



**ENVIRONMENTAL FLUID DYNAMICS PROGRAM**

**ANNUAL REPORT 2003 \***

**Ira A. Fulton School of Engineering  
Arizona State University  
Tempe, Arizona**

\*Also available from <http://www.eas.asu.edu/~pefdhome/>

## **Vision and Mission of the EFD Program**

The mission of the Environmental Fluid Dynamics (EFD) Program is to bring together researchers from Arizona State University (ASU), other domestic and international academic institutions, local industry, and state and federal institutions to initiate new research activities and enhance ongoing research at ASU pertinent to environmental transport processes. The emphasis is on collaborative and multidisciplinary research of immediate societal impact. In addition, the program facilitates single investigator research by providing infrastructure support, which includes: maintenance of state-of-the-art laboratory facilities; organization of seminars, discussion groups and workshops; arranging the visits of prominent scientists and scholars; and the initiation of new research thrusts. The current broad research thrusts include: modeling of environmental flows (short- and long-term forecasting of oceans and atmosphere); air pollution dispersion; fluid-structure interactions (for example, flow around buildings and vehicles, and wave forcing on platforms); health and epidemiological implications of environmental transports; atmospheric dispersion, especially the dynamics of aerosols and toxic releases; indoor air quality and building ventilation; prediction and remediation of natural hazards; and socio-economic and public policy issues of ecosystem management. In addition, efforts are made to initiate research involving micro- and nano-scale fluid mechanics as applied to environmental, biological and industrial flows. Both fundamental and applied research are emphasized.

## **Multidisciplinary Activities**

Considerable efforts were directed during the past year to enhance collaboration between researchers from different colleges at ASU in addressing problems related to atmospheric and oceanic transport processes. These include:

- (i) hosting a multidisciplinary seminar series covering a wide variety of topics related to environmental flows;
- (ii) inviting eminent scholars and faculty from different ASU colleges to deliver seminars in this series, so that their research expertise and interests can be better understood; as well informing them of EFD's research activities.
- (iii) organizing meetings of clusters of investigators in responding to various RFP's;
- (iv) involvement of dedicated graduate students and post-doctoral fellows from various departments in EFD research projects and coordinating their activities through the EFD office;
- (v) maintaining a cadre of post-doctoral and senior researchers, some of them shared between other

research centers such as the Center of Environmental Studies.

- (vi) initiating a new thrust on modeling and fundamental research on urban flows, in particular, those of rapidly expanding urban regions.
- (vii) maintaining close cooperation with the NSF-funded Long Term Ecological Research (LTER) Program of the Center for Environmental Studies, and the remote sensing group of the Department of Geological Sciences.
- (viii) Maintaining close cooperation with state agencies, such as Arizona Department of Environmental Quality and Arizona Department of Transportation.

Concurrent with the thrusts of the Vice President for Research's (VPR) Office, most of the efforts were focused on enhancing ASU's strengths in the area of urban fluid dynamics. This included contributing to ASU's GP2100 project and to the Consortium of Rapidly Expanding Urban Regions (CSRUR) and urban sustainability initiative. As the program is concerned with fluid dynamics of pollution dispersion, major efforts are underway to collaborate with other groups of complementary expertise. An internal research thrust on urban air pollution was started and is continuing, which is highly opportune given Phoenix's location in a complex terrain airshed beleaguered by serious air pollution problems. Ties with the Urban Security groups of the Los Alamos National Laboratory (LANL) and Lawrence Livermore National Laboratory (LLNL), Defense Threat Reduction Agency (DTRA), Army Research Office (ARO), Inv. Cientificas y Technologicas Sonora, University of Rome, and Beijing Environmental Information Center, China are continuing. By intensifying both fundamental and applied research on urban pollution and redirecting some of the internal resources, it was possible to compete for several grants in the air pollution arena. The inter-governmental agreement signed with the Arizona Department of Environmental Quality (ADEQ) is continuing and has been highly useful. Applied research on airflow and dispersion has resulted in exciting new opportunities, including funding from the Arizona Department of Transportation (ADOT) and the Department of Energy Laboratories (Lawrence Livermore National Laboratory). Other sponsors of the EFD program are the National Science Foundation (NSF; Polar Programs; Fluid Mechanics; Atmospheric Chemistry; Atmospheric Sciences), the Office of Naval Research (ONR), Army Research Office (ARO), the Southwest Center for Environmental Research and Policy (SCERP), Arizona Public Services Company, the California Air Resources Board (CARB), and the Air Force Office of Scientific Research (AFOSR).

In addition to air related research, the program pursued the area of water and marine resources, in particular, physical oceanography, wetlands, river transports and riparian ecosystems. The U.S. Office of Naval Research (ONR) continued to fund our work on ocean waves and their interaction with large objects. Several proposals were submitted to ONR to initiate work on mixing induced by topographic features and wakes in stratified fluids (the former is pending and the latter was approved in 2003). The following are some highlights of the EFD program in 2003:

- ADEQ awarded a contract to conduct flow, ozone and socio-economic modeling work in support of 8-hour ozone boundary designations for the U.S. EPA.
- A new ONR grant was approved to conduct research on underwater vehicles, such as submarines moving in the oceanic thermocline.
- EFD researchers presented and defended their work in 3 public (stake holder) meetings with regard to 8-hour ozone boundary designations.
- ADEQ awarded a grant to start a major modeling partnership between ASU and ADEQ by instituting a joint ASU/ADEQ modeling center.
- Through a DURIP (Defense University Research Initiative Program) grant a Doppler Lidar was purchased (PI. R. Calhoun). This is the first such Lidar to be purchased by a university.
- Under the intergovernmental Service Agreement signed between the Arizona Department of Environmental Quality and EFD, three new projects were funded.
- A new multiyear grant was awarded by the Office of Naval Research dealing with mine burial in coastal environments.
- A major grant was awarded by the Department of Army to participate in the Joint-Urban 2003 field experiment led by the US Department of Homeland Security.
- Professor Joseph Zehnder spearheaded the effort of starting an Atmospheric Sciences Certificate Program at ASU. This is a multidepartmental certificate program approved by the graduate college. Initiation of this program followed the admission of ASU to the University Corporation of Atmospheric Research (UCAR) in 2000; EFD played a major role in both of these activities.
- Collaborative work with colleagues from the Mathematics department (Professors Nicolaenko and Mahalov) continued on problems related to stratospheric turbulence. A major three year grant was received from the AFSOR to carry out this work.
- The multidisciplinary “Ecosystems Engineering Seminar” was continued, featuring invited distinguished seminar speakers. The multidisciplinary research funding from VPR’s Office is used for this activity. Each semester, nearly twenty students from the Departments of Chemical

Engineering, Civil and Environmental Engineering, Mechanical and Aerospace Engineering, Mathematics, Planning, Chemistry and Geography register for this course. The Faculty attendance for this seminar series is also encouraging. This seminar is cross-listed as MAE 591/CEE 591/CHE 591/MAT 591. It is also used as a platform to invite distinguished speakers recommended by the university administration or to invite prospective faculty candidates. The mailing list for the seminar series includes state agencies and local industry, and participation of individuals from these organizations is not a rarity. A listing of the 2002 Ecosystem Engineering Seminars as well as details on general Environmental Fluid Dynamics seminars is given later. The former is also being used as the capstone seminar for the Atmospheric Certificate course.

- The EFD laboratory is being used as a showcase for prospective undergraduate and graduate students. The EFD program coordinated numerous student and faculty visits, and each year the laboratory entertains hundreds of visitors.
- Professor Julian Hunt (Lord Hunt of Chesterton), former Chief Executive of the U.K. Meteorological Office and currently a Professor of Space and Climate Physics at the University College in London, continued to be a part of the visiting faculty attached to the EFD program. Under his leadership, major mathematical modeling efforts pertinent to urban flows were started and they continue to flourish.
- The Energy Management Laboratory continued to host the Industrial Assessment Center (IAC), one of 26 such Centers across the country sponsored by the US Department of Energy. The IAC provides free assessments of small and medium-sized manufacturing plants throughout Arizona and in the Las Vegas area, and makes recommendations on energy efficiency, waste reduction, and productivity improvement. A similar project was the Rebuild America Project (RAP), led by the Arizona State Energy Office. A major undertaking here was an analysis of the energy efficiency of schools, in collaboration with the Arizona Schools Facilities Board. Presently, the data gathered from the Mesa School District are being analyzed to determine the most cost-effective energy measures that can be taken by these, and other, schools. Finally, a major initiative was launched in 2002 involving biochemical sensors, in collaboration with Tony Garcia (Bioengineering), Mark Hayes (Chemistry & Biochemistry), and Ron Calhoun (MAE & EFD). Our part involves the simulation of the motions of small particles and molecules in a confined geometry, as is encountered in many types of biochemical sensors.
- Research Professor Iossif Lozovatsky participated in an international oceanic measurement program, with partial financial support from the Office of Naval Research and in collaboration with Russian

Oceanographers. The third expedition in this series was carried out in April 2002, covering a transect across the Atlantic.

### **Associated Faculty**

A number of regular and adjunct faculty members from the Departments of Civil Engineering (CE), Mechanical & Aerospace Engineering (MAE), Chemical and Materials Engineering (CME), Geography (GEO), and Mathematics (MAT) have been closely involved in the proposal development and research efforts of the EFD Program. The faculty who submitted proposals during 2003 and their affiliations are: J. Anderson (MAE), D. Boyer (MAE), P. Phelan (MAE), K. Squires (MAE), I. Lozovatsky (MAE), A. Mahalov (MAT), B. Nicolaenko (MAT), G. Raupp (CBME), S. Voropayev (MAE), D. Smith, (MAE), J. Zehnder (GEO), A. Dillner (CEE), R. Calhoun (MAE), J. Allen (CME), and S.M. Lee (CE).

Post-doctoral fellows, faculty associates and numerous visiting scientists contributed immensely to the program. The EFD program maintains a cadre of research scientists, post-doctoral fellows and visiting researchers to maintain its long-term research viability and international presence in numerous research activities. Listings of these activities are given below.

### **EFD Research Scientists in 2003**

Dr. I. Lozovatsky (Research Professor)	Dr. S. Voropayev (Research Professor)	Dr. D. Smith (Research Associate Professor)
Dr. Sang-Mi Lee (Assistant Research Professor)	Dr. S. Grossman-Clarke (Post-Doctoral Fellow)	Dr. F. Tse (Post-Doctoral Fellow)
	Dr. Andjelka Srdic (Assistant Research Professor)	Dr. Olga Alexandrova (Faculty Research Associate)
Dr. Binson Joseph (Post-Doctoral Fellow)	Dr. Gordon Moore (Faculty Research Associate)	Dr. James Anderson (Senior Research Associate)
Dr. Sergey Smirnov (Post-Doctoral Research Associate)	Dr. Xin Hua (Faculty Research Associate)	

### **Visitors to EFD in 2003**

<b>VISITOR</b>	<b>AFFILIATION</b>	<b>DATE(S)</b>
Paolo Monti	University of Rome, Italy	Dec 03
Andrea Dato	University of Rome, Italy	June – Nov 03
JCR Hunt	University College, London	April 03, and Dec 03
Peter Baines	CSIRO, Australia	Feb 03
Eliezer Kit	Tel Aviv University, Israel	May - June 03
Ted Johnson	University College, London	Nov - Dec 03

### **EFD Students 2003**

A listing of students who were supported by EFD-related projects and the Ph.D. and M.S. degrees completed under the auspices of the EFD program are listed below.

#### **EFD Graduate Students**

Dragan Zajic (MAE), John Holeman (MAE), Marko Princevac (MAE), John Rotter (MAE), Firat Testik (MAE), Jason Porter (MAE), Cristian Dumitrescu (MAE), Zhihe Zhao (MAE), Charity Coury (CHE), Jamshed Ghoush (MATH), Bong-Sik Kim (MATH), Robert Heap (MAE), David Boswell (MAE),

#### **M.S./Ph.D. Degrees completed by EFD students**

<b>FACULTY NAME</b>	<b>CANDIDATE</b>	<b>DEGREE</b>	<b>THESIS</b>
HJS Fernando	Sean Riley	MS	Decay of Convective Turbulence in the Presence of an Inversion Layer
HJS Fernando	Marko Princevac	PhD	Dynamics of Thermal Circulation in Complex Terrain

#### **EFD Undergraduate Students**

Richard Montenegro, Martin Weeden,

### **Conference Presentations 2003**

- Calhoun, R., Fernando, H.J.S., Introduction to LIDAR for Environmental Sensing Applications, FAME: Frontiers in Assessment Methods for the Environment University of Minnesota, Minneapolis, Aug 10 - Aug 13, 2003
- Grilli, S.T., Voropayev, S.I., Testik, F. and Fernando, J. “Numerical Modeling and Experiments of Wave Shoaling over Semi-Buried Cylinders in Sandy Bottom,” Proceedings, International Offshore and Polar Engineering Conference-2003, Honolulu, Hawaii, May 25-30, 2003, 405-412 (ISBN 1-880653-60-5).
- Fernando, H.J.S., “Quasi-two dimensional Flow Structures in Stratified and Rotating Turbulent Flows,” Invited paper, International Symposium on Shallow Flows, Proceedings of the International Symposium on Environmental Hydraulics (Eds. G.H. Jirka, W.S.J. Uijtewaal), June 16-18, Delft, The Netherlands, 5-13, 2003.
- Zajic, D., Fernando, H.J.S., Brown M.J., Kim, J.J. and Baik, J.J., Flow and Turbulence in Simulated City Canyons; Measurements and Computations, Sep 1-5, Fifth International Conference on Urban Climate, Lodz, Poland, 2003.
- Fernando, H.J.S., Lee, S-M. and Grossman-Clarke, S., “Some Issues Related to the Modeling of Urban Airsheds,” Proceedings, The AEESP Symposium on Frontiers in Assessment Methods for the Environment, University of Minnesota, Aug 10-13, 2003.

### **Journal Papers 2003**

- K.-L. Tse, A. Mahalov, B. Nicolaenko and HJS Fernando, “Quasi-Equilibrium Dynamics of Shear-Stratified Turbulence in a Model Tropospheric Jet,” *Journal of Fluid Mechanics*, to appear, 2003
- B. Joseph, A. Mahalov, B. Nicolaenko and K.L. Tse, “Variability of Turbulence and its Outer Scales in a Model Tropopause Jet,” *Journal of the Atmospheric Sciences*, to appear, 2003
- B. Joseph, A. Mahalov, B. Nicolaenko and K.L. Tse, 2003: “High Resolution DNS of Jet Stream Generated Tropopausal Turbulence,” *Geophys. Res. Lett.*, vol. 30, No. 10, p. 32.1-32.5
- A. Mahalov, M. Adams and B. Nicolaenko, 2003: “Clear Air and Optical Turbulence in a Jet Stream in the Airborne Laser Context,” *Navigator*, Spring NAVO MSRC, p. 16-21.
- K.-L. Tse, A. Mahalov, B. Joseph and B. Nicolaenko, “High Resolution DNS of Shear-Convective Turbulence and Its Implications to Second-order Parameterizations,” *Theor. and Comp. Fluid Dyn.* }, to appear, 2003
- JCR Hunt, J.R. Pacheco, A. Mahalov and HJS Fernando, 2003: “Effects of Rotation and Sloping Terrain on Fronts of Density Currents,” submitted to the *Journal of Fluid Mechanics*.

- Alexandrova, O., Boyer, D.L., Anderson, J. and Fernando, H.J.S. "The Influence of Thermally Driven Circulation on PM<sub>10</sub> Concentration in the Salt lake Valley," *Atmospheric Environment*, 37(3), 421-437, 2003.
- Kelly, D., Fernando, H.J.S., Gargett, A., Tanny, J. and Ozoy, E. "The Diffusive Regime of Double-Diffusive Convection: Laboratory and Observational Aspects," *Progress in Oceanography*, 56, 461-481, 2003.
- Lee, S.M., Fernando, H.J.S., Princevac, M., Zajic, D., Sinesi, M., McCulley, J., and Anderson, J. "Transport and Diffusion of Ozone in the Nocturnal and Morning PBL of the Phoenix Valley," *Journal of Environmental Fluid Mechanics*, 3, 331-362, 2003.
- Voropayev, S.A., Testik, F.Y., Fernando, H.J.S. and Boyer, D.L. "Burial and Scour Around A Short Cylinder Under Progressive Shoaling Waves," *Ocean Engineering*, 30(13), 1647-1667, 2003.
- Zhu, H., Phelan, P.E., Duan, T., Raupp, G. and Fernando, H.J.S. "Characterization and Relationships between Outdoor Air and Indoor Bioaerosols in an Office Building," *China Particuology (Journal of the Chinese Society of Particuology)*, 1(3), 119-123, 2003.
- Hunt, J.C.R., Fernando, H.J.S., and Princevac, M., "Unsteady Thermally Driven Flows on Gentle Slopes," *Journal of Atmospheric Sciences*, 60(17), 2169-2182, 2003.
- Lozovatsky, I.D., Morozov, E.G. and Fernando, H.J.S. "Spatial Decay of Energy Density of Tidal Internal Waves," *Journal of Geophysical Research*, 108 (C6), 32(1)- 32(16), 2003.
- Voropayev, S.A., Testik, F.Y., Fernando, H.J.S. and Boyer, D.L., "Morphodynamics and Cobbles Behavior in and near the Surf Zone" *Ocean Engineering*, **30**, 1741-1764, 2003.
- Fernando, H.J.S. "The Evolution of a Turbulent Patch in a Stratified Shear Flow," *Physics of Fluids*, 15(10), 3164-3169, 2003.
- Hunt, J.C.R., Vreiling, A.J., Nieuwstadt, F.T.M. and Fernando, H.J.S. "The Influence of the Thermal Diffusivity of the Lower Boundary on Eddy Motion in Convection," *Journal of Fluid Mechanics*, 491, 183-205, 2003.
- Baik, J.J., Kim, J.J. and Fernando, H.J.S. "A CFD Model for Simulating Urban Flow and Dispersion," *Journal of Applied Meteorology*, 42(11), 1636-1648.
- Tse, K.L., Mahalov, A., Nicolaenko, B. and Fernando, H.J.S. "Quasi-Equilibrium Dynamics of Stratified Turbulence in a Model Tropospheric Jet," *Journal of Fluid Mechanics*, 496, 73-103.
- Zhu, H., Phelan, P.E., Duan, T., Raupp, G.B., Fernando, H.J.S. and Che, Fengchiang, " Experimental Study of Indoor and Outdoor Airborne Bacterial Concentrations in Tempe, Arizona, USA," *Aerobiologica*, 10, 1-11, 2003.

### Other Publications 2003

- Grilli, S.T., Voropayev, S.I., Testik, F. and Fernando, J. "Modeling and Experiments of Wave Shoaling over Buried Cylinders in Sandy Bottom," ISPOE-2003, Honolulu, Hawaii, 2003, Submitted.
- Fernando, H.J.S., Voropayev, S.A. and Grilli, S.T. "Mine Burial in Coastal Environments," ONR Workshop on Mine Burial, Tampa, FL, Jan 28-30, 2003.
- Anderson, J., Fernando, H.J.S., Xin, H., Hyde, P. and Redman, "Temporal Patterns of "Unhealthy" to "Hazardous" Concentration Maxima for Coarse particles (PM10) in Southwest Phoenix During Typical Low Wind Speed Conditions," Presented at the CAP LTER Symposium, Feb 19<sup>th</sup>, 2003.
- Anderson, J. and Fernando, H.J.S. "Exposure Patterns for Particulate matter in Urban Complex Terrain Areas of the Desert Southwest," International Society for Aerosols in Medicine Meeting, Johns Hopkins University, June 2003.
- Lee, S. M., Zajic, D., Kim, J.J., Giori, W. and Fernando, H.J.S. "Numerical simulation of atmospheric flow within urban morphology, 7th annual George Mason University conference on transport and dispersion modeling. June 17-19, Fairfax, VA, 2003.
- Fernando, H.J.S. "Turbulent Patches in Stratified Shear Flows," Joint EGS/AGU Assembly, Nice, France, Geophysical Research Abstracts EAE03-A-01286, 2003 (solicited).
- Fernando, H.J.S., Princevac, M. and Hunt, J.C.R., "Unsteady Katabatic Winds on Mountain Slopes," Joint EGS/AGU Assembly, Nice, France, Geophysical Research Abstracts EAE03-A-01200, 2003.
- Hunt, J.C.R., Zilitinkevich, S., Nieuwstadt, F., Fernando, H.J.S. and Princevac, M., "Eddy Structure and Mean Flow Effects in Strong Convection," Joint EGS/AGU Assembly, Nice, France, Geophysical Research Abstracts EAE03-A-05686, 2003.
- Calhoun, R., and Fernando, H.J.S. "An Introduction to LIDAR for Environmental Sensing Applications," The AEESP Symposium on Frontiers in Assessment Methods for the Environment, University of Minnesota, Aug 10-13, 2003.
- Fink, J. Redman, C. and Fernando, H.J.S. "Deciphering the Complexities of the Urban Environment through CLEANUP (Collaborative Large-Scale Engineering Assessment Networks for Urban Processes)," The AEESP Symposium on Frontiers in Assessment Methods for the Environment, University of Minnesota, Aug 10-13, 2003.
- Calhoun, R., Fernando, H.J.S. and Peccia, J. "Tracking Aerosol Plumes – Lidar, Modeling, and in situ Measurements," SPIE Defense & Security Symposium, Sensors, Command, Control, Communications, and Intelligence (C3I) Technologies for Homeland Security and Homeland Defense, 12–16 April 2004, Orlando, Florida, USA
- Calhoun, R. and Fernando, H.J.S. "A Survey of Lidar Data for the Joint Urban Dispersion 2003 Experiment," " Am. Geophys. Union, Fall meeting.
- Lozovatsky, I. and Fernando, H.J.S., "Mixing in Abyssal Oceans and Statistics of the Bottom Boundary layer" Am. Geophys. Union, Ocean Sci., EOS xx OSxx, 2004.

Voropayev, S. and Fernando, H.J.S., "Wakes of Maneuvering Bodies in Stratified Fluids," ONR Turbulence and Stratified Wakes Program review, Oct 21-22, San Diego, CA, 2003.

Pardjyak, E. and Fernando, H.J.S., "The decay of Turbulence During Evening Transition," Bull. Am. Phys. Soc 48 (10), 144, 2003.

Fernando, H.J.S., Riley, S. and Pardjyak, E.J., "The Decay of Convective Turbulence Bounded by an Inversion," Bull. Am. Phys. Soc 48 (10), 174, 2003.

Lee, S.M., Zajic, D., Kim, J.J., Rubio, A. and Fernando, H.J.S, " Modeling of Atmospheric Flow inside urban structure" Outreach Workshop for the UH-EPA Project Review, Dec 15-17, 2003.

Fernando, H.J.S., Hyde, P. and Zehnder, J. "Phoenix as a Field Facility," Invited Presentation at the 3<sup>rd</sup> CLEANER Workshop, Duke University, February 4-5, 2003.

### Teaching Activities

The EFD program is a key contributor to the interdisciplinary graduate education in environmental sciences/engineering at ASU. The course "Ecosystem Engineering Seminar," cross-listed as MAE 591, CHE 591, CEE 591, MAT 591 was offered in both Spring and Fall 2002. This is a weekly one-hour seminar presentation by a specialist in the environmental science/engineering area. Speakers of this seminar series and their discussion topics are given below. We plan to continue this course for the next several years. In addition, a special EFD seminar series is conducted on every Friday, the details of which are given following the Ecosystems seminar listing.

### Ecosystems Seminars in 2003

<u>DATE</u>	<u>SPEAKER</u>	<u>AFFILIATION</u>	<u>TITLE</u>
1/22/03	Charles L. Redman	Center for Environmental Studies, ASU	ILTER, CES, AND THE NEXT GENERATION OF RESEARCH
1/29/03	Peter Hyde	Arizona Department of Environmental Quality	AIR POLLUTION QUIZ
2/5/03	John Snow	Oklahoma State University	FROM TORNADOES TO TRAFFIC PROBLEMS TO TERRORISTS: CHALLENGES FOR THE URBAN METEOROLOGIST
2/12/03	Mary Kay O'Rourke	The University of Arizona	EXPOSURE OF CHILDREN TO PESTICIDES IN YUMA COUNTY, ARIZONA

2/19/03	Heather Campbell	School of Public Affairs, ASU	PRICES, DEVICES, PEOPLE, OR RULES: THE RELATIVE EFFECTIVENESS OF POLICY INSTRUMENTS IN WATER CONSERVATION
2/26/03	Michael Montgomery	Environmental Protection Agency	A NEW APPROACH TO ENVIRONMENTAL CHALLENGES IN THE BORDER REGION
3/5/03	Richard Sextro	Lawrence Berkeley National Lab	UNDERSTANDING CONTAMINANT TRANSPORT AND FATE IN BUILDINGS
3/12/03	Ann Kinzig	Department of Biology, ASU	RESILIENCE THEORY, SUSTAINABILITY SCIENCE, AND URBAN DEVELOPMENT: RESEARCH OPPORTUNITIES FOR ARIZONA STATE UNIVERSITY
3/26/03	Michael Bruse	University of Bochum, Germany	ENVI-MET: A PROGNOSTIC MICROSCALE MODEL FOR THE SIMULATION OF SMALL SCALE EXCHANGE PROCESSES IN URBAN ENVIRONMENTS
4/2/03	Amanda Ormond	The Ormond Group	BARRIERS AND DRIVERS FOR RENEWABLE ENERGY DEVELOPMENT
4/9/03	Subhrajit Guhathakurta	School of Planning and Landscape Architecture, ASU	MODELING AS THEORETICAL ENDEAVOR: EXPLORING THE PEDAGOGIC AND NARRATIVE STRUCTURES OF SPATIAL SIMULATION
4/16/03	David Boyce	University of Illinois at Chicago	URBAN TRAVEL AND AIR QUALITY
4/23/03	Wesselius Lewis	Mayo Clinic Scottsdale, AZ	INHALED METALS AND RESPIRATORY DISEASE
4/30/03	James Anderson	Mechanical and Aerospace Engineering	HAZARDOUS PARTICLE POLLUTION AT DOUGLAS, ARIZONA/AGUA PRIETA, SONORA
8/27/03	Wellington Reiter	College of Architecture and Env. Design	CONSTRUCTING THE CITY
9/3/03	Darcy Anderson	AZ Dept. of Environmental Quality	AIR TOXICS MONITORING IN THE PHOENIX AREA
9/10/03	David Allen	University of Texas	THE TEXAS AIR QUALITY STUDY: STATE OF THE SCIENCE OF AIR QUALITY IN TEXAS AND IMPLICATIONS FOR AIR QUALITY

			POLICY
9/17/03	Jason Ching	NOAA / EPA	URBAN, RESOLVED, AND WITHIN-GRID AIR QUALITY MODELING AT COARSE-TO-FINE SCALES FOR HUMAN EXPOSURE MODELS
10/1/03	Bary Lefer	NCAR	BIOSPHERE-ATMOSPHERE INTERACTIONS AND THE NITROGEN CYCLE
10/8/03	Larry Scofield	AZ ADOT	NOISE POLLUTION IN THE PHOENIX AREA
10/15/03	James Anderson	ASU / MAE	EXPOSURE PATTERNS FOR PARTICULATE MATTER IN URBAN COMPLEX TERRAIN: RESULTS FROM SW PHOENIX
10/22/03	Michele Kimpel-Guzman	AZ ADEQ	IMPROVING AIR QUALITY IN AMBOS NOGALES: WHAT IS THE ROLE OF CULTURE IN SOLVING ENVIRONMENTAL PROBLEMS
10/29/03	Don Boyer	ASU / MAE	SOME EVIDENCE TO CAUTION IN THE UNQUESTIONED BELIEF IN NUMERICAL MODELS
11/5/03	David Emmitt	University of Virginia	AIRBORNE DOPPLER LIDAR INVESTIGATION OF FLOW WITHIN COMPLEX TERRAIN AND MARINE BOUNDARY LAYERS
11/12/03	William Jepson	UCLA	THE UCLA URBAN SIMULATION LAB AND VIRTUAL LOS ANGELES
11/19/03	Peter Hyde	AZ ADEQ	ELEVATED PARTICULATES CONCENTRATIONS IN THE SALT RIVER INDUSTRIAL AREA OF PHOENIX, ARIZONA
12/3/03	James Cogan	Army Resch. Lab	A HIGHLY MOBILE SYSTEM FOR BOUNDARY LAYER METEOROLOGY

## EFD Seminars in 2003

<b>DATE</b>	<b>SPEAKER</b>	<b>AFFILIATION</b>	<b>TITLE</b>
1/24/03	Peter Baines	CSIRO Atmospheric Research, Australia	ON THE CAUSES OF CERTAIN DROUGHTS
1/31/03	Zhihe Zhao	Environmental Fluid Dynamics Program, ASU	A STUDY OF SCOUR OF MINES IN SHOALING WATER
2/7/03	Ron Adrian	University of Illinois	THE SPATIAL STRUCTURE OF TURBULENT RAYLEIGH-BENARD CONVECTION
2/14/03	Firat Testik	Mechanical and Aerospace Engineering, ASU	DYNAMICS OF BOTTOM TOPOGRAPHY UNDER FIXED AND VARYING PROGRESSIVE WAVES
2/24/03	Don Boyer	Mechanical and Aerospace Engineering, ASU	FLOW PAST A SUBMARINE CANYON: A PARAMETER STUDY
2/28/03	Rodolfo Rodriguez	Chemical and Materials Engineering, ASU	TURBULENT BOUNDARY LAYER DUE TO SHEAR FLOW, ROUGHNESS AND OSCILLATORY MOTION
3/7/03	Daniel Gonzales	Chemical and Materials Engineering, ASU	SPECIATED FINE PARTICLE DEPOSITION TO A FOREST MEASURED BY EDDY-CORRELATION MASS SPECTROMETRY
3/14/03	Cristian Dumitrescu	Environmental Fluid Dynamics Program, ASU	APPLICATION OF AERMOD
3/28/03	Istvan Szunyogh	University of Maryland	SPATIO-TEMPORAL PROPAGATION OF LOCALIZED IMPROVEMENTS IN THE INITIAL CONDITIONS OF NUMERICAL WEATHER PREDICTIONS
4/4/03	Walter Giori	University of Rome, Italy	IMPLEMENTATION OF THE NEW EDDY DIFFUSIVITY PARAMETERIZATION IN A MESOSCALE MODEL
4/11/03	Susanne Grossman-Clarke	EFD/LTER, ASU	EFFECTS OF LAND COVER MODIFICATIONS IN THE MESOSCALE METEOROLOGICAL MODEL MM5 ON SURFACE ENERGETICS AND PBL

			CHARACTERISTICS IN PHOENIX
4/18/03	Binson Joseph	Department of Mathematics	NUMERICAL SIMULATION OF TURBULENCE AT THE TROPOPAUSE JET STREAM WITH AN UNDERLYING LAYER OF CONVECTION
4/25/03	Hemanth Kolera-Gokula	Mechanical and Aerospace Engineering, ASU	SIMULATION OF THE FLOW AROUND CUBIC ROUGHNESS ELEMENTS USING THE IMMERSED BOUNDARY TECHNIQUE
5/2/03	John Holeman	Environmental Fluid Dynamics Program, ASU	AN OVERVIEW OF THE CAMPBELL SCIENTIFIC KRYPTON HYGROMETER
6/5/03	Mathias Rotach	Swiss Federal Institute of Technology	TURBULENCE IN THE URBAN NEAR-SURFACE LAYER AND ITS IMPACT ON URBAN-SCALE POLLUTANT DISPERSION
8/29/03	SM Lee	Civil and Environmental Engineering, ASU	SOME ISSUES RELATED TO THE SIMULATION OF CONTAMINANT DISTRIBUTION IN COMPLEX-TERRAIN AREAS
9/5/03	Sergey Smirnov	Mechanical and Aerospace Engineering, ASU	LONG-TIME EVOLUTION OF LINEARLY STRATIFIED SPIN-UP FLOWS IN AXISYMMETRIC GEOMETRIES
9/12/03	Firat Testik	Environmental Fluid Dynamics Program, ASU	FLOW AROUND A SHORT CYLINDER PLACED ON A HORIZONTAL BOTTOM
9/19/03	HJS Fernando	ASU / MAE/EFD	TWO DIMENSIONAL FLOW STRUCTURES AND TURBULENCE IN STRATIFIED AND ROTATING FLOWS
9/26/03	Rodolfo Rodriguez	ASU / MAE	THE EFFECTS OF OSCILLATING SURFACE ROUGHNESS ON THE MEAN VELOCITY PROFILE IN A TURBULENT BOUNDARY LAYER
10/3/03	Antonio Rubio	ASU / MATH	URBAN FLOW MODELING – EVALUATION OF THE QWIC MODEL
10/10/03	Cristian Dumitrescu	ASU / EFD	GRAVITY CURRENTS
10/17/03	Binson Joseph	ASU / MATH	TURBULENCE IN MODEL TROPOPAUSE JETS
10/24/03	Iossif Lozovatsky	ASU / MAE	MIXING AND THERMOCLINE SPLITTING ON THE SHELF

10/31/03	Marko Princevac	ASU / EFD	ARIZONA STATE UNIVERSITY'S CONTRIBUTION TO THE JOINT URBAN 2003 EXPERIMENT
11/7/03	Dragan Zajic	ASU / EFD	MODELING OF MEAN WIND PROFILES ABOVE THE ROUGHNESS CANOPY USING DISTRIBUTED FORCE MODEL
11/14/03	Zhihe Zhao	ASU / EFD	NUMERICAL MODELING OF FLOW AND SCOUR NEAR THE MINE
11/17/03	Masahiko Ozaki	RITE, Japan	DISCHARGE OF LIQUID CO <sub>2</sub> INTO THE DEEP OCEAN
11/20/03	Ted Johnson	University College, London	VORTICES NEAR GAPS AND ISLANDS
11/21/03	Andrea Dato	Univ. of Rome, Italy	ESTIMATION OF THE MIXING EFFICIENCY BASED ON MEASUREMENTS IN THE ATMOSPHERIC BOUNDARY LAYER AND ANALYSIS OF TURBULENCE KINETIC ENERGY DECAY DURING EVENING TRANSITION
12/5/03	John Holeman	ASU / EFD	SURFACE LAYER ENERGY BALANCE: OKLAHOMA CITY 2003
12/8/03	JCR Hunt	University College, London	NEW CONCEPTS FOR MESOSCALE FLOWS OVER CHANGING SURFACE CONDITIONS AND IMPLICATIONS FOR LOCAL CLIMATE CHANGE

## Proposals Submitted Through the EFD Program in 2003

<b>Title</b>	<b>Investigators</b>	<b>Agency</b>
Quantifying Construction Generated PM-10	R. Calhoun (MAE) HJS Fernando (MAE/EFD) C. Fiori (Del E Webb School of Construction) J Anderson (MAE)	ADOT
Effects of Global Climate, Urban Extent, and Vehicle Technology Changes on Air Quality during 2050-2100 in a Rapidly-Expanding City	HJS Fernando (MAE/EFD) J Allen (CEE/CME) A Dillner, CME/CEE) J Anderson (MAE) S Guhathakurta (School of Architecture)	EPA
Ocean Sequestration, Modeling of Sub-Grid Scale Processes	A Srdic (MAE/EFD) HJS Fernando (MAE/EFD) K Squires (MAE) D Boyer (MAE)	DOE
Flow Induced Vibrations in a Shutdown Cooling System	L Montenegro (MAE/EFD) HJS Fernando (MAE/EFD)	APS
Urban Fluid Mechanics: Up-slope Flow and Transition	HJS Fernando (MAE/EFD)	NSF
Propulsion and Interactions of Self-Propagating Quasi-Monopolar Vortices in Rotating Stratified Fluid	S Voropayev (MAE/EFD) HJS Fernando (MAE/EFD) S Smirnov (MAE)	NSF
Flow and Mixing around Shallow Seamounts: Modeling and Observations	D Smith (MAE/EFD) HJS Fernando (MAE/EFD) I Lozovatsky (MAE/EFD)	NSF
Global Statistics of the Deep Ocean Boundary Layer	I Lozovatsky (MAE/EFD) HJS Fernando (MAE/EFD)	NSF
Wakes of Maneuvering Bodies in Stratified Fluids	S Voropayev (MAE/EFD) HJS Fernando (MAE/EFD)	ONR
8-Hour Ozone Non Attainment Boundaries Analysis and Socio-Economic Information	HJS Fernando (MAE/EFD)	ADEQ

Modeling of 8-Hour Ozone Boundaries	HJS Fernando (MAE/EFD)	ADEQ

**Awards Received Through EFD Program in 2003**

Carbonaceous Aerosol and Visibility in the Superstition Wilderness Area	A. Dillner (CEE)	AZ ADEQ
Doppler Lidar Measurement of Wind, Turbulence and Aerosol Backscatter in an Urban Environment	R. Calhoun (MAE)	Battelle
Modeling of 8-hour Ozone Boundaries	HJS Fernando (MAE/EFD)	AZ ADEQ
8-Hour Ozone Non-Attainment Boundaries Analysis and Socioeconomic Information	HJS Fernando (MAE/EFD)	AZ ADEQ
Flow Induced Vibrations in a Shutdown Cooling System	HJS Fernando (MAE/EFD)	APS
Urban Fluid Mechanics: Thermal Circulation in Complex Terrain	H.J.S. Fernando (MAE/EFD)	NSF

## EFD Facilities and Laboratories

The Environmental Fluid Dynamics (EFD) Laboratory at Arizona State University (ASU) is a 5000 sq. ft. state-of-the-art facility. A complete array of instrumentation is available for flow diagnostics and data analysis. This includes two- and one-component (TSI and Dantec) Laser-Doppler Velocimeters (including a Dantec fiber-optic system), (Sontek) three-component Acoustic-Doppler Velocimeters, two laser-induced fluorescence systems, three DigImage particle-tracking velocimetry systems (developed by the Cambridge Environmental Research Consultants; Dalziel 1993), two Particle-Image Velocimetry (PIV) systems including a stereoscopic, an in-house built three-component particle-tracking system, micro-scale conductivity probes, FP-07 thermistor probes, thermocouples and their monitoring systems. Also with the help of Professor T. Kowalewski (Polish Academy of Sciences), a combined whole-field velocity/temperature measurement (liquid-crystal thermographic) system has been installed, which will be a valuable tool for proposed research. A computer controlled heating/cooling system capable of producing any desired temperature cycle is available (Affinity Instruments chiller, 5-40°C range, 8GPM throughput).

EFD maintains an array of field equipment. Three instrumented trailers (acquired from a previous grant from the Arizona Department of Transportation) and one mobile laboratory (operated by the Center of Solid State Sciences) will be available in support of the fieldwork (see Figure I.1). The available instrument array is listed in the following tables.

### BALLOON SYSTEMS

<i>Quantity</i>	<i>Item</i>
3	9 m <sup>3</sup> Tether balloon
1	Regulators for helium gas
3	Winch
6	Tethersonde
3	Receiver
3	Amplifier
3	Antenna
4	DustTrak (3 suitcase and 2 environmental enclosure)
9	Aerosol sampler (Streaker)
1	1 1/8 Wrench for regulator

### TOWER (MAST) SYSTEMS

<i>Quantity</i>	<i>Item</i>
3	Sonic anemometer (Applied Technology, Metek USA-1; Campbell)
2	Tower (14m and 18m)
2	Cup anemometer
20	Thermocouples + Radiation shields
2	Data logger for cup anemometer and thermocouple OM-220
1	Pyrometer ( long wave )
1	Pyranometer ( short wave )
2	IR thermometer 4000.3ZL, Everest Interscience
4	Dataloggers CR, Campbell Scientific
1	Soil Heat Flux Plate HFP01SC-L
1	Net Radiometer CNR1, Kipp & Zonen
1	Krypton Hygrometer, Campbell Scientific

### Other Equipment

<i>Quantity</i>	<i>Item</i>
2	GPS Unit 76s - Garmin
4	Strobe light ( 3 white and 3 red )
1	Pocket data logger

1	Omega data logger OM-440 (back-up)
3	TEOM Instrument

Ample computer facilities (including several workstations) are available for data acquisition and reduction, including the recently opened joint ASU-ADEQ modeling center with state-of-the-art computer facilities (funded by the Arizona Department of Environmental Quality). An impressive complement to the point and profiling instrumentation described above is the recently acquired Doppler Lidar (manufacturer: Coherent Technologies) through a (DURIP) grant from the Department of Defense (PIs: R. Calhoun and H.J.S. Fernando). Owing to its eye-safe infrared laser beam (2mJ/pulse at 400Hz) and direct measurement of aerosol backscatter, this Lidar is ideally suited to measure winds and aerosols in urban environments. Three-dimensional, roughly hemispherical regions of the atmosphere (~ 25km diameter) can be scanned within minutes. ASU is the first university to acquire a commercial Lidar of this type for research purposes. The acquisition of this Lidar has opened up new research directions for ASU researchers. Field tests have demonstrated that the new Lidar can be used to detect above ambient clouds of bio-aerosols, thus allowing new combined sensor/model approaches to civil defense of major metropolitan areas such as Phoenix.



The instrumented vehicle fleet available for the proposed field studies. Three trailers (background) are fully instrumented with TEOM and DUSTRACK instruments for aerosol measurements and retractable meteorological towers for flow measurements. The mobile laboratory (foreground) operated by the Center for Solid State Science carries numerous measurement and analysis instruments.



ASU Eye-Safe Doppler Lidar manufactured by Coherent Technologies.

### **Summary**

During 2003, the EFD program continued its progress with regard to research, teaching and service activities. The Energy Management Program (headed by Professor P. Phelan, MAE) was also housed within the EFD program. The CEAS allocation of funding for the program in 2003 was \$56,000 (operations budget). Numerous ASU faculty members and research associates submitted proposals and pre-proposals through the program. The awards for 2003 totaled \$430,661. The program continued to oversee several multi-disciplinary initiatives, with participating faculty from various departments at ASU. A successful visiting faculty/scientist and post-doctoral program was in place through which, in 2003, EFD hosted 5 long-term visitors. Two excellent seminar series (Ecosystems Engineering Seminar and the EFD Seminar) were in place.

Numerous joint research publications were coordinated through the program. Steps were taken to provide infrastructure support for a first-rate graduate program; these included the offering of multi-instructor courses cross-listed between different departments. A first-rate Environmental Fluid Dynamics Laboratory accessible to the entire EFD faculty, a high-end computing support facility and a host of field experimental facilities were maintained. Service activities included organization of national and international meetings, outreach programs to local schools and consulting to several industrial outfits.

All the achievements noted in this report would not have been accomplished without the generous support of the Ira A. Fulton School of Engineering, the host-department of the program (Mechanical and Aerospace Engineering) and active participation of the EFD faculty, staff and students. The EFD program wishes to thank everyone who contributed to its research, teaching and service activities. For further information, please visit our website <http://www.eas.asu.edu/~pefdhome/>.

