Forum Math for Industry 2022:

Mathematics of Public Health and Sustainability

La Trobe City Campus

Level 2, 360 Collins Street, Melbourne

21-24 November 2022

https://apcmfi.org/fmfi2022/

Institute of Mathematics for Industry
Kyushu University

Asia Pacific Consortium of Mathematics for Industry

LA TROBE UNIVERSITY
AUSTRALIA

The talk abstracts in this volume were typeset by their authors. Only minor typographical changes have been made by the editors. The opinions, findings, conclusions and recommendations in this book are those of the individual authors.

The Asia-Pacific Consortium of Mathematics for Industry

"I Found a Whale Using Maths!" – that is the title of Matt Parker's latest youtube video. Matt is also known as the *Stand-up Maths* guy, an Australian mathematical comedian with a youtube following of over one million subscribers to his channel: this video alone attracted 216,000 views in just one week. It is an example of the meeting of applied mathematics, citizen science, and ecology. The basic premise is that Parker takes a picture of a whale's tail while on an Antarctic cruise, submits it to an online site where pattern recognition algorithm identifies that individual whale based on the distinct tail markings. Together with the coordinates of the siting, marine ecologists then have another data point in tracking whale movements and hence the state of the oceans. To take two more examples from Parker, a comedy routine on spreadsheets which has the punchline that digital images and displays are nothing but "spreadsheets", and a more involved display of stable vortices. The spreadsheet routine perhaps is a simplistic summary of image processing, but it is a start on publicising the notion that much in our world is not just computer models but in fact mathematical models. The mathematics of stable vortices explored by Helmholtz of course arise from fluid mechanics which underlies our atmospheric and climate modelling – again these are mathematical models not just "computer models". It is safe to say that industrial and applied mathematics has hit a mainstream with a mass audience in ways that were not imaginable even a couple of decades ago. In many ways the reasons are simple – mathematics has interesting and important applications to problems of the world which capture the interest and imagination of the public. In addition to Maths Stand-up, there are other channels such as Veritasium and Numberphile which popularise these deep connections.

This year marks the fortieth anniversary of the book *Sleepers Wake! Technology and the Future of Work* written by Barry Jones, a polymath who the following year was to become the Australian Federal Minister for Science. In it Jones explored what he thought then would arise from the "information revolution" and the transformation to a "Third Age" post- industrial society. Four decades is a long time with exponential growth of knowledge and technology, and many now refer to this as the "Fourth Age", but, whichever age we are in, the models that underpin the information revolution and our understanding of the natural world are fundamentally mathematical and statistical models – the models of applied and industrial mathematics.

Mathematics for Industry (MfI) continues the collaboration between industry, technology, mathematics, and society, and the Asia-Pacific Consortium of Mathematics for Industry (APCMfI) in particular continues in the role of gathering together scientists and mathematicians with the aim of creating the fundamental research that can flow in to public awareness and policy and the understanding of the world.

Previous Forums

This is the thirteenth annual Forum Mathematics for Industry (FMfI) and the second time that it has been held in Australia. The topics and locations of previous Forums are given below.

2009	Fukuoka, Japan	Casimir Force, Casimir Operators and the Riemann Hypothesis
2010	Fukuoka, Japan	Information Security, Visualization, and Inverse Problems, on the basis of Optimization Techniques
2011	Honolulu, US	TSUNAMI - Mathematical Modelling Using Mathematics for Natural Disaster: Prediction, Recovery and Provision for the Future
2012	Fukuoka, Japan	Information Recovery and Discovery
2013	Fukuoka, Japan	The Impact of Applications on Mathematics
2014	Fukuoka, Japan	Applications + Practical Conceptualization + Mathematics = Fruitful Innovation
2015	Fukuoka, Japan	The Role and Importance of Mathematics in Innovation
2016	Brisbane, Australia	Agriculture as a Metaphor for Creativity in all Human Endeavors
2017	Honolulu, US	Responding to the Challenges of Climate Change: Exploiting, Harnessing and Enhancing the Opportunities of Clean Energy
2018	Shanghai, China	Big Data Analysis, AI, Fintech, Math in Finance and Economics
2019	Auckland, New Zealand	Mathematics for the Primary Industries and the Environment
2021	Hanoi, Vietnam	Mathematics for Digital Economy

Forum Math for Industry 2022: Mathematics of Public Health and Sustainability

This year's forum will show how mathematics is used to solve problems in Public Health and Sustainability, both imperative for human existence.

We have delegates from Australia, Japan, New Zealand, Malaysia, Indonesia, India, USA, Norway and the Netherlands attending. Invited talks will include topics of epidemiology of COVID-19 and influenza, population control of invading species, degradation of agricultural lands and alluvial transport.

Organising committee

- Professor Marcel Jackson, La Trobe University, Chair, Organising Committee
- Emeritus Professor Philip Broadbridge, La Trobe University, Chair, Programming Committee
- Associate Professor Joel Miller, La Trobe University
- Dr Peter Van Der Kamp, La Trobe University
- Associate Professor Luke Bennetts, University of Adelaide
- Dr Melanie Roberts, Griffith University
- Dr Christopher Lenard, La Trobe University
- Dr Anja Slim, Monash University
- Dr Rebecca Chisholm, La Trobe University
- Associate Professor Winston Sweatman, Massey University, New Zealand
- Professor Luke Prendergast, La Trobe University
- Professor Osamu Saeki, Kyushu University
- Professor Kenji Kajiwara, Kyushu University
- Diana Heatherich, La Trobe University, Secretariat

Acknowledgements

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Kyushu University

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AUSTRALIA

Forum timetable

Monday, 21 November

Time	Name	Title
9:00–9:15		Arrival
9:15–10:00		**Opening & Acknowledgement of Country** Professor Marcel Jackson Mr Adam Cuneen, Victoria's Commissioner to North Asia Deputy Consul General Mr Shunsuke Saito, Consulate General of Japan Professor Chris Pakes, Pro Vice Chancellor (Graduate & Global Research) Professor Zainal Aziz, President of APCMfI
10:00–10:50	Wil Schilders	Mathematics: key enabling technology for scientific machine learning
10:50–11:20		Morning Tea
11:20–12:10	Bhavna Antony	Artificial Intelligence Approaches for Diagnosis and Management of Glaucoma
12:00–2:00		Lunch
2:00–2:50	Emma McBryde	The application of mathematics to pandemics: some examples of modelling used during COVID-19
2:50–3:10		Afternoon Tea
3:10–4:00	Oliver Maclaren	Identifiability analysis and predictive uncertainty for complex mathematical and simulation models
4:00–6:00		Free
6:00–7:00	**Malay Banerjee**	**Christie Eliezer Memorial Lecture** *Free public lecture [registration link]* Epidemic to immuno-epidemic models of COVID-19

Tuesday, 22 November

Time	Name	Title
9:00–9:15		Arrival
9:15-10:05	Jukka Corander	Advances in likelihood-free inference with applications to evolutionary epidemiology
10:15–10:30		Morning Tea
10:30–11:20	Natalie Thamwattana	Modelling clogging in granular assembly when treating acidic groundwater
11:20–12:10	Luke Bennetts	Modelling flexural strains at the outer margins of Antarctic ice shelves caused by ocean waves
12:10–2:00		Lunch
2:00–2:50	Masayo Hirose	An Assessment of Prediction Error under Area Level Model with Arc-Sin Transformation
2:50–3:10		Afternoon Tea
3:10–4:00	Luke Prendergast	Some considerations for measuring and interpreting heterogeneity in meta-analysis

Wednesday, 23 November

Time	Name	Title
9:00–9:15		Arrival
9:15-10:05	Andrea Bertozzi	Energy minimizing surfaces for nanovial technology
10:15–10:30		Morning Tea
10:30–11:20	David Price and Rob Moss	Supporting Australia's COVID-19 response with probabilistic forecasts
11:20–12:10	Stephen Taylor	Mathematical Modelling of nitrogen management on dairy farms
12:10–2:00		Lunch
2:00–2:50	Shizuo Kaji	Homological features of 3D medical images
2:50–3:10		Afternoon Tea
3:10–5:00		**Poster Session (Hybrid)**
5:00–6:00		Free
6:00–		Forum Dinner (registration and pre-payment required) Hotel Grand Chancellor Melbourne, 131 Lonsdale Street

Thursday, 24 November

Time	Name	Title
9:00–9:15		Arrival
9:15-10:05	Hugh Possingham	Decision science thinking applied to nature conservation
10:15–10:30		Morning Tea
10:30–11:20	iadine Chadès	Challenges of developing decision tools to guide conservation decisions
11:20–12:10		
12:10–2:00		Lunch
2:00–2:50	Freya Shearer and Gerard Ryan	Modelling through the crisis: developing methods to support decision-making in the COVID-19 pandemic
2:50–3:10		Afternoon Tea
3:10–4:00	Melanie Roberts	The effect of sediment heterogeneity on sediment yield during gully erosion
4:00–4:15	**Closing** Director Institute for Mathematics in Industry (IMI)-Kyushu University, Professor Kenji Kajiwara	

Presentation abstracts

Monday 21 November

Mathematics: key enabling technology for scientific machine learning

Wil Schilders, Eindhoven University of Technology & TU Munich Institute of Advanced Studies
President of the International Consortium of Industrial and Applied Mathematics (ICIAM)

Abstract: Artificial Intelligence (AI) will strongly determine our future prosperity and well-being, also in the area of public health and sustainability. Due to its generic nature, AI will have an impact on all sciences and business sectors, our private lives and society as a whole. AI is pre-eminently a multidisciplinary technology that connects scientists from a wide variety of research areas, from behavioural science and ethics to mathematics and computer science. Without downplaying the importance of that variety, it is apparent that mathematics can and should play an active role. All the more so as, alongside the successes of AI, also critical voices are increasingly heard. As Robbert Dijkgraaf (former director of the Princeton IAS, now our minister of science and education) observed in May 2019: "Artificial intelligence is in its adolescent phase, characterised by trial and error, self-aggrandisement, credulity and lack of systematic understanding." Mathematics can contribute to the much-needed systematic understanding of AI, for example, greatly improving reliability and robustness of AI algorithms, understanding the operation and sensitivity of networks, reducing the need for abundant data sets, or incorporating physical properties into neural networks needed for superfast and accurate simulations in the context of digital twinning. Mathematicians absolutely recognise the potential of artificial intelligence, machine learning and (deep) neural networks for future developments in science, technology and industry. At the same time, a sound mathematical treatment is essential for all aspects of artificial intelligence, including imaging, speech recognition, analysis of texts or autonomous driving, implying it is essential to involve mathematicians in all these areas. In this talk, we highlight the role of mathematics as a key enabling technology within the emerging field of scientific machine learning. And we will end with the important adagio: "Real intelligence is needed to make artificial intelligence work."

Artificial Intelligence Approaches for Diagnosis and Management of Glaucoma

Bhavna Antony, Alfred Health, Australia

Abstract: Glaucoma is a chronic neurodegenerative condition that if left untreated, can lead to blindness. The best patient outcomes are obtained if the disease can be detected early, and timely intervention can be provided. However, the diagnosis and management of the condition is difficult due to the varied presentation of symptoms and limitations of the visual function testing methods available today. Recent developments in retinal scanners have, however, now given us the ability to obtain high-resolution 3D scans of the retina. This development has fortunately coincided with the development of deep-learning and artificial intelligence (AI) approaches for the analysis of images. Here, I will give you an overview of the clinical and biological insights that can be obtained when AI approaches are used to analyse medical images, and how they can be used to alleviate the increasing demands on our healthcare system.

The application of mathematics to pandemics: some examples of modelling used during COVID-19

Emma McBryde, James Cook University

Abstract: Mathematical models have been applied to explain infectious diseases outbreaks for over a century, but have never been taken so seriously as during the recent COVID-19 pandemic, during which

they were used to synthesize evidence and inform public health action. This talk will discuss some of the models used at state level, national level and globally. It will discuss limitations and future directions for modelling.

When Australia closed its borders it did so on advice based on layered transmission and mobility models. This work suggested that by February 2020, several countries had already had cases of SARS CoV-2, without knowing it. Flight mobility suggested where the likely epidemic would spread and correctly identified changes in epicentre to Europe and later South America. I will discuss some of the modelling results that suggested this, and the importance of the early international travel restrictions.

One of the first pieces of available evidence about COVID-19 was its very specifically age-based effects, with children both less likely to acquire COVID and less likely to spread it. We used this information -along with age-specific contact matrices - to assess the potential risks and benefits of school closure. We also used age-based matrices to investigate optimal vaccine distribution at a time when vaccines were scarce. Results show that prioritising the most vulnerable (older age) was almost always a better strategy than prioritising the highest transmitters (20-30 year olds).

I will finish by discussing model refinements that are being made currently and a vision for open-science in the modelling emerging infectious diseases space.

Identifiability analysis and predictive uncertainty for complex mathematical and simulation models

Oliver Maclaren, University of Auckland

Abstract: Complex mathematical and simulation models are increasingly central in science, engineering, industry, and policy-making. COVID-19 modelling is a notable example: the New Zealand government heavily used modelling to inform its policy and received praise for an effective, science-informed approach to managing the pandemic. In addition, numerous less visible but still impactful examples of modelling work play a significant role in modern society and industry. These examples range from managing natural resources like geothermal reservoirs using numerical simulation models to elaborate theoretical mathematical models designed to understand wound healing and tumorigenesis in epithelia. However, constructing a complex simulation model is only the first step in realising its potential value: we next need to reliably connect it to empirical data to ensure its relevance to the real world. A key barrier to connecting models and data is the lack of identifiability of complex models and parameters. Identifiability refers to the ability to uniquely determine model parameters from ideal data, while practical identifiability refers to reliably estimating parameters from imperfect data. While identifiability is closely related to mechanistic understanding and is the traditional goal of scientific studies, in some applications, we may care more about model predictions than identifiability. However, the relationship between identifiability analysis and the construction of reliable predictive uncertainty bands needs more study for complex mechanistic models. In this talk, I will discuss likelihood-based frequentist tools for diagnosing parameter identifiability and constructing model predictions and the trade-offs and relationships between the two goals.

Christie Eliezer Memorial Lecture: Epidemic to immuno-epidemic models of COVID-19

Malay Banerjee, IIT Kanpur

Abstract: A wide range of multi-compartment models is available to study the epidemic progression of SARS-CoV-2. Variation in the period of infectivity, the time required for recovery, and days spent at the hospital during the disease severity vary significantly from one individual to another. These phenomena are the factors behind considering multiple compartments to study the epidemic progression due to COVID-19. The main objective of this talk is to discuss a new modeling approach for the COVID-19 epidemic,

which involves distributed recovery and death rates and the variable infectivity based upon the immunity level of the individuals. The infection transmissibility rate depends upon the immune response's strength and antibody level due to vaccination and acquired immunity. The proposed model helps to evaluate the COVID-19 epidemic situation in some countries.

This event is a free lecture open to the public. We kindly request that all attendees register at this [registration link].

Tuesday 22 November

Advances in likelihood-free inference with applications to evolutionary epidemiology

Jukka Corander, University of Oslo and University of Helsinki

Abstract: Likelihood-free inference has evolved from a seminal idea to a powerful tool for advanced statistical and mathematical modeling in roughly 20 years. Currently both computational statistics and machine learning communities are actively contributing to development of new methods for calibrating simulator-based models in the light of data or other constraints. We discuss some of the recent advances in such inference methods and illustrate them with models for epidemics and pathogen population evolution.

Modelling clogging in granular assembly when treating acidic groundwater

Natalie Thamwattana, University of Newcastle, Australia

Abstract: Acid sulphate soils (ASS) are naturally occurring sediments occupying over 200,000 km^2 of land in Australia. Acidic groundwater resulting from the oxidation of pyrite (FeS_2) in ASS is a major environmental concern particularly in the coastal regions. When exposed to air during flood mitigation drain or upon excavation (e.g. coal mining), FeS_2 can rapidly oxidise to form sulphuric acid, leading to contamination of the groundwater and causing acid drainage in underground coal mines. To treat acidic groundwater, permeable reactive barriers (PRBs) are introduced to neutralize acidity induced by pyrite oxidation in ASS terrain. PRBs (alkaline materials, e.g. crushed recycled concrete, ash, blast-furnace slag and calcitic limestone $CaCO_3$) are used as an underground filter to eradicate the contaminants through chemical and/or biological processes. However, this clogging can reduce the porosity of PRBs which in turn reduces their longevity and functionality. In this talk, we discuss modelling clogging in PRBs which is due to the accumulation of bacteria and reactive aggregates becoming coated with chemical precipitates, and the effect of the clogging on the porosity of PRBs over time.

Modelling flexural strains at the outer margins of Antarctic ice shelves caused by ocean waves

Luke Bennetts, University of Adelaide

Abstract: The extent of Antarctic sea ice is hitting record lows in response to climate change. This is exposing the Antarctic coastline to the most energetic waves on the planet that exist in the Southern Ocean. In particular, ocean waves are increasingly able to reach ice shelves that fringe about half the Antarctic coastline, which has implications for future global sea level rise. Energetic waves bend and flex the outer margins of the ice shelves, and the flexural strains imposed can propagate fractures, cause icequakes, initiate iceberg calving, and even trigger disintegration events, particularly when the ice shelf is already weakened by warming temperatures. I will present a mathematical model of ocean wave transfer to ice shelf flexure, and a series of approximations that generate predictions over a spectrum of wave frequencies and for realistic ice shelf and seabed geometries. I will discuss results for Antarctica's largest ice shelf, the Ross Ice Shelf.

An Assessment of Prediction Error under Area Level Model with Arc-Sin Transformation

Masayo Y. Hirose, Kyushu University

Abstract: An empirical best linear unbiased predictor can contribute to more efficiency, especially when the sample size within each area is not large enough to make reliable direct estimates. However, the natural back transformation could produce a bias with the arc-sin transformed data, especially when the sample size within an area is not large enough. In this study, we find explicit empirical Bayes estimators that correct biases asymptotically. Moreover, assessing its mean squared prediction error is also essential. We, therefore, explicitly obtain the second-order unbiased estimators of these mean squared prediction errors, maintaining strict positivity. The data analysis result will be shown in the conclusion to apply the proposed method to the positive rate in PCR testing for COVID-19. This is joint work with Professor Malay Ghosh and Mr. Tamal Ghosh at the University of Florida.

Some considerations for measuring and interpreting heterogeneity in meta-analysis

Luke Prendergast, La Trobe University

Abstract: Used to combine summary statistics from several studies, the huge increase in available data over the last few decades has seen a rapid increase in the usage of meta-analytic methods. Meta-analysis can guide researchers in determining new hypotheses to test, alert policy and other decision makers of previously undetected associations between important variables and interventions, and provide at least a starting point for evidence-based debate. Heterogeneity in meta-analysis refers to the variation in study characteristics (e.g., differences in cohorts, intervention strategies etc.) that leads to variation in outcomes across studies. While many perceive heterogeneity to be a nuisance since it increases estimator variance, the presence of heterogeneity can itself be very insightful. In this talk we will discuss the issue of heterogeneity, consider a variety of heterogeneity measures, including some that should be used more often (e.g., prediction intervals and the coefficient of variation), and provide some examples of how heterogeneity can offer valuable insight. Along the way, we will also see the consequences of not appropriately acknowledging the presence of heterogeneity when both conducting a meta-analysis and when reporting the findings.

Wednesday 23 November

Energy minimizing surfaces for nanovial technology

Andrea Bertozzi, UCLA

Abstract: For nearly 40 years, drugmakers have used genetically engineered cells as tiny drug factories. Such cells can be programmed to secrete compounds that yield drugs used to treat cancer and autoimmune conditions such as arthritis. I will talk about recent work from UCLA to design tiny containers that can be used to sort and to select cells based on what type they are, and which compounds — and how much of those compounds — they secrete. The methodology involves templating droplets using amphiphilic microparticles. These particles are observed to hold nearly equal volumes of aqueous liquid when dispersed in an oil-water mixture. I will discuss mathematical theory to rigorously prove that through random interactions, a system of such particles achieves this state. I will also discuss efficient numerical methods for computing low energy states for various microparticle shapes and show some examples of how these particles can be used to study single cell secretion.

Supporting Australia's COVID-19 response with probabilistic forecasts

David Price and Rob Moss, University of Melbourne

Abstract: Probabilistic forecasts have been an important component of the COVID-19 response globally. In Australia, short-term forecasts of daily case incidence and clinical demand have been reported on a regular basis to government health decision-makers — providing guidance on what is to be expected in coming weeks, and helping to inform when policy changes may be required. In this talk, we will provide an overview of the forecasting components of the Australian response: the different models that contribute to a weekly 'ensemble forecast' for case incidence, the assessment of their performance, some of the updates necessary to account for the changing landscape, and a clinical forecasting model to forecast short-term ward- and ICU-bed demand.

Mathematical modelling of nitrogen management on dairy farms

Stephen Taylor, University of Auckland

Abstract: New Zealand's climate allows for full year outdoor grazing of dairy cows and a very efficient dairy industry. One downside is the nitrogen-containing chemicals that get deposited on fields through fertilising or cows' urine, because these chemicals end up in fresh water streams. In order to understand how to mitigate this, we model this nitrogen deposition and its dynamics on a dairy farm. With Graeme Wake and Tony Pleasants

Homological features of 3D medical images

Shizuo Kaji, Kyushu University

Abstract: Modern medical imaging techniques have enabled access to the interior of the human body in the form of not only 2D images but also 3D volumes. It is, however, not easy to utilise the 3D information and analysis is often limited to a slice-by-slice investigation. We need a set of features for volumetric data to take full advantage of the 3D measurements. On the one hand, radiomic features have been proposed to capture the textural characteristics of a volume. They are computed from small patches of a volume and encode only local properties. On the other hand, persistent homology (PH) provides computational machinery to extract the global structure of a volume. In this talk, we present our software, Cubical Ripser

[1], for efficient computation of persistent homology of volumetric data. Then, we define a few types of invariants of a volumetric image based on PH and demonstrate their clinical relevance to abnormality quantification and detection in lung CT [2]. [1] S. Kaji, T. Sudo, and K. Ahara, Cubical Ripser: Software for computing persistent homology of image and volume data, arXiv:2005.12692 [2] N. Tanabe, S. Kaji, et al., A homological approach to a mathematical definition of pulmonary fibrosis and emphysema on computed tomography, J Appl Physiol, vol 131-2, 2021

Thursday 24 November

Decision science thinking applied to nature conservation

Hugh Possingham, University of Queensland

Abstract: Ecology has always had a lot of mathematical theory, which blossomed in the 1960s-1980s. One of the applied branches of ecology is nature conservation (the others are pest management and harvesting). Mathematical theory for nature conservation in the late part of the last century was naïve – ignoring important issues such as finances, efficiency and risk. Over the past 30 years our group has created a range of approaches for making conservation decisions using applied mathematics and economics – such as where to place protected areas, which threatened species to invest in, how much to spend on monitoring and whether to restore or protect habitat. I will discuss the basic maths that underpins these approaches.

Challenges of developing decision tools to guide conservation decisions

iadine Chadès, CSIRO

Abstract: Over the last 10 years, we have developed decision tools to help make informed decisions to help protect biodiversity in the face of limited resources. Developing decision tools for the conservation of biodiversity poses unique challenges to researchers, e.g. poor data context, urgent decision-making and human operated systems to cite a few. I will summarise these challenges and lessons learned from our experience developing the Integrated Spatial Prioritisation (ISP) tool and testing Artificial Intelligence decision tools in the context of adaptively managing species and their associated threats for the Saving our Species Program (NSW). While the ISP is used to guide current investment as a conservation planning tool, more needs to be done to make AI decision tools relevant to managers in areas such as interpretability and trust.

TBC

Peter Dawson

Modelling through the crisis: developing methods to support decision-making in the COVID-19 pandemic

Freya Shearer and Gerard Ryan, University of Melbourne

Abstract: Here we will talk about a range of modelling and data-analytics work conducted on a regular and ad hoc basis since 2020 to provide government health decision-makers with information to manage the COVID-19 pandemic. We will first discuss the novel metric of "Transmission Potential" (TP), which is the average potential for transmission in the community. TP can be combined with case data in a semi-mechanistic framework to calculate a continuous risk metric. In times of ongoing transmission, this metric is equivalent to the effective reproduction number of a virus, while in times of low or no transmission, the metric reverts to TP — providing decision-makers with a tool that is applicable at all stages of outbreak and suppression.

We describe the incorporation of changes to adapt the framework to novel variants and the rollout of the vaccination programme, and the downstream uses of this work in case and clinical forecasting, and contributions to the "National Plan to Reopening". We will discuss both the technical developments and policy implications of the work.

The effect of sediment heterogeneity on sediment yield during gully erosion

Melanie Roberts, Griffith University

Abstract: Gully erosion is the majority source of fine sediment that ultimately reaches the Great Barrier Reef (GBR), while also contributing to the pool of bioavailable nutrients in the lagoon. Particulate nitrogen is transported with sediment to the GBR, degrading water quality and contributing to poor outcomes including algal blooms, and potentially crown-of-thorns starfish outbreaks. Quantifying the surface area of eroded sediment is important to estimate the particulate nitrogen load, and thereby prioritise interventions.

The MERGE gully erosion model was developed in partnership with Queensland Government and the Queensland Water Modelling Network to provide a process-based model to inform gully rehabilitation actions at specific sites. In this talk I introduce MERGE-D, which extends MERGE to account for heterogeneities in sediment properties, providing an improved estimated of sediment surface area, and hence particulate nitrogen loads.

Poster abstracts

Quantitative Stochastic Homogenization of Parabolic Equations with Lower Order Terms

Man Yang, Kyushu University

Abstract: I am a doctoral student at Kyushu University. I received my master's degree in mathematics from Kyushu University in 2022 and my bachelor's degree in Mathematics from Shanghai University in 2019. My research area is probability theory and more precisely, I study the stochastic homogenization theory currently. I am also interested in the relationship between stochastic differential equations and homogenization theory.

The critical points of the elastic energy among curves pinned at endpoints

Kensuke Yoshizawa, Kyushu University

Abstract: I am a postdoctoral researcher at Institute of Mathematics for Industry in Kyushu University. I got my Ph.D. at Tohoku University in 2022 under the supervision of Prof. Shinya Okabe. Today's my poster is devoted to the presentation of optimal shapes of ideal elastic rods whose endpoints are fixed (up to zeroth order), thorough the mathematical analysis of the corresponding variational problem.

Expected number of zeros of Gaussian analytic function with finitely dependent Gaussian coefficients

Kohei Noda, Kyushu University

Abstract: I'm a doctoral student in Graduate School of Mathematics for Innovation, Kyushu University. My research area is probability theory and complex analysis related to statistical mechanics of Coulomb systems, in particular, I'm studying zeros process of Gaussian analytic function and random matrix theory under supervisor Professor Tomoyuki Shirai in my doctoral course. Also, I'm supported by WISE program (MEXT) at Kyushu University.

This is joint work with Tomoyuki SHIRAI, Kyushu University

Study on recurrences of random walks on growing k-ary trees

Shuma Kumamoto, Kyushu University

Abstract: Shuma Kumamoto received his B.S. degree in physics and M.S. degree in informatics from Kyushu University in 2020 and 2022, respectively. He is currently a Ph.D. student in mathematics at Kyushu University. His research interest includes random walk.

This is joint work with Shuji Kijima, Shiga University and Tomoyuki Shirai, Kyushu University.

Embedding spherical quandles in pin groups

Kentaro Yonemura, Kyushu University

Abstract: I am a student in Japan and am interested in knot theory and the quandle, an algebraic system related to knot theory. These days, the quandle class with a manifold structure, called smooth quandle, is my hot topic. I am looking forward to talking with you and discussing the future of mathematics.

Lyapunov Regularity for Planar Piecewise Expanding Maps

Kodai Yamamoto, Kyushu University

Abstract: I am a master course student at Joint Graduate School of Mathematics for Innovation, Kyushu University. My supervisor is Prof. Masato Tsujii at Kyushu University. I mainly study dynamical systems, especially structural stability and hyperbolicity. Recently, I am interested in Lyapunov regularity and have been researching this since I was an undergraduate student.

This is joint work with Yushi NAKANO, Tokai University and Teruhiko SOMA, Tokyo Metropolitan University.

Model Selection in Statistical Learning Theory

Naoki Nakamura, Kyushu University

Abstract: According to Occam's Razor, we should not assume too much when explaining things. In the context of Statistical learning theory, this means that we should adopt the simplest model. In general, the optimization problem for finding sparse simpler accurate model is NP-hard. Thus, practitioners don't try for searching simpler models. Currently, this problem is abandoned in machine learning. So, it is important that we answer the following practical questions: Can we show that an accurate and simpler model exists?

Multiple Zeta Values and Euler's reflection formula for the Gamma function

Karin Ikeda, Kyushu University

Abstract: I am Karin Ikeda, the first year master course student at Kyushu University. My supervisor is professor Masanobu Kaneko. I am currently studying "multiple zeta values". In particular, I have been able to give a purely algebraic proof of an identity which is closely related to Euler's reflection formula for the gamma function. For more details, please see my slides of the talk. Thank you!

This is joint work with Mika Sakata, Osaka University of Health and Sport Sciences.

Parameterising movement parameters in an onchocerciasis transmission model with a population genetic data

Himal Shrestha, La Trobe University

Abstract: Himal Shrestha is a PhD students at Nematode and Vector Genomics lab at La Trobe University, Australia. He uses genetic, environmental and epidemiological data to model transmission of a neglected tropical disease called river blindness. Himal is interested in spatial modelling and landscape genetics.

This is joint work with Shannon M. Hedtke, La Trobe University, Karen McCulloch, La Trobe University, Warwick N. Grant, La Trobe University and Rebecca Chisholm, La Trobe University.