron 780 monitor
Brachial artery diameter (BAD)- 10mHz Terason 2000 ultrasound
Flow-mediated dialation (FMD)- 10mHz Terason 2000 ultrasound
Nitroglycerin-mediated dilation (NMD)@0.4 mg sublingual

Health Effects Versus PM of Non-Ambient Origin

		Vest compliance (>60%) & low-SHS		Vest compliance (>60%)	
Health outcome	lag (day)	Obs	Risk per 10 μg/m³ (SE)	Obs	Risk per 10 μg/m³ (SE)
SBP (mm Hg)	1	80	2.53 (2.51)	108	-0.15 (2.05)
SBP (mm Hg)	2	57	-0.98 (2.90)	75	-0.37 (2.64)
DBP (mm Hg)	1	80	2.12 (1.74)	108	1.58 (1.46)
DBP (mm Hg)	2	57	-0.62 (2.12)	75	-0.59 (1.82)
Heart Rate beats/m	1	80	4.89 (2.98)	108	2.95 (2.24)
Heart Rate beats/m	2	57	-1.19 (3.71)	75	-1.25 (3.08)
BAD (mm)	1	77	**0.23 (0.12) (p=0.073)**	103	0.05 (0.09)
BAD (mm)	2	53	**-0.24 (0.14) (p=0.096)**	69	-0.18 (0.11)
FMD (%)	1	71	0.83 (1.58)	97	-0.09 (1.22)
FMD (%)	2	51	0.44 (1.83)	67	-0.77 (1.63)
NMD (%)	1	42	-1.15 (3.79)	57	0.90 (2.45)
NMD (%)	2	27	4.72 (3.13)	37	**5.00 (2.00) (p=0.026)**

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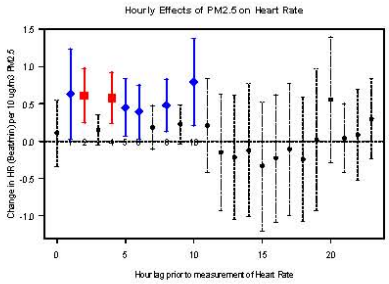
Exposure and Heart Rate



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Multipollutant Effects on Health Outcomes

Model	Outcome	Lag	Group	Risk	SE	P.value
P Fe	SBP	0	All subjects	0.0128	0.0054	0.0183
P K	SBP	2	All subjects	-0.0237	0.0108	0.0403
P Fe	DBP	0	All subjects	0.0084	0.0036	0.0188
P K	DBP	0	All subjects	-0.0124	0.0056	0.0305
P K	DBP	0	Vest	-0.0447	0.0132	0.0016
A Fe	HR	0	All subjects	-0.0163	0.0065	0.0126
A Zn	HR	0	All subjects	-0.0296	0.0145	0.0429
P NO_2	BAD	2	All subjects	-0.0049	0.0023	0.0366
P NO_2	BAD	1	Vest	0.0041	0.0019	0.0353
P NO_2	BAD	2	Vest	-0.0067	0.0029	0.0256
P K	BAD	0	All subjects	-0.0007	0.0003	0.0442
A K	BAD	1	All subjects	0.0037	0.0017	0.0380
P NO_2	FMD	0	All subjects	0.0468	0.0174	0.0079

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Data Analysis Perspective

- DEARS data analyses are primarily being performed between other major tasks by a small number of researchers. Competing time demands restricting progress in some areas
- Even so, progress across a wide number of objectives has being maintained.
- A large number of manuscripts are under journal review or draft development stage
- Objectives 1,2, and 6 have yielded majority of publications to date. Significant laboratory work in support of objective 5 has been performed. Modeling objectives ramping up.
- Large number of collaborations ongoing (internal and external)

Attachment 6- Exposure Assessment and Uncertainty Workgroup Summary

ASSESSMENT & UNCERTAINTY

Overall Summary

1) We need data on lead sooner than anything else

2) Next we need data and interpretation that will help us to develop the multipollutant science assessment

What pollutants are of greatest interest to your organization?

In order of priority:

1) Lead is most urgent as the next ISA.
2) More generally, PM and ozone the most important risk drivers. For PM, specific components, size ranges, and sources are important, especially elemental carbon, metals, organics, coarse PM, fien PM, ultrafine PM, traffic, secondary (ozone + SOA), industrial sources in non-attainment areas (e.g. steel manufacturing).
3) Remaining criteria pollutants for which ISA's will be written. (For example, DEARS data on NO2 outdoor and personal exposure and ozone concentrations at Allen Park and from personal exposure monitors would be useful.)
4) Surrogates of important multipollutant mixtures (e.g. EC or NOx for traffic)
5) HAPs.

1

Is there a need to establish pollutant relationships? If so, what are your interests?

Yes, especially for multi-pollutant AQM. The key questions are:

1) what pollutants are can be grouped in reduced for epidemiological and exposure approaches?

2) what pollutants or groups of pollutants are the best surrogates for regional or near source exposure environments? 3) What pollutants or groups of pollutants have similar origin and are likely to benefit from the same control strategy?

Are there methodological considerations regarding uncertainty data that your organization is concerned about?

Yes. Using network data for exposure assessment and epidemiology with increased reliance on using models instead of measurements to achieve more complete spatial and temporal data makes high quality measurements even more important. Better quality measurements would be especially useful for elemental carbon.

Are you concerned about the impact of non-ambient sources of pollutants and the uncertainty of using just ambient-based measures of risk assessment? If so, what pollutants and their non-abmient sources concern you?

Only to diffrentiate ambient from indoor generated pollutants. Where data has been obtained, this is useful, but it is not as high a priority as understanding indoor penetration or spatial and temporal variability of pollutants from outdoor sources. The outdoor sources are of most importance to us.

2

What data do you feel is currently lacking in the published literature concerning pollutant concentrations, pollutant sources and their impact upon human exposures. Where are you having to use assumptions in your research?

PM component variability, PM size class variability, PM source composition, associations between pollutants, indoor penetration, human activity patterns, intercity differences in both exposure factors and source apportionment, and the relationship of each of these with meteorology and land use; better tools for exposure modeling, air quality modeling, source apportionment, and hybrid and mixed models.

What multi-pollutant uncertainties confront your organization? What combinations are of greatest interest?

1) what pollutants can be grouped in reduced form epidemiological and exposure approaches
2) what pollutants or groups of pollutants are the best surrogates for regional or near source exposure environments?
3) What pollutants or groups of pollutants have similar origin and are likely to benefit from the same control strategy? The combinations of greatest interest are: traffic (PM, ultrafines, EC, NOx, CO, BTEX, butadiene, aldehydes), secondary (SOA, sulfate, ozone), Eastern regional background (PM, SO2, NOx), urban industrial (PM, EC, metals)
4) Understanding the relative importance of "exposure measurement error" in a multi-pollutant context for the broad classes of "exposure measurement error": 1) instrument measurement error, 2) detection limits, 3) spatial misalignment, and 4) other discrepancies between monitor and exposure (e.g. activity patterns, micro-environment). Which uncertainty dominates and how does their relative importance vary between species?

3

What multi-pollutant uncertainties confront your organization? What combinations are of greatest interest? - Continued

5) Providing data that will help to understand interaction terms between pairs of pollutants relevant for epidemiological studies.
6) Providing data that will help with data reduction for multipollutant epidemiological studies, development of optimal pollutant groupings by source, health outcome, and mode of action; and selection of optimal surrogates to be measured.
7) Providing information for testing spatial and temporal interpolation approaches, land use regression, air quality modeling inputs, human exposure models.
8) Evaluate exposure model performance across pollutants to determine which are done well, and which are more challenging.
9) Data that will help in the evaluation of synergistic effects in combined exposure to multiple pollutants.

Concerning pollutant sources, what information is needed to confront science areas of greatest interest? Are you interested in non-traditional source categories (residential indoor sources, local, non-NEI sources?)

Continued development of improvement of source apportionment models, including better characterizing and reducing uncertainty, incorporating meteorological data and compositional restraints into models, development of routine practical evaluation procedures for model results, including uncertainty analysis.

Are there specific source categories that you feel deserve special Agency attention at this time (near-roadway, airports, power plants)? If so, within this category, what represents the greatest unknown (e.g., general pollutant concentrations and gradients, impact on surrounding neighborhoods, spatial/temporal variability)?

Near-roadway, power plants, industrial sources of PM high in metals and EC, urban activity such as demolition and construction. Airports are a specific issue for lead, but from DEARS are not designed for that purpose.

4

Is there a need within your organization for information on environmental and human exposure factors? If so, what are they and how would such information be useful to you?

Yes, to reduce exposure misclassification. Better information is needed on spatial and temporal variability, indoor penetration, and exposures of Pb of ambient origin, all criteria pollutants, ultrafine PM, coarse PM, EC, metals, sulfate, nitrate, SOA, as well as human activity patterns and activity levels in different exposure environments, including indoor-home, indoor-work, indoor-school, commuting (in vehicle and otherwise). More reliable ventilation and building related data would be useful. Results of importance for environmental justice evaluation are especially needed.

How would access to actual measurement data be useful to you in moving specific research areas forward in your organization?

It would allow us to characterize concentration ranges and spatial patterns relevant to exposure, and 2) it would allow us to pose and investigate hypotheses related to exposure and receptor modeling relevant for understanding exposure to sources.

Suggested Questions for Workshop:

1) What are the patterns and causes of spatial and temporal variability in outdoor concentrations of lead, $PM_{2.5}$, Ozone, NO_x, ultrafine PM, coarse PM, NO_x, EC, and metals?

2) What are the relationships between these species, what factors influence them, and what are their common sources?

3) What are the most important exposure factors for these species and how do they differ among species? (e.g., spatial and temporal variability, indoor penetration, human activity, breathing rate, meteorology, built environment, others?)

4) What urban and regional sources are the most important contributors of exposure to these species?

5) How can DEARS data help to develop a better multi-pollutant air quality management strategy?

Human Exposure Modeling

- Data needs for:
  - Single pollutants
  - Multi-pollutant relationships
  - Individual sources or relative impacts of sources
  - Other (specific to human exposure)

Scale ?

- Purpose
  - NAAQS ISAs
  - NAAQS Exposure & Risk Assessment (APEX model)
  - NATA (HAPEM model)
  - ??

Spatial scale:
national/regional/state/county/intra-urban
Temporal scale:
annual/seasonal/daily/hourly

Data Needs for Single Pollutants?		TYPE	SCALE	
		Ambient air conc. / Indoor vs outdoor / Personal exp / Specific micro or activity?	*Spatial* (national / regional / state-county / intraurban)	*Temporal* (annual / seasonal / daily / hourly)
NAAQS ISA & Exp/Risk Assess.	O_3	Ambient air	Intra-urban variability	Hourly to 8-hour daily maximum
		Personal exposures for evaluation (ME & total)	Intra-urban variability	
	$PM_{2.5}$ mass and species [specifically nitrate, sulfate, EC, OC, and crustal]	Ambient air	Intra-urban variability	Daily – hourly
		Indoor/outdoor & personal exp for evaluation of exposure model predictions	Variability across regions; within urban areas	Daily – hourly; Seasonal
		Non-residential micros, vehicles for inputs		Daily
		High exposure activities – near roadways?		
	PM_{coarse} mass	Ambient air	Variability across regions; within urban areas	Daily
		Indoor/outdoor for model inputs	Variability across regions; within urban areas	Daily ; Seasonal
		Personal exp for evaluation		Daily ; Seasonal

Data Needs for Single Pollutants?		TYPE	SCALE	
		Ambient air conc. / Indoor vs outdoor / Personal exp / Specific micro or activity?	*Spatial* (national / regional / state-county / intraurban)	*Temporal* (annual / seasonal / daily / hourly)
NAAQS ISA & Exp/Risk Assess.	CO & NO_2	Ambient air	Intra-urban variability	Hourly
		High concentration MEs: on-road and near roadways	Intra-urban variability, near-road conc. gradient	Hourly
		Indoor/outdoor ME factors for model inputs	Intra-urban variability	Hourly to Daily (concentration linked)
		Personal exposures for evaluation (ME & total)	Intra-urban variability	Hourly to 8-hour daily maximum
		Indoor sources for model inputs (as resources permit)	Regional variability SES variability	Hourly to Daily
	SO_2	Source emission profiles	By source type (EGUs, refineries, etc.)	5-minute to hourly
		Source concentration profiles	Near source gradient by source type (EGUs,, etc.)	
		Ambient air	Intra-urban variability	
		Personal exposures for evaluation (ME & total)	Intra-urban variability	
	Pb	Possible data needs for IUBK combined exposure-dose model used for children and All-ages Pb model under development. [IUBK model considers ingestion and inhalation]	Intra-urban variability	Longer time scales – aggregate exposure over multiple years

Data Needs for Single Pollutants?		TYPE	SCALE	
		Ambient air conc. / Indoor vs outdoor / Personal exp / Specific micro or activity?	*Spatial* (national / regional / state-county / intraurban)	*Temporal* (annual / seasonal / daily / hourly)
NATA/ HAPEM	Benzene (BTEX)	Ambient air from monitor or model	National coverage at census tract/block resolution	Annual, seasonal, monthly, diurnal
		Indoor/outdoor for micro inputs	Regional	Annual, seasonal, monthly
		Attached garages, other sources for model inputs	Regional	Annual, seasonal, monthly
	Aldehydes	Ambient air	National coverage at census tract/block resolution	Annual, seasonal, monthly, diurnal
		Indoor/outdoor for micro inputs	Regional	Annual, seasonal, monthly
		Other residential sources?	Regional	Annual, seasonal, monthly
	Other *national* risk drivers?			
	Other *regional* risk drivers?			

Data Needs for Multipollutant Relationships?		TYPE	SCALE	
		Ambient air conc. / Indoor vs outdoor / Personal exp / Specific micro or activity?	*Spatial* (national / regional / state-county / intraurban)	*Temporal* (annual / seasonal / daily / hourly)
NAAQS ISA & Exp/Risk Assess.	Ozone and PM	Ambient air relationships	Variability across regions; within urban areas	Daily
	$PM_{2.5}$ species [specifically nitrate, sulfate, EC, OC, and crustal]	Ambient air relationships	Variability across regions; within urban areas	Daily
		Indoor/outdoor relationships	"	"
	$PM_{2.5}$ and air toxics	Ambient air relationships	Variability across regions; within urban areas	Daily ??
		Indoor/outdoor & personal	"	"
	CO/NO_2/UFP/EC (traffic pollutants)	Ambient air relationships	Variability across regions; within urban areas	Hourly to daily (possibly seasonal)
		Indoor/outdoor relationships	"	"
	$PM_{2.5}/NO_x/SO_x$	Microenvironments (e.g., office, school, vehicles)		
NATA/ HAPEM	Criteria pollutants and toxics??		National??	

Data Needs for Individual Sources/Relative Impact of Sources?		TYPE	SCALE	
		Ambient air conc. / Indoor vs outdoor / Personal exp / Specific micro or activity?	*Spatial* (national / regional / state-county / intraurban)	*Temporal* (annual / seasonal / daily / hourly)
NAAQS ISA & Exp/Risk Assess.	Point Sources (e.g., power plants, industry)	Ambient air	Variability across regions; within urban areas	Daily ??
		Indoor/outdoor & personal	"	"
	Mobile Sources	Ambient air	Variability across regions; within urban areas	Daily ??
		Indoor/outdoor & personal	"	"
	Regional vs. local sources	Ambient air	Variability across regions; within urban areas	Daily ??
		Indoor/outdoor & personal	"	"
	Indoor/activity sources	Source strength (linked to activities)	Variability across regions; within urban areas	(sub-)Hourly, Daily
NATA/ HAPEM	Others for toxics??			

Other Data Needs for Human Exposure Modeling?		TYPE	SCALE	
		?	*Spatial* (national / regional / state-county / intraurban)	*Temporal* (annual / seasonal / daily / hourly)
NAAQS ISA & Exp/Risk Assess.	Air exchange rates	Direct measures of residential air exchange	Variability at all spatial scales	Daily-hourly for model inputs, All temporal scales for evaluation
		Non-residential (e.g., office, school, vehicles)		Daily
	Survey questions	Residential window/door opening and AC use		Daily, monthly
		Non-residential HVAC (e.g. office, school)		Daily
		Vehicle window and ventilation use		
	Human activity data	Source activities	National to regional	
		Time spent outdoors at moderate or greater exertion for asthmatics (O_3, SO_2) & outdoor workers (O_3)	Regional to intra-urban variability	Daily
	Air quality modeling output		Regional to local-scale	
NATA/ HAPEM	Others??			

Environmental and Atmospheric Modeling

Question: What information from measurement studies are useful in supporting CMAQ model performance evaluation?

Response:

- Ideally, measurements made for the purpose of model evaluation are spatially dense and have a high temporal frequency (e.g. hourly). The spatial density is dependent on the species of interest being measured, but generally air quality model simulations are performed using horizontal grid spacing of 12km or less. Additionally, measurements should be made in one location for an extended period of time (e.g. a year) in order to assess whether the model is able to capture the seasonal variations in species concentrations that often occur, which is difficult to impossible to do when monitoring equipment is frequently moved to different locations.
- Measurements of ozone, PM (total and speciated), and other criteria pollutants as well as CMAQ modeled toxics would be useful.
- In additional to air quality measurements, collocated measurements of meteorological variables (e.g. temperature, wind speed and direction) are also critical to assessing the air quality model performance.
- Information on any local emissions sources. For example, if the monitor will be impacted by a local emissions source, for which detailed information will probably not be available in the emissions inventory (e.g. parked car, gas station), knowing about this source would be useful.

Question: What information would be useful to help make improvements CMAQ to further allow it to support exposure modeling?

Response: Information that would help to improve CMAQ predicted concentrations on finer temporal and spatial scales. In these terms, CMAQ would benefit from:

- continuous/hourly measurements,
- measurements for extensive periods of time,
- placement of measurement sites on the neighborhood-scale throughout an urban area.

Question: Is there potential use of micro-scale source information (e.g. presence of local gas station, freeway distance, etc) relative to neighborhood-based pollutant measurements?

Response: Yes! When evaluating a model, it is important to understand the quality of the model inputs. Knowing source information would allow one to understand the quality of the emissions being used in the model. Though it may be difficult to report actual source emissions during the measurement period, just knowing that the source is there and it's location relative to the measurement site would be useful. The same could be said for meteorological inputs. If any meteorological measurements are taken, then they could be compared to those being used by the model. It is important to determine the difference between poor model performance because of inadequate model inputs and poor performance because a change should be made to the algorithms in the model.

Question: If you could design a field study meeting your most critical data measurement needs, what would that study involve (location, duration, time resolution, spatial resolution, pollutant selection)?

Response: While CMAQ performance comparisons with ozone and PM tell us whether CMAQ is getting the "right answer", we need more complete set of chemical measurements to determine if we are properly characterizing the pathways for ozone and PM formation, i.e. the "right reason". Unless we can ensure the latter, we cannot have confidence that emissions reductions will really reduce ozone and PM2.5. In addition to a large scale sampling of criteria and toxic pollutants focused on evaluating CMAQ predictions, it is critical to have a few supersites that sample a more complete set of precursor and product concentrations. In particular:

Nitrogen cycling	Radicals	Biogenic vs anthropogenic contributions
• Organic nitrates (including speciation) • Peroxyacyl nitrates • NO2 and NO • Nitric acid	• OH • HO2 • Organic peroxy radicals	• Isoprene and other alkenes • Oxygenated VOCs • Biogenic SOA tracers • Anthropogenic SOA tracers

Question: Are there other models that could benefit from the measurement data for model validation?

Response: Yes, other photochemical models, such as CAMx, would also benefit from the measurement studies discussed here. In addition, dispersion models, such as AERMOD, would also find this data useful.

Question: What multipollutant mixtures are of the highest interest?

Response: In general, ozone and PM ($PM_{2.5}$ & $PM_{10-2.5}$) components are of interest. In addition, toxic pollutants which have high risk and are also prevalent in most urban areas are of interest. Until more information is known about additivities or synergies of toxic pollutants, a wide range of toxic compounds over consistent sampling times and locations should be collected.

Attachment 9- Health and Epidemiology Workgroup Summary

Health and Epidemiology

Overall Summary

1) We need more research on health outcomes beyond cardiovascular and respiratory effects, and mortality.

2) More studies on susceptible populations is needed.

3) Improvements in multi-pollutant modeling are needed.

4) Better characterization of exposure is necessary.

What links between air pollutants and disease have not been well established?

- Developmental and reproductive outcomes
- Cancer
- Neurological/CNS outcomes
- Inflammatory/Autoimmune diseases (e.g., diabetes, rheumatoid arthritis)
- Development/Progression of disease (e.g. asthma) (as opposed to prevalence)

What potentially susceptible populations need further study?

- Genetics/Epigenetics
- Preexisting disease (e.g., Diabetes)
- Obesity/BMI
- Socioeconomic status
- Race/Ethnicity
- Children/Elderly (mechanistic evidence)

What improvements in multi-pollutant modeling are needed?

- Multi-pollutant modeling
  - How can we disentangle the effects of individual pollutants from the ambient mixture?
    - Example: Health effects with CO are observed at very low levels. Is the effect due to CO or is CO a marker for traffic?
  - How do we model multi-pollutant exposure in epidemiological models?
    - Are all pollutants put into the model as individual variables?
    - Can pollutants be combined into some type of indicator variable?
    - Can pollutants be combined into source categories?

What improvements in characterizing exposures are needed?

- Windows of exposure
  - Establishing consistent exposure periods across studies
  - Determining the appropriate windows of exposure depending on the health outcome and pollutant chemistry and dispersion characteristics
- Coarse and Ultrafine PM
  - Need a better understanding of the spatial and temporal patterns

What improvements in characterizing exposures are needed?

- PM composition (All size fractions)
  - Are certain constituents considered more toxic than others?
  - Is the current monitoring adequate for health studies?
  - Characterization of geographic heterogeneity in composition
- Ambient vs. Non-ambient
  - Non-ambient concentrations can be greater than ambient levels
  - Assessments of non-ambient exposures are needed in the context of large epidemiological studies
  - Are there differences in ambient vs. non-ambient exposures with respect to composition and size distribution (for PM)?

Common Needs

Data need	Exposure & uncertainty	Atmospheric modeling	Human exposure modeling	Health & epidemiology
High frequency spatial and temporal measurement data of criteria pollutants	✓	✓	✓	✓
O_3 & PM and multipollutant measures and establishment of relationships, including health effects	✓	✓	✓	✓
High quality meteorology	✓	✓		
Macro and micro emission source identification and composition	✓	✓	✓	✓
Short time interval pollutant measures	✓	✓	✓	✓
Nitrogen cycling/radicals/biogenics		✓		
Application of other models (CAMx; AERMOD)		✓		
Lead findings	✓	✓		
Multipollutant groupings	✓			✓
PM component findings	✓		✓	✓
Establishment of source surrogates	✓			
HAPs-VOCs, and non-HAP-VOCs, PAHs, findings including health effects	✓	✓	✓	✓
Improved models using ambient data	✓			
Impact of personal & indoor air quality on ambient assessment, including health effects	✓		✓	✓
Human and environmental exposure factors	✓		✓	✓

Common Needs (continued)				
Data need	**Exposure & uncertainty**	**Atmospheric modeling**	**Human exposure modeling**	**Health & epidemiology**
exposure misclassification	✓			
Measurement uncertainty error & exposure misclassification	✓			✓
PMcoarse data findings	✓		✓	✓
Effect of specific multipollutant sources upon susceptible subpopulations				✓
Stationary monitoring of long duration (consistent location)		✓		

Detroit Exposure and Aerosol Research Study (DEARS)

Data Analysis Workshop-Part 2

EPA- RTP Campus-room C112

November 30th, 2010

1:00-3:00 pm

Agenda

Welcome and introductions	Tim Watkins (NHEERL Acting Division Director)
Workshop overview	Tim Watkins (NHEERL)
Part 1 Review	Ron Williams (NERL)
Research data gaps and the DEARS	Ron Williams (NERL)
Invitation to participants	Roy Fortmann (NERL)
Adjournment	Roy Fortmann (NERL)

ASSESSMENT & UNCERTAINTY

Overall Summary

1) We need data on lead sooner than anything else

2) Next we need data and interpretation that will help us to develop the multipollutant science assessment

Environmental and Atmospheric Modeling

Overall Summary Data Needs

1. Spatially dense and high temporal frequency of PM, ozone, air toxics, etc
2. Speciation of PM associated with saturation monitoring
3. High quantity/high quality meteorological data of a given area
4. Local emission sources
5. Nitrogen cycling/radicals/biogenics measurements

1

Human Exposure Modeling

Overall Summary Data Needs

1. Single pollutant concentrations
2. Multi-pollutant relationships
3. Individual sources and impacts of sources
4. Exposure factors (human/environmental)
5. Wide range of temporal and spatial scales measurements
6. Determinants for PMSHEDS and potentially other models in support of the NAAQS

Health and Epidemiology

Overall Summary

1) We need more research on health outcomes beyond cardiovascular and respiratory effects, and mortality.

2) More studies on susceptible populations is needed.

3) Improvements in multi-pollutant modeling are needed.

4) Better characterization of exposure is necessary.

2

Attachment 13-DEARS Publication Plan

Title	Description	Lead	Objective	
The Detroit Exposure and Aerosol Research Study - study design and overview	Overall study design and goals/objectives	Williams	1	Published
Temporal and spatial variability of air toxics in DEARS	Describe VOC and aldehyde data - assess factors affecting outdoor variability and temporal variability (daily, weekly, seasonal)	Vette	1	Draft under development
Spatial and temporal variability of PM2.5 components across the Detroit airshed	Describe PM2.5 components data - assess factors affecting outdoor variability and temporal variability (daily, weekly, seasonal)	Vette	1	Partially covered by 2010 Rodes et al
Relationship between PM2.5 collected at Residential Outdoor Locations and a Central Site	Relationship between PM2.5 collected at Residential Outdoor Locations and a Central Site	George	1	Published 2010
Optimizing Recruitment and Retention Strategies for a Complex General Population Pollutant Exposure Study in Detroit, Michigan.	Recruitment findings	Phillips	1	In Press 2010
Correction of Observed Mass for Relative Humidity in a Personal Nephelometer	RH effects on nephelometers	Lawless	1	Draft report awaiting revision to manuscript form-
Observable health effect relationships with multip-pollutant personal, indoor and community-based measures of a Detroit cohort	Linked health effects study with the DEARS	Rob Brook	1	Published 2010
Personal, indoor and outdoor mass concentration relationships of elemental PM2.5 components in the DEARS	Determining the intra and intervariability of PM2.5 elemental components relative to community measures	Stevens	1	Submitted 2010
Influence of sources on aldehydes using a novel passive monitor: Methodological considerations and exposure assessment	Evaluate effect of local sources on carbonyls (acrolein, formaldehyde and acetaldehyde)	Whitaker	2	Pending development by Whitaker
The impact of mobile sources on air toxics measured outdoors of residences in the DEARS	Develop and evaluate distance to roadway methodology dependent on wind direction. Focus on Southfield Fwy. Sites	Barzyk/George	2	Published 2009
Impact of mobile sources on residential concentrations and human exposures of air pollutants	Application of models developed for outdoor spatial gradients to evaluate residential concentrations and personal exposures. Assess role of housing characteristics and air exchange rate on indoor infiltration of MSAPs	Possbily NCEA	2	NCEA has an interest in working on this.
Comparison of National-Scale Air Toxics Assessment (NATA) modeled predictions for benzene with measurement data in Detroit, USA		George	2,3	Under journal revision
Influence of type of roadway on concentrations of mobile source air toxics and related air pollutants	Comparison and evaluation of MSATs and MSAPs adjacent to a highway (Southfield Fwy), an arterial (E. 7 Mile) and the Ambassador Bridge	(NCEA?)	2	NCEA
Characterization of particles and gases on roadways in Detroit: high-time resolution mobile monitoring of air pollutants	Analysis of mobile monitoring results in near-road DEARS neighborhoods -	Jeff Brook as lead	2	Brook yet to provide raw data
Spatial variation of PMcoarse mass concentrations in Detroit	PM coarse mass relationship and new sampler description	Thornburg, Rodes	2	Published 2010
The effects of diesel emissions on outdoor, indoor and personal measures at sites proximate to the Ambassador Bridge: Indoor infiltration and exposure analysis	Examine the impact of the Ambassador Bridge on concentrations of diesel-related emissions, including infiltration and personal exposure factors	Baxter/Barzyk	2	Published 2009
Quantative Compliance in Personal Exposure Sampling: Basic Concepts	Impact of monitoring compliance upon measurement uncertainty	Williams with RTI	3	Undergoing final EPA clearance
Evaluation of the integrated regional/local-scale modeling approach for predicting spatial variability in air pollutant concentrations within urban areas using the DEARS residential outdoor and central site monitoring data	Comparison of spatial variability in air quality modeling output within Detroit with DEARS data during two 2005 seasons	Burke	4	Initial results presented at 2010 CMAS

DEARS Publication Plan, continued

Title	Description	Lead	Objective	
Evaluation of residential air exchange rates and pollutant-specific mass balance equation parameters	Report to be received in 2010	Burke	4	Potential 2011 conversion to manuscript
Influence of housing characteristics and meteorological conditions on residential air exchange rates in Detroit	Summarizes within-home and between-home variance in air exchange rates and compares results to those from other cities (RIOPA study)	Isaacs	4	Journal submission in 2011
Application and evaluation of the SHEDS model for estimating exposures to multiple air pollutants for the DEARS population	Model evaluation	Burke	4	Ongoing
Evaluation of the SHEDS model for estimating exposures to PM components for the DEARS population	SHEDS-PM model evaluation with 2005 air quality modeling data from OAQPS and comparison to DEARS measurements	Burke	4	Alion WA developing infiltration parameters, getting 2005 Detroit AQ model output from OAQPS, will follow RTP PM2.5 SHEDS eval work
PM sources and spatial variability in Detroi	PMF, CMB using XRF and OC/EC	Duvall		Under journal review 2010
Spatial analysis of PM sources in Detroit	Spatial analysis of industrial sources using CMB-focus on point source variability	Bereznicki	5	Work just initiated, planned 2011 submission
Integrated organic and inorganic factor inputs for source apportionment	Use of multiple source profile data sets in establishing source impacts	Olson	5	Planned 2011 submission
Selection and observation of unique organic markers for source apportionment in a complex airshed	Viability of select markers for source apportionment	McDow	5	McDow to draft in 2011
Factors impacting personal exposures to ambient PM and gaseous copollutants	identification of source factors and confounder/surrogate relationships	Meng	6	Manuscript under final EPA review
Factors affecting total personal exposures to NO2	Use of mixed models to determine impact of human and environmental factors on personal NO2	Williams	6	Manuscript under final EPA review
Relationships between community measures and personal exposures of volatile organic compounds and copollutants	Mixed model analyses of air toxics data relating personal exposures to indoor, outdoor and ambient concentrations	Vette	6	Journal submission in 2011
Source strengths and other micro-environmental factors associated with real time personal, residential and outdoor PM2.5 monitoring	Determine the relationship between time activity patterns and survey information with observed PM2.5 mass concentrations via the MIE	Davyda Hammond	2,3,4	Data bases being developed-Hammond to draft in 2011
Integration of DEARS and Health Heart	Daily PM versus Cardiovascular effect	Brook	1,2	Published 2010
Intgration of Health and MIE data findings	Real-tijme PM2.5 impact upon cardiovascular health effects	Rob Brook	1	Awaing full acceptance by EHP 2010
Integration of Health and DEARS	Personal temperature and health effects	Brook	1	Undergoing journal review 2010
Integration of Health and PM components	Observable health effects linked to PM and gaseous components	Williams	2	Undergoing final EPA clearance
Spatial PM findings from the WOEAS	Spatial relationships in the WOEAS	Wheeler	1,2	In Press 2010
Comparsion of XRF and ICP-MS techniques for low volume sampling	Methodological comparison	Niu	1	Published 2010
Personal, residential and community elemental relationships	Impact of location upon PM components	Stevens	1	Submission planned for 2011
Modeling residential air exchange rates from questionnaire and meteorology	Evaluation of mechanistic air exchange rate models with PFT measurements	Breen	4	Basic model published 2010
Evaluation of EMI with indoor and personal PM2.5 (and other pollutant) measurments	Evaluation of EMI uisng questionnaires and residential indoor and personal PM2.5 (and other pollutant) measurements	Breen	4	Work to be conducted in 2011 in support of NEXUS
Comparison of exposure estimates from refined and screening-level models in assessments of air toxics risks	DEARS measurements used to evaluate exposure estimates from SHEDS and NATA in demonstration of "value added" when refined exposure modeling is performed for high risk area identified in screening level assessment (NATA)	Burke	4	Output to be determine

Common Needs

Data need	Checks	Output	Need date	DEARS useful	Products	Current progress
High frequency spatial and temporal measurement data of criteria pollutants	4	1.publications defining concentration variablity 2.database	Pb 7/11 O_3 7/11 NOx/SOx 6/12 Mult Pol 6/12 PM /14	1.limited 2.limited	1. Continuous PM measures and resulting health associations 2. available	1.Short-term exposures and health impacts under journal review. Impact of indoor sources on total exposures to be drafted in 2011. Ultimately to be challenged versus CV outcomes in 2012. 2.Continuous personal & indoor & outdoor & ambient PM2.5 database has been assembled.
O_3 & PM and multipollutant measures and establishment of relationships, including health effects	4	1.publications reporting spatial and temporal correlations and impact of multi-pollutant scenarios upon health outcomes 2. database	Pb 7/11 O_3 7/11 NOx/SOx 6/12 Mult Pol 6/12 PM /14	1.Yes 2.Yes	1. Drafts of multipollutant impact on health and factors impacting exposures to O3, NO2, SO2 relationships to ambient sources 2. available	1.Three articles under EPA review 2.available
Macro and micro emission source identification and composition	4	1. publications defining regional sources. Articles defining impacts of non-ambient sources, including ETS 2.database	Pb 7/11 O_3 7/11 NOx/SOx 6/12 Mult Pol 6/12 PM /14	1.Yes 2. Yes	1. Articles on regional and indoor sources 2.Database of local sources	1.Submitted or drafted 2. available

Data need	Checks	Output	Need date	DEARS useful	Products	Current progress
Short time interval pollutant measures	4	1. Publications on concentration variability. Pubs on hourly data from PM and gases needed 2. database	Pb 7/11 O_3 7/11 NOx/SOx 6/12 Mult Pol 6/12 PM /14	1. Limited 2. Limited	1.Temperature impact on health. Short-term PM impacts on health 2. available	1.Articles in final journal review. 2.temp database being prepared for NCEA
HAPs-VOCs, and non-HAP-VOCs, PAHs, findings including health effects	4	1. Publications on HAP pollutant levels and spatial/temporal relationships. Factors (sources) influencing relationships important. Impact of HAPS on health. 2. database	Pb 7/11 O_3 7/11 NOx/SOx 6/12 Mult Pol 6/12 PM /14	1.Yes 2.Yes	1. Spatial and temporal relationships and factors influencing these relationships. Method considerations in selecting organic markers. Use of organic markers in source apportionment 2. in development	1. Articles to be submitted in FY 2011. CV health impacts analyzed in 2011. 2. database fully assembled in FY2011.
PM component findings	3	1. publications on organic and inorganic speciation for all PM size fractions. 2. database for model evaluation	Pb 7/11 O_3 7/11 NOx/SOx 6/12 Mult Pol 6/12 PM /14	1. Yes 2. Yes	1. PM2.5 and PMcoarse speciation. Spatial and temporal variability and relationships. Factors influencing component relationships with respect to proximity could be performed 2. in development	1. Articles reporting spatial and/or temporal NO3, SO4, EC & PM2.5 elemental data in process. Other topics could be examined. PMcoarse findings to be summarized in 2011 and reported in 2012. 2. PM2.5 data available, PMcoarse available in 2011.

Data need	Checks	Output	Need date	DEARS useful	Products	Current progress
Impact of personal & indoor air quality on ambient assessment, including health effects	3	1. Publications on non-ambient source impacts to personal exposures and resulting health outcomes. 2. Model evaluation 3. Model development 4. database	Pb 7/11 O_3 7/11 NOx/SOx 6/12 Mult Pol 6/12 PM /14	1.Yes 2.Yes 3.Yes 4.Yes	1. articles on personal&indoor&ambient gas and PM2.5 speciation as they relate to ambient monitoring. Articles reporting impact of PM of ambient and non-ambient origin. Articles reporting impact of PM and gas source origins on health 2. PMSHEDS evaluation 3. EMI development 4. available for PM2.5 and gases	1. Article defining personal, and non-ambient sources on total exposures published (2010). Article on PM sources and CV health in press. Article on PM species and gas impact on health submitted. Personal, indoor, outdoor, ambient elemental relationships under EPA review. VOC comparisons drafted. Two articles on exposures to O3, NO2, SO2 under EPA review. Article to be developed in 2011 defining indoor sources, ultimately to be linked with CV outcomes (2012). 2. PMSHEDS evaluation underway 3. EMI to be developed in 2011 4. PM2.5 and gas data available
Human and environmental exposure factors	3	1. Publications on factors impacting use of ambient monitoring as a surrogate of exposure. 2. database	Pb 7/11 O_3 7/11 NOx/SOx 6/12 Mult Pol 6/12 PM /14	1.Yes 2.Yes	1. Articles needed defining factors and their impact on personal exposure for PM, PM species and gases. 2.Development of factors database	Articles drafted on factors impacting personal exposure to ambient and non-ambient sources of O3, NO2, S02. Similar work proposed for PM2.5 and its components (2012) 2. gas and PM data and factor data fully available

Data need	Checks	Output	Need date	DEARS useful	Products	Current progress
PMcoarse data findings	3	1. Need articles on spatial temporal relationships and use of ambient as a surrogate of exposure. Need articles defining coarse speciation and its variability due to time/space. Need articles on personal exposures. Need pubs on impact of coarse PM on health effects 2. database for model development	Pb 7/11 O_3 7/11 NOx/SOx 6/12 Mult Pol 6/12 PM /14	1.Yes 2. Yes	1. Article on spatial and temporal variability. 2.Development of speciated database	1. Article published in 2010. Laboratory work being completed on speciation during 2011. 2. Speciated database developed in 2011.
High quality meteorology	2 or less	1. Met database of a given location of sufficient depth and duration.	Pb 7/11 O_3 7/11 NOx/SOx 6/12 Mult Pol 6/12 PM /14	1. No	1. None anticipated	1. No action
Nitrogen cycling/radicals/ biogenics	2 or less	1. Database needed as modeling input	Pb 7/11 O_3 7/11 NOx/SOx 6/12 Mult Pol 6/12 PM /14	1.No	1. None anticipated	1. No action
Application of other models (CAMx; AERMOD)	2 or less	1. Database for model evaluation	Pb 7/11 O_3 7/11 NOx/SOx 6/12 Mult Pol 6/12 PM /14	1. Limited	1. None currently planned	1. No action

Data need	Checks	Output	Need date	DEARS useful	Products	Current progress
Lead findings	2 or less	1. Publications on spatial/temporal relationships. Impact of lead concentrations at low levels of interest. Establishment of low dose health response. 2. panel study incorporating biomarker recovery 3. exposure database	Pb 7/11 O_3 7/11 NOx/SOx 6/12 Mult Pol 6/12 PM /14	1. Yes 2. No 3. Yes	2. Articles on personal & indoor & outdoor concentrations and spatial/temporal relationships. Article on variability between and within neighborhoods. 2. No panel study planned 3. Database released to OTAQ/NCEA. More work proposed relating to PMcoarse speciation	1.Articles either under journal review or being developed. Anticipate 2011 submission. 2. None 3. All available data released.
Multipollutant groupings	2 or less	1. Publications on what pollutants might be grouped to represent a source.	Pb 7/11 O_3 7/11 NOx/SOx 6/12 Mult Pol 6/12 PM /14	1.Yes	1. Examination of pollutants representative of a near-road environment. Examination of HAPS that might be representative of select source categories including organic and inorganic profiles.	1. 2009 pub on near road VOCs but did not address primary issue. Article describing HAPS as source markers to be submitted in 2011.

Data need	Checks	Output	Need date	DEARS useful	Products	Current progress
Establishment of source surrogates	2 or less	1. Publications on identification of surrogates to represent an exposure source category	Pb 7/11 O_3 7/11 NOx/SOx 6/12 Mult Pol 6/12 PM /14	1.Maybe	1. Sufficient data is probably available to examine this issue in an exploratory way.	1. No action
Improved models using ambient data	2 or less	1. Database	Pb 7/11 O_3 7/11 NOx/SOx 6/12 Mult Pol 6/12 PM /14	1. Yes	1.Evaluation of PMSHEDS. Development of EMI for NEXUS using DEARS inputs	1. PM2.5 and factor data needed for PMSHEDS. PMcoarse component inputs needed. EMI-NEXUS to be developed in 2011.
exposure misclassification	2 or less	1. Publications on determinants relating erroneous source identification or over/under representing one or more source contributions to health effect associations. Specific discussions on various error source terms would be of value.	Pb 7/11 O_3 7/11 NOx/SOx 6/12 Mult Pol 6/12 PM /14	1. Yes	1. Articles reporting impact of ETS on total personal exposures and impact of ETS on observed health effects for PM of ambient and non-ambient origin. Articles describing non-ambient source impacts on NO2 exposures.	1. Articles published or in press concerning ETS impacts (2010). More work could be performed in this area if resources permitted. Non-ambient NO2 source impactions defined in multiple articles under EPA review.

Data need	Checks	Output	Need date	DEARS useful	Products	Current progress
Measurement uncertainty error & exposure misclassifi-ication	2 or less	1. Publications relating imprecision of a given measurement to accurately represent an exposure metric	Pb 7/11 O_3 7/11 NOx/SOx 6/12 Mult Pol 6/12 PM /14	1. Yes	1. Ability of an ambient monitor to act as an appropriate surrogate for personal exposures to PM, PM components, gases, VOCs are being examined and summarized.	1. 2010 publication defining necessary PM2.5 personal monitoring to reflect acceptable error. Impact of PM2.5 personal monitoring compliance error on CV outcomes in press. Articles on VOC and SVOC error to be reported in 2011.
Effect of specific multipollutant sources upon susceptible subpopulations	2 or less	1. Need pubs dealing with impact of copollutants on various subpopulations	Pb 7/11 O_3 7/11 NOx/SOx 6/12 Mult Pol 6/12 PM /14	1. No. DEARS was a general population	1. Supported NEXUS development	1. NEXUS is ongoing study
Stationary monitoring of long duration (consistent location)	2 or less	1. Database needed for model input and involving extensive monitoring in a given location	Pb 7/11 O_3 7/11 NOx/SOx 6/12 Mult Pol 6/12 PM /14	1. No	1. None	1. No action.

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