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# 1 APPLIED MATHEMATICS AT UNSW, 2000

In 2000, the Department was pleased to welcome Clio Cresswell as a Visiting Fellow. Clio completed her PhD in Painlevé Analysis under Nalini Joshi.

This has been another productive year for the Department, with high levels of activity maintained in both research and teaching programs. A highlight of the year was the award to Professor Sloan of the Thomas Ranken Lyle Medal of the Australian Academy of Science. This is awarded every two years for original mathematics or physics. The Department congratulates Ian on the award of yet another honour to recognise his distinguished contributions to research in Computational Mathematics.

The members of the Geophysical Fluid Dynamics Group were extremely active during the year. Thus, Michael Banner continued as Chair of the Scientific Committee for Ocean Research Working Group with reference to the role of wave breaking in upper ocean dynamics. Lance Leslie continued as Director of the Centre for Atmospheric Modelling and Prediction. He is currently Chair of the World Meteorological Organization's Committee on Comparison of Regional Model Experiments. He is also a member of the Australian Academy of Science Committee on Meteorology and Oceanography. Jason Middleton continued as a member of the Board of Airborne Research Australia and as a member of the Antarctic Science Advisory Committee. QEII Fellow Matthew England remains a member of the Scientific Steering Committees for the Australian Community Ocean Model and the Ocean Carbon Cycle Model Intercomparison Project. He continued in his positions as Honorary Research Associate at CSIRO Atmospheric Research and as an Honorary Research Fellow of the Antarctic CRC. The year saw the departure of Brian Sanderson who was an active member of the Geophysical Fluid Dynamics Group.

Ian Sloan has continued in his role as Chair of the International Program Committee for ICIAM 2003 which is to be held in Sydney. He completed his term as President of the Australian Mathematical Society but remains on the Council as Vice President. In addition to these onerous responsibilities, he has acted as Chair of the Mathematical Sciences Sectional Committee of the Australian Academy of Science. Rob Womersley has continued his involvement in regional and national activities connected with high performance computing. In particular, he is Co-Director of the New South Wales Centre for Parallel Computing. A highlight this year within the Computational Mathematics Group has been the publication of Bill McLean's book *Strongly Elliptic Systems and Boundary Integral Equations* by Cambridge University Press.

Within the Nonlinear Phenomena Group, Colin Rogers was appointed to the Mathematical Sciences Sectional Committee of the Australian Academy of Science. He continued in the honorary position of Membre Associé of the Centre de Recherches Mathématiques, Université de Montreal. Liqun Qi was on leave during 2000 at Hong Kong Polytechnic

University. During that period he was appointed Chair of the working party for the newly formed Pacific Optimization Research Activity Group.

Many members of the Department travelled overseas to be involved in research collaborations or to attend international conferences. Michael Banner presented a lecture at a Gas Transfer Symposium in Miami USA on his current research in small-scale wave breaking. Bruce Henry presented papers at the ANZIAM 2000 Meeting in Waikato, New Zealand and at the International Conference on Fractals 2000 in Singapore. Vaithilingam Jeyakumar travelled to Atlanta, USA to present a paper at the 17th International Symposium on Mathematical Programming. Bill McLean spent six weeks in the UK. During that time he was at the University of Bath for two weeks and participated in an IMA conference on boundary integral methods. The remainder of the time was spent at Strathclyde University in Glasgow where he was involved in an EPSRC supported collaboration with Professor Mark Ainsworth on boundary element discretizations of hypersingular integral equations. John Murray spent the first six months of 2000 on sabbatical at the Los Alamos National Laboratory. He also made research visits to the British Columbia Cancer Agency in Canada and co-authored a presentation in San Francisco on anti-retroviral HIV therapy at the 7th Conference on Retroviruses and Opportunistic Infections. Liqun Qi gave invited lectures at the National University of Singapore, Hong Kong Baptist University, at the National Cheng Kung University and Academia-Sinica in Taiwan as well as at the 17th International Symposium on Mathematical Programming in Atlanta. He also visited Kyoto University and Shimane University in Japan. In addition, in what was another very active year, Liqun gave invited talks at the International Workshop on Optimisation and High Technology Applications at the First Sino-Japan Optimization Meeting in Hong Kong. Towards the end of the year he also visited the Chinese Academy of Sciences in Beijing. Ian Sloan travelled to Bath in the UK and presented results on inverse scattering problems from three-dimensional objects at an international conference on boundary integral methods. He also gave an invited presentation on approximation on the sphere at an international conference on Monte Carlo and quasi-Monte Carlo methods held in Hong Kong. Colin Rogers spent periods as a Visiting Professor at Hong Kong University of Science and Technology, Instituto de Matematica Pura e Aplicada (IMPA) in Rio de Janeiro and at the Departamento de Matematica, Universidad de Buenos Aires. He presented invited lectures in Hong Kong at City University of Hong Kong, Hong Kong Polytechnic University as well as at an International Workshop on Numerical Partial Differential Equations held at Hong Kong University of Science and Technology. Elsewhere, he gave invited lectures at the Universidad de Buenos Aires in Argentina, Suranee University of Technology in Thailand and at Imperial College London in the UK.

International visitors to the Department were again numerous in all areas and a

vigorous seminar and doctoral program was maintained.

The research areas of the Department are currently grouped as follows:

- Computational Mathematics
- Geophysical Fluid Dynamics
- Nonlinear Phenomena
- Optimisation and Optimal Control

The research of the Department was again recognised by substantial support from the Australian Research Council.

Overall, the Department enjoyed another successful year in 2000. It looks forward to 2001 with enthusiasm.

Colin Rogers,  
Head, Department of Applied Mathematics

## 2 STAFF

### 2.1 Academic and Professional Staff

#### Professors

Michael L Banner, BE MEngSc *Sydney*, PhD *Johns Hopkins*  
Lance M Leslie, BA/MA Prelim. *Melbourne*, BSc (Hons) MSc *Sydney*, PhD *Monash*  
Jason H Middleton, BSc PhD *Monash*  
Colin Rogers, BA *Oxford*, MEd *Toronto*, MSc PhD DSc *Nottingham*, FinstP, FAA  
Ian H Sloan, BA BSc *Melbourne*, MSc *Adelaide*, PhD *London*, FAIP, FAA

#### Visiting Professors

MJ Ablowitz, BS *Rochester*, PhD *MIT*  
Grafton Hui, BSc *Peking*, PhD, DSc *Southampton*  
Vidar Thomée, Fil Kand *Lund*, Fil Dr *Stockholm*, KVA (*Sweden*)  
P Winternitz, BSc, MSc *Leningrad*, PhD *Dubna*

#### Associate Professors

Vaithilingam Jeyakumar, BSc *Jaffna*, PhD *Melbourne*  
Liqun Qi, BS *Tsinghua*, MS PhD *Wisconsin*

#### Senior Lecturers

Peter J Blennerhassett, BE *Western Australia*, PhD *London*  
Bruce Henry, BSc PhD *NSW*  
William D McKee, BSc *Adelaide*, MSc *Flinders*, PhD *Cambridge*  
William McLean, BSc *Queensland*, PhD *ANU*  
John F Middleton, BSc PhD *Monash*  
John M Murray, MSc *NSW*, PhD *Washington*  
Alex H Opie, BSc DipEd *Melbourne*, PhD *Monash*, FAIP  
Y Shao, BSc *Zhongshan*, Dipl Met *University of Bonn*, PhD *Flinders*  
Robert S Womersley, BSc *Adelaide*, MSc PhD *Dundee*

#### Lecturers

Mahadevan Ganesh, MSc *Trichy*, PhD *Bombay*  
David C Guiney, BSc PhD *Adelaide*

### **Associate Lecturers**

Eileen M Sheppard, BSc *London*

### **Visiting Fellow**

Clio Cresswell, BSc. PhD *UNSW*

### **QE2 Research Fellows**

Matthew England, BSc PhD *Sydney*

Wolfgang K Schief, Dipl Phys. *Ludwig Maximilians U*, PhD *Loughborough*

### **Honorary Associates**

Donghui Li, Honorary Visiting Fellow

David A Mustard, BSc *Sydney*, MSc *NSW*

Gongbing Peng, Honorary Visiting Fellow

William E Smith, MSc *Sydney*, MSc *Oxford*, PhD *UNSW*, MinstP, MAIP

Yufei Yang, Honorary Visiting Fellow

### **Research Associates**

Thang Cao, BSc *Macquarie*, BSc *Melbourne*, MSc, PhD *UNSW*

Parviz Irannejad, BSc, MSc *University of Tehran*, PhD *UNSW*

Liping Xia, MSc, PhD *University of Hong Kong*

Hou-Duo Qi, BSc *Peking*, PhD *Chinese Academy of Sciences*

Guanglu Zhou, PhD *Chinese Academy of Sciences*

### **Professional Officer**

Gregory H Nippard, BSc *Sydney*

## **2.2 Staff Changes**

**Defeng Sun** moved to The National University of Singapore as an Assistant Professor.

## 2.3 Committee Memberships, Awards and Invitations

**Michael Banner** continued as chair of the Scientific Committee for Ocean Research (SCOR) Working Group on "The Role of Wave Breaking in Upper Ocean Dynamics". This group of specialists from Australia, Britain, Canada, Japan, Russia and the USA is producing an authoritative review article on recent research developments in this area that should be influential in guiding future research effort. A review article is in preparation for publication in the open literature.

**Matthew H England** continued to serve on the Editorial Boards for the Journal of Marine Systems and the Journal of Ocean and Atmospheric Data Management. He is a member of the Scientific Steering Committees for the Australian Community Ocean Model (ACOM) and the Ocean Carbon Cycle Model Intercomparison Project (OCMIP), and was a contributing author for the IPCC Third Assessment Report on Climate Change (due for publication in 2001). He continued as an Honorary Research Associate at CSIRO Atmospheric Research and an Honorary Research Fellow of the Antarctic CRC. He was asked to be an invited speaker at the European Geophysical Society XXVI General Assembly and the American Geophysical Union 2001 Boston Conference. In 2000, Matthew was also awarded an ARC Large Grant for 2001–2003 ("Mid-latitude variability in the Southern Ocean and its role in Australian climate").

**Lance Leslie** is Director of the Centre for Atmospheric Modelling and Prediction, a UNSW centre within the School of Mathematics that receives almost all of its funding from external grants. It functions at the Kensington campus. Professor Leslie has remained an editor of Meteorology and Atmospheric Physics and is on the American Meteorology Society Awards Committee. He is Chair of the World Meteorological Organization's Committee on Comparison of Regional Model Experiments (COMPARE), and on the Australian Academy of Science Committee on Meteorology and Oceanography. He is a Reader for Australian Research Council Grants.

**Jason Middleton** continued as a member of the Antarctic Science Advisory Committee, which advises the Minister for the Environment on matters concerning the conduct and planning of science in Antarctica, and a Board member of Airborne Research Australia, a Major National Research Facility which utilises aircraft for airborne scientific investigations concerning meteorology, air quality and remote sensing of the earth.

**Liqun Qi** was the Chair of the Nonsmooth Optimization Cluster at the 17th International Symposium on Mathematical Programming, Atlanta, USA, August, 2000 and the Co-Chair of the First Sino-Japan Optimization Meeting, Hong Kong, October, 2000. In October 2000, the Pacific Optimization Research Activity Group (POP) was established with the aim to promote optimization research activities in this region. Liqun Qi is the chair of the working committee of POP.

**Colin Rogers** continued on the Editorial Boards of *J. Mathematical Analysis and Applications*, *Studies in Applied Mathematics* and the *International Journal of Nonlinear Mechanics*. He continues to hold honorary positions as *Membre Associé* at the *Centre de Recherches Mathématiques*, *Université de Montréal*, Canada and as *Adjunct Principal Research Scientist* at the *Center for Dynamical Systems and Nonlinear Studies*, *Georgia Institute of Technology*, USA. His research was recognised by appointment to one of four *Faculty of Science and Technology Professorships* instituted in 2000. He was appointed to the *Scientific Committee* for the *XIth International Conference on Waves and Stability in Continuous Media* to be held in *Porto Ecole*, Italy in 2001. He was also coorganiser of a *Special Session on Geometry and Soliton Theory* at the *Australian Mathematical Society Meeting* held in *Queensland* in mid-year.

**Wolfgang Schief** was invited to give two lectures at the *Technische Universität Berlin*, Germany as part of a visit in September/October.

**Ian Sloan** continued his work as *Chair of the International Program Committee* for *ICIAM 2003*, the *fifth International Congress on Industrial and Applied Mathematics* to be held in *Sydney* from July 7–11, 2003. In the middle of the year he finished his term as *President of the Australian Mathematical Society*, but remains on the *Council* as *Vice President*. He chaired the *Mathematical Sciences Sectional Committee* of the *Australian Academy of Science*, and was chosen for the *Academy's Thomas Ranken Lyle Medal* for distinguished research in mathematics or physics.

**Rob Womersley** is involved in a range of regional and national activities related to high performance computing. He is *Co-Director* of the *New South Wales Centre for Parallel Computing (NSWCPC)*, which, together with *Sydney VisLab*, helped lay the foundations for the establishment of the *AC3, Australian Centre for Advanced Computing and Communications* based at the *Australian Technology Park*. He is also on the organizing committee for the *Sydney Financial Mathematics Workshop*.

### 3 AREAS OF RESEARCH

The Department of Applied Mathematics is highly regarded internationally as a centre for research, both fundamental and applied. The main areas of research are listed below, together with members of the Department involved as well as current adjunct faculty.

#### Computational Mathematics

*M Ganesh, W McLean, I H Sloan, R Womersley*  
*Adjunct Faculty: V Thomée*

Early in 2000 the former Numerical Analysis group decided to refocus, taking a broader view of its research and teaching role in the Department and the School. The new name, Computational Mathematics, is intended to reflect that broader view, which now embraces computational optimisation and high performance computing, as well as the more traditional areas, and which encourages strong interactions with applications and with other groups in the School. Some areas of present research concentration are: boundary integral equations; efficient methods for linear and non-linear parabolic equations; approximation and integration problems on the sphere; multiple integration in large numbers of variables; and direct and inverse scattering from three- dimensional objects.

### **Geophysical Fluid Dynamics**

*M Banner, P Blennerhassett, M England, D Guiney, L Leslie, W McKee, J F Middleton, J H Middleton, B Sanderson*

This group applies analytical and computational methods, as well as observation and data analysis, to problems of engineering, environmental fluid mechanics, physical oceanography and meteorology. Areas of concentration include convection, stability of shear flows, water waves, internal gravity waves, wave-mean flow interaction and wave-topographic interaction. In the area of physical oceanography and meteorology, the group seeks to observe and model the physical processes occurring in the oceans and atmospheres. Methodologies used range from sea-going experiments and data analysis to numerical and analytical modelling. Interests include wind-wave generation, understanding the circulation of the coastal ocean and atmosphere and studying the dynamics of regional seas from the tropics to Antarctica. A developing interest is in climate change and its effects on a regional scale.

### **Nonlinear Phenomena**

*P Blennerhassett, B Henry, C Rogers, W Schief*  
*Adjunct Faculty: MJ Ablowitz, R Grimshaw, WH Hui, P Winternitz*

Nonlinear equations are not, in general, amenable to exact solution and yet they model important physical processes such as chaos, soliton propagation and turbulence. The advent of the computer allied to such analytic techniques as the inverse scattering transform has paved the way for many advances in these subjects. The main interests of this group lie in nonlinear stability, chaos, fractals, image compression, bifurcations, nonlinear wave phenomena, Bäcklund and Darboux transformations, Painlevé analysis and the geometry of soliton theory.

## Optimization and Optimal Control

*V Jeyakumar, J Murray, L Qi, H.-D. Qi, R Womersley, G. Zhou*

This group has interests in nonsmooth optimization, nonlinear optimization, mathematical programming, stochastic optimization, combinatorial optimization, multi-objective optimization, global optimization and optimal control. Computational methods and applications are prominent features. Current research includes the development and analysis of numerical methods for minimax problems, variational inequalities, reformulation and smoothing methods, nonlinear programming and optimal control. Applications include mathematical finance, cancer treatment and HIV, approximation and integration over the sphere and data mining.

## 4 RESEARCH ACTIVITIES

During 2000, departmental members have worked on a wide range of research projects in applied mathematics, and have participated in collaborative research activities with several distinguished researchers. The main research activities for the year are given below.

**Michael Banner** Research papers with colleagues in my air-sea interaction group were submitted on classical problems at the air-sea interface, particularly on wave breaking. Our paper (Banner, Babanin and Young) which appeared in the *Journal of Physical Oceanography*, describes the analysis of a set of observations that supports the proposition of a common threshold behaviour for parameterising the probability of wave breaking of the dominant ocean waves. Another paper on the extension of this work to shallow water environments (Babanin, Young and Banner) has been accepted to appear in the *Journal of Geophysical Research*. An extension of these ideas to shorter wind wave components was undertaken in a collaborative investigation with Johannes Gemmrich and David Farmer. This introduced considerable additional complexity in the analysis techniques due to directionality and riding waves. Nevertheless, good progress was made and a paper is in preparation.

On an important application of small-scale wave breaking, a companion paper to a previous paper (Banner and Peirson, *JFM*, 1998), on the strength and distribution of the wind drift layer current over short, intermittently breaking wind waves that are very strongly forced by the wind and implications for air-sea gas transfer was refined and presented at a specialist Gas Transfer symposium in Miami, June 2000. It is being revised for resubmission to the *Journal of Fluid Mechanics*.

This year also saw the publication of the first paper and acceptance of the second paper in the Journal of Physical Oceanography describing the Southern Ocean Waves Experiment (SOWEX). This innovative international collaborative air- sea interaction experiment was staged over the Southern Ocean in June 1992, with Banner as the Chief Investigator and involving scientists from UNSW, the CSIRO Divisions of Oceanography and Atmospheric Research, NASA Goddard Space Flight Center and the University of Massachusetts. The project has provided fundamental data quantifying the sea state response to wind stress and wind speed variations. It has significantly extended our knowledge of the sea surface drag coefficient, particularly for gale force wind conditions. It has also contributed a definitive data set on the electromagnetic bias due to ocean waves needed for correcting the TOPEX-POSEIDON satellite altimeter sea surface topography measurements now used routinely to monitor the global ocean circulation.

Ongoing research projects during 2000 included

- further measurement of the probability of occurrence of breaking waves for storm conditions at the Bass Strait oil platform and the influence of breaking waves on the vertical structure of upper ocean currents;
- observational and computational model studies of the wave number spectrum of ocean wind waves, featuring a new source term for the spectral dissipation due to wave breaking;
- an observational study of the source term balance in shallow water wave spectral evolution.

*Australian Collaborators during 2000:* I.R. Young (ADFA/U. Adelaide): Shallow Water Wind Wave Evolution - Source Terms. A. Babanin (ADFA): Deep and shallow water wave breaking dependences. *Overseas Research Collaborations during 2000:*

M.A. Donelan, Rosenstiel School of Marine and Atmospheric Sciences, University of Miami: Shallow water wind wave evolution - source terms.

W.K. Melville, Scripps Institute of Oceanography, La Jolla, California: Shallow water dissipation rates due to wave breaking.

D.M. Farmer, Institute of Ocean Sciences, Sidney, British Columbia and J. Gemmrich, Netherlands Institute for Sea Research, Texel, The Netherlands: Breaking probability analysis in the wave spectrum.

**Peter Blennerhassett** continued research in the field of linear and nonlinear hydrodynamic stability, with the main emphasis being on the stability of time periodic flows. Work on the instability of unsteady flows was continued with Dr Bassom (Exeter University, U.K.) who visited for 2 months. During the visit work on the linear and

nonlinear stability of some impulsively generated flows was completed and submitted for publication. Work on the stability of flat Stokes layers continued, with calculations being undertaken to discover the behaviour of linear theory growth rates as a function of the Reynolds number of the flow.

**Matthew England** continued his research activities in large-scale physical oceanography, ocean modelling, and climate processes. Particular interests include the parameterisation of mixing in ocean models, the circulation and variability of the Southern Ocean and its role in climate, assessing ocean models using geochemical tracers, and estimating climate change, ocean CO<sub>2</sub> uptake, and future sealevel rise. Research continues in the ocean's thermohaline circulation, stability, and feedback to the atmosphere. In 2000, Matthew initiated development of the first off-line simulation of tracer transport derived from a global eddy-resolving model. He also contributed a chapter to the *Encyclopedia of Ocean Sciences* on the topic of chemical tracer applications in ocean models. Other studies include the simulation of thermally-driven flow in Jervis Bay, model analyses of ENSO variability (in collaboration with Prof. L. Leslie and J. Brown). International collaborations include an ocean model of CO<sub>2</sub> uptake (with Dr. H. Thomas), a study of model/observed flow in the South Atlantic (with Dr. L. Stramma), and an investigation of mixed layer parameterisation in large-scale models (with Dr. H. Goosse).

**Mahadevan Ganesh** continued his research in three areas of computational mathematics: development of parallel computational schemes for linear time-dependent problems, simulation of some biological models and boundary integral methods for inhomogeneous elliptic problems. In collaboration with researchers in Korea, UK and USA, he submitted/revised four research papers. All the four joint papers were accepted for publication in international journals. He also started a new research work (in collaboration with Graham and Sloan) on the implementation of a fully discrete spectral method for exterior problems in acoustic scattering.

**Bruce Henry** In collaborative work with Dr Murray Batchelor and Dr Bob Burne, Australian National University, and Dr Simon Watt, Bruce explored their mathematical model for patterning produced by successive laminations in stromatolites. Stromatolites are layered sedimentary rocks produced as a result of trapping and binding of sediment grains by mat-like microbial communities. Laminations in real samples were digitized and compared with model simulations in an effort to provide a reliable set of indices for classifying stromatolites. Bruce presented results from some of this work at the ANZIAM 2000 Meeting, Waikato, New Zealand.

In a collaboration with Dr Susan Wearne, Mount Sinai School of Medicine, New York, Bruce introduced a reaction-diffusion equation with fractional order temporal derivatives to model pattern formation in reaction-diffusion systems whenever the diffusion is anomalous sub-diffusion. A visit by Dr Wearne early in the year led to the investigation

of pattern formation in a two species fractional activator-inhibitor system. Dr Henry and Dr Wearne derived conditions for Turing instability induced pattern formation in this model system. In other work with Dr Wearne, Bruce has been using fractal analysis to investigate the morphology of neurons.

In a collaboration with Dr David Rail (neurologist), and Dr Simon Watt, Bruce introduced an evolutionary model for the early development of the nervous system. The model was introduced to explore a possible mathematical framework for Edleman's theory of Neuronal Darwinism; that the early neural development could proceed by chance connections with many connections being eliminated by a survival of the fittest mechanism. Bruce reported this work at the International Fractals 2000 Conference held in Singapore.

Bruce's long time collaboration with Professor John Grindlay, University of Waterloo, Canada, on the dynamics and statistical mechanics of lattice models for solids with few degrees of freedom remains ongoing with more recent work focusing on perturbation methods for resonantly coupled oscillators. Dr Alex Opie is also a collaborator in this work.

Bruce attended The Australian and New Zealand Institute for Applied Mathematics Meeting, Waikato, New Zealand, February 2000 and the International Conference on Fractals 2000, Singapore, April 2000.

**Vaithilingam Jeyakumar** continued to pursue research in Variational Analysis, Optimization and their applications. His research during the year focussed on nonsmooth optimization, complementarity problems, and data classification by optimization methods. At the beginning of the year he began work with the fourth year student Ben Waterhouse on developing efficient methods for solving machine learning problems of large-scale data classification. As an outcome of this investigation, a linear programming based method was developed for solving data classification problems. He also completed the work with his PhD student, Xiang Wang, on the development of variational conditions without the usual Lipschitz continuity for nonsmooth optimization problems. Xiang subsequently completed his PhD work in June. During the latter part of July, Professor Dinh The Luc, University of Avignon, arrived at UNSW for a month long visit. On Luc's arrival, they continued their on-going collaborative research on approximate Jacobian based variational analysis and applications. Substantial progress was made on developing optimality conditions for mathematical programming problems with continuous data. He also completed work on nonsmooth complementarity problems, which was started a couple of years ago during the visit of Andreas Fischer, University of Dortmund, Germany. This resulted in a publication on descent algorithms for complementarity problems involving continuous maps. In August, he presented a paper on modern Lagrange multipliers at the 17th International Symposium on Mathematical Programming, Atlanta,

USA. During the latter part of the year, he worked on composite optimization problems and nonsmooth analysis with Phan Tinh of Hue University, Vietnam, who visited UNSW for 3 months.

**Lance Leslie** has continued his work in all aspects of atmospheric modelling from global scales down to microscales. The research areas include severe weather of many kinds (tropical cyclones, floods, drought, windstorms, soil erosion events, mountain waves) as well as air quality. The 2000 Olympics was a highlight of the year and CEAMP models were available to the Bureau of Meteorology under ARC funding.

Professor Leslie as Director of CEMAP enjoyed a large number of distinguished visitors during 2000. These included Professor J.L. Chan, City University of Hong Kong, at ANSTO; Professor Gong-Bing Peng, Senior Member of the Chinese Academy of Sciences; Dr Robert Abbey Jr, Senior Research Program Manager of the US Office of Naval Research; and John L. Marshall, head of the satellite section of the Bureau of Meteorology Research Centre, Melbourne. During the year Professor Leslie acted as an external PhD examiner at the University of Hong Kong and at Monash University.

**Bill McKee** continued his research on water wave propagation across shearing currents by developing a purely numerical model. Early results indicate that previously-developed analytical approximations are quite good in most circumstances of practical interest. He also continued to supervise the work of David Ghisolfi on the formation of oceanic fronts off Brazil. David has now submitted his Ph.D. thesis.

**Bill McLean** Bill McLean's book, *Strongly Elliptic Systems and Boundary Integral Equations*, was published in March by Cambridge University Press. For the second half of 2001, Bill was on internal release and spent six weeks in the U.K. during September and October. He spent two weeks at the University of Bath and for part of this time took part in an IMA conference on boundary integral methods, speaking on recent work with Olaf Steinbach (University of Stuttgart). The rest of his time in the U.K. was spent in Glasgow, where he collaborated with Prof. Mark Ainsworth of Strathclyde University on multilevel diagonal scaling preconditioners for boundary element discretizations of hypersingular integral equations. The EPSRC supported this research project with a visiting fellowship that paid all local expenses.

**Jason Middleton** continued his oceanographic research on the topic of headland eddies, participating in a series of experiments investigating wake flows around Bass Point, south of Sydney. Greg Nippard prepared and implemented these experiments which also provide data for the PhD work of Chris Aiken. In conjunction with Moninya Roughan, further work was undertaken analysing the East Australia Current data set, acquired in 1998 and 1999 from Research Vessel Franklin. Ann-Marie Wong continued her work on Antarctic ocean circulation driven by sea-ice formation. David Ghisolfi submitted his PhD thesis on river outflows off the Brazilian coast in December, while

Peter Coutis' PhD thesis on tidal upwelling and island wakes was submitted in May.

**John Middleton** continued research into the Shelf-slope Circulation in the Great Australian Bight, (ARC-supported, 1997-1999). The goals of this project were to conduct a sequence of numerical studies to determine:

1. the dynamics of wind-forced downwelling slope currents and the conditions for the existence of undercurrents (UCs).
2. the importance of alongshelf density gradients and the role of Bass Strait in determining the Zeehan Current off the west coast of Tasmania.
3. the effect of variable shelf bathymetry and nature of the "mean" slope currents within the Bight during both summer and winter.

**Idealised Models** These goals have been largely met, with some notable surprises. The study of wind-forced downwelling (Middleton and Cirano 1999; Goal 1) showed that thermal wind shear within the bottom boundary layer can lead to UCs over the slope that continue to grow in magnitude after 90 days of forcing. Previous studies had assumed that the UC would be steady and the result of internal friction, while here the alongslope gradient of sea level is shown to accelerate the growing UC. In a companion study of wind-forced upwelling, (Middleton 2000) the conclusions made by Sugimotohara and Kitamura (1984) regarding the important dynamics were shown to be wrong. The late time circulation has been shown to be dominated by new physical effects within the surface mixed layer, rather than linear CTWs as claimed by these authors.

An idealised study of the effect Bass Strait on adjacent slope currents was also made (Middleton and Platov 2001a; Goal 2) and shows that the currents are little affected by the presence of the strait. The results are explained in terms of CTW scattering by the strait.

**Winter and Summertime Models of the Great Australian Bight** High resolution models of the circulation within the Bight have also been developed, and a detailed description of the shelf slope circulation and dynamics has been determined (Goal 3). The models are driven by February and August averaged meteorology, and nested within output from the OCCAM global ocean model. A surprising feature is the development of a westward flowing northern boundary current along the shelf slope, that results from the equatorward Sverdrup transport within the southern ocean (Middleton and Cirano 2001). This current is identified as the Flinders Current and its existence is supported by both the numerical results and limited observations.

While the northward Sverdrup transport leads to upwelling near the slope (depths below 600m), during wintertime, the winds downwell isotherms to depths of 400m, and drive a poleward coastal current from Albany to Tasmania (Cirano and Middleton 2001). Off the north-west Tasmanian shelf, this current is identified as the Zeehan Current.

Baroclinic instability is shown to be the cause of the 60 km scale eddies that grow over the outer slope. These eddies dominate the shelf-slope circulation east of the Eyre Peninsula.

In the summertime case, the mean coastal winds reverse, and while the coastal and slope currents are equatorward, a poleward current is found along the shelf break. (Middleton and Platov 2001). The poleward current results from the convergence of the northward Sverdrup transport with the offshore Ekman transport, and the topographic Sverdrup transport induced within the wide sloping shelf of the bight. The eddies found off Port Lincoln are also shown to be caused by baroclinic instability, although they are quite small in amplitude (2-3 cm/s).

The analysis of these model results was facilitated by the development of Seascape, a Matlab based windows graphical package (Platov and Middleton, 2000)

A Tidal Model of the Bight A barotropic model of the tides for the region was also developed and results found to compare favourably with coastal sea level data (Middleton and Platov 2000b), and the tidal amplification within both Spencers Gulf and Bass Strait was identified to result from a 1/4 wave damped resonance mechanism.

A Fjord Problem Analytical solutions for the problem of Kelvin wave scattering in a Fjord were also obtained. An idealised step like topography was assumed and for the two layer fluid adopted, the amplitudes of the scattered internal waves were found to be of order  $g/g'$  times the incident barotropic wave. The significance of the results is that  $g'$ , the reduced gravity is of order 100-1000 smaller than  $g$ , so that very large amplitude waves and wave breaking may occur. Numerical solutions are being developed for comparison (Middleton and Sanderson, 2001).

**John Murray** continued his sabbatical in Los Alamos for the first half of 2000. This was eventful in many ways. Research with Alan Perelson on HIV and hepatitis B produced several papers that are in various stages of submission to journals. On more mundane matters, the evacuation of Los Alamos due to bush fires gave us all a chance to experience the fate of refugees, admittedly in Santa Fe.

HIV research with members of the National Centre in HIV Research and Clinical Epidemiology progressed well on several projects, including immune reconstitution after highly active antiretroviral therapy (HAART), HIV-1 DNA and RNA dynamics after HAART, and epidemiology of HIV and hepatitis C among injecting drug users.

Dr Murray visited Dr Andrew Coldman at the British Columbia Cancer Agency twice in the first half of 2000 to conclude some previous research and commence a new project on scheduling cancer chemotherapy.

Dr Murray attended the 7th Conference on Retroviruses and Opportunistic Infections in San Francisco in February, where he was a coauthor of a presentation on vaccination and treatment interruption of HIV infected patients on successful antiretroviral therapy.

**Alex Opie** continued his work on two problems, namely, the thermodynamic limit behaviour of arrays of particles coupled by springs, and a generalization of discrete Fourier transforms for dealing with non-linear dynamical systems. The former was a continuation of work with Dr John Grindlay of the University of Waterloo whilst the latter problem also involved Dr Bruce Henry.

**Liqun Qi** continued his research work in nonlinear programming, variational inequalities and generalized Newton methods. In particular, he applied generalized Newton methods to constrained approximation problems. Ten papers were published in 2000, nine more papers have been accepted for publication. In addition, a special issue “Nonsmooth and Smoothing Methods” of the Journal Computational Optimization and Applications, edited with Professor Fukushima was published in 2000. In March, he visited the Faculty of Business Administration, National University of Singapore, and gave an invited lecture. In April he visited Department of Mathematics, Hong Kong Baptist University, Hong Kong, Department of Mathematics, National Cheng Kung University, Tainan, Taiwan, and Institute of Mathematics, Academia Sinica, Taipei, Taiwan, and gave invited lectures. In August, he gave an invited talk at the Cluster of Complementarity and Variationalities, the 17th International Symposium on Mathematical Programming, Atlanta, USA, and chaired the Nonsmooth Optimization Cluster of that Symposium. In September, he visited Department of Applied Mathematics and Physics, Kyoto University, and Department of Mathematics, Shimane University, Matsue, Japan. In October, he gave an invited talk in the International Workshop on Optimization with High Technology Applications, Hong Kong, and chaired the First Sino-Japan Optimization Meeting, Hong Kong. In November, he visited the Academy of Mathematics and System Sciences, The Chinese Academy of Sciences, Beijing, China.

**Colin Rogers** has continued his research on Bäcklund transformations of surfaces and the geometry of soliton theory. A major result established during the year connects a well-known hydrodynamic system with an integrable Heisenberg spin equation allied with a geometric constraint. A monograph co-authored with Wolfgang Schief entitled “Bäcklund and Darboux Transformations. Geometry and Modern Applications in Soliton Theory” was completed during the year and is to be published by Cambridge University Press. During 2000, invited lectures were presented in Hong Kong, at the China-Sweden Workshop on Numerical Partial Differential Equations, at City University of Hong Kong and the Hong Kong Polytechnic University. A series of lectures were presented at Hong Kong University of Science and Technology where he was Visiting Professor during the month of January. There followed a period at Instituto de Matematica Pura e Aplicada, Rio de Janeiro, Brasil where he also presented a series of lectures on the geometry underlying soliton theory. Invited lectures overseas were also presented in the Department of Mathematics, University of Buenos Aires, Argentina, the Department of Mathemat-

ics, Suranaree University of Technology, Thailand and the Department of Mathematics, Imperial College London, in the UK. Within Australia, lectures were presented in the Department of Mathematics at the University of Queensland and at a Solitons and Geometry Special Session co-organised at the Australian Mathematical Society Meeting in Queensland.

**Wolfgang Schief** has continued his research on the project ‘The generation and application of Geroch-type transformations in soliton theory’ as part of his QEII Fellowship. The aim of the project is to bring together for the first time the analysis of symmetry transformations of Geroch type as known for the Ernst and Einstein-Maxwell equations of general relativity and infinitesimal Bäcklund transformations in the context of a very general integrable (soliton) system, the so-called Loewner-Konopelchenko-Rogers (LKR) system.

Dr Schief has also pursued his research on the amalgamation of soliton theory, classical differential geometry, difference geometry and continuum mechanics. In particular, he has worked on solitonic connections with hydrodynamics and magnetohydrodynamics with Professor Rogers. Projects were initiated with Professor A.I. Bobenko, Technische Universität Berlin, Germany and Dr. P. Vassiliou, University of Canberra. Projects were completed with Professor A. Degasperis, Università di Roma I, Italy and Professor B. G. Konopelchenko, Università di Lecce, Italy.

**Ian Sloan** continued his researches on a variety of problems in numerical analysis, approximation theory and problems of continuous complexity. Highlights included a study (involving spectacular numerical experiments) of polynomial interpolation on the sphere with R. Womersley; the development of new classes of cubature rules for integration over many dimensions, with former student S. Joe (Waikato) and his student F. Kuo; and the further development with M Ganesh and I Graham (Bath) of a global approach to direct and inverse scattering problems from three-dimensional objects. Results on the third topic were presented in October at an international conference in Bath on boundary integral methods, and on the second at an international conference in Hong Kong on Monte Carlo and quasi-Monte Carlo methods in November.

**Rob Womersley** continued research on the development, analysis and application of methods for solving optimization problems arising in approximation theory, finance and engineering. One project is the work with Professor Ian Sloan on the choice of interpolation points on the sphere, how good such interpolation can be, and approximation and cubature over the sphere. Another project, with Alan Brace of National Australia Bank, is on stochastic volatility models.

## 5 RECENT PUBLICATIONS

### 5.1 Journal Articles and Conference Papers since 1998

In the following list, papers are grouped by staff member. Thus, papers with more than a single author from the department appear more than once.

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## 5.2 Books and Edited Proceedings since 1997

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## 5.3 Applied Mathematics Reports 2000

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**Henry BI** and Wearne SL, Fractional reaction-diffusion, Applied Mathematics Report AMR00/2.

Rail DL, **Henry BI** and Wearne SD, Self-organized criticality models of neural development, Applied Mathematics Report AMR00/3.

Batchelor MT, Burne RV, **Henry BI** and Watt SD, Deterministic KPZ model for stromatolite laminae, Applied Mathematics Report AMR00/4.

D-H Li and **Qi L**, A stabilized SQP method via linear equations, Applied Mathematics Report AMR00/5.

A Fischer, **Jeyakumar V** and Luc DT, Solution point characterizations and convergence analysis of a descent algorithm for nonsmooth continuous complementarity problems, Applied Mathematics Report AMR00/6.

**Qi L** and Yang Y, A globally and superlinearly convergent SQP algorithm for nonlinear optimization, Applied Mathematics Report AMR00/7.

**Sloan IH** and **Reztsov AV**, Component-by-component construction of good lattice rules, Applied Mathematics Report AMR00/8.

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**Middleton John F** and Platov G, Slope circulation set-up near a strait: an idealised study, Applied Mathematics Report AMR00/21.

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## 6 EXTERNAL RESEARCH SUPPORT FOR 2000

The Department maintains a strong commitment to high quality research, and consistently attracts significant funding from the Australian Research Council.

### 6.1 Australian Research Council Large Grants Scheme

**ML Banner** \$62,000  
Ocean wave breaking threshold and energy loss

**LM Leslie, Y Shao** \$82,000  
Sub-seasonal variability of rainfall and soil moisture in El Nino years: Understanding and prediction

<b>LM Leslie</b>	\$102,000
NSW Fire Services-Development of real-time and research models for predicting fire weather and prescribed burn days over south-eastern Australia	
<b>LM Leslie</b>	\$77,000
Strategic Development	
<b>JH Middleton</b>	\$52,000
Recirculating flows in the coastal ocean	
<b>L Qi</b>	\$59,000
Smoothing and non-interior point methods	
<b>L Qi/R Womersley</b>	\$62,000
SI and OP-Free algorithms for non-linear programming	
<b>I Sloan</b>	\$79,000
Numerical Integration and approximation in high dimensions	
<b>I H Sloan, W McLean and M Ganesh</b>	\$71,214
Numerical analysis of evolution problems in several variables	

## **6.2 Australian Research Council Small Grants Scheme**

<b>M Banner</b>	\$10,000
Critical energy and momentum growth rates in shoaling water waves	
<b>P Blennerhassett</b>	\$5,000
Stability of unsteady flows	
<b>M England</b>	\$11,000
A Southern Ocean Model intercomparison project	
<b>B Henry</b>	\$5,000
Pattern formation in temporal fractional reaction-diffusion systems	
<b>V Jeyakumar</b>	\$15,000
Nonsmooth iterative methods for optimisation problems	

<b>L Leslie</b>	\$12,000
Air quality analysis and prediction over the greater Sydney region using a new coupled atmospheric and chemical microphysical forecasting model	
<b>JF Middleton</b>	\$20,000
The effects of canyons and capes on upwelling and downwelling	
<b>L Qi and RS Womersley</b>	\$13,000
Newton-type methods for semidefinite problems and constrained approximation	
<b>W Schief and C Rogers</b>	\$19,600
Discretisation and geometry of solitonic systems. Application of Bäcklund transformations and Lie group symmetries	
<b>W Schief and C Rogers</b>	\$15,300
Isothermic surfaces and $K$ -nets in elastic membrane theory and engineering design	

### 6.3 External Collaborative Grants

<b>M England, ARC QEII Fellowship</b>	\$10,500
Circulation and variability in the Southern Ocean and its influence on Australian climate	
<b>M Banner</b>	\$19,000
Office of Naval Research (Impact of air-sea interaction research on larger-scale geophysical flows)	
<b>L Leslie</b>	\$68,000
Process studies at the air-sea interface (BMRC-USA Office of Naval Research sub-contract)	
<b>L Leslie</b>	\$130,000
Tropical cyclone intensity and structure (Office of Naval Research)	
<b>L Leslie</b>	\$140,000
Wave breaking influence in a coupled model of the atmospheric-ocean (Office of Naval Research)	
<b>Shao</b>	\$13,000
RTA Investigation of Roadside Pollution	
<b>Shao</b>	\$45,000
CRC Modelling of salt transport and accumulation in irrigated areas	

## 7 VISITORS

- Dr Robert Abbey, Jr., US Office of naval Research, 14–19 February, 2000 (L Leslie)  
Professor Bjorn Birnir, University of California, Santa Barbara, 4 December, 2000 (Y Shao)  
Dr Andrew Bassom, University of Exeter, 5 July–6 September, 2000 (P Blennerhassett)  
Professor Daomin Cao, Institute of Applied Mathematics, Chinese Academy of Sciences, Beijing, 1 July–1 October 2000 (V Jeyakumar)  
Professor Xianjun Chen, Shimane University, Japan, 6 August–6 September, 2000 (L Qi)  
Professor Johnny Chan, City University of Hong Kong, 12–18 January, (L Leslie)  
Professor Peter A Clarkson, University of Kent, UK, 19–20 April, 2000, (C Rogers)  
Professor Robert Conte, Saclay Paris, France, 15–22 March, 2000 (C Rogers/W Schief)  
Dr George Cresswell, CSIRO Marine Research, 13–15 July, 2000 (M England/J Middleton)  
Dr Fraser Davidson, Australian Defence Force Academy, 13–16 October, 2000 (M England)  
Professor Vladimir Demyanov, St Petersburg State University, Russia, 2–5 February, 2000 (V Jeyakumar)  
Professor Assen Dontchev, American Mathematics Society, 10–23 July, 2000 (L Qi/R Womersley)  
Professor kai-Tai Fang, Hong Kong Baptist University, 30 June–19 July, 2000 (L Qi/R Womersley)  
Professor Athanasis Fokas, Imperial College London, 28 June–1 July, 2000 (C Rogers)  
Professor Francisco Facchinei, University of Roma, Italy, 14–29 July, 2000 (L Qi/R Womersley)  
Professor W Freeden, University Kaiserslautern, Germany, 19 October–4 November, 2000 (I Sloan)  
Dr Mark Gibbs, University of Otago, 4–5 June, 2000 (M England/J Middleton)  
Dr Stuart Godfrey, CSIRO Marine Research, June 2000 (M England)  
Dr Elena Goloubeva, Russian Academy of Sciences, 16 February–4 April, 2000 (M England/J Middleton)  
Dr Ivan Graham, University of Bath, 26 April–26 May, 2000 (I Sloan)  
Dr Andrew Hassell, 8–9 June, 2000 (Y Shao)  
Professor Alex Ioffe, Israel Institute of Technology, 3–8 August, 2000 (L Qi)  
Feng Hua, 1 August 2000–1 February 2001 (M Banner)  
Professor B Konopelchenko, 1 February–1 July 2000 (C Rogers/W Schief)  
Professor W.H. Hui, Hong Kong University of Science & Technology, 19–20 December, 2000 (C Rogers)  
Professor Christian Kanzow, 10 June–8 July 2000 (L Qi/R Womersley)

Professor Michael Lacey, Georgia Institute of Technology, 7–9 August, 2000 (M England)  
 Professor Donghui Li, 9 November–31 December, 2000 (L Qi)  
 Dr D T Luc, University of Avignon, France, 1–31 July, 2000, (V Jeyakumar)  
 Professor H Mhaskar, California State University, 2 December, 2000 (I Sloan)  
 Dr Andrew Moore, University of Colorado, August (M England)  
 Dr Bradley Morris, University of Plymouth, UK, 6–9 March, 2000 (J Middleton)  
 Professor R O'Malley, Washington University 11–14 December, 2000 (I Sloan)  
 Professor Alexander Nepomnyaschy, Technion, Israel 28–29 July, 2000 (M Banner)  
 Dr Peter Oke, College of Oceanic and Atmospheric Sciences, Oregon State University,  
 February 2000 (M England)  
 Professor G Peng, 1 January–31 December, 2000 (L Leslie)  
 Professor Bernard Pailharpe, University of California at San Diego, 14–18 August, 2000  
 (L Leslie)  
 A/Prof Charitha Pattiaratchi, University of Western Australia (M England)  
 Dr Abbey Perumpanani, Boston Consulting Group, Sydney, 23 November, 2000  
 (M Ganesh)  
 Professor E Polak, University of California, Berkeley, 9–23 July, 2000 (Q Qi/R Womers-  
 ley)  
 Professor Geoffrey Prince, 1 January 2000–8 January 2001 (W Schief)  
 Professor Dingguo Pu, 16 June–31 December, 2000 (L Qi/R Womersley)  
 Dr Julie Pullen, Marine Meteorology Division, 11–12 May, 2000 (J Middleton/M Eng-  
 land/L Leslie)  
 Dr D Ralph, University of Melbourne, 16–17 December, 2000 (L Qi/R Womersley)  
 Dr Joachim Ribbe, University of Concepcion, Chile, 28 February–10 March, 2000 (M Eng-  
 land)  
 Mr Hjalti Sigurjónsson, Agricultural Research Inst., Reykjavik, Iceland, 1–30 March,  
 2000 (Y Shao)  
 Dr G Stuart, CSIRO Marine Research, 26–28 June, 2000 (M England/J Middleton)  
 Professor Vidar Thomée, Chalmers University of Göteborg, 5 December–19 January,  
 2001 (I Sloan)  
 Professor Phan Nhat Tinh, Hue University, Vietnam, 16 October 2000–15 January, 2001  
 (V. Jeyakumar)  
 Professor Wouter Verbraak, 12 November 1999–13 May, 2000 (L Leslie/Middleton)  
 Dr Hua Wang, School of Geography & Oceanography, ADFA, 10–12 July, 2000 (M Eng-  
 land/J Middleton)  
 Professor P Winternitz, University of Montreal, 1 November 1999–31 January 2001  
 (C Rogers)  
 Dr Trudy Wohlleben, University of Alberta, May 2000 (M England)

Professor Henryk Wozniakowski, Columbia University & University of Warsaw, 15 January–5 February, 2000 (I Sloan)

Professor Steve Wright, Argonne National Laboratory, USA, 3–23 July, 2000 (L Qi/R Womersley)

Professor Yufei Yang, 11 May, 1999–December 2000, (L Qi)

Professor H Yin, Chinese Academy of Sciences, Beijing, 16 June–31 December, 2000 (L Qi/R Womersley)

Dr G Zhao, National University of Singapore, 17–30 June, 2000 (D Sun)

Professor Y You, April–June 2000 (M England)

## 8 CONFERENCES AND SEMINARS

Professor Colin Rogers was the co-organiser of a special session on Soliton Theory held at the Annual Australian Mathematical Meeting held at the University of Queensland.

### 8.1 Applied Mathematics Seminars

Organizer: M Ganesh

21 March

Professor Robert Conte, CEA Saclay, France

*Perturbative methods for the Painlevé test*

28 March

Dr H Zhuang

*Sensitivity of air pollution model to the variation of land-surface properties. A case study for the Taichung region*

19 April

Professor Peter Clarkson, University of Kent, U.K.

*On the relationship between the discrete and continuous Painlevé equations*

11 May

Dr Ivan Graham, University of Bath, U.K.

*Divergence free mixed finite elements for groundwater flow problems*

29 June

Professor Thanasis Fokas, Imperial College, London

*The Painlevé equations and application to the Hele-Shaw problem*

28 July

Professor Alexander Nepomnyashchy, The Technion, Isreal  
*Convective instabilities in fluid systems with an interface*

3 August

Dr Andrew Bassom, University of Exeter, UK  
*The linear stability of flat Stokes layers*

26 October

Professor W Freeden, University of Kaiserslautern, Germany  
*Geomathematical aspects of multiscale modelling*

2 November

Prof W Freeden (University of Kaiserslautern, Germany)  
*Spherical wavelets with local support*

9 November

Ben Waterhouse, NSW  
*Optimisation solutions to data mining*

23 November

Dr A Perumpanani, Boston Consulting Group, Sydney  
*Interactions of hyperbolic and parabolic PDES during cancer invasion*

24 November

Professor WH Hui, Hong Kong University of Science & Technology  
*A unified coordinate system for computing multi-dimensional flow*

11 December

Dr Rod Halburd, Loughborough University, UK  
*The Painlevé property for difference equations*

12 December

Professor R O'Malley  
*Renormalization for nearly-linear oscillators*

18 December

Professor WH Hui, Hong Kong University of Science & Technology  
*Difficulties of shock-capturing methods and how to overcome them*

## 8.2 Special Seminars

19 April

EW Schulz, JFD

*The cross-wind component of wind stress*

30 November

Guy Nicholson, student

*Spurious resonance in numerical semi-Lagrangian schemes: Diagnosis and solutions*

30 November

Ben Waterhouse

*A new data classification technique: Support vector machine*

30 November

Mohamad Elali

*History of Inertia*

30 November

Stephen Stefanac

*Modelling and prediction of fog formation*

## 8.3 Joint Pure-Applied Seminars

23 May

Dr Geoff Prince (La Trobe University, Australia)

*Singularity analysis of second order ODE's - Part I*

25 May

Dr Geoff Prince (La Trobe University, Australia)

*Singularity analysis of second order ODE's - Part II*

## 8.4 Applied Mathematics-Statistics Seminar

7 December

Professor B Maslowski, Czech Academy of Sciences

*Fractional Brownian motion driven SPDE's*

14 December

Professor Bjorn Birnir, University of California, Santa Barbara

*The scaling of fluvial landscape*

19 December

Professor W H Hui, Hong Kong University of Science & Technology

*Difficulties of shock-capturing Methods and how to overcome them*

20 December

Professor W H Hui (Hong Kong University of Science & Technology)

*A Unified Coordinate System for Computing Multi-Dimensional Flow*

## 8.5 Computational Mathematics Seminars

18 May

Dr I Graham, University of Bath, UK

*Fully discrete spectral boundary integral methods on smooth closed surfaces in  $R^3$*

15 June

Professor I Sloan and Dr M Ganesh

*Computational schemes for inverse problems*

29 June

Professor I Sloan and Dr M Ganesh

*Computational schemes for inverse problems*

3 August

Professor I Sloan

*Beating quasi-Monte Carlo intractability with lattice rules*

12 December

Professor H Mhaskar, California State University

*Edge detection in a periodic function*

3 November

Professor W Freeden, University of Kaiserslautern, German

*Vectorial spherical harmonics*

22 November

Dr Y Jeon, A-Jou University, Korea

*A local boundary element method*

## 8.6 Optimization Seminars

Organizer: Rob Womersley

15 June

Professor Gongyun Zhao, National University of Singapore

*A review of complexity and convergence of interior point methods*

## 8.7 Nonlinear Dynamics Seminars

Organizer: Bruce Henry

## 8.8 Oceanography, Meteorology and Fluid Mechanics

Organizer: Matthew England

10 February

Peter Oke, College of Oceanic and Atmospheric Sciences, Oregon State University

*Assimilation of Surface Velocity data into a Coastal Ocean Model*

1 March

Dr Joachim Ribbe, Program for Studies in Regional Physical Oceanography and Climate (PROFC), University of Concepcion

*A Mass, Heat, and Freshwater Budget for the South Pacific in a Coarse Resolution Ocean General Circulation Model*

3 March

Chris Aiken, School of Mathematics, UNSW

*Instability in the Coastal Zone*

8 March

Dr Brad Morris

*Institute of Marine Studies, University of Plymouth, Plymouth. Measurements of the Response of a Coastal Inlet Using Video Monitoring Techniques*

10 March

Ann-Marie Wong, School of Mathematics, UNSW

*Shelf Water Circulation Wilkes Land Antarctica*

17 March

David Ghisolfi, School of Mathematics, UNSW

*Fronts along the Southern Brazilian Coast*

19 March

Haixiong Zhuang, School of Mathematics, UNSW

*Sensitivity of Air Pollution model to the variation of land-surface properties: A case study for the Taichung region*

12 April

Dr Yaping Shao, School of Mathematics, UNSW

*Modelling Atmosphere and Land-Surface Interactions*

19 April

Eric Schulz, School of Mathematics, The University of New South Wales

*The cross-wind component of wind stress*

26 April

Professor Michael Banner, UNSW

*The Southern Ocean Waves Experiment: Sea-surface response to wind speed and wind stress variations*

3 May

Dr Matthew England, UNSW

*Southern Ocean variability in observations and a coupled climate model*

8 May

Dr Trudy Wohleben, University of Alberta

*Flow Simulations for a High Arctic Polythermal Glacier*

12 May

Dr Julie Pullen, Oregon State University

*Modelling Studies of the Coastal Circulation off Northern California*

21 June

Thomas Roudil, Ecole Polytechnique, Palaiseau, France

*Reflection of wave energy from bends in a channel, Study of directional properties of breaking wind waves*

21 June

Thierry Cerisier, Ecole Polytechnique, Palaiseau, France

*Southern Ocean circulation in an eddy-resolving global model*

27 June

Dr Stuart Godfrey, CSIRO Marine Research, Hobart

*Modelling Sea Surface Temperature anomalies in the Indian Ocean using observed fluxes*

4 July

Dr Mark T. Gibbs, Department of Marine Science, University of Otago, NZ

*Modelling circulation and larval transport in a New Zealand fjord*

11 July

Dr Hua Wang, School of Geography and Oceanography, ADEFA, UNSW

*Modelling circulation in Jervis Bay*

20 July

A/Professor Charitha Pattiaratchi, Centre for Water Research, University of Western Australia

*The unique oceanic environment off western Australia*

3 August

Dr Scott Chambers ANSTO

*Canopy controls on land-atmosphere interaction: The effects of large-scale clearing for agricultural purposes*

9 August

Dr Andrew Moore, Program in Atmosphere and Ocean Science, University of Colorado

*Differences in opinion on how to trigger an el nino*

14 September

Dr Wouter Vebraak, University of Utrecht, Netherlands

*The Modelling of Sea Breezes*

16 October

Dr Fraser Davidson, School of Geography and Oceanography, Australian Defense Force Academy

*Modelling wind driven circulation in Trinity and Conception Bay, Newfoundland*

5 December

Dr Chris Reason, Earth Sciences, University of Melbourne

*Indian Ocean influences on Australian and southern African weather and climate*

## 9 GRADUATE PROGRAMME

The Department maintains an active programme of study at the graduate level, by both course work and research. The degrees that can be obtained by course work at the graduate level are the Master of Science and Technology in Mathematics (MScTech) and Graduate Diploma in Oceanography (GradDip). The Doctor of Philosophy (PhD) and Master of Science (MSc) degrees are research degrees, obtained by carrying out a research project under the supervision of a member of staff. A total of 38 students were enrolled during 2000 for studies leading to higher degrees.

### 9.1 PhD Programme

The PhD degree provides a training in research up to the level necessary for initiating and carrying out unsupervised original work. The normal requirement for admission is an honours degree with a good class of honours but transfer from MSc candidature is also possible for MSc candidates who are making exceptional progress. Part-time PhD candidature is encouraged but only for candidates who can spend at least 20 hours per week on their research and are able to maintain regular contact with the university. A total of 30 students were enrolled in PhD programmes during 2000.

<b>Student</b>	<b>Research Topic</b>	<b>Supervisor</b>
Chris Aiken	Oceanography	Jason Middleton
Jaci Brown	Climate modelling	Leslie/England
Gregory Buckley	Flow over topography	Broutman
Bruce Buckley	Meteorology	Leslie
Mauro Cirano	Ocean circulation modelling	John Middleton
Geoff Clark	Pollution dispersion	Leslie
Peter Coutis	Upwelling processes in the coastal ocean	Jason Middleton
Simon Evans	Oceanography	John Middleton/Broutman
ZhanHai Gao	Optimal control	Murray
David Ghisolfi	Oceanography	McKee/Jason Middleton
Jose Gomes de Mattos Alves	Wind waves	Banner
Xuan Jiang	Nonlinear dynamics	Henry/Broutman
Eunjoo Jung	Pollution modelling	Shao
F Khoury	Computational fluid dynamics	Broutman/Womersley
Sam Lee	Optimization	Qi/Sun
An Li	Turbulent particle transport	Shao/Sanderson

Bill Lilley	Atmospheric pollution	Shao
Anthony Macks	Modelling of stratified ocean flows	Jason Middleton
Lixin Qi	Climate change	Leslie
Moninya Roughan	Coastal processes	Jason Middleton
JinBao Song	Wave breaking	Banner
Eric Schultz	Air-sea interaction	Sanderson
Elly Spark	Mesoscale meteorology	Leslie/Dunsmuir
Neil Stilgoe	Ocean modelling	Sanderson
Kwok Tan	Atmospheric modelling	Leslie
Xiang Wang	Approximate Jacobians	Jeyakumar
Zhou Wang	Acid soil phenomena	Shao
Anne-Marie Wong	Oceanography	Jason Middleton
Peng Xu	Land salination	Shao
Haixiong Zhuang	Pollution modelling	Shao

In 2000, 10 students were awarded a PhD in applied mathematics.

- Gary Bruce Brassington *High order methods for computational geophysical fluid dynamics* (Lance Leslie)
- Clio Lisa Cresswell *The discrete Painlevé equations: hierarchies, Bäcklund transformations and singularity confinement* (Nalini Joshi/Bruce Henry)
- Hua Lu *An integrated wind erosion modelling system with emphasis on dust emission and transport* (Yaping Shao)
- Karen Karmen Lau *Multistage quadratic stochastic programming* (Rob Womersley)
- Helen Jane Reid *Modelling coastally trapped wind surges over southeastern Australia* (Lance Leslie)
- Guanglu Zhou *Algorithms for variational inequalities and minimizing a sum of norms* (Liqun Qi)
- Christopher Jude Amies *Mathematical optimisation of radiation treatment of tumours* (John Murray)
- Xiang Wang *A new generalised Jacobian and its application in nonsmooth, optimisation* (V. Jeyakumar)
- Jose Henrique Gomes de Mattos Alves *A saturation-dependent dissipation source function for wind-wave modelling applications* (Michael Banner)
- Mauro Cirano *Wintertime circulation within the Southeast Indian Ocean: A numerical study* (John Middleton)

## 9.2 MSc Programme

The MSc degree provides a basic training in research. Each candidate is given an individual research topic, after consultation with members of staff, and carries out research on the topic under the personal supervision of a member of staff. An honours degree is normally required for admission as an MSc candidate, but applicants with good pass degree may be admitted to a qualifying programme, which usually consists of part or all of the honours year of the department. The MSc degree can be undertaken either full-time or part-time (or in some cases, externally). A total of 4 students enrolled in MSc programmes during 2000.

<b>Student</b>	<b>Research Topic</b>	<b>Supervisor</b>
Ken Gatt	Meteorology	Leslie
Edmund Lu	Financial Mathematics	Womersley
Agus Santoso	Climate Variability	England
Jiwon Park	Nonlinear dynamics	Henry

In 2000 two students completed coursework masters degrees:

Susan Wearne completed the Mmath degree (supervised by Bruce Henry) and Haixiong Zhuang completed the MscTech degree (supervised by Yaping Shao)