NARSTO

Emission Inventory Workshop

Sponsored by:

Innovative Methods for Emission Inventory Development and Evaluation

October 14 – 17, 2003

Pickle Research Center
University of Texas
Austin, TX

NARSTO Emission Inventory Workshop:

Innovative Methods for Emission Inventory Development and Evaluation

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Sponsored by:

NARSTO and CEC

Hosted by:

University of Texas, Austin

Notice: The United States Environmental Protection Agency (EPA) has contributed funding for the printing of this program. The views expressed in these Precedings are those of the individual authors and may not necessarily reflect the views and policies of the EPA. Scientists in EPA have prepared the EPA sections, and those sections have been reviewed in accordance with EPA's peer and administrative review policies and approved for presentation and publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

NARSTO Workshop on Innovative Methods for Emission-Inventory Development and Evaluation

Message from the Workshop Co-Chair

Emission inventories are the foundation for air quality management activities and are essential for development of cost-effective emission control strategies. However, the quality of emission inventories often limits their effectiveness and utilization since the time and energy/cost required to develop emission inventories generally exceeds the resources available. The focus of this Workshop is to identify and prioritize new and innovative tools, techniques, and methods to prepare or evaluate emission inventories with improved quality, cost, and timeliness.

The Workshop will focus on new and innovative methodologies related to the development of emission inventories and emission factors, the evaluation and assessment of the adequacy and quality of emission inventories, the application of emission inventories in air quality management activities, and the development of real time emissions inventories for field studies and air quality forecasting. Although most emission-inventory methodologies are applicable to characterization of any species, the emphasis of the Workshop will be on criteria air pollutants and their precursors. Priority will be placed on current controversial issues, including but not limited to, emissions of multicomponent volatile organic compounds, ammonia, and primary organic particulate matter as well as transient and fugitive releases. In keeping with the NARSTO charter, emission inventory issues related to the United States, Canada, and Mexico will be addressed. Methodologies which can advance current approaches for point, area, mobile, and biogenic sources in the 3-5 year as well as the 10-20 year timeframe are of interest.

Following an overview and background session, the Workshop will be organized in breakout sessions. Breakout sessions will consist of presentations on new and innovative techniques related to a topic area followed by discussion of the participants to identify and prioritize techniques which can make an impact in the emission inventory community and are strong candidates for additional research and development funding. The product of the Workshop will be a synthesis paper with findings and recommendations.

NARSTO is a public/private partnership, whose membership spans government, the utilities, industry, and academia throughout Mexico, the United States, and Canada. Its primary mission is to coordinate and enhance policy-relevant scientific research and assessment of tropospheric pollution behavior; its activities provide input for science-based decision-making and determination of workable, efficient, and effective strategies for local and regional air-pollution management. NARSTO was formerly an acronym for “North American Research Strategy for Tropospheric Ozone.” However, the term NARSTO has become simply a wordmark signifying this tri-national, public-private partnership for dealing with multiple features of tropospheric pollution, including ozone and suspended particulate matter. More information on NARSTO and the Workshop can be found at http://www.cgenv.com/narsto/.

The Workshop is co-sponsored by the Commission for Environmental Cooperation (CEC) of North America. The CEC is an international organization created by Canada, Mexico and the United States under the North American Agreement on Environmental Cooperation (NAAEC). The CEC was established to address regional environmental concerns, help prevent potential trade and environmental conflicts, and to promote the effective enforcement of environmental law. The Agreement complements the environmental provisions of the North American Free Trade Agreement (NAFTA). More information on the CEC can be found at http://www.cec.org.

J David Mobley

J. David Mobley

Co-Chair, NARSTO Emission Committee

Schedule at a Glance

Time	Session
Tues, Oct 14	
1:00 - 5:00	General Session
5:00 - 7:00	Poster Session and Mixer
Wed, Oct 15	
8:30 - 11:30	Source and Flux Measurements
	Mobile and Tunnel Studies
	Ground and Aircraft Observations
11:30 - 1:00	Lunch (On Your Own)
1:00 - 5:00	Source and Flux Measurement
	Mobile and Tunnel Studies
	Satellite Observations
Thurs, Oct 16	
8:30 - 11:30	Air Quality and Receptor Modeling
	Emission Modeling
	Evaluation and Uncertainty Assessment
11:30 - 1:00	Lunch (On Your Own)
1:00 - 5:00	Air Quality and Receptor Modeling
	Emissions Modeling
	Data Management
Fri, Oct 17	
9:00 - 12:00	Report Out and Closing Remarks

NARSTO Emission Inventory Workshop

Tuesday, October 14, 2003

1:00 pm Welcome by David Mobley, US EPA and Steve Cadle, GM (NARSTO Emission Committee Co-Chairs)

1:15 pm “The Importance of Emission Inventories from a Policy and Political Perspective,” David Schanbacher, Texas Commission on Environmental Quality.

1:45 pm “The Role of Emission Inventories in Environmental Policy Decisions Over the Next Few Years in Canada, Mexico, and US,” Paul Miller, Commission for Environmental Cooperation.

2:15 pm “Emission Inventory Vulnerabilities and Recommendations to Minimize Them,” George Hidy, Envair.

2:45 pm Break

3:00 pm “Emission Inventory Needs and Enhancements Planned for Canada,” Marc Deslauriers, Environment Canada.

3:30 pm “Emission Inventory Needs and Enhancements Planned for Mexico,” Lenora Rojas Bracho, Mexico INE

4:00 pm “Emission Inventory Needs and Enhancements Planned for the US,” Phil Lorang, US EPA.

4:30 pm Organization and Charge to Breakout Groups, David Mobley, US EPA.

5:00 pm Adjourn to Poster Session

5:00 pm - 7:00 pm Poster Session and Mixer - Sponsored by ERG.

Tuesday, October 14, 2003

Poster Session	**Facilitator:**	**Paula Fields, ERG**
	Scribes:	**Jake Hales, Envair**
		Jozef Pacyna, NIAR

1. "Rethinking Emissions Inventories: Theory, Innovation, and Practice Within the Southern Oxidants Study," E. Cowling, North Carolina State University; C. Cardelino, Georgia Institute of Technology; C. Furiness, North Carolina State University.
2. "Preliminary Results of the MeditAIRaneo Project: A Novel Approach to Derive the Emission of Biogenic Volatile Organic Compounds (VOC Relevant) to Ozone and Aerosol Formation in Temperate Areas of Europe," P. Ciccioli, Instituto di Metodologie Chimiche del CNR, Italy; P. Stefani, Università della Tuscia, Italy; A. Scifo, Environmental System Analysis Srl, Italy; R. Valentini, Università della Tuscia, Italy; A. Metallo , Università La Sapienza, Italy; M. C. Cirillo, R. De Lauretis, APAT, Italy; A.A. Poli Environmental System Analysis, Italy.
3. "Screening of NIF 3.0 Format Submissions to the National Emission Inventory," J. Paumier, MACTEC, Inc; R. Thompson, A. Pope, and S. Dombrowski, US EPA.
4. "Texas Air Quality Study 2000 (TexAQS) Special Point Source Inventory," J. Mellberg, G. Cantu, R. Thomas, J. Smith, J. Neece, Texas Commission on Environmental Quality.
5. "Use of MOBILE6 to Develop and Quality Assure "Link-Based" Inventories for the 8-County Houston/Galveston Nonattainment Area," C. Kite, Texas Commission on Environmental Quality.
6. "A Conceptual Model to Adjust Fugitive Dust Emissions to Account for Near Source Particle Removal in Grid Model Applications" T. Pace, US EPA.
7. "Measurement of PM_{10} Emission Factors from Paved Roads Using On-Board Particle Sensors," D.R. Fitz, C. Bufalino, College of Engineering-Center for Environmental Research and Technology, University of California, Riverside.
8. "Fuel-Based Mobile Source Emission Inventory Methods," D.H. Stedman and G.A. Bishop, University of Denver.
9. "Measurement and Modeling of Vehicle Tailpipe Emissions Based Upon On-Road Data from Portable Instruments," H. C. Frey, North Carolina State University.
10. "The Development of Real World Emissions Inventories Using Portable Vehicle Emissions Monitors (PEMS)," M. Vojtisek-Lom, P. J. Wilson, T. Albrechcinski, Clean Air Technologies International, Inc.
11. "On-Road Measurement of Automotive Particle Emission Factors by Ultraviolet Lidar and Transmissometer," H. Moosmüller, C. Mazzoleni, P.W. Barber, H.D. Kuhns, R E. Keislar, and J.G. Watson, Desert Research Institute.
12. "Development of the MOBILE6-Mexico Emission Factor Model," S. Kishan, A.D. Burnette, M. Hebets, ERG, Inc.
13. "Federal Highway Administration's Particulate Matter Ambient Concentration and Traffic Correlation Study," K.N. Black, Federal Highway Administration.

14. "Decadal Trend in Emissions of Benzene Relative to Other NMHC's: Evidence from Ambient Atmospheric Measurement," D.D. Parrish, B.J. Howard, P.D. Goldan, W.C. Kuster, F.C. Fehsenfeld, Aeronomy Laboratory, National Oceanic and Atmospheric Administration.
15. "Use of DOAS Data at Two Monitoring Sites to Locate Benzene Emissions in Tampa, Florida," C. Amalifitano, K. Kenty, N. Poor, S. Campbell, University of South Florida; T. Tamanini, C. Lopez, Environmental Protection Commission of Hillsborough County.
16. "The Application of Density Measurement of Greenhouse Gases Using Aircrafts and Kite Planes for GHG Inventory Verification," H. Nakane, G. Inoue, and T. Aizawa, Center for Global Environmental Research (CGER) of National Institute for Environmental Studies of Japan (NIES).
17. "Development of the API Compendium for Estimating Greenhouse Gas Emissions," K. Ritter, American Petroleum Institute; S. Nordrum, ChevronTexaco; T. Shires, URS Corporation.
18. "State-of-the-Art Greenhouse Gas Emission Inventory Guidance and Tools," A. Choate, P. Groth, R. Freed, M. Stanberry, ICF Consulting; A. Denny, US EPA.
19. "Establishment of the Intergovernmental Panel on Climate Change (IPCC) Emission Factor Database," J. Mangino, US EPA; K. Tanabe, IPCC NGGIP-TSU, Hayama, Japan; T. Pulles, TNO, Netherlands; K. Mareckova, SHMU, Slovakia.
20. "GHG Emission Inventories for Agroecosystems: Role of GIS and Process-based Models in Developing Site Specific Emission Factors, Assessing Variability, and Providing Uncertainty Estimates," W. Salas, Applied Geosolutions, LLC; C. Li, University of New Hampshire.
21. "Global Emission Inventory Activity (GEIA) – Moving Forward," P. Middleton, GEIA Center.
22. "Global Satellite Observation of Greenhouse Gas Emissions - Evergreen," A. Goede, Royal Netherlands Meteorological Institute; J. M. Pacyna, Norwegian Institute for Air Research and other EVERGREEN Partners.
23. "Scientific Top-to-Bottom Estimation of Large-Scale Heavy Metal Emissions for the Modeling and Environmental Assessment in Russia and other NIS Countries," S. Gromov, Inst of Geography RAS, Russia; S.Kakareka, Inst for Problems of Natural Resources Use & Ecology, Belarus; and J. Pacyna, Norwegian Inst for Air Research, Norway.
24. "Global Emission of Mercury from Anthropogenic Sources in 2000," E.G. Pacyna and J. M. Pacyna, Norwegian Institute for Air Research.
25. "The US Mercury Emission Inventory for the Arctic Council Mercury Project" K. Rackley, A. Pope, D. Mobley, S. Durkee, D. Steele, M. Engle, US EPA.
26. "St. Louis Community Air Project (CAP) Toxics Emission Inventory Development," M. Freebairn, Missouri Department of Natural Resources.

Note: The poster session and mixer are sponsored by ERG.

Wednesday, October 15, 2003

Session 1. Source and Flux Measurements

Facilitator: Kathy Pendleton, Texas
Dick Karp, API
Scribe: Mollie Freebairn, Missouri

8:30	am	“Measurement Methods, Innovative Source and Flux Measurements,” A. Cuclis and D. Byun, University of Houston.
8:45	am	“Direct Flux Measurements of Volatile Organic Compounds,” B. Lamb, S. Pressley, E. Velasco, E. Allwine, H. Westberg, Washington State University; T. Jobson, M. Alexander, P. Prazellor, Pacific Northwest National Laboratory.
9:00	am	“Estimation of Cooling Tower VOC Emissions Based on Actual Measurements,” K.N.T. Olson, Texas Commission on Environmental Quality; G. Sarwar, S. Chang, A. Webb, V. Torres, R. Corsi, University of Texas at Austin.
9:15	am	Open Discussion
10:00	am	Break
10:15	am	“Evaluation of Passive FTIR to Determine Efficiency of Operating Industrial Flares,” K.N.T. Olson, Texas Commission on Environmental Quality; W. Crow, URS; B. Spellicy, IMACC.
10:30	am	“The Use of a Gas Imaging Device for Detecting Fugitive Emissions and the Potential Underestimation of Fugitive Emissions in Chemical Plants and Refineries,” M. Smylie, ENVIRON.
10:45	am	“Inferring Industrial VOC Emissions Inventories Based Upon VOC Observations,” M. Estes, J. Jarvie, D. Boyer, J. Smith, J. Price, Z. Fang, S. Wharton, Texas Commission on Environmental Quality.
11:00	am	Open Discussion
11:45	am	Lunch (On Your Own)
1:00	pm	“A Passive Flux Denuder for Evaluating Emissions of Ammonia at a Dairy Farm,” D.R. Fitz, J.T. Pisano, University of California.
1:15	am	“Leaf, Canopy, Landscape, and Regional Measurements for Developing and Evaluating Biogenic VOC Emission Models,” A. Guenther, J. Greenberg, P. Harley, T. Karl, E. Nemitz, A. Turnipseed, C. Wiedinmyer, National Center for Atmospheric Research.
1:30	pm	“An Improved Measurement Method and New Speciated PM2.5 Emission Factors for Stationary Combustion Sources,” G.C. England, O.M.C. Chang, S. Wien, GE Energy and Environmental Research Corporation; K. Stirling, U.S. Department of Energy National Petroleum Technology Office; B. Liebowitz, New York State Energy Research and Development Authority; J. Watson, J. Chow, B. Zielinska, Desert Research Institute; and P.K. Hopke, Clarkson University.
1:45	pm	Open Discussion
2:15	pm	Break

Wednesday, October 15, 2003

Session 1. Source and Flux Measurements

Facilitator: **Kathy Pendleton, Texas**
Dick Karp, API
Scribe: **Mollie Freebairn, Missouri**

2:30 pm “Design of a Next Generation Dilution Sampling System to Quantify Fine Particulate Emissions from Combustion Systems,” A.L. Robinson, E. Lipsky, E. Weitkamp, Carnegie Mellon University.

2:45 pm “PI-SWIRL: A New Technique for Measuring Wind Blown Dust Emission Potential,” V. Etyemezian, S. Ahonen, J. Gillies, H. Kuhns, H. Moosmüller, D. Nikolic, Desert Research Institute; and M. Pitchford, NOAA.

3:00 pm “Emission Factors for Visibility Impairment from Fugitive Dust Emissions,” H. Moosmüller, R. Varma, W.P. Arnott, J. Walker, H.D. Kuhns, V. Etyemezian, and J.A. Gillies, Desert Research Institute.

3:15 pm “Measuring Trace Gas Fluxes from an Aircraft Platform,” P.V. Doskey, V.R. Kotamarthi, M.S. Pekour, D.R. Cook, M.T. Ritsche, Argonne National Laboratory; B.T. Jobson, J. Hubbe, Pacific Northwest National Laboratory.

3:30 pm Open Discussion

Session 2. Mobile and Tunnel Studies

Facilitator: **Steve Cadle, GM**
Gene Tierney, US EPA
Scribe: **Dana Coe, Sonoma**

8:30 am “EPA’s Plans to Estimate the Criteria Air Pollutant Emissions of Highway Vehicles and Off-Highway Equipment with MOVES,” G. Tierney, US EPA.

8:45 am “Utilization of Tunable Infrared Laser Sensors for Cross-Road Mobile Source Emissions Characterization and Quantification,” M.S. Zahniser, D.D. Nelson, J.B. McManus and C.E. Kolb, Aerodyne Research, Inc.

9:00 am “Mobile Laboratory Mounted Fast Response Instrument Methods for On-Road Vehicle Emissions Measurements,” C.E. Kolb, S.C. Herndon, J.B. McManus, J.H. Shorter, M.S. Zahniser, D.D. Nelson, J.T. Jayne, M.R. Canagaratna, D.R. Worsnop, Aerodyne Research, Inc.; B.K. Knighton, Montana State University; E. Dunlea, M. Zavala, L.T. Molina, and M.J. Molina, Massachusetts Institute of Technology.

9:15 am “Spatially-Resolved, Direct Measurement of Road Dust Emissions from Vehicles,” H. Kuhns, V. Etyemezian, J. Gillies, D. Nikolic, S. Ahonen, Desert Research Institute.

9:30 am Open Discussion

10:00 am Break

10:15 am “Automotive Particulate Matter and Gaseous Emission Factors from On-Road Measurement in Las Vegas, NV,” C. Mazzoleni, H.D. Kuhns, H. Moosmüller, R.E. Keislar, P.W. Barber, D. Nikolic, N.F. Robinson, and J.G. Watson, Desert Research Institute.

Wednesday, October 15, 2003

Session 2. Mobile and Tunnel Studies	**Facilitator:**	**Steve Cadle, GM** **Gene Tierney, US EPA**
	Scribe:	**Dana Coe, Sonoma**

10:30	am	"Identification of Excessive Emissions System Failure Rates in High-Mileage Fleet Vehicles Based on Networkcar's Continuous On-Board Emissions Monitoring System," M. Banet, Reynolds Company.
10:45	am	"Measurements of Marine Vessel Emissions," E.J. Williams, B. Lerner, University of Colorado; A.M. Middlebrook, J.F. Meagher, F.C. Fehsenfeld, NOAA.
11:00	am	"Analysis of Motor Vehicle Emissions in a Houston Tunnel during the Texas Air Quality Study 2000," G.R. McGaughey, N.R. Desai, D.T. Allen, University of Texas at Austin; R.L. Seila, W.A. Lonneman, U.S. EPA; M.P. Fraser, Rice University; R.A. Harley, University of California-Berkeley; A.K. Pollack, ENVIRON Intl Corp; J.M. Ivy, J.H. Price, Texas Commission on Environmental Quality.
11:15	am	Open Discussion
11:45	am	Lunch (On Your Own)
1:00	pm	"Pacific 2001: Cassiar Tunnel Study - Particulate Matter Emissions Measurements," L. A. Graham, C. Gray, Environment Canada; S. Rogak, T. Brakel, University of British Columbia.
1:15	pm	"Estimation of Mobile Emission Ratios for Sulfur, Nitrogen, Carbon and Mercury from Field Measurements in Atlanta, GA," E.S. Edgerton, Atmospheric Res. & Analysis, Inc.; J.J. Jansen, Southern Company.
1:30	pm	"Estimation of Paved and Unpaved Road Dust Emissions in Mexico," M.E. Wolf, P.G. Fields, ERG, Inc.; S. González-Ayala, International Communities Research Center.
1:45	pm	"Characteristics of the Monterrey Metropolitan Area Vehicle Fleet and Its Estimated Emissions," G. Mejia, F. Obregón, J. Sánchez, J. Daumerie, Center for Environmental Quality, ITESM, Mexico; J. Horne, Massachusetts Institute of Technology; A. Burnette, ERG.
2:00	pm	Open Discussion
2:30	pm	Break
2:45	pm	"Comparison of Remote Sensing Measurements of On-Road Vehicle Emissions in Chicago and Denver with MOBILE6 Predictions," T. Stoeckenius, C. Tran, ENVIRON International Corp.
3:00	pm	"Traffic-Related Emission Factors in Two Major Freeways in Southern California," R.C. Yu, Y. Zhu, W.C. Hinds, J.R. Froines, University of California at Los Angeles.
3:15	pm	"Temporal Patterns in Nitrogen Oxide Emissions from Diesel Engines," R. Harley, University of California at Berkeley.
3:30	pm	"EPA's Utilization of Portable Emission Measurement Systems (PEMS)," and "NMIM: EPA's Consolidated Emissions Modeling System for MOBILE and NONROAD," G. Tierney, US EPA.
3:45	pm	Open Discussion

Wednesday, October 15, 2003

Session 3. Ground and Aircraft Observations

Facilitators: George Hidy, Envair
Paul Miller, CEC
Scribes: Elaine Chapman, PNNL
David Parrish, NOAA

8:30	am	"Using Ambient Measurements to Critically Evaluate the Temporal Trends of U.S. Carbon Monoxide Emission Inventories," D.D. Parrish, NOAA.
8:45	am	"Assessing Anthropogenic Emissions Inventories Using Measurements From Aircraft," T.B. Ryerson, F.C. Fehsenfeld, J.S. Holloway, D.D. Parrish, M. Trainer, NOAA; E.L. Atlas, S.G. Donnelly, S. Schauffler, V. Stroud, NCAR Atmospheric Chemistry Division.
9:00	am	"Biomass Burning Emission Estimates using SEARCH Measurements," E.S. Edgerton, Atmospheric Res. & Analysis, Inc; J.J. Jansen, Southern Company.
9:15	am	"Tower Based Real Time Monitoring System for Quantifying Fugitive Emissions," J.A. Gillies, H. Kuhns, V. Etyemezian, D. Nikolic, H. Moosmüller, and W.P. Arnott, Desert Research Institute.
9:30	am	Open Discussion
10:00	am	Break
10:15	am	"Emission Inventory Development through Highly-Time-Resolved Ambient Sampling," J.M. Ondov, University of Maryland.
10:30	am	"Real-Time Monitoring of Gases and Aerosols Reveals Source Contributions to Air Quality," N. Poor, C. Amalfitano, University of South Florida; J.M. Ondov, P. Pancras, S. Gazula, University of Maryland; P. Dasgupta, R. Al-Horr, Texas Tech University.
10:45	am	"Development of an Integrated Emission Profile for a Coke Facility with Fence-Line Measurements Using Highly-Time-Resolved Instruments," A.L. Robinson, E. Wietkamp, E. Lipsky, Carnegie Mellon University; P. Pancras, J.M. Ondov, University of Maryland.
11:00	am	"Characterization of the Diurnal PM Peaks at Sunland Park, New Mexico," N. Cadenas, W. Li, J. Walton, University of Texas at El Paso; R. Arimoto, New Mexico State University; H. Morales, D. Trujillo, University of Texas at El Paso.
11:15	am	Open Discussion
11:45	am	Lunch (On Your Own)

Wednesday, October 15, 2003

Session 3. Satellite Observations

Facilitators: George Hidy, Envair
Paul Miller, CEC
Scribes: Elaine Chapman, PNNL
David Parrish, NOAA

1:00 pm	"Utilization of NASA Data and Information to Support Emission Inventory Development," D. Neil, J. Fishman, NASA; J. Szykman, US EPA.
1:15 pm	"Remote Sensing of Tropospheric Carbon Monoxide," D.P. Edwards, National Center for Atmospheric Research.
1:30 pm	"Global Inventory of Nitrogen Oxide Emissions Constrained by Space-Based Observations of NO_2 Colums," R.V. Martin, Dalhousie University; D. J. Jacob, Harvard University; K.V. Chance, T.P. Kurosu, Harvard-Smithsonian Center for Astrophysics; P.I. Palmer, M.J.Evans, Harvard University.
1:45 pm	"Top-Down Isoprene Emission Inventory for North America Constructed from Satellite Measurements of Formaldehyde Columns," D.J. Jacob, D.S. Abbot, P.I. Palmer, Harvard University; R.V. Martin, K.V. Chance, Harvard-Smithsonian Astrophysical Observatory.
2:00 pm	Open Discussion
2:30 pm	Break
2:45 pm	"Improving Biogenic Emission Estimates with Satellite Imagery," T.E. Pierce, NOAA.
3:00 pm	"Development of A Forest Fire Smoke Emission and Dispersion Model Using Real-time MODIS Data," W.M. Hao, J.M. Salmon, B. Nordgren, USFS Rocky Mountain Research Station, Missoula Fire Sciences Laboratory.
3:15 pm	"Estimation of Biomass Smoke Emissions and Transport using Satellite and Surface Observations," R.B. Husar, S. Raffuse, Washington University in St. Louis.
3:30 pm	"Use of Remotely-Sensed Data in the Development and Improvement of Emission Inventories," S.M. Roe, J. Hearne, E.H. Pechan and Associates; T. Summers, R. Sedlacek, D. Jenkins, Arizona Department of Environmental Quality.
3:45 pm	Open Discussion

Thursday, October 16, 2003

Session 4. Air Quality and Receptor Modeling

Facilitators: Robin Dennis, US EPA/NOAA
Luisa Molina, MIT
Scribe: Bill Benjey, US EPA/NOAA

8:30	am	"Positive Matrix Factorization Analysis of Volatile Organic Compound Concentrations in Houston, TX," B. Buzcu, M.P. Fraser, Rice University.
8:45	am	"Source Apportionment of VOCs in the Houston, Texas Area," S.G. Brown, H.R. Hafner, Sonoma Technology.
9:00	am	"An Innovative Method for Source Identification and Apportionment of PM: Isotope Measurements of Carbon Species (OC/EC) via Thermal Desorption/Combustion & GC-IRMS," L. Huang, W. Zhang, J. Brook, D. Ernst, A. Chivulescu, G. Lu, and S. Sharma, Meteorological Service of Canada.
9:15	am	Open Discussion
10:00	am	Break
10:15	am	"Implications on Contributing Sources by Chemical Composition in Regional Surficial Soil," H. García , W.W. Li, J. Walton, University of Texas at El Paso; R. Arimoto, C. Schoeesslin, S. Sage, R. Okrasinski, J. Greenlee, W. Gutman, New Mexico State University.
10:30	am	"Separating the Contribution of Gasoline and Diesel Vehicles to Ambient Fine Particle Levels: Verification of Results from Receptor Models," M.P. Fraser , B. Buzcu, Z.W. Yue, University of Houston; G.R. McGaughey, N.R. Desai, D.T. Allen, University of Texas; R.L. Seila, W.A. Lonneman, US EPA; R.A. Harley, University of California, Berkeley.
10:45	am	"Tropospheric Chemical Data Assimilation and Inverse Modeling at the Meteorological Service of Canada," R. Ménard, A. Robichaud, Y. Yang, S. Polavarapu, Meteorological Service of Canada; J. Kaminski, York University; E. Cosme, McGill University.
11:00	am	Open Discussion
11:30	am	Lunch (On Your Own)
1:00	pm	"Inverse Modeling to Estimate NH_3 Emission Seasonality and the Sensitivity to Uncertainty Representations," A.B. Gilliland, NOAA; H. Im, M.L. Stein, University of Chicago.
1:15	pm	"Industrial Hydrocarbon Emission Adjustments Used in 2002 Houston-Galveston-Brazoria Ozone SIP Modeling," J. Smith, D. Boyer, M. Estes, G. Cantu, R. Thomas, Texas Commission on Environmental Quality.
1:30	pm	"Estimates of Anthropogenic Secondary Organic Aerosol Formation in Houston, Texas," W. Dechapanya, M. Russell, D.T. Allen, University of Texas at Austin.
1:45	pm	Open Discussion
2:30	pm	Break
2:45	pm	"Sensitivity of Urban Ozone Formation to Chlorine Emission Estimates," S. Chang, E. McDonald-Buller, Y. Kimura, G. Yarwood, ENVIRON International Corp; J. Neece, Texas Natural Resource Conservation Commission; M. Russell, P. Tanaka, D. Allen, University of Texas at Austin.

Thursday, October 16, 2003

Session 4. Air Quality and Receptor Modeling	**Facilitators:**	**Robin Dennis, USEPA/NOAA**
		Luisa Molina, MIT
	Scribe:	**Bill Benjey, US EPA/NOAA**

3:00 pm “Weekday-weekend Emissions Patterns in Southern California: Observations and Implications,” D. Coe, L. Chinkin, T. Funk, C. Gorin, S. Reid, P. Stiefer, Sonoma Technology, Inc.

3:15 pm “How the Representation of Emissions Inventories in Air Quality Regulatory Modeling in the Presence of High Temporal Variability Effects the Choice of Control Strategies,” M. Webster, M. Symons, H. Jeffries, University of North Carolina; T. Tesche, D. McNally, Alpine Geophysics.

3:30 pm Open Discussion

Session 5. Emission Modeling	**Facilitators:**	**David Allen, U of Texas**
		Roger Westman, Allegheny Co
	Scribe:	**Susan Wierman, MARAMA**

8:30 am “Incorporating Boiler-Level Data from EPA’s Acid Rain Program into a Modeling Emission Inventory,” R. Thomas, T. Lawshae, G. Cantu, J. Mellberg, Texas Commission on Environmental Quality.

8:45 am “CEM Data Analysis and Use,” M. Janssen, LADCO; G. Judson, Wisconsin-DNR; K. Baker, LADCO.

9:00 am “Stochastic Modeling of Ambient Ozone Formation with Emission Variability,” Y. Kimura, J. Nam, D. Allen, University of Texas at Austin.

9:15 am “The Development of a Stochastic Emissions Inventory for Industrial Emissions in Houston/Galveston Texas and Its Use in Photochemical Modeling,” H. Jeffries, M. Webster, M. Symons, University of North Carolina; T. Tesche, D. McNally, Alpine Geophysics.

9:30 am Open Discussion

10:00 am Break

10:15 am “Sesquiterpene Emissions and Secondary Organic Aerosol Formation Potentials for Southeast Texas,” W. Vizuete, V. Junquera, D.T. Allen, University of Texas at Austin.

10:30 am “Emissions Associated with Forest, Grassland, and Agricultural Burning during the Texas Air Quality Study,” A. Katamreddy, V. Junquera, D. Allen, University of Texas at Austin.

10:45 am “Improving the Mexico City Biogenic VOC Emissions Inventory,” L.G. Ruiz-Suárez, P. Domínguez, M. Alegre, Y. Jarquín. J. Cruz, Centro de Ciencias de la Atmósfera, UNAM, Circuito Exterior, Ciudad Universitaria, México.

11:00 am Open Discussion

11:30 am Lunch (On Your Own)

1:00 pm “NH_3 Emission Inventories for Agroecosystems: Role of GIS and Process-based Models in Developing Site Specific Emission Factors, Assessing Variability, and Providing Uncertainty Estimates,” W. Salas, Applied Geosolutions, LLC; C. Li, University of New Hampshire.

1:15 pm “Development of the Next Generation of an Ammonia Emission Inventory,” M. Janssen, LADCO.

Thursday, October 16, 2003

Session 5. Emission Modeling (Continued)

Facilitators: **David Allen, U of Texas**
Roger Westman, Allegheny Co
Scribe: **Susan Wierman, MARAMA**

1:30 pm “Assembling Emission Inventories of Primary Carbonaceous Aerosols,” D.G. Streets, Argonne National Laboratory; T.C. Bond, Natl Center for Atmospheric Research; G.R. Carmichael, J. Woo, University of Iowa; Z. Klimont, Intl Institute for Applied Systems Analysis, Austria.

1:45 pm “Integrated SO_x Emission Trend Estimation for the Sustainability Transition,” R. Husar, J. Agan, K. Miller, J. Reynolds, C. Reid, J. Husar, S. Falke, Washington University in St. Louis.

2:00 pm Open Discussion

2:30 pm Break

2:45 pm “Evaluating the Performance of a Comprehensive Regional Emissions Inventory Using Field Data,” C. Durrenberger, D. Allen, University of Texas at Austin; J. Price, Texas Commission on Environmental Quality.

3:00 pm “Comparison of Emissions Processing Systems and Emissions Inventories used for Houston-Galveston Air Quality Studies,” D.W. Byun, S. Kim, University of Houston.

3:15 pm “OPen Emissions Models (OPEM)—Re-Thinking The Emissions Modeling Paradigm,” M. Janssen, LADCO; Z. Wang, University of California, Riverside.

3:30 pm Open Discussion

Session 6. Evaluation and Uncertainty Assessment

Facilitator: **Rich Halvey, WGA**
Cyril Durrenberger, U of TX
Scribe: **Lisa Graham, Env Canada**

8:30 am “Quantification of Uncertainty in Emission Factors and Emission Inventories,” H. C. Frey, North Carolina State University.

8:45 am “Pacific 2001: Cassiar Tunnel Study – Emission Rate Uncertainty Assessment,” L. A. Graham, D. Dey, Environment Canada.

9:00 am “Evaluation of On-Road Vehicle Emissions Inventory,” E. M. Fujita, Desert Research Institute; T. Stoeckenius ENVIRON International Corp.

9:15 am “Comparing the Point and Non-Point Source Emission Inventory to Ambient Data in Houston,” J. Jolly, F. Mercado, D. Sullivan, Texas Commission on Environmental Quality.

9:30 am Open Discussion

10:00 am Break

10:15 am “Comparison of Biogenic Isoprene Emission Estimates with Aircraft Measurements during the Texas Air Quality Study,” J. Song, W. Vizuete, D. Allen, University of Texas at Austin.

Thursday, October 16, 2003

Session 6. Evaluation and Uncertainty Assessment

Facilitator: Rich Halvey, WGA
Cyril Durrenberger, U of TX
Scribe: Lisa Graham, Env Canada

10:30 am “Improved Methods of Developing Biogenic Emissions Inventories,” M. Estes, J. Smith, F. Mercado, Texas Commission on Environmental Quality.

10:45 am “Characterizing Airmass Outflow using Daily Biomass Burning Emission Inventories in Support of Flight Measurement Campaigns,” J. Woo, G.R. Carmichael, University of Iowa; D. Streets, Argonne National Laboratory; G. Kurata, University of Technology, Japan; Y. Tang, University of Iowa.

11:00 am “Evaluating Regional Emission Estimates Using Field Observations,” G.R. Carmichael, Y. Tang, University of Iowa; G. Kurata, Toyohasi University of Technology, Japan; I. Uno, Kyushu University, Japan; D.G. Streets, Argonne National Laboratory; N. Thongboonchoo, J. Woo, S. Guttikundi, University of Iowa; A. White, University of California at Davis; T. Wang, Polytechnic University, Hong Kong; D.R. Blake, University of California at Irvine; E. Atlas, A. Fried, Natl Center for Atmospheric Research; B. Potter, University of Tulsa; M.A. Avery, G.W. Sachse, NASA Langley; S.T. Sandholm, Georgia Institute of Technology; Y. Kondo, University of Tokyo, Japan; R.W. Talbot, University of New Hampshire; A. Bandy, D. Thorton, Drexel University; A.D. Clarke, University of Hawaii.

11:15 am Open Discussion

11:30 am Lunch (On Your Own)

Session 6. Data Management

Facilitator: Rich Halvey, WGA
Cyril Durrenberger, U of TX
Scribe: Lisa Graham, Env Canada

1:00 pm “Developing the Mexico National Emissions Inventory,” P.G. Fields, M.E. Wolf, ERG, Inc.; G. Acosta-Ruiz, Acosta y Asociados; R. Halvey, Western Governors Association.

1:15 pm “Innovative Methods for Emission-Inventory Development and Evaluation,” T. Chico, Z. Pirveysian, South Coast Air Quality Management District; N. Meskal, Ecotek, MST Solutions Inc.

1:30 pm “Development of a GIS-based Area Source Emission Inventory in the Paso del Norte Air Quality Basin,” H.A. Olvera, W.W. Li, University of Texas at El Paso.

1:45 pm “GIS-Integrated Emissions Inventory Software Solution,” J.L. The, M. Johnson, S. Koo, M. Hilverda, C. The, Lakes Environmental Software, Inc., Canada.

2:00 pm Open Discussion

2:30 pm Break

2:45 pm “Networked Environmental Information System for Global Emissions Inventories (NEISGEI),” B. Hemming, US EPA; S. Falke, University of Washington, St. Louis; T. Keating, US EPA.

Thursday, October 16, 2003

Session 6. Data Management

Facilitator: **Rich Halvey, WGA**
Cyril Durrenberger, U of TX
Scribe: **Lisa Graham, Env Canada**

3:00	pm	"Automating the Integration of Heterogeneous EPA Databases," E. Hovy, A. Philpott, University of Southern California; B. Hemming, US EPA.
3:15	pm	"Compilation and Design of a Distributed Emissions Database of North American Electric Generating Utilities," G. Stella, Alpine Geophysics; S. Falke, Washington University in St. Louis; T. Keating, US EPA.
3:30	pm	"An Integrated Fire, Smoke and Air Quality Network," S. Falke, R. Husar, Washington University in St. Louis, B. Hemming, US EPA.
3:45	pm	Open Discussion

Friday, October 17, 2003

Session 7. Closing Session

9:00 am “EPA Policy or Research Official’s Perspective on Emission Inventories and Innovative Approaches.”

9:30 am Report Out of Priorities and Recommendations from Breakout Session Topics with Open Discussion and Synthesis Period:

Measurement Methods
- Source and Flux Measurements
- Mobile and Tunnel Studies
- Ground, Aircraft and Satellite Observations

Analysis and Application Methods
- Air Quality and Receptor Modeling
- Emission Modeling
- Evaluation, Uncertainty Assessment and Data Management

11:00 am Closing Remarks, Marc Deslauriers, Leonora Rojas Bracho and Phil Lorang

11:45 am Outline of Plans for the Synthesis Paper from the Workshop, Steve Cadle

Plenary Session

The Importance of Emission Inventories from a Policy and Political Perspective

David Schanbacher, P.E.
Texas Commission on Environmental Quality

Emission inventories are one of the keystones of the air quality management process. The policy and political communities often take for granted the technical and scientific foundation of emission inventories when determining the economic and societal impacts of regulations. Inaccurate emission inventories make the policy maker's job much more difficult. Regulations based on faulty inventories can be less effective than anticipated. Unfortunately, we have found ourselves in the difficult situation in Texas of dealing with an air quality attainment strategy for Houston without the technical certainty of an accurate emissions inventory. So, this presentation will emphasize the importance of the technical and scientific efforts of emission inventory developers and evaluators in devising a effective air quality management strategy. In addition, the research efforts to improve the accuracy, quality, timeliness, and cost of emission inventories will be endorsed. Finally, a note of appreciation will be acknowledged for the dedicated efforts of the emission inventory community in attempting to provide the necessary data and information for the policy maker while enduring the general criticism of not delivering it better and faster.

The Role Of Emission Inventories In Environmental Policy Decisions Over The Next Few Years In Canada, Mexico, And The US

Paul J. Miller
North American Commission for Environmental Cooperation
Montréal, Québec, Canada

North American emission inventories are increasingly sophisticated, with improvements in the level of detail, frequency of updating, and public access. Emission inventories, however, also vary considerably in different regions of North America in their methodologies, level of detail, and public accessibility. The need to develop regional plans to reduce visible haze, fine particles, smog, and long-lived air-borne toxics is creating greater pressure for developing high quality, comprehensive and current air emission inventories that can be exchanged easily across international boundaries. These emission inventories should be compatible so that they can be more easily incorporated into regional, bilateral and trilateral initiatives.

There are a number of policy drivers for developing compatible trinational air emission inventories in North America. These include:

- Domestic regulatory and statutory planning requirements that involve atmospheric modeling of airsheds across international boundaries, including multi-day smog or haze events and the long-range transport of persistent toxics in the environment.
- The need for sufficiently detailed information that allows planners to focus on where effective and practical reduction targets exist.
- Transparent data reporting of comparable quality across the three North American countries that can support possible future international emissions trading programs.
- Tracking of air pollutant and greenhouse gas emission trends to monitor the effectiveness of control measures across North America.
- Supporting public “right-to-know” policies through readily accessible information on air pollutants and greenhouse gases emitted in local communities and across the continent.

In June 2001, the environment ministers of Canada, Mexico and the United States, acting in their capacity as Council of the North American Commission for Environmental Cooperation (CEC), adopted a resolution promoting comparability of North American air emission inventories. As a result of this directive, the CEC is supporting work to develop a national air emissions inventory in Mexico, and to facilitate the cross-border exchange of air emission inventory information through linkages of existing databases.

Conventional Emissions Inventories: Maximizing Strengths and Minimizing Vulnerabilities

G. M. Hidy
Envair/Aerochem

The development of local and national emissions inventories in North America has followed a long established practice, largely designed in the early 1970s. NARSTO reviews in 2001 (ozone) and 2003 (PM) have noted that inventories serve a number of different purposes that require different levels of accuracy and precision in space and time. Applications address needs for source specific inventories used for permitting and regulatory compliance, urban and regional planning, industrial technology change, and air quality modeling. Inventories are based on a simple formula incorporating an emission factor, a process input rate, an activity pattern, and an emission control factor. The acquisition of these data for a large number of sources has proceeded over the years based on limited testing of single sources, and subsequent organization by local and national authorities. The inventories have been extended using emissions models to extrapolate inventory data in space and time for air quality assessments.

The emissions inventories prepared by Canada, Mexico and the United States generally have served a number of qualitative and semi-quantitative applications well for regulatory management processes. Nevertheless, the inventories (and the models) have long been known to have critical inaccuracies which have directly affected management decisions in a number of locations. Recently the requirements for quantification of emissions has reached a point where uncertainties for all categories, especially the large source categories, need to be defined or determined. This has placed substantial demands on the current system that have led investigators to seek a combination of innovative ways to verify the inventories using source measurements, air monitoring data, and air quality modeling techniques. These approaches vary in costs from "modest to very expensive". To minimize the vulnerability to decision making, new, innovative practical approaches to emissions characterization are needed, that will complement the conventional inventories. The key to adopting a new portfolio of techniques emerging from the technical community will be the integration of the conventional practice with the new methods such that long term trends in emissions and human activities are documented.

Emission Inventory Needs And Enhancements Planned For Canada

Marc Deslauriers
Environment Canada, Pollution Data Branch, Hull, Quebec, Canada

Emission inventories are used in Canada to monitor the progress of current emission reduction programs and initiatives, and evaluate the need for future adjustments. They are also used to support the scientific assessment of the air pollution problems, inform the public, and support the reporting requirements of domestic and international protocols and agreements. In order to meet these requirements, Environment Canada is now embarking on a process to compile and update its comprehensive emission inventories and projections for key air pollutants such as Particulate Matter (TPM, PM_{10}, $PM_{2.5}$), Sulphur Oxides (SOx), Nitrogen Oxides (NOx), Volatile Organic Compounds (VOCs), Carbon Monoxide, (CO), and Ammonia (NH3) on an annual basis. Mandatory reporting of these air pollutants for industrial and commercial facilities is now required on an annual basis. This information is reported to the National Pollutant Release Inventory (NPRI), which provides public access to the reported information. Additional reporting requirements for the NPRI program are currently in place and are being developed, such as the speciation VOC and PM emissions. As we increase the reporting requirements for industrial and commercial facilities and assess the accuracy of the emission estimates for various sources, the need for reproducible, accurate, and comparable emission measurement and calculation methods becomes more prominent. Canadian emission inventories are constantly being improved but there are still a number of areas where more research, measurements, and improved methodologies are required. Improvements to the Canadian emission inventories are required for mobile sources, fugitive dust, NH3 and PM emissions from agricultural activities, speciation of VOC and PM emissions, quantification of filterable and condensable particulate matter, and the temporal/spatial allocation of the emissions.

With improved emission inventories, Environment Canada in collaboration with the provincial/territorial governments and various stakeholders, will be in a better position to develop the emission reduction plans and programs required to achieve by 2010, the Canada-Wide Standards for ambient levels of PM and Ozone. These plans and programs will also allow Canada to meet its emission reduction commitments identified under the Canada-US Air Quality Agreement.

This presentation will describe the current and future emission inventory activities and improvements in Canada. The papers and posters presented during this workshop will address some of the emission inventory needs of Canada and allow for the identification and prioritization of additional research for the coming years.

Emission Inventory Needs and Enhancements planned for Mexico

Adrián Fernández Bremauntz and Lenora Rojas Bracho
Instituto Nacional de Ecologia
Mexico, DF 04530, Mexico

Championed by Mexico's National Institute of Ecology (INE) and sponsored by the United States EPA, the Western Governors' Association (WGA) and the North American Commission for Environmental Cooperation (NACEC), Mexico's National Emissions Inventory project started out in 1995 with the initial purpose of developing a methodology and an Execution Plan to complete Mexico's National Emissions Inventory. Its products so far have been several manuals for the development of emissions inventories in Mexico and training material, as well as the Mexicali Emissions Inventory. Phase II of three of the project is currently coming to a close, with the completion of the inventory for the six bordering states. The full product should be concluded by 2004.

In itself, the project represents a novel effort to put together disperse and limited emissions information, available in very diverse formats of variable quality. It has brought together energy, environmental and transport authorities, as well as private organizations and NGOs in Mexico.

Once completed, the Inventory will serve as the primary tool to reformulate or otherwise confirm current air quality improvement policies and to develop better regulations, detect specific information needs, evaluate current emissions databases and serve as a baseline for air quality prognosis. Overall, it represents a unique opportunity to congregate all stakeholders with an impact on air quality to become involved in this assessment, which will serve as foundation for a more science-based approach to decision making in Mexico, will support a better understanding of air quality issues in the Mexico-US border region and will provide critical information for a North American emissions inventory.

Emission Inventory Needs And Enhancements Planned For The US

Phil Lorang, US EPA

Accurate and appropriately detailed emission inventories are needed on a continuing basis in any area with air quality problems for purposes of public information, source permitting, compliance monitoring, community risk assessment, and accountability. In the United States, we have begun a special period when several specific and time-critical needs will apply on top of these continuing and general needs. Nonattainment boundaries for the 8-hour ozone and PM2.5 ambient standards will be established within the next 14 months, setting off a new three-year cycle of developing State Implementation Plans to reach attainment. Plans to improve regional visibility will also need to be developed in the same time period; five multi-state organizations have been formed and are significantly funded by the Congress and EPA to perform joint technical work on regional visibility. Current and projected emission inventories are fundamental to the development of state plans for all three clean air goals, and tracking implementation progress. Also, at the federal level, EPA faces statutory deadlines for developing residual risk standards for hazardous air pollutants from dozens of source categories. Since these standards are based on a benchmark for acceptable risk, air quality modeling based on source-specific emission estimates is a critical factor in establishing the need for new emission limits. Also, EPA has a near-term regulatory agenda that includes new federal rules for interstate transport of air pollutants, hazardous air pollutants from electric generating units, and hazardous air pollutants from motor vehicles and nonroad equipment and engines. EPA and other federal agencies also wish to advance non-regulatory approaches for protecting the public from air pollution, for example by providing air pollution forecasts and by managing prescriptive burning to minimize public exposure to smoke. These types of programs also pose emission inventory needs. In sum, the emission inventory needs of the US cover all three North American countries.

To meet these needs, EPA, other federal agencies, states, and multi-state organizations are at work, in some cases through active and close partnerships and in others through separate but mutually informed efforts. This presentation will describe the current mechanisms for working together and communicating and emission inventory areas with notable work in progress or planned. Some issues for attention during the workshop may then become apparent.

Poster Session

Poster 1: Rethinking Emissions Inventories: Theory, Innovation, and Practice Within the Southern Oxidants Study

Ellis Cowling[1], Carlos Cardelino[2], and Cari Furiness[1]
[1]North Carolina State University, Raleigh, NC; [2]Georgia Institute of Technology, Atlanta, GA

Since its inception in 1988, scientists and engineers within the Southern Oxidants Study have been systematically rethinking the assumptions that have undergirded US policies for management of ozone and particulate matter pollution. We believe that cost-effective management of air pollution can only be achieved if management plans are based on amounts of precursors **actually present in the air** rather than on amounts of precursors **believed to be present** on the basis of emissions inventories. EPA publication AP-42 and, more recently, the Emissions Inventory Improvement Program (EIIP) have been important sources of guidance for development of emissions inventories.

The prevalent policy assumption has been that decreases in emissions of anthropogenic precursors, mainly in counties designated to be part of a given non-attainment area should be sufficient to bring the area into compliance with the standard. EPA requires that states use emissions-based mathematical models (the Urban Airshed Model has been preferred) to make an “attainment demonstration” for a “model episode” under “extreme weather conditions” that were expected to provide an “an adequate margin of safety” for the health of people and welfare of ecosystems within the non-attainment area.

Weaknesses in emissions inventories have always been one of the largest sources of worry about the adequacy of this theory and the veracity of these policy assumptions. Thus, during the past 14 years, SOS scientists developed, used, and promoted a series of innovative approaches to evaluate and improve emissions inventories and the ways inventory information is used in state implementation plans.

These innovations have included: 1) Important parts of the Biogenic Emissions Inventory System (BEIS) for isoprene emissions from hardwood (especially oak) forests, terpene emissions from coniferous forests, and NO_x emissions from well-fertilized row-crop and pasture lands; 2) NO_x emissions from lightning strikes; 3) Increased use of traffic counters, remote sensing methods, tunnel studies, information on street and highway grades, and the phenomena of “power enrichment” during acceleration and on heavy grades in estimating VOC and NO_x emissions from motor vehicles; 4) Use of fuel sales statistics as a check on VOC, NO_x, and CO emissions from motor vehicles, off-road construction equipment, aircraft, railroads, pleasure boats, commercial shipping, and equipment powered by small internal combustion engines; 5) CO, VOC, and NO_x emissions from biomass burning in incinerators, pulp and paper mills, controlled burning of crop and forest residues, highway construction sites, and burning of downed timber following hurricanes, ice storms, and other extreme weather events, 6) CO emissions from wild fires within nearby and regional urban, suburban, and rural areas, 7) CO emissions from wildfires in far-distant locations in the US, Canada, and Mexico; 8) Inverse modeling of VOC and NO_x emissions; 9) Use of survey data to determine ozone sensitivity to point sources; 10) Influence of isoprene emissions in regional ozone modeling, 11) Differences in ozone production efficiency of NO_x emissions from large and small power plants; 12) Methane and CO contributions to ozone production in the Nashville/Middle Tennessee Ozone Study, 13) Emissions of ethene, propene, and other light alkenes from petroleum processing facilities in the Houston-Galveston areas of Texas, 14) Ammonia emissions from animal feeding operations, fertilizer applications, industries and motor vehicles; 15) Effectiveness of regulatory practices that distinguish “reactive” from “negligibly reactive” VOCs and then exclude “negligibly reactive” VOCs from ozone and $PM_{2.5}$ precursor inventory requirements; 16) Evaluating emissions inventories using air concentration measurements from towers, tall buildings, tethered balloons, and aircraft; 17) Changes in the ratio of NO_x to VOC emissions as a result of changes in fuels used in motor vehicles; and 18) Relative importance of local area sources, nearby point sources, regional background sources, and far-distant remote sources.

Poster 2: Preliminary Results Of The MeditAIRaneo Project: A Novel Approach To Derive The Emission Of Biogenic Volatile Organic Compounds (VOC Relevant) To Ozone And Aerosol Formation In Temperate Areas Of Europe

Ciccioli P.[1], Stefani P.[2], Scifo, A.[3], Valentini R.[2], Metallo A.[4], Cirillo M.C.[5], De Lauretis R.[5], Poli A.A.[3]
[1]Istituto di Metodologie Chimiche del CNR, via Salaria km 29.300 Monterotondo Italy; [2]Università della Tuscia, via C. de Lellis snc Viterbo (Italy); [3]Environmental System Analysis Srl, Via Trento Bracciano (Italy); [4]Università La Sapienza, Rome (Italy); [5]APAT, Via V. Brancati Rome (Italy).

On a global scale, terrestrial forest ecosystems are the major source of VOC on earth. Due to their high reactivity toward OH radicals and ozone, biogenic VOC can greatly contribute to the formation of tropospheric ozone and secondary organic aerosols that can both affect the earth climate through radioactive forcing. Mediterranean ecosystems play an important role, particularly in southern Europe, California, and portions of South Africa and Southern Australia where high emissions of anthropogenic ozone precursors (VOC and NO_x) and particulate matter take place. Present estimates of biogenic VOC emissions in Europe are based most on the CORINAIR approach and they do not take into account the latest findings about emission behaviour of Mediterranean vegetation species that were obtained through complex field and laboratory studies performed in Italy, Spain, France, Portugal and Greece. In addition to the poor description of ecophysiological processes, the idea to group biogenic VOC into isoprene, monoterpenes and other biogenic VOC it does not help in modelling both ozone aerosol formation. This happens because of the rather different chemical reactivity of monoterpenes towards OH radicals and ozone and photolysis rate and reactivity of oxygenated VOC. To improve the emission inventory of Southern Europe, a three-year project, called “MeditAIRaneo”, was launched in Europe. It involves National Reference Centres of Italy, France, Greece, Spain and Portugal. The approach used in Italy to improve the emission inventory with respect to the CORINAIR is based on the following improvements:

1) Basal maximum emissions of isoprene and individual monoterpenes following light and light and temperature algorithms have been derived for the most important vegetation species in Italy.
2) Seasonality terms have been introduced into emission algorithms to account for the change of basal emission through the year due to changes in the phenological and physiological state of leaves.
3) Terms to take into account for the emission of VOC from litter have been added.
4) Accurate maps to get high resolution spatial information have been used according to the CARBODATA project (*Novel Maps for Forest Tree Species in Europe*, by Renate Köble e Günther Seufert, JRC Ispra, Institute for Environment and Sustainability).

For some key species, predictions obtained through the CORINAIR and the MeditAIRaneo approach have been validated through field experiments. Based on the preliminary data acquired we believe that this research activity can greatly contribute to improve the accuracy of existing emission inventories of biogenic VOC in the Mediterranean regions and to develop new guidelines to be adopted by EMEP/CORINAIR. This would be of help in the compliance of the UN-ECE Convention on Long Range Transboundary Air Pollution by Mediterranean countries and to the European policy (NEC, CAFE), in general.

Reference

Guenter A. (1999) Modeling Biogenic Volatile Organic Compound emissions to the atmosphere. In: *Reactive hydrocarbons in the atmosphere*, edited by C.N. Hewitt, Academic press, New York pp. 98-116.

EMEP/CORINAIR, 2002 update: *Atmospheric Emission Inventory Guidebook*. Technical Report N. 30 (third edition).

Poster 3: Screening of NIF 3.0 Format Submissions to the National Emission Inventory

James Paumier
MACTEC, Inc.

Rhonda Thompson, Anne Pope, Sally Dombrowski
US EPA

With the inclusion of data developed and submitted by State, local, and tribal agencies, the Emission Factor and Inventory Group (EFIG) prepares the National Emission Inventory (NEI), a high quality national inventory of both criteria and toxic pollutants that can be used for a variety of purposes. Regional offices are crucial to the validation of the inventory data provided by these agencies. The quality assurance of an inventory is an iterative process between these agencies and Regional offices with a final QA check by EFIG before loading into the NEI. A software tool with a simple user interface is available for use on a personal computer to identify possible problems with an inventory early in the iterative process.

The tool is currently being upgraded to include emissions quality control (QC) checks for hazardous air pollutants (HAPs) and criteria pollutants. These checks are to include Top ‘10’ lists (10 will be the default, but the number can be modified by the user) for the sum of all HAPs and for specific pollutant categories selected by the user. By selecting two databases, year-to-year comparisons will be possible. The reports generated by this initial version of the QC tool will allow the user to identify those emissions that may be grossly in error.

The purpose of this paper is to review the changes that have occurred between version 2.0 and version 3.0, present some of the QC checking found in the emissions QC tool and possible functions for future updates, the possible inclusion of HAP QC-style reports for criteria pollutants in the QA tool, and the impact of these changes on the QA/QC tool.

Possible topic area: Database Management, Documentation, and Auditing or Emission and Air Quality Modeling

Poster 4: Texas Air Quality Study 2000 (TexAQS2000) Special Point Source Inventory Development

Jocelyn Mellberg, Gabriel Cantu, Ron Thomas, Jim Smith, Jim Neece
Texas Commission on Environmental Quality

During the past two years, the TCEQ staff prepared a special hourly inventory for point sources in the Houston and Beaumont areas. This data has been used to prepare the Mid-Course Reviews of the Houston/Galveston area's State Implementation Plan (both Phase I and Phase II). For the Texas portion of the point source emission inventory, data from the 2000 TCEQ's point source database (PSDB) has been used for modeling Houston ozone episode. First, the inventories were supplemented with hourly data from the Environmental Protection Agency's acid rain database. In addition, the 2000 inventory was supplemented with data obtained during the TexAQS2000 special inventory. Episode-day and hour-specific point source emissions data were collected from August 15, 2000 through September 15, 2000. These data were obtained by surveying the largest industrial sources of VOC and NOx in the Houston and Beaumont areas to account for specific operating conditions, upsets, start-ups, and shut-downs during the TexAQS2000. TCEQ contacted 83 companies in HGB and BPA. Of these companies, and 74 companies provided data. Respondents to the survey were expected to account for a large proportion of the VOC and NOx point source emissions in the nonattainment areas. In the HGB area, companies that responded to the survey accounted for approximately 50% of the Ozone Season Daily (OSD) NOx emissions and 70% of the OSD VOC emissions. And in the BPA area, respondents accounted for 60% of OSD NOx emissions and 70% of the OSDVOC emissions. Many companies supplied daily and even hourly chemical speciation profiles as part of the survey. This data has been used to develop the CB-IV and SAPRC speciation profiles used in CAMx. This talk will describe the results of the special inventory and how those results were incorporated into the Texas point source modeling inventory.

Poster 5: Use of MOBILE6 to Develop and Quality Assure “Link-Based” Inventories for the 8-County Houston/Galveston/Brazoria Nonattainment Area

Chris Kite
Texas Commission on Environmental Quality

Under contract to the Texas Commission on Environmental Quality (TCEQ), the Texas Transportation Institute (TTI) has utilized MOBILE6 to develop “link-based” inventories for the 8-County Houston/Galveston nonattainment area. 2000 “base case” and 2007 “future case” inventories have been developed with MOBILE6 to photochemically model an ozone episode that originally occurred from August 22 to September 1, 2000. For each roadway “link” throughout the area, average speed and vehicle miles traveled (VMT) estimates per hour are coupled with MOBILE6 emission rates for each of the 28 vehicle types to obtain temporally and spatially allocated inventories for each episode day. These link-based MOBILE6 inventories were converted into a binary gridded format acceptable for photochemical modeling input with the 2x version of the Emissions Preprocessor System (EPS2x). Similar MOBILE6 link-based inventories have also been received for the following other metropolitan areas in Texas: Austin, Beaumont/Port Arthur, Corpus Christi, Tyler/Longview/Marshall, San Antonio, and Victoria.

By running various scenarios for Harris County in both 2000 and 2007, TCEQ staff have been able to determine that NOX emission levels are most sensitive to VMT mix, local age distributions, and the relative humidity input. Due to significantly higher NOX emission rates from heavy-duty diesel vehicles (HDDVs), the amount of VMT assigned to each of the MOBILE6 HDDV classes has a significant impact on total NOX emission levels. Currently, MOBILE6 VMT mix defaults are based on annual nationwide mileage accumulation rate estimates by vehicle type and do not vary by roadway type, time-of-day, or day-of-week. In addition, MOBILE6 VMT mix defaults do not vary between urban and rural areas, which is an important distinction for the HDDV8A and HDDV8B classes that accumulate the overwhelming majority of their VMT in rural areas. Due in part to relatively “new” age distributions for the light-duty gasoline truck (LDGT) classes, little difference in MOBILE6 emission rates was found among the LDGV and LDGT1-4 vehicle types for Harris County in both 2000 and 2007. Consequently, the NOX, VOC, and CO emissions from passenger cars, pickups, and SUVs do not appear to be very sensitive to the distribution of VMT among the LDGV and LDGT1-4 classes. The relative humidity input (new with MOBILE6.2) was found to have a significant impact on estimated NOX emissions among just light-duty gasoline vehicles and motorcycles. MOBILE6 does not show any effect from changing the humidity input on heavy-duty diesel NOX, even though the NOX emission rates from HDDVs are relatively high.

Poster 6: Measurement of PM_{10} Emission Factors from Paved Roads Using On-Board Particle Sensors

Dennis R. Fitz, Charles Bufalino
College of Engineering-Center for Environmental Research and Technology
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Based on emission factors derived from the AP-42 algorithm, particulate matter from paved roads has been estimated to be a major source of PM_{10} of geologic origin. This is an empirical formula based on upwind-downwind measurement of PM_{10} concentrations and is dependent solely on the silt loading of the pavement and the weight of vehicles. A number of upwind-downwind studies conducted in urban areas to validate this algorithm have been generally unsuccessful because the PM_{10} concentration difference between upwind and downwind often is within the measurement uncertainty. In the approach presented here PM_{10} concentrations were measured directly on moving vehicles in order to improve the measurement sensitivity for estimating the emission factors for vehicle on paved roads. Optical sensors were used to measure PM_{10} concentrations with a time resolution of approximately ten seconds. Sensors were mounted in the front and behind the vehicle in the well-mixed wake. A special inlet probe was designed to allow isokinetic sampling under all speed conditions. As a first approximation the emission factor was based on the concentration difference between front and back of the test vehicle and the frontal area. The emissions factors for a wide variety of roads in southern California ranged from 64 to 124 mg/km. These are consistent with but generally lower than measurements using upwind-downwind techniques. This technique is useful for quickly surveying large areas and for investigating hot spots on roadways caused by greater than normal deposition of PM_{10} formi

Poster 7: A Conceptual Model to Adjust Fugitive Dust Emissions to Account for Near Source Particle Removal in Grid Model Applications

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For a number of years air quality analysts have recognized that fugitive dust emission inventories, when coupled with air quality models, substantially overestimate PM2.5 ambient crustal material when compared to the crustal material found in ambient samples. Fugitive dust categories of interest include unpaved and paved road dust, dust from highway, commercial and residential construction, agricultural tilling, windblown dust from agricultural and other exposed land, quarrying and other earthmoving. In the mid 1990's, the U.S. Environmental Protection Agency's (EPA) Office of Air Quality Planning and Standards (OAQPS) began to use, as an interim measure, a "divide-by-four"factor to "adjust" the fugitive dust emission estimates in grid modeling analyses to obtain better agreement between the regional model results and ambient data. Since then, the EPA has been actively working to understand the reasons for the ambient-emissions differences. Work by the U.S. EPA, Desert Research Institute, Western Regional Air Partnership, Midwest Research Institute and University of Utah have concluded that much of these emissions are removed near the source by interaction of the plume with the ground, nearby vegetation and structures. This paper reviews these efforts, proposes a conceptual model of fugitive dust removal processes near the source and compares this model with recent field studies that measure near source removal. This conceptual model is intended as an improvement to the "divide-by-four" approach that may be useful for adjusting fugitive dust emission inventories when used in grid models.

Poster 8: Fuel-Based Mobile Source Emission Inventory Methods

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A single on-road remote sensor can be used to provide both public information (a SMART SIGN can be used to motivate voluntary emissions related repairs) and a mobile-source emission inventory. The public information aspect has been quantified and published. The process by means of which one can create a fuel-based mobile source emission inventory for CO, HC and NOx has been carried out in Denver and compared to the MOBILE model. Mobile modeling for the Denver metropolitan area predicts 794 metric tons per day of CO in 2001 reducing to 710 by 2006. We measured 582 in 2000. This is a smaller emission, and has a slower observed rate of decrease between 1996 and 2000 than the model predicts. Fuel-based emission inventory has quantifiable uncertainty. Emission measurements at several locations chosen for high and low socioeconomic factors span the range of possibilities for the urban area. The other source of potential uncertainty is the fuel use. State total data for fuel sales are uniformly available and generally of high quality. Apportionment of the state total to a given urban area or district is more difficult. Two methods which have been investigated are apportioning by vehicle registration and apportioning by population. It turns out that these two methods agree very closely and are probably not a major source of added error. Mobile source, fuel based inventories, with estimated uncertainties, for various cities in Texas will be presented based upon on road emissions data.

Poster 9: Measurement and Modeling of Vehicle Tailpipe Emissions Based Upon On-Road Data from Portable Instruments

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In recent years, portable emission measurement systems (PEMS) have become available that can be temporarily installed in a vehicle. For example, using PEMS, the effect of changes in traffic signal timing and coordination on selected primary arterials were evaluated. Data for CO2, CO, NO, and hydrocarbon (HC) tailpipe emissions and for vehicle activity (e.g., vehicle speed, engine parameters) were collected on a second-by-second basis. In total, over 1,200 one-way trips were made with more than 20 vehicles. A pilot study was used to identify key factors influencing on-road emissions and as input to the design of an evaluation study. In the evaluation study, data were collected intensively with a small number of vehicles on two corridors before and after signal timing and coordination changes were implemented. A 10 to 20 percent reduction in emissions of CO, NO, and HC associated with improved signalization was observed on Walnut Street. For Chapel Hill Road, a comparison of peak and off-peak time periods revealed that emissions rates were typically 40 to 60 percent less for uncongested versus congested traffic flow. Based upon second-by-second data from PEMS, as well as dynamometer data for facility-specific cycles, an empirically-based modal method for modeling vehicle emissions has been developed and demonstrated. Using hierarchical-based regression tries, vehicle specific power (VSP) was identified as the key explanatory variable for Tier 1 vehicle emissions. Fourteen VSP modes were developed. Additional explanatory variables were selected based upon HBTR. Uncertainty in mean emission rates for each mode and for predictions of trip emissions were quantified. The conceptual model was validated by comparison with two independent data sets. Recommendations were developed for emissions rate estimation in EPA's new MOVES model.

Poster 10: The Development Of Real World Emissions Inventories Using Portable Vehicle Emissions Monitors (PEMS)

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In the past, the traditional development of vehicle emissions data bases and fleet inventories has been based on laboratory measurements of representative vehicles using chassis dynamometer driving cycles representative of projected driving patterns. These measurements are relatively expensive, limited in scope, and are not necessarily representative of vehicles in actual operation on and off road.

In recent years the development and use of Portable Emissions Monitoring Systems (PEMS) have opened new possibilities for the quantitative, accurate measurement of vehicle emissions under real world operating conditions. The use of PEMS are becoming increasingly accepted for use by federal, state and private agencies for the efficient, economical, accurate and representative measurement of vehicle emissions.

The OEM-2100 Montana system, manufactured and used by Clean Air Technologies and several university and other research groups, has been used to measure real-time particulate and gaseous (HC, CO, CO2 and NOx) emissions on fleets of cars, trucks, commuter vans, school and transit buses, delivery vans, construction equipment, ferry boats, and other equipment. This data was used to quantify the overall fleet emissions, to evaluate the impact of advanced technologies, alternative fuels and exhaust gas aftertreatment devices, but also the impact of traffic signal optimization, traffic pattern improvements, driving style, extended idling of heavy-duty trucks, and other means which are difficult to evaluate using traditional laboratory testing.

The results of these studies demonstrated that the emissions from vehicles having presumably like engines and performance can vary significantly. Therefore, relative to laboratory studies, on road real world measurements have the distinct advantage of providing more representative assessments of fleet total and regional total emissions inventories relative to limited laboratory studies.

Poster 11: On-Road Measurement of Automotive Particle Emission Factors by Ultraviolet Lidar and Transmissometer

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Emission factors are needed for tailpipe emissions of criteria pollutants from mobile sources. Such emission factors can be obtained with two complementary approaches: 1) measurement of emissions from a very limited number of vehicles under a large variety of operating conditions (examples are dynamometer studies, on-board instrumentation, or open plume measurements with chase vehicles) or 2) measurement of emissions from a large number (>105) of vehicles under a limited variety of operating conditions (examples are remote sensing, roadside, and tunnel studies). Only the remote sensing approach yields emission factors for a large number of individual vehicles. The resulting emission distributions across the fleet are needed for designing cost efficient emission reduction policies. While Vehicle Emissions Remote Sensing Systems (VERSS) for gaseous emissions have been used for more than a decade, no such system for measuring particulate matter (PM) emissions has been available.

A novel VERSS for the on-road measurement of fuel-based PM emission factors is described. This system utilizes two complementary PM channels using ultraviolet Lidar and transmissometry for the measurement of PM mass column content behind a passing vehicle. Ratioing the PM mass column content with the carbon mass column content, simultaneously measured with infrared absorption, yields the fuel-based PM emission factor. Transmissometry directly yields PM extinction coefficients without calibration, while the Lidar measurement of PM backscatter coefficients is calibrated through laboratory measurements of gases with well-known backscatter coefficients. The PM mass column content is calculated from these extinction and backscatter coefficients with the help of mass backscatter and extinction efficiencies obtained from theoretical calculations. This novel VERSS has been used extensively in a major air quality study and example data are presented.

Poster 12: Development of the MOBILE6-Mexico Emission Factor Model

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A version of the MOBILE6 motor vehicle emission factor model has been developed for use in Mexico. MOBILE6-Mexico incorporated Mexico-specific data into the MOBILE6 emission factor model previously developed by the U.S. Environmental Protection Agency. Experience gained during the previous development of Mexico-specific versions of the MOBILE4 and MOBILE5 models proved valuable in the development of the MOBILE6 model. Emission factors estimated by MOBILE6 were used to develop municipality-level motor vehicle emission estimates for the Mexico National Emissions Inventory (NEI) project. Draft results for the six northern Mexican states of Baja California, Sonora, Chihuahua, Coahuila, Nuevo León, and Tamaulipas were completed in July 2003 (these results are presented in a companion presentation by Fields).

This presentation will focus on the overall development process of the MOBILE6-Mexico model. The process will be presented in a step-by-step fashion, showing how parts of the U.S. model were adapted to the Mexican context. A detailed discussion of the Mexico-specific data used to develop the model will be provided. Differences between the new model and the previously developed MOBILE5-Mexico will be discussed, as well as areas of potential future improvement.

Poster 13: Federal Highway Administration's Particulate Matter Ambient Concentration and Traffic Correlation Study

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Federal Highway Administration

Federal Highway Administration (FHWA) has been performing a study to determine if accurate correlations could be made between the vehicle component of particulate matter (PM) emissions and ambient air concentrations. The reason this study is being conducted is to determine whether the current mobile source emission inventories are accurately reflecting the vehicle contribution. Ambient air quality is a function of the emissions of all sources in addition to the weather and the local site geography. The concentrations of pollutants are also a function of the reactivity of the compounds being emitted. Because of the complexity and inter-reactivity of the sources and the atmosphere, trying to correctly apportion the mobile source component is a challenge.

Ambient concentrations are measured to provide "instantaneous" information about air quality conditions in an area. Air quality models are used to "predict" future air quality resulting from specific changes to an area due to demographic changes, economic activity, and air quality improvement programs that have been established to reduce air pollution. The basis of air quality improvement programs begins with an emission inventory establishing the contribution from all sources. The permitting process for stationary sources requires monitors and monitoring programs capable of accounting for air pollution releases generated by the specific permitted industries. Mobile sources do not have this capability and rely on the development of inventories from emission factor models such as the MOBILE model and from traffic data. Both traffic data and emission factors calculated by the MOBILE model have significant variability, measuring traffic volume as a surrogate for monitoring direct emissions and comparing this with the ambient concentrations throughout the day is intended to assess the accuracy of the mobile source emission inventory.

This paper outlines the FHWA Particulate Matter - Traffic Correlation Study and provides comparison data between the emission inventory for a specific area and the correlation effort between vehicles activity and ambient concentration. The study was performed for five cities representing different geographic areas and vehicle fleets. It illustrates how inventory data compares to monitored ambient concentrations and traffic and how these can be used to determine the accuracy of the mobile source component of ambient particulate matter concentrations.

Poster 14: Decadal Trend in Emissions of Benzene Relative to Other NMHC's: Evidence from Ambient Atmospheric Measurements

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Over the last three decades air pollution control efforts have led to a several fold decrease in the emissions of non-methane hydrocarbons (NMHC's) in the U.S. The 1990 Clean Air Act Amendments (CAAA) required the U.S. EPA to identify and regulate hazardous air pollutants. Benzene is a ubiquitous NMHC that was targeted for particular control efforts under the EPA's Urban Air Toxics Program. We will examine a wide suite of ambient measurements made in the U.S. over the past three decades. In particular we will investigate the temporal change of the ratio of benzene to other related NMHC's that are not targeted under the toxics program. The goal will be to determine to what extent benzene has recently decreased at a faster rate than the NMHC's that were not identified as toxics. This determination from ambient measurements will be compared to the trends suggested by emission inventories. One limit encountered in this evaluation is that the PAMS data are affected by large systematic errors that prevent their utilization in this regard.

Poster 15: Use of DOAS Data at Two Monitoring Sites to Locate Benzene Emissions in Tampa, Florida

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In May 2002 as part of the Bay Regional Atmospheric Experiment (BRACE), continuous measurements of benzene were made at two monitoring sites in Tampa, Florida. These measurements were intended to help identify mobile source contributions to air pollutant levels at Sydney, a rural site ~5 km south of a major interstate highway, and at the eastern end of the Gandy Bridge, an urban site ~45 m from a state highway. At these fixed monitoring sites, the benzene plume was recognized with a data pattern that depended on the wind vector and the distance from the polluting location. Both forward and backward wind trajectory analyses indicate the source of benzene as petroleum tank farms located between the Sydney and Gandy Bridge sites, rather than motor vehicle emissions. Data analysis software was developed that given the associated meteorological data, points to the polluting sources with reasonable accuracy. The software is based on reverse analysis of the wind vector and to the known patterns of diffusion and dispersion of the pollutant. Distance of the pollution source is not measured directly, but it is statistically calculated from intersections of plumes during separate wind shifts and from the shape of the data ("angle of attack") of the data stream. Longer data observations and more than one monitoring site provide greater confidence and precision, nevertheless, a single site and a single event may suffice to point to a specific location. This method can be applied to all other airborne pollutants.

Poster 16: The Application Of Density Measurement Of Greenhouse Gases Using Aircrafts And Kite Planes For GHG Inventory Verification

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of National Institute for Environmental Studies of Japan (NIES)

1. Outline of the measuring methodology developed by the National Institute for Environmental Studies

The Center for Global Environmental Research (CGER) of the National Institute for Environmental Studies (NIES) has succeeded in developing measuring methods of greenhouse gases using aircrafts and kite planes.

Conducting measurements of vertical profiles of wind, and density of CO2 and water vapor using aircrafts, wide-area flux observations clarify the relationships between their spatial distributions and ground surface measurements. Distributions of CO2 density at high-altitude was measured with CO2 sensor loaded on kite planes, flying every two hours. Moreover, distribution of CO2, humidity, temperature, wind direction and velocity at high-altitude were measured using kitoons loading air sampling tube and meteorological sensors.

2. Issues and concerns for non-CO2 greenhouse gas inventories

Total emissions of non-CO2 greenhouse gases (GHG) (CH4, N2O, HFC, PFC, and SF6) of Japan in 2000 are 95 million metric tons of CO2 equivalent (approximately 7% of all greenhouse gases). It is nearly the same amount as Japan's emission reduction target of the Kyoto Protocol, 6%, and this fraction should be much higher in the rest of the nations in the Southeast Asian region. It is considered to be difficult to compile inventories of non-CO2 emissions from each source. Insufficient coverage for non-CO2 emissions, even SF6, has been pointed out. Estimating inventory data utilizing the measurements of atmospheric density levels would be efficient to enhance completeness of GHG inventories and measures against global warming.

3. Application of the estimating methodology in developing non-CO2 GHG emission inventories

Based on the measurement of densities of CO2, CH4, N2O, HFCs, PFCs, SF6, CO, and H2 using aircrafts, analysis on the correlation between these data will be implemented. Application of such methodology to potential inventory verification measures will be examined.

Poster 17: Development of the API Compendium for Estimating Greenhouse Gas Emissions

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Understanding the sources and quantities of greenhouse gas (GHG) emissions is critical to developing an emissions inventory that accurately represents a facility's operations. In response to continued interest by its member companies about consistency in GHG emissions estimation, the American Petroleum Institute (API) developed a Compendium of Greenhouse Gas Emissions Estimation Methodologies for the Oil and Gas Industry. The Compendium is a result of more than a year long effort by API to screen, evaluate and document a range of calculation techniques and emission factors that could be useful for developing GHG emissions inventories.

In developing the Compendium, API reached out to sibling organizations and reviewed their guidance documents, along with emerging national and international protocols and internal company GHG estimation protocols. This paper provides a brief overview of the Compendium development and introduces the technical approach and techniques for estimating carbon dioxide (CO2) and methane (CH4) emissions. It also discusses the process undertaken to compare and reconcile different estimation methodologies used by other organizations.

Through this work, API is expanding the dialogue among the global oil and gas industry and pursuing consistency in GHG emissions estimation to ensure comparability and the eventual fungibility of emission reductions. Findings from the pilot phase distribution of the Compendium are addressed in this paper, as well as enhancements planned for the 2003 update of the document.

Poster 18: State-of-the-Art Greenhouse Gas Emission Inventory Guidance and Tools

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This year, the U.S. EPA State and Local Climate Change Program (SLCCP) is unveiling revised guidance to states on conducting greenhouse gas emission inventories. For the first time since EPA began providing guidance to states on estimating greenhouse gas emissions in 1992, the guidance will be accompanied by and a suite of user-friendly inventory complementary spreadsheet tools.

The revised inventory guidance, Volume VIII of the EIIP series, reflects the latest information on data sources, as well as emission factors and methods that are reflects the latest methodologies, emission factors, and data sources available to assist states in estimating their greenhouse gas emissions. consistent with the Intergovernmental Panel on Climate Change (IPCC) Guidelines and the Inventory of U.S. Greenhouse Gas Emissions and Sinks. Understanding The corresponding tools are designed to help states overcome the key hurdles to developing state greenhouse gas emission inventories and updating existing inventories, namely the difficulty states face in obtaining data availability and the time and effort needed necessary to set design a framework for up the infrastructure to calculating emissions, EPA developed a series of spreadsheet tools that will reduce the burden associated with developing a new inventory or updating an existing inventory. Both the guidance and the tools cover the full range of greenhouse gases and sources covered in the national inventory, including carbon dioxide emissions from fossil fuel combustion, industrial processes, land-use change and forestry, agricultural liming, and incineration; methane emissions from stationary combustion, mobile combustion, coal mining, oil systems, natural gas systems, manure management, enteric fermentation, rice cultivation, agricultural residue burning, landfills, and wastewater treatment; nitrous oxide emissions from stationary combustion, mobile combustion, nitric acid production, adipic acid production, manure management, agricultural soil management, agricultural residue burning, incineration, and wastewater treatment; and high-Global Warming Potential gas emissions from industrial processes and substitutes for ozone-depleting substances. Where possible, EPA has provided the tools provide default activity data and emission factors at the state level for the full time series from 1990 through 2000. EPA plans to update the tools periodically to incorporate significant changes to the methodologies and to update default activity data. Although it is unlikely that EPA will be able to update the guidance and underlying data sets each year, EPA plans to update the tools periodically to incorporate significant changes to the methodologies. Both the guidance and the tools cover the full range of greenhouse gases and sources covered in the national inventory. The SLCCP is in the process of designing a supplemental tool that will enable states to project emissions from greenhouse gas sources to the year 2020. States and localities armed with the updated guidance, the emission estimation tools and ultimately, the projection tool, will be better prepared to assess emissions and to create effective strategies to reduce emissions in the future.

Poster 19: Establishment of the Intergovernmental Panel on Climate Change (IPCC) Emission Factor Database

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The quality of national greenhouse gas (GHG) inventories depends substantially on reliable emission factors. Many countries have indicated that an easily accessible public database on GHG emission factors with supporting scientific information would help improve the quality of GHG inventories in a cost-effective way. Sharing of research information would also enable countries to use or develop emission factors that are more applicable to their national circumstances than previously published Intergovernmental Panel on Climate Change (IPCC) default emission factors without having to bear the associated research costs. A database on GHG emission factors with supporting scientific information would also support the future review and update of the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories under the IPCC-NGGIP. In respond to this need, the Technical Support Unit (TSU) of the IPCC has developed an emission factor database (EFDB). The primary goal of the EFDB is to grow towards a recognized library, where users can retrieve and submit emission factors and other parameters with background documentation that can be used for estimating GHG emissions in national inventories. The IPCC EFDB was recently released after a two-year development period that began in July of 2000, and which included the participation of inventory experts from many countries in the design, review, and pilot testing of the database. The EFDB currently provides a web-based platform for submission and retrieval of new emission factor and parameter data, with future plans for CD ROM version availability. An EFDB Editorial Board has also been established with the objective of ensuring all emission factors and other parameters contained in the EFDB are scientifically sound according to pre-defined criteria.

Poster 20: GHG Emission Inventories for Agroecosystems: Role of GIS and Process-based Models in Developing Site Specific Emission Factors, Assessing Variability, and Providing Uncertainty Estimates

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Biogeochemical processes that control GHG and Ammonia emissions from agroecosystems, like denitrification, nitrification, and ammonia volatilization, are non-linearly coupled with anthropogenic and ecological drivers that are highly variable in space and time. As a result, static emission factors (EFs) cannot capture this variability without development of detailed site and management specific Efs. In addition, EFs typically do not provide estimates of uncertainties particular to a set of conditions. Therefore, assessment of impact of agricultural management alternatives on trace gas emissions and nutrient fluxes needs to be done in a modeling context that incorporates "mass balance" constraints. GIS process-based models can simulate spatially heterogeneous conditions that control temporal and spatial patterns of GHG and ammonia emissions.

This paper will present an overview of a suite of GHG (CO_2, CH_4, NO, and N_2O) and NH_3 emissions inventories using GIS data and a process-based biogeochemical model called Denitrification-Decompostion, or DNDC. Coupled with the inventories are uncertainty analyses that focuses on quantifying how biophysical factors (e.g. soil properties), environmental conditions (e.g. precipitation, temperature) and management alternatives (e.g. amount and timing of fertilizer/manure application, types of manure application, tillage, irrigation) impact the production of GHG, changes in terrestrial C stocks, and NH_3 volatilization. Uncertainties generated from the modeled processes as well as from the input data sets are assessed through two levels of sensitivity analyses. First, individual variables are varied across their range of expected values while all other variables are held constant to identify those variables that cause the majority of variance in modeled trace gas emissions, C stocks, and nutrient availability. Secondly, to examine the interaction between variables, Latin Hypercube Sampling (LHS) is utilized. LHS is based on a stratified sampling approach that creates statistically significant results with appreciably fewer model runs. The LHS technique ensures that the entire range of each variable is sampled. Statistical summaries of the model results produce indices of uncertainty that relate the effects of heterogeneity of input variables to model predictions of GHG and NH_3 emissions.

Poster 21: Global Emissions Inventory Activity — Moving Forward

Paulette Middleton, GEIA Center Director

The Global Emissions Inventory Activity (GEIA) is a major crosscutting activity of the International Global Atmospheric Chemistry (IGAC) Project, a core project of the International Geosphere-Biosphere Program. Since its inception in 1990, GEIA has been providing necessary, quality assured emission inventories for comprehensive global assessments of past, present and future atmospheric chemistry, air quality and climate change. GEIA's virtual Center at http://geiacenter.org provides data and other timely information on global emissions work. The 2001 GEIA initiatives called for enhanced interaction with the modeling community and expansion of the formal GEIA efforts. As a first step, GEIA now provides short state of science reviews on emissions of individual chemicals and source categories. In early 2003, planning for further expansion of GEIA to better server the global community as a coordinator of crosscutting emissions activities worldwide was initiated. Some of the new topic areas for GEIA's information distribution activities include: inventories on more flexible levels of spatial and temporal scales; past and future emissions; land-ocean-air exchange activities; emissions modeling; intercomparisons of inventories; and evaluation of emissions/inverse modeling. Possible changes in the meaning of the GEIA acronym to better capture news new activities also are being considered. The summary of the available state of science short reviews and the status of the future of GEIA planning effort will be presented.

Poster 22: Global Satellite Observation Of Greenhouse Gas Emissions - Evergreen

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The Kyoto Protocol, which the EU has recently ratified, calls for a quantitative reduction in greenhouse gas emissions by the year 2008 to 2010. However, global emissions, sources and sinks, are not yet accurately known. The new EU EVERGREEN project proposes to improve this situation by using the measurements of ENVISAT, a European Earth Observation satellite. Improved greenhouse gas emission inventories will be produced from a combination of measurements and (inverse) modeling. The feasibility and quality of the method will be assessed. Measurements include (partial) columns of various trace gases. The focus is on methane and carbon monoxide, and on regional and seasonal variations. The concentrations of trace gases measured by SCIAMACHY and MIPAS will be retrieved and validated. The use of measured trace gas distributions, rather than emissions, is expected to produce more accurate radiative forcing calculations. Carbon dioxide source and sink strengths will be included on a best-effort basis. End user involvement in the project is arranged through the participation of one coal industry and several national/ European institutes, with responsibility for environment and climate issues. Limitations and requirements for a space-borne Global Climate Observing System for top-down emission inventory assessments will be established.

Poster 23: Scientific Top-to-bottom Estimation Of Large-scale Heavy Metal Emissions For The Modeling And Environmental Assessment In Russia And Other NIS Countries

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There is an actual necessity fixed by several reasons to evaluate atmospheric heavy metal emissions for the territory of New Independent States (NIS - countries of the former USSR) covered up to 1/6 of continental world surface. The majority of them are to estimate possible remarkable input of their anthropogenic sources into global/regional emissions with internationally compatible base of inventory and to respond evident demands of comprehensive data for long-range modeling of hemispheric/transboundary pollution as well as to provide information for scientific integrated assessment of natural cycles and environmental impact.

The special co-operative project were completed on development of heavy metal emission evaluation and their implementation for flux estimates for NIS territory with participation of scientists from Norway, Russian Federation, Belarus, Uzbekistan under the support by EU INTAS. General methodological problems and procedures are considered based on up-to-bottom scientific approaches for emission evaluation based on common-use statistics of fuel consumption and industrial activity. The developed achievements in methodology and calculation of emission factors were received with respect to technological peculiarities of industrial production in NIS obtained from earlier case studies and current literature analysis. Also the procedures were created to do an effective application of available statistics on economic and other activities published by governmental agencies as well as from other reports of environmental protection agencies and international authorities (UN ECE, OECD, US DoE, World Bank, UNFCCC etc.), from specific literature and conclusions of national scientists and industry experts.

During the emission evaluation the following steps were also included in procedure: collection and verification of published emission and statistical data; specifying of point sources; performing of emission calculation and verification; spatial distribution of emission based on density of population and location of large point sources. According to estimation for 1990-1997 more than 60% and 50% of total emission of lead and cadmium are provided for the region in Russian Federation, correspondently. The inputs of sources of different categories into total emissions are varied both from country to country and by metal. The emissions were presented as fields of area sources according to GEIA grid with more precise values and their spatial distribution than earlier.

This project is funded by EU INTAS (Ref: № 97-31581).

Poster 24: Global Emission Of Mercury From Anthropogenic Sources In 2000

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An estimate of the global emission of mercury from anthropogenic sources in 2000 is presented. Major emphasis is placed on emissions from stationary combustion sources, non-ferrous metal production, pig iron and steel production, cement production and waste disposal. Emission estimates are based on information received from environmental protection authorities in various countries and the author's calculations using emission factors and statistical data. About three quarters of the total anthropogenic emissions of Hg originate from combustion of fuels, particularly coal combustion in China, India, and South and North Korea. In general, the Asian countries contribute about 60 % to the global emissions of mercury to the atmosphere. Europe and North America seem to contribute less than 25 %. The major chemical form of mercury emitted to the atmosphere is gaseous elemental mercury, contributing with about 50 % to the total emissions, followed by gaseous bivalent mercury with 40 %. The Hg emissions on particles contribute only about 10 % to the total emissions. Again, Asia contributes about 50 % to the total emissions of all individual chemical forms of mercury. Concerning the accuracy of the Hg emission estimates, the following values were obtained: 25 % for stationary fossil fuel combustion, 30 % for industrial sources (e.g. non-ferrous metal production, cement production and iron and steel production) and a factor of 3 for waste disposal.

Poster 25: The US Mercury Emission Inventory for the Arctic Council Mercury Project

Karen Rackley, EPA Office of Research and Development
Anne Pope, EPA Office of Air and Radiation
David Mobley, Stan Durkee, and Doug Steele, EPA Office of Research and Development
Marilyn Engle, EPA Office of International Affairs

The Arctic Council, an intergovernmental forum addressing common concerns faced by the governments and people of the Arctic (www.artic-council.org), has decided to act to reduce exposures to a number of priority pollutants in the Arctic region, and therefore, has initiated a mercury project via the Arctic Council Action Plan (ACAP). The Danish EPA is leading the project with a Steering Group comprised of representatives from all eight Arctic countries, i.e., Canada, Denmark, Finland, Iceland, Norway, Russia, Sweden, and the United States. The overall project objective is to contribute to a decrease of mercury releases from Arctic countries. This will be accomplished partly by contributing to the development of a common regional framework for an action plan for the decrease of mercury emissions, and partly by evaluating and selecting one or a few specific point sources for implementation of control measures. It is felt that the decrease of mercury releases from key sources should serve as a demonstration of existing possibilities, giving inspiration to other control measures in the region.

The first step in the project is the development of an inventory of mercury releases to the air, land, and water. Characterization of mercury usage and its disposition will provide the framework for an action plan and strategy for decreasing the amount of mercury in the environment. A detailed questionnaire, now being completed by each Arctic country, was developed to ensure consistency in reporting and, thereby, allow comparisons among data in different countries. These data include key information on modeling parameters for major industrial sources (e.g., latitude/longitude, stack parameters, chemical composition, and emissions control technology).

EPA completed the U.S. portion of the questionnaire to provide data and information to the project. All data are publicly available and most are from EPA inventories, e.g., the National Emissions Inventory (NEI) for air emissions and the Toxics Release Inventory (TRI) for solid waste disposal and water discharges. The results characterize the mobilization of mercury in the US to the air, land, and water. Air releases are the primary contributor to mercury contamination. The most significant air source category in the United States is coal combustion. Other sources of air emissions include gold mining, chlor-alkali plants, municipal and medical waste combustors/incinerators, and industrial combustors. The overwhelming contributor to total releases is land disposal associated with minerals mining, predominately gold mining, which is bound up with other substances; however, the environmental impact of this action is uncertain. The data indicated that there were minimal discharges of mercury to water bodies.

The United Nations Environmental Program (UNEP) is participating in this project and is considering this work for application to other regional programs and developing/re-industrializing countries. In addition to serving as a model for international data exchange on mercury and other pollutants, the ACAP project should result in availability of data to enable assessment of mercury issues in the Arctic. The overall project is to help intended to identify research opportunities for engineering demonstrations that provide scientific information on mercury control options in the Arctic and around the world.

Poster 26: St. Louis Community Air Project (CAP) Toxics Emission Inventory Development

Mollie Freebairn
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An innovative, community-based environmental protection project is taking place in St. Louis, to investigate toxic air pollution, and inform and enable city residents and businesses to address the problems that are found. As part of this project, ambient air monitoring of about 90 toxic pollutants has been done, health benchmarks for many of them have been determined, and a toxics emission inventory has been developed. The inventory covers point, area, and on- and offroad mobile sources in the City of St. Louis. Point source toxic emissions were obtained from Emission Inventory Questionnaires (EIQs), and quality controlled such as by comparing and reconciling differences with the Toxics Release Inventory (TRI). Area source toxic emissions were obtained from the 1996 National Toxics Inventory (NTI), and an analysis has been made of their accuracy. Plans for a local bottoms-up area source inventory were also prepared, but found to be too resource intensive to carry out. Onroad mobile modeling and speciation for toxics was conducted first using MOBILE5b, and most recently the latest draft of MOBILE6.2. Offroad mobile emissions were obtained from the 1996 NTI. An analysis of the strengths and errors in the inventory is given. Monitoring found the highest levels of formaldehyde in any city to date. Current efforts to refine the emission inventory and include biogenic sources to account for the high formaldehyde levels are described.

Source and Flux Measurements

Measurement Methods, Innovative Source and Flux Measurements

Building Emissions Inventories with Remote Sensing Open Path Spectroscopy

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For more than 20 years emissions of volatile organic compounds (VOCs) from refineries and chemical plants have been made using AP-42 and other estimating techniques developed by the Environmental Protection Agency, the American Petroleum Institute and other petrochemical organizations. These estimating techniques are relied on for developing emissions inventories in the U.S., Canada, and Europe and in many other parts of the world. Measurements of VOCs using Differential Absorption Light Detection and Ranging (DIAL LIDAR or DIAL) in Europe and aircraft canister measurements in the U.S. indicate that standard estimating techniques produce inventories that are consistently understated by a factor of 3-10, and can be understated by factors as large as 25-50.

DIAL, Fourier Transform Infra-red (FTIR) and Differential Optical Absorption Spectroscopy (DOAS) are three methods that have been used with open paths to measure VOCs in petrochemical facilities. DIAL has the distinct advantage of being able to create 2 and 3 dimensional plots of concentrations and can identify “hotspots”, but is very expensive and complicated to operate. FTIR offers the advantage of being able to speciate the myriad of compounds in a VOC filled atmosphere, but can also be technically challenging to operate successfully. However improved computing and mapping of the signature fingerprints of compounds has reduced this problem. DOAS is the simplest of the technologies but can be difficult in practice because it (like FTIR) requires a retro-reflector to obtain a signal. DIAL technology uses particles in the gas plumes to obtain a signal, but sometimes those reflections provide very weak signals.

Underestimated VOC inventories in petrochemical facilities may create VOC and ozone reduction strategies and regulations that cannot be successful because they do not address significant sources of VOCs. Identifying the best technology for the task will be critical for gaining a better understanding of true emissions. This paper critiques and contrasts the three open path techniques in their ability to deliver results for creating an accurate accounting of VOCs in petrochemical facilities.

Direct Flux Measurements of Volatile Organic Compounds

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Eddy covariance (EC) flux methods and fast response chemical sensors have matured to the point where it is now possible to make direct emission measurements of a range of volatile organic compounds (VOCs). In addition, new variations on EC methods, called disjunct eddy covariance (DEC), provide further flexibility in coupling a variety of chemical sampling methods or sensors to turbulence measurements to yield direct emission measurements. These EC and DEC methods provide a way to obtain direct measurement of VOC fluxes from forested environments and the potential to yield similar data for urban environments. Because these systems can be operated in a continuous, automated manner, long term measurements covering a wide range of conditions are possible. The source footprints from EC/DEC methods generally extend from a few hundred meters to several kilometers and, as such, the data provide a basis for direct evaluation of emission models and/or gridded emission inventories. In this presentation, EC flux measurements of isoprene and associated CO2, H2O, and heat fluxes from a northern deciduous forest are presented that cover complete growing seasons from 1999 through 2003. To illustrate the potential of these methods in urban environments, preliminary results from an urban flux tower operated for several weeks in Mexico City will also be discussed. In the Mexico City study, a fast alkene sensor was employed in EC mode and a proton transfer reaction mass spectrometer (PTR-MS) was used in DEC mode to measure various VOC fluxes in a densely populated section of Mexico City.

Estimation Of Cooling Tower VOC Emissions Based On Actual Measurements

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Industrial Cooling Towers at Petrochemical and Refining facilities have the potential to emit extremely large amounts of VOC emissions. The most common method for estimating emissions is the use of AP-42 emission factors but these factors do not take into account the unique design, operation and maintenance of the specific heat exchange system for each process unit. Much more accurate emission estimates would be obtained if the concentration of "strippable VOC" in the cooling water could be accurately determined and used in conjunction with the cooling water circulation rate to determine actual emissions.

There are many methods that have been available for leak detection but they do not necessarily provide quality assured data to quantify emissions. To assure accurate accounting of emissions, TCEQ and the University of Texas have evaluated existing methods by performing detailed laboratory tests and developing improvements to establish the certainty of data obtained from these methods. In addition to identifying process fluid leaks into the cooling water as soon as possible, some of these methods provide measurements with the desired data quality so that data can be used to accurately calculate and speciate VOC cooling tower mass emission estimates.

Evaluation of Passive FTIR to Determine Efficiency of Operating Industrial Flares

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Elevated flares are commonly used by petrochemical and refining facilities to abate emissions resulting from process vents and emission events. EPA has determined, based on previously flare testing, that under certain operating conditions (tip velocity and btu value of the waste gas) a flare should be expected to provide 98-99% destruction efficiency. Emissions are commonly estimated based on the waste gas flow rate and composition with an assumed 98-99% destruction efficiency. However, during actual flare operation there may be many conditions that affect flare efficiency as well as periods of time when actual operation is not within the EPA defined range. Some previous data indicates that under these conditions efficiency can deviate significantly from 98-99%.

The best information concerning flare efficiency would be from actual real-time measurements during flare operation. It has not been possible to measure flare efficiency of an operating flare because the flame is not enclosed. TCEQ, URS and IMACC have been evaluating passive FTIR as a possible method for determining real time actual flare efficiency. The intent of this project is to provide data and methodologies to be used to improve emission estimates for flares. The project involves:

- testing of an instrument to determine the capability of passive FTIR to provide the desired data quality for measurements of flare combustion and destruction efficiency, and estimated mass emission rates over a range of operating conditions; and
- gathering of combustion efficiencies, destruction efficiencies, total mass emissions and, to the extent possible, speciated emissions from flares operating under a variety of conditions.

The Use Of A Gas Imaging Device For Detecting Fugitive Emissions In Chemical Plants

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Since the early 1980s, federal and state regulatory agencies have supported the development and eventually required the implementation of leak detection and repair (LDAR) programs for control of fugitive emissions from a variety of industries. The currently required LDAR procedure (EPA Method 21) involves placing a gas sampling instrument probe at the surface of each piece of applicable equipment and measuring the volatile organic compound (VOC) concentration as the probe is moved along the surface of the equipment. If the measured VOC concentration is above the level defining a leak, the component must be repaired or replaced to reduce the concentration to an acceptable level.

Method 21 has several shortcomings. It does not provide mass emissions rates of detected leaks. In addition, Method 21 measures only the hydrocarbon drawn through its probe. In addition, the number of designated components in a chemical plant/refinery to be tested for leaks can be quite large, making leak detection monitoring very time consuming, manpower intensive, and expensive.

EPA is currently supporting several initiatives for the refining and chemical industries involving new technologies that may lead to better and more cost effective fugitive emission control within these industries. Optical gas imaging has emerged as a promising candidate technology.

This paper presents the results of field studies comparing the fugitive emissions leak control effectiveness using optical gas imaging technology to that which would be obtained using the current Method 21 protocol. Preliminary results indicate that the gas imaging system is able to identify high leakers while monitoring both regulated and unregulated components, and is able to do so at a rate three to 50 times faster than the monitoring rate using Method 21.

Inferring Industrial VOC Emissions Inventories Based Upon VOC Observations

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Texas Commission on Environmental Quality

Observations of light alkenes collected during the TexAQS 2000 study in August-September 2000 suggested that the industrial emission inventories for these compounds were substantially underestimated. Hourly automated gas chromatography data, VOC canister data analyzed by gas chromatography and mass spectroscopy, and chemiluminescent alkene measurements were among the measurements used to infer emission rates. The ambient air samples were linked to possible emission sites by various methods, including dispersion modeling, trajectory analysis, and statistical analysis. Several methods have inferred emissions of generally the same magnitude. The inferred emissions were used in photochemical modeling simulations, and were found to improve the model performance.

A Passive Flux Denuder for Evaluating Emissions of Ammonia at a Dairy Farm

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Passive samplers have been shown to be an inexpensive alternative to direct sampling. Diffusion denuders have been developed to measure the concentration of species such as ammonia, which is in equilibrium with particulate ammonium nitrate. Conventional denuder sampling has required active sampling that inherently requires air pumps and therefore electrical power. To estimate emissions of ammonia from a fugitive source would require and array of active samplers and meteorological measurements to estimate the flux. A recently developed fabric denuder was configured in an open tube to passively sample ammonia flux. Passive and active samplers were collocated at a dairy farm at the California State University, Fresno, Agricultural Research Facility. During this comparison study ammonia flux measurements were made at the dairy farm lagoon before and after the lagoon underwent acidification. Comparisons were made of the flux measurements obtained directly from the passive flux denuder and those calculated from an active filter pack sampler and wind velocity. The results show significant correlation between the two methods, although a correction factor needed to be applied to directly compare the two techniques. This passive sampling approach significantly reduces the cost and complexity of sampling and has the potential to economically develop a larger inventory base for ambient ammonia emission

Leaf, Canopy, Landscape, and Regional Measurements for Developing and Evaluating Biogenic VOC Emission Models

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Biogenic volatile organic compounds (BVOC) have an important role in determining the chemical composition of atmosphere. As a result, these compounds may be important for air quality, visibility, biogeochemical cycling, climate and radiative forcing, and the health of the biosphere. This presentation will provide an overview of recent field measurements of biogenic VOC emissions from North American (Canada, U.S., Costa Rica) landscapes. Flux measurement methods that will be described include leaf-scale (enclosure measurements), canopy-scale (above-canopy tower measurements), landscape-scale (tethered balloon), and regional-scale (aircraft measurements) observations. Isoprene, methanol, α-pinene, β-pinene, acetaldehyde, acetone, ethanol, and ethene contribute more than 75% of the total North American BVOC carbon flux with an additional 25 BVOC contributing nearly all of the remainder. Recent advances in analytical techniques have considerably improved our ability to measure most of these compounds. These have been applied to enclosure measurement methods that have greatly increased our understanding of the physiological and genetic processes that control emission variations. Seasonal and diurnal variations characterized with above-canopy tower eddy flux measurements enable us to evaluate canopy scale emission models. Tethered balloon observations throughout the daytime mixed layer are used to examine the combined processes of emissions, transport and chemistry. Airborne studies are the most effective means of quantifying regional BVOC fluxes and recent advances, and plans for future work, will be described.

An Improved Measurement Method And New Speciated PM2.5 Emission Factors For Stationary Combustion Sources

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To understand the contribution of stationary sources to ambient PM2.5 (i.e., particles smaller than 2.5 microns or PM2.5), accurate inventories of the mass and chemical composition of source PM2.5 and precursor emissions is needed. The present work focuses on: (1) Developing valid emission factors and speciation profiles for stationary sources found in oil, gas and power generation industries; (2) designing a new dilution sampler design for improved applicability to stationary sources; and (3) establishing a robust standard methodology for fine PM source characterization.

Dilution sampling methods offer advantages over traditional stack sampling methods for determining chemical speciation of fine particle and precursor emissions because: a broader range of sampling media and methods can be employed; the same sampling/analysis methods used for chemical speciation of ambient PM2.5 can be employed providing directly comparable results; traditional hot filter/impinger methods are subject to substantial positive bias due to SO2/sulfate artifacts and excessive nucleation. Measurements representative of the near-field plume from a stationary source require sufficient residence time in the dilution sampler to allow condensation and growth of key aerosol constituents. Pilot-scale combustor tests burning straight and doped natural gas, No. 6 fuel oil, and coal indicate that near-equilibrium aerosol conditions can be achieved at much shorter residence times (10 seconds) than previously thought, enabling a more compact dilution sampler design. An ASTM Task Group has been formed to develop a consensus standard for stationary source dilution sampling. Field tests on several full-scale gas- and residual oil-fired sources characterized emissions of mass, ions, anions, elemental and organic carbon, volatile and semivolatile organic compounds. New speciated emission factors will be presented.

Design Of A Next Generation Dilution Sampling System To Quantify Fine Particulate Emissions From Combustion Systems

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Characterizing PM2.5 emissions from combustion systems is difficult because of the high temperatures and moisture content of exhaust gases. Upon exiting the stack the combustion products are rapidly cooled and diluted with ambient air, during which time processes such as coagulation, condensation, and nucleation change the size and composition of the PM emissions. Dilution sampling is a technique that has been developed to examine the influence of rapid cooling and dilution on PM emissions from combustion systems. A dilution sampler rapidly mixes hot exhaust gases with a specified amount of conditioned air and allows for processes such as nucleation, condensation, and coagulation to occur. Understanding the effects of sampling conditions is critical in order to interpret measurements made with a dilution sampler and to optimize sampler design. Although dilution sampling has been widely employed for characterizing emissions from engines, relatively little work has been done using other combustion systems such as power plants. Current samplers such as the Cal-Tech dilution sampler are large and challenging to operate which makes them difficult to deploy in the field.

Design of an improved dilution sampling system for source sampling requires a better understanding of the influence of parameters such as dilution ratio and residence time on the measured PM composition and size distribution. This talk examines the effects of these parameters using measurements made while sampling from a pilot-scale coal combustor, wood stove and diesel engine. Sampling was performed using two different dilution systems: a sampler similar in design to the Cal-Tech dilution sampler (Lipsky et al., 2002), and a much smaller sampler based on porous frit and an eductor pump. Both systems can be operated at dilution ratios between 10 and 100, and allow for aging times up to 1 minute. Measurements include PM2.5 composition (organic and elemental carbon, ions, and metals) and particle number distribution using a scanning mobility particle spectrometer (SMPS). The results indicate that particle number distribution is very sensitive to dilution parameters, especially in the nucleation mode. PM2.5 mass and composition are also sensitive to dilution conditions.

E. Lipsky, C. O. Stanier, S.N. Pandis, A.L. Robinson (2002) *Energy and Fuels* 16(2): 302-310.

PI-SWIRL: A New Technique for Measuring Wind Blown Dust Emission Potential

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Ambient air quality standards for particulate matter (PM) are violated in numerous locations across North America. In many of these locations, fugitive dust is thought to be responsible for a substantial share of the problem. The magnitude of PM emission in the form of windblown fugitive dust depends on the wind speed as a function of height above the surface and the wind erosion potential of the surface. Macro-scale factors that affect the wind erosion potential of a surface include the degree of vegetative cover and fetch length. Micro-scale effects include surface roughness , the surface matrix particle size distribution, and the matrix particle adhesion characteristics.

A new device is being tested for its ability to rapidly and repeatably measure the wind erosion potential of a soil surface. The Portable In-Situ WInd eRosion Laboratory (PI-SWIRL) was developed at DRI. Unlike conventional field wind tunnels, the device is easy to set up in the field, requiring only between 10 and 15 minutes for a measurement that covers approximately one square meter of surface area. The PI-SWIRL is intended to measure the inherent tendency for a soil to erode and emit PM in response to a shear stress generated immediately above the soil. The presence or extent of medium- and large-scale vegetative cover is not directly accounted for by the PI-SWIRL. This paper will focus on a discussion of the design of the PI-SWIRL as well as some preliminary data.

Emission Factors for Visibility Impairment from Fugitive Dust Emissions

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The U.S. EPA's 1999 Regional Haze Rule sets the stage for a 65-year effort to return visibility to its natural state at 156 national parks and wilderness areas. Visibility impairment is mostly caused by light scattering from suspended particles, with important contributions from both fine (e.g., sulfate, carbonaceous particles) and coarse size fractions (e.g., entrained mineral dust). Current particulate emission factors quantify emissions of particulate matter (PM) mass and are used in conjunction with the U.S. EPA's health-based PM2.5 and PM10 standards. For visibility applications, we propose to use emission factors quantifying the flux of PM scattering cross sections, which are directly relevant to visibility impairment. Such emission factors are useful for non-hygroscopic particles available for long-range transport, where the flux of scattering cross section is largely conserved during mixing and transport.

As an example, we have measured scattering cross section emission factors for mineral dust entrained by military vehicles from an unpaved road in Ft. Bliss, TX. A novel nephelometer with an enhanced capability for accurately measuring scattering from large particles is used to determine the scattering coefficients in vehicle dust plumes 100 m downwind of the unpaved road at a height of 5.7 m above ground. Fluxes and emission factors for scattering cross section are calculated from these data in conjunction with vertical plume concentration and wind velocity data. The resulting scattering cross section emission factors are stratified as function of vehicle weight and speed.

Measuring Trace Gas Fluxes from an Aircraft Platform

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Work at Argonne National Laboratory supported by the U.S. Department of Energy, Office of Science, Office of Biological and Environmental Research, Climate Change Research Division, under contract W-31-109-Eng-38.

Nonmethane organic compounds (NMOCs) are precursors to ozone and aerosol formation. Global-scale emissions of NMOCs from biogenic and anthropogenic sources are approximately 1200 and 130 Tg C a-1, respectively. Evaluations of NMOC emission inventories developed for rural and urban areas (which contain large uncertainties) necessitate direct measurement of landscape-scale fluxes. The main objectives of this research are (1) to develop aircraft-based methodologies for measuring the rate of exchange of NMOCs with environmental surfaces and (2) to make observations of the vertical flux and concentration profiles of NMOCs and their oxidation products above urban and rural landscapes in order to evaluate chemical-transport models and emission inventories. The measurement approach uses a variety of eddy sampling techniques in concert with fast- and slow-response chemical and turbulence sensors to determine air-surface exchange rates. A description of the eddy sampling techniques and sensors will be presented. In addition, results from a field experiment designed to measure the flux of isoprene from a forested site will be described.

Mobile and Tunnel Studies

EPA's Utilization of Portable Emission Measurement Systems (PEMS)

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Portable emission measurement systems (PEMS) are becoming increasingly capable of providing very high quality emission and activity information on motor vehicles and engines. EPA has been purchasing and deploying these devices to gather emission factor and activity information in various test programs. Available technology will be discussed. Data from EPA test programs will be reviewed in comparison with existing sources of information. Plans for future deployment will be addressed.

Utilization of Tunable Infrared Laser Sensors for Cross-Road Mobile Source Emissions Characterization and Quantification

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Recent advances in laser sensor technology allow the characterization of on-road motor vehicle emissions utilizing real-time measurement techniques that do not rely on traditional tunnel studies or the require the lane restrictions often necessary to utilize commercial cross road remote sensing instruments. Quantification of a wide range of gaseous pollutants from individual on-road vehicles can be determined by utilizing tunable infrared laser differential absorption spectroscopy (TILDAS) techniques operating at ~0.01 s time resolution deployed in open path (cross road) configurations. Examples of TILDAS cross road remote sensing data will be presented along with recent instrumentation advances using quantum cascade lasers. Advantages of TILDAS remote sensing instrumentation include the ability to measure across multiple lane highways, the capability to redirect the optical system to measure low (light duty vehicle) and high (heavy duty diesel) exhaust plumes, and the ability to measure a wider range of exhaust pollutants in addition to the NO, CO and unspeciated VOC measurements accessible to commercial instruments, including NO2, N2O, NH3, and individual VOCs such as CH2O, CH4, C2H2, and C2H4. Compared to earlier lead salt tunable diode laser TILDAS instruments, the easier and more reliable spectral tuning and the great reduction or elimination of cryogenic cooling possible with quantum cascade (QC) lasers allow QC-TILDAS remote sensing instruments to be operated either autonomously or with greatly reduced operator attention.

Mobile Laboratory Mounted Fast Response Instrument Methods for On-Road Vehicle Emissions Measurements

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The development of sensitive, rugged, fast response (<1 to 3 s) instrumentation allows the real-time, on-road characterization of gaseous and fine particulate motor vehicle emissions using mobile laboratory methods. Trace gaseous emissions of CO, H2CO, NO, NO2, HONO, NH3, SO2, CH4, C2H2, C2H4, and C2H6 can be measured by tunable infrared laser differential absorption spectrometers (TILDAS) while selected oxygenated (CH3OH, CH3CHO) and aromatic (benzene, toluene, xylenes) VOCs can be quantified by proton transfer reaction mass spectrometry (PTR-MS). The non-refractory chemical components of fine exhaust particles can be determined as a function of particle size on time scales a short as 2 s by sampling and analyzing exhaust plumes using aerosol mass spectrometry (AMS) techniques. Exhaust plume CO2, total nitrogen oxide content (NOy), and total fine particle number density and surface area can all be monitored with 1 s resolution using instruments that have been commercially available for some time. The use of these sampling instruments aboard a mobile laboratory deployed in both on-road survey and vehicle chase modes to characterize and quantify fleet and individual vehicle emissions in urban environments and on highways will be presented. Recent data for vehicles from Mexico City and New York City will be highlighted.

Spatially-Resolved, Direct Measurement of Road Dust Emissions from Vehicles.

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Traditional estimates of paved and unpaved road dust emissions have relied on analysis of silt samples obtained by vacuuming and/or sweeping of material from roads. This process is time-consuming and limited in the amount of spatial coverage achievable. Testing Re-entrained Aerosol Kinetic Emissions from Roads (TRAKER) is a technique that allows for measurement of road dust emissions in real-time and over a large spatial scale. Particle sensors that are mounted behind the front tires of a vehicle are influenced by the PM10 dust generated from the contact of the tire with the road. A background measurement of particle concentrations is obtained simultaneously near the front bumper of the vehicle. The difference in the signals between the influence monitors and the background monitor is directly related to the amount of road dust emitted. A Global Positioning System (GPS) receiver is used to simultaneously log the location of each data point.

The TRAKER system has been collocated on an unpaved road with horizontal flux towers. Based on the relationship between PM10 dust flux and TRAKER signal , the road dust emission potential can be inferred for all roads surveyed by TRAKER. TRAKER has been used to build road dust emission inventories, assess the effects of road sanding and sweeping on paved road emissions, and monitor seasonal changes in emissions for winter to summer.

Automotive Particulate Matter and Gaseous Emission Factors from On-Road Measurement in Las Vegas, NV

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Detailed and accurate emission inventories are needed to design cost-effective measures to attain compliance with ambient air quality standards. The need for inventories of particulate matter (PM) emissions is driven by ambient PM standards and by the Regional Haze Rules. These regulations are designed to reduce health effects and visibility impairment due to elevated PM concentrations. Mobile sources make a significant, yet poorly quantified, contribution to total PM emissions. Remote sensing is an established and effective technology to determine gaseous emission factors for a large number (e.g., 105-106) of individual vehicles. Very recently, we have developed a remote sensor based on ultraviolet Lidar (light detection and ranging) and transmissometry for the measurement of automotive PM emission factors.

Here, we present the results of a large field study conducted in Las Vegas, NV. Carbon monoxide (CO), hydrocarbon (HC), and nitrogen oxide (NO) emission factors were measured with a conventional gaseous remote sensor, while those for PM were measured with our new instrument. Fuel-based emission factors for nearly 150,000 vehicles were measured over a three-year period (spring and summer 2000-2002). Emission factor distributions are analyzed for each pollutant and averaged data are compared to values from previous studies and to the U.S. EPA's models. The large skewness of these distributions is evident for both gaseous pollutants and PM. It has important implications for emissions reduction policy, since the majority of emissions are attributed to a small fraction of vehicles. Determination of vehicle speed, acceleration, and other vehicles characteristics, made it possible to stratify emissions by vehicle specific power, model year, fuel type, and weight class. The stratified results show important patterns in the distribution of emissions factors.

Identification of Excessive Emissions System Failure Rates in High-Mileage Fleet Vehicles Based on Networkcar's Continuous On-Board Emissions Monitoring System

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The paper, prepared by Networkcar with input from the California Air Resources Board ('ARB'), will describe and verify a model and experimental program used to calculate emissions reductions using a wireless emissions-monitoring device (called the CAReader) on 1,000 taxicabs participating in ARB's Clean Fleets program. The program will assess the impact of continuously monitoring the emissions systems of high-usage (typically over 50,000 miles per year) vehicles over a five-year period.

The commercially available emissions-monitoring device, currently also monitoring several thousand consumer-owned vehicles, dynamically measures and reports the status of the taxicabs' emission systems to effectively control oxides of nitrogen (NOx), hydrocarbons (HC), and carbon monoxide (CO). The device collects emissions-related data from a host vehicle's on-board diagnostic (OBD-II) system and transmits these data over a conventional wireless network to an Internet-based computer system. The computer system analyzes the data to perform a federally approved OBD-II Inspection and Maintenance ('I/M') emissions test, and posts the results on a secure web site (www.networkcar.com). Failing vehicles that would otherwise continue to drive in a heavily polluting condition are dynamically detected and reported. Without this monitoring, non-compliant taxicabs can drive unchecked while emitting excess NOx into the environment; these levels persist even though the vehicle appears to function properly. With the remote monitoring system installed, polluting vehicles are quickly identified and repaired to reduce the amount of excess pollutants.

This is the first time a cost-effective aftermarket product has been available for continuously monitoring the emissions of most 1996 and newer cars and light trucks.

Measurements of Marine Vessel Emissions

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Emission of oxidized nitrogen and sulfur compounds from large marine vessels constitutes a significant source of these species. For example, nitrogen from this source represents more than 14% of all combustion emissions globally (1). But these emissions are also important regionally in coastal areas and locally in ports since it has been estimated (1) that 70% of all ship emissions occur within 400 km of land. Currently, the best available inventory data are compiled from marine fuel usage and various emission factors. Sulfur emission factors are directly related to the sulfur content of fuel while nitrogen emission factors are primarily related to the engine type: slow-speed diesel, medium-speed diesel, and other (generally steam-turbine). The average emission factors used in inventories come from a Lloyd's Register of Shipping sponsored emissions research program in which unmodified, in-service marine vessel emissions were measured directly at the stack. While the results from this program represent the best available data, the significance of marine vessel emissions suggests that additional evaluation of emission factors be conducted.

During the 2002 New England Air Quality Study (NEAQS 2002) the NOAA research vessel Ronald H. Brown was equipped with trace gas and aerosol monitoring instrumentation for the purpose of investigating the factors that affect air quality in coastal New England. As a part of that study, numerous opportunities arose to measure gaseous and particulate emissions from marine vessels, both in port and underway. This talk will present measurements from the NEAQS 2002 and relate those data to current inventory estimates of marine vessel emissions.

(1) Corbett, J.J., et al., Global nitrogen and sulfur inventories for oceangoing ships, *J. Geophy. Res.*, 104, 3457-3470, 1999.

Analysis of Motor Vehicle Emissions in a Houston Tunnel during the Texas Air Quality Study 2000

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Measurements from a Houston tunnel were used to develop fuel consumption based emission factors for CO, NO_x, and Non-Methane Organic Compound (NMOC) for on-road gasoline vehicles. The Houston NO_x emission factor was at the low range of emission factors reported in previous (primarily pre-1996) tunnel studies while the NMOC emission factor was slightly higher than that reported in the previous tunnel studies. The fuel based tunnel emission factors for CO, NO_x and NMOC were compared to emission estimates calculated by the MOBILE5b and MOBILE6 models by making estimates of fuel efficiencies. The MOBILE6 emissions estimate for CO from gasoline vehicles was over twice that provided by the tunnel measurements and predicted by MOBILE5b. NMOC and NO_x emission factors based on the tunnel data were consistent with the MOBILE6 estimates.

Pacific 2001: Cassiar Tunnel Study — Particulate Matter Emissions Measurements

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Vehicle emission sampling was conducted at the Cassiar Tunnel in Vancouver during August 9-15, 2001. This was a 7-day study with 3 sampling periods each day. The goals of the Cassiar Tunnel Study were:

- To obtain accurate mass emission rates for a wide range of pollutants emitted from motor vehicles.
- To compare the emissions measured at the tunnel (>150,000 vehicles over 7 days) with chassis dynamometer measurements of a limited number of vehicles (70 vehicles over 5 weeks).
- To obtain current emission profiles for on-road vehicles for use in source apportionment studies.

One of the key unknowns in understanding ambient particulate matter concentrations, PM sources and the transformation processes is the relative importance of primary and secondary particles. The questions that must be answered in developing computer models to predict air quality are:

- How much of the ambient particle loading is due to primary emissions vs. secondary formation reactions?
- How large is the (on-road) transportation contribution to both primary and secondary particles?

Measurements of PM10, PM2.5 and PM1 by cyclone for mass, OC&EC, ions, metals and speciated organics were made along with particle size distribution and number concentration measurements. As part of the particulate matter measured at the tunnel comes from sources other than tailpipe emissions (e.g. tire wear, concrete or asphalt dust), an attempt was made to account for this re-entrained road dust contribution by the comparison of PM2.5 samples with additional PM10 and PM1 samples for mass, OC&EC and metals and by comparison to road dust samples collected inside the tunnel at the start of the study. Preliminary emission rate results will be presented for some of these PM species. Details of the implementation of the study will be presented, along with the use of a tracer gas to verify tunnel airflow measurements.

Estimation of Mobile Emission Ratios for Sulfur, Nitrogen, Carbon and Mercury from Field Measurements in Atlanta, GA

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This presentation uses high temporal resolution gas and particle data from a site in Atlanta, GA to estimate mobile emission ratios for a variety of gaseous species (including NOx, SO2 and elemental Hg) and particulate species (including PM2.5 mass, elemental carbon and total carbon). Data are analyzed for the Jefferson Street SEARCH site, where a wide variety of gas, particle and meteorological measurements have been made with 1-minute to 60-minute time resolution since August 1998. The analysis approach focuses on covariance of target species with CO during periods of nocturnal stagnation. Under these conditions, locally emitted pollutants increase significantly under the nocturnal boundary layer. Linear regression analysis is used to extract the emission ratio of interest (i.e., relative to CO). Emission ratios will be presented for a number of what appear to be purely gasoline and diesel events. Results for the 4-year period 1998-2002 will be presented for NOx:CO, PM2.5:CO and EC:CO. Year to year variability will be assessed. Data for a shorter period of record (i.e., 2002) will be used to estimate elemental Hg:CO emission ratios. Results will be compared with expected ratios based on emission inventories and the literature.

Estimation of Paved and Unpaved Road Dust Emissions in Mexico

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The first comprehensive national emissions inventory for the country of Mexico is currently under development (a general overview of the Mexico National Emissions Inventory (NEI) project is discussed in a companion presentation by Fields). Two key area source categories in the Mexico NEI are re-entrained dust from paved and unpaved roads. Parameters needed to calculate re-entrained dust emission factors include silt loading, silt content, surface moisture content, mean fleet vehicle weight, mean fleet vehicle speed, and precipitation. Subsequently, it is necessary to determine the vehicle kilometers traveled (VKT) for paved and unpaved roads in order to apply the appropriate emission factors.

This presentation will present the innovative approach used to estimate the percentage of VKT traveled on paved and unpaved roads. The approach builds upon the work previously done to estimate on-road motor vehicle activity data for the Mexico NEI. This presentation will demonstrate the process used to allocate VKT over paved and unpaved roadways in seven representative urban areas of different sizes, including the identification of unpaved roads, development of a GIS data set for unpaved roads, and the estimation of unpaved road VKT. The satellite images and aerial orthographic photographs used to identify unpaved roads will be discussed, as well as the data analysis and interpretation methodologies used. The unpaved road VKT estimation process using traffic modeling initially conducted for the development of the Mexico NEI motor vehicle activity data will also be presented.

Characteristics of the Monterrey Metropolitan Area Vehicle Fleet and Its Estimated Emissions

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The vehicle feet in the Monterrey Metropolitan Area (MMA) has increased from 687,000 vehicles in the year 1995 to more than 1,100,000 in the year 2003. The pollutant concentrations in the air have exceeded the 24-hour air quality standard of 150 µg/m3 for PM10 several days of the year as well as the one-hour average of 0.11 ppm for ozone. Moreover, since air quality monitoring activities started in 1993, the annual average standard of 50 µg/m3 for PM10 has been exceeded in the MMA, except for the year of 1997. Feasible air pollution control strategies based on technical, economic and political issues need to be implemented. However, a reliable and "up-to-date" emission inventory does not exist. The last emission inventory for the MMA was calculated in 1995. In this work we present the results of a study to characterize the vehicle fleet of the MMA and its emissions. The fraction of unregistered vehicles is considered in the mobile source emission inventory. This fraction was estimated during a recent study that compared the results of an on-road vehicle survey to the registration database. It includes non-registered, out-of-the-state and out-of–the-country vehicles. The emissions are estimated and compared using the MOBILE5 model adapted for the MMA and the MOBILE 6 model. A proposed pattern of spatial distribution of emissions is presented based on a study of vehicles sampled in different parts of the MMA. Recommendations are given to improve the data in the vehicle registration files and in the estimated emissions. The study and data presented is a foundation for the development of the MOBILE6 model for Mexican vehicles (MOBILE6-Mexico) and to improve the estimates of air pollutant emissions.

Comparison of Remote Sensing Measurements of On-Road Vehicle Emissions in Chicago and Denver with MOBILE6 predictions

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Remote sensing device (RSD) measurements of vehicle exhaust plumes have been collected over a period of years in Denver (1999 – 2001) and Chicago (1997 – 2000). Each year's measurements were made over a period of a few days with the location and time of year held constant from one year to the next. Previous analyses of these data have shown that they provide an accurate and consistent portrayal of light-duty vehicle exhaust emissions for the fleet and driving conditions observed at each monitoring location. As part of a series of analyses designed to evaluate EPA's MOBILE6 emission factor model, ENVIRON undertook a comparison of the Denver and Chicago RSD data with corresponding fleet average vehicle exhaust emission factors predicted by MOBILE6. RSD measurements represent the ratios of hydrocarbons, carbon monoxide, and nitrogen oxide to carbon dioxide in the vehicle exhaust plume over approximately a one-half second time interval. These measurements together with a few reasonable assumptions about the combustion process can be used to determine the percent HC, CO, and NO in the exhaust plume and, from the carbon balance, mass emissions in grams per kg of fuel. MOBILE6, on the other hand, predicts tailpipe emission factors in units of grams/mile. Data used to derive MOBILE6 emission factors originate from direct measurements of HC, CO, and NOx mixing ratios in the tailpipe exhaust during vehicle operation over a prescribed dynamometer driving cycle. Expressing MOBILE6 g/mile factors in g/kg of fuel (or vice versa) requires an estimate of the instantaneous fuel economy which is not available from the RSD data used in this study. Since MOBILE6 only provides fleet average fuel economy figures and the instantaneous vehicle specific fuel economy may vary significantly from the average, comparisons were based on ratios of mass emission factors (HC/NOx and CO/NOx). Comparisons were also made of the relative changes in emissions with vehicle age and model year as predicted by MOBILE6 and as observed in the RSD data. Dependency of emissions on driving mode (as measured by the vehicle specific power) is examined and implications for the MOBILE6/RSD comparison explored.

Traffic-Related Emission Factors in Two Major Freeways in Southern California

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Despite great efforts have been made, uncertainties remain to be a major issue for the methodology used to estimate motor vehicle emission factors. This study is sought to apply measurements of pollutants in the vicinity of major freeways to estimate traffic-related emission factors. Carbon monoxide (CO) and black carbon (BC) were measured upwind and downwind at various distance from two major freeways I-405 and I-710 in Southern California, one mostly occupied by gasoline-powered cars and the other dominantly by heavy-duty diesel trucks,. A line-source Gaussian dispersion model was applied to fit these data. We adopted the concept of mixing zone, a region directly over the freeway as a zone of uniformly mixed emissions and turbulence, in CALINE4 model and a power function to model vertical dispersion parameter. The method of least squares of errors between model predictions and observations was used to simultaneously estimate the coefficients of the vertical dispersion as well as the emission factors. We found the emission factors of CO were 35.5 and 10.6 g/km vehicle for I-405 (diesel < 5%) and I-710 (diesel > 25%), respectively, consistent with the fact that gasoline-powered vehicles emitted more CO than diesel-powered trucks. The emission factors of BC were estimated to be 0.075 and 0.048 g/km vehicle for I-710 and I-405, respectively, again, consistent with the fact that diesel-powered trucks emitted more soot particles than gasoline-powered vehicles. These values are comparable with those values estimated by published other studies using different methodology. It is concluded that the horizontal profile of airborne pollutions near freeways and the line-source Gaussian dispersion model are successfully used to estimate emission factors for aggregate vehicular traffic in major freeways. This methodology is demonstrated to be an excellent tool to re-examine the uncertainties of emission factors estimated by traditional methods.

Temporal Patterns in Nitrogen Oxide Emissions from Diesel Engines

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A fuel-based approach to estimating on-road diesel engine exhaust emissions will be described that relies on fuel sales rather than distance traveled. Changes in NOx emissions between 1990 and 2000 are assessed. Diesel exhaust is now the dominant mobile source of NOx emissions. While NOx emissions from gasoline-powered passenger vehicles decreased during the last decade, emissions from diesel engines increased in both relative and absolute terms. This state of affairs is due to rapid growth in the total amount of diesel fuel consumed, a focus on controlling emissions from light-duty vehicles, and ineffective controls that failed to achieve intended reductions in diesel NOx emissions during the 1990s.

Weigh-in-motion traffic count data are used to define the temporal distribution of emissions on fine time scales. Compared to light-duty passenger vehicles, diesel truck traffic is found to have different temporal distributions of emissions on diurnal and weekly time scales. Large decreases in diesel truck traffic on weekends cause a significant perturbation to the NOx budget for urban areas. These changes can be an important contributor to weekday-weekend differences in photochemical air pollution.

EPA's Plans to Estimate the Criteria Air Pollutant Emissions of Highway Vehicles and Off-Highway Equipment with MOVES

Gene Tierney
EPA Office of Transportation and Air Quality

MOVES is EPA's new mobile source air pollutant emissions model. It will replace the current MOBILE6 and NONROAD models with one completely redesigned to offer consistent emission rate estimation across multiple scales.

This presentation briefly reviews the scope of MOVES_GHG, the first version of MOVES , and the methodology EPA is using to estimate the greenhouse gas emissions of highway sources. Where data is available MOVES_GHG uses second-by-second measurements to calculate and bin vehicle specific power and associates this with emission rates. Ongoing work with the engine friction component of this power calculation promises to eliminate most dependence on driving patterns or average speed. Where such data is not available MOVES_GHG uses a Physical Emission Rate Estimator (PERE), which is calibrated to known data.

MOVES_GHG will also include life cycle analysis, i.e. upstream emissions estimates (well to pump analysis) for advanced technology vehicles through the use of GREET.

The presentation elaborates EPA's plans for expanding MOVES to include criteria air pollutants and non-highway mobile sources, including:

- modeling cold start and running emissions using VSP
- elaboration of PERE to model engine and tailpipe emissions
- accounting for high-emitting vehicles
- including the effect of odometer reading and/or vehicle age
- more elaborate consideration of the effects of local emission control programs
- emission rate adjustments for temperature, humidity, altitude and fuel
- inclusion of evaporative emissions

Finally the presentation touches on how the uncertainty estimates of MOVES_GHG may be adapted for these more elaborate emission rate calculation methods.

NMIM: EPA's Consolidated Emissions Modeling System for MOBILE and NONROAD

Gene Tierney
EPA Office of Transportation and Air Quality

EPA's National Mobile Inventory Model (NMIM) is a consolidated emissions modeling system for EPA's MOBILE and NONROAD models. It generates county inventories using MOBILE6 and NONROAD at scales ranging from individual counties to the nation. Its primary improvements over MOBILE and NONROAD are 1) the inclusion of all the required county data for the nation in a single database, 2) an easy-to-use graphical user interface, 3) "shortcuts" for generating national inventories, 4) tools for aggregation and post-processing, and 5) distributed processing capability to enhance performance. When national inventories have previously been constructed from MOBILE and NONROAD, the necessary input data have been widely scattered in disparate formats and have required additional specialized software to convert this data into input files for MOBILE and NONROAD, to run the models, to integrate the results into a final inventory, and to post-process the results into forms suitable for the national inventories or for emissions processors. NMIM accomplishes all of these tasks in a single package. NMIM is written in Java, which works directly with the database using Structured Query Language (SQL). The database management system is MySQL, a widely-used, fast, open-source database. MOBILE and NONROAD remain Fortran executables, which are called by NMIM.

Ground and Aircraft Observations

Using Ambient Measurements To Critically Evaluate The Temporal Trends Of U.S. Carbon Monoxide Emission Inventories

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Carbon monoxide (CO) plays important roles in the photochemistry of the global troposphere. It provides a large fraction of the "fuel" for the photochemical production of ozone, and its reaction with the hydroxyl radical is the primary sink for that critical species. Global emission inventories of CO are derived from integration of the inventories of the world's nations (http://arch.rivm.nl/env/int/coredata/edgar/). Comparison of these national inventories presents an enigma. Western Europe, with a population 40% greater than the U.S., reports CO emissions smaller by nearly a factor of 2. Further, Western European emissions reportedly are decreasing by 2.3 %/year, while U.S. emissions are thought to be nearly constant (0.2%/year increase). Given the large resources devoted to catalytic converters on U.S. automobiles (the primary source of CO), the lack of a significant decrease in U.S. emissions is surprising.

The U.S. EPA is a source of contradictory information regarding temporal trends of national CO emissions. One website (http://www.epa.gov/air/aqtrnd01/carbon.html) indicates a 6% increase (0.7%/year) from 1992 to 2001. In contrast, the 2000 U.S. EPA report "National Air Pollutant Emission Trends, 1900 – 1998" indicates a decrease of 1.9%/yr from 1985 to 1998 while the recent update to that report (http://www.epa.gov/ttn/chief/trends/trends01/trends2001.pdf) shows a 2.9% decrease from 1985 to 2000. Our goal here is to use ambient measurements to discriminate between these conflicting inventories.

Measured ambient levels of CO have decreased at a significantly faster rate than any of the emission inventories. Urban CO levels decreased by 4.9%/year (based on the annual mean of the 2nd highest maximum 8-hr average for about 350 predominately urban and suburban monitoring sites nationwide) from 1985 to 1999. This corresponds to a decrease of more than a factor of 2 over this period. *Hallock-Waters et al.* [1999] report that rural CO levels in the U.S. Mid-Atlantic region decreased at approximately 5 ppbv/year from 1989 to 1997. This decrease is consistent with the decrease in the urban emissions. These trends in ambient measurements cannot be reconciled with the tabulated emission trends, and indicate errors in the latter. CO emissions, particularly from the mobile sources that dominate urban CO levels, evidently have decreased significantly faster than recognized in emission inventories.

Measured CO and NO_x concentrations in U.S. urban areas show that the CO/NO_x vehicular emission ratio has decreased at an average annual rate of 7 to 9% from 1987 to 1999 (i.e. a factor of ≈3). This rate of decrease is at least twice that derived from mobile source emission inventories. These considerations all indicate that the rate of decrease of U.S CO emissions is underestimated in current emission inventories. We conclude that the control strategies that have been implemented, particularly catalytic converters on automobiles, are significantly more efficient at reducing CO emissions than recognized by the inventories.

Assessing Anthropogenic Emissions Inventories Using Measurements From Aircraft

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Near-field airborne measurements downwind of anthropogenic point and area sources can provide an independent assessment of emissions inventory values for NOx, CO, CO2, SO2, and a wide variety of VOCs. The accuracy of emissions ratios determined from aircraft data can be quite high, with uncertainties determined by instrumental calibrations uncertainties, typically ±5-10%. Absolute emission rates from point sources can also be determined with uncertainties of approximately ±20% or better under optimal meteorological conditions. Comparison of aircraft estimates to inventory values for urban, power plant, petrochemical industrial, and marine diesel emissions will be presented. In general, emissions from point sources equipped with continuous emissions monitoring systems (CEMS) are accurately estimated in the inventories, but significant discrepancies exist for other anthropogenic source types.

BIOmass Burning Emission Estimates using SEARCH Measurements

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Biomass burning is an important source of atmospheric particles and gases in many parts of the world. Extensive burning occurs in the southeastern U.S. during fall and winter, both as a source of heat and also as a means of disposal for accumulated stocks of carbonaceous material. Relatively large fires, which can last several days or longer, provide opportunities to measure combustion products and to gain an understanding of emissions for a range of particles and gases.

SEARCH is a long-term research program investigating spatial and temporal variability of fine particulate matter, and gases across the southeastern U.S. The SEARCH network includes 8 research sites in four rural-urban pairs. Each site is equipped with an array of equipment to measure meteorological variables and trace gases (CO, NO, NO2, HNO3, NOy and SO2) fine particulate mass, elemental carbon, ammonium, nitrate, and sulfate with 1-minute temporal resolution; CO2, fine particulate organic carbon and total carbon with hourly time resolution.

This paper uses data from SEARCH to estimate emissions ratios for carbon (CO2, elemental carbon, organic carbon), nitrogen (NO, NOx, particulate nitrate and ammonium) and sulfur (SO2 and particulate sulfate) in several biomass-burning events. Emissions ratios are calculated relative to CO, since this is a relatively stable tracer species and because it is measured with high sensitivity and frequency. Resulting emission ratios are compared across events and then with non-biomass sources (e.g., urban and point source plumes) to evaluate robustness and uniqueness of signatures.

Similarities and differences between observed ratios and those from other types of biomass burning (e.g., rain forest and savannah) are discussed.

Tower Based Real Time Monitoring System for Quantifying Fugitive Emissions

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A multi-tower measurement system incorporating real-time particulate matter (PM) mass concentration, particle sizing, and meteorological instruments to quantify mass fluxes and emission factors for fugitive emissions is presented. The system can also integrate collocated real-time visibility measurements for regional haze emissions assessments. The three 12-m towers are equipped with up to 16 TSI DustTraks (4 to 6 per tower) to measure mass concentration (PM_{10}, $PM_{2.5}$, or PM_1) at multiple heights above ground level. GRIMM model 1.108 Particle Sizers are used to obtain particle size distributions (0.4-20 µm) of the emitted PM. The towers can be placed at varying distances downwind of the source to characterize deposition and dispersion of the emissions. Visibility instruments that have been integrated into the system include the DRI photoacoustic instrument (light absorption), integrating nephelometer (light scattering), and cavity ring-down extinction meter. Data acquisition is accomplished with a network of portable computers running a custom-designed LabView program that synchronizes data collection and writes the acquired data to a Microsoft Access compatible database. Instrument sampling rates are typically 1 Hz. Data are visualized in real-time, which provides an important first level of quality assurance and control.

This system has been used to measure PM_{10} emissions and to develop emission factors for civilian and military vehicles traveling on unpaved roads at Ft. Bliss, TX. The multi-tower network has also been used to assess near source dust deposition and removal processes for fugitive dust plumes advecting over a sparsely vegetated desert surface. A modified single-tower has been used to measure PM_{10} and $PM_{2.5}$ fluxes from vehicle exhaust and resusepended road dust for paved roads.

Emission Inventory Development through Highly-time-resolved Ambient Sampling

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Highly-time resolved metals measurements have been made at five urban locations and near a coke oven using the University of Maryland Semicontinuous Elements in Aerosol Sampler. In each case, aerosol slurry samples were collected at 30-minute intervals, i.e., at periods short relative to changes in wind direction, and analyzed off-line by mutli-element graphite furnace Atomic Absorption Spectroscopy for up to 12 elements useful as markers of primary particle emissions of high-temperature combustion sources. At this resolution, the plumes of individual sources, including the coke oven, coal-fired power plants, a copper smelter, and a battery recycling plant, have been readily observed as excursions in time series profiles of the concentrations of the various marker elements. Over the scale of 20 to 40 km, wind and source angles are nearly identical when the former are relatively constant during the time required for plume transport. In College Park, MD, the temporal pattern in the airborne Se concentrations correlated well with that of the generating load of a coal-fired power plant 16-km to the southwest. When combined with ambient measurements of SO_2, a pollutant whose emission rate is measured with a continuous monitor, it should be possible to estimate emission rates of primary particles and their constituents. For at least some sources, high-frequency ambient measurements could obviate the need for in-stack measurements for development of emission inventories. Ambient ground-level measurements made in the vicinity of the above mentioned sources will be presented along with some preliminary estimates of emission rates from a coal-fired power plant.

Real-Time Monitoring of Gases and Aerosols Reveals Source Contributions to Air Quality

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In May 2002, the Bay Regional Atmospheric Chemistry Experiment (BRACE) held a month-long intensive monitoring campaign with ambient air quality measurements made at 5 sites within ~20 km of Tampa Bay. The objectives of the BRACE were to improve estimates of the atmospheric nitrogen deposition, to apportion the atmospheric nitrogen to among its contributing sources, and to assess the Tampa Bay air quality before and after the re-powering of a major coal-fired utility. At one rural site to the east of Tampa were deployed a differential optical absorption spectrophotometer (DOAS), a semi-continuous elements in aerosol sampler (SEAS), and a semi-continuous acidic and basic gas and aerosol sampler based on ion chromatography (IC). With the DOAS were measured at minute resolution sulfur dioxide, nitrogen dioxide, ozone, and o-xylene; at a 30-min resolution the SEAS captured 12 discernible elements useful as markers of primary particle emissions for high-temperature combustion sources; the IC had 15-min resolution of sulfur dioxide, nitric acid, nitrous acid, hydrochloric acid, oxalic acid and ammonia; and sulfate, nitrate, nitrite, chloride, oxalate and ammonium. This combination and temporal resolution of gases and aerosol samples reveals interesting relationships strongly suggestive of known regional nitrogen sources, for example, fertilizer manufacturing and coal combustion, and offers the opportunity to assess inventories by comparing predicted with measured species ratios over a wider range of chemical species.

Development Of An Integrated Emission Profile For A Coke Facility With Fence-line Measurements Using Highly-time-resolved Instruments

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Highly time-resolved ambient measurements create the opportunity to develop integrated emission profiles for industrial facilities with a large number of emission points that are difficult to characterize using traditional source sampling techniques. To illustrate this approach and to update emission profiles for important sources in the Pittsburgh region, a suite of continuous and integrated measurements was made at both a fenceline site adjacent to coke production facility and a background site. Continuous measurements included meteorological data, CO, SO_2, NO_x, NO, $PM_{2.5}$ mass, and particle size distributions from 3 nm to 1 μm. A combination of meteorological data and pollutant measurements at the fenceline and background sites were used to determine when the coke plant plume was impacting the fenceline site. For example, ratios of SO_2 at the fenceline sampling site to the background site as large as 25 are observed when the fenceline site is in the plume. Semi-continuous measurements of OC/EC (2 hr resolution) and trace metals (30 minute resolution) were made to obtain highly time-resolved composition data. The plume contains greatly elevated OC/EC concentrations; for example, ratios of peak plume OC and EC concentrations to the background site were 18 and 48, respectively. The plume also contains greatly elevated metals concentrations; for example ratios of peak plume Se levels to the background were often greater than a factor of 8. Reasonable agreement is observed between the fenceline measurement and the stated plant emissions for NOx, SOx, and $PM_{2.5}$. The following integrated emission profile was developed for the coke facility (expressed as % PM2.5 mass): OC 27.39; EC 16.78; Al 0.4427; As 0.0381; Cd 0.0010; Cr 0.0025; Cu 0.0205; Ni 0.0020; Mn 0.0304; Fe 0.2959; Pb 0.0740; Se 0.0283; and Zn 0.1101.

Characterization of the Diurnal PM Peaks at Sunland Park, New Mexico

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Spikes of airborne particulate matter (PM) are routinely observed in the evening hours at Sunland Park, New México, one of the three sister cities in the Paso del Norte (PdN) border region. These PM episodes appear to be highly localized within the New México portion of the PdN air quality basin with no known sources in the area.

A study was conducted in the winter of 2002 to determine the composition of and identify potential sources for the evening PM ($PM_{2.5}$ and PM_{10}) peaks at Sunland Park. Continuous 5-minute average $PM_{2.5}$ mass concentrations were recorded on 2 TEOMs. Twenty-four average $PM_{2.5}$ and $PM_{2.5-10}$ and time-resolved $PM_{2.5}$ samples were collected on Teflon and quartz filters using dichotomous air monitors and TEOM/ACCU instruments, respectively, for element, ion, and carbon analyses. Concurrent meteorological monitoring was also conducted at the site.

The evening hourly PM concentration frequently peaked at levels 1 to 2 orders of magnitude higher than the 24-hr average. Elevated trace elements such as Pb and Sb were observed in some of the samples. Statistical analyses of the hourly $PM_{2.5}$ data and other environmental parameters such as wind speed, wind direction, mixing height, humidity, and solar radiation were performed to determine the association of PM episode and other environmental factors. Results of the element, ion, and carbon (EC/OC) analyses will be used to assist in the identification of PM potential sources in the area.

Satellite Observations

Utilization of NASA Data and Information to Support Emission Inventory Development.

Doreen Neil and Jack Fishman
NASA

Jim Szykman
EPA

Over the next decade, data to inform air quality management decisions and policies will need to cover large spatial domains to accommodate decisions which more frequently cross geopolitical boundaries, including intercontinental boundaries. Until now, the study of air pollution relied primarily on ground based measurements, episodic field intensive studies, and chemical transport modeling. However, more frequent and spatially comprehensive assessments are needed to understand the interaction between global air pollution and regional air quality. The air quality management community requires consistent measurement methods capable of national coverage to make such assessments.

IDEA (Infusing satellite data into environmental air quality applications) is a joint project between NASA and EPA to improve air quality assessment, management, and prediction by infusing (NASA) satellite measurements into (EPA) analyses for public benefit. IDEA is sponsored by both EPA and NASA's Earth Science Applications Program. The IDEA project has evaluated existing satellite based measurements of the criteria pollutants O_3, SO_2, NO_2, CO, and aerosols ($PM_{2.5}$) in comparison with (EPA) ground based measurements. Such measurements can have profound impact in the study of emerging issues in air quality, particularly in the evaluation of emissions and transport.

We will present recent case studies of the relationship between satellite measurements and ground monitors, with visualization of recent large scale pollution events captured by satellites and compared with EPA ground monitors. We show how satellites can provide the pseudo-synoptic view of pollution events across North America unlike any other system and discuss planned demonstration projects.

Remote Sensing of Tropospheric Carbon Monoxide

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Satellite remote sensing offers the best opportunity of making global measurements of tropospheric trace gases and aerosol over extended periods of time. However, “seeing” the troposphere presents major challenges that are only just being met. Until now, studies have relied on field campaigns, regular ground-based and aircraft measurements from specific sites, and an important input from chemical-transport modeling. This paper will review the contribution of the Terra/MOPITT mission to our understanding of anthropogenic emissions of carbon monoxide, the subsequent tropospheric transport, and the impact on regional and global scale air quality and chemistry. The way in which these measurements have been used to in conjunction with a chemical transport model to provide top-down emissions estimates will also be discussed.

Global Inventory of Nitrogen Oxide Emissions Constrained By Space-based Observations of NO_2 Columns

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We use tropospheric NO_2 columns that we retrieve from the Global Ozone Monitoring Experiment (GOME) satellite instrument for 1996-97 to derive top-down constraints on emissions of nitrogen oxides ($NO_x = NO + NO_2$), and combine these with *a priori* information from a bottom-up emission inventory (with error weighting) to achieve an optimized *a posteriori* estimate of the global distribution of NO_x emissions. The *a priori* inventory is based on the Global Emission Inventory Activity and scaled to 1996-97. We use the GEOS-CHEM model to calculate the local relationship between GOME NO_2 columns and NO_x emissions as our top-down constraint. The derived NO_x emissions for industrial regions are aseasonal, despite large seasonal variations in NO_2 columns, confirming the validity of the method. Top-down errors in monthly NO_x emissions are about 50%, comparable to bottom-up errors over source regions. Our global *a posteriori* estimate for annual land surface NO_x emissions (37.7 Tg N yr^{-1}) agrees closely with the *a priori* (36.4) and with an independent bottom-up inventory (EDGAR 3.0) (36.6). Spatial and monthly variations in *a posteriori* emissions are similar to the *a priori* (r^2=0.86), but there are significant regional differences. *A posteriori* NO_x emissions are higher by 50-100% in the Po Valley, Tehran, and Riyadh urban areas, and by 25-35% in Japan and South Africa. Biomass burning emissions from India, central Africa, and Brazil are lower by up to 50%; soil NO_x emissions are appreciably higher in the western United States, the Sahel, and southern Europe.

Top-down Isoprene Emission Inventory For North America Constructed From Satellite Measurements Of Formaldehyde Columns

Jacob, D.J.[1], D.S. Abbot[1], P.I. Palmer[1], R.V. Martin[2], K.V. Chance[2]

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Formaldehyde (HCHO) columns measured from space by solar UV backscatter provide a proxy for local emissions of reactive volatile organic compounds (VOC). During the growing season in North America, the main reactive VOC contributing to the HCHO column is isoprene. We have compiled a 7-year global record (1995-2001) of HCHO column data from the GOME satellite instrument, and we use these data here to construct a top-down inventory of isoprene emissions and to better understand the factors controlling this emission. Regional relationships between HCHO columns and isoprene emissions are obtained from a global tropospheric chemistry model (GEOS-CHEM), which is also used as an intermediary to validate the GOME data with in situ HCHO measurements from surface sites and aircraft. The top-down isoprene emission inventory generated from the GOME data shows general similarities but also some significant differences with current inventories (GEIA, BEIS). Particularly high emissions are found in the Ozarks. The GOME data reveal a seasonal and interannual variability of isoprene emission that is broadly consistent with current algorithms where it is driven by leaf area index (LAI) and temperature. Discrepancies are explored in terms of possible flaws in the emission algorithms. Critical to the progress of our top-down approach for mapping reactive VOC emissions is better laboratory data for the HCHO yields from the oxidation of different VOCs under different atmospheric conditions including at low NO_x.

Improving Biogenic Emission Estimates with Satellite Imagery

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Notice: This is an abstract of a proposed presentation and does not necessarily reflect the United States Environmental Protection Agency (EPA) policy. The actual presentation has not been peer reviewed by EPA. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

This presentation will review how existing and future applications of satellite imagery can improve the accuracy of biogenic emission estimates. Existing applications of satellite imagery to biogenic emission estimates have focused on characterizing land cover. Vegetation data in the current version of the Biogenic Emissions Inventory System (BEIS) are largely based on the USGS National Land Cover Characteristics (NLCC) dataset, which is derived from AVHRR imagery. The NLCC data have been further augmented with a forest fraction database available at 1 km resolution from the U.S. Forest Service and based on analysis of AVHRR, LANDSAT, and ground-truth measurements. Xu et al. ("Estimates of biogenic emissions using satellite observation", *Atmospheric Environment*, vol. 36, 2002) demonstrate the utility of using monthly AVHRR data to more directly drive biogenic emission calculations. Beyond characterizing vegetation, satellite imagery is being used quite promisingly to perform inverse analysis of biogenic emissions. Researchers at Harvard University are using data from the GOME platform to derive formaldehyde patterns across the United States as a check against estimated isoprene emission distributions. The GOME data suggest that the distribution of isoprene is correctly represented in a model like BEIS and that the BEIS2 estimates may be underestimated. Satellite imagery can provide meteorological data fields that are vital to biogenic emission algorithms. For example, work supported by the TNRRCC has used GOES data to more accurately depict photosynthetically available radiation (PAR) for input to the GloBEIS program. In addition to current applications of satellite imagery, this presentation will review how emerging satellite imagery datasets may improve future modeling tools. Areas of possible improvements include refined temporal estimates in leaf biomass, quantitative measures of drought stress on vegetation, and better discrimination of vegetation species types.

*On assignment to the National Exposure Research Laboratory, U.S. Environmental Protection Agency.

Development of A Forest Fire Smoke Emission and Dispersion Model Using Real-time MODIS Data

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The Fire Chemistry group at the Missoula Fire Sciences Laboratory has been conducting research into using data from the MODerate resolution Imaging Spectroradiometer (MODIS) to predict and monitor emissions from forest fires nationwide. A MODIS instrument is aboard two NASA satellites: Terra and Aqua. The Fire Lab has a Direct Broadcast (DB) antenna to receive the MODIS data in real time as the satellites pass overhead. This data is used to monitor area recently burned using two methods: a preliminary near-IR spectral test being developed at NASA and the convex hull of the cumulative active fire pixel centers (hot spots) when thick smoke obscures the burn scar. Emissions from this burning can then be estimated using emission factors from previous studies conducted by our group. A NOAA model will then be used to predict the dispersion of the emissions at three-hour intervals over the next 3- or 4-day period. The Hayman fire is used as a case study to demonstrate the model. The results of this case study are compared to measurements of CO mixing ratio (ppbv) from the Measurement of Pollution in the Troposphere (MOPITT) instrument. A validation of the methodology used for monitoring burned area from MODIS data in real time is also presented. This validation rests on comparison against USFS, BLM, and Canadian Forest Service fire perimeters from several major fire events in the U.S. and Canada in 2001 and 2002.

Estimation of Biomass Smoke Emissions and Transport using Satellite and Surface Observations

Rudolf B. Husar and Sean Raffuse
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There is increasing evidence that biomass smoke is the dominant contributor to the regional carbonations aerosols over the Western US and possibly over the Southeastern US as well. Unfortunately, the current data are inadequate to provide quantitative biomass smoke emission estimates. Even speciated PM data are largely inconclusive regarding the contribution of biomass smoke to PM. These measurement problems associated with smoke emissions severely hamper the management of PM2.5 and Regional Haze.

Biomass fires smoke emissions are intermittent 'point' sources. Because of the large emission densities near the fire, current environmental satellites sensors such as MODIS, AVHRR, SeaWiFS and TOMS can detect the smoke from small and large fires. This work-in-progress utilizes the 8 wavelength, 1 km resolution SeaWiFS sensor to detect and quantify the smoke aerosol. A novel co-retrieval algorithm first retrieves the smoke/haze-free surface reflectance and subsequently the smoke optical thickness is retrieved for each cloud-free pixel at local noon. The smoke plume vertical optical thickness is converted to aerosol mass using retrieved size distribution. The smoke flux (emission rate) for each individual plume is obtained from surface wind data near the fires.

The smoke emission measurement methodology using combined satellite and surface data will be illustrated for the 2000 and 2002 smoke seasons. The emission and smoke transport for large fires (Idaho, 2000; Quebec, 2002) as well as from small fires (Southeastern US, 2000) will be illustrated. It is hoped that the challenging full development and evaluation of this smoke emission methodology as well as the routine monitoring of the unpredictable, episodic smoke emissions will be a collaborative community effort.

Use of Remotely-Sensed Data in the Development and Improvement of Emission Inventories

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This paper explores the use of satellite imagery and aerial photography in the development and improvement of emission inventories. E.H. Pechan & Associates, Inc. and the Arizona Department of Environmental Quality have used remotely-sensed data in the development of emission inventories for particulate matter less than 10 microns (PM10) and in the development of border area inventories for toxic and criteria air pollutants. Satellite imagery has been used to develop detailed land use data to support the development of bottom-up emission estimates for windblown dust and agricultural sources. These data have also been used to develop refined spatial surrogates for use in emissions modeling. Additional uses of remotely-sensed data in the development and improvement of emission inventories are explored. These uses include aerial photography in the quality assurance of geo-coded point source locations, aerial photography in the identification of important land use features (e.g. disturbed natural areas), and satellite imagery in the development of temporal distributions in crop cover and related emissions. The availability, capabilities, and costs of different remotely-sensed data sources are also described.

Air Quality and Receptor Modeling

Positive Matrix Factorization Analysis of Volatile Organic Compound Concentrations in Houston, TX

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Recent measurements during TexAQS 2000 have found that emissions of volatile organic compounds (VOCs) from petrochemical facilities are underestimated in existing emission inventories. To further investigate the sources of VOCs in Houston, receptor modeling has been performed on ambient air samples collected in Deer Park, Texas. Concentrations of 55 different VOCs measured hourly between January 29 and December 31, 2001 were obtained from data collected by the Texas Commission on Environmental Quality (TCEQ). In the current research, VOC data were divided into weekly intervals and positive matrix factorization (PMF) was applied to the hourly VOC data in each interval to determine source profiles and contributions. PMF receptor modeling isolated profiles resembling the composition of known sources, including motor vehicle exhaust, petrochemical production, petroleum refining, natural and liquefied petroleum gas, and gasoline headspace vapors. The temporal variability in source contribution during 2001 was determined as well as the overall magnitude of contribution from these sources. The calculated source contributions have been compared to existing inventories, and the relationship between source contributions and ozone concentrations and wind direction has been used to better understand the relationship between VOC emissions and ozone formation.

Source Apportionment of VOCs in the Houston, Texas Area

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Hourly concentrations of over fifty volatile organic compounds (VOCs) were measured between 1998 and 2001 by automated gas chromatographs (auto-GCs) at a number of sites in Houston, Texas, as part of the Photochemical Assessment Monitoring Stations (PAMS) program. This extensive database was collected and analyzed in order to further understand emissions in the Houston area and the role of specific sources, source areas, compounds, and meteorology in ozone formation. The Clinton Drive site is well suited for detailed source apportionment analysis using Positive Matrix Factorization (PMF) because it is located in the heavily industrialized Houston Ship Channel, where extremely high concentrations of reactive ozone-forming VOCs are commonly found in abundance. One advantage of PMF is that it uses error estimates for each individual data point, which is different than other source apportionment tools. Using this corresponding error matrix allows PMF to appropriately scale and treat missing and below detection data differently than the "true" measured data. This effort allows specific factors and sources to be identified and analyzed, with the overall goal to determine their potential impact on ozone formation in the area.

Source apportionment using PMF was successfully completed on the dataset of over 21,000 hourly observations of 39 species from 1998 to 2001. Mass was well reconstructed by the model, and numerous sources were identified. Most factors showed significant dependence on wind direction, indicating specific source areas. When compounds in the source profiles were scaled by their ozone formation potential using the Maximum Incremental Reactivity (MIR) scale, no individual source appeared to dominate the total reactivity. Only six factors were significantly higher on mornings of ozone episodes, indicating that these sources may be more important in ozone exceedences. This paper will further discuss results and implications with regard to ozone formation and emission sources.

An Innovative Method for Source Identification and Apportionment of PM: Isotope Measurements of Carbon Species (OC/EC) via Thermal Desorption/Combustion & GC-IRMS

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Carbonaceous aerosols play an important role in environment related issues, e.g. air quality, human health and global climate. However, the relative contribution of different emission sources, their formation mechanism, their atmospheric transformation and transport are not well understood. Because of their carbonaceous nature, $^{13}C/^{12}C$ ratios (expressed as $\delta^{13}C$, i.e. relative deviation to the international standard in ‰) of bulk carbon fractions (i.e., organic carbon and elemental carbon) in airborne PM could provide valuable information for their sources and formation processes. It is known that aerosols originate from ***different emission sources***, e.g. fossil fuel combustion, biomass burning and vegetation emissions etc., through ***different formation processes***, i.e. primary combustion emission (high temperature) and secondary photochemical production (low temperature). The $\delta^{13}C$ of EC is expected to remain constant once formed during combustion because of its inert nature and thus, should reflect the source signature. In contrast, the $\delta^{13}C$ of OC (organic carbon) is expected to undergo varying amounts of change due to photochemical processes, and this should depend upon the original compound and on the history of the air mass. Therefore, the distribution of $\delta^{13}C$ among bulk carbon fractions may provide valuable information for PM formation processes and correspondent sources.

In this study, we have developed a method using a step-wise heating thermal desorption/combustion OC/EC analyzer coupled with GC-IRMS (Gas Chromatography separation, followed by a Isotopic Ratio Mass Spectrometer analysis) to measure $^{13}C/^{12}C$ ratios of bulk carbon fractions from filter samples of atmospheric particle. These fractions are released at different temperature ranges and different redox conditions. In the current method we focus on three fractions, i.e., low OC (organic carbon), high temperature OC plus carbonate carbon (CC) and EC (elemental carbon). The overall precision of the method is ~ 0.3‰ and the results compare well with the conventional off-line method, differing by an average of 0.1‰, which is the accuracy of the method.

We have applied the method to study fine (PM2.5) particles collected at several contrasting locations. These were: three surface sites in the Lower Fraser Valley (LFV) of British Columbia (**Golden Ears Park**, which is expected to be significantly influenced by biogenic sources; **Cassiar Tunnel**, which is dominated by motor vehicle emissions and **Slocan Park**, which is a typical urban background area and could show the results of different sources mixing), an aircraft-based platform flying well-within the free troposphere over the LFV, and Alert, NWT, a baseline station in high Arctic (summer and winter). As expected, differences in $\delta^{13}C$ and its distribution patterns of bulk carbon fractions among the sampling locations were observed. The findings of the study will be presented. It is concluded that the combination of the isotopic compositions of different carbon components and the correspondent abundances of the carbon components is likely to be a useful tool to constrain source identification and apportionment for ambient particle samples.

Implications on Contributing Sources by Chemical Composition in Regional Surficial Soil

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The goal of the study was to chemically characterize Particulate Matter (PM) produced from presumptive sources of fugitive dust in the El Paso del Norte Region located on both sides of the U.S.-México border. Chemical analyses on 18 elements (As, Be, Cd, Cr, Co, Pb, Mn, Ni, Sb, Ag, Al, Ba, Ca, Cu, K, Mo, Na, and Zn) were conducted on soil samples collected at 18 sites during February 23-25, 2000 to provide chemical signatures for potential contributors to the dust load in the region. The samples were collected at eighteen sites during 23-25 February 2000, separated by size using sieves and a cyclone train, acid digested in a microwave, and analyzed by ICP-MS.

The application of Cluster and Principal Components Analyses consistently produced three groups of elements: (1) Ag-As-Cd-Cu-Mo-Pb-Sb-Zn; (2) Al-Ba-K-Ca-Co; and (3) Be-Cr-Mn-Ni, which explained 51%, 28% and 12% respectively of the data variance. A Redundancy Analysis demonstrated that: (1) distance to a smelter and size of the soil fraction were the main explanatory variables; and that (2) Ag, As, Ba, Cd, Mo, Mn, Na, Pb, Sb concentrations decreased with increasing distance from the smelter. Enrichment factors calculations, using Al as the reference element, indicated that the first group of elements had their highest enrichment factors on the fine size fraction, and that the second group of elements was associated with a crustal source.

Separating the Contribution of Gasoline and Diesel Vehicles to Ambient Fine Particle Levels: Verification of Results from Receptor Models

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The ability to separately track emissions of fine particles from gasoline and diesel powered vehicles has received significant attention as studies of the health effects of particles have shown diesel particulate matter to be highly toxic and mutagenic. One method used for this is receptor modeling. To answer whether the receptor models use can correctly separate emissions from gasoline and diesel vehicles, samples of fine particulate matter were collected in a roadway tunnel near Houston, TX during two separate sampling periods: one sampling period from 1200-1400 local standard time and one sampling period from 1400-1600 local standard time. During the two sampling periods, the tunnel traffic contained roughly equivalent numbers of heavy-duty diesel trucks. However, during the late afternoon sampling period, the tunnel contained twice as many light-duty gasoline-powered vehicles. The effect of this shift in the vehicle fleet affects the overall emission index (grams pollutant emitted per kilogram carbon in fuel) for fine particles and fine particulate elemental carbon. Additionally, this shift in the fraction of diesel vehicles in the tunnel is used determine if the chemical mass balancing techniques used to track emissions from gasoline-powered and diesel-powered emissions accurately separates these two emission categories. The results show that the chemical mass balancing calculations apportion roughly equal amounts of the particulate matter measured to diesel vehicles between the two periods, and attribute almost twice as much particulate matter in the late afternoon sampling period to gasoline vehicles. Both of these results are consistent with the traffic volume of gasoline and diesel vehicles in the tunnel in the two separate periods and validate the ability for organic molecular markers to separate these two primary sources of fine particles.

Tropospheric Chemical Data Assimilation and Inverse Modeling at the Meteorological Service of Canada

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A tropospheric chemical data assimilation effort is developing at the meteorological service of Canada. The objectives are to implement in real-time an air quality forecasting and assimilation system and to develop in collaboration with universities the science of chemical data assimilation and inverse methodologies. While data assimilation has been used for operational weather prediction for decades its application to atmospheric chemistry is recent. Chemical data assimilation has specific challenges and objectives that are different from typical meteorological data assimilation problems.

One effort consist in assimilating surface ozone observations in real-time using the model CHRONOS with a domain covering North America. We will discuss the estimation of error statistics, the choice of covariance models, the quality control, the validation of objective analyses, and the predictability skill due to assimilation. Results from this and the past year will be presented. While developing an operational effort, research is also being pursued in a dual estimation of state and sources, i.e. a combined data assimilation and inverse modeling system. In particular we found that the estimation problem can be separated into two estimation problems one for the observed and the other for the unobserved variables, leading to a computationally effective method to perform multivariate (or multispecies) and dual state-source estimation. We will also discuss a method used obtain the cross error covariance statistics needed for the implementation of such systems, and some preliminary results will be presented. Finally and if time permits, we will also discuss our efforts to assimilate satellite observations using a global coupled meteorological-air quality model, GEM-AQ, in particular with CO observations from MOPITT and results from aerosol assimilation.

Inverse Modeling To Estimate NH_3 Emission Seasonality And The Sensitivity To Uncertainty Representations

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Inverse modeling has been used extensively on the global scale to produce top-down estimates of emissions for chemicals such as CO and CH_4. Regional scale air quality studies could also benefit from inverse modeling as a tool to evaluate current emission inventories; however, underlying assumptions such as the linearity between emission and concentration changes can limit the applicability of inverse modeling. Ammonia (NH_3) has been found to be a reasonable candidate because a strong linearity exists between NH_3 emission adjustments and the response of modeled ammonium wet deposition. Further, the uncertainty in the emission estimates, especially on a monthly time scale, is quite large. While we anticipate that NH_3 emissions from agricultural non-point sources have a strong seasonal pattern, the intra-annual variability of these primary NH_3 sources is not yet understood well-enough to incorporate into current NH_3 emission inventories. Along with the USEPA Community Multiscale Air Quality (CMAQ) model and NH_4^+ wet concentration data, an inverse modeling approach has been used to estimate monthly adjustments to the NH_3 emission field over the Eastern United States. The first series of results, presented in Gilliland et al. [2003], offer the most comprehensive estimate of seasonal NH_3 emission variability to date. These seasonal variations in NH_3 emissions were shown to be essential for the prediction of nitrogen-containing compounds in that study. Further tests are now being conducted where a variety of uncertainty representations are considered in the inverse modeling calculations. These sensitivity tests will provide a more thorough range of emission adjustment estimates for each month and will test the rigor of the seasonal variability suggested by Gilliland et al. [2003].

Industrial Hydrocarbon Emission Adjustments Used in 2002 Houston-Galveston-Brazoria Ozone SIP Modeling

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Texas Commission on Environmental Quality

The Texas Air Quality Study (TexAQS) was one of the largest and most comprehensive air quality studies ever conducted. Approximately 250 researchers from over 35 institutions joined the TCEQ to collect data from the period August 15 - September 15, 2000, primarily in the Houston/Galveston/Brazoria ozone nonattainment area of the Upper Texas Coast. Air quality and meteorology were sampled at several locations, and a total of six research aircraft participated in the study. While the study yielded (and has in fact continued to yield) an enormous amount of information related to air quality in the study region, perhaps the most remarkable finding is that the atmospheric concentrations of light olefins are many times higher than can be explained from the reported emissions of these compounds. Furthermore, aircraft observations clearly associated these very high olefin concentrations with industrial sources in the area. Light olefins, particularly ethylene and propylene, are extremely reactive photochemically and are believed to contribute significantly to the rapid rises in ozone concentrations and extremely large peak concentrations which occur frequently in the airshed.

The TCEQ Modeling staff modeled an ozone episode from the TexAQS period for a State Implementation Plan (SIP) revision which was approved on December 13, 2002. When photochemical grid modeling was conducted using an emissions inventory compiled employing routine methods, peak ozone was severely under-predicted almost universally throughout the episode. Based on the TexAQS conclusions and additional aircraft measurements, an adjustment was applied to the industrial emissions of a group of highly-reactive compounds (principally olefins). After applying this adjustment, model performance improved markedly and the TCEQ was able to develop a coherent picture of the ozone formation processes taking place during the TexAQS time frame. In this presentation, the authors describe the photochemical modeling conducted and discuss the effects of adjusting the emissions on the model outcome

Estimates Of Anthropogenic Secondary Organic Aerosol Formation In Houston, Texas

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An important component of emission inventory development in support of fine particulate matter modeling is the development of emission estimates, by source category, for secondary organic aerosol precursors. Secondary Organic Aerosol (SOA) formation due to precursor emissions from anthropogenic sources in the Houston/Galveston (HG) area was estimated by multiplying the anthropogenic emissions of SOA precursors by fractional aerosol coefficients (FAC). The analysis indicated that area and non-road mobile sources contributed 56% of the aerosol precursor emissions, while mobile and point sources contributed 27% and 16%, respectively. However, due to high SOA yields of the precursors emitted by point sources, especially emissions of terpenes from pulp and paper processing and emissions of aromatics, point source emissions resulted in 53% of the projected SOA from anthropogenic sources in the Houston-Galveston (HG) area. Estimated SOA formation rates were consistent with average concentrations of particle phase organic carbon in the Houston-Galveston area.

Sensitivity of Urban Ozone Formation to Chlorine Emission Estimates

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Recent evidence has demonstrated that chlorine radical chemistry can enhance tropospheric VOC oxidation and has the potential to enhance ozone formation in urban areas. In order to investigate the regional impacts of chlorine chemistry in Southeastern Texas, preliminary estimates of atmospheric releases of atomic chlorine precursors from industrial point sources, cooling towers, water and wastewater treatment, swimming pools, tap water, reactions of chlorides in sea salt aerosols, and reactions of chlorinated organics were developed. To assess the potential implications of these estimated emissions on urban ozone formation, a series of photochemical modeling studies was conducted to examine the spatial and temporal sensitivity of ozone and a unique marker species for chlorine chemistry, 1-Chloro-3-methyl-3-butene-2-one (CMBO), to molecular chlorine emissions estimates. Based on current estimates of molecular chlorine emissions in Southeastern Texas, chlorine chemistry has the potential to enhance ozone mixing ratios by up to 11-16 ppbv. Impacts varied temporally, with emissions from cooling towers primarily responsible for a morning enhancement in ozone mixing ratios and emissions from residential swimming pools for an afternoon enhancement. Maximum enhancement in CMBO mixing ratios ranged from 59-69 pptv.

Weekday-weekend Emissions Patterns in Southern California: Observations and Implications

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Over the past ten years, average peak ozone concentrations in Los Angeles were as much as 55% higher on weekends than on weekdays (under comparable meteorological conditions), even though weekend ozone precursor emissions are low relative to weekday emissions. Over the past three years, Sonoma Technology, Inc., (STI) has conducted several measurement programs to study weekday-weekend (WD-WE) activity patterns for sources of ozone precursor emissions. The objectives were (1) to formulate improved diurnal and weekly emissions activity profiles, which are used as inputs to air quality models, for several source categories; and (2) to contribute (in conjunction with other concurrent research efforts) to the general understanding of weekday-to-weekend variability in air quality, which has been noted in Los Angeles and other urban areas. STI's measurement programs encompassed an array of emissions source categories: on-road mobile, off-road mobile, major point, residential area, and commercial area sources. A variety of measurement techniques were used. Data were collected by monitoring traffic volumes on surface streets, by surveying residents and businesses by telephone and mail, by monitoring individual volunteers' travel activity patterns with the use of in-vehicle instruments (i.e., global positioning system receivers with data loggers), by acquiring freeway-based traffic volume data, and by acquiring data from the continuous emissions monitoring systems (CEMS) of major stationary point sources. This paper will present a synthesized overview of STI's methods and findings with the findings of other researchers. In addition, this paper will include a discussion of the implications of these findings with respect to weekday-to-weekend differences in emissions and ozone air quality in the South Coast Air Basin of southern California. In summary, it will be shown that:

1) WD-WE variabilities in activity patterns have quantifiable impacts on ROG and NO_x emissions in Los Angeles.
2) When these quantifiable impacts are used to adjust the emission inventory of southern California, it appears that weekend emissions patterns favor ozone formation in Los Angeles to a greater extent than do weekday emission patterns.
3) This phenomenon is due to increased ROG:NO_x ratios toward a more efficient ozone production regime and a reduced morning titration capacity of ozone by NO_x.

How the Representation of Emissions Inventories in Air Quality Regulatory Modeling in the Presence of High Temporal Variability Effects the Choice of Control Strategies

Mort Webster, Mike Symons, Harvey Jeffries
University of North Carolina

Tom Tesche and Dennis McNally
Alpine Geophysics

Conventional wisdom is that “bad ozone” days are mostly caused by “bad meteorology”, because the emissions inventory is “about the same” every weekday. This has resulted in the regulatory efforts to lower the *average* emission rates during these “bad meteorology” days and thereby achieve the National Ambient Air Quality Standards. In situations like those in cities with very large industrial complexes, like Houston, Texas, however, new data suggests that there are more days with “ozone forming” meteorology than there are bad days, and that instead, “bad ozone days” are actually associated with “bad emissions” days. That is, with world-class industrial facilities densely packed along the ship channel and with a large shipping port, and with very large gasoline production, the industrial point source emissions inventory can not be well characterized by current State and EPA emissions inventory preparation methods. New industrial measurements and the results of the Texas Air Quality Study in August of 2000 clearly show that modeling inventories can not capture the complexity of the actually emissions. This case has important implications for both regulatory support tools and for the design of efficient regulation itself.

Using a process described in another abstract (The Development of a Stochastic Emissions Inventory for Industrial Emissions in Houston/Galveston Texas and Its Use in Photochemical Modeling, Jeffries, et al.), we have produced an alternative analysis tool, a stochastic emissions inventory generator, and have applied it to the Houston case.

Using this tool and a detailed air quality model, we evaluate alternative policy designs for achieving attainment. In particular, we will show that policies that focus on incentives to reduce the high non-standard emission events (i.e., that “clip the tail” of the distribution) promise to be much more cost-effective approaches to reaching attainment. The possible design of a cap-and-trade system, particularly of the appropriate time-interval for allowances, is also explored.

Emission Modeling

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Incorporating Boiler-Level Data from EPA's Acid Rain Program into a Modeling Emission Inventory

Ron Thomas, Tom Lawshae, Gabriel Cantu, Jocelyn Mellberg
Texas Commission on Environmental Quality

This presentation will describe procedures developed by TCEQ modeling staff to improve an ozone-season point source emissions inventory for episodic photochemical modeling by incorporating data compiled by EPA's Acid Rain Program (ARP). Presently, in the evolution of the science of photochemical modeling, it has become almost routine (not only in Texas, but around the nation) to utilize the hourly ARP data for a specific ozone episode. Similarly, the ARP database and availability of the data have evolved as more potential users have asked for the data in various formats and levels of detail.

The ARP archives hourly emissions from all of the electric generating facilities (power plants) in the country required to report emissions quarterly under the ARP. These hourly emissions data offer a more physically accurate representation of the quantity and temporal (day-of-the-week and hour-of-the-day) allocation of emissions from the power plants than ozone-season daily estimates, thanks in part to the reliability of Continuous Emissions Monitors.

TCEQ has been using ARP data in State Implementation Plans attainment demonstrations since 1998. This presentation will discuss: the evolution of the use of these data, pitfalls encountered since 1998, solutions, development of ARP-to-NEI cross references, boiler and stack configurations, VOC and CO interpolation from NOx and SO2 data, ozone modeling results with and without this hourly data, quality assurance, and the EPA resources available today.

CEM Data Analysis and Use

Mark Janssen
LADCO

Gwen Judson
Wi-DNR

Kirk Baker
LADCO

The Midwest RPO/LADCO used the 1999 and 2000 Hourly CEM data to drive chemical transport modeling. This paper will review the methods used to make the CEM data usable in photochemical models. Additionally, this paper will discuss the results of sensitivity modeling and the impacts of using day specific CEM data for regional modeling. Finally this paper will discuss the results of aggregating the complex temporal profiles into representative profiles for base and future year modeling.

Stochastic Modeling Of Ambient Ozone Formation With Emission Variability

Yosuke Kimura, Junsang Nam, David Allen
University of Texas

Variability in emissions from large point sources can cause variability in the processes that control ambient ozone formation and the potential effectiveness of control strategies, if the control strategies are based on annual average data on emissions of reactive hydrocarbons and oxides of nitrogen. Ambient measurements and field studies in the Houston-Galveston area have shown that extreme variability in point source reactive hydrocarbon emissions can occur.

This presentation will describe the relationships between "upset" release events and extremely high ambient ozone concentrations. A stochastic approach to modeling emissions has been used to model emission variability from multiple sources. Variability in emissions from individual sources is first characterized as random phenomena, with average values and standard deviations of emission rates based on long-term monitoring data. The randomized emissions are then used as an input for a Monte-Carloanalysis where a photochemical simulation is repeated for thousands of emission scenarios, in order to derive the distribution of ozone concentrations expected with variability in precursor emissions. The modeling framework is used to examine the effectiveness of various control strategies.

The Development of a Stochastic Emissions Inventory for Industrial Emissions in Houston/Galveston Texas and Its Use in Photochemical Modeling

Harvey Jeffries, Mort Webster, Mike Symons
University of North Carolina;

Tom Tesche, Dennis McNally
Alpine Geophysics.

It has become abundantly clear since the Texas Air Quality Study of August 2000 (TEXAQS) and subsequent unprecedented analysis efforts in the last two years that the industrial point source VOC emissions in Houston are poorly represented by the standard Texas Commission on Environmental Quality (TCEQ) and EPA derived emissions inventory reporting systems. This has led to significant difficulties in achieving adequate photochemical model performance needed for State Implementation Plans for Ozone.

Hourly measurements of actual flare flows and weekly cooling tower water concentration measurements, supplied by several large industrial sources as part of an on-going study, and recent research-instrument visualization of actual fugitive emissions of olefins conducted for TCEQ show that the industrial sources are very dynamic, exhibiting a stochastic emissions pattern, but, in the case of flares, with mean annual values that comply with emissions permits. Further, the newly expanded reported upset-database has also been analyzed and characterized.

These industrial measurements have been used to create sets of probability distribution functions (PDFs) that can be applied to the standard model emissions input files produced by TCEQ for use in SIP modeling with the CAMx Photochemical Grid Model. That is, we can describe a point source stochastic emission inventory for HGA. Instances of this emissions inventory can be created with different properties and these can be used in the model to estimate the effects on ozone production. Box model and photochemical grid models differ, however, in their abilities to respond to values drawn from these stochastic emissions inventories. Process analysis studies have been conducted to explain why these models respond differently. Process analysis has also been used to connect these two modeling approaches to permit their use together to explore the consequences of stochastic variation in point source emissions inventories.

In this presentation, we will show many examples of industrial point source measurements for flares and cooling towers. We will show the PDFs that describe these and will connect the shapes of the PDFs with technology at the sources. We will show the results of applying these PDFs to TCEQ's modeling point source inventory. We will compare selected species PDFs from the stochastic EI and from observations. And we will describe the effects that the uses of stochastic EI's have on ozone production in box models and in photochemical grid models.

Sesquiterpene Emissions And Secondary Organic Aerosol Formation Potentials For Southeast Texas

William Vizuete, Victoria Junquera, David T. Allen

Biogenic volatile organic compounds (BVOCs) emitted by vegetation include isoprene, monoterpenes ($C_{10}H_{16}$), and sesquiterpenes ($C_{15}H_{24}$). Sesquiterpene emissions account for approximately nine percent of the total biogenic emissions of non-methane hydrocarbons (NMHCs) in several forests in the United States. The importance of sesquiterpenes lies in their reactivity and potential for secondary organic aerosol formation (SOA). In southeast Texas experimental evidence was obtained during the summer of 2000 showing significant formation of biogenic SOA in the atmosphere. Radiocarbon (^{14}C) analyses of fine particulate matter in air samples found a considerable fraction of ^{14}C, or geologically modern carbon. The ratio of $^{14}C/^{13}C$ correlated strongly with the ratio of organic carbon to elemental carbon (OC/EC). This correlation suggested that the fraction of modern carbon in a sample is directly related to the amount of SOA and therefore that biogenic emissions may be a significant source of SOA precursors. The aims of this study are to estimate the sesquiterpene emissions from vegetation in southeast Texas and assess the potential contribution of these emissions to SOA formation. A modified version of the Global Biosphere Emissions and Interactions System (GloBEIS) was used to predict biogenic sesquiterpene emissions in the Houston-Galveston Area (HGA) in southeast Texas. The estimates were based on a land cover database containing more than 600 land cover categories at a resolution of approximately one kilometer and emission factors taken from literature. Average sesquiterpene emission fluxes were estimated to be between 0.07 and 0.65 kg Carbon/km^2-hr. Fluxes at the lower end of the estimated range are consistent with observed concentrations of geologically modern carbon in Houston aerosol.

Emissions Associated with Forest, Grassland, and Agricultural Burning during the Texas Air Quality Study

Anil Katamreddy, Victoria Junquera, David Allen[*]
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An inventory of emissions of particulate matter ($PM_{2.5}$), nitrogen oxides (NO_X), non-methane hydrocarbons (NMHC), and carbon dioxide (CO_2) from outdoor fires was performed for the period of August 1 to September 30, 2000. The domain over which fire emissions were estimated was centered on the Houston/Galveston-Beaumont/Port Arthur (HGBPA) region in Texas. Outdoor fires have been traditionally overlooked as emission sources in regional photochemical modeling, but this study has shown that fire emissions are important on an episodic basis, and that their magnitude has a strong seasonal dependence. Information on fire location and burned acreage was gathered from state and federal agencies. Fuel loadings (in tons of fuel/acre) and emission factors (in pounds of pollutant emitted/ton of fuel) were based on land use data specific for the state of Texas and emission factors from literature. Wildfires were the main source of emissions during the study period; other outdoor fires, such as agricultural, slash and prescribed burns were found to contribute relatively little to emissions because these types of burns are carried in the winter rather than in the summer months. Emissions exhibited considerable variability during the study period and were highest from August 31 to September 6. During the days of highest fire activity, September 4 and 6, the estimated emissions were 3700, 260, 330, and 50 short tons of CO, NMHC, $PM_{2.5}$, and NO_X, respectively. Emissions of CO and NMHC during days of high fire activity exceeded emissions from light duty gasoline vehicles in the urban areas of southeast Texas. Emissions from fires were compared with $PM_{2.5}$ concentrations in the HGBPA Subdomain measured using Tapered Element Oscillating Microbalances (TEOMs). The observational data coincide qualitatively with the predictions in this study in that the maximum TEOM $PM_{2.5}$ concentrations occurred on September 4 and 6.

Improving the Mexico City Biogenic VOC Emissions Inventory

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We present advances in a project aiming to reduce uncertainty in the Mexico City biogenic VOC emissions inventory. Work was carried out to obtain emission factors form dominant species under different climatic conditions. To focus further especiated measurements efforts, a ranking by measuring intensity of total emissions is being carried out on several relevant species. Uncertainty in national forestry inventory, a most important source of information is being assessed. Also, uncertainty on activity data will be reduced by measuring the leaf area index of disturbed and undisturbed forests of pine, abies and quercus in different sites in the Valley of Mexico. With these later data a perturbation index will be introduced into the emissions inventory equations.

NH_3 Emission Inventories for Agroecosystems: Role of GIS and Process-based Models in Developing Site Specific Emission Factors, Assessing Variability, and Providing Uncertainty Estimates

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Biogeochemical processes that control GHG and Ammonia emissions from agroecosystems, like denitrification, nitrification, and ammonia volatilization, are non-linearly coupled with anthropogenic and ecological drivers that are highly variable in space and time. As a result, static emission factors (EFs) cannot capture this variability without development of detailed site and management specific Efs. In addition, EFs typically do not provide estimates of uncertainties particular to a set of conditions. Therefore, assessment of impact of agricultural management alternatives on trace gas emissions and nutrient fluxes needs to be done in a modeling context that incorporates “mass balance” constraints. GIS process-based models can simulate spatially heterogeneous conditions that control temporal and spatial patterns of GHG and ammonia emissions.

This paper will present an overview of a suite of GHG (CO_2, CH_4, NO, and N_2O) and NH3 emissions inventories using GIS data and a process-based biogeochemical model called Denitrification-Decompostion, or DNDC. Coupled with the inventories are uncertainty analyses that focuses on quantifying how biophysical factors (e.g. soil properties), environmental conditions (e.g. precipitation, temperature) and management alternatives (e.g. amount and timing of fertilizer/manure application, types of manure application, tillage, irrigation) impact the production of GHG, changes in terrestrial C stocks, and NH_3 volatilization. Uncertainties generated from the modeled processes as well as from the input data sets are assessed through two levels of sensitivity analyses. First, individual variables are varied across their range of expected values while all other variables are held constant to identify those variables that cause the majority of variance in modeled trace gas emissions, C stocks, and nutrient availability. Secondly, to examine the interaction between variables, Latin Hypercube Sampling (LHS) is utilized. LHS is based on a stratified sampling approach that creates statistically significant results with appreciably fewer model runs. The LHS technique ensures that the entire range of each variable is sampled. Statistical summaries of the model results produce indices of uncertainty that relate the effects of heterogeneity of input variables to model predictions of GHG and NH_3 emissions.

Development of the Next Generation of an Ammonia Emission Inventory

Mark Janseen
LADCO

The purpose of this work is to develop a national mechanistic model of ammonia emissions from the top four livestock categories: hogs, poultry, beef cattle, and dairy cattle. This partially mechanistic model would be derived from the work of Robert Pinder at Carnegie Mellon University. This model would combine experimental results and physical principles to explain variations in emissions rates with a focus on temporal and geographic variation. This project seeks to extend his work on dairy cattle to include the other three categories of livestock. The model would use a combination of local climatological and meteorological data including ambient temperature, precipitation, and wind speed. It will also include a national farming practices model incorporated at the county level so that variation in local farming practices can be reflected in the model. These farming practices data include animal housing, waste storage, seasonal confinement, and a waste spreading calendar. Pinder's techniques needs to be extended in several important ways. While his model focuses on the development of annual emissions inventories based on seasonal average temperatures, chemical transport models need emission estimates for each hour of each day of the year gridded cells as small as 4km. It will, therefore, be necessary to make the model read the gridded hour- and day-specific meteorological fields and calculate emissions for a specific hour and day and a model grid cell. Recent chemical transport modeling suggests that the hourly variation of ammonia emissions is important in understanding particulate nitrate formation.

Assembling Emission Inventories of Primary Carbonaceous Aerosols

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Primary carbonaceous aerosols have become increasingly important in the last few years, because of growing awareness of their important role in global climate change, in addition to their well-known effects on human health. Black carbon (BC), which is closely related to elemental carbon, and organic carbon (OC), which represents a range of organic compounds in aerosol form, are the two components of carbonaceous aerosols. Primary emissions of these species are difficult to estimate for a variety of reasons, and existing global inventories are flawed. Emissions for North America *per se* are only now being developed. This paper will present results from a new global inventory (*Bond, T.C., D.G. Streets, K.F. Yarber, S.M. Nelson, J.-H. Woo, and Z. Klimont, "A Technology-Based Global Inventory of Black and Organic Carbon Emissions from Combustion," submitted to Journal of Geophysical Research, April 2003*). Some of the difficulties encountered in estimating such emissions will be discussed. These include: (a) how to reconcile emission factors for individual source types, when these may have been developed by unreliable and incompatible measurement techniques; (b) how to relate emissions of fine particles to emissions of larger-size particles and take into account the non-carbonaceous constituents of particles of all sizes; (c) how to take account of "super-emitting" sources, which may contribute a large fraction of the emissions from a given source category; (d) how to account for rapidly fluctuating emission sources like biomass burning; (e) how to allow for intercontinental transport of fine particles in the northern hemisphere; and (f) how to estimate the uncertainty of emission estimates. Results for North America will be presented, and recommendations for the development of further, more-detailed compilations for this region will be made.

Integrated SOx Emission Trend Estimation for the Sustainability Transition

R. Husar, J. Agan, K. Miller, J. Reynolds and C. Reid, J. Husar, S. Falke
Washington University in St. Louis

This is an integrated trend analysis for the aggregate US SOx emission, for the period 1940-2100. The emissions model is based on a causality tree that linearly links emissions to population dynamics through a set of coefficients that account for energy consumption, fuel mix and technological factors. The analysis is based largely on historical data (1940-2000) on the causal factors: population, economic activity, energy/fuel use and SOx emissions. The time-pattern of the coefficients is fitted to historical data. Special attention is focused on the time trends of fuel switching and sulfur removal and/or recovery in various source categories.

A spatial allocation methodology based on mass and energy conservation will be demonstrated. In particular, the resulting spatial transfer functions (tensors) associated with the distribution of electric energy (electric power grid) and the flow of coal from the mines to the consumers will be illustrated.

The exploration of future SOx emissions during the sustainability transition, (2000-2100) is conducted by scenarios which include (1) assumed pattern of key drivers, population and energy-materials use/per person (2) extrapolation of trends in fuel mix and sulfur removal/recovery in each of the major sectors, particularly for electric utilities.

The emissions model is initially developed for sulfur oxides, which is the dominant man-made $PM_{2.5}$ component in most areas of the US. However, the methodology is applicable to other pollutants mobilized by fuels and minerals, e.g. mercury. The SOx emissions analysis is intended to aid long-term air quality management processes such as those specified by the Regional Haze Rule (attainment by 2065). Anticipated users of the model include EPA, Regional Planning Organizations and individual state agencies.

Evaluating the Performance of a Comprehensive Regional Emissions Inventory Using Field Data

Cyril Durrenberger and David Allen
University of Texas at Austin,

Jim Price
Texas Commission on Environmental Quality

Data from the Texas Air Quality Study, conducted during the summer of 2000, have been used to evaluate emission inventories for southeast Texas. Other presentations in this meeting (if accepted) will report the details of performance evaluations for biogenic inventories, point source inventories, mobile source inventories, emissions from fires and emissions of secondary organic aerosol precursors.

Comparisons between modeling, based on current emission inventories, and field data suggest that current methods for estimating emissions of biogenics are reasonable, while emission inventories for point sources and mobile sources have significant problems in key emission categories. This presentation will provide an overview of the comparisons, focusing on the following questions:

1). Are the magnitudes of the emissions correct?

2). Are the emissions adequately and correctly speciated?

3). Are the emissions correctly distributed spatially? and

4). Are the emissions correctly distributed temporally?

This presentation will also describe the strengths and limitations of using field measurements to infer emission rates and the key uncertainties that need to be addressed to improve the inventories.

Comparison of Emissions Processing Systems and Emissions Inventories used for Houston-Galveston Air Quality Studies

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An emissions inventory (EI) is one of the essential data for air quality modeling. Prior to use in model simulations, the EI must be processed and converted into the suitable data formats accepted by air quality models (AQMs) such as CAMx and CMAQ. Since the model simulations using different EIs may result in significantly different pollutant concentrations for the same episode, it is important to compare emissions inventories currently used with such studies. Furthermore, even the same EI processed with different emission processing systems may present different model-ready emissions data. They depend on the methodologies of spatial and temporal allocations and speciation methods used in the emission processing systems, such as Emissions Preprocessing System (EPS2) and the Sparse Matrix Operator Kernel Emissions (SMOKE) modeling system.

To study air quality in the Houston-Galveston Area (HGA), Texas Commission of Environmental Quality (TCEQ) has prepared the more updated Texas Emissions Inventory, which has been processed with EPS2. In order to utilize the Texas EI with other air quality models, we have processed the EI with SMOKE using a set of computer codes and quality assurance procedures in the Texas Emissions Inventory Preparation System (TEIPS). One of the key benefits of using SMOKE system is that it allows easy extension of the chemical mechanisms permitting investigation of the effects of the specific chemical components on the ozone production. With some additional efforts, the SMOKE system can be extended to include speciated particulate emissions and air toxics species. In this study, we compare emissions inventories available for Houston-Galveston air quality studies, for example, the Texas EI, NET96 and NEI99 processed with EPS2 and SMOKE, respectively.

OPen Emissions Models (OPEM)—Re-Thinking The Emissions Modeling Paradigm

Mark Janssen
LADCO

Zion Wang
UC Riverside.

This approach is intended to propose a new construct for emissions modeling. The authors intend to have a balanced review of the state of the science as well as a forward thinking design of a new system that would meet those needs. A public domain relational database management system (RDBMS) will be used as a backbone for emissions processing system while all functionalities in currently available emissions processing system are retained.

Emissions modeling is the act of calculating complex emissions inventories of air pollutants from raw data. The usual form of this calculation is emission factor times activity equaling emissions estimates. The reality of emissions modeling is much more complex than this simple equations. The most common use of emissions modeling is to prepare emissions estimates for photochemical or chemical transport modeling. The estimates required for this modeling must match those of a specific real day or an artificial day in the future. The estimates must also reflect the spatial resolution of the modeling system, and finally they must characterize the chemical species required by the chemical mechanism in the chemical transport model.

It is important to distinguish between emissions models and emissions processors. Emissions processors use spatial, temporal, and speciation processors to modify pre-existing emissions estimates to create pseudo-day specific emissions estimates. Emissions models create new emissions estimates based on a variety of factors. Often the two terms are used interchangeably but the distinction can be important when describing building new tools. Common examples of Emissions models are modern Mobile sources models, Biogenics, and Nonroad. Examples of emissions processors are Point and Area source models that generate model ready estimates based on SIP like annual countywide emissions inventories. SMOKE and EMS-2002 are combinations of emissions models and emissions processors.

The development of a high quality regional emissions model has traditionally been an expensive undertaking. Models like EMS and SMOKE can cost millions to develop and implement. These older development structures have revolved around a single contractor hiring high cost experts to code the model in a relatively insulated environment. These models did not rely on the expertise inherent in the community. This community based development structure has been critical to the development of the Linux operating system has been proven to work effectively for models like MM5. This proposal is not seeking a large initial outlay of resources to build this new tool instead we are looking for community supporters that are interested in development of some aspect of the model with in-kind resources.

Evaluation and Uncertainty Assessment

Quantification of Uncertainty in Emission Factors and Emission Inventories

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Over the last five years, work has been underway at NCSU to demonstrate methods for quantification of uncertainty in emission factors and emission inventories applied to case studies for point, area, and mobile sources with respect to nitrogen oxides, volatile organic compounds, carbon monoxide, and hazardous air pollutants. Methods include the use of expert judgment and empirical approaches. The latter includes bootstrap simulation to quantify uncertainty based upon either empirical or parametric distributions of inter-unit variability in emission and activity factors. Techniques for dealing with mixtures of distributions, censored (non-detected) data, measurement errors, and dependencies have been demonstrated. Two prototype software tools have been developed. AUVEE demonstrates the quantification of uncertainty in emission and activity factors, and for an inventory, based upon the example of utility NO_x emissions, for averaging times of six to twelve months. AuvTool is a stand-alone tool for fitting alternative parametric distributions to data, evaluating goodness-of-fit, and quantifying uncertainty in selected statistics. This talk will briefly review methods supported with illustrative examples based upon data for specific source categories. For example, in recent work, a probabilistic hourly NO_x emission inventory for 32 units of 9 coal-fired power plants in the Charlotte domain was propagated through the Multiscale Air Quality Simulation Platform. Intra-unit autocorrelation in emissions and inter-unit dependence were accounted for. Work is currently underway with regard to uncertainty in air toxic emissions in the Houston area. The implications of results of this ongoing research program with regard to quantification of uncertainty in emission inventories are addressed.

Pacific 2001: Cassiar Tunnel Study – Emission Rate Uncertainty Assessment

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Vehicle emission sampling was conducted at the Cassiar Tunnel in Vancouver during August 9-15, 2001. This was a 7-day study with 3 sampling periods each day. The goals of the Cassiar Tunnel Study were:

- To obtain accurate mass emission rates for a wide range of pollutants emitted from motor vehicles.
- To compare the emissions measured at the tunnel (>150,000 vehicles over 7 days) with chassis dynamometer measurements of a limited number of vehicles (70 vehicles over 5 weeks).
- To obtain current emission profiles for on-road vehicles for use in source apportionment studies.

A preliminary assessment of the sources and magnitudes of the various uncertainties affecting the emission rate calculations from the tunnel study measurements will be presented. The uncertainty assessment methodology used follows the structure required by ISO 17025 accreditation.

Evaluation Of On-road Vehicle Emissions Inventory

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This paper provides an overview of methods for evaluating on-road emissions inventories. The methods are described in a guidance document that describes the technical basis, assumptions, limitations, and data requirements for each method and recommends a step-wise application of the methods. The initial steps utilize readily available data to reconcile the spatial and temporal patterns (including long-term trends) in ambient pollutant concentrations and ratios and volatile organic compound (VOC) speciation profiles with corresponding data derived from emission estimates. Additional "top-down" evaluations that may be considered in the second level involve fuel-based inventory, source apportionment by receptor modeling, and performance evaluations of air quality simulation models. This guidance document is intended to allow state and local air pollution agencies to assess the uncertainties associated with on-road emission inventories and to identify areas for improvement. Results of the applications of these evaluation methods in California's South Coast Air Basin over the past fifteen years will be reviewed as a case study.

Comparing the Point and Non-Point Source Emission Inventory to Ambient Data in Houston: A Fine-Resolution Approach

John Jolly, Fernando Mercado, and David Sullivan
Texas Commission on Environmental Quality

Analyses of data collected in the Texas Air Quality Study in 2000 (TexAQS) have revealed the important role of Houston's industrial emissions on ozone levels. Atmospheric scientists have shown that some VOC compounds that are emitted in large amounts by industry are critically important to the rapid ozone formation and high ozone concentrations that occur there. As well, research has shown that these compounds are often dramatically underreported in the TCEQ point source emission inventory (EI).

However, few of these studies have looked at the role of non-point source EI categories in a detailed manner. In this project, we compare VOC:NOx ratios and individual species ratios measured at area monitors with the same ratios from several combinations of inventory categories, including point and non-point sources. We employ emissions data for four anthropogenic non-point source categories (area, non-road, mobile, and ships), drawn from a fully speciated version of an inventory used in recent photochemical modeling.

Our study both follows and expands upon an established methodology for comparing VOC:NOx and individual species ratios, which has been used in several studies in recent years. The methodology involves comparing ratios from a gridded emission inventory to those from one or more subject monitors located within the grid, for purposes such as inventory verification. Various combinations of grid cells are used for comparison; emissions from the cells composing the upwind quadrant of the grid are one common combination. While upwind quadrants are used in our study, their limitations are apparent in Houston, where the irregular geographic distribution of the numerous point sources makes such a coarse approach – grouping all sources in a 90-degree sector together – less than ideal. For that reason, we also employ a finer resolution approach, whereby VOC:NOx and species ratios are compared for 10-degree wind direction bins. Using this finer resolution approach for both point and non-point sources yields a very detailed look at the Houston EI, which will help in adjusting it to better reflect reality. Also, the accuracy of this approach should make it a useful improvement for future EI:Ambient reconciliation studies.

Comparison Of Biogenic Isoprene Emission Estimates With Aircraft Measurements During The Texas Air Quality Study

JiHee Song, William Vizuete, David Allen
University of Texas, Austin, Texas

Biogenic emissions of isoprene from the hardwood and mixed hardwood-conifer forests of eastern Texas dominate the hydrocarbon emission inventory in Texas east of the 99th meridian. Extensive land cover surveys, coupled with emission factors available through the Global Biosphere Emissions and Interactions System (GLOBEIS), were used to estimate the magnitude and spatial distribution of biogenic hydrocarbon emissions. In this presentation, the accuracy of the emission estimates will be assessed by comparing aircraft based observations of isoprene concentrations to the concentrations of isoprene predicted using a 3-D gridded photochemical model employing the biogenic hydrocarbon emission inventory. This comparison between coupled emission and photochemical model predictions and aircraft measurements provides a rigorous performance analysis for the inventory. The computational tools used in performing the comparison will also be described.

Improved Methods of Developing Biogenic Emissions Inventories

Mark Estes, Jim Smith, and Fernando Mercado
Texas Commission on Environmental Quality

Biogenic emissions were simulated during a severe ozone episode in August-September 2000 using an advanced emissions model, GloBEIS3. This model corrects some problems in earlier modeling systems, and adds new features that allow greater testing of emission sensitivities. Biogenic emissions modeling requires large-scale fields of photosynthetically-active solar radiation temperature, and other parameters in order calculate emissions. Satellite data analysis and mesoscale monitoring network data were used to develop the required fields. The photosynthetically-active solar radiation data were derived from GOES8 data, and yielded data fields of 4km x 4km resolution. Temperature data fields were created by applying kriging techniques to urban, rural, coastal, and buoy meteorological data. The modeling results were compared to available data from routine monitoring and to TexAQS 2000 data to determine how accurately the model simulated the observations.

Characterizing Airmass Outflow using Daily Biomass Burning Emission Inventories in Support of Flight Measurement Campaigns

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To support field experiments and complex atmospheric models such as STEM-2K1, high resolution emission inventories are needed. In addition to "traditional" anthropogenic emissions inventory, we developed new daily biomass burning emissions inventory using survey of national, regional, and international publications as well as satellite (AVHRR and TOMS Aerosol Index) information. Together with anthropogenic emissions inventory, the biomass burning emissions played a successful role in the chemical weather forecast during NASA Trace-P experiment. By using a combination of existing techniques (multivariate analysis, Chemical Mass Balance analysis, trajectory analysis and 3D modeling) applied to experimental and emission inventory data, we characterize sources signatures related to different regions and fuel/activity. Five DC8 flights with16 flight segments associated with outflow events are analyzed for this purpose. Recently, we are developing "Trans-Pacific" emission inventories to support of NOAA ITCT flight measurement campaign using what we learned from TRACE-P experience. This paper will present results from a new biomass burning inventory, air mass characterization using combined inventory/modeling/analysis and the pilot results for ITCT domain (Asia, Former Soviet Union, North America, and Central America). Some of the possibilities will be discussed to find better solutions to enhance emission inventories for such large scale. These include: (a) how to reduce data errors to enhance "signals" for both survey data and satellite data; (b) how to generalize emissions estimating methodology for such extended domain like inter-continental scale; (c) how to generate fast-response emissions for flight measurement planning through chemical weather forecasting; and (d) how to evaluate estimated emissions using various measurement/modeling information with consideration of source-receptor distance.

Evaluating Regional Emission Estimates Using Field Observations

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This paper focuses on techniques to integrate field studies, with models and emission estimates to evaluate and improve emissions. Measurements obtained during the NASA TRACE-P, NSF Ace-Asia, and NOAA-ITCT-2K1 experiments are used in conjunction with regional modeling analysis to evaluate emission estimates for Asia. A comparison between the modeled values and the observations is one method to evaluate emissions. Based on such analysis it is concluded that the inventory performs well for the light alkanes, CO, ethylene, SO_2, NO_x. Furthermore, based on model skill in predicting important photochemical species such as O_3, HCHO, OH, HO_2, and HNO_3, it is found that the emissions inventories are of sufficient quality to support preliminary studies of ozone production. These are important finding in light of the fact that emission estimates for many species (such as speciated NMHCs and BC) for this region have only recently been estimated and are highly uncertain. Using a classification of the measurements built upon trajectory analysis, we compare observed species distributions, and ratios of species, to those modeled, and to ratios estimated from the emissions inventory. It is shown that this technique can reconstruct a spatial distribution of propane/benzene that looks remarkably similar to that calculated from the emissions inventory. A major discrepancy between modeled and observed behavior is found in the Yellow Sea, where modeled values are systematically under-predicted. The integrated analysis suggests that this may be related to an under-estimation of emissions from the domestic sector. The emission is further tested by comparing observed and measured species ratios in identified megacity plumes. Many of the model derived ratios (e.g., BC/CO, SO_x/C_2H_2) fall within ~25% of those observed, and all fall outside of a factor of 2.5. Discussion of how these techniques could be used in support of upcoming experiments in North America will also be presented.

Data Management

Developing the Mexico National Emissions Inventory

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The first comprehensive national emissions inventory for the country of Mexico is currently under development. The Mexico National Emissions Inventory (NEI) project, which began in 2001, is being conducted in three phases over three years. Phase I covered program planning and organization, and development of the Inventory Preparation Plan. Phase II included the development of the inventory for the six northern Mexican states of Baja California, Sonora, Chihuahua, Coahuila, Nuevo León, and Tamaulipas. On-going work (to be completed in September 2004) will result in an emissions inventory for the remaining Mexican states. The Mexico NEI includes emissions estimates for seven pollutants (VOC, CO, NO_x, SO_2, PM_{10}, $PM_{2.5}$, and NH_3) generated by point, area, natural, and on- and off-road mobile sources.

This presentation will present the results of Phases I and II, including the methods used, data obtained, and uncertainties assessed for the northern states inventory. Emphasis will be placed on how data were collected for point sources, including state-by-state efforts to identify existing data and compile these data into one comprehensive database for all point sources in Mexico. Area source emissions will be described in terms of their data collection efforts, and results of the national fuels balance. Emission factor models developed especially for Mexico (e.g., NONROAD-Mexico) will be described. (Details on development of the MOBILE6-Mexico model, and the innovative approach to estimating reentrainment emissions from paved and unpaved roads in Mexico will be discussed in companion presentations by Kishan and Wolf) A workshop to present the results of the draft northern states inventory is scheduled for July 2003; as appropriate, the outcome of this workshop, including any significant changes in methods and data that are cited by workshop participants will be discussed in this presentation.

Innovative Methods for Emission-Inventory Development and Evaluation

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Starting with the 2000-2001 reporting period the South Coast Air Quality Management District (SCAQMD) has consolidated both the Annual Emissions Inventory Report Program and the Toxic Emissions Inventory Report Program to establish a comprehensive point source emission inventory for criteria and toxic emissions that can have an impact on air quality. The consolidated Annual Emissions Reports (AER) filed by over 3,000 facilities provide the basis for the SCAQMD point source emissions inventory. The challenging task of consolidation was greatly facilitated by the development and implementation of a new AER reporting software developed for the SCAQMD by Ecotek.

For the last seven years, Ecotek has been SCAQMD consultant for the AER program. Ecotek's responsibilities include: assistance with design of the reporting forms and supplemental instructions, software development, information dissemination and public assistance including internet support, information tracking and record keeping, compilation of data files relative to emissions and fees, and data file QA/QC.

The new AER reporting software was instrumental in providing a simplified reporting option allowing the linkage and integration between the criteria and toxic air pollutants. Furthermore, the new AER reporting software is user friendly, reduces chances for errors, improves the data quality and accuracy, and assists the users with the transition to the new consolidated program. Accuracy of the emissions inventory has significant implications since it is used for planning, rule development, and emission fee calculations, as well as determining the applicability of federal, state, or local programs.

The success of this user friendly AER reporting software can be measured by the large and constantly growing number of facilities choosing software as a reporting option: this year 82% of the reporting facilities have used the AER reporting software. The software increased the AER program's overall efficiency both at user and District levels.

This demonstration will illustrate the use of the new SCAQMD AER reporting software for consolidated reporting of criteria and toxic emissions.

Development of a GIS-based Area Source Emission Inventory in the Paso del Norte Air Quality Basin.

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Area source emissions in the El Paso/Ciudad Juarez (PdN) air quality basin are estimated as countywide or region-wide totals. Previously, the totals were spatially allocated into smaller gridded cells for use in air quality modeling by redistributing the totals according to proportional factors developed from surrogate information. This paper presents a procedure, which simplifies the redistributing process and increases the spatial resolution of the allocated area source emissions, using geographic information systems (GIS).

The 1996 CO, NOx, and VOCs emission inventory of the PdN region was used in this study. GIS was used to spatially allocate area source emissions into U.S. census tracks for El Paso and Mexican AGEBS for Ciudad Juarez, which contain geographically accurate information on population and human activities. Demographic and land use information was used to categorize the region into six areas by emission activity. The six major emission activity areas in the PdN air quality basin are: commerce, residence, country, mountain, military, and industry. Three of these six categories were selected to match with the definitions of emission activities in the Area and Mobile Source (AMS) codes (commerce, residential, industrial). Area source emissions were estimated using the U.S. Environmental Protection Agency's National Emissions Trends database. Specific emissions were identified and further categorized into the remaining three activity area categories. This resulted in individual emission estimates for each AMS code category. Emission estimates for each activity were grouped and distributed through their corresponding activity areas. The distribution was made using an activity factor defined for each activity area. Finally, the allocated emissions were transposed to an overlaid grid by spatial proportionality.

Our GIS-based redistributed area source emissions were compared favorably to that used in previous CAMx ozone modeling. Application of the redistributed area source emissions is air quality model is expected to yield more reliable ozone predictions in the PdN air quality basin.

GIS-Integrated Emissions Inventory Software Solution

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The Tribal Emissions Inventory Software Solution (TEISS) provides a graphical, user-friendly application for creating and maintaining a comprehensive emissions inventory. The system includes an integrated GIS platform providing all users with the tools to visualize and query inventory data within a spatial environment. TEISS incorporates all related emissions guidance and models into one central, unified interface where results and computations are compiled and stored in an SQL database. The data handling solution allows database vendor independence, allowing for easy data-sharing and making the system compatible with any of the major Database Management Systems, such as ORACLE, MS-SQL Server, MySQL, and Interbase.

The system supports emissions estimations based on AP-42, NEI, and EIIP guidelines through a series of real-time, Windows-based calculators. Over 200 calculators address emissions from a variety of sources and processes while also providing extensive descriptions for each process. Flexibility is extended with an intuitive interface to create and implement user-defined emissions calculators at any time within the system.

Emissions estimation models are tightly integrated allowing for seamless model execution and sharing of data from models such as NONROAD, MOBILE6, WATER9, and TANKS. An integrated graphical interface for MOBILE6 was developed for inclusion with TEISS, removing much of the complexity commonly associated with vehicle emissions estimation.

TEISS allows for rapid review of emissions data and enables production of reports and data import and export to several formats including EPA NEI Input File format (NIF 2.0/3.0) for easy incorporation of data into national databases. Complete support for GIS standard metadata is provided through an integrated utility that fully implements the Federal Geographic Data Committee's Content Standard for Digital Geospatial Metadata. The technologies and database design behind TEISS are explained while demonstrating the importance of a unified, GIS-based emissions inventory solution.

Networked Environmental Information System for Global Emissions Inventories (NEISGEI)

Brooke L. Hemming, US EPA/ORD
Stefan Falke, Washington University, St. Louis
Terry Keating, US EPA/Office of Air and Radiation

NEISGEI is an international program designed to serve the growing need for improved emissions inventory information by the international community for the assessment of regional and global air pollutant flows. The program strategy involves the development and implementation of new information technologies to facilitate data sharing and analysis among the members of the proposed international emissions inventory community. We seek to maximize the ability to access and compare data produced by different organizations, to understand the differences, and to identify and fill in the gaps. This is made possible — without having to change current practices in emission inventory development methods and reporting formats — by using the very newest methods being researched and developed by the computer sciences research community. This program will serve emissions inventory developers and users operating at all geo-spatial scales, from urban to regional to hemispheric and global scales.

The program goals include:

- Improved interaction within the international community of emissions inventory developers;
- The application of state-of-the-art and emerging information technologies to develop an Internet-based "distributed" database network with a portal for access to emissions inventory and complementary data sets for air quality analysis;
- Recruitment of inventory data providers from across geo-spatial scales, local to global; identification of regions for which data is missing;
- Facilitation of technology cooperation and assistance with air quality managers and researchers in these regions;
- Development of interoperable software tools designed to make maximum use of the distributed database network.

We are inviting governmental, non-governmental, and scientific organizations that are capable of providing expertise and possible funding to join with us in the formation of this consortium.

The EPA has partnered with participants in the US National Science Foundation Digital Government Research who will develop the technological infrastructure needed to create the NEISGEI network. Projects that will build the IT infrastructure for data-sharing at the district, regional and international scales are underway, and will be described in greater detail in subsequent talks in this session:

- Development of a North American emissions inventory under the auspices of the Commission for Environmental Cooperation
- Development of a national forest fire emissions inventory, in conjunction with the US Forest Service and the US Department of Interior
- Development of a California state-level network of county emissions inventories that will link local air quality management districts with the California Air Resources Board, and the EPA.

For more information, see our website: http://www.neisgei.org

Automating the Integration of Heterogeneous Databases: The California Air Resources Network (CAREN)

Eduard Hovy and Andrew Philpott
Information Sciences Institute, University of Southern California

Brooke Hemming
US EPA/ORD

Human impacts on the atmosphere have grown to the degree that they can no longer be treated as purely localized phenomena. Plumes of anthropogenic air pollution can be seen in dramatic satellite imagery, showing particulate matter flowing from China to the western United States, from the northeastern US into the Arctic and northern Europe, from Central America into US central states. The transport of pollutants results in enhanced background levels across all geospatial scales. Within the US, efforts are underway by regional planning organizations to assemble the data needed to track this phenomenon at the regional and national scales, and to develop appropriate air quality management strategies.

A significant stumbling block for these efforts is the difficulty inherent in reconciling the range of data types and database formats that have been developed by the independent agencies responsible for local air quality and emissions data collection. The integration of data from neighboring districts and states often requires hands-on manipulation which can add months to years to the process of preparing a national emissions inventory. These delays are amplified when the assembly of international inventories is attempted, as is the case with the inventory that is mandated under the international Convention on Long-range Transboundary Air Pollution (CLRTAP).

The University of Southern California Information Sciences Institute has been funded through the NSF Digital Government Research program to develop a form of information technology that will not only overcome the obstacle of reconciling air pollution emissions and related data contained in incompatible databases, but will do so in an automated fashion, yielding a dramatic reduction in necessary staff resources for creating harmonized data sets. As database formats evolve and additional international datasets become available for the development of air quality policy that accounts for the influence of distant pollution emissions, the automated ISI data acquisition and integration tool will efficiently expand the database. Air quality management organizations from the urban to the international scale will benefit from this new capability.

The authors will present, here, the first case for which this new information technology will be applied: the Internet-based integration of emissions inventories from individual air quality management districts in California to form CAREN: The California Air Resources Network."

Compilation and Design of a Distributed Emissions Database of North American Electric Generating Utilities

Gregory Stella
Alpine Geophysics

Stefan Falke
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In an age of international air quality agreements and annexes, a real need is seen for a state-of-knowledge application of emission inventories for purposes of public outreach, emission trends reporting, fulfilling data requests, control strategy application studies, benefit analyses, and estimating air quality in large regional areas. However, without consistent emission data sets within the domain of study, results of these applications can be speculative, at best. The Commission for Environmental Cooperation (CEC) has been working closely with North American federal environmental agencies to try and gather the latest emissions data which can be used to sure up these end results.

The objective of this study is to recommend and demonstrate to the CEC approaches for the comparability of techniques and methodologies for data gathering and analysis, data management, and electronic data communications for promoting access to publicly available environmental information held by public authorities of each of the three participating countries. We have identified, acquired, and compiled available power plant data from across North America and used these data in demonstrating the functionality of a distributed emissions database. A "mapping" of emissions data among country inventories was applied in accessing disparate emissions data and in designing an integrated relational database. Web browser interfaces provide functionality for querying, retrieving, and exploring the relational databases.

An Integrated Fire, Smoke and Air Quality Network

Stefan Falke and Rudolf Husar
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Brooke Hemming
US EPA - Office of Research and Development

The management of fire, smoke, and air quality is tasked to multiple agencies at federal, state, and local levels. The diversity in data collection methods, data reporting requirements, data formatting schemes, data analysis methods, and data presentation create a daunting challenge for the integration of these data. However, integration of these heterogeneous datasets is precisely what is called for by federal and regional organizations in order to derive a more comprehensive understanding of forest fires, including particulate matter emissions, and their impacts.

Through a Digital Government project funded by the US EPA, the Forest Service and the NSF, Washington University in St. Louis and George Mason University are developing an innovative network using evolving web services technologies with the objectives of providing uniform web-based access to, cataloging of, and display of distributed fire related data for fire, smoke, and air quality managers. This paper presents the project's progress to date.

The network uses software "middleware" components to link to and transform disparate data and offer them to end users through an easy-to-use web browser front end. The middleware components, based on web services and data standards, handle the data transformations and integration 'behind the scenes' and provide end users with the level of detail they desire; whether "raw" data or "value-added" information such as maps of fire locations or patterns of emissions. The data and tools included in the network are based on input from the user community.

The middleware components are built on the distributed Voyager (dVoy) infrastructure, a spatial-temporal framework that enables multi-dimensional data access and displays (i.e. maps and time series). The fire, smoke, and air quality network extends the dVoy infrastructure to accommodate new data types for fire and smoke applications and creates new web services for advanced fire-related data display and analysis.

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