Air Sensors 2013: Data Quality & Applications

Abstracts

Posters

1 Sensors and Sensor Needs for Atmospheric Research at the National Center for Atmospheric Research

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Within the National Center for Atmospheric Research, the Earth Observing Laboratory has a mission to develop and deploy atmospheric observing facilities for research supported by the National Science Foundation, with the broad goal of advancing scientific understanding of the Earth System.

Our developments are driven by broad science needs of the atmospheric science community, and therefore flexibility is critical. Each year, our facilities are used as we conduct many field experiments. One area of emphasis is in-situ sensors. Depending on each project's needs, sensors and the infrastructure to support them may be deployed anywhere on (or above) Earth, in quite varied environments, and always with different sensor combinations and configurations. Deployment platforms for our in-situ sensors may be:

- A spatially extensive ground-based network,
- A dense local network, often on tall towers,
- Balloon-borne packages (for example radiosondes),
- Dropsondes released from aircraft (manned or unmanned) to target specific meteorological events,
- Dropsondes released from long-term balloons floating in the stratosphere, and
- Combinations of these

This poster describes some of our capabilities, and also focuses on our sensor development needs which may be synergistic with EPA Sensor needs.

Desirable sensor characteristics: the best data possible, low power, light and compact, reliable, relatively inexpensive, works over a range of environmental conditions (temperature, pressure, within precipitation, etc.)

A wide range of measurement capabilities are needed: chemical species, dynamics and basic state variables, aerosol properties, hydrometeor characteristics, vegetation characteristics, and more.

2 Co-location Validation of Low-cost Mobile Air Quality Monitors

Ricardo Piedrahita, Yifei Jiang, Kun Li, Xiang Yun, Nicholas Masson, Ashley Collier, Michael Hannigan, Robert Dick, Qin Lv, Li Shang

Low-cost mobile air quality monitors (M-Pods) have been developed, validated, and deployed in a small field study. We present results of instrument validation tests and discuss the advantages and shortcomings of developing and administering such a system. Validation tests include assessing inter-monitor variability, sensor measurement drift over time, and changes in sensor sensitivity over time.

8 M-Pods were co-located with regulatory monitoring equipment for two week-long periods. We present results for the pollutants carbon monoxide, carbon dioxide, ozone, nitrogen dioxide, and VOCs. VOC, ozone, nitrogen dioxide, and CO measurements are made using metal oxide semiconductor sensors, while the carbon dioxide sensors are of the non-dispersive infrared variety.

3 Organic Semiconductors as Environmental Sensors - Ammonia Case Study

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Many of the air sampling methods currently used for personal exposure assessment are based on integrated air sampling techniques developed more than 20 years ago. There is a need for a new generation of fast, real-time, highly sensitive detection methods for gases and vapors. In this poster we describe the development of materials capable of detecting ammonia at sub-ppm concentrations. Ammonia is an irritant gas and health risk in both occupational and non-occupational settings. Existing direct reading methods for detecting ammonia suffer from a number of limitations such as low sensitivity, non-portable, poor selectivity, high cost. We have developed a highly sensitive material that can be incorporated into a low cost, real-time sensor based on organic field-effect transistors (OFET) that use tris(pentafluorophenyl)borane (TPFB) as a receptor. We have used OFETs with this additive to detect concentrations as low as 450 ppb v/v, the highest sensitivity yet demonstrated from semiconductor films we have tested. Additionally, these OFETs also show considerable selectivity with respect to other common organic vapors, and stability during storage. We are now moving forward to develop a promising next generation ammonia sensor consisting of flexible and printable sensors which can be fabricated at large scale and extremely low cost.

4 Simple Low–Cost Aerosol Field Sampler for Deployment by Volunteers

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Due to the complexity of the chemical and physical properties of atmospheric aerosol, its ambient concentrations and effects remain extremely difficult to predict. In our analysis of the situation, the use of a very few sophisticated, yet very expensive instruments may provide high fidelity information at a few locations for a short period of time, but at a high cost of hardware and highly trained scientific personal in the field. Instead, our objective is to develop a very simple, inexpensive (price target below $100) sampling device based on advanced technology that could be simply deployed by personnel without scientific training and then retrieved for return to a central laboratory where the captured aerosol particles would be analyzed for mass, ion, carbon, metals, and biological materials. In addition to off-line analysis, the simple sampling device might have very simple real-time monitoring capability using light emitting diodes to obtain time series data. The sampler is enabled by consumer electronics and by nanofiber filters which have sufficiently low pressure drop with acceptable collection efficiency to allow the use of a computer cooling fan to provide an air flow of 3 lpm for 24 hours. In this presentation we will discuss the results of a pilot study aimed to characterize a prototype of the sampler.

5 Monitoring Air Quality and Weather Conditions with Mobile Platforms

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Global Science and Technology

Global Science & Technology, Inc. (GST) developed a mobile environmental observation network for the National Oceanic and Atmospheric Administration (NOAA). GST's Mobile Platform Environmental Data (MoPED) system receives environmental data from partner Weather Telematics, who has teamed up with commercial fleets of vehicles that sample environmental conditions along major transportation routes. The mobile platform observations include ozone in addition to traditional meteorological attributes, such as air temperature and relative humidity. A fleet of 1500 vehicles nationwide operates 24 hours daily (except Sunday), recording environmental observations at 10-second intervals while conducting their routes. Millions of observations are taken over thousands of miles of geography each day. This sampling frequency provides detail at a microscale level, which aids in the detection of small-scale occurrences that might be missed by observing stations that are spaced further apart.

GST has established quality control methodologies, which include the comparison of mobile platform observations to external sources such as airport weather reports or AirNow ozone readings. GST is working on data studies with Sonoma Technology to compare mobile platform data in areas where AirNow data can be directly compared. Initial findings suggest that mobile platforms might have a positive bias; however, the comparison methodology is evolving and in many instances the mobile platform data values are similar to AirNow values. Further study is needed, particularly because mobile platforms are in a dynamic, environment, whereas AirNow stations are static. GST is also participating in ozone sensor validation studies with the EPA.

6 Selective Benzene Detection Using MWCNT Randomly Decorated with Metal Clusters: From Nano2hybrid Atomic Structures to Gas Sensing Device

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Carbon nanotubes decorated with metal cluster nanostructures were studied for molecular recognition at the nanoscale. Although the sensor response from a number of pristine and functionalized SWNT gas sensors have already been demonstrated, little attention has been paid to metal decorated nanotubes. The key concept is to use relatively small metallic clusters that donate or accept a significant amount of charge upon adsorption of a target molecule. We specifically investigated systems based on carbon nanotubes whose surfaces are decorated with Rh, Pt or Ni clusters as well as characterized and non-decorated CNT. The nature of the metal-nanotube interaction was initially studied. The atomic structure of these metal nanoclusters and their effect on the intrinsic electronic quantum transport properties of the nanotube are also demonstrated. Thereafter, multi-wall CNTs were decorated with metal clusters using two different synthesis techniques: oxygen RF plasma treated tubes were decorated with either thermally evaporated gold clusters from a wire or a gold colloid solution. The result was a device for the selective detection of benzene gas with sensitivity in the range of ppb at ambient temperature in the presence or absence of oxygen and easy to handle.

The detection of benzene gas in the presence of other interfering gases at ambient temperature is achieved by implementing a signal processing module that acquires the signals from the sensors and using pattern recognition techniques, such as PCA or regression models. In this way, the presence or absence of benzene can be determined and quantified within the ppb-ppm range.

7 Carbon Nanotube-Based Gas Sensors for Food and Petrochemical Industries

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Carbon nanotube (CNT)-based gas sensors have been developed for the detection of various analytes ranging from ethylene in food industry to volatile organic chemicals (VOCs) in chemical and petrochemical industries in our group. The sensing system can be optimized to obtain high sensitivity and selectivity with respect to the target analyte by either covalently or noncovalently modifying CNTs with selectors or designing devices with better performance. Here, we report an ethylene sensor based on the mixture of CNT and selective copper (I) complex and a NH3 sensor fabricated by mechanically drawing SWCNT on a paper. An integrated preconcentrator/SWCNT gas sensing system is also presented for the detection of benzene, toluene, and xylenes (BTX). The system can differentiate BTX gases of low parts-per-million (ppm) concentrations with high selectivity and fast response time, which makes it promising for on-site field monitoring.

8 Low Power and Wireless Air Pollution Monitors

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The advent of electrochemical cells capable of measuring ppb levels of air pollutants has opened up the possibility of more cost effective networks of air monitors. Monitors could now be battery powered and have wireless communications, and thus be simple to install. Lower cost also means that networks of monitors could be deployed to give spatial as well as time related data. This will enable improved understanding of the causes of pollution and how to remedy them.

However, the availability of the sensors is just one link in the chain, and research has shown that the correct processing of the data is essential in obtaining reliable results. Data processing can also be used to check sensor performance and remove zero offsets.

This poster describes a monitoring system based on electrochemical cells that has the above benefits. The compact design allows simple installation of multiple monitors into critical air pollution locations, allowing direct measurement of pollution and the effects of any remedial actions.

Any new monitoring system must be field proven and this poster also shows initial test data obtained from a trial system operating in a real environment.

9 Application of Low Cost Sensors to Evaluate Source Emissions

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Commercial low cost air quality sensors have become increasingly available in recent years. These sensors are of interest for air monitoring and emissions research. The low price point, small size, and low power consumption enable multiple sensors to be employed in dense network configurations. Sensor networks may be particularly attractive in complex source environments, such as fugitive emissions and area sources covering large spatial scales. EPA ORD researchers are assessing the application of these low cost sensors for in situ source emissions characterization, including laboratory and field scoping studies as well as model development. The sensors under evaluation include metal oxide, electrochemical, optical, and non-dispersive infrared sensors. Several sensors were recently tested alongside reference instruments at a forest fire study at Eglin Air Force Base, FL. The overall wireless network approach was successful and merits further assessment in source emission studies. Laboratory testing includes exposure chamber tests to observe sensor performance over a range of pollutant concentrations and under varying environmental conditions. Finally, in order to derive source information from a sensor network monitoring approach, a model called SEnsor NeTwork INtelligent Emissions-Locator (SENTINEL) is being developed which will graphically depict area concentrations from multi-node inputs of sensor data.

10 Air Sensors for Science, Technology, Engineering and Math Outreach

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New low cost air pollution sensors and communication technology affords a unique opportunity for science, technology, engineering, and math (STEM) outreach by scientists, who participate in events ranging from classroom presentations to engineering festivals. Interactive demonstration units can be developed using available low cost components, such as a sensor and communications housed in a clear container, with sensor signals controlling visual data indicators. EPA ORD recently designed one such system which was displayed at the 2012 World Maker Faire and has been used locally at museum and school demonstrations. The setup demonstrated how an LED array can be used to indicate relative air pollutant levels. Additional more visually pleasing and interactive designs are in development for future demonstration applications. Sensors can be designed to address specific problems/pollutants of interest to provide for the greatest possible learning experience. For example, nitrogen dioxide, carbon monoxide, and particulate matter sensors could be used to indicate pollution in areas with traffic exhaust, while carbon dioxide sensors could support user-interaction and allow a participant to trigger a visual indicator when they exhale on the sensor. Building these sensor systems facilitates hands-on learning and provides additional STEM opportunities for school groups and can also be used at many types of outreach events. These systems provide a novel and interactive platform to learn about scientific research, programming, electronics, and air pollution in a real world application.

11 RETIGO: A Web-based Tool for Geospatial Timeseries Visualization

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Air monitoring data collection on moving platforms – an instrumented person, bicycle, or vehicle – is now conducted frequently by researchers and citizen scientists. Portable air monitoring instruments with real-time detection capability and advancements in global positioning system (GPS) technology now allow very high spatial and temporal resolution of air pollution data. The traditional mode of evaluating complex geospatial data has been to collect the field data and then utilize sophisticated data analysis and geographical information tools to process and visualize the data. These tools and a skilled analyst are currently and are expected to continue to be relied upon to extract meaningful information from these geospatial data sets. However, these analytical approaches generally take significant time and expertise to conduct, limiting those involved with the analysis process. To simplify the review of geospatial data and expand participation in the analysis process, the Real-Time Geospatial Data Viewer web-based tool is under development and will provide an easy plug-and-play review of geospatial time series. The freely available program will allow data to be viewed in time and space, as well as providing options to reference the geospatial data in terms of distance to a location of interest (e.g., traffic emissions), incorporate ancillary meteorology data, and overlay web-available regional air quality readings.

12 Nanowire-Nanocluster Hybrid Sensor Technology for Environmental Monitoring

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Next-generation environmental monitors suitable for integration with smart-phone and other mobile platforms require single-chip ultra low-power sensor technology capable of recognizing multiple threats. Traditional sensor technologies, such as electrochemical, catalytic, and photoionization based detectors all have significant limitations in terms of physical size, power requirement, sensitivity, selectivity, range, and operating life.

We have developed a novel chemical sensor architecture by combining the sensitive transduction capability of gallium nitride (GaN) nanowires together with the enhanced catalytic efficiency of metal and metal-oxides nanoclusters (with diameters in the range of 2 – 10 nanometers). Using multicomponent nanocluster design, we can produce sensors with high selectivity to any small set of chemicals, currently not possible with any other technology. We have shown that GaN nanowires decorated with nanoclusters of titanium dioxide can be used to detect volatile organic compounds, such as benzene, toluene, ethylbenzene, and xylene – commonly referred to as BTEX at concentration levels as low as 50 ppb. The photocatalytic metal-oxide nanoclusters allowed room-temperature sensor operation using only UV excitation. These sensors also detected nitroaromatic explosive compounds such as trinitrotoluene at levels of 500 ppt in air. By adding platinum to the titanium dioxide nanoclusters, the same sensors can be "retuned" to respond to hydrogen, methanol, and ethanol. The unique strength of our technology is that it allows us to design sensors for variety of applications by simply re-designing the metal/metal-oxide nanocluster. This enables fabrication of arrays of multiple sensors on a single chip capable of identifying various types of chemical pollutants.

13 Tunable MEMS Microsensor Arrays for Trace Gas-Phase Analyses

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Electronic nose (e-nose) technology offers the possibility for inexpensive, multi-point chemical monitoring, but a number of inter-related technical challenges must be met in order to insure that an e-nose reliably measures target compounds in practical background environments. We describe the features and capabilities of an array-based, chemiresistive microsensor approach under development at NIST/Gaithersburg. Miniature MEMS device platforms are employed that consist of arrays of “microhotplate” elements (100 µm) which are individually addressable and include functionality for rapid temperature control (< 5 ms) and electrical characterization of locally-deposited sensing films. Different film compositions (primarily semiconducting oxides or conducting polymers) are incorporated to produce orthogonal analytical information, and nanostructured morphologies are utilized to enhance sensitivity (to the ppb level and below). A variety of signal processing methods (including ANN, PCA, LDA) have been used on the high-density data streams, which are acquired from multiple, temperature-programmed elements, to allow recognition and quantification of target species. We illustrate how the sensing arrays have been tuned, by choices of materials and temperature-modulation cycles, to realize application-specific chemical monitoring capabilities of relevance to sectors ranging from homeland security (toxic industrial chemicals) and environmental monitoring (VOCs), to medical breath analysis (trace gas-phase biomarkers) and space exploration (biogenic gases in non-air backgrounds). The utility of a number of enabling aspects, such as monolithic (CMOS-based) device/electronics integration, target-library pretraining algorithms, classification of unknowns, lifetime extension methodology, transient approaches to shorten response times, and efficient array-based processing/performance studies on sensing materials, will also be described.

14 BEACON: Berkeley Atmospheric CO_2 Observation Network

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BEACON <http://beacon.berkeley.edu> is a new approach to observing atmospheric gases over an urban area. Instead of using a small number of extremely sensitive instruments to measure "representative" concentrations for a large area, we blanket interesting locations with a high density (~2 km) grid of instruments. Individually, measurements from these locations are of moderate quality, but when taken together can produce an accurate, highly resolved picture of real-time pollutant concentrations. Currently, BEACON focuses on observing plumes of carbon dioxide (CO_2), a major greenhouse gas, in Alameda County, California. We are extending the network to measure several criteria air pollutants using modern electrochemical gas sensors, and plan to expand past our initial deployment of 30 monitoring stations in Summer 2013. BEACON takes an open-data and open-source approach, with millions of high-frequency measurements made publicly available via a modern web API backed by a scalable and high-performance time-series database (OpenTSDB). We use freely available, open-source tools like R and GitHub to generate and share analyses, as well as packages for scaffolding novice users. BEACON also benefits from local community engagement. We are also building relationships with civic and environmentally oriented hackerspaces in the Bay Area, participating in events such as the February 2013 EcoHack in San Francisco. Local science partners, including schools and museums, host participatory workshops where we work with science teachers to construct curricula incorporating BEACON science and data into their classrooms. We adopt this approach to maximize replicability and reach, recognizing that climate change and local air pollution are more than technical problems, and that cutting-edge infrastructure can be used to generate valuable data for multiple stakeholders with varying interests, affiliations, and expertise.

15 Assessing US-Mexico Border-related Traffic Pollution in San Ysidro, CA Using CitiSense, a Cell Phone Based Sensing System

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San Ysidro, CA, is a low-income minority community located immediately adjacent to the busiest border crossing in the world, the San Ysidro Port of Entry (POE), and is intersected by two major freeways. Heavy duty trucks also cross the community on their way north from the commercial truck border crossing at Otay Mesa, a few miles to the east. Exposure to pollutants emitted from heavy traffic has been linked to an increased risk of childhood asthma, reduced lung development and other adverse effects, and exposure disparities are thought to increase risks of diseases in low-income minority communities. In partnership with a local community-based organization, Casa Familiar, we propose to deploy new cell-phone-based smart sensors (CitiSense) with children at schools at varying distances from traffic sources and link to concurrent school air monitoring of toxic agents and carcinogens in traffic exhaust. As a first step, we present results from measuring the air quality at schools across San Ysidro with the CitiSense monitor in conjunction with fixed site monitoring for the traffic pollutants ultrafine particles and black carbon. Results show strong spatial gradients in traffic pollutants near the US-Mexico POE and busy roadways including high levels at nearby schools, especially for ultrafine particles and carbon monoxide. This work may lead to reducing exposures in minority communities through citizen sensing to provide support for the community to develop action plans as needed, such as requesting performance standards for reduced US-Mexico border delays.

16 An Adhoc Wireless Sensor Network for Roadside Carbon Monoxide Monitoring

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Wireless sensor networks are becoming increasingly important as an alternative for environmental monitoring because they can be assembled ad hoc and cost less. They can also be placed where traditional monitoring methods are difficult to site. In this study, a carbon monoxide wireless sensor network (CO-WSN) was developed to measure carbon monoxide concentrations at a major traffic intersection near the University of Cincinnati main campus. More than one year of CO data and traffic data were collected. The WSN has been calibrated against temperature and relative humidity. Solar panel was used to power the WSN.

The 1 hr-average CO concentrations were found to range from 0.1-1.0 ppm which is much lower than the National Ambient Air Quality Standards (NAAQs) standard of 35 ppm (1 hr ave). 97% of the total traffic volume is from passenger vehicles. The total traffic volume based on a 1-hour average showed good correlation (R square=0.82) with the 1-hr average CO-WSN concentrations for morning and evening peak time periods whereas CO-WSN results provided a moderate correlation (R square =0.42) with 24 hours traffic volume due to fluctuated changes of the meteorological conditions. The effects of meteorology and seasonal data trends will be discussed. The pros and cons of the outdoor deployment and the applicability of the CO-WSN will also be provided.

17 Design of an Ozone Sensing Wristwatch Using Quartz Tuning Fork Oscillators

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A major challenge for determining human exposure to airborne substances is to make the sensor suite small and portable enough that it can be worn or carried comfortably and unobtrusively. The size and portability constraints are often limited by the power supply, size of display, and size of the sensors. For portable air quality sensor systems to be economically feasible the sensors also need to be low cost, mechanically robust, while having high sensitivity and specificity to the gas of interest.

This project examines the use of quartz tuning fork oscillators used in wristwatches as the sensing element since they are manufactured in large volumes and cost only a few cents. The tuning fork sensors also have the advantage of being low power and small form factor such that multiple tuning fork sensors can be placed into a small device that can be worn as a wrist watch, or clipped to clothing as a badge. Ozone was chosen as the target gas and is measured by detecting changes in the resonant frequency of the tuning fork as the ozone reacts with the polymer coating on the sensor. The main focus of this work is to examine designs where the total power consumption of the sensor system averages less than 250 microwatts. Aspects of the mechanical design will also be presented.

18 A Liquid Crystal-based, Direct-read, Passive Badge for Hydrogen Sulfide

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Workplace exposures of hydrogen sulfide (H_2S) have been reported in a number of industries such as oil and gas extraction, tanneries, animal waste disposals, etc. While exposure to high concentrations of H_2S can be deadly, prolonged exposure to H_2S at low levels can lead to serious respiratory, neurological, and dermatological problems. Current OSHA guidelines for H_2S are ceiling exposure of 20 ppm and a time-weighted average (TWA) exposure of 10 ppm. The American Conference of Governmental Industrial Hygienists (ACGIH) has recently lowered their threshold limit values to 1 ppm for a TWA exposure. Existing devices for H_2S measurement using electrochemical sensors are inaccurate at these levels and have known history of cross-interferences. Sorbent tube based methods require off-site analysis, introducing long lag-times between sample collection and data retrieval. Therefore, the need for a simple, accurate, and specific direct-readout monitoring device has long been recognized. A direct-read, passive badge that provides accurate on-site exposure assessment to H_2S has been developed using liquid crystal (LC) technology. This technology relies on the use of materials with chemically functionalized surfaces that, upon exposure to H_2S, trigger changes in the optical properties of the LC. Change in the appearance of the badge can be analyzed visually or optically to yield a quantifiable dose response. These badges show a predictable linear dose response behavior from 0.1 - 20 ppm TWA with a limit of detection at 0.54 ppm-hr total dose. The badges have been demonstrated to be functional in 0–40°C temperature and 0–80% relative humidity (RH) ranges. Performance of the badge has been tested at various H_2S concentrations from 1 to 15 ppm, at 20–80% RH and at temperatures from 22–40°C. The results of these environmental tests show a linear response from 1.6–92 ppm-hr of H_2S, with a correlation coefficient of 0.98. The LC badges show no response to 30 ppm sulfur dioxide and their performance is not affected by face velocities from 5–92 cm/sec. These results demonstrate that these direct-read badges based on LC technology can be used for monitoring workplace exposures and have potential for ambient air sampling for long-term exposure assessment at environmentally relevant concentrations.

19 Towards Flexible Gas Sensors based on ZnO Nanowires

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ZnO nanostructures have been widely used in gas sensing applications due to their large surface-to-volume ratio, good thermal stability, good biocompatibility, and high electron mobility. Here we report our ongoing efforts in developing ZnO nanowires (NWs) based gas sensors on flexible PET substrate. The ZnO nanowires were synthesized by the vapor–liquid–solid (VLS) method, using both the Au film and patterned ZnO powder as catalysts. After the growth of nanowires, the assembly and alignment of nanowires represents a key step for the device fabrication. Recently we reported a simple and effective method to transfer and align the ZnO nanowires on PET substrate, which combines the strain-release assembly of nanowires and a heated contact printing process. Based on the strain release assembly and contact printing, three representative flexible devices were fabricated on PET substrate for a range of potential applications: (1) Stretchable SiNW devices that feature constant resistance under large strains. (2) Flexible SiNW strain sensors that exhibit large gauge factors. (3) Flexible ZnO nanowires based UV sensors show reliable photo response and quick recovery. Furthermore, a simple and low-cost fabrication process was developed to fabricate highly conductive and stretchable silver nanowires (AgNWs) conductors, based on which, capacitive strain sensors and tactile sensors were fabricated.

20 Exploration of Novel Particulate Monitor Designs

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One of the goals of the ASSIST center is to develop low cost, low power, portable or wearable particulate monitors. The power consumption of particulate monitors is especially challenging, since air sampling is required and usually laser diodes are used as a light source. Size and mechanical robustness are also issues, since most current systems with the exception of RTI MicoPEMtm are large, fragile and bulky. This poster explores some novel particulate monitor designs with the emphasis on proposing designs that reduce the cost, size, and power consumption.

21 Towards Microwatt Nanosensors For Gas Sensing

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One of the goals of the ASSIST center is to produce ultra-low power sensor systems such that the systems can be powered by the human body or the environment. Ideally, we would like each sensor modality to consume less than 100 microwatts so multiple sensors can be combined in systems where the total power consumed including computation and transmission of data is less than 1 milliwatt.

Gas sensors pose a special challenge since typical metal oxide gas sensors consume hundreds of milliwatts of power. This poster examines the challenges of making low power metal oxide gas sensors by scaling devices to the nano-regime where the small mass allows the structure to be heated to high temperatures with small amounts of power. As an example, a low cost, laser lithography method is used to form nanowires. This technique, when used in conjunction with a supporting membrane or a low thermal conductivity substrate, allows the metal oxide material to be heated at a high rate with little input power. An alternative approach is also presented where atomic layer deposition of titanium dioxide is performed on micro-hotplate devices. Atomic Layer Deposition provides precise thickness control of conformal coatings, enabling high specific surface area which leads to increased sensitivity. Using these approaches, we anticipate ultra-low power sensors in the microwatt regime with high sensitivity and selectivity.

22 Handheld Low Cost Nanofiber Sensor for Environmental Monitoring of VOCs and Ozone

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VOCs and ozone are important Hazardous Air Pollutants (HAPs) in the outdoor and indoor environments. Between 30 and 70 million workers in the United States are routinely exposed to potentially unhealthy working conditions due to poor indoor air quality. RTI has been developing a Nanofiber Sensor Platform (NSP) using electrospun composite polymer nanofibers (ECPNs) combined with printed electronics for environmental monitoring. We used polymer composite-sensing material with the incorporation of Carbon Nanotubes (CNTs) to adjust the conductivity for the composite materials. Such an integrated sensor system could be used for detecting various targeted chemicals. In this sensor, the composite polymer nanofibers form chemo-resistor sensing materials and the conductivity of these composite sensing materials changes with chemical vapor exposure. The polymer composite chemistry and surface functionality of the nanofiber material are highly tunable to provide a wide platform for detecting various interested analytes. Furthermore, ECPNs are made of inexpensive starting materials (polymer and conductive additives) and a simple and highly reproducible nanofiber manufacturing process greatly reduces the total cost of the sensor system, making it a potential throw-away device. RTI has developed first prototype nanofiber sensor system, which operates on two AAA batteries and has a size comparable with a cell phone. The sensitivity and selectivity of the sensor to different vapor analytes will also be discussed.

23 A Robust, Low-cost Particle Monitor and Data Platform for Evaluation of Cookstove Performance

Michael Johnson, Ajay Pillarisetti, Tracy Allen, Dana Charron, David Pennise, Kirk R. Smith

Household air pollution in 2010 was responsible for ~3.5 million premature deaths and an additional 500,000 through contributions to outdoor air pollution. While interventions to reduce this burden exist – including a range of household cooking interventions – reliable, standard, and low-cost methods for (1) assessing cookstove performance in the field and for (2) objectively monitoring usage of interventions are relatively new and pose significant data management and analysis challenges.

In response to these difficulties, PICA – the Platform for Integrated Cookstove Assessment – is being developed by Berkeley Air Monitoring Group, UC Berkeley, and EME Systems. Current methods for assessing cookstove performance rely on multiple sensors, each with a unique piece of software, resulting in data management complexities and inefficiencies. PICA builds on our experience with inexpensive, data-logging, portable pollutant sensors by offering a central software suite that can easily integrate data streams from multiple devices and by providing an user-friendly interface to deploy and download data from Berkeley Air's pollution and usage measurement devices.

The project also aims to improve Berkeley Air's current set of instrumentation, with a focus on an upgraded UCB Particle and Temperature System (UCB-PATS) and refined algorithms for the Stove Use Monitoring System (SUMS). Upgrades to the UCB-PATS include new signal processing routines, improved battery life, and addition of an optional CO sensing module. Improvements to the SUMS focus on rapid analysis of temperature traces to determine duration and number of cooking events per monitoring period.

24 Empowering Communities to Clean the Air through Citizen Science and Civic Dialogues: Neighborhood Air Quality Sensing and Policy Conversations

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New inexpensive sensing technologies prove valuable for increased public participation in community-based research. Local health officials, community researchers and informal science educators have together encouraged citizens to confront the health impacts of mobile-source air pollution, effects of traveling via heavily trafficked routes, and the urban heat island effect. A series of iterative, ongoing community data-gathering efforts have drawn upon the passion of local bicycle commuters to serve as mobile test platforms and the power and availability of area high-school students. These small field studies were planned in collaboration between students and expert mentors, comprised of planners from the City of Cambridge and Somerville Transportation Equity Partnership and scientists from Boston University, MIT, Harvard, and Tufts Universities. This process considered basic research questions, developing simple protocols for measuring pollutants such as nitrogen oxides, fine particulate matter, temperature, and relative humidity, whose findings became fodder for respectful discussion amongst peers, the public, and scientific stakeholders. Merging participatory sensing research with conversations facilitates consideration among the lay-public around issues such as individual decision-making in the face of uncertain risk, seeking low-traffic routes for exercise or commuting, the role of communities in guiding policy decisions, and innovative, crowd-sourced strategies to inform the planning of healthier cities. A series of public presentations and videos have helped translate complex environmental health topics into accessible information for diverse publics. Partnerships between museums, research scientists, and civic planners show promise for collecting valuable geospatially distributed environmental data while convening multi-directional conversations between the public around potential solutions.

25 Quantitative Analysis of Multi-VOC Mixtures by Micro-Scale Gas Chromatography: Recent Successes in Environmental Monitoring and Prospects for 'Citizen Sensing'

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We recently field tested an autonomous prototype microfabricated gas chromatograph (μGC) for monitoring parts-per-trillion concentrations of trichloroethylene (TCE) in homes suffering from TCE vapor intrusion. We have also constructed and demonstrated a μGC for high-speed determinations of explosive marker compounds at similar concentrations. We are currently adapting one of these prototypes for analyzing diacetyl (DA) in saliva for biological monitoring of worker exposures to DA. In all of these instruments we employ a front-end sampling subsystem of conventional design for selectively capturing VOCs (to achieve sub-ppb detection limits), and a microfabricated analytical subsystem for focusing, injecting, chromatographically separating and detecting target analytes. The latter comprises the following Si/glass batch-microfabricated components: a microfocuser, two series-coupled, wall-coated microcolumns, and an array of nanoparticle-coated chemiresistors (μCR). We are now pursuing applications where required detection limits are in the mid-ppb range and there is no need for the sampling subsystem. This μGC, referred to as a Personal Exposure Monitoring Microsystem (PEMM), will be battery operated, autonomous, and small/light-weight enough to mount on the belt, yet capable of simultaneous exposure measurements of ~10-15 user-selectable VOCs every ~10 minutes in real-world environments. With a bread-board version of the PEMM we captured, separated and detected the components of a 14-VOC mixture, obtained response patterns for each from the μCR array, and achieved detection limits of <70 ppb (<5 ppb for benzene) in <6 min. We believe that this technology holds promise for future citizen sensing applications where speciated analyses of VOCs are desired.

26 Mobile Health Sensor for Personal Exposure Assessment

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Centre for Bioelectronics and Biosensors, the Biodesign Institute, Arizona State University

Closely related to people's health, both indoor and outdoor air pollution catches more and more people's concerns today. Instead of using bulky and expensive equipments at fixed monitoring site for pollutants detection, portable, low cost, and reliable sensor device, if made, can give more accurate personal exposure assessment and eventually benefit people's health. We hereby have developed the multifunctional portable mobile health sensor device for $PM_{2.5,}$ HCHO, CO_2, NO_2, and O_3 detection. The device can communicate with smartphone via Bluetooth for data transmission, analysis and display.

The $PM_{2.5}$ is detected by using the tuning fork crystal. Coated with an adhesive polymer layer, the low-cost and stable tuning forks are highly sensitive to mass change induced by $PM_{2.5}$ adsorption. The detection limit (2mins sampling) can be as low as 3μg/m^3. The sensor shows high stability and its sensitivity doesn't show obvious decay within 45 days when exposed to ambient air.

The colorimetric sensing technology has been developed to detect NO_2, O_3, HCHO, and CO_2 simultaneously by integrating four kinds of sensing probes in one single chip. The corresponding detection limits (1minute sampling) for O_3, NO_2, HCHO, and CO_2 are as low as 20ppb, 10ppb, 30ppb and 400ppb.

The mobile health sensor will meet people's need for quick, reliable, and low cost detection of air pollutants.

27 A Wireless and Wearable Sensor for Detection of Environmental Volatile Organic Compounds

Cheng Chen, Francis Tsow, Xiaojun Xian, Yue Deng, Erica Forzani, Nongjian Tao
Arizona State University, Biodesign Institute

To improve our understanding of indoor and outdoor personal exposures to common environmental toxicants daily released into the environment, new technologies that can monitor and quantify the toxicants anytime anywhere are needed. This poster presents a wearable sensor to provide such capabilities. The sensor combines the selective molecular binding polymer and micro-fabricated quartz tuning fork detector, which can communicate with a common smart phone through Bluetooth, and allow for accurate measurement of volatile organic compounds at personal level in real-time. The sensor's performance was validated using Gas Chromatography-Mass Spectrometry (GC-MS) and Selected Ion Flow Tube-Mass Spectrometry (SIFT-MS) reference methods in a variety of environments and activities. Field tests were carried out to examine personal exposure in various scenarios including: indoor and outdoor environments, traffic exposure and personal exposure in different cities, countries, and near the 2010 Deepwater Horizon's oil spill. These field tests not only validate the performance, but also demonstrate the unprecedented high temporal and spatial toxicant information provided by the new technology.

28 VIPER: Wireless Sensor Communication

Joe Schaefer, Robert Cibulskis, John Campbell

The U.S. EPA's Environmental Response Team (ERT) has developed an open, standards-based wireless sensor communication system utilizing Safe Environment Engineering's LifeLine Wireless Monitoring system as a core technology leveraged and enhanced by ERT custom software drawing on the SCRIBE.NET enterprise data model to provide capture, aggregation, persistence, communication, and visualization of sensor data in a manner applicable to a wide range of environmental monitoring equipment and field monitoring scenarios.

Custom software (VIPER Survey Controller) assists the user in composing and controlling a field survey with great flexibility. In addition to managing the LifeLine hardware and software, the VIPER Survey Controller captures real-time sensor data in DHS-standard Common Alerting Protocol (CAP) messages. Though the LifeLine software already provides CAP for several sensors/systems, more sensors and systems can integrate with VIPER by simply transmitting CAP to a VIPER Survey Controller. If a sensor/system does not natively provide CAP, lightweight software referred to as a "MeterApp" can be developed to translate data from its native format to CAP. As VIPER Survey Controller collects and stores data locally, it also transmits the data to the server by way of a dedicated instance of SCRIBE.NET.

A set of server applications and services enable logical organization of individual runs/surveys, as well as real-time alarm monitoring and rolling time-weighted-average (TWA) calculations for individual sensors. VIPER is currently supporting emergency response operations within Superfund in all 10 EPA regions. Most recently it was used during the Hurricane Sandy response, the Paulsborro, NJ trail derailment and the recent national political conventions.

29 A Scientist with Sensors and Spare Time: Backyard Comparisons of Particulate Matter Sensors

Tim S. Dye
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Numerous low-cost sensors and commercial devices that measure particulate matter are starting to be used by organizations, sensor developers, researchers, and DIYers, yet few studies have compared data from these sensors to reference instruments. In this study, three light-scattering devices were evaluated–Shinyei PPD42NS ($15), Shinyei PPD62PV ($160), and Dylos 1700 ($300)–and compared to a reference instrument: the Thermo PDR-1500. Comparisons were performed outdoors in a residential neighborhood in northern California. The instruments were compared at higher concentrations using a smoke generator and simple chamber (cardboard box). Results showed good agreement between the reference Thermo PDR and the Dylos small sensor ($R^2 > 0.90$). The Dylos sensor was responsive to rapid changes in $PM_{2.5}$ measured by the Thermo PDR. Comparisons with the Shinyei PPD42NS and Thermo PDR were inconsistent at low concentrations (less than 40 µg/m^3), but responsive at higher concentrations (greater than 200 µg/m^3). The next step is to expand this intercomparison study over a longer time period, with more instruments, in an urban environment, and under a range of weather conditions. Following the expanded intercomparison, we would deploy a network of 20 to 30 sensor systems across a region of interest.

30 iMet-1-RSB Research Radiosonde

Fred Clowney
InterMet Systems

The iMet-1-RSB is an atmospheric radiosonde designed for integration with custom sensor packages. The sonde measures conventional meteorological variables (pressure, temperature, relative humidity, GPS derived winds) and includes a serial cable to receive additional sensor data. The combined stream is encoded and transmitted as FM over the 403 MHz meteorological band.

Data is encoded using the publicly available Bel-202 format, which can be received and decoded using COTS devices. The RSB is most frequently used with ECC-type ozone sensors but can be integrated with any device capable of serial data output.

The RSB can be deployed with high altitude weather balloons, low altitude tether balloons, or as a stationary device. The RF transmitter can be replaced with other transfer devices such as Bluetooth or configured to store data in non-volatile memory for later retrieval. It can be connected directly to a network and has been integrated into UAVs.

InterMet is a Michigan based manufacturer of high-accuracy, low-cost sensor systems and is interested in teaming with developers looking for product design capabilities and medium-volume manufacturing capacity. Additional information is available at www.intermetsystems.com.

31 Air Quality Data Analysis and Visualization with Open Source Programming Languages

Ryan Brown, Daniel Garver
US Environmental Protection Agency Region 4, Atlanta, Georgia

Agencies rely on air quality data analysis and visualization for planning and decision making. At the same time, state, local, and federal budgets and resources are currently shrinking. Leveraging open source platforms for data analysis can provide real value to agencies including cost savings, time savings, better and more reliable analysis, as well as increased collaboration and transparency. Open source programming languages such as Python and R are free tools that can help achieve these goals. Both of these languages have active communities that have already developed significant code for data manipulation, statistical analysis, and data visualization. These languages are relatively easy to learn and read, and are ideal for scientists and engineers (part time programmers).

EPA Region 4 staff in Atlanta are utilizing Python and R to increase data analysis and visualization capabilities, with the goal of better informing decision makers. In a relatively short time period working with these tools (about one year), significant gains have already been realized in automation of routine data pulls and increased analytical capabilities.

32 Potential for Mapping Minute-to-minute Carbon Monoxide and Nitrogen Dioxide Measurements Collected by Millions of Mobile Sensors Deployed Worldwide

Albert Donnay
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EPA's monitoring of carbon monoxide (CO) and nitrogen dioxide (NO_2) is limited to fixed detectors located in fewer than 300 of 3,033 US counties. They are mounted at various heights and distances from roadways that are not representative of most drivers' actual on-road exposures. Fortunately, EPA and others may soon be able to obtain more meaningful CO and NO_2 exposure data from a growing global network of mobile sensors.

Mercedes and BMW have been installing air control modules in vehicles since 1998 and 2000, respectively. Each contains two metal oxide sensors: one tuned to CO to detect gasoline exhaust and the other to NO_2 for diesel. When either signal starts rising, the vehicle's computer switches vents from "fresh air" to "recirculate" and then waits to reopen them until the sensor readings fall below preset thresholds. An estimated 3 million are deployed in USA and millions more globally, concentrated in major cities where air pollution is worst.

These sensors have excellent specifications with a life expectancy of 10 years even in vehicles kept outdoors. Their data output is not currently used for any other purpose but could easily be converted to ppb units, stamped with time and GPS, and uploaded to mapping applications. Data could be sold by subscription in both real-time formats (to vendors of weather and traffic apps, for example) and as time-averaged trends (over minutes to days or months) for specific vehicles or all vehicles travelling in any geographic area (from single intersections to entire continents).

So which company will be first to sell these data? And will EPA buy?

33 Semi-continuous Metals Monitoring in the Industrial Midwest

Motria Caudill, PhD
US EPA Region 5; Air Monitoring & Data Analysis Section

Ambient air monitoring for speciated metals using traditional filter-based methods is very resource-intensive and produces relatively few data points, making it impractical for short-term health exposure and source apportionment studies. The most advanced metals monitor currently available is the Pall Xact 625 Fence-Line Monitor which measures 23 trace elements in near real-time with a built-in x-ray fluorescence analyzer. The Xact produces ambient concentrations in one-hour increments, matching the reporting frequency of continuous gaseous instruments. EPA Region 5 has deployed the Xact in multiple Midwest industrial communities to compare its measurements with existing filter-based technology, to characterize community exposures, and to develop analysis techniques appropriate for the large number of measurements collected. Target industries in Ohio and Indiana are ferroalloy producers and integrated steel plants; future deployments are planned to a lead battery recycler, steel mini-mill, and steel mill byproduct recycler. To date, peak one-hour concentrations at these sites were as high as 50 ug/m^3 for iron, 5 ug/m^3 for manganese, 0.2 ug/m^3 for lead, and somewhat less for other toxic metals including cadmium, nickel, and mercury. Various statistical techniques have been applied to quantify contributions from target metallurgic industries and other nearby sources. Short-term deployment of the Xact and prompt data analyses are intended to support EPA enforcement investigations, reduce community exposures in criteria pollutant nonattainment areas, and inform the permitting process.

34 Geospatial Monitoring of Air Pollution of Hydrogen Sulfide and Methane Around Facilities in Region 5

Marta Fuoco, U.S. EPA R5

Region 5 has been planning and collaborating with the Office of Research and Development (ORD), National Risk Management Research Laboratory (NRMRL) under the Advanced Monitoring Initiative Grant to optimize an advanced prototype cavity ring-down spectroscoper (CRDS) with integrated GPS and meteorological instrumentation that when used in a mobile environment can obtain rapid real-time measurements downwind of potential sources. The CRDS measures two parameters – H_2S and CH_4. This instrument compliments and enhances work in the Region through fence line monitoring, aiding in siting other monitors in areas of highest concentration, and screening level analysis. In addition, the detection of a methane plume can trigger a SUMMA can grab sample that will allow for additional monitoring of VOCs; an application that has been developed into this system. This is particularly valuable in assessing H_2S and methane in communities impacted by landfills, CAFOs, pulp and paper mills, and oil and gas facilities. Since obtaining this instrument, R5 has used it in source identification, GIS mapping, strength estimation (in its mobile mode), and high sensitivity ambient measurements (in its stationary mode) to characterize H_2S and CH_4 in ambient air at an oil and gas facility, landfill, waste water treatment plant, as well as in other collaborations.

35 Advances in Particulate Matter Exposure Assessment Instrumentation

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RTI International
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Recent advances in exposure assessment technologies, especially for difficult cohorts like children or senior citizens, enable stronger correlation between the environmental stressor and adverse health outcome. The MicroPEM technology provides exposure data that can significantly enhance health and safety in both residential and occupational settings in an unobtrusive package. The ability to reduce exposure misclassification bias is the key to strengthening the exposure-health link. The MicroPEM is deployed in three current particulate matter exposure studies. One study is examining environmental causes of acute respiratory disease in children. Senior citizen's exposure to carcinogens in particulate matter from nearby point sources is another. Lastly, exposures to biomass cookstove smoke are being measured in developing countries. Successes and improvements will be discussed using data quality indicators and practical considerations for deploying the MicroPEM in each study. The focus will be the ability to link exposure data to the specific health outcome of interest for each study. Additional facets to be discussed include prediction of inhaled dose from the accelerometer and nephelometer data, compliance with study protocols as measured by an accelerometer, integrated filter gravimetric and speciation detection limits, automatic nephelometer calibration and relative humidity correction, comparison of data from the MicroPEM and other exposure monitor technologies used in previous studies, MicroPEM performance in high concentration environments, system cycle options to obtain 7-day samples, and feasibility of conducting large scale mail-out studies.

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Research Highlights for Mobile Sensors and Apps

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The public has long been interested in understanding what pollutants are in the air they breathe so they can best protect their environmental health and welfare. The current air quality monitoring network consists of discrete stations with expensive equipment operated by state and local agencies. Because both the number of stations and the pollutants they measure are limited, location-specific data are relatively sparse. Thus, actual concentrations to which individuals are exposed each day are generally unknown. Significant advances in mobile sensors and software applications offer unique opportunities for citizen-based sensing that could ultimately help fill these gaps. Highlights of recent research on mobile sensors were compiled for fourteen example pollutants: the six criteria pollutants (carbon monoxide, lead, ozone, nitrogen dioxide, particulate matter, and sulfur dioxide) plus several hazardous air pollutants and indicators – specifically acetaldehyde, acrolein, ammonia, benzene, 1,3 butadiene, formaldehyde, hydrogen sulfide, and methane. From the review of selected recent literature, nanotechnology and spectroscopic techniques were identified as prominent t themes. Low-cost, mobile sensors were found to emphasize gases, while chemical-specific particle sensors appear to represent a current gap. Evolving mobile sensors and systems appear capable of detecting air pollutants at concentrations near many health-based standards, notably for most criteria pollutants, while guideline concentrations for several of the other pollutants assessed may not be reliably detected. Development needs for mobile apps include user interfaces that are stable across different devices and can provide real-time, high-resolution spatial coverage across community, neighborhood, and individual scales. Also useful would be data displays for a suite of pollutants with links to practical context, including how measured concentrations compare to health-based standards and guidelines for the respective settings.

A RTI MicroPEM

Quentin Malloy, Jonathan Thornburg, Seung-Hyun Cho, Ryan Chartier, Charles Rodes, Randy Newsome
RTI International

The RTI MicroP*EM™* is lightweight (< 240 g), portable, and quiet. Developed by a research team led by RTI International with support from NIEHS, it will help scientists better understand the relationship between aerosol environmental contaminants in the air and potential adverse health effects. The new approach collects both acute (real-time) and chronic (integrated) level aerosol exposure data, along with built-in acceleration sensors to determine individual activity levels while predicting how fast adults, and potentially children, breathe pollutants in their environment. The advancement enables scientists to calculate potential dosage – how much pollutant enters the respiratory system – in real time.

B VIPER: Wireless Sensor Communication

Joe Schaefer, Robert Cibulskis, John Campbell

The U.S. EPA's Environmental Response Team (ERT) has developed an open, standards-based wireless sensor communication system utilizing Safe Environment Engineering's LifeLine Wireless Monitoring system as a core technology leveraged and enhanced by ERT custom software drawing on the SCRIBE.NET enterprise data model to provide capture, aggregation, persistence, communication, and visualization of sensor data in a manner applicable to a wide range of environmental monitoring equipment and field monitoring scenarios. Custom software (VIPER Survey Controller) assists the user in composing and controlling a field survey with great flexibility. In addition to managing the LifeLine hardware and software, the VIPER Survey Controller captures real-time sensor data in DHS-standard Common Alerting Protocol (CAP) messages. Though the LifeLine software already provides CAP for several sensors/systems, more sensors and systems can integrate with VIPER by simply transmitting CAP to a VIPER Survey Controller. If a sensor/system does not natively provide CAP, lightweight software referred to as a "MeterApp" can be developed to translate data from its native format to CAP. As VIPER Survey Controller collects and stores data locally, it also transmits the data to the server by way of a dedicated instance of SCRIBE.NET.

A set of server applications and services enable logical organization of individual runs/surveys, as well as real-time alarm monitoring and rolling time-weighted-average (TWA) calculations for individual sensors. VIPER is currently supporting emergency response operations within Superfund in all 10 EPA regions. Most recently it was used during the Hurricane Sandy response, the Paulsborro, NJ trail derailment and the recent national political conventions.

C Multi-Pollutant Monitoring at High Spatial and Temporal Resolution: The Berkeley Atmospheric Carbon Observation Network (BEACON)

David Holstius[1], Jill Teige[2], Katja Weichsel[2], Holly Maness[2], Andrew Hooker[2], Edmund Seto[1], Ron Cohen[2]
[1]Environmental Health Sciences, School of Public Health, UC Berkeley
[2]College of Chemistry, UC Berkeley

The BEACON network measures gas concentrations and meteorological parameters at 30 locations approximately 2 km apart in Alameda County, California. BEACON takes an open-data approach, with millions of high-frequency measurements made publicly available via a unified RESTful web API. Our API is backed by a scalable and high-performance time-series database (OpenTSDB) and a geodatabase built with Django. On top of this layer, we provide an R library that includes prepackaged interactive visualizations. The library and API are used to generate and share replicable analyses, as well as tutorials for scaffolding novice users.

D Selective Benzene Detector

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A device for selective benzene detection will be presented and explained in detail. It is based on four MWCNT sensors decorated with Rh, Pt, or Ni clusters as well as characterized and non-decorated CNT. The device is able to discriminate other compounds than benzene and will measure at the ppb range at ambient temperature in the presence or absence of oxygen. The detector is portable and easy to handle in the field. Some of the device benefits are selectivity to benzene, high sensitivity (LOD 25 ppb), low production cost, no humidity effect and very low power consumption.

E Hand-held Particle Sensor & Web-based Visualization Tools

Chris Bartley

In all its projects, the CREATE Lab seeks to effect positive, lasting, and meaningful change in communities around the world by coupling deep problems with understanding, innovation, and cultural transformation. We demonstrate here our new, low-cost air quality monitor as well as open-source data visualization tools. Come for a hands-on demo of the air quality monitor and try out the visualization tools as data is gathered in real time.

F Cost-efficient Networks of Sensors for Continuous Monitoring of Diffuse Pollution, Practical Application to Odorant Compounds

Olivier Zaouak[1], Bruno Aubert[1], Jean-Baptiste Castang[2]
[1]Cairpol, France
[2]EM Research Labs LLC, GA

The miniature cost-efficient sensors, Cairsens, for O_3/NO_2, H_2S and NH_3 monitoring will be presented and before a release in summer 2013, the new $PM_{2.5}$ sensor, Cairsol Vif, will be exhibited.

A tech demo of the autonomous wireless measurement system obtained by combining Cairsens with wireless communication, a solar panel, and a backup battery (CairNet) will be performed. The user-friendly interface (CairMap) that centralizes and permits a rapid and easy management of Cairnet measurement data will be presented; an example of on-line and real-time network monitoring of odorous compounds emitted by a waste water treatment plant in France will be displayed.

G A Wireless and Wearable Sensor for Detection of Environmental Volatile Organic Compounds

Cheng Chen, Francis Tsow, Xiaojun Xian, Yue Deng, Erica Forzani, Nongjian Tao
Arizona State University, Biodesign Institute

A wireless and wearable VOC sensor will be demonstrated. The sensor combines the selective molecular binding polymer and micro-fabricated quartz tuning fork detector, which can communicate with a common smart phone through Bluetooth, and allow for accurate measurement of volatile organic compounds at personal level in real time.

H Citizen Science Using Air Pollution Sensors & EPA's C-FERST (Community-Focused Exposure and Risk Screening Tool)

Valerie Zartarian, Shannon O'Shea, Ronald Williams, Richard Allen

EPA's Community-Focused Exposure and Risk Screening Tool (C-FERST) is a web-based "toolkit" that provides access to a variety of information resources that can help communities learn more about environmental issues and risks in their area, in order to create healthier places to live. C-FERST includes community guidance, fact sheets, maps, reports, a local data table, potential solutions, and best practices. This tool provides information to assist communities with identifying and analyzing environmental issues and the actions they can take to address them. By providing tools, data, potential solutions, and a venue for sharing community-level solutions, C-FERST helps build capacity and engage communities in addressing their own environmental health issues. The beta test version currently on the EPA website is being refined, tested, and used by several pilot communities. The primary impact of this tool is anticipated to be use by EPA and other agencies, communities, and other end users taking actions to improve public health. After external peer review, C-FERST will be available to the public in 2014 for broad use to support community assessments. C-FERST is expected to increase the quality and accessibility of science in environmental health decision-making. The live demo will illustrate how:

1. to upload air pollution sensors data into C-FERST maps that also include many other data layers, emphasizing that EPA doesn't maintain the citizen-collected data;
2. information on types of community air sensors can be provided through C-FERST (emphasizing that EPA doesn't endorse use of particular equipment); and
3. C-FERST can support community-based sensing for non-regulatory purposes (Regions, Program Offices, external stakeholders), and environmental education.

I Managing, Quality Controlling, and Displaying Big Data: the Data Management System (DMS)

Briana J. Gordon
Sonoma Technology, Inc., Petaluma, CA

The portability and accessibility of low-cost small air quality sensors make it possible to collect extremely large amounts of data in short amounts of time. Big data can be difficult to analyze, particularly when errors and invalid values cloud trends. In order to address these issues, Sonoma Technology, Inc. (STI) developed the Data Management System (DMS) for the U.S. EPA and several air districts. The DMS allows large amounts of data to be quickly and easily ingested, quality controlled, processed, and visualized. The most popular features of DMS include user-friendly creation of quality control checks, time-series graphs, scatterplots, and wind- or pollution-rose diagrams. The DMS was originally developed to manage 1-hour, 15-minute, and 1-minute data. Recently, the DMS was modified to accommodate higher frequency (1-second) pollutant data as well. During the technical demonstration, we will show the utility and practical application of the DMS and explain how it can help communities manage and make sense of big data.

J Compact Multi-pollutant Mid-IR Laser Spectroscopic Trace-gas Sensor - Towards Applications in Distributed Wireless Sensor Networks

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Sensing of airborne chemicals will play a major role in improvement of emissions inventories. Recent studies indicated that industrial emissions may be 10-20x greater than estimates from standard emission factors. New trace-gas sensors capable of autonomous wireless sensor network (WSN) operation will enable large area pollution monitoring and verification of emission rates. In this demo we present our first laser spectroscopic trace-gas WSN platform that provides a basis for development of new emission monitoring technologies. A fully functional single-molecule (CO_2) sensor node, an example WSN deployment, and an ongoing work towards multi-pollutant WSNs targeting benzene and ammonia will be discussed.

K AQMesh - Low Power and Wireless Air Pollution Monitors

Alan Vidal
LANDTEC, Colton, CA, USA

The advent of electrochemical cells capable of measuring ppb levels of air pollutants has opened up the possibility of more cost effective networks of air monitors. Monitors could now be battery powered and have wireless communications, and thus be simple to install. The lower cost also means that networks of monitors could be deployed to give spatial as well as time related data. This technical demonstration allows participants to view the AQMesh monitoring system based on electrochemical cells that have the above benefits. The compact design allows simple installation of multiple monitors into critical air pollution locations, allowing direct measurement of pollution.

L Using Portable Gas Detectors for Analysis of Exhaled Breath Gas

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Demonstration will show how KWJ's Pocket CO and other portable detectors designed to measure gases in air can be used to measure the same gases in exhaled breath. [Bring your own detector.] The procedure takes under one minute and can be done by anyone who can hold their breath for 10 seconds. Depending on design, most instruments can be exposed to both static breath samples (via a plastic bag) and flowing samples (via a straw attached to the calibration hood).

Breath collection protocols can distinguish mouth and lung fractions of any exhaled gas and also track the rate of uptake during exposures and off-gassing after. They also can be used to measure gases in human flatulence (not demonstrated). Biomedically relevant gases include NO, NO_2, O_3, O_2, CO_2, CO, H_2S, H_2, pentane, toluene, ethanol and formaldehyde.

Promoting the breath measurement potential of portable gas detectors would significantly extend the market for these devices and make them more personally meaningful to consumers, especially those with chronic medical conditions such as asthma and heart disease. In addition to being able to provide them with early warning of exposures that could provoke their symptoms, these devices could be used to track their body's response to medications as well as pollutants. Designing features to accommodate the hygienic collection of multiple breath samples using disposable bags or straws would make toxic gas detectors much more useful to emergency first responders. They could then use exhaled gases to quickly and non-invasively triage individuals who may have recently been exposed to any particular nuclear, biological or chemical agent.

M AirCasting: Share Your Air

Michael Heimbinder

AirCasting is a platform for recording, mapping, and sharing health and environmental data using your smartphone. Each AirCasting session lets you capture real-world measurements, annotate the data to tell your story, and share it via the CrowdMap. AirCasting has fostered a DIY environmental monitoring community which maps thousands of measurements a month from enviro-sense and bio-sense devices. As finalists for the My Air, My Health Challenge Michael Heimbinder (HabitatMap), Michael Taylor (Carnegie Mellon CREATE lab), Carlos Restrepo (NYU Wagner), and George Thurston (NYU School of Medicine) will be using the AirCasting platform to conduct a pilot in New York City for a future community health study investigating the correspondence between exposures to carbon monoxide and fine particulate matter and changes in heart rate variability.

N Wearable Low-Cost Air Quality Monitor Tech Demo

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Wearable low-cost air quality monitors (M-Pods) were developed to assess personal exposure of CO_2, O_3, NO_2, CO, and total VOCs. Commercially available low-cost sensor technologies were used in the M-Pod, with the aim of improving our understanding of quantification and uncertainty for sensors that are already widely in use. The M-Pods are part of an ecosystem that includes an Android application to collect, view, and share data, and a web-based analysis platform. The technology demonstration will allow people to wear an M-Pod and interact with the Android phone displaying the data. Users can also try the web interface, where they can view their data through time-series, distribution plots, summary statistics, and maps.

O Personal Device for Counting Airborne Ultrafine Particles

Sang Young Son

University of Cincinnati

Epidemiologic studies of the impact of traffic-related air pollution on human health are frequently limited by the use of surrogate, ambient, or modeled exposure. The need for personal monitoring is evident in susceptible subpopulations, particularly children, who spend significant time at schools and in vehicles, in addition to their homes. Further, children may have high levels of physical activity and be in close proximity to particulate sources that result in higher levels of exposure than those recorded at stationary sampling sites. In order to address current limitations in characterizing exposure, an innovative personal and wearable particle counter capable of measuring, with high spatiotemporal resolution, real-time exposure to ultrafine particles (UFP) has been developed based on the principle of heterogeneous water condensation and validated in laboratory settings and field tests.

The developed personal & wearable ultrafine particle (PWUFP) counter provides superb capabilities in terms of airborne particle counting. The counter performance is tested and validated using the aerosol particle calibration instruments. The tests show that the developed can count every single-particle up to 200,000 particles/cm^3 to particle down to 4.5 nm with sensitivity. This sensitivity is covering most of environmental particles including Diesel Exhaust Particle (DEP), bio-aerosol, and organic compounds of different air pollution sources. The developed counter has a wearable format with approximately 990 cm^3-counter volume and high-mobile-sustainability (up to ± 5-graviatational acceleration mobile condition). By employing a Global Positioning System (GPS), the PWUFP counter provides real-time PM concentration every 1 second with 2-meter spatial resolution.

P RETIGO: A Web-based Tool for Geospatial Timeseries Visualization

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Air monitoring data collection on moving platforms – an instrumented person, bicycle, or vehicle – is now conducted frequently by researchers and citizen scientists. Portable air monitoring instruments with real-time detection capability and advancements in global positioning system (GPS) technology now allow very high spatial and temporal resolution of air pollution data. The traditional mode of evaluating complex geospatial data has been to collect the field data and then utilize sophisticated data analysis and geographical information tools to process and visualize the data. These tools and a skilled analyst are currently and are expected to continue to be relied upon to extract meaningful information from these geospatial data sets. However, these analytical approaches generally take significant time and expertise to conduct, limiting those involved with the analysis process. To simplify the review of geospatial data and expand participation in the analysis process, the Real-Time Geospatial Data Viewer web-based tool is under development and will provide an easy plug-and-play review of geospatial time series. The freely available program will allow data to be viewed in time and space, as well as providing options to reference the geospatial data in terms of distance to a location of interest (e.g., traffic emissions), incorporate ancillary meteorology data, and overlay web-available regional air quality readings.

Q Safecast

Naimisaranya Busek

Safecast is a global network for collecting and sharing citizen and community measurements to empower people with data about their environments. We will demo the bGeigieNanoKit radiation sensor, Safecast radiation data visualization and show prototypes of modules currently in development using off the shelf gas sensors to, when combined with already available sensors, enable any individual to assemble a low cost sensing systems for measuring air quality and enable sharing of that data to benefit their communities.