# Robert Zimmerman

*Curriculum Vitae*

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## Education

2018–2024 **University of Toronto**, Toronto, ON
**PhD in Statistics (Direct Entry)**
Thesis title: *Copulas: New Theory and Methods*
Supervisor: Prof. Radu V. Craiu

2012–2016 **University of Waterloo**, Waterloo, ON
**Bachelor of Mathematics – Graduated with Distinction**
  **Mathematical Finance (Honours)**
  **Statistics (Honours)**
  **Pure Mathematics (Joint Honours)**

2010–2012 **University of Ontario Institute of Technology**, Oshawa, ON
Completed 23 undergraduate courses across two degree programs
  Software Engineering and Management (Honours)
  Applied and Industrial Mathematics (Honours)

### Relevant Upper-Year/Graduate/Topics Courses

- Information Geometry
- Optimal Transport
- Likelihood Theory
- Statistical Learning Theory
- Probability Theory
- Random Matrix Theory
- Copulas and Dependence Modelling
- Sampling and Experimental Design
- Simulation and Monte Carlo Methods
- Forecasting
- Stochastic Processes
- Measure Theory
- Groups/Rings/Fields/Number Theory
- Real/Complex/Fourier Analysis
- Quantitative Risk Management
- Stochastic Finance
- Portfolio Optimization Models
- Computational Financial Modelling

## Research Experience

2024–Present **Research Associate**, *Department of Mathematics, Imperial College London*, London, UK
Supervisor: Prof. David A. van Dyk

2019–2024 **PhD Candidate**, *Department of Statistical Sciences, University of Toronto*, Toronto, ON
Supervisor: Prof. Radu V. Craiu
Relevant research projects:

- *On primitives of distribution functions*: We show that any continuous distribution supported on a bounded interval is characterized by the primitives of its corresponding cdf evaluated at a single point by exploiting a connection to the Hausdorff moment problem (conceived and developed without faculty supervision).
- *Classifying flaring and quiescent states via state-space models*: We model flaring activity in active coronae as a continuous latent process which drives bivariate observed photon emissions (supervisor: Prof. David A. van Dyk).
- *Latent variable copulas*: We utilize data augmentation to develop an MCMC algorithm for sampling from posterior distributions of regression-based factor copulas with both continuous and discrete outcomes (supervisor: Prof. Radu V. Craiu).
- *Arbitrarily irregular copula densities*: We defined a novel class of absolutely continuous copulas which are simultaneously highly regular and highly pathological (co-author: Michaël Lalancette; conceived and developed without faculty supervision).

- *Hidden Markov models with copulas*: We proposed a copula-based extension of the hidden Markov model and developed a theoretically-justified variation of the EM algorithm to perform estimation (supervisors: Profs. Radu V. Craiu and Vianey Leos Barajas).
- *Extensions of Consensus Monte Carlo*: We showed that certain cases of the consensus Monte Carlo approach to MCMC can be embedded in a statistical model with desirable properties (supervisor: Prof. Radu V. Craiu).
- *Sampling from the Anderson-Darling test statistic*: We developed several Monte Carlo algorithms to produce samples distributed according to the Anderson-Darling test statistic (course project for Prof. Jeffrey S. Rosenthal).

2016–2018  **Manager, Quantitative Analytics**, *Retail Model Development, TD Bank Group*, Toronto, ON
Relevant projects:

- Development of proprietary statistical risk models based on newer statistical techniques and comparison with internal benchmark and industry-standard models
- Development of many new techniques to enhance the model development process (for example, using parallel processing to dramatically reduce waiting times for massive dataset cleansing and aggregation processes, and developing an efficient data visualization technique to generate 3D surface plots for empirical bivariate distributions)
- Preparation of comprehensive sets of documentation for all models, including complete theoretical justifications and detailed explanations at both technical and non-technical levels

Spring 2016  **NSERC Undergraduate Research Assistant**, *University of Waterloo*, Waterloo, ON
I integrated generalized additive models within finite mixture models, estimated model parameters via the EM algorithm and constructed a classifier in R which performed well on both real-world datasets and less structured simulated data (supervisor: Prof. Ryan P. Browne).

## Publications and Presentations

### Publications and Preprints

**Zimmerman, R., van Dyk, D. A., Kashyap, V. L., and Siemiginowska, A. (2024).** *Separating States in Astronomical Soures Using Hidden Markov Models: With a Case Study of Flaring and Quiescence on EV Lac.* Monthly Notices of the Royal Astronomical Society. 534(3):2142–2167. doi:10.1093/mnras/stae2082

**Zimmerman, R., Craiu, R. V., and Leos Barajas, V. (2023).** *Copula Modelling of Serially Correlated Multivariate Data with Hidden Structures.* Journal of the American Statistical Association. 119(548):2598–2609. doi:10.1080/01621459.2023.2263202

**Lalancette, M. and Zimmerman, R. (2022).** *A new family of smooth copulas with arbitrarily irregular densities.* (arXiv:2204.04336) (under revision)

### Presentations

Fall 2024  **Invited Talk:** *Separating states in astronomical sources using hidden Markov models.* CMStatistics 2024. London, UK.

Fall 2024  **Poster Presentation:** *Hidden Markov modeling of X-ray light curves.* 25 Years of Chandra Science Symposium. Boston, MA.

Fall 2024  **Invited Talk:** *Hidden Markov modeling of X-ray light curves.* CHASC AstroStatistics Center (Harvard & Smithsonian). Boston, MA.

Spring 2024  **Contributed Talk:** *Separating flaring and quiescent states in active coronae using state-space models.* SSC 2024 Annual Meeting. St. John's, NL.

Winter 2024  **Contributed Talk:** *Understanding coronal flare activity using state-space models.* Statistics Graduate Student Research Day. Toronto, ON.

Winter 2022  **Contributed Talk:** *A new family of smooth copulas with arbitrarily irregular densities.* CMStatistics 2022. London, UK.

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| Summer 2022 | **Contributed Talk:** *Copula modelling of serially correlated multivariate data with hidden structures.* SSC 2022 Annual Meeting. Online. |
| Summer 2022 | **Poster Presentation:** *Copula modelling of serially correlated multivariate data with hidden structures.* BFF7. Toronto, ON. |
| Winter 2021 | **Invited Talk:** *Copula modelling of serially correlated multivariate data with hidden structures.* CMStatistics 2021. London, UK. |
| Summer 2016 | **Contributed Talk:** *Finite mixtures of nonparametric regression models with generalized additive components.* Canadian Undergraduate Mathematics Conference. Victoria, BC. |
| Winter 2015 | **Capital One Data Mining Cup**, *University of Waterloo*, Waterloo, ON<br>Developed statistical strategies for bidding on search keywords, training on unsupervised noisy data; I led the development of our team's methodology and delivered much of our presentation to industry executives (finishing third out of 16 teams across three universities). |

## Awards and Honours

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| Spring 2024 | **Donald A.S. Fraser Doctoral Award**, *University of Toronto*, Toronto, ON<br>A $3,000 faculty-nominated award given to a senior PhD student whose dissertation work contains significant contributions to statistical theory |
| Spring 2024 | **Department of Statistical Sciences Teaching Assistant Award**, *University of Toronto*, Toronto, ON<br>A $2,000 faculty-nominated award given to students who demonstrate quality in their TA work as measured by student evaluations and faculty input |
| Fall 2023 | **Ontario Graduate Scholarship**, *University of Toronto*, Toronto, ON<br>A $15,000 merit-based scholarship for excellence in graduate studies at publicly-assisted universities in Ontario |
| Winter 2023 | **Mitacs Globalink Research Award**, *Mitacs and University of Toronto*, Toronto, ON<br>A $6,000 research award to support graduate students in conducting a 12- to 24-week research project in another country |
| Winter 2022 | **Ontario Graduate Scholarship**, *University of Toronto*, Toronto, ON<br>A $15,000 merit-based scholarship for excellence in graduate studies at publicly-assisted universities in Ontario |
| Winter 2022 | **SGS Conference Grant**, *University of Toronto*, Toronto, ON<br>Financial support for eligible students to present their research at an academic conference |
| Fall 2021 | **Queen Elizabeth II Graduate Scholarship in Science and Technology (Declined)**, *University of Toronto*, Toronto, ON<br>A $15,000 merit-based scholarship for excellence in graduate studies in science and technology |
| Winter 2018 | **RCRM Standing Ovation Award**, *TD Bank Group*, Toronto, ON |
| Fall 2017 | **Principles in Practice Award**, *TD Bank Group*, Toronto, ON<br>Annually recognizes employees in the top 10% of performers |
| Winter 2017<br>Fall 2016 | **Act for Impact Award**, *TD Bank Group*, Toronto, ON<br>Recognizes employees selected by managers, based on direct observation or through input from peers, colleagues, business partners and/or management |
| Spring 2016 | **Undergraduate Student Research Award**, *NSERC*, Waterloo, ON<br>A $4,500 award intended to nurture interest and fully develop potential for a research career in the natural sciences and engineering |
| Winter 2016<br>Fall 2015 | **Term Dean's Honours List**, *University of Waterloo*, Waterloo, ON<br>Recognizes full-time undergraduate mathematics students with term averages of at least 87% |
| Fall 2011<br>Winter 2011<br>Fall 2010 | **Term President's List**, *University of Ontario Institute of Technology*, Oshawa, ON<br>Recognizes full-time students with semester GPAs of at least 3.8 |

## Teaching Experience

### Course Instruction and Teaching Assistance

**Fall 2023**    **Course Co-Designer: Advanced Computational Methods for Statistics I (STA2311)**, *Department of Statistical Sciences, University of Toronto*, Toronto, ON
STA2311 is a new course required for most first-year students in the Statistical Theory and Applications PhD stream at the University of Toronto. The course focuses on optimization and sampling techniques (focusing on both underlying motivation and theoretical justification). Prof. Radu V. Craiu and I designed the course in full; in addition to TA work, my responsibilities included development of content (syllabus, a majority of lecture slides, many theoretical and practical applications, and assignment/exam questions) and some lecture delivery. Much of the content is expected to be re-used in future offerings of the course (course content).

**Spring 2024**
**Spring 2022**
**Spring 2021**
**Spring 2020**    **Course Instructor: Probability and Statistics II (STA261)**, *Department of Statistical Sciences, University of Toronto*, Toronto, ON
STA261 is intended to be the most advanced introduction to mathematical statistics available to second-year Statistics Specialist students at the University of Toronto. I redesigned the course completely (including preparing a new syllabus, slides, and fully original assignment/exam questions) and taught it four times in both online and in-person settings (course content).

**Winter 2019**    **Course Co-Instructor: Why Numbers Matter (STA201)**, *Department of Statistical Sciences, University of Toronto*, Toronto, ON
STA201 is intended to introduce quantitative reasoning in a variety of fields to non-science students at the University of Toronto. I co-taught this course (including writing a number of lectures, as well as numerous assignment/exam questions) with Prof. Karen Huynh Wong (course content).

**2018-Present**    **Teaching Assistant**, *Department of Statistical Sciences, University of Toronto*, Toronto, ON
- STA2312: Advanced Computational Methods for Statistics II (Graduate) (Prof. Keith Knight, Winter 2024)
- STA2211: Probability Theory II (Graduate) (Prof. Xiaofei Shi, Winter 2024)
- STA2311: Advanced Computational Methods for Statistics I (Graduate) (Prof. Radu V. Craiu, Fall 2023)
- STA2111: Probability Theory I (Graduate) (Prof. Jeffrey S. Rosenthal, Fall 2022 and Fall 2023)
- STA303: Methods of Data Analysis II (Head TA for Emily Somerset, Spring 2023; Prof. Liza Bolton, Winter 2022; Head TA for Alexander Stringer, Spring 2019)
- STA3431: Monte Carlo Methods (Graduate) (Prof. Jeffrey S. Rosenthal, Fall 2021)
- STA2112: Mathematical Statistics I (Graduate) (Prof. Jessica Gronsbell, Fall 2021)
- STA 257: Probability and Statistics I (Prof. Luai Al Abadi, Spring 2021)
- STA220: The Practice of Statistics I (Head TA for Prof. Karen Huynh Wong, Fall 2020 and Fall 2019; course revitalization, Spring 2019; Profs. Karen Huynh Wong and Fodé Tounkara, Fall 2018)
- STA 490: Statistical Consultation, Communication, and Collaboration (Prof. Alison Gibbs, Fall 2019–Winter 2020; Prof. Nathalie Moon, Fall 2019–Winter 2020)
- STA201: Why Numbers Matter (Head TA for Prof. Karen Huynh Wong, Winter 2019)
- STA302: Methods of Data Analysis I (Prof. Mark Ebden, Fall 2018)

### Teaching Presentations

**Fall 2022**
**Fall 2021**    **MFI R Bootcamp**, *University of Toronto*, Toronto, ON
I designed and presented a four-hour R bootcamp for the department's Masters of Financial Insurance students, intended to bring them up to speed on beginner-to-intermediate R programming within statistical contexts.

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| Fall 2015<br>Winter 2015<br>Fall 2014 | **Introductory MATLAB Tutorial**, *University of Waterloo*, Waterloo, ON<br>I wrote and presented several very popular introductory MATLAB tutorials to a mathematically-inclined audience of 30 people, tailoring my examples to this audience (for example, I showed how MATLAB's numerical linear algebra capabilities could be used to efficiently estimate the stationary distribution of finite-state ergodic Markov chains from sample data). |
| Winter 2015 | **Introductory Investments Tutorial**, *University of Waterloo*, Waterloo, ON<br>At the request of the Mathematical Finance Students' Association membership, I wrote and presented a two-hour tutorial for mathematics students, integrating material from the Canadian Securities Course with mathematical concepts (for example, I derived the standard bond pricing formula with known coupon payments and explained how such coupon payments would be taxed under different scenarios). |

## Employment History Outside of Academia

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| 2018<br>2017–2018<br>2016–2017 | **Manager, Quantitative Analytics**<br>**Senior Quantitative Analyst**<br>**Risk Modelling Analyst**, *Retail Model Development, TD Bank Group*, Toronto, ON<br>My primary role at TD was to build statistical risk models for the bank's US retail portfolios for use in the CAR (Basel) and CCAR-DFAST frameworks, as well as ALLL and IFRS9 applications. I accumulated experience in every aspect of model development for this purpose: data exploration, SAS coding, portfolio segmentation, modelling, validation, stress testing and documentation. Many of the models were instrumental in meeting stringent regulatory requirements set by the Federal Reserve in the US and by the Office of the Superintendent of Financial Institutions in Canada. I was also involved in the bank's participation in regulatory exercises run by these institutions (e.g., CCAR-DFAST) and compliance. My roles in innovation, writing and research are discussed above. |
| Spring 2015 | **Electronic Equity Analyst**, *Equity Trading Group, Scotia McLeod*, Toronto, ON<br>I became adept with relational databases, and wrote algorithms and automated computation procedures to develop useful summary statistics of the group's trading activities, sparing a great deal of tedious daily manual computation. I also integrated R into the system to generate time series analyses for forecasting profits and losses over various time horizons. |

## Leadership and Service

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| 2021–2023 | **Reviewer**<br>Served as a reviewer for the *Canadian Journal of Statistics*. |
| 2016-2018 | **Mentor**, *TD Bank Group*, Toronto, ON<br>Mentored five new hires through their first several months, guiding them through the basics of SAS programming and the relevant statistical modelling and regulatory environments. |
| 2014-2016 | **President**, *Mathematical Finance Students' Association (MFSA)*, Waterloo, ON<br>Elected president of the MFSA for five semesters from Spring 2014 to Winter 2016, I led a team to organize countless MFSA-sponsored events, including programming tutorials, general meetings and social events. We also collaborated with Bloomberg L.P. and Capital One to co-host two large-scale competitions: the *Code B Hackathon* and the *Data Mining Cup*. I also planned and received approval for five termly club budgets; negotiated funding for social events and office improvements; increased membership from the previous high of 76 to 119; provided advice and information about the Mathematical Finance program to first- and second-year students; and wrote and presented various MATLAB and investment tutorials (details above). |

## Programming Knowledge

- R*
- SQL*
- Java
- Python
- SAS*
- Markdown
- MATLAB
- LaTeX*
- C++
- VBA

*Advanced proficiency

## Main Extracurricular Interests

**Classical Music**

I am a self-taught pianist and amateur composer, having cultivated an interest in classical music history and theory since age 10. Since I have become familiar with most of the classical piano repertoire, and accumulated hundreds of books on music history and performance as well as published scores, I consider classical music to be my greatest non-mathematical passion.

**Sports**

As well as being an avid (and frequently unrequited) fan of Toronto sports teams, I take a hobbyist's interest in the developing field of sports analytics.