Research in Review

Issue 1: FY 2013 - 2014

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Recent Seminars

6/11/2015

Deriving Roof Albedo for Seven California Cities Using Remote Sensing

George Ban-Weiss, Ph.D.
University of Southern California

6/12/2015

Evaluation of Regional Isoprene Emission Estimates in California

Allen H Goldstein, Ph.D.
UC Berkeley

6/24/2015

Clean Air Leadership Talks with the 2014 Haagen-Smit Clean Air Award winners:

John C. Wall, Cummins, Inc.
Donald R. Blake, UC Irvine
Kirk R. Smith, UC Berkeley

Check out these and upcoming Research Seminars on our webpage at *arb.ca.gov/research/seminars/seminars.htm*

For More Information

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Welcome

We are pleased to introduce Research in Review, a newsletter that will keep you informed about the Air Resources Board's recently completed research projects. As with California's other environmental policy successes, the State's progress on air quality and climate change issues relies on a strong scientific foundation. ARB's research goals of informing health-based air quality standards, reducing air pollution exposures, and protecting California from the potential impacts of climate change are met through a diverse portfolio of projects.

Each issue of Research in Review will have a brief description of the project and results along with the ARB Contract Number that you can use to look up the full project description, link to the full report, see if a Research Seminar has been scheduled which presents the research problem and results from the Lead Investigator, and more, on our website at *www.arb.ca.gov/research*.

Bart E. Croes, P.E.

Chief, Research Division.

Air Pollution and Climate Change Study

The CalNex study in May and June of 2010 examined the nexus between air pollution and climate change, involving four airplanes, an ocean-going research ship (photo at right), two air monitoring supersites (Bakersfield and Pasadena), and more than 150 highly trained scientists in a joint collaboration between the National Oceanic and Atmospheric Administration (NOAA) and the California Air Resources Board (ARB). The study answered important scientific questions about emissions, chemical transformations, atmospheric transport, and climate processes in California. The data collected during CalNex is being used to improve ARB's emission inventory for greenhouse gases and to inform air quality models used to help develop strategies for attaining air quality standards for ozone and particulate matter of less than 2.5 microns ($PM_{2.5}$) in the South Coast and San Joaquin Valley Air Basins. *Final Report 10-326* synthesizes results from the 100-plus peer-reviewed publications that resulted from the study. *Final Reports 09-317* and *09-333* describe important results for ozone and $PM_{2.5}$. *Final Report 10-305* analyzes data from the associated Carbonaceous Aerosols and Radiative Effects Study (CARES) that took place in northern California in June 2010.

Health

Traffic Pollution Negatively Impacts the Health of the Elderly

The effect of air pollution on elderly residents with coronary artery disease living in retirement communities in the Los Angeles area was examined as part of a larger study funded by the National Institutes of Health. Although the residents spend most of their time indoors, this does not shield them from outdoor pollutants, as the study revealed that a sizeable portion of indoor particles originate from traffic. An association was found between the exposure to traffic-related air pollutants and the expression of genes linked to pathways involved in oxidative stress, inflammation, and coagulation. These pathways are postulated to be part of the mechanism by which air pollution contributes to the progression of cardiovascular disease. *Final Report 09-341*

Childhood Exposure to High Particulate Matter Levels Compromises the Development of the Immune System and Lung Function

An unexpected confluence of factors – a large colony of primates that live outdoors and a series of wildfires in the Sacramento Valley that occurred just after the annual birthing season – presented a unique opportunity to assess the effects of high-level wildfire-enriched $PM_{2.5}$ exposure on infants. As the first study of infant exposure to wildfire-enriched $PM_{2.5}$, the results suggest that infancy is a period during which high $PM_{2.5}$ exposures may adversely influence development of the branch of the immune system that combats infectious disease. These exposures may also adversely affect the development of lung function, leading to changes that will persist into adulthood. *Final Report 10-303*

$PM_{2.5}$ Exposure Can Be Associated with Brain Inflammation and Other Central Nervous System Effects

Numerous studies have demonstrated that exposure to $PM_{2.5}$ is associated with increased heart and lung disease and death; however, little is known about the effects on the brain. This study took advantage of a multi-city project sponsored by the Health Effects Institute to expose mice for six months to concentrated ambient $PM_{2.5}$ in five cities with very different pollutant source profiles – Irvine, CA; Lansing, MI; New York, NY; Sterling Forest, NY; and Seattle, WA. Both inflammatory and oxidative changes in brain tissue were observed. Although such changes are part of the body's normal response mechanisms, their persistence over a prolonged time period might contribute to serious health impacts such as Alzheimer's and Parkinson's Disease. Overall, PM from Irvine and Seattle elicited greater increases in oxidative stress markers than did PM from Lansing; this may reflect higher contributions of fuel combustion detected at the first two sites. These results suggest that ambient PM may produce adverse health outcomes in the brain. *Final Report 08-306*

Urban $PM_{2.5}$ May Be More Toxic than Rural PM

Biological mechanisms through which inhaled particles influence heart and lung disease are not completely understood, and the extent to which differences in $PM_{2.5}$ chemical composition between urban and rural particles influence health effects is largely unknown. Mice were exposed to $PM_{2.5}$ from urban (Sacramento) and rural (Davis) locations, as well as to samples of the same $PM_{2.5}$ treated to neutralize metals or endotoxin. The study compared the production of mediators of blood clotting and inflammation in lungs and blood. Both urban and rural $PM_{2.5}$ elicited inflammatory effects, although the effects were greater with exposure to urban $PM_{2.5}$. In addition, the results suggest that metals did not contribute to inflammatory effects, while endotoxin was a significant contributor to the inflammatory effects of both urban and rural $PM_{2.5}$. *Final Report 10-302*

Indoor Air Quality

Some Residential In-duct Air Cleaners Can Emit Indoor Ozone above the Current California Limit

ARB's air cleaner regulation limits ozone emissions from portable air cleaning devices, but residential in-duct devices are exempt due to a lack of an accepted test method. This study developed a test method and constructed a laboratory test apparatus (photo at right), and tested several types of in-duct devices in the apparatus and in homes. Two of the devices produced substantial amounts of ozone. Based on test results and modeling analyses, some in-duct air cleaners can increase residential levels of ozone above the current California limit for portable air cleaners. *Final Report 09-342*

Climate Change & Energy

Modeling Optimal Pathways to a Low-Carbon Economy in California

An optimization model of the California energy system was used to understand how California can meet its 2050 target for greenhouse gas emissions (80 percent below 1990 levels). This model represents the energy supply (energy resources, electricity generation, and fuel production and infrastructure) and energy demand (commercial, residential, transportation, industrial, and agriculture) sectors in California and simulates the technology and resource requirements needed to meet projected energy service demands. These model choices vary based upon policy constraints (e.g., a carbon cap, fuel economy standards, renewable electricity requirements), as well as technology and resource costs and availability. Multiple scenarios were developed to analyze the changes and investments in low-carbon electricity generation, alternative fuels and advanced vehicles in transportation, resource utilization, and efficiency improvements across many sectors. Model results show that major energy transformations are needed but that achieving the 80 percent reduction goal for California is possible at reasonable average carbon reduction costs. *Final Report 09-346*

Evaluating California's Methane Emissions Inventory

A robust emissions inventory is necessary for the successful development and implementation of California's greenhouse gas reduction program. ARB and several partners have established a Statewide Greenhouse Gas Monitoring Network to measure methane, carbon dioxide, and other climate pollutants. An analysis of the network data suggests that statewide methane emissions are 1.3 to 1.7 times greater than previously known. The majority of emissions are located in the Central Valley, and ongoing research is expected to provide new information to better understand sources of methane and their emissions. *Final Report 09-348*

Local Government Planning Assistance

Two tools were developed to assist California local and regional governments with Assembly Bill 32 and Senate Bill 375 compliance in meeting greenhouse gas and per capita vehicle miles traveled (VMT) targets. The VMT Impact Tool allows users to easily estimate the implications of neighborhood type – for any census tract, city, or region in California – on eight different land use and transportation system characteristics. *Final Report 09-343*

The Land Use and Residential Energy (LURE) Tool allows local governments to quickly compare various land use scenarios accommodating new growth in residential housing to identify which scenario would result in the lowest residential energy use and greenhouse gas emissions. *Final Report 10-323*

A third study used remote sensing to quantify cool roof reflectance and potential in seven California cities: Bakersfield, Long Beach, Los Angeles, Sacramento, San Diego, San Francisco, and San Jose. *Final Report 10-321*

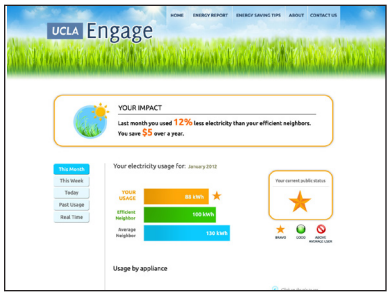
Building Operators are the Key to Bridge the Gap between Potential and Actual Energy Savings in Commercial Buildings

Changes in operations can save 5-30 percent of building energy use at low cost, yet these changes are often not implemented. This study identified two main obstacles in how building operators approach energy use and conservation in their work. First, while building operators have the technical means to reduce energy use there are social, organizational, and technical constraints that limit their ability and motivation. Second, current combinations of buildings, management, and expectations leave many occupants dissatisfied with their indoor environment. These results suggest that shifting the focus of energy use reduction strategies to better include building operators requires: 1) increasing the visibility and status of building operators, 2) improving their ability to see how energy is used, and 3) better integration of the indoor environment with energy efficiency. *Final Report 09-327*

Air Movement as an Energy-Efficient Way to Achieve Occupant Comfort

In California, heating and cooling in commercial buildings consumes roughly one third of their total energy use. Energy savings of 15-20 percent can be achieved by a widened thermostat setpoint range adjustment of 5˚F. This study demonstrated that acceptable office comfort can be provided by very low-wattage fans for a wide range of interior temperatures and humidities. Fans can be used to augment the performance of other energy-efficient technologies, such as radiant-cooled ceilings and natural ventilation. Computer control over fan speed and direction will enable a new generation of extremely efficient and effective devices for providing air movement cooling within buildings. *Final Report 10-308*

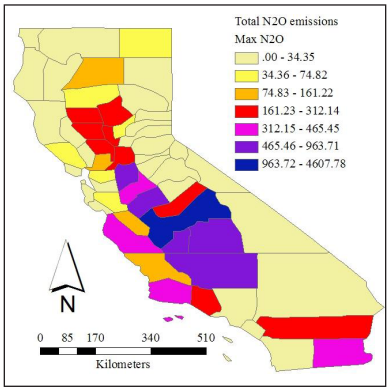
Health-based Messaging More Effective at Inducing Energy Conservation



Reductions in energy usage in the residential sector are needed in order for California to meet its greenhouse gas reduction targets. This study deployed advanced residential energy monitoring technology in 120 apartments in Los Angeles to investigate how real-time appliance-level energy usage information and periodic messages can induce conservation behavior. Health-based messages, which communicate the public health impacts of electricity production, outperformed monetary savings information as a driver of behavioral change in the households. Health messaging was particularly effective for families with children, who achieved up to 20 percent savings. No significant conservation impact was found for participants who received messages informing them about monetary savings. *Final Report 10-332*

Agricultural Emissions

Modeling Nitrous Oxide Emissions from Agricultural Soil Management in California



Agricultural soil is a major source of nitrous oxide (N_2O), a potent greenhouse gas. A process-based modeling tool that incorporates California-specific soil, crop, and management practice information was developed and validated against field test data of N_2O emissions collected from multiple cropping systems in California. The modeled results indicated that the N_2O fluxes vary greatly among different crops and are affected by site-specific environmental factors such as soil properties and weather conditions, as well as management practices. The modeling tool along with its associated database is being used by ARB to produce detailed N_2O emissions estimates based on prevalent agricultural land use and management practices. *Final Report 10-309*

Nitrous Oxide Emissions from California's Feed Production at Dairy Farms

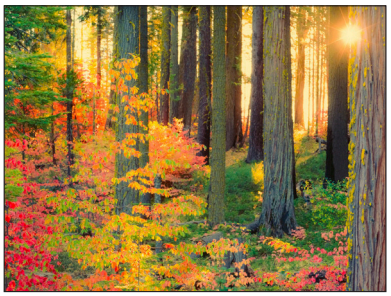
The greenhouse gas nitrous oxide (N_2O) is produced by soil microorganisms. Nitrogen (N) inputs, and soil moisture and carbon stimulate the production of N_2O, which accounts for about one-third of all greenhouse gases from California's agricultural sector. Nitrogen inputs, crop N removal, and cumulative N_2O emissions were measured in three dairy feed production systems receiving liquid and solid manure, as well as synthetic N fertilizer. The annual emission rate of N_2O from the dairy feed fields varied substantially. The N application rate, soil water content, and soil texture were the main factors controlling N_2O emissions. To lower N_2O emission potential, applying N incrementally in moderate doses with the irrigation water according to crop N demand is recommended. *Final Report 09-325*

Nitrogen Oxide Emissions from Agricultural Soils

Agricultural soils are a known source of NO_X, which contributes to the formation of ozone and $PM_{2.5}$. It is estimated that about 20 to 30 percent of the world's NO_X emissions are produced in soils by microorganisms, but their contribution to California's NO_X emissions was unclear. This study measured NO_X fluxes from five major California cropping systems. The soil emissions of NO_X from irrigated agricultural land are estimated to be between 3 to 4 percent of the total statewide NO_X. *Final Report 09-329*

Air Pollution

Evaluating California's Biogenic Volatile Organic Compound Emission Inventory

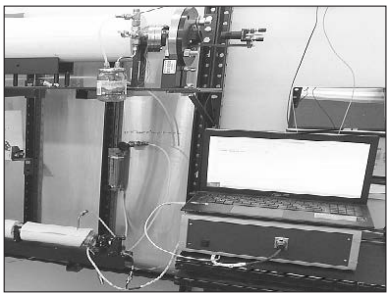


Vegetation in California is a large source of biogenic volatile organic compounds (BVOCs) that contribute to ozone and $PM_{2.5}$ formation. Isoprene is the most important BVOC, with the vast majority of emissions assumed to be from oak trees, based on measurements at leaf and branch levels. First-time aircraft measurements at an ecosystem scale throughout California found that ARB's BVOC emission inventory was generally within 20 percent agreement with the measurements. The measurements confirmed oak woodlands in the foothills of the Sierra Nevada and Coastal Ranges as the primary isoprene emission source in California, with a limited contribution from eucalyptus trees in the Central Valley. Where the model differs from the aircraft data, the issue is likely a combination of discrepancies in the underlying land cover maps, meteorological parameters, and leaf area index data. *Final Report 09-339*

Primary Organic Aerosol Volatility

To improve air quality models used to help develop strategies for attaining air quality standards for $PM_{2.5}$, the primary organic aerosol (POA) emitted from gasoline- and diesel-fueled vehicles was studied at atmospherically realistic concentrations (photo at right). The majority (~75-80 percent) of the particle emissions were elemental carbon that will not evaporate in the atmosphere, with the highest emissions occurring during the cold start and/or hard accelerations. The remaining fraction (~20-25 percent) was POA that could be broadly classified as a semi-volatile material (similar to motor oil) or an effectively non-volatile material (hypothesized to be fuel combustion products). The POA emissions were generally more volatile during the cold start and less volatile after the engine and exhaust system reached operating temperatures. *Final Report 10-313*

Measurement of Low Levels of Sulfur Dioxide Emissions



Sulfur is an important component of combustion and lubricant-derived particles, but current instruments are not capable of measuring the very low sulfur dioxide concentrations typical of vehicles burning today's fuels. A differential optical absorption spectrometer (DOAS) that can measure low levels of sulfur dioxide emissions was constructed, tested, and evaluated for use in ARB's heavy-duty vehicle emissions testing program (photo at right). *Final Report 10-312*

About the Air Resources Board's Research Program

California's progress on addressing environmental problems is guided by a strong scientific knowledge base. The Air Resources Board sponsors a comprehensive program of research into the causes, effects, and solutions of the air pollution problem, supporting its regulations on cars, trucks, fuels, power plants, and other sources. The research is done under the guidance of ARB's Research Screening Committee and in partnership with the University of California system and other research institutions.

Learn more about these projects including their final reports, public seminars, articles in scientific journals, and other products by visiting *www.arb.ca.gov/research*.