APPLIED MATHEMATICS

ANNUAL RESEARCH REPORT

2002

Editor: Bruce I Henry

Address: School of Mathematics
UNSW Sydney 2052
Australia

Telephone: 02 9385 7044
Fax: 61 2 9385 7123
email: b.henry@unsw.edu.au

Typeset: Mayda Shahinian

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1 APPLIED MATHEMATICS AT UNSW, 2002

The inaugural Professor of Applied Mathematics was appointed at the University of New South Wales in 1959. The Department of Applied Mathematics was established in the early 1960's. The Departments of Pure Mathematics, Applied Mathematics and Statistics together now constitute the School of Mathematics. It is located in the Red Centre, part of the Science Precinct of the Kensington Campus

The University of New South Wales has now one of the leading Applied Mathematics Departments in Australia, with an outstanding program of research and teaching. The year 2002 has seen important achievements by, and developments in, the Department.

The Department celebrated some significant personal achievements during 2002. Michael Banner was awarded the Sverdrup Gold medal of the American Meteorological Society. This award, named after Harald Ulrik Sverdrup, a pioneer in the field of oceanography, recognizes outstanding contributions to the scientific knowledge of interactions between the oceans and atmosphere. Ian Sloan was honoured by receiving (jointly with A. J. Van der Poorten) the first George Szekeres Medal of the Australian Mathematical Society. This award recognizes a combination of outstanding research achievement and service to the profession in Australia over many years. Late in the year, the Australian Research Council announced 5 years of funding for the Centre of Excellence for Mathematics and Statistics of Complex Systems. Colin Rogers and Ian Sloan (together with Tony Dooley in Pure Mathematics) are Chief Investigators for the Centre, making UNSW one of the major nodes for the Centre of Excellence.

The Department made several appointments during the year. Matthew England completed his tenure of an ARC QEII Fellowship and joined the Department as Senior Lecturer in July. Thanh Tran was previously at Deakin University and before that was Postdoctoral Fellow at the Australian National University, and joined the Department as Senior Lecturer in January. These appointments have not only given stability to the staffing profile of the Department, but they have also strengthened our expertise in the fields of Oceanography and Computational Mathematics. Robert Womersley was appointed as Associate Professor in April. This appointment reflects Rob's considerable contribution to the Department in terms of research in Optimization and Computational Mathematics and to the development of Financial Mathematics within the School of Mathematics. Mark Baird joined the Department as ARC Postdoctoral Fellow in January.

Our links with the international scientific community are vigorous. Members of the Department engaged in many scholarly activities during the year. Lance Leslie continued as chair of the World Meteorological Organization's Committee on Comparison of Regional Model Experiments, and remained on the American Meteorological Society Awards Committee. Ian Sloan continued his work as Chair of the International Program Committee for ICIAM 2003, to be held in Sydney in July 2003. Colin Rogers is the Aus-

tralian representative (with Neil Trudinger) on the organizing Committee for the Pacific Rim Conference on Mathematics, to be held in Vancouver, Canada in 2004. Vaithilingam Jeyakumar served on the Advisory Committee for the 7th International Conference on Generalized Convexity/Monotonicity, held in Hanoi, Vietnam in 2002.

The members of the Department were extremely active on Editorial Boards of major international journals. Bill McLean continued as Associate Editor of the Australian and New Zealand Industrial Applied Mathematics (ANZIAM) journal. 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 joined as Associate Editor of the SIAM Journal on Numerical Analysis, and continued on the Editorial Boards of the Journal of Complexity, Computational Methods in Applications, and Advances in Computational Mathematics. Matthew England remained on the Editorial Boards of the Journal of Marine Systems and the Journal of Ocean and Atmospheric Data Management. Vaithilingam Jeyakumar has been invited to join the Editorial Board of the ANZIAM journal as Associate Editor.

Our links with the Australian scientific community are equally vigorous. Jason Middleton continued as a member of Antarctic Science Advisory Committee and as a Board member of Airborne Research Australia. He remained as a reader for the Australian Research Council. Lance Leslie remained on the Australian Academy of Science Committee on Meteorology and Oceanography, and as a Reader for the Australian Research Council. Colin Rogers served as Deputy Chair of the Sectional Committee for Mathematical Sciences of the Australian Academy of Science. Matthew England continued as a member of the Scientific Steering Committees for the Australian Community Ocean Models (ACOM).

Many members of the Department travelled overseas to be involved in research collaborations or to attend conferences. Bruce Henry presented the plenary lecture at the International Workshop on Complex Systems, Pukyong National University, Korea. Matthew England presented an invited talk at the 34th International Liege Colloquium, Liege, Belgium. Colin Rogers presented invited lectures at the International Symposium on Computational mathematics and Applications in Dalian, China, and at the International Nonlinear Evolution Equations and Dynamical Systems Meeting in Cadiz, Spain. He spent the early part of the year at Hong Kong University of Science and Technology, where he presented the distinguished lecture at the Annual Meeting of the Hong Kong Society of Theoretical and Applied Mechanics. Invited lectures were also presented at the University of Cambridge, the Universita di Roma, and at the Universita di Lecce, Italy. Wolfgang Schief travelled to Germany, where he gave three series of lectures at the Technische Universitat Berlin. He also presented invited lectures at the Department of Applied Mathematics and Theoretical Physics, University of Cambridge, and at the Euro Conference on Symmetries and Integrability of Difference Equations V, in Giens, France. Michael Banner attended the Mark Donelan Anniversary Air-Sea Interaction Symposium

in Miami, USA, and the Seventh International Workshop on Wave Modelling in Banff, Canada. John Roberts presented an invited talk at the Euro Conference on Symmetries and Integrability of Difference Equations V, in Giens, France. John Murray travelled to Los Alamos National Laboratory, USA, and to the British Columbia Cancer Agency, Canada, to continue his research collaborations in the areas of cancer chemotherapy and HIV modelling.

The current areas of research and a brief record of the research activities in the Department are described later in the report. The research of the Department was again recognized by substantial external support.

The Department maintained an active program of study at the graduate level, by both course work and research. A total of 15 students were enrolled during 2002 for studies leading to higher degrees, and 7 additional students were awarded a PhD in Applied Mathematics in 2002. The Department also conducted a review of its undergraduate courses in 2002, redesigned its second year courses, and introduced a new second year course, Biomathematics, to broaden its teaching program.

In summary, 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 50 research papers in 2002 in leading professional journals.

All in all, the Department recorded a very successful year in 2002. The highest priority in 2003, of course, will continue to be the maintenance of the Department's high international standing in its chosen areas of research.

Vaithilingam Jeyakumar[1]
Head, Department of Applied Mathematics.

[1]The author has gained valuable information on the history of the Department from the discussion, which he had with Jim Franklin, George Szekeres, Ian Sloan and Jim Douglas.

2 STAFF

2.1 Academic and Professional Staff

Scientia Professor

Ian H Sloan, BA BSc *Melbourne*, MSc *Adelaide*, PhD *London*, FAIP, 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 Professors

Vaithilingam Jeyakumar, BSc *Jaffna*, PhD *Melbourne*
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*
Thanh Tran, BSc Hons *HCM City*, PhD *UNSW*

Lecturer

David C Guiney, BSc PhD *Adelaide*

Associate Lecturer

Eileen M Sheppard, BSc *London*

QE2 Research Fellows

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

Research Fellows

Suxia Liu, PhD *Inst f Geography, Chinese Academy of Sciences* MS BE *Hohai, Nanjing, China*
Hou-Duo Qi, BSc *Peking*, PhD *Chinese Academy of Sciences*

Senior Research Officers

Ekaterini E Kriezi, MSc Ms Civil Eng PhD *Auth Greece*
Russel P Morison, MSc *Monash*
Lixin Qi, MS Chinese Acad Meteo Sci, BSc *Zhongshan*, PhD UNSW

Visiting Professors

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

Adjunct Associate Professor

Russell Standish, BSc PhD ANU

Visiting Fellows

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

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*
Frances Kuo, BCMS PhD *Waikato*
Jian Li, BSc *Inner Mongolia*, PhD *Shanghai Univ. Sci. Tech.*
Suxia Liu, BEng, MEng *Hohai*, PhD *Inst. Geography, Chinese Academy of Sciences*
Senyue Lou, PhD *Fudan*
Peter Oke, BSc PhD *UNSW*
Xiaoqun Wang, PhD *St Peterburg State* (Russia)
Liping Xia, MSc, PhD *University of Hong Kong*
Guanglu Zhou, PhD *Chinese Acad Sci*

Professional Officer

Gregory J Nippard, BSc *Sydney*

Computer System Officer

D.J. Dowsett, BSc *Sydney*, BA *Macquarie*

2.2 Appointments and Promotions

Mark Baird took up an ARC Postdoctoral Fellowship in 2002.
Matthew England completed tenure of an ARC/QEII Research Fellowship December 32, 2002, and took up appointment as Academic Staff (Level C).
Yapping Shao was promoted to Associate Professor in 2002.

2.3 Committee Memberships, Awards and Invitations

Michael Banner was awarded the Sverdrup Gold medal of the American Meteorological Society. This award, named after Harald Ulrik Sverdrup, a pioneer in the field of oceanography, is granted to researchers who make outstanding contributions to the scientific knowledge of interactions between the oceans and the atmosphere. The citation for this award was "for advancing the understanding of wave dynamics, especially wave breaking and the role of waves in air-sea interaction." It is awarded by the President of the Society on the advice of an international committee appointed in consultation with representatives of the Scripps Institute of Oceanography, La Jolla, California and the University of Bergen, Bergen, Norway. He attended the Mark Donelan Anniversary Air-Sea Interaction Symposium, in Miami and the Seventh International Workshop on Wave Modelling, Banff, Canada in October.

Matthew H England was an invited speaker at the 34th International Liege Colloquium on Tracers in Ocean Dynamics, Liege, Belgium, 2002. He 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. He continued as an Honorary Research Associate at CSIRO Atmospheric Research and an Honorary Research Fellow of the Antarctic CRC.

Bruce Henry presented the opening invited talk at the 1st International Workshop on Complex Systems, Pukyong National University, Busan, Korea in June. He presented talks at ANZIAM 38th Applied Mathematics Conference in February and at the Australian Statistical Mechanics Meeting in November.

Vaithilingam Jeyakumar served as a member of the Advisory Committee for the 7th International Conference on Generalized Convexity/Monotonicity, held in Hanoi, Vietnam.

Lance Leslie is the Director of the Centre for Environmental 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 continued as a reader for the Physics, Chemistry and Geosciences Expert Advisory Committee of the Australian Research Council. He also continued as 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.

John Roberts was an invited speaker and participant at 'Symmetries and Integrability of Difference Equations (SIDE) V' in Giens, France. In December 2002, John was awarded travelling funds for 2003 under the Scientific Visits to Europe programme of the Australian Academy of Science.

Colin Rogers continued on the Editorial Boards of Journal of 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. He is the Australian representative with Neil Trudinger on the organising Committee for the Pacific Rim Conference on Mathematics to be held in Vancouver, Canada in 2004. He is Deputy Chairman of the Sectional Committee for Mathematical Sciences of the Australian Academy of Science. He was an invited speaker at the International Symposium on Computational Mathematics and Applications in Dalian, China and at the International Nonlinear Evolution Equations and Dynamical Systems Meeting in Cadiz, Spain.

Wolfgang Schief was invited to give three lectures at the Technische Universität Berlin, Germany as part of his visits in February and June. In May, he visited the Department of Applied Mathematics and Theoretical Physics (DAMTP) at the University of Cambridge where he presented an invited lecture. In June, he gave a lecture at the Euro Conference 'Symmetries and Integrability of Difference Equations (SIDE) V' in Giens, France.

Ian Sloan continued his preparations for the scientific program at ICIAM 2003, and for his role as President of the International Council for Industrial and Applied Mathematics, which will commence after the Congress. He was honoured during the year by receiving (jointly with A.J. Van der Poorten) the first George Szekeres Medal of the Australian Mathematical Society).

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.

Applied Analysis and Optimization

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

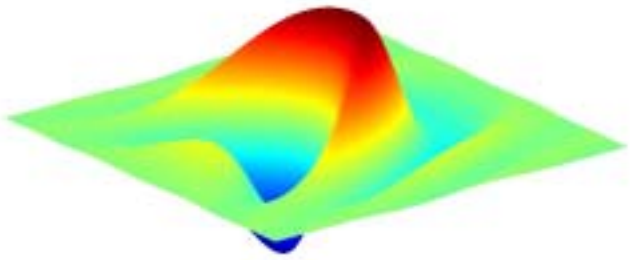


Figure 1: Surface of a minimization objective function

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

J Murray, B I Henry

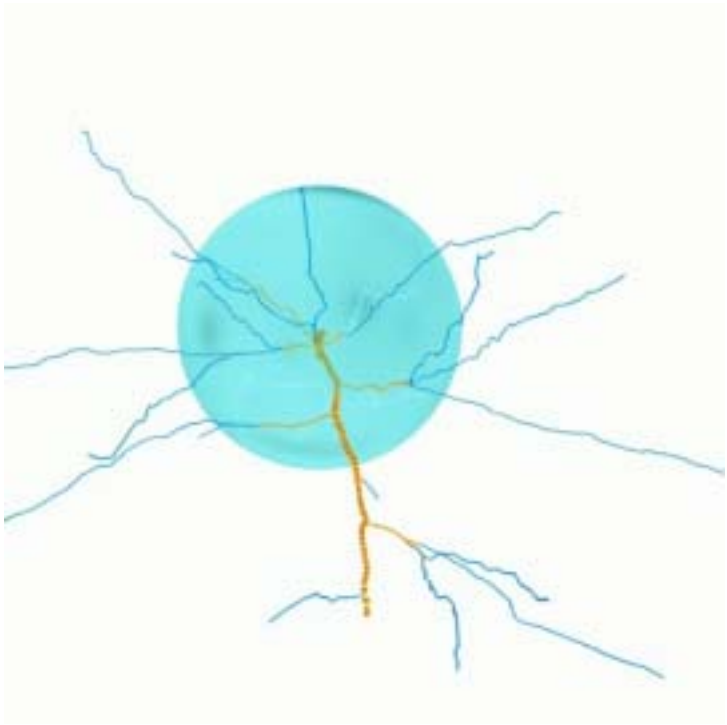


Figure 2: Digitized image of a pyramidal neuron from a macaque monkey

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 H Sloan, T Tran, R Womersley
Adjunct Faculty: V Thomée

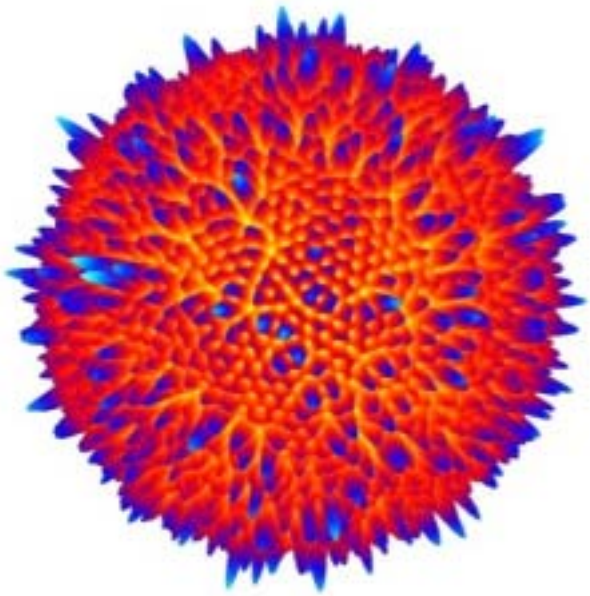


Figure 3: Function used in interpolating points on a sphere

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 for Mathematics and Statistics of Complex Systems.

Geophysical Fluid Dynamics

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

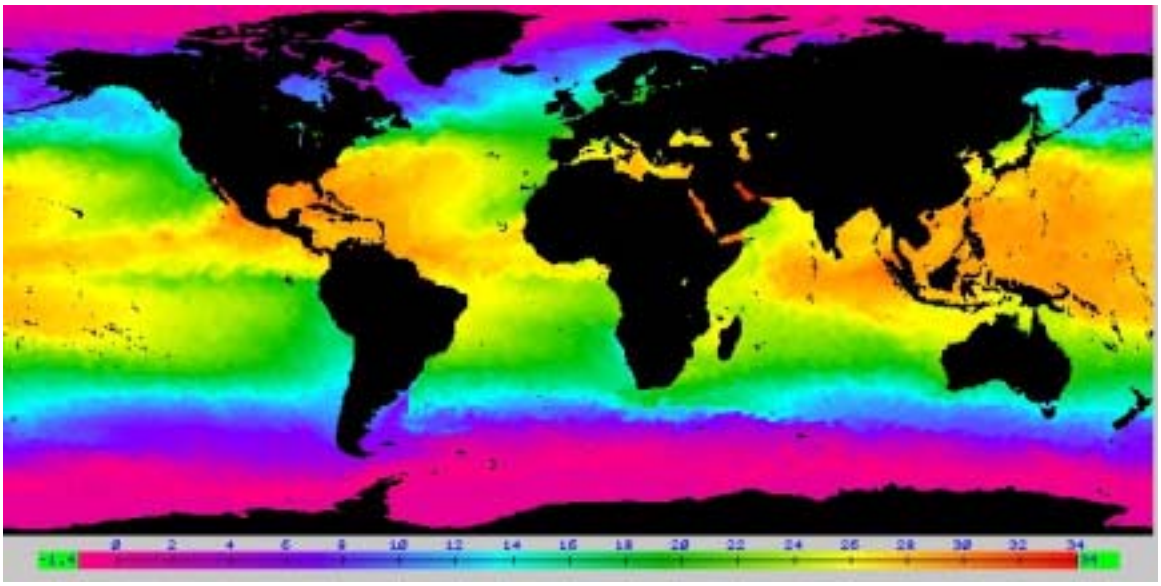


Figure 4: Thermoclines in global climate modelling

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 I Henry, J Roberts, C Rogers, WK Schief

Adjunct Faculty: MJ Ablowitz, AP Bassom, R Grimshaw, WH Hui, P Winternitz

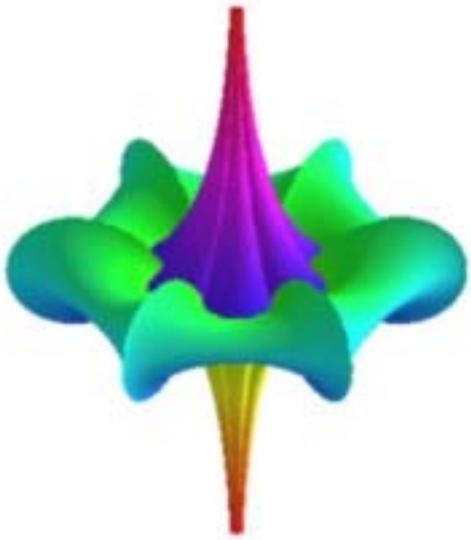


Figure 5: Breather Soliton Surface of the Nonlinear Schrödinger Equation

"... 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.

The Department is continuing to develop research and application in new areas. Two areas currently under development are Financial Mathematics and Stochastic Models.

Financial Mathematics

Figure 6: A feasible region for semi-definite programming

Quantitative finance and risk management have become increasingly mathematical, using sophisticated techniques from stochastic calculus and related numerical methods. This area will continue to grow, involving collaboration with the Department of Statistics within the School and the School of Banking and Finance and the Department of Actuarial Studies from the Faculty of Commerce and Economics.

Stochastic Models

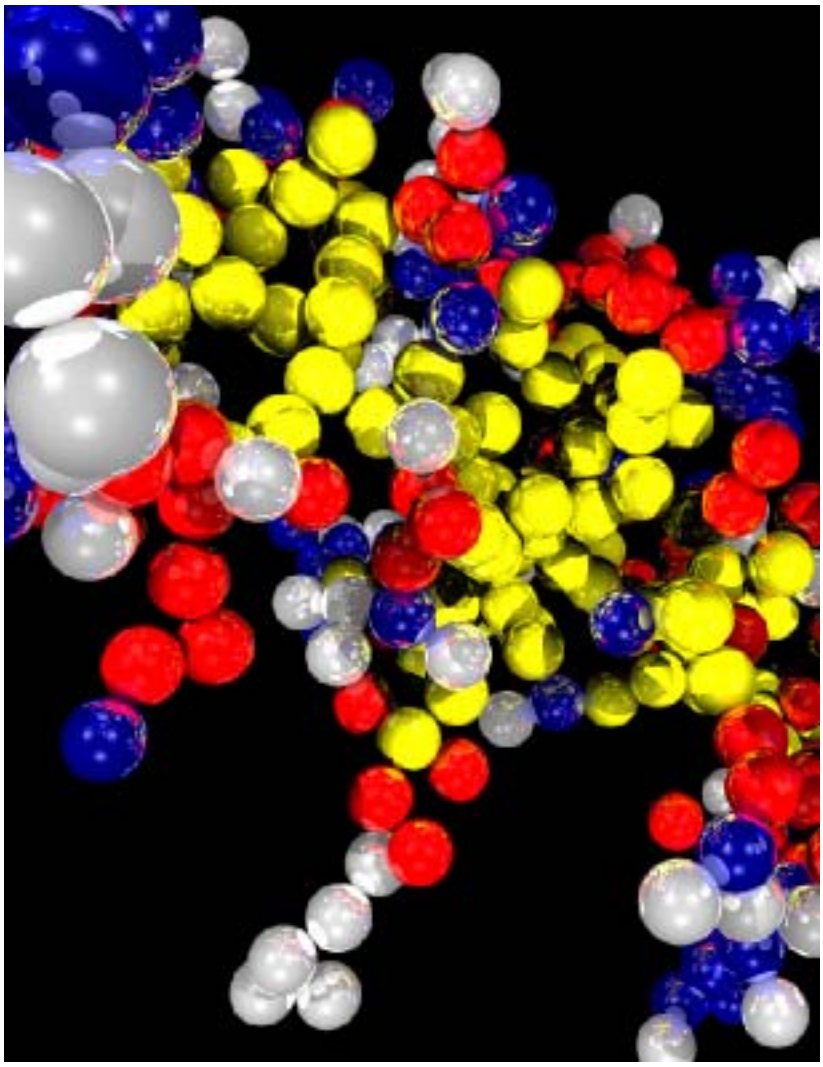


Figure 7: Stochastic dillusion limited aggregation in 3D

Stochastic methods are essential to develop higher levels of understanding of systems in which there are uncertainties. Uncertainties are ubiquitous in ocean-atmosphere systems, financial systems and biomedical systems. For example, two recently developed tools that have proven particularly useful for analysing aperiodic and noisy data are the multifractal spectrum and the wavelet transform. The incorporation of stochastic methods in Applied Mathematics is seen as one of the key areas for future development, and will benefit greatly from collaboration with the Department of Statistics.

4 RESEARCH CENTRES

Centre for Environmental Modelling and Prediction (CEMAP)

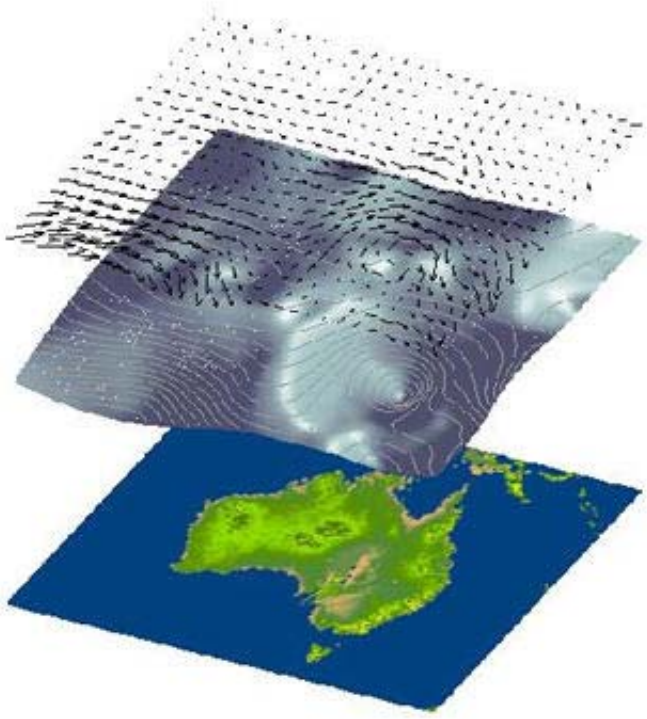
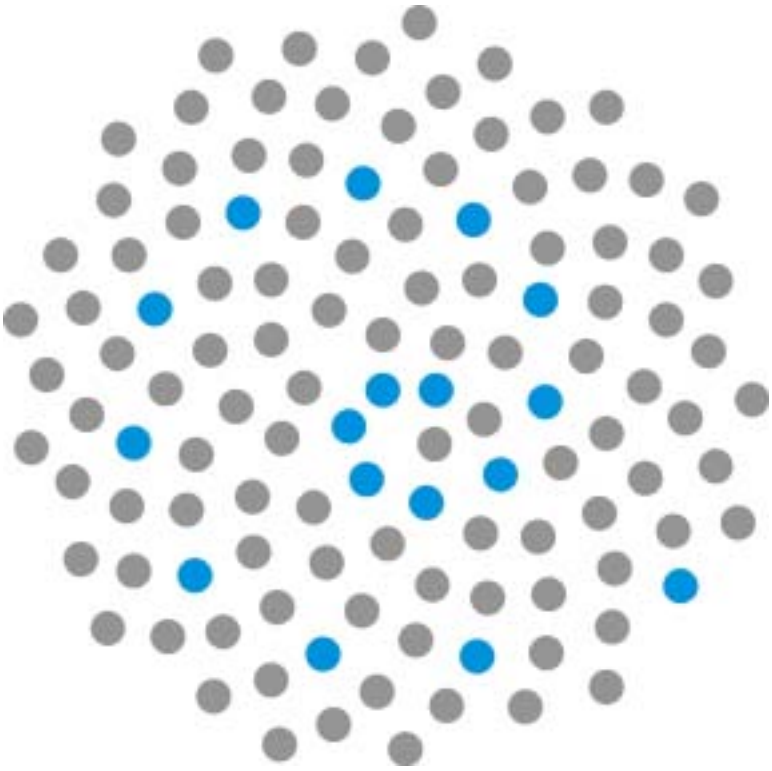


Figure 8: Multiscale numerical weather prediction over Australia

This is a University Research Centre within 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.

ARC Centre of Excellence for 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 center include nonlinear dynamical systems, Monte Carlo methods, and scientific computation.

5 RESEARCH ACTIVITIES

During 2002, 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.

Mark Baird's research in biological oceanography involved both modeling and field work. He began an ARC Postdoctoral Fellowship to investigate numerical modeling of plankton population dynamics in the East Australian Current. In 2002 a biological sub-module for the Princeton Ocean Model was developed, and simulations run on the APAC supercomputer facility at ANU. This work involves a collaboration with Assoc. Professor Iain Suthers from the School of Biological, Earth and Environmental Sciences, and Professor Jason Middleton.

At the same time, Dr Baird undertook field work to correlate nutrient uptake measurements with energy dissipation on coral reef flats. This research involved field trips to Warraber Island, Torres Strait (with Dr Brander from the School of Biological, Earth and Environmental Sciences, Dr Roughan, Scripps Institution of Oceanography and Professor Jason Middleton), and Kaneohe Bay (with Professor Atkinson and Dr Falter from the University of Hawaii, and Dr Hearn, from ADFA). The research at Warraber Island confirmed under field conditions a physical relationship between energy dissipation and nutrient uptake published by Dr Hearn, and based on original theoretical work by the George Batchelor.

Michael Banner In research papers appeared with colleagues and/or collaborators in his air-sea interaction group on classical problems at the air-sea interface, particularly on wave breaking. These include: Two modelling papers in the Journal of Physical Oceanography with Jinbao Song, describing a new perspective on deep water wave breaking, in terms of focusing of wave energy in nonlinear wave groups.

A data analysis paper in the Journal of Physical Oceanography with Johannes Gemmrich and David Farmer for open ocean storm waves that supports this new perspective on wave breaking. It reports a common spectral saturation threshold behaviour for parameterising the probability of wave breaking for different scales of ocean wind waves.

A modelling paper with Henrique Alves and Diana Greenslade in the Global Atmosphere Ocean System on the application of this work aimed at improving the reliability of wave forecasts in severe winds.

Two other papers were accepted for the Journal of Physical Oceanography and will appear in 2003. One of these papers, (Alves, Banner and Young), revisits the classical issue of fully developed wind seas and apply modern global hindcasting techniques to refine the classic Pierson-Moskowitz database and full-development wave parameters. The other (Alves and Banner) describes a new form of the spectral dissipation source term based on a local spectral saturation threshold.

A paper with Bill Peirson on the strength and distribution of the wind drift layer current over short, intermittently breaking wind waves very strongly forced by the wind and implications for air-sea gas transfer will appear in the Journal of Fluid Mechanics early in 2003.
Ongoing research projects during 2002 included:

- 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.

Australian Collaborators during 2002:
I.R. Young and A. Babanin (U. Adelaide): Shallow water wind wave evolution - source terms; also, deep and shallow water wave breaking dependences.
Overseas Research Collaborations during 2002:
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.) who visited for 7 weeks. Work on the linear stability of oscillatory flow in channels and pipes was initiated, with the results for wide channels confirming our earlier instability results for the semi-infinite Stokes layer. Our new predictions for the instability of oscillatory flow in a circular pipe are getting closer to the existing experimental observations, but there is still some differences to explain.

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, assessing ocean models using geochemical tracers, and 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 2002, Matthew documented for the first time the variability of Antarctic Intermediate Water (AAIW) in a coupled climate model (JPO, submitted), as well as exploring AAIW pathways (JPO, in press) and its sensitivity to moisture transport in the atmosphere (GRL, in press). Other studies include the simulation of thermally-driven flow in Jervis Bay, analyses of paleoclimate states in a coupled model (JPO, submitted), and an investigation of the role of an oscillatory westerly wind

belt in controlling Southern Ocean climate (J. Climate, submitted). International collaborations include an ocean model of CO_2 uptake (with Dr H. Thomas), studies of water-mass stability (with Dr O. Saenko), and climatological wind forcing of the oceans (with Dr C. Reason).

Mahadevan Ganesh continued his research work on three classes of problems: finite element methods for partial differential equations; fully discrete methods for boundary integral equations on slender bodies and high-order algorithms for obstacle scattering in three dimensions.

Dr Ganesh completed a paper in collaboration with Prof. Bernard Bialecki and his PhD student Mr Kassim Mustapha. In this paper they proposed, analysed and implemented a finite element method with quadrature for elliptic problems.

Dr Ganesh developed an efficient fully discrete spectral method with analysis for solving first- and second-kind boundary integral equations on slender spheroids. This work will form a basis for his future research (in collaboration with Professor Greg Rodin) on developing efficient preconditioners for solving partial differential equations on slender domains.

Dr Ganesh made substantial progress on developing high-order algorithms for solving high-frequency acoustic scattering problems in three dimensions. In collaboration with Professor Ian Sloan, he received a five-year (2003-2007) ARC Discovery Grant, to continue his research work on developing advanced computational algorithms in three dimensions.

Bruce Henry in collaboration with Dr Murray Batchelor, Australian National University, continued their studies of random walks on discrete lattices with absorbing boundaries. They obtained, exact algebraic solutions for absorption probabilities on lattice tubes. Dr Henry presented results to the Australian Statistical Mechanics Meeting in Melbourne 2002.

In a collaboration with Dr Susan Wearne, Mount Sinai School of Medicine, New York, Dr Henry continued to investigate new measures for the spatial complexity of dendritic arbors of neurons. Their current focus is on dendritic branching complexity and dendritic taper as possible determinates of different functional properties. Dr Wearne presented results from some of this work to the 7th International Fractals Conference, held in Spain 2002. Other aspects of this work were presented in poster format at the Society for Neuroscience 32nd Annual Meeting, held in Orlando, USA 2002.

In collaborative work with Professor Kyungsik Kim, Department of Physics, Pukyong National University, Korea, Dr Henry investigated diffusion generated by deterministic maps.

Vaithilingam Jeyakumar continued his research across a number of areas of Optimization and Mathematical Programming. His research during the year focussed on cone-convex programming, semidefinite programming and nonsmooth optimization. A visit by Professor Gue Myung Lee, Pukyong National University, Korea, in the middle of the year, coupled with the collaboration of Dr Nguyen Dinh, Pedagogical Institute of Ho Chi Minh city, Vietnam, led to the development of a new sequential Lagrange multiplier theory for infinite dimensional cone-convex programming, including semidefinite programming. With this work, he developed new sequential necessary and sufficient optimality conditions for convex programming problems in the absence of any regularity condition, and derived various characterizations of solution sets of optimization model problems involving multi-objectives, and cone-constraints. A by-product of this work is a sequential Lagrangian duality theory for non-differentiable convex programs. This collaborative work resulted in 4 papers during the 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 very active. A two month long visit by Professor Nguyen Yen, Hanoi Institute of Mathematics, Vietnam, saw the completion of the collaborative work on solution stability of inequality systems involving nonsmooth continuous maps.

Professor Jeyakumar's work on the application of set containment characterizations for generating knowledge-based support vector machine classifiers also continues. Recently he was invited to join the Editorial Board of the ANZIAM Journal.

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. He was co-editor of the book "Environmental Modelling and Prediction" which appeared in late 2001 and has already gone into a second printing.

Professor Leslie as Director of CEMAP enjoyed a large number of distinguished visitors during the year. These included Professor J.L. Chan, City University of Hong Kong; 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 Dr John Le 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. He also attended two national and three international meetings as an invited participant.

Finally, Professor Leslie received an ARC Large Grant and two US Office of Naval Research Grants. Two of these were jointly awarded with Professor Michael Banner, also from the School.

Bill McKee continued his work on wave propagation across a shearing current. He supervised the project work of the Master of Science and Technology student Rebecca Quaggin in this area and is writing up a paper for publication. He has also begun to investigate how the numerical method devised to treat the general problem can be used to study waves trapped by a jet-type current. His Ph.D. student David Ghisolfi produced the amended version of his thesis early in 2001. The degree has now been awarded. Dr McKee and David Ghisolfi are working on two papers stemming from the thesis on oceanic fronts off the coast of Brazil. Dr McKee also supervised the final stages of the writing up of Greg Buckley's Ph.D. thesis on internal waves.

Bill McLean began two new projects. With Professor Vidar Thomée, he investigated a parallel algorithm for a class of evolution equations with memory, and with Professor Ivan Graham (University of Bath) he studied the effect of anisotropic mesh refinement on the conditioning of boundary element equations. From 1-7 December Dr McLean attended an Oberwolfach meeting on *New Trends in Boundary Elements*, where he spoke on multilevel diagonal-scaling preconditioners. He continued as an associate editor of the *ANZIAM Journal*.

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 completed his research into the Shelf-slope Circulation in the Great Australian Bight. The broad goals of this project were to conduct a sequence of numerical studies to determine the dynamics of wind-forced downwelling slope currents and the conditions for the existence of undercurrents along with the importance of thermohaline forcing, topography and the nature of the circulation during both summer and winter.

In summary, these goals have been very well met with the nature of the circulation determined and new physics established. The study of wind-forced downwelling (Middleton and Cirano 1999) detailed the importance of thermal wind shear and alongshore sea level gradients in driving undercurrents and in the detachment of water into the interior. In a companion study of wind-forced upwelling, (Middleton 2000) the conclusions made in the foundation paper of Suginohara and Kitamura (1984) were shown to be wrong.

The late time circulation has been shown to be dominated by new physical effects within the surface mixed layer. An idealised study detailed the effect of Bass Strait on adjacent shelf currents (Middleton and Platov 2000).

High-resolution numerical models of the winter and summer "mean" circulation were determined and the results compared favourably with data from the region. A surprising and important result is the development of an extensive westward flowing current (the Flinders Current) along the shelf slope, that is shown to result from the equatorward Sverdrup transport within the southern ocean (Middleton and Cirano 2002). The dynamics of this current were shown to be similar to western boundary currents.

While the Flinders Current leads to deep upwelling near the slope during wintertime, the model results and data show winds to downwell isotherms to depths of up to 400m, and in agreement with observations, drive an eastward coastal current from Albany to Tasmania (Cirano and Middleton 2003). The magnitude of this model current can be large (up to 40cm/s) where the shelf is narrow and is in good agreement with observations. Off the west Tasmanian shelf, this current is named the Zeehan Current and results show it to be driven by winds and cross-shelf (rather than along-shelf) density anomalies. In the summertime case, the mean coastal winds reverse, although the Flinders Current remains and is shown to converge with shelf currents leading to an eastward current over the shelf break and downwelling (both observed). Nearest the coast, upwelling is found and compared with classical wind-forced upwelling and that which arises from advection alone (Middleton and Platov 2003).

In addition, studies were also made of the tidal circulation (Platov and Middleton 2000a) and new algorithms determined to reduce numerical errors (Platov and Middleton (2001). In addition, a windows interface package ("SeaScape") was developed for visualisation and analysis of the extensive model output (Platov and Middleton 2000b). The package can handle a larger variety of coordinate systems than any currently available.

New areas of study relate to upwelling off central Chile which is one of the most biologically productive in the world. Following a visit by Ole Leth (University of Concepcion, Chile), a first study (Leth and Middleton 2003) has shown that this unusually high productivity may well result from a cyclonic eddy that repeatedly forms off Punta Lavapie and acts to drive deep nutrient rich water in the shallow waters of the Gulf Of Aruaco. This work is near submission. A further study outlining the role of the Bio Bio trench is planned.

Craig Arthur (MSc students) has begun work on the causes of undercurrents off Chile and elsewhere.

Sylvain Andraud (practicum student 2002) developed a model of the tidal and wind forced circulation within Botany Bay. The model was calibrated against observations obtained by Professor Jason Middleton's group. It is planned that this model will be used for both scientific and management purposes regarding Botany Bay.

John Murray's continued his work in biomathematics, in particular in the areas of cancer chemotherapy and HIV. Collaborations continued with researchers at the Los Alamos National Laboratory in the US and the British Columbia Cancer Agency in Canada. This resulted in Dr Murray visiting those Centres in June, 2002.

John Roberts concentrated on various aspects of integrable maps in 2002. With Mr Apostolos Iatrou (La Trobe), he published a second paper on a new class of planar integrable maps that include and generalise the well-known QRT maps. Together with Iatrou and Dr Reinout Quispel (La Trobe), he showed how the techniques used to create these new planar maps could be extended to higher dimensional integrable mappings. In two preprints late in 2002, Dr Roberts showed how integrability in planar rational maps could be detected by studying their orbit statistics over finite fields (i.e. integrable and nonintegrable maps of the real plane have very different orbit distributions in the reduction over finite fields). This was joint work with Dr Franco Vivaldi (Queen Mary, London), who visited UNSW in April, and Mr Danesh Jogia (UNSW).

Dr Roberts' ongoing collaborations include: investigation of symmetries and reversing symmetries of planar polynomial automorphisms (with Professor Michael Baake, University of Greifswald); exploring duality in integrable maps (with Dr Reinout Quispel (La Trobe) and Professor Hans Capel (Amsterdam)); as well as further intensive investigations with Vivaldi and Jogia into order and chaos of rational maps over finite fields.

Colin Rogers has continued his research in collaboration with Dr Schief on hidden integrability in nonlinear continuum mechanics. This work has established solitonic connections 'in alia' in hydrodynamics, the theory of fibre reinforced materials and elastic membranes. Current work involves liquid crystal theory. During the early part of this sabbatical year, he held a position as Visiting Scholar at Hong Kong University of Science on Technology where he presented a series of lectures on the Geometry of Soliton Theory. While there he gave the Distinguished Lecture at the Annual Meeting of the Hong Kong Society of Theoretical and Applied Mechanics as well as invited lecture at the Centre for Chaos Control and Synchronization, City University of Hong Kong. Subsequently during the year he held Visiting Professorships in turn, at the University of Cambridge and University di Roma. Invited lectures were presented at the Isaac Newton Institute, University of Cambridge, the Dipartimento di Fisicá and Dipartimento di Metodi e Modelli Matematici per le Scienze Applicate at the Universita di Roma. While in Italy, an invited lecture was presented at the Dipartimento di Fisica, Universita di Lecce. Elsewhere in Europe, invited lectures were presented at the Department of Mathematical Sciences, Loughborough University of Technology, UK. A highlight this year has been the publication of Colin Rogers and Wolfgang Schief's book Backlund and Darboux Transformations; Geometry and Modern Applications in Soliton Theory by Cambridge University Press.

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 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 the isolation of hidden integrable structures in hydrodynamics, magnetohydrodynamics, the theory of fibre-reinforced media and the theory of shell membrane equilibria and on the algebro-geometric origins of discrete 'master' soliton system.

Projects were initiated and completed with Professor AI Bobenko, Technische Universität Berlin, Germany, Professor AS Fokas, University of Cambridge, UK, Dr AD King, University of Bath, UK and Professor C Rogers, The University of New South Wales, Australia.

Ian Sloan continued his energetic activities in a number of areas. With Associate Professor Womersley new approaches to approximation on the sphere were developed, through an unusual combination of theoretical mathematics and advanced studies of cubature on the sphere. With Josef Dick, Xiaqun Wang, Frances Kuo (Waikato), Henryk Woźnioakowski (Columbia and Warsaw), Greg Wasilkowski (Kentucky) and Fred Hickernell (Hong Kong Baptist University) he continued to contribute to the understanding, and the construction, of quadrature rules in hundreds of dimensions. With Ganesh, Womersley, Graham (Bath) and Chen (SUNY Stony Brook) further progress was made on the inverse problem for acoustic scattering from three-dimensional objects. With Rolf Grigorieff (BTU Berlin) progress was made on the remarkable properties of (1-dimensional) splines with multiple knots.

Thanh Tran was delighted to return to UNSW and join the Department and the Computational Mathematics Group in January 2002. He continued his research in efficient solvers for boundary integral equations (BIEs). He completed, with Prof. E. Stephan and Dr. M. Maischak (Hannover), a paper on multiplicative Schwarz methods for BIEs on a surface in 3D and another paper (with Stephan) on overlapping additive Schwarz methods. He also developed a new interest in *a posteriori* error estimations for nonlinear parabolic equations, with Dr. T-B. Duong (UNSW). One paper has been published from this project. A new project, with Assoc. Prof. 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 was started in the year. A paper is being written up.

In December 2002 he was invited to speak at the Mathematisches Forschungsinstitut Oberwolfach Meeting on New Trends in Boundary Element.

Rob Womersley continued to work on a variety of projects with the common theme of efficient computational methods, particularly those related to optimization problems, approximation over the sphere and mathematical finance. He worked with Professor Sloan on interpolation and cubature problems on the sphere, with Ben Goldys (Statistics) and Alan Brace (NAB, BNP-Paribas) on stochastic volatiltiy models in finance, HongXian Yin (Chinese Academy of Sciences) and Lucien Polak (Berkely) of adaptive smoothing for minimax problems.

6 RECENT PUBLICATIONS

6.1 Journal Articles and Conference Papers since 2000

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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6.2 Books and Edited Proceedings since 2000

W. McLean, *Strongly Elliptic Systems and Boundary Integral Equations*, Cambridge University Press, 2000.

Y. Shao, *Physics and Modelling of Wind Erosion*, Vol. 23. Kluwer Academic Publishers, 2000.

C. Rogers and W. K. Schief, *Bäcklund and Darboux Transformations; Geometry and Modern Applications in Soliton Theory*, Cambridge University Press, 2002.

6.3 Applied Mathematics Reports 2002

V Jeyakumar, Characterizing set containments involving infinite convex constraints and reverse-convex constraints, Applied Mathematics Report AMR02/1.

John Middleton, The mean summertime circulation along australia's southern shelves: a report, Applied Mathematics Report AMR02/2.

D. Sheen, **IH Sloan** and V Thomée, A parallel method for time-discretization of parabolic equations based on Laplace transformation and quadrature, Applied Mathematics Report AMR02/3.

FJ Hickernell, **IH Sloan** and GW Wasilkowski, On tractability of weighted integration over bounded and unbounded regions in rs, Applied Mathematics Report AMR02/4.

B. Bialecki, **M Ganesh** and **K Mustapha**, A Petrov-Galerkin method with quadrature for elliptic boundary value problems, Applied Mathematics Report AMR02/5.

V Jeyakumar, G.M. Lee and N. Dinh, Lagrange multiplier conditions characterizing optimal solution sets of convex programs, Applied Mathematics Report AMR02/6.

EP Stephan and **T Tran**, An overlapping additive schwarz preconditioner for boundary element approximations to the Laplace screen and lame crack problems, Applied Mathematics Report AMR02/7.

T Tran and T-B Duong, A complete analysis for some a posteriori error estimates with the finite element method of lines for a nonlinear parabolic equation, Applied Mathematics Report AMR02/8.

V Jeyakumar, GM Lee and N Dinh, Nnew sequential lagrange multiplier conditions characterizing optimality without constraint qualification for convex programs, Applied Mathematics Report AMR02/9.

C Cresswell and N Joshi, Consistent composition of backlund transformations produces confined maps, Applied Mathematics Report AMR02/10.

H Qi and X. Yang, Nonsmooth analysis of spectral functions, Applied Mathematics Report AMR02/11.

J Henrique, GM Alves and **ML Banner**, Revisiting the pierson-moskowitz asymptotic limits for fully-developed wind waves, Applied Mathematics Report AMR02/12.

J Henrique, GM Alves, DJM Greenslade and **ML Banner**, Impact of a saturation-dependent dissipation source function on operational hindcasts of wind-waves in the Australia region, Applied Mathematics Report AMR02/13.

ML Banner, JR Gemmrich and DM Farmer, Multi-scale measurements of ocean wave breaking probability, Applied Mathematics Report AMR02/14.

V Jeyakumar, GM Lee and N Dinh, Solution sets of convex vector minimization problems, Applied Mathematics Report AMR02/15.

JAG Roberts, D Jogia and F Vivaldi, The Hasse-Weil bound and integrability detection in rational maps, Applied Mathematics Report AMR02/16.

JAG Roberts and F Vivaldi, An arithmetical method to detect integrability in maps, Applied Mathematics Report AMR02/17.

7 EXTERNAL RESEARCH SUPPORT FOR 2002

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 $64,700
Incorporation of wave breaking into coupled marine wind-ocean wave models for severe weather conditions

M Banner, L Leslie $130,000
Wave breaking influence in an operational coupled model of the atmosphere-ocean wave boundary layers under very high wind conditions

M Banner and IR Young $67,743
Modelling ocean waves in coastal waters - a new approach based on recent physical insight into wave breaking

M England $56,700
Midlatitude variability in the Southern Ocean and its role in Australian climate

Jason Middleton $63,000
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 WK Schief $65,650
Deformation of isothermic surfaces and K- nets in membrane theory and nonlinear elasticity. Application of solitonic methods

IH Sloan, W McLean and M Ganesh $85,000
Numerical analysis of evolution problems in several variables

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

IM Suthers and ME Baird $66,184
Development of a mechanistic model of marine biological activity

7.2 Queen Elizabeth II Fellowships

M England $10,000
Circulation and variability in the Southern Ocean and its influence on Australian climate

WK Schief $10,000
Generation and application of Geroch-type transformations in soliton theory

7.3 University Research Support

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

BI Henry (CI), SL Wearne (PI) $10,000
Applications of fractional reaction-diffusion equations

V. Jeyakumar $15,000
Non-convex optimisation with applications to machine learning problems of data classification

JH Middleton, ME Baird and M Roughan $12,500
Circulation and nutrient uptake on a coral cay reef flat

JM Murray $8,500
Quantitative analysis of human immunodeficiency virus, hepatitis B virus, and T cell response

JAG Roberts $10,000
A number-theoretic test for integrability in discrete dynamical systems

C Rogers and WK Chief $15,000
Crack problems in layered elastic materials. Application of iterated Darboux Transformations

7.4 IREX Grant

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

7.5 External Collaborative Grants

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

SL Wearne (PI), BI Henry (Consultant) $156,000
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

7.6 Centre of Excellence

Late in the year the ARC announced 5 years of funding for the Centre of Excellence for Mathematics and Statistics of Complex Systems. Colin Rogers and Ian Sloan (together with Tony Dooley of Pure Mathematics) are Chief Investigators for the Centre, making UNSW one of the major nodes for the Centre of Excellence. Funding and Centre activities will commence in 2003.

8 VISITORS

Dr Rick Alves, Marine Hydraulics Laboratory UFSC Brazil, 5 April–7 June, 2002 (M Banner)
Professor Pablo Amser, University of Buenos Aires, Argentina, 16–31 August, 2002 (C Rogers)
Dr Michael Baake, U of Greifswald, Germany, 3–22 November, 2002 (J Roberts)
Dr Noel Barton, CISIRO, 11-12 June, 2002 (B Henry)
Dr Andrew Bassom, U of Exeter, 5 July–27 August, 2002 (P Blennerhassett)
Professor Bernard Bialecki, Colorado School of Mines, 4 February– 15 August, 2002 (M Ganesh)
Professor John Blake,University of Birmingham, 26-27 April, (I Sloan)
Dr Mark Blyth, Imperial College, London, 24–26 July, 2002, (J Roberts)
Professor Gue-Myung Lee, Pukyong National University, Pusan, Korea, August 2002 (V. Jeyakumar)
Professor Rolf Grigorieff, Technical University, Berlin, 27 January–17 February, 2002 (I Sloan)
Professor Benqi Guo, Maths, U of Manitoba, 12–19 May, 2002, (T Tran)

Dr Fei Huang, Ocean U of Qingdao, China, 1 August, 2002–1 August, 2003, (M England)
Professor John Johnson, U of East Anglia, 12–5 March, 2002, (J Middleton)
Dr Bernard Kachoyan, Defence Science & Technology, Sydney, 12 June, 2002, (B Henry)
Professor Gue Myong Lee, Pukyong National University, Korea, 20 July–20 August, 2002, (V Jeyakumar)
Dr Ole Leth, U de Concepcion, Chile, 10 November–20 December, 2002, (John Middleton)
Dr Ligia Munteanu, Institute of Solic Mechanics, Romanian Academy, 14 January–14 February, 2002, (C Rogers)
Dr Alex Opie, 23 July 2001–23 July 2003
Professor Elijah Polak, Dept of Electrical Engineering & Computer Sciences, University of California at Berkeley, 7–22 June, 2002, (R Womersley)
Professor Dongwoo Sheen, Seoul National University, Korea, 18-31 January, 2002, (I Sloan)
Dr Ernst Stephan, University of Hannover, 16 July–3 August, 2002, (T Tran)
Professor Vidar Thomée, Chalmer University of Technology, Sweden, 2 December 2001 - 2 February 2002, (I Sloan)
Dr Franco Vivaldi, Queen Mary, University of London, 19 April–5 May, 2002, (J Roberts)
Professor G. Wasilkowski, U of Kentucky, 15 March–30 April, 2002, (I Sloan)
Dr Susan Wearne, Biomathematics, Mount Sinai School of Medicine, NY, 2–19 December, 2002, (B Henry)
Dr Ghuyen Dong Yen, Hanoi Institute of mathematics, Vietnam, 16 October–15 December, 2002, (V Jeyakumar)
Dr Hongxia Yin, City University of Hong Kong, 1 January-31 December 2001 (R Womersley)
Dr Zhuwen Zhang, Dept of Physical Oceanography, State Oceanic Administration, China, 31 July–31 August, 2002 (M Banner)

9 CONFERENCES AND SEMINARS

9.1 Applied Mathematics Seminars

Organizer: John Roberts

11 January
Professor V. Thomée (Chalmers University of Technology
Maximum-norm estimates for parabolic finite element equations

15 January
Professor Leonard Schwarz (University of Delaware)
Recent progress in the numerical modelling of the thin-layer flow

31 January
Professor Vidar Thomée (Chalmers University of Technology)
A maximum-norm estimate for the resolvent of a finite element discretization of the Laplacian

5 February
Professor Rolf Grigorieff (Technical U Berlin)
Resolvent estimates for discretised second order derivative: A journey to a logarithm free world on irregular meshes

14 February
Dr Bill McLean (UNSW)
Time discretization of an evolution equation via Laplace transforms

14 March
Mr Narcyz Ghinea (honours student)
Arbitrage pricing for options in a Black-Scholes market

21 March
Dr Jeff Dewynne (Oxford)
Three singular perturbation problems in mathematical finance

28 March
Dr Mahadevan Ganesh (UNSW)
A new class of constructive approximations on the sphere

4 April
Professor Greg Wasilkowski (University of Kentuchy)
Weighted integration for functions over unbounded domains

10 April
Dr Peng Shi (Defence Science & Technology, SA
Robustness of Markovian jump systems

10 April
Professor John Hearne (University of Natal, South Africa)
Optimising revenue from game ranches

11 April and 18 April
Mr Paul Leopardi (UNSW)
Practical computation with Clifford Algebras

26 April
Professor John Blake (University of Birmingham)
Bubbles: Acoustic, explosive, nuclear, optical and shock induced

2 May
Dr Franco Vivaldi (University of London)
Piecewise affine dynamical systems

9 May
Professor Bernard Bialecki (MCS, Colorado School of Mines)
A spectral collocation method for the Helmholtz equation

16 May
Professor Benqi Quo (University of Manitoba, Canada)
Approximation theory of the P-version of the finite element method in the framework of the Jacobi-weighted Besov Spaces

20 June
Professor Elijah Polak (DEE&CS, University of California, Berkeley)
Consistent approximations and approximate functions and gradients in optimal control

18 July
Professor Ernst Stephan (University of Hanover)
Least squares methods for transmission problems with finite elements and boundary elements

25 July
Dr Mark Blyth (Imperial College, London)
Chaotic flow in a pulsating pipe

22 August
Professor Pablo Amser, (University of Buenos Aires)
Some nonlinear problems arising in Black-Scholes type equations

26 August
Dr Andrew Bassom (University of Exeter)
The linear stability of flat Stokes layers

5 September
Dr Adelle Coster (Electrical Engineering, UNSW)
Synchronisation and the propagation of electrical activity in the heart

9 September
Dr Robert Bursill (School of Physics, UNSW)
The density matrix renormalisation group in quantum many-body physics

10 September
Dr Vicky Mak (University of Melbourne)
On the asymmetric travelling salesman problem with replenishment arcs

14 November
Professor Michael Baake (University of Greifswald, German)
Dynamics of recombination

21 November
A/Professor Reinout Quispel (La Trobe University)
What kind of ODEs are there, and how can one solve them numerically?

9.2 Biomathematics Seminar

18 October
Dr Miles Davenport (School of Pathology, UNSW)
Epidemiological modelling of the HIV epidemic

9.3 Computational Mathematics Seminars

Organizer: Thanh Tran

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

21 November
Dr Xiaoqun Wang (UNSW)
On effective Dimensions and the construction of weighted Lattice Rules and financial applications

21 November
Mr Josef Dick (UNSW)
On the convergence rate of the component-by-component construction of good lattice rules

9.4 Sphere Seminars

6 June
A/Professor Rob Womersley (UNSW)
Geometric aspects of distributing points on the sphere

22 August
Dr Kerstin Hesse
Harmonic Splines I: Reproducing kernel Hilbert spaces & splines

5 September – 17 October
Dr Kerstin Hesse
Harmonic Splines Series

23 October
A/Professor Denis Winch (University of Sydney)
Classical potential theory and modern satellite magnetic date

9.5 Mathematics and Aviation Seminars

16 September
Robert Sherman (NCAR,USA)
Aviation turbulence research activities in the US

16 September
Todd Lane (NCAR, USA)
Numerical modelling of thunderstorm- generated turbulence

9.6 Oceanography, Meteorology and Fluid Mechanics Seminars

Organizer: Matthew England

12 February
Goran Brostram, Dept of Oceanography, Earth Sciences Centre, Goteborg University
The sensitivity of the thermohaline circulation to equator- to-pole density forcing

20 February
Professor Ken Melville, Scripps Institute of Oceanography, La Jolla
The initial generation of wind waves and Langmuir circulations

13 March
John Johnson, School of Mathematics, University of East Anglia
Models of the broad coastal zone of the North East Atlantic

22 March
Matthew England, CEMAP, School of Mathematics, UNSW
Ocean Circulation Modelling: applications to climate, marine pollution,and biological cycles

9 May
Jose Henrique Alves, School of Mathematics, UNSW
Revisiting the Asymptotic Limits for Fully-Developed Wind Waves

13 May
Gary Brassington, College of Oceanic and Atmospheric Sciences, Oregon State University
A Unified Layered Theory of Wind-Driven Equatorial and Mid-latitude Circulation

5 June
Chris Aiken, Program in Atmospheric and Oceanic Sciences, University of Colorado, Boulder
Effects of Stochastic Wind Forcing on Quasi- Geostrophic Mesoscale Variability

8 July
Willem Sijp, School of Mathematics, UNSW
Effect of the Drake Passage throughflow on global climate

8 July
Matthew England, School of Mathematics, UNSW
Interannual to Centennial Variability of Southern Ocean Water Masses

8 July
Willem Sijp (UNSW)
Effect of the Drake passage throughflow on global climate

8 July
Peter Oke, School of Mathematics, UNSW
Sensitivity of extratropical ocean circulation to variations in surface wind stress

25 July
Moninya Roughan, SCRIPPS Institution of Oceanography
On the East Australian Current: Upwelling and Separation

25 July
Clifford J. Hearn, Oceanography, UNSW@ADFA
Coral Reef Hydrodynamics and the Darwin Paradox

22 August
Tom Dennis (Energetech)
The Energetech Wave Energy System

5 November
Peter Oke, School of Mathematics, UNSW
The ocean's response to wind stress variations associated with the Antarctic Oscillation

12 November
Eric Schulz, School of Mathematics, UNSW
Motion correction for ship borne turbulence sensors

19 November
Mark Baird, School of Mathematics, UNSW
A size-based plankton population model in an idealized 2-D ocean basin

13 December
Ryo Furue, Center for Climate System Research, University of Tokyo
Roles of the Southern Ocean in controlling the abyssal circulation

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 15 students were enrolled during 2002 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 11 students were enrolled in PhD programmes during 2002.

Student	**Research Topic**	**Supervisor**
Jaci Brown	Climate modelling	Leslie/England
Josef Dick	High dimensional integration	Sloan
Eunjoo Jung	Pollution modelling	Shao/Leslie
Paul Leopardi	Approximation on the sphere	Sloan/Womersley
Kassim Mustapha	Fully discrete computational methods & analysis for elliptic & parabolic problems	Ganesh/Sloan
Francis Reid	Hydrodynamic Stability	Blennerhassett
A Sen Gupta	Global Ocean Modelling	England
Willem Sijp	Climate Studies	England
Peng Xu	Land salination	Shao
Haixiong Zhuang	Pollution modelling	Shao
Anne-Marie Wong	Oceanography	Jason Middleton

In 2002, 7 students were awarded a PhD in applied mathematics.

- An Li *Computational modelling of sediment entrainment and motion in atmospheric surface layer* (Yaping Shao)
- Lixin Qi *Cut-off low pressure systems over southern Australia* (Lance Leslie)
- Zhou Wang *A numerical model for the study of sediment diagenesis, iron-phosphorus dynamics, and microphytobenthos* (Yaping Shao)

- Moninya Roughan *On the East Australian Current: upwelling and separation* (Jason Middleton)
- Peter Robin Oke *The effects of the East Australian Current on the nearshore zone* (Jason Middleton)
- Peter M. Tate *The rise and dilution of buoyant jets and their behaviour in an internal wave field* (Jason Middleton)
- Eric Schulz *Air-sea flux parametrizations in shallow tropical sea* (Brian Sanderson/M. Banner)

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 4 students enrolled in MSc programmes during 2002.

Student	**Research Topic**	**Supervisor**
KL Batt	Mesoscale Meteorology	Leslie
PA Graham	Timing of antiretroviral therapy for HIV	Murray
GN Grice	Constant speed flows & the nonlinear Schrödinger equation	Wolfgang
Agus Santoso	Climate Variability	England