AMSI SUMMERSCHOOL 20
IN THE MATHEMATICAL SCIENCES

6–31 JAN 2020 LA TROBE UNIVERSITY

EVENT REPORT

AMSI AUSTRALIAN MATHEMATICAL SCIENCES INSTITUTE

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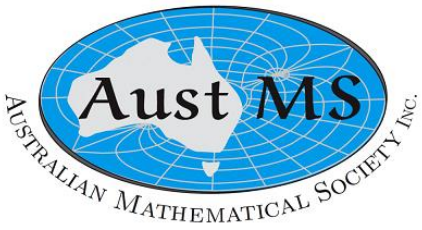
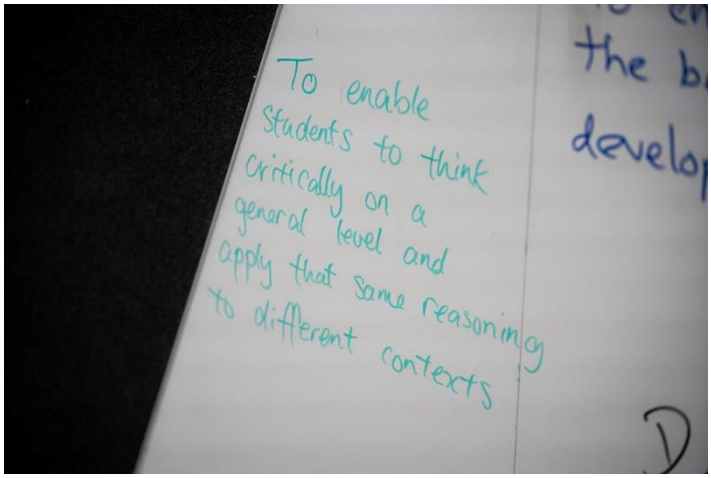


AMSI Summer School 2020

in the Mathematical Sciences

La Trobe University

6 – 31 January 2020


To enable
students to think
critically on a
general level and
apply that same reasoning
to different contexts


AMSI

FOREWORD

The AMSI Summer School is one of five premier flagship events hosted each year around Australia, and forms part of the Securing Australia's Mathematical Workforce: 2016-2020 agreement between AMSI and the Department of Education. Now in its 18th year, this key program has become of the most important calendar events for honours and postgraduate students in the mathematical sciences and cognate disciplines.

Hosted over four weeks, the program offers eight distinct subjects and gives students the opportunity to learn from highly experienced lecturers from all around Australia.

The complete program, comprising course content and extra activities, is designed to align with the project objectives of the agreement to:

- Strengthen research training and the work-readiness of advanced mathematical sciences graduates
- Promote university-industry collaborations that will encourage the private sector employment of mathematical sciences graduates
- Attract and improve the retention of senior undergraduate students in the mathematical sciences, with particular attention to women and Aboriginal and Torres Strait Islander students

AMSI Summer School 2020 was jointly funded by the Australian Mathematical Sciences Institute (AMSI) and the Australian Government's Department of Education, with support from La Trobe University, the Australian Mathematical Society (AustMS), Australian New Zealand Industrial and Applied Mathematics (ANZIAM), the Statistical Society of Australia (SSA), the Australian Signals Directorate and Optiver.

"Everything that occurred last month felt like it added value to my life. The intellectual material, the people, and the leisure activities. The whole month was nothing but positive and I cannot express my gratitude for that fact.

AMSI Summer School acts as a filter for the kinds of value system that I connect with most. It may not have been the stated purpose but the school has made me feel less alone, more relatable, and more like I have options for expressing my intellectual and personal interests into the future. Not only maths peers but people with similar social viewpoints, similar creative hobbies, all sorts of things. I did not expect any of this but I cannot imagine what it would be like now without these connections I have made."

Jarvis Carroll, University of Tasmania

DIRECTOR'S REPORT

The AMSI Summer School is one of the most important national events on the mathematical calendar for honours, masters and PhD students. It enables senior undergraduate students, honours students, postgraduate students and early-career researchers to come together over four weeks, take advanced courses in pure and applied mathematics, statistics and cognate disciplines which may not be offered in their home institutions, and meet and socialise with their peers from all over Australia. This is especially beneficial for students from smaller institutions. For academics, it is an opportunity to lecture and interact with the brightest students from around Australia.

In 2020, the AMSI Summer School was held at La Trobe University Melbourne campus from January 6 to January 31. The 2020 Summer School attracted 163 students from 18 institutions representing every Australian state (this is only eight students short of the record attendance in 2019). Support to attend the Summer School was provided to 50 students through AMSI Travel Grants. Students participated in eight intensive courses covering all aspects of the modern mathematical sciences, from pure and applied mathematics to statistics and cognate disciplines, to teaching and learning at the tertiary level. The courses, which incorporated lectures, practice classes and computer labs, were delivered by 12 experts from five universities around Australia. There were 108 students sitting the final exam on February 12; almost all of them for credit, and four for interest.

One of the highlights this year was the engagement and really good spirit among the students. They were dedicated, enthusiastic, positive and passionate about what they were learning. Encouraging and stimulating networking between students was as much important. To facilitate that, a large number of program extras (which were very popular among the students) was organised this year. This included the public lecture on climate change modelling by Professor David Karoly (CSIRO), with more than 120 attendees; five lunchtime lectures including one on epidemics modelling; two movie nights, sports-centre activities and the rock-climbing session; the Career Day, the Women in STEM lunch and the Equity and Diversity in STEM Q&A session; two weekend bus excursions; wildlife sanctuary tours and the campus tours, and weekly BBQs and the closing dinner.

Finally, I would like to thank the sponsors, without whom this event would not be possible, and the many people who worked tirelessly in the year-long planning and execution of the Summer School. The Program Standing Committee gave significant thought in choosing a broad range of topics and lecturers, which were relevant, appealing and would complement the programs at students' home institutions. The high registrations and student engagement attests to the quality of this program. In the latter part of 2019, the Organising Committee worked almost full-time on the preparation of the Summer School. Particular thanks go to Natasha Freeman, Patricia Eliadis and Luke Prendergast from La Trobe University, and Tim Brown, Chloe Pearse and Anna Muscara from AMSI.

Dr Yuri Nikolayevsky—Event Director, AMSI Summer School 2020

COURSE PROGRAM

The academic program consisted of eight courses throughout the intensive four-week timetable. Students were given the opportunity to enrol in up to two courses and had the option to take one course for credit, completing assessment tasks including a final examination, and obtaining a passing grade.

Courses offered could be roughly categorised as follows:

Differential Geometry and Symmetry

Dr Romina Arroyo, The University of Queensland
Dr Ramiro Lafuente, The University of Queensland

Geometric Group Theory

Dr Alejandra Garrido Angulo, The University of Newcastle
Professor Murray Elder, University of Technology, Sydney
Dr Lawrence Reeves, The University of Melbourne

Applied Nonlinear Partial Differential Equations

Professor Philip Broadbridge, La Trobe University
Dr Dimetre Triadis, La Trobe University

Dynamic Processes Spreading on Networks

Dr Joel Miller, La Trobe University

Effective Teaching, Effective Learning in Quantitative Disciplines

Associate Professor Katherine Seaton, La Trobe University

The Finite Element Method

Dr Bishnu Lamichhane, The University of Newcastle

Random Fields: Mathematical Theory and Spatial Statistical Applications

Associate Professor Andriy Olenko, La Trobe University

Markov Chains with Applications *(Sponsored by SSA)*

Professor Malwina Luczak, The University of Melbourne

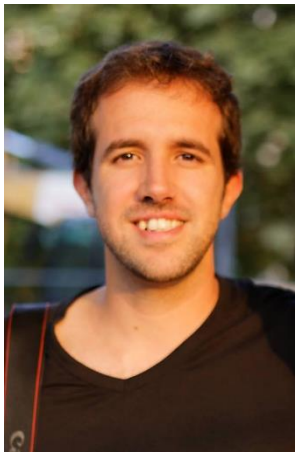
"Being able to engage in a formal course in an area of mathematics that I thoroughly enjoy was a fantastic experience. The interactions that were possible due to the offering of this course have increased my enthusiasm and drive to continue my mathematics career. Both Romina and Ramiro were friendly, approachable and knowledgeable, which made this course enjoyable. The fact that we were able to be introduced to open problems in this field allowed for the course to be viewed as a foundation for further work, not merely another course which is designed to relay information.

[AMSI Summer School] is thus far the epitome of my experiences in higher education. The event has inspired me to continue to progress towards a mathematical oriented career and not branch off to some related field."

Daniel Sykes, University of New England

Differential Geometry and Symmetry

Dr Romina Arroyo and Dr Ramiro Lafuente, The University of Queensland



Synopsis: Symmetries appear naturally in a wide range of mathematical and physical theories. They usually arise as groups acting as transformations of a certain space while preserving a given structure. Studying geometric spaces with symmetries not only provides us with a rich source of examples, but also gives rise to new rigidity phenomena and nicer structural properties which become interesting in their own right.

In this course we covered the basic concepts in differential and Riemannian geometry. After that we introduced Lie groups and homogeneous Riemannian manifolds (Riemannian manifolds with a transitive group of isometries), and describe their geometric properties. Our main focus was in the study of state-of-the-art questions involving curvature and special metrics such as Einstein and Ricci solitons. Along the way, special attention was given to important open problems in the field.

Course Overview:

- Smooth manifolds, tangent vectors and spaces, vector fields
- Riemannian metrics, covariant derivative, curvature.
- Brief introduction to Lie groups, Lie algebras and homogeneous spaces
- The geometry of homogeneous Riemannian manifolds
- Homogeneous Einstein and Ricci soliton metrics

Number of students who completed the course:	**29**
Number of students who passed the course for credit:	**8**
Agreed the course was of a high standard:	**92%**

"I enjoyed the lectures the most in this course. Romina and Ramiro are both very good lecturers and presented the content in a fun and easy to understand manner."

Max Carter, The University of Newcastle

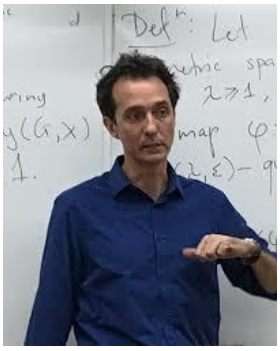
Geometric Group Theory

Dr Alejandra Garrido Angulo, The University of Newcastle

Prof. Murray Elder, University of Technology Sydney

Dr Lawrence Reeves, The University of Melbourne





Synopsis: Groups and geometry are ubiquitous in mathematics. This course introduced students to the study of infinite groups from the geometrical viewpoint and drew on ideas from low-dimensional topology, hyperbolic geometry and notions of self-similarity (fractal geometry). The principal focus was the interaction of geometry/topology and group theory: through group actions and suitable translations of geometric concepts into a group theoretic setting.

Course Overview:

- Free groups and presentations, ping-pong lemma
- Cayley graphs, quasi-isometries, Milnor-Švarc lemma
- Hyperbolic groups
- Embedding theorems, decision problems
- Nilpotent groups, soluble groups
- Growth of groups
- Self-similar groups

Number of students who completed the course:	**29**
Number of students who passed the course for credit:	**10**
Agreed the course was of a high standard:	**100%**

"It was significantly different to any course I've done before."

Thomas Munn, The University of Adelaide

"The topic is not one which is offered at my home institution… and it was a very interesting course which opened me up to a new area I'd heard about but hadn't done much study in."

Alastair Anderberg, The University of Newcastle

Applied Nonlinear Partial Differential Equations

Professor Philip Broadbridge, La Trobe University

Dr Dimetre Triadis, La Trobe University

Synopsis: Partial differential equations (PDEs) model an enormous variety of continuum dynamic processes, including fluid dynamics, elasticity, solute and heat diffusion, subterranean hydrology, population dynamics, electromagnetic fields and gravity. Nonlinearity (or dependence of PDE coeffcients on dependent variables) is essential to explain some familiar phenomena such as thermal ignition and wave breaking. Some helpful techniques were applied to develop a conceptual understanding of nonlinear waves and nonlinear diffusive processes, with minimal theory of function spaces. These techniques included the method of characteristics, asymptotic approximations, symmetry reduction and integrable models.

Course Overview:

Part A Nonlinear Waves

- The theory of characteristics for first-order PDEs.
- Weak solutions for first-order PDEs in conservation form.
- Hyperbolic, parabolic and elliptic second-order PDEs.

Part B Nonlinear Diffusion

- Role of Burgers' equation in gas dynamics and soil-water flow
- Initial-boundary value problems with Burgers' equation
- Nonlinear heat conductivity and nonlinear diffusivity
- Initial-boundary problems with integrable nonlinear diffusion models
- Reaction-diffusion equations with blow-up; similarity reductions
- Reaction-diffusion equations with logistic source. Stable travelling waves
- Theory of Lie Symmetry reductions

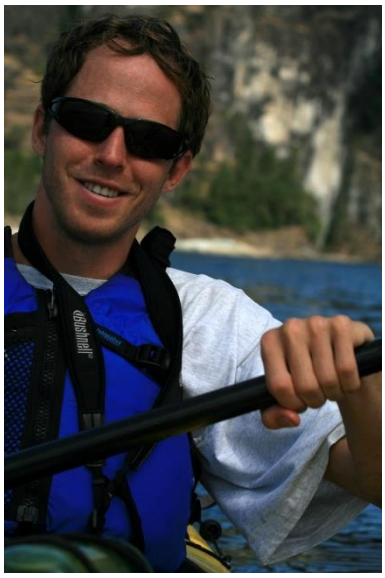
Number of students who completed the course:	**11**
Number of students who passed the course for credit:	**6**
Agreed the course was of a high standard:	**100%**

"The lecturers were nice and easy to approach. The class was hard but the lecturers both had a relaxed way so it didn't feel like the pace was overwhelming at any time. The course was a very general look and meant it could be taken by people of all backgrounds."

Anonymous

Dynamic Processes Spreading on Networks

Dr Joel Miller, La Trobe University



Synopsis: Networks form the substrate along which many infectious diseases and ideas spread. Understanding how the structure of a network interacts with a spreading process is an important step in its control. The importance of infectious disease control has been clear for some time. More recently it has become clear that our social networks are highly susceptible to the spread of false information, which can be used by adversaries to damage countries.

We developed differential equations models that perform well at predicting the spread of stochastic simulations in random network networks. We also compared those models with simulations in networks generated from real observations (there are a number of sources of such measured networks).

Our goal was to gain experience developing relevant models, and to understand how interactions between individuals can affect how a disease or idea spreads. We used this to provide some insight into how to reduce (or enhance) a spreading process.

Course Overview:

- Introduction to spreading processes
- Introduction to random networks (the “configuration model”)
- Introduction to Python
- Biological contagions
- Social contagions

  Interacting contagions

Number of students who completed the course:	**27**
Number of students who passed the course for credit:	**17**
Agreed the course was of a high standard:	**87%**

“The content of this course was distinct to anything else I have learnt, and the content was delivered in a thoroughly enjoyable way… Joel Miller was a fantastic, clear, and enthusiastic lecturer.”

Anonymous

“[I enjoyed] *The relevance to my own upcoming honours project and also to many of the issues the world is facing today - mostly obviously, coronavirus, but also the spread of fake news or the construction of social networks.”*

Cassady Swinbourne, The University of Tasmania

Effective Teaching, Effective Learning in Quantitative Disciplines

Associate Professor Katherine Seaton, La Trobe University

Synopsis: The aim of this subject was to introduce those who will be tutors in the mathematical sciences to the theories, principles and practice of university learning and teaching in this area. This subject was designed to provide practical, discipline-specific and best-practice strategies for teaching and assessment so as to enhance student engagement and learning in mathematics. Through a series of sequential online modules, supplemented by face-to-face workshops, we examined how students learn in mathematics and how you can use this knowledge to plan your lessons and how you go about giving feedback.

Course Overview:

- Demonstrate an enthusiasm for the discipline of mathematics and a commitment to developing a student learning community that is respectful of the individual learner
- Use knowledge of the discipline and how students learn (both generally and in the discipline) to select appropriate teaching and learning activities for mathematics classes
- Develop a repertoire of strategies to create positive learning environments that are supportive and engaging, and that allow students to gain feedback to enhance their learning
- Plan how you will evaluate and reflect on the effectiveness of your teaching through collection of evidence about student learning and student engagement

Number of students who completed the course:	**13**
Number of students who passed the course for credit:	**6**
Agreed the course was of a high standard:	**100%**

"Excellent lecturer who delivered an online course in person and made it work. The content was very worthwhile, not just for teaching but for my own learning. Really enjoyed getting to teach other course participants in the mock tutorial!"

Anonymous

"It is not a course that is held anywhere else in this context... the wide variety of different kinds of alternative teaching tools, e.g. escape room, kahoots, that we got a chance to see is very useful and empowering as it gives us ideas to deal with restrictions that a course coordinator may have on how a subject is taught."

Anonymous

The Finite Element Method

Dr Bishnu Lamichhane, The University of Newcastle

Synopsis: The finite element method is one of the most powerful techniques in approximating the solution of partial differential equations arising in the mathematical modelling of many physical and engineering processes. The finite element method is based on firm mathematical foundation, where mathematical tools from functional analysis, approximation theory and variational calculus are applied to analyse the whole approximation process. This course aims at introducing the theory and computation of finite element techniques for elliptic and parabolic partial differential equations. Applications to heat transfer, elasticity and image processing will be discussed.

Course Overview:

This course provided an introduction to the finite element method. The following topics were covered:

- Weak formulation: weak formulation of partial differential equations, Sobolev spaces, well-posedness, finite element discretisation, error estimates
- Finite element spaces: linear and quadratic finite element methods in one, two and three dimensions, construction of some finite element spaces, reaction-diffusion and convection-reaction-diffusion problems
- Implementation: programming linear and quadratic finite element methods for convection-reaction-diffusion problems, time-dependent problems
- Applications: heat transfer, image processing and solid mechanics

Number of students who completed the course:	**11**
Number of students who passed the course for credit:	**4**
Agreed the course was of a high standard:	**100%**

"I really liked Bishnu's explanations and his nicely handwritten notes. I think Bishnu is a great lecturer and takes care to make sure everyone is up to date with the concepts that he introduces."

Bao Anh Vu, University of Wollongong

"I enjoyed being challenged with mathematics beyond my level... Bishnu has a very good in-class persona and was supportive and encouraging to all students… The part of the course on applications was very interesting and gave me an idea of how maths is applied to image processing and problems in mechanics."

Cameron McLaren, RMIT

Random Fields: Mathematical Theory & Spatial Statistics Applications

Associate Professor Andriy Olenko, La Trobe University

Synopsis: The course surveyed the theory of spatial stochastic processes and statistics models, and their applications to a wide range of data including GIS (geographic information systems). It covered the methodology for spatial modelling, estimation and prediction, and spectral analysis of spatial processes.

Course Overview:

The first part of the course covered various topics in the theory of random fields (stochastic processes indexed by points of multidimensional spaces or manifolds). Spectral and correlation properties of random fields were studied. Gaussian spatial processes and several extensions to non-Gaussian and spatial-temporal scenarios were covered. Smoothness and other geometric properties of random fields were investigated.

The second part was devoted to the methodology and applications in spatial modelling. Random fields were main tools for various types of statistical analysis, estimation, spatial prediction and experimental design. All the methods presented in this part were introduced in the context of specific real-world data using R software.

Number of students who completed the course:	**61**
Number of students who passed the course for credit:	**41**
Agreed the course was of a high standard:	**91%**

"Highly qualified lecturer and interesting course."

Puja Kandel, La Trobe University

"I particularly enjoyed the blend of mathematical theory presented in lectures with the applied nature of the lab sessions taught in R. "

Oliver Lountain, The University of Adelaide

Markov Chains with Applications

Professor Malwina Luczak, The University of Melbourne

Synopsis: Markov chains are widely used as models of real-world processes, especially where it is important to incorporate a degree of randomness in the evolution of the system.

For instance, when modelling the outbreak of a disease in a population, the current state of the system can be captured reasonably accurately by the number of people presently infected and the number of those susceptible to the disease, but the future course of the epidemic cannot normally be known with any confidence. It may be influenced by a few chance events, especially when the number of infectives is small (such as at the start or near the end of the outbreak), which may have a crucial impact on how long it takes before the epidemic is contained and how many people will end up being infected.

This course covered some important aspects of the theory of Markov chains, in discrete and continuous time. We start with the basics, including a discussion of convergence of the time-dependent distribution to equilibrium as time goes to infinity, in the case where the state space has a fixed size. We then studied concepts and results regarding the long-term and limiting behaviour of large systems; this involved looking at convergence of the distribution to equilibrium, also letting the state space size become larger and larger.

An important phenomenon in that context is that of phase transition, where the behaviour of a large system changes radically as the value of a parameter moves through a critical value. This is best studied by considering a sequence of systems, and letting the parameter value be a function of the system size.

Examples of applications were given, including some basic epidemic models, as well as models arising in statistical physics and computer science.

Course Overview:

1. Preliminaries from measure-theoretic probability
2. Probability spaces; sequences of random variables; conditional probability and expectation; Martingales and stopping times
3. Markov chains in discrete and continuous time
4. Definitions and examples; transient evolution; hitting times; invariant distributions and convergence to equilibrium
5. Couplings; total variation distance; mixing time
6. Sequences of Markov chains; rapid mixing and the cutoff phenomenon; concentration of measure and approximation by differential equations
7. Examples and applications will be given throughout the course; these will include a selection from the following: epidemic models, Glauber dynamics, random walks, load-balancing systems

Number of students who completed the course:	**33**
Number of students who passed the course for credit:	**16**
Agreed the course was of a high standard:	**87%**

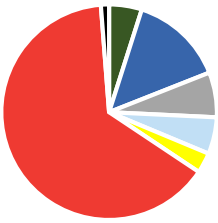
Sponsored by the Statistical Society of Australia

"I really loved the Markov Chains course. Malwina was excellent, and her lecture notes were (and still are) extremely helpful."

Jacob Coreno, The University of Melbourne

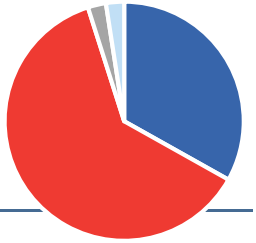
PARTICIPATION BREAKDOWN

Enrolments by Institution	
Australian National University	11
La Trobe University	53
Macquarie University	3
Monash University	19
Murdoch University	1
Queensland University of Technology	1
RMIT University	8
Swinburne University of Technology	1
The University of Adelaide	9
The University of Melbourne	22
The University of New England	1
The University of New South Wales	5
The University of Newcastle	6
The University of Queensland	10
The University of Sydney	6
The University of Western Australia	1
The University of Tasmania	4
The University of Wollongong	2
TOTAL	163



STATE/TERRITORY

ACT	8	5%?
NSW	23	14%
QLD	11	7%
SA	9	6%
TAS	5	3%
VIC	105	64%
WA	2	1%
INTERNATIONAL	0	0%



GENDER

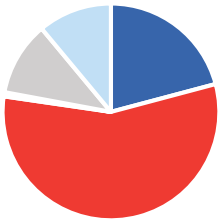
Female	54	33%
Male	101	62%
Other	4	2.5%
Prefer not to disclose	4	2.5%

ATSI STATUS

No	162	99%
Yes	0	0%
Prefer not to disclose	1	1%

RESIDENCY STATUS

Australian Citizen	83	51%
Permanent Resident	5	3%
Student Visa	73	45%
Other	2	1%
Prefer not to disclose	0	0%



ACADEMIC STATUS

Undergraduate	18	11%
Honours	34	21%
Masters	92	56%
PhD	18	11%
Early-Career Researcher	0	0%
Other	1	1%

GRANTS

AMSI Travel Grants

AMSI Travel Grants are offered to support AMSI Member students attending flagship higher-education events by funding their travel and accommodation. AMSI Summer School 2020 grants were funded by AMSI, La Trobe University and the Australian Government's Department of Education and were determined on a competitive basis. In 2020, AMSI Travel Grants were awarded to 50 students from 13 AMSI Member universities:

- Diclehan Erdal, Australian National University
- Murdock Grewar, Australian National University
- Michael Howes, Australian National University
- Dashneet Singh, Australian National University
- David Winter, Australian National University
- Fan Xu, Australian National University
- Rachel Zhang, Australian National University
- Farzaneh Boroumand, Macquarie University
- Abhay Kulkarni, Macquarie University
- Ali Shariati, Macquarie University
- Patrick Bur, Monash University
- Liam Yemm, Monash University
- Jia Jun Ooi, Murdoch University
- Cameron Baulderstone, The University of Adelaide
- Alexander Lai De Oliveira, The University of Adelaide
- Shan Shan Lin, The University of Adelaide
- Oliver Lountain, The University of Adelaide
- James McCusker, The University of Adelaide
- Thomas Munn, The University of Adelaide
- Liam Stoldt, The University of Adelaide
- Stuart Teisseire, The University of Adelaide
- Michael Ucci, The University of Adelaide
- Daniel Sykes, The University of New England
- Jiayi Li, UNSW
- Xiongwen Ke, UNSW
- Alastair Anderberg, The University of Newcastle
- Max Carter, The University of Newcastle
- Mikayla Goodwin, The University of Newcastle
- Joao Vitor Pinto e Silva, The University of Newcastle
- Bonnie Cramton, The University of Queensland
- Cameron Gordon, The University of Queensland
- Christopher Hanson, The University of Queensland
- Chelsea Just, The University of Queensland
- Lawrence Lo, The University of Queensland

- Nizhum Rahman, The University of Queensland
- Bryce Stansfield, The University of Queensland
- Patrick Sykes, The University of Queensland
- Jack Thompson, The University of Queensland
- Ling Xu, The University of Queensland
- Supavit Dumrongprechachan, The University of Sydney
- Timothy Lapuz, The University of Sydney
- Timothy Simich, The University of Sydney
- David Wiggins, The University of Sydney
- Zhao Zheng, The University of Sydney
- Alexander Rohl, The University of Western Australia
- Madeleine Cockerill, The University of Tasmania
- Cassady Swinbourne, The University of Tasmania
- Jarvis Carroll, The University of Tasmania
- Thomas Futcher, The University of Wollongong
- Bao Anh Vu, The University of Wollongong

"I really enjoyed being surrounded by lots of people who are mathematically literate. It cannot be understated how terrible it is to have nearly no one who is a peer to talk about your work or studies so it was fantastic to have such a plethora of ideas and personalities to interact with in the context of mathematics."

Anonymous

"It was great to be in a really social environment where everybody had very similar interests and similar goals. The course was wonderful and I learnt a lot and got a head start on my honours, but it was the friends and experiences that were the best part of the Summer School."

Madeleine Cockerill, The University of Tasmania

"Networking with other like-minded individuals is an experience I cannot put value on. It was so good to be able to realise I was not alone… I thoroughly enjoyed the public lectures as they provided an insight into the possibilities for future studies and areas I could potentially move into."

Sarah Shotter, The University of Newcastle

EVENT HIGHLIGHTS

Opening Ceremony

The 2020 Summer School was officially opened on Monday 6 January by La Trobe Deputy Vice Chancellor (Research and Industry Engagement) Professor Susan Dodds and Professor Robert Pike (Provost, College of Science, Health and Engineering). Both guests spoke about the importance of diversity and inclusion as well as the impressive innovations the mathematical sciences have been able to offer humanity, particularly in modern times. Of particular note was the importance of mathematics in the climate change debate. AMSI Director Professor Tim Brown and Event Director Dr Yuri Nikolayevsky also welcomed students to La Trobe and Summer School. The event was hosted in the Hoogenraad Theatre in the La Trobe LIMS building. It was attended by approximately 200 guests including students, staff and other honoured guests. Formalities were followed by morning tea, a group photo and tours of the campus.

Diversity in STEM Event

As part of the Careers Day Fair, a Diversity in STEM event was hosted. Designed as a panel session, the event brought together various professionals from different parts of mathematics to highlight the achievements and some of the challenges from diverse voices in the field. The panel touched on their experiences in STEM and gave the audience more of an insight into some of the challenges that hinder diversity and inclusion in academia and the workforce. Panel members included those from the LGBTQI+ and migrant communities as well as those living with disability. Attendees were encouraged to participate in lively and informative discussions around these barriers and think more broadly about the ways they can participate and create a more inclusive community. AMSI and La Trobe would like to thank Dr Sarah Stephenson (Murdoch Children's Research Institute/ founding member of QueersInScience), Stephanie Marinis (masters student, La Trobe University), Haylo Roberts (microbiologist, geneticist and science communicator) and Dr Bishnu Lamichhane (The University of Newcastle) for their time.

"Having a large community of maths people around is really amazing. It's the first time in my life I've been able to go to an event like this… it was really eye opening to see this type of community outside of uni."

Bryce Stansfield, The University of Queensland

Careers Day Fair

The Careers Day Fair is always a highlight for students attending Summer School, providing valuable information and contacts for student careers pathways. This year, the event was hosted by AMSI Director Professor Tim Brown. Presentations about career pathways in mathematics were given by:

- CSIRO's Data 61
- Optiver
- Australian Signals Directorate
- Bureau of Meteorology
- APR Intern

This was followed by two different panel sessions about pathways for Graduates in the Mathematical Sciences and a Diversity in STEM panel. These panel sessions gave students the opportunity to find out more about different career paths available to them, exposure to different career experiences and a chance to engage in deeper discussion with members of industry. AMSI would like to thank the following panel members for their time:

Choose Your Own Adventure—Pathways for Graduates in the Mathematical Sciences
Nicole Meaker, CISCO
Sam Salehi, Trustwave, an Optus Company
Michael Camarri, Cognizant
Chloe Pearse, AMSI (Panel MC)

Diversity in STEM Panel Session
Dr Sarah Stephenson, Murdoch Children's Research Institute/ founding member of QueersInScience
Stephanie Marinis, La Trobe University
Haylo Roberts, microbiologist, geneticist and science communicator
Dr Bishnu Lamichhane—The University of Newcastle
Chloe Pearse, AMSI (Panel MC)

The Careers Day Fair also included an expo where students were able to talk with presenters, panel speakers and stall holders individually about career paths and graduate employment opportunities. 120 students participated in the event with positive feedback from both presenters and students. In particular, students found the day very informative, discovering career pathways they did not realise were available to them.

SOCIAL EVENTS

Welcome Reception

At the end of the first day of the program, students and teaching staff were invited to a BBQ dinner on the Thomas Cherry Lawn to meet and make friends in a relaxed and informal environment. The evening was well attended with approximately 130 students arriving for dinner. The event continued well into the evening with students staying to enjoy the La Trobe surroundings and company.

Women in Maths Networking Event

A Women in Maths event was hosted early in the first week of Summer School. This specialised event gave female staff and students the chance to meet over lunch and share their experiences studying and working in the mathematics fields. This event was lead by a panel including Professor Kate Smith-Miles (The University of Melbourne), Associate Professor Katherine Seaton (La Trobe University) and Dr Anja Slim (Monash University), who participated in a Q&A about their career paths and their unique experiences as women in mathematics. Feedback from students was that this event was particularly inspiring. This event attracted approximately 50 students.

Weekly BBQs

Barbecues were hosted on campus on a weekly basis. Students and teaching staff gathered on the Thomas Cherry Lawn each Thursday to socialise and relax over lunch. These events were well attended with approximately 50-70 students in attendance in any given week.

"I'm really glad I got to see the twelve apostles, and a wine tour is not something I'd pick for myself but I really enjoyed it."

Anonymous

Twilight tour of La Trobe Wildlife Sanctuary

The team at La Trobe arranged twilight tours of their wildlife sanctuary. Armed with torches and sturdy footwear, staff and students were treated to a guided tour of the longest running ecological restoration project in Australia. Guests engaged in wildlife spotting of some of Australia's most unique creatures and learnt about natural history in this region of Melbourne. These sessions were very popular with both twilight tours being booked out.

Weekend Excursions

Two weekend excursions were arranged as an opportunity for interstate students to see some of the sights of Greater Victoria as well as give them some respite from the intensity of their day-to-day classes. On the first weekend, students visited the Great Ocean Road, seeing landmarks including the Great Ocean Road Memorial Archway, Gibson's Steps, The Twelve Apostles and Loch Ard Gorge. Students also visited Torquay, Apollo Bay and Port Campbell. Forty students attended this excursion. The second excursion was a winery tour through the Yarra Valley region, with students visiting wineries in Seville East, Wandin North, Coldstream and Yarra Glen. This excursion was also immensely popular with 34 students and teachers in attendance.

Movie Maths

Throughout the Summer School program, two movie nights were hosted. This was another opportunity for students to relax and enjoy each other's company outside of the classroom. Enjoyed by all who attended, the movies were *Hidden Figures* (2016) and *The Man Who Knew Infinity* (2015).

"The chance to meet other interested maths students at a similar level to myself, this motivates me to engage in further study and to deepen my understanding of mathematics. It also expands my world view in unexpected and exciting ways."

Alastair Anderberg, The University of Newcastle

"AMSI Summer School is an awesome place to make friends, especially if you can't go out much or don't like going outside. I enjoyed AMSI Summer School mostly because I got to talk to so many different people doing Mathematics & Statistics [sic] all over Australia and get to know them, and see situations from so many different points of view. It also taught me so many valuable lessons that I don't think we could learn outside… the Summer School had guided me to know what I really want to do in the future."

Jia Jun Ooi, Murdoch University

Lunchtime Lectures

Lunchtime lectures were also a common fixture throughout the program. These lecturers covered a novel aspect of mathematics and challenged students to see outside the square and see mathematics in action in new ways. Accompanied by lunch, these events were immensely popular. One lecture was hosted each week, with the Maths Craft lecture hosted a second time by popular demand. A sporadic lecture was organised to discuss the modelling around the spread of the topical Corona Virus COVID-19. AMSI and La Trobe would like to thank the following lecturers for their time:

- Associate Professor Katherine Seaton and Michael Assis—Maths Craft
- Professor Brian Davey—Abelian groups and their role in the pathological behaviour of braids and the downfall of democracy
- Dr Marcel Jackson—Mathematics and rhythm
- Dr Joel Miller—Mathematical contributions to the early response to emerging epidemics

Sporting and Outdoor Activities

By special request by students, a social rock-climbing event was hosted. This was very popular as it allowed students to take time out from their studies and bond over other light-hearted and casual physical activities. Students also took advantage of local gym and swimming pool facilities on campus.

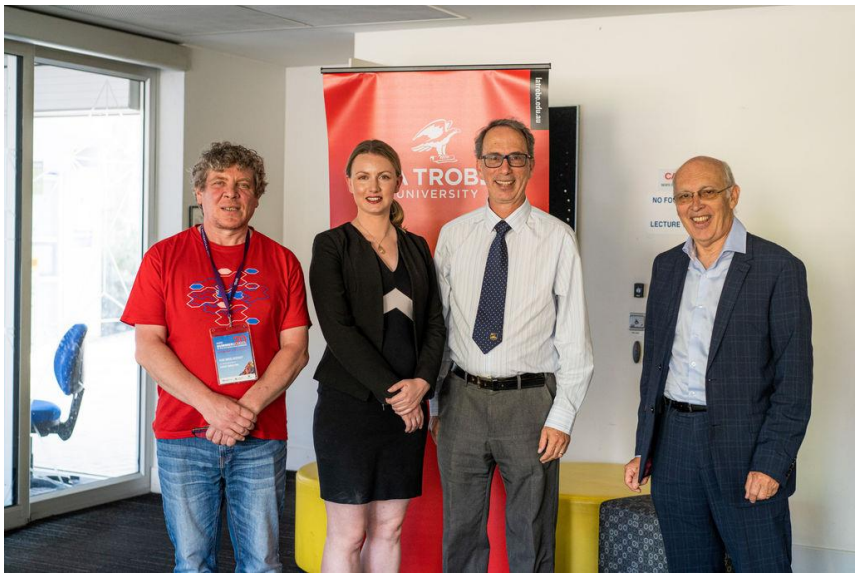
Closing Dinner

A twilight buffet dinner hosted at the Eagle Bar was the perfect way to bring the Summer School to a close. Students gathered to say thank you to the staff, reflect on the four weeks of the program and enjoy a last dinner together before the last day of classes. The event was attended by approximately 100 students.

"I think the best thing was the people I met, I made really good connections and it felt really good to be surrounded by a group of people who understood me in a different way to the way people at home do. Being able to stay together in a college really helped this bonding and the social events too."

Anonymous

PUBLIC LECTURE



The public lecture is one of the major events of the Summer School and is an opportunity for the general public to get a sneak peek into the world of the mathematical sciences. Professor David Karoly from the CSIRO was the guest speaker in 2020, presenting his lecture *'Modelling the climate system to understand the human role in recent climate change*'. The event was hosted at the West Lecture Theatre I at La Trobe's Bundoora campus. In light of the highly topical issue of climate change in Australia and around the world, this lecture was very popular, attracting approximately 150 attendees from both the Summer School and the general public. The lecture was followed by a rigorous Q&A session where audience members could delve deeper into some of the concepts covered in the presentation. There were many positive reviews of the event. This lecture was recorded and has attracted 566 views since being uploaded on the AMSI YouTube channel in February 2020.

"I enjoyed the opportunity to study a course that is not available at my university and learn from specialist lecturers. It has helped to broaden my knowledge and gain exposure to as many different areas of mathematics as possible."

Rachel Zhang,
Australian National University

STUDENT PROFILE

Making academic and research connections at AMSI Summer School 2020

Zhao Mei Zheng, University of Sydney

Pursuing an honours degree in Mathematics (Applied), Zhao Mei Zheng's interests encompass epidemiology and vector-borne diseases. As a recent exchange program participant at Cornell University (undertaking microbiology, entomology and mathematics courses), Mei appreciates the potential of AMSI travel grants towards network building and future collaboration.

"I've been able to meet exciting and passionate mathematicians from Perth, Adelaide and Tasmania; I wouldn't have if AMSI travel grants didn't exist. There are brilliant minds across the nation and being able to bring us together in the same space is amazing. I believe the connections formed during our month together at Summer School will hold strong throughout our academic careers."

Mei is currently studying mathematical models capturing the dynamics of infectious diseases spreading through communities. This involves differential modelling as well as graph network modelling. The potential impact of this research is significant, enabling a better understanding of how various factors can affect disease spread and prospective control strategies.

"(This) travel grant is bringing together very bright and intriguing people and I hope this continues", enthuses Mei. "I've always been fascinated by epidemiological studies, however the course I took at AMSI Summer School, Dynamic Processes Spreading on Networks, revealed another approach to modelling disease spread focused mainly on graphs and simulations using Python. Without the travel grant I wouldn't have been able to travel interstate to meet inspiring professors and fellow peers."

Mei cites a university alumnae mathematics panel for women as an inspiration during her high-school years and sees inclusion of more women and wider ethnicities in mathematics events such as AMSI Summer School as a key aspect to improve upon across the discipline.

So, what does Mei regard as the most important outcome from the School and where will she be five years from now? "It would be a mixture of the skills I learnt in our modelling course as well as the connections I made. I hope to be working at a research institute modelling the spread of various infectious diseases."

FEEDBACK ANALYSIS

Fifty-three percent of attendees completed the post-event feedback form commenting on their experiences at the 2020 Summer School. On the whole, the survey data suggests that this program continues to be integral to the mathematical sciences landscape in the higher education sector, giving students a platform to make valuable networks, broaden their knowledge and open up possibilities for future study and career paths in mathematics and statistics. In rating their overall experience where 1 signalled poor performance and 10 excellent, the average rating for the 2020 program was 8.8, which is consistent with results from 2019.

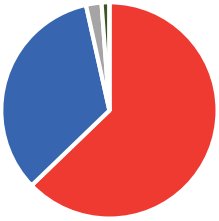
Of those that completed the survey, 44 per cent of students cited that their motivation for attending was to gain credit towards their degree. An additional 37 per cent attended to broaden their knowledge and 8 per cent attended to learn from a specific lecturer. Six per cent noted networking and socialising to be their motivation for attending, highlighting the importance of community.

Once again, the AMSI Summer School program demonstrated to participants the importance of mathematical sciences qualifications and their wide and varied application in industry. Fifty-five per cent of survey respondents noted that participating in the program strengthened their resolve to pursue a PhD in mathematics (28 per cent strongly agreed; 27 per cent agreed), while 65 per cent of students felt the Careers Day event provided good information and advice about careers and job opportunities (41 per cent agreed; 24 per cent strongly agreed).

Below is a further breakdown of thoughts and comments regarding the 2020 program.

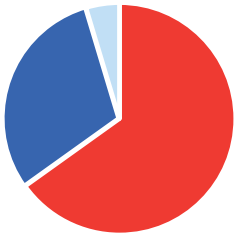
OVERALL, THE SCHOOL WAS OF A HIGH STANDARD

Strongly Agree	63%
Agree	34%
Neutral	2%
Disagree	1%
Strongly Disagree	0%

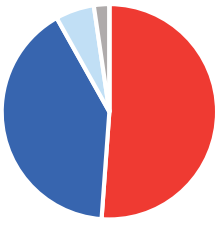


OVERALL, THE SCHOOL WAS WELL-ORGANISED

Strongly Agree	65%
Agree	30%
Neutral	5%
Disagree	0%
Strongly Disagree	0%

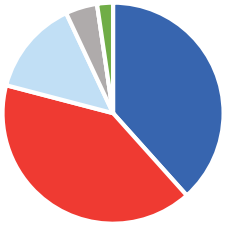


THE COURSES OFFERED PROVIDED A GOOD VARIETY OF SUBJECTS



Strongly Agree	51%
Agree	41%
Neutral	6%
Disagree	2%
Strongly Disagree	0%

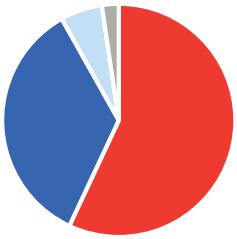
I MADE USEFUL CONTACTS AND NETWORKS AT SUMMER SCHOOL



Strongly Agree	38%
Agree	41%
Neutral	14%
Disagree	5%
Strongly Disagree	0%
Prefer not to say	2%

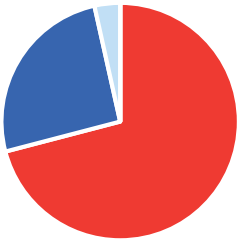
I WILL APPLY KNOWLEDGE GAINED FROM THE SCHOOL TO MY CURRENT AND FUTURE STUDIES/ACTIVITIES

Strongly Agree	57%
Agree	35%
Neutral	6%
Disagree	0%
Strongly Disagree	0%
Prefer not to say	2%

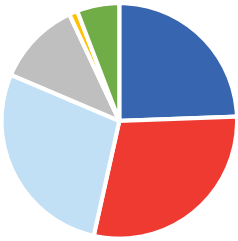


I WOULD RECOMMEND SUMMER SCHOOL TO OTHERS

Strongly Agree	71%
Agree	26%
Neutral	3%
Disagree	0%
Strongly Disagree	0%

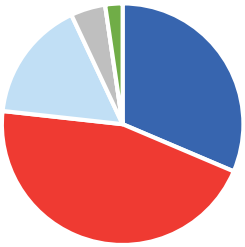


AS A RESULT OF THE CAREER RELATED CONTENT OF THIS SUMMER SCHOOL, I AM CLEARER ABOUT MY EMPLOYMENT OPTIONS



Strongly Agree	24%
Agree	29%
Neutral	28%
Disagree	12%
Strongly Disagree	1%
Prefer not to say	6%

THIS SUMMER SCHOOL HAS EXPOSED ME TO THE POSSIBILITIES THAT MATHEMATICS CAN BRING TO MY FUTURE CAREER

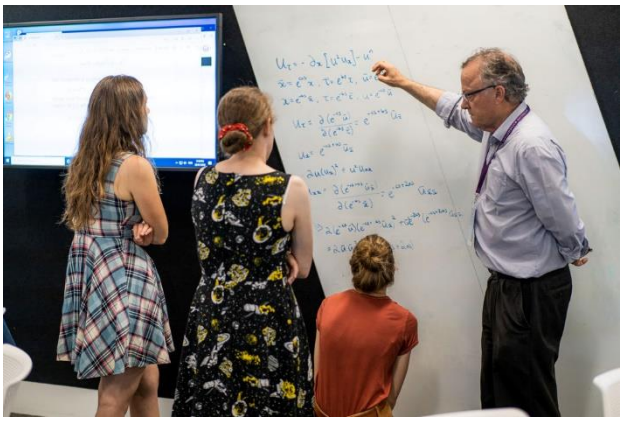


Strongly Agree	32%
Agree	45%
Neutral	16%
Disagree	5%
Strongly Disagree	0%
Prefer not to say	2%

When asked about the main intention in their current career planning, 28 per cent of survey respondents said they were looking to apply their skills in a STEM related profession (not research or teaching). Six per cent look to teach at a tertiary and higher education level and two per cent aspire to teach at a primary or secondary school level. Survey feedback points overwhelmingly at research being the ideal career choice for students with 48 per cent hoping to enter the academic sphere to conduct research within a higher education context. An additional seven per cent noted they wished to conduct research in a research institute context (such as CSIRO) and five per cent aim to be researchers within a STEM profession.

"It was a great opportunity for me to meet new friends, to get exposure about the job opportunities while mastering my knowledge in the subjects I took."

Ravindi Nanayakkara, La Trobe University



MEDIA RELEASE

Climate Change: It's All in the Numbers

The debate may rage on but the scientific basis of climate change is clear and the numbers are in to prove it, according to international climate change and climate variability expert and Australian Mathematical Sciences Institute (AMSI) Summer School Public Lecturer Professor David Karoly.

"Our understanding of climate change really is in the numbers. Mathematics and statistical analysis are critical tools used to model and understand changes to our climate system over time and the underlying driving causes," says Professor Karoly.

As well as the science underpinning our understanding of recent observed climate change in Australia, Professor Karoly will also explore Australia's role in next-generation global modelling.

"I will shed some light on the next generation of global climate modelling now underway and Australia's role in Phase 6 of the global Climate Model Intercomparison Project," says Professor Karoly.

Respected globally, Professor Karoly currently leads the Earth Systems and Climate Change Hub in the Australian Government's National Environmental Science Program at CSIRO.

Free to attend, this event is open to mathematical and non-mathematical audiences of all ages. Join Professor Karoly live in Melbourne or stream online nationally from 6.30pm Wednesday 29 January at La Trobe University. Register: ss.amsi.org.au/public-lecture/

AMSI Director Professor Tim Brown said the Institute was delighted to have Professor Karoly on board for the 2020 Summer School public lecture, an important opportunity to highlight the role of mathematics in one of the biggest challenges facing the global community.

"David is a leader in his field and an important voice in the ongoing global response to climate change. We are excited to provide this opportunity for Australians to engage with maths in the context of climate change and the significant challenges this poses," said Professor Brown.

This public lecture is one of the many exciting program extras on offer during the 2020 AMSI Summer School hosted by La Trobe University from 6 – 31 January 2020. In Australia's biggest residential honours and postgraduate maths event, participants study two subject areas (one for credit) over four weeks.

As well as an outstanding specialist subject program designed to supercharge knowledge and expertise, students benefit from keynote speakers, social and networking opportunities and careers and diversity events.

Summer School 2020 is delivered as part of AMSI's Australian Government Securing Australia's Mathematical Workforce program. Event sponsors include AMSI, the Australian Government Department of Education, La Trobe University, AustMS, ANZIAM and SSA.

More information: https://ss.amsi.org.au

MEDIA REPORT

Bushfires and the climate change debate were at the heart of the media coverage for AMSI Summer School 2020. Centred around Professor David Karoly's public lecture topic, *Modelling the Climate System to Understand the Human Role in Recent Climate Change,* the media campaign received wide coverage nationally. With the unprecedented Black Summer fires still raging across the eastern states, this public lecture proved to be very topical and of immediate interest to both Summer School students and members of the public. An article published on news.com.au focused on the recent bushfire season and the impact of climate change. This article was syndicated in a further 37 news publications including *The Herald Sun, Courier Mail, The Daily Telegraph* and *The Advertiser*. A second article appeared in four Fairfax newspapers across Australia including *The Age, Sydney Morning Herald, WA Today and Brisbane Times*. This article focused on climate change in reference to the Australian Open and the intense summer temperatures. A breakdown of publications promoting the Summer School public lecture is listed below:

- Greenie Watch
- Fraser Coast Chronicle
- Tweed Daily News
- Gladstone Observer
- Chinchilla News
- The Morning Bulletin
- News Mail
- The Queensland Times
- Sunshine Coast Daily
- Charleville Western Times
- The Chronicle
- The Coffs Coast Advocate
- Byron Shire News
- Ballina Shire Advocate
- The Daily Mercury
- The Daily Examiner
- Surat Basin Online
- Central Queensland News
- Northern Star
- Coolum & North Shore News
- Lismore Echo
- South Burnett Times
- Stanthorpe Border Post
- The Gympie Times
- The Ipswich Advertiser
- Central Telegraph
- Balonne Beacon
- Dalby Herald
- Gatton Star

- Central & North Burnett Times
- Whitsunday Times
- Warwick Daily News
- News.com.au
- The Advertiser
- The Daily Telegraph
- The Courier-Mail
- Herald Sun
- The Western Star
- The Age
- WAtoday.com.au
- Brisbane Times
- The Sydney Morning Herald

Professor Karoly's public lecture topic also received coverage through social media generating significant conversation. Twenty posts across Facebook and Twitter were noted from organisations and individuals including the National Earth Systems and Climate Change Hub, AMSI and ACEMS. These posts produced a total of 19 retweets and 10 Facebook shares across the mathematical sciences community and the general public.

Professor Karoly also appeared on ABC Breakfast and on ABC Radio to discuss climate change in January. While the Summer School public lecture was not specifically mentioned, this publicity indirectly assisted in the promotion of the event.

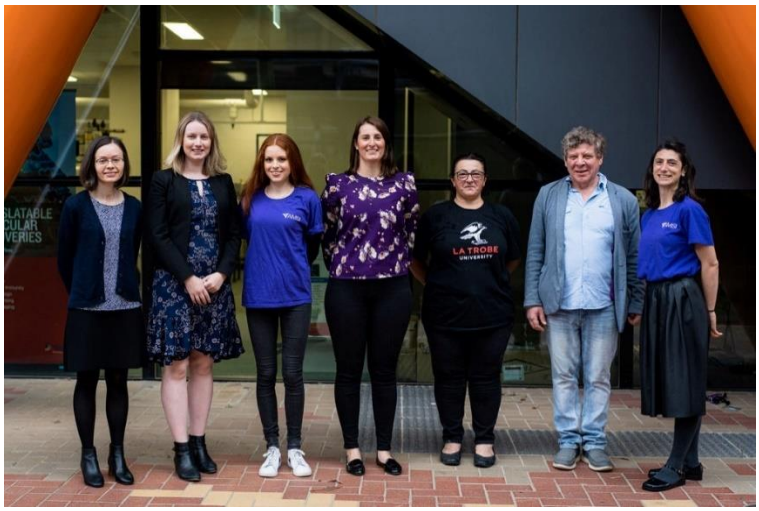
COMMITTEES

Program Committee

- Yuri Nikolayevsky (Event Director), La Trobe University
- Luke Prendergast (Head of School, Mathematics and Statistics), La Trobe University
- Tim Brown (Director), Australian Mathematical Sciences Institute
- Guoyin Li (Summer School 2019 Co-Director), UNSW
- Shane Keating (Summer School 2019 Co-Director), UNSW
- Simon Clarke (AMSI Summer School 2018 Director), Monash University
- Chloe Pearse (Program Manager, Research and Higher Education), Australian Mathematical Sciences Institute
- Galina Levitina, UNSW
- Giang Nguyen, The University of Adelaide
- Ivan Guo, Monash University
- Murray Elder, Monash University
- Bronwyn Hajek, University of South Australia
- Anna Muscara (Committee Secretary), Australian Mathematical Sciences Institute

Organising Committee

- Yuri Nikolayevsky (AMSI Summer School 2020 Director), La Trobe University
- Luke Prendergast (Head of School, Mathematics and Statistics), La Trobe University
- Natasha Freeman, La Trobe University
- Patricia Eliadis, La Trobe University
- Chloe Pearse, Australian Mathematical Sciences Institute
- Anna Muscara, Australian Mathematical Sciences Institute



"I want the event organisers to know they've done an amazing job, and I hope AMSI Summer School continues to be held for many many years into the future... Best 4 weeks of my university life! I'm really happy I participated, and thank you so much for the wonderful time!"

Bao Anh Vu,
University of Wollongong

DIFFERENTIAL GEOMETRY & SYMMETRY

GEOMETRIC GROUP THEORY

APPLIED NONLINEAR PDEs

DYNAMIC PROCESSES SPREADING ON NETWORKS

EFFECTIVE TEACHING, EFFECTIVE LEARNING IN QUANTITATIVE DISCIPLINES

THE FINITE ELEMENT METHOD

RANDOM FIELDS: MATHEMATICAL THEORY & SPATIAL STATISTICS APPLICATIONS

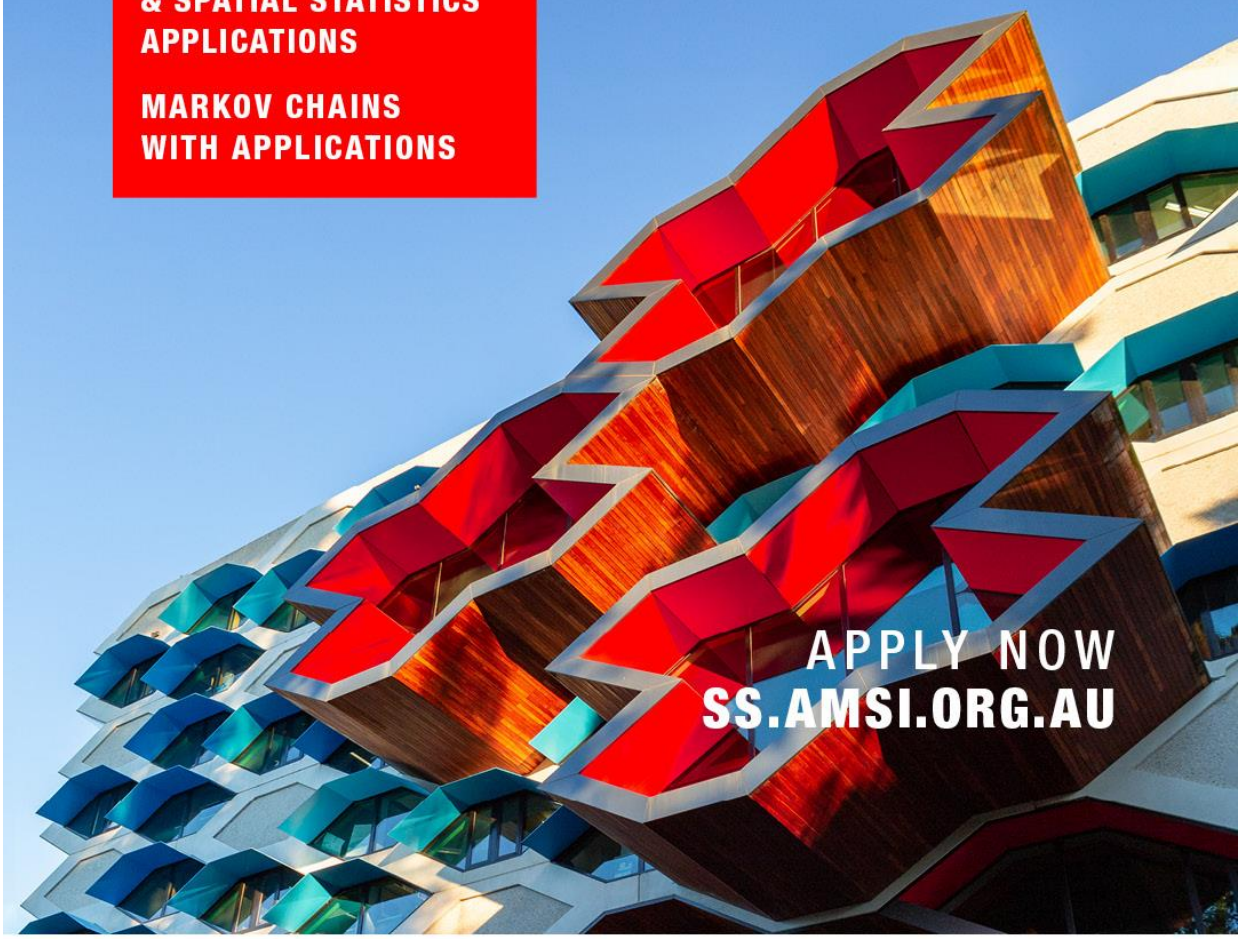
MARKOV CHAINS WITH APPLICATIONS

AMSI 20 SUMMER SCHOOL

IN THE MATHEMATICAL SCIENCES

6–31 JAN 2020

LA TROBE UNIVERSITY



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