APPLIED MATHEMATICS

ANNUAL RESEARCH REPORT

2003

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1 APPLIED MATHEMATICS AT UNSW, 2003

In 2003, the Department continued its tradition of internationally recognized research, and hosting a large number of distinguished mathematical scientists. The Department also celebrated some significant achievements during the year.

Staffing. During the year, the Department welcomed the appointment of Adelle Coster and Chris Tisdell as new Lecturers. They bring new areas of expertise in mathematical analysis of biological systems, and differential and difference equations, that complement our growing strength in the research areas of Biomathematics and Nonlinear Phenomena.

Bruce Henry is congratulated on his promotion to Associate Professor.

Bill McKee and David Guiney both retired after many dedicated years of service in the Department.

Personal Achievements. Michael Banner was elected as a Fellow of the American Meteorological Society. Frances Kuo achieved the unique distinction of being awarded the inaugural Information Based Complexity Young Researcher Award. The award was for work in quasi-Monte Carlo methods carried out during her PhD degree at the University of Waikato, New Zealand. Late in the year she was awarded a prestigious UNSW Vice-Chancellor's Postdoctoral Fellowship, which she will take up in 2004. Colin Rogers and Ian Sloan were awarded Centenary Medals by the Australian Government. Ian Sloan (along with Alf van der Poorten of Macquarie University) was presented with the Inaugural George Szekeres Medal of the Australian Mathematical Society. In October, Ian took up the position of President of the International Council for Industrial and Applied Mathematics for a four-year term.

Funding Triumph. During the year, the research of the Department of Applied Mathematics was again recognized by a record level of support from the Australian Research Council with a total of over $800,000, being awarded in four Discovery Projects for three years. In addition, Hou-Duo Qi was awarded a prestigious Australian Research Council QEII Fellowship for five years.

Conferences and Workshops. Department hosted a successful two-day workshop on Mathematics of Computation and Approximation, in honour of Professor Ian Sloan's 65th birthday. Many members of the Department were also involved in the preparation for the largest applied mathematics event ever held in the Southern Hemisphere, the 5th International Congress of Industrial and Applied Mathematics (ICIAM2003), held at the Sydney Convention Centre in July. Vaithilingam Jeyakumar co-organized a two-day workshop on Continuous Optimization at the Australian Mathematical Sciences Institute in Melbourne in December. John Roberts co-organized a minisymposium on Integrable Systems as part of ICIAM2003 in Sydney in July.

Links with International Scientific Community. Our links with international scientific community are vigorous. Members of the Department engaged in many scholarly activities during the year. Matthew England remained as a member of the Scientific Steering Committee for the Ocean Carbon Cycle Model Intercomparison Project (OCMIP). Vaithilingam Jeyakumar served on the International Program Committee of the 6th international conference of the Association of Asia Pacific Operations Research Society (APORS2003), held in New Delhi, India. He continued to serve on the Scientific Committee for the 3rd international conference on Optimization and Control with Applications, to be held in Chongqing, China, 2004 and on the Program Committee for the International Conference on Optimization Techniques and Applications (ICOTA2004), to be held in Ballarat, 2004. John Middleton was appointed to the Executive of the International Association of the Physical Sciences of the Oceans (IPASO), and is a member of the local organizing committee for the international assembly in Cairns, 2005. Ian Sloan continued his work as Chair of the International Program Committee for ICIAM 2003.

Editorial Board Activities. Members of the Department were extremely active on Editorial Boards of major international journals. Matthew England remained on the Editorial Board of the Journal of Marine Systems. Vaithilingam Jeyakumar and Bill McLean continued as Associate Editors of the Australian and New Zealand Industrial Applied Mathematics (ANZIAM) journal. John Middleton joined the Editorial Board of the international journal on Progress in Oceanography as an Associate Editor. Colin Rogers remained on the Editorial Boards of Journal of Mathematical Analysis and Applications, Studies in Applied Mathematics and the International Journal of Nonlinear Mechanics. Ian Sloan continued on the Editorial Boards of the Journal of Complexity, Computational Methods in Applications, Journal of Integral Equations and Applications, Advances in Computational Mathematics and SIAM Journal on Numerical Analysis.

Lectures at International Conferences. Many members of the Department travelled overseas to attend conferences or to be involved in research. Michael Banner presented an invited lecture at the Wave and Operational Oceanography Workshop in Brest, France. Matthew England gave an invited lecture at the 1st joint assembly of the European Geophysical Society and the American Geophysical Union in Nice, France. Vaithilingam Jeyakumar presented a lecture at the Asia-Pacific Operations Research Society (APORS203) in New Delhi, India. Colin Rogers presented invited lectures at the University of Buenos Aires in Argentina and at Hong Kong Polytechnic University. Wolfgang Schief gave invited lectures at the Geometry and Visualization Conference in Tokyo Metropolitan University, Japan, and at the Integrable Systems and Nonlinear Dynamics (ISLAND)-2 in Scotland. Ian Sloan presented invited lectures at the Nonlinear Analysis Conference in Ho Chi Minh City, American Mathematical Society Meeting in Baltimore, Cubature Formulae Conference in Kranznoyarsk, Siberia, and at a Workshop on Computational Analysis on the Sphere in Nashville, Tennessee. Robert Womersley

delivered an invited lecture at the Workshop on Computational Analysis on the Sphere in Nashville, Tennessee.

The Department maintained an active program of study at the graduate level, by both course work and research. A total of 22 students were enrolled during 2003 for studies leading to higher degrees.

The Department of Applied Mathematics at UNSW is an exhilarating place of research, where some 20 academic staff attracted numerous visiting mathematical scientists, several research students and associates to their research groups, engaged in high level of international research activity, and published over 60 research papers in 2003 in leading professional journals and refereed conference proceedings.

All in all, the Department recorded a very successful year in 2003. The highest priority in 2004, of course, will continue to be the maintenance of the Department's high international standing in its chosen areas of research.

Vaithilingam Jeyakumar
Head, Department of Applied Mathematics

2 STAFF

2.1 Academic and Professional Staff

Scientia Professor

Ian H Sloan, BA BSc *Melbourne*, MSc *Adelaide*, PhD *London*, FAIP, FAust MS, FAA

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

Associate Professor and Head of Department

Vaithilingam Jeyakumar, BSc *Jaffna*, PhD *Melbourne*

Associate Professors

Yaping Shao, BSc *Zhonghsan*, Dipl Met *University of Bonn*, PhD *Flinders*
Robert S Womersley, BSc *Adelaide*, MSc PhD *Dundee*

Senior Lecturers

Peter J Blennerhassett, BE *Western Australia*, PhD *London*
Matthew England, BSc PhD *Sydney*
Mahadevan Ganesh, MSc *Trichy*, PhD *Bombay*
Bruce Henry, BSc PhD *UNSW*, FAIP
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*
John AG Roberts, BSc *ANU*, PhD *Melbourne*
Wolfgang K Schief, Dipl Phys. *Ludwig Maximilians U*, PhD *Loughborough*
Thanh Tran, BSc Hons *HCM City*, PhD *UNSW*

Lecturers

Adelle Coster, BSc Hons PhD *UNSW*
Chris C. Tisdell, BSc PhD *Queensland*

Honorary Associate Professor

Russell Standish, BSc PhD *ANU*

Adjunct Professor

M. Barnsley, BA *Oxford* PhD *London*

Research Fellow

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

Visiting Professors

Gongbing Peng, MSc *Moscow National University*
Vidar Thomée, Fil Kand *Lund*, Fil Dr *Stockholm*, KVA *(Sweden)*

Visiting Fellows

Clio Cresswell, BSc PhD *UNSW*
Alex H Opie, BSc DipEd *Melbourne*, PhD *Monash*, FAIP
Hongxia Yin, BSc *Hebei*, MSc *Beijing*, PhD *Chinese Academy of Science*

Honorary Visiting Fellow

James Neptune Lyness, DPhil *Oxford University*
Yufei Yang, PhD *Hunan University*

Senior Research Assistant

Lixin Qi, MS Chinese Acad Meteo Sci , BSc *Zhongshan*, PhD UNSW
Moninya Roughan BSc Hons, PhD *UNSW*

Honorary Associates

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

Research Associates

Mark Baird, BE *Sydney*, MSc *Hawaii*, PhD *Warwick*
Kerstin Hesse, Diploma *Kaiserslautern*
Ekaterini Kriezi, MSc PhD Ms Civil Eng *Auth Greece*
Frances Kuo, BCMS PhD *Waikato*
Stephen Langdon, BA Mathematics *Oxford*, PhD *Bath*
Suxia Liu, BEng, MEng *Hohai University*, PhD *Inst. Geography, Chinese Academy of Sciences*
Patrick Timko, PhD *Memorial University of Newfoundland*, MSc Dipl BSc *Alberta*
Xiaoqun Wang, PhD *St Peterberg State* (Russia)2002

Professional Officer

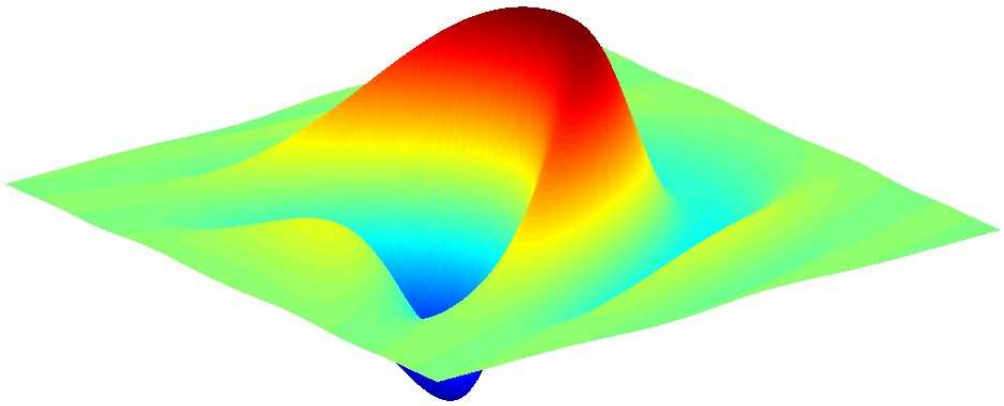
Gregory J Nippard, BSc *Sydney*

Computer Systems Officer

Dave Dowsett, BSc *Sydney*, BA *Macquarie*

3 AREAS OF RESEARCH

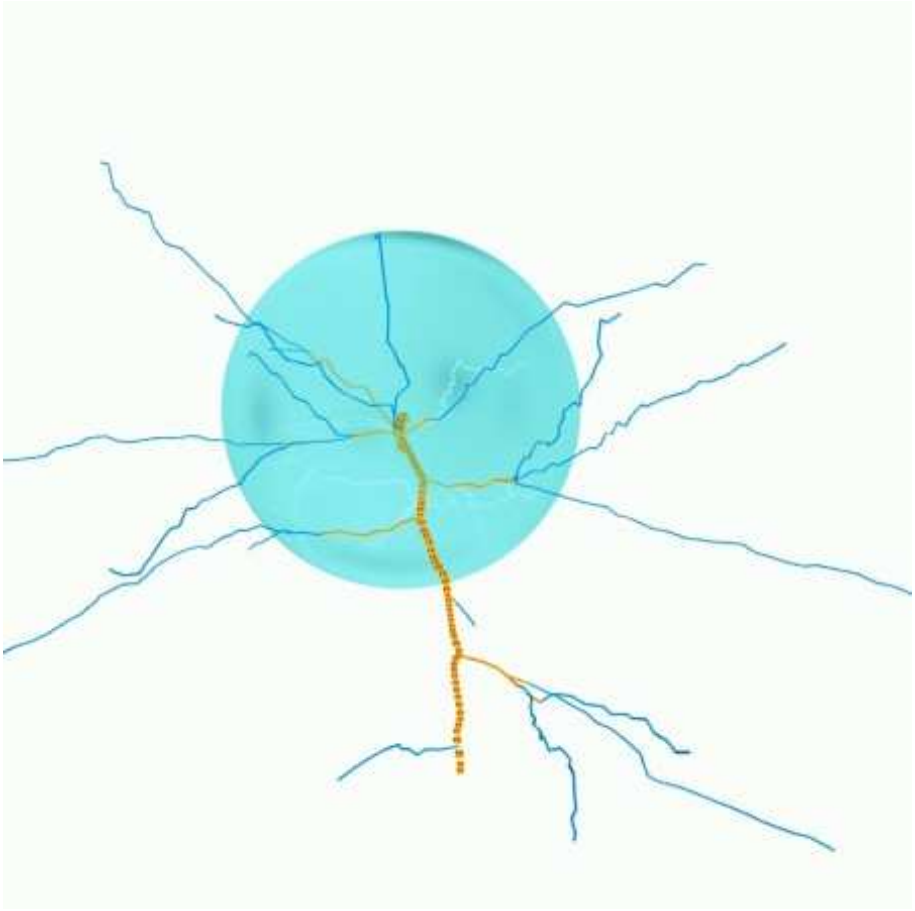
The Department of Applied Mathematics is highly regarded internationally as a centre for research, both fundamental and applied. The main areas of research are listed below,



Applied Analysis and Optimization

V Jeyakumar, J Murray, H.-D. Qi, R Womersley

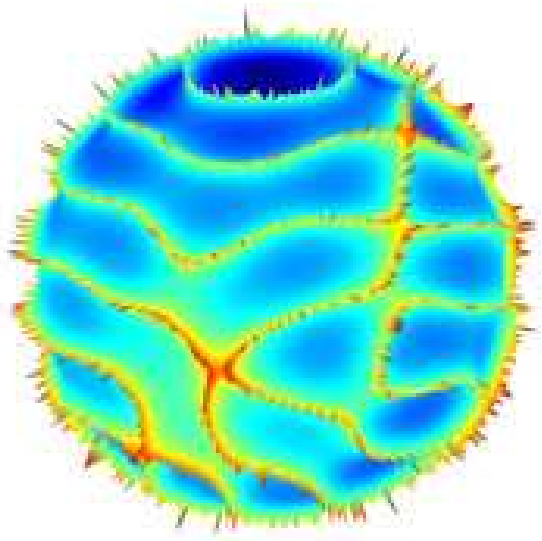
Optimization is the science that integrates information into mathematical models whose solution yields optimal decisions. Optimization is the most widely used branch of Applied Mathematics in commerce and industry. Research areas of special focus include the variational analysis of nonsmooth optimization problems, global optimization and the development of computational methods for structured constrained optimization problems. These areas are both of intrinsic mathematical interest and have wide applications including mathematical finance, medicine and constructive approximation. Extensive use is made of modern nonlinear functional analysis and high performance computing. Applied Mathematics at UNSW aims to expand its activities to develop discrete optimization.



Biomathematics

A Coster, B Henry, J Murray

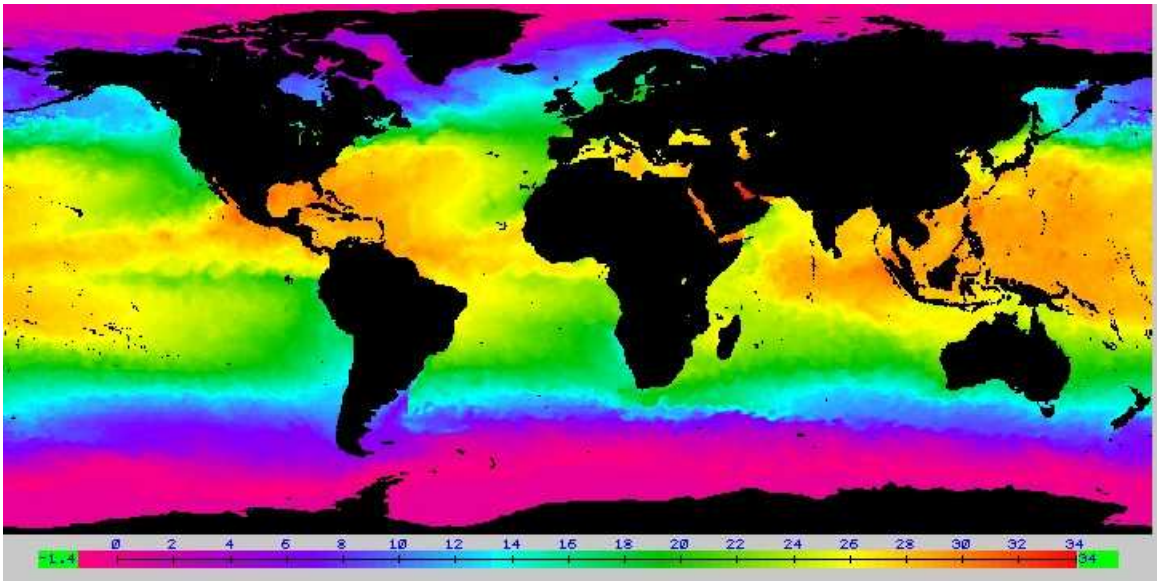
The discipline of biology is changing from a mostly descriptive science to a quantitative science. Biomathematics is facilitating this transition by developing new techniques to convert the logical but qualitative models of biology into formulae that can be used for quantitative prediction and improvement as well as for extracting patterns from complex data. The recently formed Biomathematics group at UNSW already has internationally competitive research projects in HIV, epidemiology, bioelectric phenomena and tumour growth. It has significant links with biomedical research centers both overseas and within Australia, and is well positioned to expand and make major contributions to the field.



Computational Mathematics

M Ganesh, W McLean, I Sloan, T Tran, R Womersley

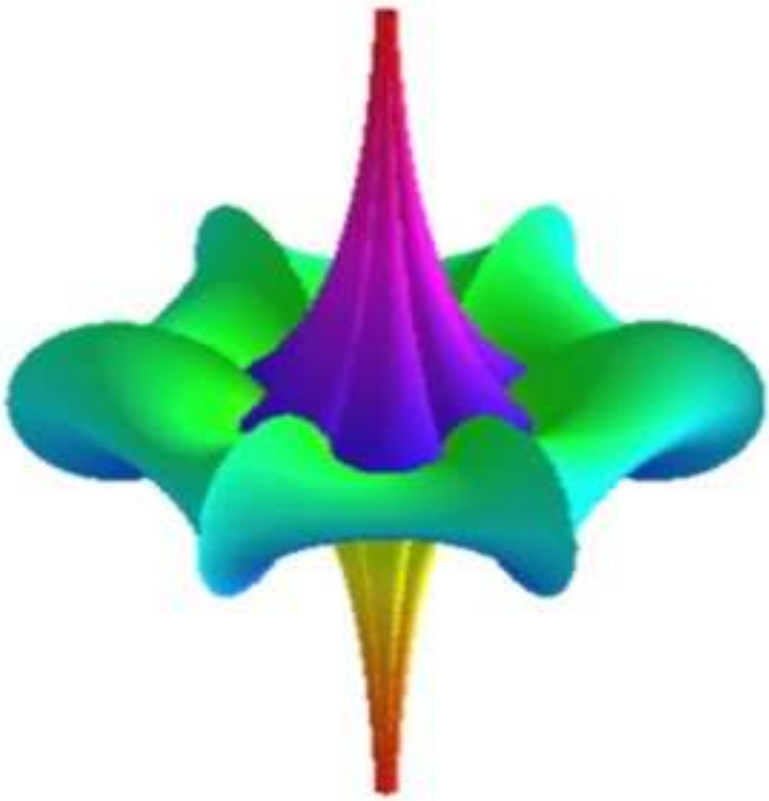
The design and analysis of computational algorithms, an area of strength at an internationally distinguished level at UNSW, underpins computational modelling in every area of technology and science, and nowadays in finance, medicine and the environment. Some areas of special focus include advanced methods for differential and integral equations, and algorithms for high dimensional problems. Developments in quantum computing are expected to become of increasing importance. Academic and research staff in this area make extensive use of high performance computing and advanced visualisation, in combination with modern analysis. They have strong involvement in the Centre of Excellence in Mathematical and Statistical Modelling of Complex Systems.



Geophysical Fluid Dynamics

M Banner, P Blennerhassett, M England, L Leslie,J F Middleton, J H Middleton

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

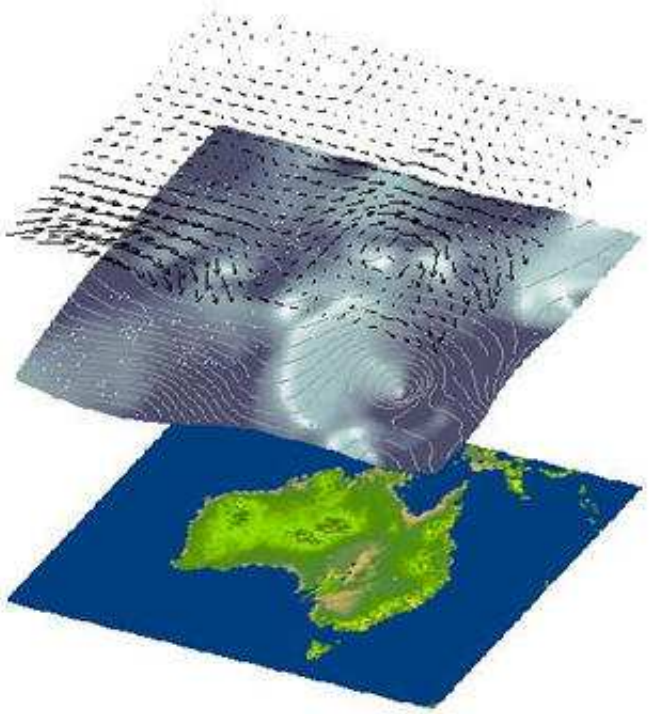
P Blennerhassett, B Henry, J Roberts, C Rogers, W Schief, C Tisdell

"... the progress of physics will to a large extent depend on the progress of nonlinear mathematics of methods to solve nonlinear equations" W.Heisenberg, Nobel Laureate 1932.

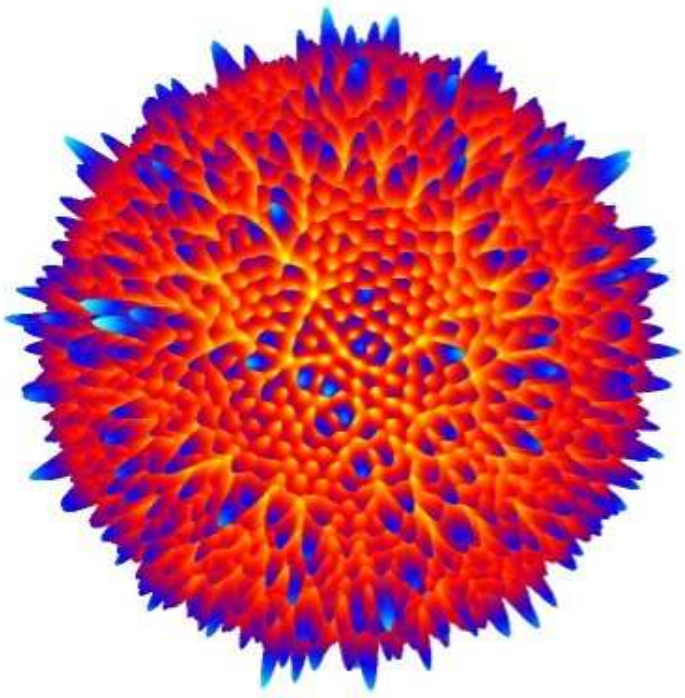
Nonlinear equations describe fundamental physical phenomena in nature ranging from chaotic behaviour in biological systems, plasma containment in tokomaks and stellarators for energy generation, to solitonic fibre optical communication devices. The Nonlinear Phenomena Group at UNSW is world-renowned for its work in soliton theory and dynamical systems and attracts visitors of international repute in these areas on a regular basis. Its activities have been recognised by Chief Investigator representation in the recently awarded Centre for Excellence in Mathematical and Statistical Modelling of Complex Systems. This will provide a base for a major research programme involving the analysis of complex physical and biological systems and the systematic investigation of potential new areas of application of modern soliton theory in magneto hydrodynamics, the fabrication of fibre-reinforced composites and elastic shell structure design.

4 RESEARCH CENTRES

Centre for Environmental Modelling and Prediction (CEMAP)



This is a Research Centre in the School of Mathematics, consisting of members from the Department of Applied Mathematics. It is one of Australia's largest and most successful teaching and research groups in meteorology and oceanography, providing high quality postgraduate teaching programmes in environmental modelling and prediction. The Centre produces state-of-the-art environmental prediction models, including coupled ocean-atmosphere-land surface models and predictive systems for the weather, ocean and land surface climate, with a focus on extreme conditions. The center also produces publications in quality journals and monographs, documentation, software, as well as associated analysis tools for end-users.



Centre of Excellence in Mathematics and Statistics of Complex Systems

In December 2002 the Federal Government announced funding of $11M over five years for the centre. Its mission is to stimulate research in mathematical and statistical modelling of complex systems, and to encourage cross-fertilization of ideas and techniques. Special areas of focus for the centre include dynamical systems, Monte Carlo methods, and scientific computation. The University of New South Wales is one of the four major partners of the Centre (the others being the University of Melbourne, the lead partner, the Australian National University, and the Australian Mathematical Sciences Institute. Of the three Chief Investigators at UNSW, two (Professors Colin Rogers and Ian Sloan) are in the Department of Applied Mathematics.

The Centre of Excellence began operating in earnest late in 2003, and already is having an effect. Robert Womersley and Wolfgang Schief were appointed as Associate Investigators, Frances Kuo (Research Associate) was supported jointly by the Centre and an ARC Discovery Grant, and Josef Dick received a Centre of Excellence PhD scholarship. The Centre of Excellence co-sponsored two Workshops in 2003 (see later). Postdoctoral positions within the Centre were advertised late in 2003, resulting in Research Associate offers to Josef Dick (to work with Ian Sloan in quasi- Monte Carlo Methods) and Kassem Mustapha (to work with Colin Rogers in nonlinear dynamics).

5 RESEARCH ACTIVITIES

During 2003, 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's ongoing research projects during 2003 included:

• further laboratory measurements of nonlinear wave group evolution to breaking to validate the growth rate threshold proposed by Song and banner (2002)

• analysis of upper ocean ADCP measurements of near-surface current shear, 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.

His Australian collaborators during 2003 included: L.M. Leslie (UNSW): Air-sea coupling in severe marine environments; I.R. Young and A. Babanin (U. Adelaide): Shallow water wind wave evolution - source terms; W. Peirson (UNSW): Wave breaking through nonlinear wave group focusing. Overseas Research Collaborations during 2003 included: M.A. Donelan, Rosenstiel School of Marine and Atmospheric Sciences, University of Miami: Shallow water wind wave evolution - source terms.

Peter Blennerhassett continued research in the field of linear and nonlinear hydrodynamic stability, with the main emphasis being on the linear stability of time dependent flows. This work on the instability of unsteady flows was continued with Dr Bassom (Exeter University, U.K.), a research student, Frank Reid and a vacation scholar, Robert Niebuhr.

Adelle Coster joined Applied Mathematics at the beginning of 2003. Her interests lie in the mathematical analysis of biological systems, in particular electrically excitable cells and cell dynamics. Some of her research projects are listed below: Nonlinear dynamics of pulse coupled oscillators: this research concerns the abnormal heart rhythms known as arrhythmias. It involves theoretical and analytic work using abstract models of the excitable cells in the heart to identify the connectivity and patterns of activity that initiate abnormal rhythms. If we can gain an understanding of the mechanisms by which the natural pacemaker controls the rhythms in the heart, then we can use this knowledge to identify protocols and methodologies for implantable artificial pacemakers that can arrest abnormal heart rhythms before they convert to potentially fatal arrhythmias. This project has received a ARC Discovery Grant for 2004-2006. Kinetic analysis of GLUT4 trafficking in fibroblasts and adipocytes (fat cells): here we are investigating the effect of insulin on glucose uptake. In muscle and fat cells, insulin stimulates the delivery of the glucose transporter GLUT4 from an intracellular location to the cell surface, where it facilitates the reduction of plasma glucose levels. Understanding the molecular mechanisms that mediate this translocation event involves integrating our knowledge of two fundamental processes - the signal transduction pathways that are triggered when insulin binds to its receptor and the membrane transport events that need to be modified to divert GLUT4 from intracellular storage to an active plasma membrane shuttle service. Specialised properties of GLUT4 and the cells in which it is produced mean that insulin can acutely regulate glucose uptake - and indeed there is accumulating evidence that irregularities in GLUT4 trafficking underlie type 2 diabetes. A novel fluorescence based assay has recently been developed by Professor David James and collaborators at the Garvan Institute for Medical Research, to study the trafficking of GLUT4 which has provided the basis for a detailed kinetic analysis of GLUT4 in adipocytes and their precursor cells, fibroblasts. By applying the assay to live cells either in the absence or presence of insulin it has been possible to obtain detailed information about the recycling properties of GLUT4. We have subjected these data to a detailed mathematical modelling analysis and have made several novel observations regarding the location and movement of the glucose transporters in the cell membrane system. This work is in collaboration with Professor David James at the Garvan Institute of Medical Research, and is the subject of a NHMRC Project grant application. The Virtual Charophyte: Modelling Salt Tolerance: Salt-tolerance is an important survival mechanism for plants and of high relevance to agriculture with increasing amounts of arable land becoming saline. Studying the mechanisms involved in salt-tolerance in cells of higher plants is very difficult due to their extremely small

sizes. In this study two large celled water plants that are ancestors of higher plants are being investigated; the two are electrophysiologically identical apart from their salt-tolerance. We are developing unified ionic (salt) transport models for these two types, which will give insights into the subtle mechanisms of salt-tolerance that have implications for the production and development of salt-tolerant higher plants (such as crops) in the future. Such plants may tolerate not only high salinity environments but also could be used in the remediation of salt-affected land. This is the subject of a ARC Discovery grant application and is joint work with Dr Mary Beilby and Dr Terry Chilcott of the Department of Biophysics, School of Physics, UNSW. Extraction and Classification of Events from Triaxial Accelerometer Data: Accelerometry is a technique that allows body movement to be directly and continuously measured and quantified in a natural setting for the patient. The patterns of movements are reflected in the accelerometer signals. For unsupervised home monitoring (such as detection of falls in the elderly) it is necessary to be able to automatically identify key activities and events from the accelerometer signals as close as possible to the event. This project involves the development of an automatic system to interpret the signals received from a triaxial accelerometer. There are four primary steps involved in this, namely (i) distinguishing activity from resting states, (ii) identification and classification of the activity, (iii) extraction of relevant parameters, and (iv) the taking of any appropriate action. It is also possible to extract an energy expenditure measure from the triaxial accelerometer signal data, which is an important clinical measure of well-being. The work is a collaboration with Professor Branko Celler of the School of Electrical Engineering and Telecommunications and Associate Professor Nigel Lovell of the Graduate School for Biomedical Engineering, UNSW.

Matthew England continued his research activities in large-scale physical oceanography, ocean modelling, and climate processes. Particular interests include the circulation and variability of the Southern Ocean and its role in climate, estimating climate change, ocean CO_2 uptake, and future sealevel rise. Research continues in the ocean's thermohaline circulation, stability, and feedback to the atmosphere. In 2003, Matthew documented the variability of Antarctic Intermediate Water (AAIW) in a coupled climate model (J. Phys. Oceaography, in press), as well as exploring AAIW pathways (J. Phys. Oceaography, 2003) and its sensitivity to moisture transport in the atmosphere (Geophys. Res. Lett., 2003). Other studies include analyses of paleoclimate states in a coupled model (J. Phys. Oceaography, in press), and an investigation of the role of an oscillatory westerly wind belt in controlling Southern Ocean climate (J. Climate, in press). Matthew assessed atmospheric circula-

tion associated with anomalous variations in North Pacific wintertime blocking (Mon. Weath. Rev., in press), the interannual variability of the Indonesian Throughflow and its linkage with ENSO (J. Climate, submitted), and stochastically forced modes of interannual Southern Ocean SST variability in a simple coupled model (J. Climate, submitted). Late in 2003 he discovered a link between rainfall extremes over southwest Australia and South Indian Ocean variability (J. Climate, submitted).

Mahadevan Ganesh continued his research work on the development and on the analysis of computational algorithms for partial differential and boundary integral equations. He completed three research papers on numerical solutions of partial differential equations: In collaboration with his PhD student Mr Mustapha, he proposed, analysed and implemented an ADI Galerkin scheme with quadrature for hyperbolic problems; a diffusion-modified quadrature method for reaction diffusion equations. Further, in collaboration with Mr. Mustapha and Professor Bialecki, he developed a Petrov-Galerkin scheme with quadrature for solving semi-linear parabolic problems.

In collaboration with Prof. Sloan and Dr. Langdon, he has been developing an efficient algorithm to solve very high frequency acoustic scattering problems using boundary integral equation formulations.

Bruce Henry's collaborative work with Professor Murray Batchelor, Dr Bob Burne, and Dr M Jackson, from the Australian National University, developed a simple biotic model for the growth of stromatolites. Modern stromatolites are laminated microbiolites that are analagous to colonial corals in the sense that living tissue is restricted to the surface. Ancient stromatolites, if biotic in origin, represent the earliest evidence of life on Earth (some of the stromatolites found in Western Australia date back 3.5 billion years).
Our biotic model which consists of upward growth of a phototropic map and mineral accretion normal to the surface of the map, can reproduce the essential morphologies of ancient stromatolites.

In collaborative work with Dr Susan Wearne, Dr Patrick Hof, and Dr Paul Rothnie, Mount Sinai School of Medicine, New York, Bruce developed and implemented new

scaling measurements of the dendritic branching complexity of neurons. The new scaling exponents which are measured in an abstract dendrogram space are better determinates of functional properties than similar scaling exponents measured in real Euclidean space.

In collaborative work with Dr Trevor Langlands and Dr Susan Wearne, Bruce further explored their fractional calculus model for pattern formation with anomalous diffusion. They established the existence of Turing pattern formation in this model system.

Vaithilingam Jeyakumar continued to work on a variety of projects across a number of areas of Optimization, Mathematical Programming and Applied Analysis. His research during the year focused on semidefinite programming, and convex optimization with applications. With Professor Gue Myung Lee (Pokyong National University, Korea and Associate Professor Nguyen Dinh, Pedagogical Institute of Ho Chi Minh city, Vietnam), a new approach to convex optimization was developed using a global constraint qualification. A month long visit by Associate Professor Dinh, in the middle of the year, saw the completion of semidefinite programming duality theory avoiding any constraint qualifications.

With John Ormerod, work on the application of semidefinite programming was undertaken to classify large-scale data sets incorporating prior knowledge. This work led to the development of a new computational method for solving Machine Learning problems of large-scale data classification, and to the completion of John's Honours thesis. A month long visit by Professor Miguel Goberna, University of Alicante, Spain, at the later part of the year, led to the extension of his recent work on set containment characterizations to systems involving strict inequalities. In December, in conjunction with Professor Alex Rubinov (University of Ballarat), he organized a two-day workshop on Continuous Optimization at the Australian Mathematical Sciences Institute in Melbourne. This meeting led to two new international research collaborations, which include: exploring conjugate duality without interior-point conditions (with Associate Professor Regina Burachik, Engenharia de Sistemas e Computacao, Rio de Janeiro, Brazil); investigation of nonlinearly constrained best approximations problems (with Professor Hussion Mohebi, Shahid Bahonar University of Kerman, Iran). Substantial progress was made on both new projects in the New Year.

His ongoing work on the applications of the new generalized Jacobian for nonsmooth continuous maps, invented recently by him and Professor Dinh The Luc, remains active with the aim of completing a research monograph.

Lance Leslie has continued his work in a variety of atmospheric modelling areas from global scales down to microscales. These include mesoscale and urban meteorology, high performance computing, predictability, and numerical weather prediction. Other research areas include severe weather events, prediction of air quality, and soil erosion modeling.

Bill McKee retired in July 2003, but is still associated with the department as a Visiting Fellow. He is continuing his work on the propagation of water waves across a shearing current. Two papers appeared in 2003 - one with Mike Hirschhorn from Pure Mathematics on the analytical evaluation of some improper double integrals arising in lee wave theory and another with his former student David Ghisolfi on oceanic fronts off southern Brazil.

Bill McLean visited the Isaac Newton institute at Cambridge University, for four weeks in January and February, as part of the programme, *Computational Challenges in Partial Differential Equations*. During September and October, he held an EPSRC Visiting Fellowship at the University of Bath, working with Ivan Graham on the conditioning of boundary element equations. The aim of this research is to prove sharp bounds on the extremal eigenvalues, and hence on the condition number, of the system matrix in cases when the boundary element mesh has a strongly anisotropic edge refinement.

Jason Middleton continued his oceanographic research on the topic of headland eddies, contributing to publications with Chris Aiken and Andrew Moore. In addition a new field project concerning nutrient uptake and circulation on a coral reef flat was planned with Greg Nippard, Moninya Roughan, Dr Baird and Rob Brander (School of Biological Earth and Environmental sciences) and implemented on Warraber Island, Torres Strait. 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. This work led to the completion of Moninya's PhD thesis which was approved through the year. He also co-supervised Jocelyn Dela-Cruz from the School of Biological Sciences whose PhD was submitted in October. Ann-Marie Wong continued her work on Antarctic ocean circulation and bottom water formation driven by sea-ice Formation. Peter Oke's PhD thesis on the east Australia Current was awarded, as was Peter Tate's PhD thesis on the rise and dilution of buoyant jets in the coastal ocean.

John Middleton continued his work into ocean shelf/slope dynamics with particular focus on Australia's southern shelves and Chile. Two papers have been re-submitted on the upwelling system off Punta Lavapie, Chile. The first shows that a likely mechanism for the enhanced biological productivity near Punrta Lavapie is related to the specific geometry of the region and prevailing winds. [The region can account for 2catch.] In particular, we have shown (Leth and Middleton 2004), the upwelling favourable winds lead to an equatorward coastal current and upwelling of water from depths of 250 m to 100 m or so. In conjunction with this upwelling, Point Lavapie deflects the equatorward current offshore leading to the formation of a cyclonic eddy that pumps deep nutrient rich water towards the adjacent Gulf of Aruaco. This water is then advected into the Gulf by a shallow headland eddy. An additional study dealing with the effects of remote forcing by El Nino/ La Ninais is also underway.

An additional paper was also written (Middleton and Leth 2004) that looks at the initial set-up of the wind-forced upwelling and the role of finite wind patterns in limiting the upwelling. The results were used to show that the equatorward boundary condition in numerical studies is crucial to getting the correct degree of upwelling. For our Chile study, we were able to show that the location of the adopted boundary condition was fortuitously correct.

John also continued his work on the shelf circulation along Australia's southern shelves. Two papers on the mean summer and winter circulation have appeared. In addition, further research has been supported through a grant of $423,000 obtained in collaboration with Tim Ward of the S.A. Research and Development Institute. The grant funded a one-year pilot study of the Trophodynamics of the Great Australian Bight. As part of this study, the first model of the ocean circulation that is driven by 6hourly winds and fluxes of heat and salt was developed (Middleton and Platov, 2004). In agreement

with limited observations, the model shows that the upwelling occurs as a 200 m deep plume to the south east of Kangaroo Is. This plume is advected to the west of the island and then towards the Eyre Peninsula.

In collaboration with Dr Gennady Platov (Novosiberk) and A/Prof Nathan Bindof (CRC Antarctic Research), further development of this model is planned for the next 5 years: our goal will be to develop an accurate hindcast/forecast model for the region. The Bureau of Meteorology have also indicated that they are keen to collaborate. In collaboration with Dr Mark Baird (UNSW) and SARDI, the modelling study here will also form part of a larger study to examine the biological consequences of the upwelling. A study dealing with the Ocean circulation around the eastern Bass Strait and Tasmanian regions is near completion and will be submitted soon.

Craig Arthur (MSc) is continuing to examine wind events that can force the upwelling favorable Flinders Current along the southern slope of Australia's continental shelf. The role of canyons in upwelling will be examined. John is also assisting Einar Oalson (MSc exchange; Iceland) in the development of a model for the ocean circulation around Iceland.

John Murray developed research topics in the general area of biomathematics. He published papers on epidemiology (the spread of HIV and hepatitis C virus among injecting drug users), transmission of drug resistant HIV, the way in which the immune system changes over our life-time, and general principles in cancer chemotherapy. His work expanded on these and related topics: how antiretroviral therapy may influence the spread of HIV, how drug resistance and treatment effectiveness are related. Much of this research is in collaboration with research centres from Australia and overseas.

John Roberts has continued his research into symmetries and reversing symmetries of polynomial automorphisms (with Professor M Baake, Greifswald), the creation of integrable maps (with Mr A Iatrou, La Trobe) and the detection of integrable maps (with Mr D Jogia, UNSW and Dr F Vivaldi, University of London). In 2003, publications on each of these topics appeared. In particular, the algebraic aspects of studying rational maps over finite fields seems open to many extensions and these were pursued vigorously in the second half of 2003 with Vivaldi in London (as part of an SSP programme). This work yielded many new and interesting results which will be written up in 2004. Also as part of his SSP, John visited Dr C Viallet at the University Pierre et Marie Curie and Professor H Capel at the University of Amsterdam. With Capel and Professor R Quispel, La Trobe, a new duality method of constructing higher-dimensional integrable maps is being investigated.

Danesh Jogia started a PhD on integrable maps with John in March 2003. In 2003, Rahmi Rusin successfully completed her MSc coursework thesis supervised by Dr Roberts. In October, John supervised a Year 11 student for a week as part of the CSIRO Student Research Scheme.

As part of his SSP in Session 2, John worked at Queen Mary, University of London with Dr Franco Vivaldi. John was awarded funds from the Australian Academy of Science, through its Scientific Visits to Europe Scheme, and by the EPSRC, through a Visiting Fellowship, to support this work. He gave invited lectures at the Department of Mathematics, University of Greifswald, and the Institute for Theoretical Physics, University of Amsterdam.

Colin Rogers has continued his research in collaboration with Dr Schief on hidden integrability in nonlinear continuum mechanics. This work has established solitonic connections 'inter alia' in hydrodynamics, the theory of fibre reinforced materials and the deformation of elastic membranes. His work in this area is conducted as a Chief Investigator within the recently awarded ARC Centre of Excellence for Mathematics and Statistics of Complex Systems. A new area of research involves the study of the geometry of liquid crystals and biological membrane.

Wolfgang Schief has continued his research on the project 'The generation and application of Geroch-type transformations in soliton theory' as part of his Queen Elizabeth II (QEII) Fellowship. The aim of the project is to bring together for the firrst time the analysis of symmetry transformations of Geroch type as known for the Ernst and Einstein-Maxwell equations of general relativity and infinitesimal Backlund transformations in the context of a very general integrable (soliton) system, the so-called Loewner-Konopelchenko-Rogers (LKR) system. Wolfgang 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 the isolation of hidden integrable structures in hydrodynamics, magnetohydrodynamics, the theory of shell membrane equilibria, liquid crystal theory and on the algebro-geometric origins of discrete master soliton system. His collaborators included Professor A.I. Bobenko, Technische Universität Berlin, Germany, Professor F. Burstall and Dr, A.D. King, University of Bath, UK, Dr. S.-Y. Lou, Shanghai Jiao Tong University, China and Professor C. Rogers, The University of New South Wales, Australia.

Ian Sloan continued his research in a number of areas. In quasi-Monte Carlo methods he conducted joint research with Xiaoqun Wang, Frances Kuo and Josef Dick, Henryk Woźniakowski (Columbia and Warsaw), Greg Wasilkowski (Kentucky) and Fred Hickernell (Hong Kong Baptist University). In this work the interest is in determining and achieving the best possible results for problems such as multiple integration in high dimensions for a variety of settings. Work on point distribution and approximation problems on the sphere continued with Robert Womersley, Kerstin Hesse and PhD student Paul Leopardi. A new project, with the aim of developing a method for certain parabolic problems with memory, was begun with William McLean and Vidar Thomée. With Ganesh and Steve Langdon progress was made on an efficient method for high frequency scattering of acoustic waves from three-dimensional objects.

Chris Tisdell progressively moved into the field of dynamic equations on time scales.

Chris established and solidified international research links by inviting (and hosting) several distinguished professors to UNSW. Chris actively collaborated with these, and other, eminent mathematicians during 2003.

Chris also continued to make scientific advancements in the fields of differential and difference equations. He received research support from the Australian Academy of Science for some of these endeavours.

Over five research papers were accepted for publication during the year.

Thanh Tran continued his research in efficient solvers for boundary integral equations (BIEs). He completed a paper on preconditioners for the h-p version Galerkin boundary element method in 3D. His interest in a posteriori error estimations for nonlinear parabolic equations was developed, and another paper, with Dr. T-B. Duong (UNSW), was completed. His collaboration with Associate Professor S. Rahman and PhD student A. Teimoori (School of Petroleum Engineering, UNSW) on the use of BIEs to calculate permeability tensor in naturally fractured reservoirs resulted in a paper to be published in J. Petroleum Science and Technology, and two refereed conference papers.

In January he delivered an invited talk at the Nonlinear Analysis Conference in Ho Chi Minh City.

Rob Womersley works on the development, analysis and application of optimization methods and the use of computational techniques in areas ranging across Finance, Management, Engineering and Science. Particular projects include extremal fundamental systems of points on the sphere and their use for polynomial interpolation and cubature with Ian Sloan, minimum energy point distributions on the sphere and torus (with Ed Saff, Vanderbilt, USA), optimal discretization of continuous optimization problems with Lucien Polak (EECS, UC Berkeley, USA), existence of solutions to under-determined nonlinear systems and spherical designs (with Xiaojun Chen (Hirosaki University, Japan), market models of implied volatility (with Ben Goldys). He is also interested in the effective use of high performance computing, in particular ScaLAPACK, for high dimensional global optimization problems.

6 RECENT PUBLICATIONS

6.1 Journal Articles and Conference Papers since 2001

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.

Publications

[1] **M. E. Baird**, Numerical approximations of the mean absorption cross-section of a variety of randomly oriented microalgal shapes, *J. Math. Biol.*, **47** (2003), 325–336.

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6.2 Books and Edited Proceedings since 2001

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5. **M. Ganesh and K. Mustapha**, A crank-Nicolson and ADi Galerkin method with quadrature for hyperbolic problems, AMR03/5 .
6. **M. Ganesh**, Fully discrete spectral methods for boundary integral equations on slender spheroids, AMR03/6.
7. **W. McLean** and V. Thomée, Time discretization of an evolution equation via laplace transforms, AMR03/7.
8. F.J. Hickernell, **I.H. Sloan** and G.W. Wasilkowski, On tractability of weighted integration for certain banach spaces of functions, AMR03/8.
9. F.J. Hickernell, **I.H. Sloan** and G.W. Wasilkowski, On strong tractability of weighted multivariate Integration, AMR03/9.
10. A. Iatrou and **J.A.G. Roberts**, Integrable mappings of the plane preserving biquadratic invariant curves III, AMR03/10.
11. **I.H. Sloan** and H. Woźniakowski, When does monte carlo depend polynomially on the number of variables? AMR03/11.
12. E. Novak, **I.H. Sloan** and H. Woźniakowski Tractability of approximation for weighted korobov spaces on classical and quantum computers, AMR03/12.
13. **M. Ganesh** and I.G. Graham, A high-order algorithm for obstacle scattering in three Dimensions, AMR03/13.
14. N. Dinh, **V. Jeyakumar** and G.M. Lee, Sequential lagrangian duality for abstract convex programs without regularity condition, AMR03/14.
15. **J. Dick and F.Y. Kuo**, Reducing the construction cost of the component-by-component construction of good lattice rules, AMR03/15.
16. **J. Dick and F.Y. Kuo**, Constructing good lattice rules AMR03/16.
17. **X. Wang, I.H. Sloan and J. Dick**, On korobov lattice rules in weighted korobov spaces, AMR03/17.
18. **F.Y. Kuo and I.H. Sloan**, Quasi-Monte Carlo methods can be efficient for integration over products of spheres, AMR03/18.

19. **K. Hesse and I.H. Sloan**, Worst-case errors in a sobolev space setting for cubature over the sphere S^2, AMR03/19.
20. **X. Wang and I.H. Sloan**, Why are high-dimensional finance problems often of low effective dimension? AMR03/20.
21. **J. Dick**, On the convergence rate of the component-by-component construction of good lattice rules, AMR03/21.
22. V. Thomée and L.B. Wahlbin, Maximum-norm estimates for finite-element methods for a strongly damped wave equation, AMR03/22.
23. **M. Ganesh** and **K. Mustapha**, A fully discrete adi method for a class of hyperbolic problems in three dimensions, AMR03/23.
24. **J. Dick, I.H. Sloan, X. Wang** and H. Woźniakowski, Good lattice rules in weighted Korobov spaces with general weights, AMR03/24.
25. **J. Dick** and **X. Wang**, A hybrid construction method for good lattice rules in weighted korobov spaces, AMR03/25.
26. **W.D. McKee**, The propagation of water waves across a shearing current, AMR03/26.
27. **T. Tran**, Additive schwarz preconditioner for the h-p version boundary element approximation to the hypersingular operator in three dimensions, AMR03/27.
28. B. Bialecki, bf M. Ganesh and **K. Mustapha**, A Crank-Nicolson Petrov-Galerkin method with quadrature for quasi-linear parabolic problems, AMR03/28.
29. **J. Dick** and F. Pillichshammer, Multivariate integration in weighted hilbert spaces based on walsh functions and weighted sobolev spaces, AMR03/29.
30. **J. Dick** and F. Pillichshammer, On the mean square weighted L^2 discrepancy of randomized digital (t, m, s)-nets over Z^2 AMR03/30.
31. **K. Hesse** and **I.H. Sloan**, High-order numerical integration on the sphere and extremal point systems, AMR03/31.
32. **C.C. Tisdell** and H.B. Thompson, On the existence of solutions to boundary value problems on time scales, AMR03/32.
33. J. Henderson, **Tisdell** and W.K.C. Yin, UNiqueness implies existence for three-point boundary value problems for second order dynamic equations, AMR03/33.
34. J. Henderson and **C.C. Tisdell**, Topological transversality and boundary value problems on time scales, AMR03/34.
35. P. Amster, M.C. Mariani, **C. Rogers** and **C.C. Tisdell**, On two-point boundary value problems in multi-ion electrodiffusion, AMR03/35.

7 EXTERNAL RESEARCH SUPPORT FOR 2003

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

7.1 Discovery Project Grants

M Banner and L Leslie $67,544
Incorporation of wave breaking into coupled marine wind-ocean wave models for severe weather conditions

M Banner, L Leslie $105,000
Wave breaking influence in an operational coupled model of the atmosphere-ocean wave boundary layers under very high wind conditions

M England and CJC Reason $57,500
Midlatitude variability in the Southern Ocean and its role in Australian climate

B Henry and SL Wearne $60,000
Diffusion driven pattern formation and signal propagation in spatially complex excitable media

Jason Middleton $87,000
Coastal processes driven by the East Australia current

L Qi, RS Womersley and Y Ye $55,000
Generalized Newton methods for constrained approximation problems and sum of norms problems

C Rogers and W Schief $75,000
Deformation of isothermic surfaces and K- nets in membrane theory and nonlinear elasticity. Application of solitonic methods

IH Sloan and M Ganesh $100,000
Advanced computational algorithms for three-dimensional systems

IH Sloan, H Woźniakowski, S Joe, RS Womersley $70,000
Multivariate integration and approximation

IM Suthers and ME Baird $67,967
Development of a mechanistic model of marine biological activity

7.2 ARC- Linkage Grant

IM Suthers, ME Baird and GI Tuckerman $26,500
A biogeochemical study of a coastal lagoon - assessment of a mechanistic model

7.3 ARC-CSIRO Linkage Grant

M England and R Matear $193,035
Quantifying the role of the Southern Ocean for anthropogenic CO2 uptake

7.4 SARDI and FRDC - Research Grants

ME Baird and IM Suthers $6,611
Trophodynamics of the Great Australian Bight: a coupled physical-biological model

T Ward, John Middleton, C Bullman $423,000
Trophodynamics of the Great Australian Bight

7.5 University Research Support

P Blennerhassett $5,000
Stability Properties of oscillatory flow in pipes and channels

M England $15,000
Souther Ocean water-masses: stability, variability and long-term change

M England $12,000
Extratropical ocean variabiligy and its role in extremes and predictability of Australian climate

V Jeyakumar $15,000
Nonsmooth variational conditions characterizing solution sets of
cone-constrained convex optimisation problems

L Leslie and L Qi $12,000
Incorporating ensemble forecast techniques in a numerical model for
tropical cyclone simulation and prediction

JM Murray $12,000
Quantitative analysis of human immunodeficiency virus,
hepatitis B virus, and T cell response

JAG Roberts $16,000
Detection and creation of discrete integrable dynamical systems

C Tisdell $10,000
On the existence of multiple solutions to nonlinear boundary value problems
for system of second order, ordinary differential equations

7.6 IREX Grant

IH Sloan, M Ganesh and B Bialecki $15,000
Computational schemes for initial-boundary value problems

7.7 External Collaborative Grants

M Banner, IR Young and A Banain (Adelaide) $75,000
Modelling of finite depth wind wave dissipation

JAG Roberts, F.Vivaldi $GBP 10,000
Integrable maps over finite fields: period distribution

SL Wearne (PI), BI Henry (Consultant) $US156,000
Biophysically-based modelling of the velocity storage neural integrator,
(US National Institute of Health Grant)

SL Wearne (CI), P.R. Hof (CI), BI Henry(Consultant) $US90,000
Mathematical analysis and modelling of dendritic branching and spine
distribution as correlates of neural integration and age-related deficits
in working memory, Howard Hughes Medical Institute Grant

8 VISITORS

1. Dr Emily Pidgeon, Scripps Institution of Oceanography, USA (M England)
2. Professor Burak Aksoylu, 3–15 July, 2003
3. Professor Robert Anderssen, CSIRO, 13–16 July, 2003 (I Sloan)
4. Professor Kendall Atkinson, IOWA, 13–16 July, 2003 (I Sloan)
5. Professor Xiaojun Chen, Hirosaki University, Japan, 1 August–12 September, 2003 (R Womersley)
6. Dr Andrew Coldman, British Columbia Cancer Agency, 16–30 August, 2003 (J Murray)
7. Professor Tony Degasperis, University of Rome, 7–28 January 2003 (C Rogers)
8. Dr Jeff Dewynne, 17–22 September, 2003
9. Dr Nguyen Dinh, Pedagogical Institute of Ho Chi Minh City, 6 October–14 November, 2003 (V Jeyakumar)
10. Professor Graeme Fairweather, Colorado School of Mines, 13–16 July, 2003 (I Sloan)
11. Professor Willi Freeden, Kaiserslautern, 13–16 July, 2003 (I Sloan)
12. Professor Miguel Goberna, University of Alicante Spain 17 November–15 December, 2003 (V Jeyakumar)
13. Professor Ivan Graham, Bath, 13–16 July, 2003 (I Sloan)
14. Professor Bingsheng He, Nanjing University of China, 30 October–3 November, 2003, (H Qi)
15. Professor Johnny Henderson, Baylor University TX USA, 3–21 June, 2003 (C Tisdell)
16. Professor Thomas Hou, Caltech 13–16 July, 2003, (I Sloan)
17. Professor Colin Ingalls, University of New Brunswick, 6–15 May, 2003, (D Chan)
18. Dr Gilbert Kaufmann, University Hospital, Basel Switzerland, 17–28 May, 2003 (J Murray)
19. Professor Reiner Kress, Gottingham 13–16 July, 2003 (I Sloan)
20. Prof Rajesh Kulkarni, Michigan State University, 4–19 May, 2003 (D Chan)
21. Prof Rekha Kulkarni, Indian Institute of Technology, 3–4 July, 2003 (I Sloan)
22. Professor John Frances Le Marshall, Bureau of Meteorology, Melbourne, 1 April 2003–1 April 2006 (L Leslie)
23. Dr Ben McNeil, Princeton University, USA (M England)

24. Professor Adriano Montanaro, Universita' di Padova, Italy,10–19 September 2003 (C Rogers)
25. Professor Jan Van Neervan, Delft University, 2–31 January, 2003 (M Banner)
26. Professor Harald Niederreiter, Singapore, 6–19 July, 2003 (I Sloan)
27. Professor Gongbing Peng, Chinese Academy of Sciences, 1 April, 2003–1 April 2006 (L Leslie)
28. Professor Alan Perelson, LosAlamos National Laboratory, 2–12 April 2003 (J Murray)
29. Dr John Perram, Maersk McKinney Moller Institute, Denmark, 2–31 January, 2003 (M Banner)
30. Professor Alan Peterson, University of Nebraska, 14 May– 2June 2003 (C Tisdell)
31. Dr Emily Pidgeon, Scripps Institution of Oceanography, USA, December, 2003 (M England)
32. Dr Guennady Platov, Novosibirsk, 03 November–21 December, 2003 (J Middleton)
33. Professor Elijah Polak, University of California, 6–21 June, 2003 (R Womersley)
34. Professor Liqun Qi, Hong Kong Polytechnic University, 1 September–1 October, 2003 (C Rogers)
35. Dr Ramajayam Sahadevan, 6 November, 2003 (J Roberts)
36. Professor Edward Saff, Vanderbilt, 13 July–3 August, 2003 (Ian Sloan)
37. Professor Avraham Sidi, 3–4 July, 2003 (I Sloan)
38. Miss Flora Shi, Casimir Catholic College, 7–10 October, 2003 (J Roberts)
39. Professor E Stephan, Hannover, 13–17 July 2003 (I Sloan)
40. Professor Vidar Thomée, Chalmers, 12–26 July, 2003 (I Sloan)
41. Professor Vidar Thomée, Chalmers, 2 December–15 January 2004 (I Sloan)
42. Professor Lloyd Nick Trefethen, Oxford, 13–16 July, 2003 (I Sloan)
43. Dr Franco Vivaldi, Queen Mary, University of London, 3–17 April, 2003 (J Roberts)
44. Professor Lars Wahlbin, Cornell, 13–16 July, 2003 (I Sloan)
45. Dr Xiaoqun Wang, Tsinghua University, (I Sloan)
46. Dr Susan Wearne, Mount Sinai School of Medicine NY, 4–16 August, 2003 (B Henry)
47. Professor Wolfgang Wendland, Stuttgart, 13–16 July, 2003 (I Sloan)
48. Professor Henryk Wozniakowski, Warsaw and Columbian University, 1 July–12 August, 2003 (I Sloan)
49. Professor Vladimir Zakharov, Arizona, 16 July, 2003 (I Sloan)

9 CONFERENCES AND SEMINARS

9.1 ICIAM 2003

Many memebers of the Department were involved in the preparations for the largest applied mathematics event ever held in the Southern Hemisphere, the fifth International Congress of Industrial and Applied Mathematics held at the Sydney Convention Centre in July. Ian Sloan was the Chair of the International Program Committee for ICIAM 2003 and a key member of the Organising Committee. Many members of the Department assisted with the mammoth task of classifying and assessing abstracts of talks. Others assisted by organising and participating in minisymposia and sessions of contributed talks, or helping with publicity. The School of Mathematics also assisted in a very direct way, by being a major financial sponsor of the event.

9.2 Workshop on the Mathematics of Computation and approximation

This two-day event, in honour of Ian Sloan's 65th birthday, was held in the days following ICIAM 2003 to take advantage of the large number of distinguished overseas mathematicians in Sydney at that time. The program, consisting of fifteen invited talks of outstanding quality, was organised by Dr M Ganesh.

9.3 Workshop on Computational Analysis on the Sphere

This workshop, held in Nashville, Tennessee, in November 2003 was co-sponsored by the ARC Centre of Excellence for Mathematics and Statistics of Complex Systems. It was in a real sense a UNSW Applied Mathematics event, with four members of the Department (Sloan, Womersley, Hesse and Leopardi) taking part.

9.4 Applied Mathematics Seminars

Organizer: John Roberts

23 January
Professor John Perram (The Maersk Mc-Kinney Moller Institute for Production Technology, University of Southern Denmark)
Experiments with IT- enhanced teaching of dynamical systems and analytical mechanics using Mathematica

31 January
A/Professor Michael Nielsen (University of Queensland)
Quantum information and computation

13 February
Professor Philip Treharne (Cambridge University)
Boundary value problems for systems of linear evolution equations

13 March
Professor Georg Gottwald (University of Sydney)
A new test for Chaos

20 March
Professor K Konno (Department of Physics, Nihon University, Tokyo)
Initial value problems of the vortex equation-stretching and shrinking of vortex filaments

27 March
Professor P. Forrester (University of Melbourne)
Random matrices and Painlevé Theory

4 April
Professor Alan Perelson (Los Alamos National Laboratory, USA)
hiv Reservoirs, Low steady state viral loads, and viral blips

10 April
Dr Franco Vivalid (Queen Mary, University of London)
Discrete dynamics and algebraic numbers

15 May (3 talks)
Mr Duraid Madina (High performance Computing Support Unit, UNSW)
Quantum Computation: The Good, the bad and the ugly

5 June
Mr Paul Leopardi
A generalized FFT for Clifford algebras

3 July
Dr Burak Aksylu (Department of Computer Science, California Institute of Technology
Multilevel solvers in computer graphics applications

3 July
Professor Avram Sidi (Computer Science Department, Technion -Israel Institute of Technology
New quadrature methods for Fredholm integral equations from nonlinear two-point boundary value problems

16 July
Professor Vladimir Zakharov (University of Arizona)
New solutions in dynamics of an ideal fluid with free surface

21 July
Professor Lucien Polak (UC Berkeley)
An algorithm for generalized semi-infinite optimization problems based on augmented Lagrangians

24 July
Professor E.B. Saff (Vanderbilt University
Logarithmic potentials with external fields

7 August
Professor Kenji Kajiwara (Kyushu University)
Hypergeometric solutions for the discrete Painlevé equations

27 August
Dr Mark Baird (UNSW)
Applications of bio-mechanics in aquatic ecosystems

27 August
Dr Neil Holbrook (Division of Environmental and Life Sciences, Macquarie University)
Can Pacific Ocean thermocline depth anomalies be simulated by simple linear one-dimensional and two-dimensional models?

28 August
Dr Gary Froyland (BHP Billiton Innovations, Melbourne)
Statistically optimal almost-invariant sets

29 August
Dr Alex James (Sheffield Hallam University, UK)
Modelling growth and foraging in fisheries recruitment

4 September
Professor Xiajun Chen (Hirosaki University, Japan)
Nonsmooth discretized constrained optimal control problems

23 October
Professor Vladimir Novikov (Landau Institute for Theoretical Physics, Moscow)
Perturbative symmetry approach: integrability conditions for PDE's

22 September
Dr John Terry (Loughborough University, UK)
Nonlinearity in Neural systems: from microscopic formulation to macroscopic detection

7 November
Kassim Mustapha (UNSW)
A Petrov-Galerkin method with quadrature for elliptic boundary value problems

18 November
Dr Bill McLean (UNSW)
Quadrature for boundary element methods

4 December
Professor Vidar Thomée (Chalmer University of Technology
Basic semigroup theory and initial value problems

5 December
Dr Liam Wagner (Department of Mathematics & St John's College, University of Queensland)
Marine reserve design and optimal inter-reserve distance spacing

8 December
Elizabeth Smith (Honours Student)
Simple box models of the ocean's thermohaline circulation

10 December
Professor Edwin Howard Armstrong (Columbia University)
Algorithms and complexity for continuous problems on quantum computers

11 December
Professor Vidar Thomée (Chalmer University of Technology)
Analytic semigroups and parabolic problems, with spatial discretization

11 December
Professor Robert Clark, FAA, Director of ARC Centre of Excellence for Quantum Computer Technology
How to develop logic elements for a silicon-based solid state quantum computer

16 December
Professor Vidar Thomée (Chalmer University of Technology)
Operational calculus and time stepping

9.5 Oceanography and Meteorology Seminars

Organizer: Matthew England

27 May
Dr Ben McNeil, Princeton University
Inferring global carbon sinks using oceanic CFC measurements

4 June
Dr Bill McKee, UNSW
The propagation of water waves across a shearing current

18 June
Agus Santoso, UNSW
Antarctic intermediate water variability in a coupled climate model

3 July
Dr Johnny Chan, City University of Hong Kong, and Director, Shanghai Typhoon Institute
Potential vorticity tendency in tropical cyclone motion

14 August
Dr Mark Baird, UNSW
A pelagic ecosymstem model with bio- mechanical descriptions of biological processes in a idealised 1-D ocean basin

12 December
Dr Emily Pidgeon, Scripps Institution of Oceanography
Observations of Diurnal structures on the central California coast

10 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 22 students were enrolled during 2003 for studies leading to higher degrees.

10.1 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 16 students were enrolled in PhD programmes during 2003.

Student	**Research Topic**	**Supervisor**
Jaci Brown	ENSO and IOD dynamics and teleconnections	Leslie/England
Josef Dick	High dimensional integration	Ian Sloan
Alex Sen Gupta	Decadal to multi-century global ocean ventilation processes	England
Danesh Jogia	Integrable maps	Roberts
Eunjoo Jung	Wet deposition and convective transport of aerosols	Shao/Leslie
Paul Leopardi	Approximation and point distribution on the sphere	Sloan/Womersley
Catherine Morgan	Robust optimization and naval applications	Womersley
Kassim Mustapha	Fully discrete computational methods & analysis for elliptic & parabolic problems	Ganesh/Sloan
Agus Santoso	Natural variability of Southern Ocean water-masses	England
Lila Singh	Atmospheric modelling and photochemical smog	England

Elly Spark	Mesoscale meteorology	Leslie/Dunsmuir
Willem Sijp	Climate response to large-scale topographic and hydrological perturbations	England
Kwok Tan	Atmospheric modelling	Leslie
Peng Xu	Land salination	Shao
Haixiong Zhuang	Atmosphere-ocean surface and atmosphere-land surface interactions	Shao
Anne-Marie Wong	Oceanography	Jason Middleton

10.2 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 6 students enrolled in MSc programmes during 2003.

Student	**Research Topic**	**Supervisor**
KL Batt	Mesoscale Meteorology	Leslie
Craig Arthur	The Flinders Current and role of Canyons in upwelling	John Middleton
Pimphen Charoen	Immunological Dynamic System	Murray
Francis Reid	Hydrodynamic Stability	Blennerhassett
PA Graham	Timing of antiretroviral therapy for HIV	Murray
GN Grice	Constant speed flows & the nonlinear Schrödinger equation	Wolfgang

10.3 Honours Programme

In 2003 two students completed Honours degrees in Applied Mathematics:

Student	**Research Topic**	**Supervisor**
John Ormerod	Semidefinite programming approaches to support vector machines	V Jeyakumar
Elizabeth Smith	On the stability of the ocean's thermohaline circulation in a box model	M England