

Environmental Fluid Dynamics Program

Annual Report 2000

College of Engineering and Applied Sciences

Arizona State University

Tempe, Arizona

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 enhance and intensify research activities pertinent to environmental transport processes. The emphasis is on collaborative and multidisciplinary research. In addition, the program facilitates single-investigator research in EFD by providing infrastructure support, which includes: maintenance of extensive laboratory facilities; organization of seminars, discussion groups and workshops; arranging the visits of prominent scientists and scholars; and the development of new research areas. The current broad research thrusts include: the modeling of environmental flows (short- and long-term forecasting of oceans and atmosphere); 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; ecosystems responses; indoor air quality and building ventilation; prediction and remediation of natural hazards; and the sociological and public policy dimension 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. The major thrust will be on fundamental research, but practical applications are also emphasized

Multidisciplinary Activities

During the past year, considerable attempts were made to enhance the collaboration between researchers from different colleges at ASU in addressing problems related to ecosystem transports. To this end the following ways and means were employed: (i) having a multidisciplinary seminar series covering a wide variety of topics related to environmental flows; (ii) inviting faculty from different colleges to deliver seminars in this series, so that their research expertise and interests can be better understood; (iii) organizing meetings of clusters of investigators in responding to various RFP's; (iv) having dedicated graduate students from various departments involved 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; (vi) initiating a new thrust on modeling and fundamental research on urban flows; and (vii) maintaining close cooperation with the

NSF funded Long Term Ecological Research (LTER) Program of the Center for Environmental Studies. Concurrent with the thrusts of Vice Provost for Research's (VPR) Office, most of the efforts were focussed on enhancing ASU's strengths in the area of urban dynamics. As the program is concerned with the fluid dynamics of pollution dispersion, efforts were made to interface with other groups of complementary expertise. An internal research thrust on urban air pollution appeared to be highly opportune, given ASU's location in a complex-terrain airshed beleaguered with serious air pollution problems. Ties with the epidemiology research group of the University of Arizona, the Urban Security groups of the Los Alamos National Laboratory (LANL) and Lawrence Livermore National Laboratory (LLNL), Inv. Cientificas Y Tecnologicas Sonara and Beijing Environmental Information Center, China were established. Some of these ties are expected to fill existing niches at ASU due to lack of expertise in the areas of health effects, pollution and large-scale numerical modeling. 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 and water pollution area as well as to initiate an inter-governmental agreement with Arizona Department of Environmental Quality (ADEQ). Our thrust in applied research on air pollution has resulted in exciting new opportunities, including funding from the Arizona Department of Transportation (ADOT) and the Army Research Office (ARO). Other sponsors of the EFD program are the National Science Foundation (NSF), the Office of Naval Research (ONR), the Southwest Center for Environmental Research and Policy (SCERP, EPA prime), 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, oceanographic wetlands, river transports and riparian ecosystems related research. The U.S. Office of Naval Research (ONR) continued to fund our work on ocean waves and their interaction with large objects (Boyer, Fernando, and Voropayev), mixing in oceans (Lozovatsky and Fernando), and ocean convection (Smith). Also, the NSF polar program awarded a three year grant to study arctic ice melting problems. The funding from the U.S. Department of Education under the Graduate Assistance in Areas of National Need Program (PI's: Fernando, Raupp, Phelan and Fox) continued. The following are some highlights of the EFD program in 2000:

- Professor Joseph Zehnder joined the ASU Geography department with a joint appointment in Mathematics. He brings in expertise in dynamical meteorology and atmospheric physics to the EFD group. Professor Zehnder was previously attached to the Atmospheric Sciences Department of the University of Arizona.
- During EFD-related departmental searches, offers were made to three young accomplished researchers and all offers were accepted. Drs. Jonathan Allen and Ann Dillner, both atmospheric chemists, joined ASU with joint appointments in the departments of Civil and Environmental

Engineering and Chemical Engineering. They bring much needed expertise in organic chemistry to ASU's environmental research portfolio. Dr. Ron Calhoun accepted a position in the Mechanical and Aerospace Engineering department. His expertise is in the area of field experimentation related

to atmospheric dynamics.

- Drs. Susanne Grossman-Clark, Heng Sun, Luis Farfan, and Binson Joseph joined the EFD cadre of post-doctoral fellows. All of them are numerical/theoretical modellers. Dr. Grossman-Clark has a joint appointment with the LTER group of the Center for Environmental Studies and works on problems related to nitrogen cycling in the atmosphere as well as air pollution modeling. Dr. Heng Sun carried out numerical studies on urban street canyon flows. Drs. Farfan and Joseph worked on atmospheric mesoscale modeling using community models such as the NCAR-Penn State MM5 model.
- Collaborative work with colleagues from the Mathematics department (Nicolaenko and Mahalov) continued on problems related to stratospheric mixing. A major advance in this regard is the interfacing of an atmospheric mesoscale model with a direct numerical simulation model to study the nature of turbulence in stratospheric jets. This work is being sponsored by AFOSR.
- Discussions and personnel exchange with the Urban Security group of the LANL continued. To this end, graduate student Eric Pardyjak, an EFD student, was hired as a research assistant by LANL to work on modeling related to urban security.
- The program continued to work on air pollution problems of the El Paso, Texas, area. This work is supported by the Southwest Center for Environmental Research and Policy. An intense modeling effort of the El Paso-Ciudad Juarez airshed is in place and we embarked on an ambitious effort to develop a pollution inventory for the El Paso-Ciudad Juarez airshed (which was previously unavailable).
- The Graduate Assistance in the Areas of National Need (GAANN) award granted by the U.S. Department of Education continued, with the focus area being Environmental Technology. Seven graduate students from the Departments of Civil and Environmental Engineering, Mechanical and Aerospace Engineering and Chemical Engineering are supported by this grant.
- The multidisciplinary “Ecosystems Engineering Seminar” is being conducted every semester, featuring invited distinguished seminar speakers. The multidisciplinary funding from the Provosts’ Office is used for this activity. Each semester, nearly thirty 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 encouraging. This seminar is cross-listed as MAE 591/CEE 598/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 year 2000 Ecosystem Engineering Seminars as well as details on general Environmental Fluid Dynamics seminars is given later.

- 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 continue to flourish.
- Work in the Energy Management Laboratory headed by Professor Pat Phelan featured both educational and research projects. Two on-going projects funded by the U.S. Department of Energy, the Industrial Assessment Center and the Rebuild Arizona Project, involve teams of students providing expertise in energy conservation, waste management, and productivity enhancement to manufacturing firms and commercial building owners. Research activities included a multi-investigator study of the application of photocatalytic oxidation to improving indoor air quality, and field and laboratory studies of the feasibility of utilizing a high-voltage, capacitance-based technology for industrial water treatment in cooling towers, reverse-osmosis systems, and evaporative coolers.
- A five year inter-governmental agreement was formulated and executed with the Arizona Department of Environmental Quality. The first grant under this program started in 2001, and involves modeling of the Douglas-Aqua Prieta airshed.
- A group dealing with nano-fluid mechanics continued to function, in particular to deal with biomotors at the nano-scale. This group consists of Wayne Frasch (Botany), Pat Phelan (MAE), Lars Chapsky (MAE) Michael Kozicki (CESSER) and Joe Fernando (MAE). A pre-proposal was submitted to the Nano-Scale Science and Engineering program to seek support for this work.
- A major proposal was submitted to the NSF Science and Technology program to establish a center for “Multiscale Environmental Transport Studies (METS)”. Investigators from five collaborative universities (University of California, San Diego; University of Arizona; University of California, Irvine; California Institute of Technology; Northern Arizona University; and two National Laboratories (Los Alamos and Pacific Northwest) participated in this proposal.
- The EFD group participated in the Vertical Transport and Mixing Experiment (VTMX) of the Department of Energy; we were one of two Universities funded along with nine national laboratories to partake in this program that dealt with urban meteorology. The results are presented in a special website <http://vtmx.eas.asu.edu/vtmx>.
- Dana Perry of the EFD program (and department of Chemistry) was awarded the first George Beakly studentship for multidisciplinary studies. This is a \$15,000 one year fellowship.

- The work on the Tempe Town Lake meteorological monitoring project continued. A new meteorological station was positioned in the east dam of the lake. Students from McKemy middle school continued to work under the supervision of the PI's Nancy Selover and Anthony Brazel.
- A major proposal was submitted to the Western Government Association (WGA) to establish a Western region air modeling and training center. We were one of three finalists in the competition. The proposal was scrutinized by a panel from the Western Region Air Partnership.
- Under the aegis of the EFD program, Mr. Leonard Montenegro completed the design of a new environmental mister system for the Orbital Corporation. His design was awarded [U.S. Patent 6,095,434](#).
- 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 first expedition in this series was carried out in [November 1999](#), covering a transit across the Atlantic.
- A new web page was completed for the EFD program with links to various other relevant sites and our own field experiments <http://www.eas.asu.edu/~pefdhome/>.

Associated Faculty:

A number of regular and adjunct faculty members from the Departments of Civil and Environmental Engineering (CEE), Mechanical & Aerospace Engineering (MAE), Chemical, Biological and Materials Engineering (CBME), Geography (GEO), Geology (GEOL), Climatology (CLM) and Mathematics (MAT) have been closely involved in the proposal development and research efforts of the EFD Program. The faculty who submitted proposals during 2000 and their affiliations are:

J. Anderson (MAE), R. Balling (GEO), N. Berman (CBME), D. Boyer (MAE), A. Brazel (GEO), D. Chau (MAE), P. Phelan (MAE), K. Squires (MAE), A. Ellis (GEO), P. Fox (CEE), I. Lozovatsky (MAE), A. Mahalov (MAT), B. Nicolaenko (MAT), G. Raupp (CBME), S. Voropayev (MAE), D. Smith, (MAE), N. Selover (CLM).

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 stability and presence. Listings of these activities are given below.

EFD Research Scientists (2000):

Dr. I. Lozovatsky (Research Professor)	Dr. S. Voropayev (Research Professor)	Dr. D. Smith (Research Associate Professor)
Dr. Sang-Mi Lee (Post-Doctoral Fellow)	Dr. S. Grossman-Clarke (Post-Doctoral Fellow)	Dr. F. Tse (Post-Doctoral Fellow)
Dr. Serban Constantinescu (Post-	Dr. Andjelka Srdic (Post-Doctoral	Dr. Olga Alexandrova

Doctoral Fellow)	Fellow)	(Faculty Research Associate)
Dr. Binson Joseph (Post-Doctoral Fellow)	Dr. Gordon Moore (Faculty Research Associate)	

Visitors to EFD in 2000 (who spent more than one month):

Visitor	Affiliation	Date(s)
George Golitsyn	Russian Academy of Sciences, Moscow	Jan 00 – Feb 00
Katherine Vanderplank	Univ. of Western Australia	Jan 00 – Feb 00
Marcel Cremers	Eindhoven Univ. of Technology, Netherlands	Jan 00– May 00
Erik Kieft	Eindhoven Univ. of Technology, Netherlands	Jan 00 – May 00
Julian Hunt	University College, London,	Mar 00, Aug 00
Hong Zhu	Beijing Institute of Microbiology and Epidemiology, China	June 00 – May 01
Eliezer Kit	Tel-Aviv University, Israel	Sept 00 – Oct 00
Tomasz Kowalewski	Polish Academy of Sciences, Poland	Sept 00 – Nov 00
Paolo Monti	University of Rome, Italy	Sept 00 – Dec 00
Sun Heng	Huazhong Univ. of Science and Technology, China	Dec 00 – May 01
Peter Baines	CSIRO, Australia	Dec 00

EFD Students 2000:

A listing of the 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 Undergraduate Students: Destry Lucas; Eric Loomis; Richard Montenegro.

EFD Graduate Students:

Erin Wajda (CBME)	Marko Princevac (MAE)	Brian Chan (MAE)
Rodolfo Vasquez-Rodriguez (CBME)	Shaila Nahar (CEE)	Eric Pardyjak (MAE)
Joan Gable (CEE)	John Rotter (MAE)	Sergey Smirnov (MAE)
Duan Tianhua (MAE)	Sean Riley (MAE)	Frank Yu (CBME)
Dan Castillo (CBME)	Dana Perry (CHEM)	Ivan Tomljenovic (MAE)
Firat Testik (MAE)	Michael Arzabe (MAE)	Michael McNamee (MAE)

M.S./Ph.D. Degrees completed by EFD students:

Faculty Name	Candidate	Degree	Thesis
HJS Fernando	Michael McNamee	MS	An Experimental Study of Axi-Symmetric Turbulent Puffs: Their Motion, Dilution and Sedimentation
HJS Fernando	John Rotter	MS	The Evolution of Kelvin-Helmholtz Billows in Non-Stratified and Stratified Shear Flows
HJS Fernando	Michael Arzabe	MS	Evaluation of Deep Zone Flow Fields in Constructed Wetlands Using a Physical

			Model
Patrick Phelan	Manuel Reynaldo Trujillo	MS	Prototype Development for a Mesoscale Compressor

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 2000. 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.

Ecosystem Engineering Seminars in 2000:

Date	Speaker	Affiliation	Title
1/19/00	Jerome Fast	Pacific Northwest Labs	Simulations of Local and Regional Scale Ozone Transport in the Vicinity of Phoenix During Spring 1998
1/26/00	Jeffrey Weil	CIRES, Univ. of Colorado	Dispersion and Air Pollution in the Convective Boundary Layer: Experiments, Models, and Observations
2/2/00	Diane Hope	ASU, Biology	Studying an Urban Ecosystem: The Central AZ Phoenix Long Term Ecological Research
2/9/00	Peter Hyde	AZ ADEQ	Air Pollution Issues in Phoenix, AZ
2/16/00	Van C. Bowersox	Natl. Atmospheric Deposition Prgrm.	NAPD-Tracking the Chemical Climate of North America, a Case Study: Impact of the 1990 Clean Air Act Amendments
2/23/00	Philip Krider	University of Arizona	Recent Advances in Lightning Research
3/1/00	James Anderson	ASU, MAE/EFD	Asian-Pacific Regional Aerosol Characterization Experiment: A Preview
3/8/00	Wen-Whai Li	U of Texas at El Paso	Overview of Air Pollution Issues and Research in the Paso Del Norte Region
3/22/00	Peter Sullivan	NCAR	The Use of Turbulence Simulation to Study Planetary Boundary Layer Dynamics
3/29/00	Julian Hunt	University College, London	Research Challenges on Adaptation to Climate Change
4/5/00	Gregory Poulos	Colorado Research Associates	Cases-99: An Unexpected View of the Nocturnal Boundary Layer
4/12/00	Sanjay Reddy	Carollo Engineers	Improving Process Design Using Computational Fluid Dynamics
4/19/00	Bob Duce	Texas A&M University	The Ocean, the Atmosphere, Biology, and Chemistry—Surprising Linkages?
4/26/00	Mario Castaneda	AZ ADEQ	ADEQ Border Program

8/23/00	Jonathan Fink	ASU/OVPR	Project Phoenix 2100: Building a National Urban Environmental Research Agenda
8/30/00	Julian Hunt	University College, London	Coriolis Effects in Climate and Weather Predictions
9/6/00	Eric Betterton	U of A, Atmos. Sciences	Environmental Fate of Azide Derived from Automobile Airbags
9/13/00	Rick van Schoik	SCERP, San Diego	Environmental Research at the U.S.-Mexican Border
9/20/00	Robert Balling	ASU/Climatology	CO2 and Climate Change: Update from Global to Urban Scales
9/27/00	Rob Melnick	ASU/Morrison Inst. for Public Policy	Public Policy Making and the Environment: Keeping the Agenda in Balance
10/4/00	Susanne Grossman-Clarke	ASU/efd	Direct Effects of Elevated Atmospheric CO2 on Energy and Water Fluxes Between Plant Canopies and the Atmosphere
10/11/00	Peter Hyde	AZ ADEQ	Applied Environmental Science: The Perspective from ADEQ
10/18/00	William Cotton	Colorado State University	Aerosol Influences on Clouds and Climate
10/25/00	Charles Bischoff	Jorden&Bischoff Law Offices	Arizona Environmental Law with Respect to Air Quality
11/1/00	James Anderson	ASU/efd	The Pelti Project: Developing an Inlet to Efficiently Sample Aerosols from Research Aircraft
11/8/00	Grant Heiken	Los Alamos Natl. Labs	Modeling Cities-The Los Alamos Urban Security Initiative
11/15/00	Steve Nix	NAU	Wet-Weather Flow Management-A Historical Perspective
11/29/00	Andrew Ellis	ASU/Geography	A Potential Long-Lead Forecast tool for Monsoon Season Ozone Concentrations in Phoenix
12/6/00	Dustin Watson	ADOT	Environmental Planning Activities at ADOT

Environmental Fluid Dynamics Seminars in 2000 :

Date	Speaker	Affiliation	Title
1/21/00	G.S. Golitsyn	Institute for Atmospheric Physics, Moscow, Russia	Principle of the Fastest Response, PFR, Hydrodynamics, Geophysics, Astrophysics
1/28/00	Paul Linden	U of California, San Diego	Particle-Laden Flows and Sewage Treatment
2/4/00	James McWilliams	U of California, Los Angeles	The Wave-Driven Ocean Circulation
2/11/00	Eric Pardyjak	ASU, MAE	Decay in the Atmospheric Boundary Layer-PAFEX I
2/16/00	Norden Huang	NASA Goddard Space	A New Method for Nonlinear and

		Flight Center	Nonstationary Time Series Analysis and its Application
2/18/00	Rafael Pacheco	ASU, Mathematics	Effects of Rotation on Fronts of Density Currents
2/25/00	Fotis Sotiropoulos	Georgia Institute of Technology	Chaotic Convection in Confined Swirling Flows with Vortex Breakdown
3/3/00	John Rotter	ASU, MAE	The Evolution of Kelvin-Helmholtz Instabilities in Shear Layers
3/10/00	Christopher Brennen	California Inst. of Technology	Cloud Cavitation: Observations and Simulations
3/24/00	Anatoli Tumin	Tel-Aviv University, Israel	Spatial Theory of Optimal Disturbances
3/30/00	Gary Briggs	NOAA, US EPA	Three Tunnels-Harmonizing Experiments on Dense Gas Vertical Mixing
3/31/00	Sang-Mi Lee	ASU, EFD	The Study on the Effects of Mass Inconsistency on Air Quality Modeling
4/7/00	James Brasseur	Pennsylvania State University	Structure of the Unstable Atmospheric Boundary Layer and Issues in its Prediction with Large Eddy Simulations
4/14/00	Ted Yamada	Yamada Science&Art Corporation	Review of the Mellor and Yamada Turbulence Closure Model and its Applications in Atmospheric Boundary Layer Simulations
4/21/00	Brian Chan	ASU, MAE	Modeling of Up-Slope Flow in Complex Terrain
4/28/00	Marko Princevac	ASU, MAE	Modeling of Complex Terrain Flow Processes
8/25/00	Joe Zehnder	ASU/Geography	An Overview of Tropical Cyclogenesis in the Eastern North Pacific
9/1/00	Andjelka Srdic	ASU/EFD	F1-ATPase as a Source of Vorticity
9/8/00	Tianhua Duan	ASU/MAE	Transport and Reaction of Passive Photocatalytic Oxidation of Contaminants in Indoor Air
9/15/00	Martin Crapper	U of Edinburgh, Scotland	Measurement and Modeling of Fluid and Particulate Flows for Environmental Engineering Applications
9/20/00	Claude Cambon	Ecole Centrale de Lyon, France	Dispersion and Structuring Effects in Rotating and/or Stably Stratified Flows
9/22/00	Sutanu Sarkar	Univ. of Calif., San Diego	Turbulence and Mixing in Stably Stratified Flows with Nonvertical Shear
9/29/00	Sergey Smirnov	ASU/MAE	Late-Wake Vortex Structures in a Stratified Fluid
10/6/00	Kwan Leung Tse	ASU/Mathematics	Quasi-Equilibrium Dynamics of Shear-Stratified Turbulence for a Model of Atmospheric Jet at the Tropopause
10/13/00	Eliezer Kit	Tel-Aviv Univ., Israel	Nonlinear Wave Groups: Experiment vs. Simulation Based on NLS, MNLS and Zakharov Models

10/20/00	Kyle Squires	ASU/MAE	An Approach to Wall-Layer Modeling for Large Eddy Simulations
10/27/00	David Smith	ASU/MAE	Convective Formation of Arctic Ocean Eddies
11/1/00	John Foss	Michigan State Univ.	Operational Experience with the PWM-CTA
11/3/00	Sean Riley	ASU/EFD	Decay of the Convective Boundary Layer
11/17/00	Melvyn Shapiro	NOAA	Research Aircraft Observations and Numerical Simulations of Jet Stream/Frontal Zone Inertia Gravity Waves and Stable Laminae
12/1/00	Marko Princevac	ASU/EFD	VTMX Field Experiment-Salt Lake City 2000

Multidisciplinary and Cross-Departmental Publication Activity

Several multidisciplinary papers have been published in Journals and Conference Proceedings, which are listed below. This list complements publications resulting from single-investigator projects. It also includes the papers published by the EFD research faculty.

Multidisciplinary Journal Papers 2000:

- Fernando, H.J.S., Lee, S.M., Anderson, J., Princevac, M., Pardyjak, E. and Grossman-Clarke, S. 2000: Urban Fluid Mechanics: Air Circulation and Contaminant Dispersion in Cities, *Environmental Fluid Dynamics Journal* **1**.
- Lozovatsky, I.D., Morozov, E.G., and Neiman, V.G., 2000. Decay of the energy of internal tidal waves generated near submarine ridges. *Doklady Earth Sciences*, **375** (2), 245-248.
- Mahalov, A., Pacheco, J.R., Voropayev, S.I., Hunt, J.C.R., and Fernando, H.J.S. 2000: Effects of rotation on fronts of density currents. *Physical Letters*, **A 270**, 149-156.
- Voropayev, S.I., Cense, A.W., McEachern, G.B., Boyer, D.L. and Fernando, H.J.S. 2000: Dynamics of cobbles in the shoaling region of a surf zone. *Ocean Engineering*, **28**, 1-26.
- Tse, K.L., Mahalov, A., Nicolaenko, B. & Fernando, H.J.S. 2000: A spectral domain decomposition method and its application to the simulation of shear-stratified turbulence, *Lecture Notes in Physics*, Springer-Verlag, **566**, 353-378.
- McGuinness, D.S., Boyer, Don L. and Fernando, H.J.S., Laboratory Study of Mean Flow Generation in Rotating Fluids by Reynolds-stress Gradients 2000: *JGR-Oceans*, 11,691-11,707, **106** (C6).

Conference Papers 2000:

International Conferences:

- Fernando, H.J.S., Princevac, M., Hunt, J.C.R. and Pardyjak, E. Thermal Circulation in Complex Terrain:

- A Case of Urban Fluid Mechanics, 5th International Symposium of Stratified Flows - British Columbia, Canada, July 2000.
- Srdic-Mitrovic, A. N., Fernando, H. J. S., Lucas, D., Mahalov, A. and Nicolaenko, B., Localized Turbulent Structures in Stratified Rotating Flow, 16th Arizona Fluid Mechanics Conference, Arizona State University, 2000.
- Lozovatsky, I.D., Ksenofontov, A.S., Fernando, H.J.S., The formation of step-like structure in near surface and near-bottom pycnoclines, 2000b, Stratified Flows II, (Ed. G. Lawrence, R. Pieters, N. Yonemitsu), University of British Columbia, Vancouver, Canada, 1215-1220.
- Mahalov, A., Pacheco, J.R. Voropayev, S.I., Fernando, H.J.S. and Hunt, J.C.R. Dynamics of fronts of density currents in the presence of background rotation, 2000. Proceedings of the Fifth International Symposium on Stratified Flows. V.II, 1123-1128. University of British Columbia, Vancouver, Canada.
- Voropayev, S.I., Smirnov, S.A. and Brandt, A. Dipolar eddies in a stratified shear Flow, 2000. Proceedings of the Fifth International Symposium on Stratified Flows. V.1, 143-148. University of British Columbia, Vancouver, Canada.
- Voropayev, S.I., Smirnov, S.A., Filippov, I.A. and Boyer D.L., Large eddies and vortex streets behind moving jets in a stratified fluid. 2000. Proceedings of the Fifth International Symposium on Stratified Flows. V.1, 149-154. University of British Columbia, Vancouver, Canada.
- Lee, S. M., Anderson, J. and Fernando, H. J. S., The Numerical Simulation of Synoptically Influenced Local Wind Circulation in El Paso Airshed, , 2000 SCERP (The Southwest Center for Environmental Research and Policy) Technical conference, Oct. 11-13, 2000, Cd. Juarez, Chihuahua, Mexico.
- Lozovatsky, I. and Fernando, H.J.S., Turbulence in stratified patches on a shallow shelf, Proceed. Of Int. Conf. on Oceanic Fronts and related phenomena, (K.N. Fedorov Memorial Symposium), UNESCO, St. Petersburg, 1998; UNESCO workshop series # 159, UNESCO, 2000, Moscow, GEOS, 2000, 314-319.
- Domestic Conferences:**
- Princevac, M., Fernando, H.J.S. & Boyer, D.L. Modeling of Complex Terrain Flow Processes, Air and Waste Management Association, 93rd annual conference, Salt Lake City, June 2000.
- Lee, S. M., Ellis, W. and Fernando, H. J. S. Evaluation of Mesoscale Meteorological Models using PAFEX-1 Measurements, The 4th annual George Mason University Transport and Dispersion Modeling Workshop, Jul 11-12, Fairfax, VA, 2000.
- Tse, K.L., Mahalov, A., Nicolaenko, B., and Fernando, H.J.S., Quasi-equilibrium dynamics of shear-stratified turbulence for a model of atmospheric jet at the tropopause, APS Fluid Dynamics Meeting, 2000.
- Voropayev, S.I., Smirnov, S.A. and Boyer D.L., Modeling and control of large eddies generated by maneuvering self-propelled bodies in stratified fluids, 2000. Abstracts of the ONR Turbulence and Wakes Review, 13-14. October 30-31, 2000. University of Arizona, Tucson, AZ.
- Voropayev, S.I., Smirnov, S.A., Brandt, A. and Vanderplank, K., Dipolar structures in stratified flow with vertical shear, 2000. Abstracts of the Sixteen Arizona Fluid Mechanics Conference, 10-11. February 25-26, 2000. Arizona State University, Tempe, AZ.

Voropayev, S.I., Smirnov, S.A. and Boyer D.L., Large eddies in the wake of a momentum source, moving in a stratified fluid, 2000. Abstracts of the Sixteen Arizona Fluid Mechanics Conference, 11-12. February 25-26, 2000. Arizona State University, Tempe, AZ.

Pacheco, J.R., Mahalov, A., Voropayev, S.I., Fernando, H.J.S. and Hunt, J.C.R. Effects of rotation on fronts of density currents, 2000. Abstracts of the Sixteen Arizona Fluid Mechanics Conference, 15. February 25-26, 2000. Arizona State University, Tempe, AZ.

Chapters in Books 2000:

Montenegro, L., Strang, E. and Srdic, A.N., Application of Advanced Optical Techniques to Turbomachinery, Handbook of Machinery and Dynamics, Editors: P. Foulkner and E. Logan, Marcel Dekker Publishing, New York, 2000.

Voropayev, S.I. 2000. Jets and vortex structure formation and interactions in stratified and rotating fluids. Turbulent Mixing in Geophysical Flows (Eds. P.F. Linden and J.F. Redondo). CIMNE, Barcelona, 225-247.

Babin, A., Mahalov, A. and Nicolaenko, B., Fast Singular Oscillating Limits of Stably Stratified Three-Dimensional Euler-Boussinesq Equations and Ageostrophic Wave Fronts, to appear in "Mathematics of the Atmosphere and Ocean Dynamics", Cambridge University Press, (manuscript 65 pages), 2000.

Fernando, H.J.S. and Smith, D.C., IV. "Small-Scale Processes in Geophysical Flows," In: Mixing in Geophysical Flows: Turbulent Mixing in Geophysical Flows (Eds. P.F. Linden and J.F. Redondo). CIMNE, Barcelona, 100-125.

Proposal Activity

A listing of proposals and pre-proposals submitted through the program as well as the funded research projects for 2000 follows:

Proposals Submitted Through the EFD Program in 2000:

Title	Investigators	Agency
Linking Size Resolved Morphology, Composition, and Optical Properties of Dust Particles	J. Anderson (EFD)	DOE
Transport of Oxidants and other Contaminants in Complex-Terrain Airsheds	J. Anderson (EFD), HJS Fernando (MAE/EFD)	DOE
Individual Particle Investigations of East Asian Aerosols During ACE-Asia	J. Anderson (EFD)	NSF
Urban Fluid Mechanics: Thermal Circulation in Complex Terrain	HJS Fernando (MAE/EFD)	NSF
Acquisition of a Multiprocessor Computer-Server for the Study of Multiscale Environmental and Industrial Systems	B. Nicolaenko (MATH), A. Mahalov (MATH), HJS Fernando (MAE/EFD), H. Reed (MAE)	NSF
Interpretation of SHEBA Data Using Numerical Models	D. Smith (MAE/EFD), HJS Fernando (MAE/EFD)	NSF
Biomolecular Motor-driven Nanoscale Transport	W. Frasch (BIO), HJS Fernando	NSF

	(MAE/EFD), L. Chapsky (MAE), P. Phelan (MAE)	
Technical Assistance for Energy Efficiency and Reliable Energy in China and the Asia Pacific	P. Phelan (MAE), D. Chau (MAE)	DOE
Multi-Scale Atmospheric Analysis of Particulate Concentration and Flow in the Douglas-Aqua Prieta Airshed	A. Ellis (GEO), HJS Fernando (MAE/EFD)	SCERP
Meso-Scale Modeling Support for the Paso Del Norte Air Program	HJS Fernando (MAE/EFD), J. Anderson (EFD), N. Berman (CBME)	SCERP
Modeling for Compression and Visualization of High-Dimensional Data	A.Razdan (PRISM), G. Farin (CSE), G. Nielson (CSE), HJS Fernando (MAE/EFD)	NSF
Cold Boundary Layer Dynamics: Turbulent Energy Transfer Over Snow	A. Ellis (GEO), A. Brazel (GEO), HSJ Fernando (MAE/EFD)	NSF
ASU Industrial Assessment Center	P. Phelan (MAE), D. Chau (MAE)	University City Science Center
Nanoscale Flow Control using Biomolecular Motors	L. Chapsky (MAE), P. Phelan (MAE), HJS Fernando (MAE/EFD), W. Frash (BIO)	NSF
Proposal to Develop a WRAP Regional Modeling Center	HJS Fernando (MAE/EFD), J. Zehnder (Geography)	Western Governor's Assoc.
Lateral and Vertical Mixing in Marginal Zones	L. Lozovatsky (MAE/EFD), HJS Fernando (MAE/EFD)	ONR
Laboratory Benchmarks for the Development of Numerical Models	D. Boyer (MAE), HJS Fernando (MAE/EFD), A. Srdic (MAE/EFD)	ONR
METS: A Center for Multi-Scale Environmental Transport	H.J.S. Fernando (MAE/EFD), J. Anderson (MAE/EFD), G. Raupp (CEAS), J. Zehnder (GEO)	NSF
A Proposal to Develop a WRAP Regional Modeling Center (WRAP/RMC)	H.J.S. Fernando (MAE/EFD), J. Zehnder (GEO)	Western Governor's Association
Studies of Mine Burial in Coastal Environments	H.J.S. Fernando (MAE/EFD), S. Voropayev (MAE/EFD), A. Srdic (MAE/EFD), B. D. Boyer (MAE)	ONR

Pre-Proposals Submitted Through the EFD Program in 2000:

Office of Naval Research (ONR):

Technology Concept: Mine Scavenger PI: N. Macia, L. Montenegro

Laboratory Modeling of Ice-Ocean Processes PI: H.J.S. Fernando, S. Voropayev

Coupled Hydrodynamic/Biological Modeling of Oceanic Thin Layers PI: H.J.S. Fernando, I. Lozovatsky

Modeling Lead Related Processes in PIPS3.0 PI: D. Smith

Modeling for Compression and Visualization of High-Dimensional data PI: A. Razdan, G. Iarin, G. Nielson, and H.J.S. Fernando

Formation of Thin Layers in Oceans PI: H.J.S. Fernando, I. Lozovatsky

Environmental Protection Agency (EPA):

Photocatalytic Technologies for Mitigation of Indoor Air Pollution, PI: G. Raupp, P. Phelan, K. Squires, H.J.S. Fernando

Funded Research Projects in 2000:

Title	Investigators	Agency
Interpretation of SHEBA Data Using Numerical Models	D. Smith (MAE/EFD) HJS Fernando (MAE/EFD)	NSF
A Field Study of Particulate Emissions from Major Roadways in the Phoenix Airshed	J. Anderson (MAE/EFD) HJS Fernando (MAE/EFD)	ADOT
Effects of Roughness and Thermal Inhomogeneities	HJS Fernando (MAE/EFD)	ARO
Meso Scale Modeling	HJS Fernando (MAE/EFD)	SCERP
Urban Fluid Mechanics	HJS Fernando (MAE/EFD)	NSF
Vertical Transport and Mixing in Complex Terrain	HJS Fernando (MAE/EFD)	DOE
Urban Fluid Mechanics REU	HJS Fernando (MAE/EFD)	NSF
Laboratory Benchmarks for the Development of Numerical Models	D. Boyer (MAE), HJS Fernando (MAE/EFD), A. Srdic (MAE/EFD)	ONR

Community Interaction and Service

The program continued to maintain liaisons with the community at large through several programs. The EFD program participated in the ASU Neighborhood Grant Program by successfully competing for a grant from the President's office. This project involves the monitoring and modeling of microclimatic changes occurring due to the filling of the Tempe Town Lake (P.I.'s. Nancy Selover, Tony Brazel and H.J.S. Fernando) A group of students from the McKemy junior high in Tempe together with their science teachers are participating in this 3-year project.

The members of the EFD group delivered several community lectures, including several talks at a number of local elementary and high schools.

Environmental Modeling Group

The numerical modeling and prediction group has become one of the key elements of the EFD program. The EFD group currently uses a host of numerical models, including MM5 and HOTMAC for

meteorological predictions, Models-3/CMAQ and ADMS/URBAN for air quality predictions and SMOKE for emissions processing. Also CFD models are being developed to predict neighborhood scale flows and flows through urban canyons. High end computer facilities are available, which includes SGI Origin 2000, SUN Enterprise 450 and, Deq/Compaq ES40 (4x500 MHz processors) computers. A range of software is also being used, for example Unidata GEMPAK for MM5 preprocessing and display, Vis5D for meteorological visualization, and Fluent for general computational fluid dynamics work.

Environmental Fluid Dynamics Laboratory

The EFD laboratory and program offices are currently housed in a 6000 sq. ft. area in the Technology Center and Technology Annex. The laboratories are housed in TC101, TCB 209, and TCB 211 and the student offices are located in TCB207 and ERC 522. It consists of state-of-the-art environmental flow modeling facilities, such as a 104-ft long wave tank, a recirculating stratified shear flow channel, a stratified shear flow tunnel, a 40 x 1.5 x 1 ft computer-controlled tow tank, an open-loop counter flowing stratified shear flow tunnel, an ice-room to mimic environmental phenomena occurring in polar regions, small wave tanks, facilities for particle dispersion and settling studies, several convection chambers and three computer-controlled rotating tables to simulate the effects of Earth's rotation on fluid motions. These facilities are instrumented with modern flow diagnostic devices such as back-scatter, fiber-optic and forward-scatter laser Doppler velocimetry systems, digital particle tracking systems, particle-image velocimeter systems, numerous digital image-processing systems, hot-film and hot-wire anemometers, and various high-precision conductivity and temperature sensing devices. The laboratory also maintains a variety of instruments (e.g. sonic anemometers, aerosol monitors) and accessories (tethered meteorological tower) for air quality studies. A host of personal computers and state-of-the-art workstations provide computer resources to the laboratory.

Summary

During 2000, the EFD program continued its progress with regard to research, teaching and service activities. The Energy Management Program (P. Phelan, MAE) was also housed within the EFD program. The CEAS allocation of funding for the program in 2000/01 was \$40,000 (operations budget). Numerous ASU faculty members and research associates submitted proposals and pre-proposals through the program. The awards for 2000 totaled \$1,356,485 and the expenditures were \$1,776,226. 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 2000, nine scientists spent more than a month at ASU. 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 and high-end computing support 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 College of Engineering and Applied Sciences, 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/> .