

EDUCATION

University of Toronto

Doctor of Philosophy (PhD), Aerospace Science and Engineering

Toronto, Canada

September 2018 – June 2024

Thesis: [Provably stable discontinuous spectral-element methods with the summation-by-parts property: Unified matrix analysis and efficient tensor-product formulations on curved simplices](#)

Advisor: David Zingg

Carleton University

Bachelor of Engineering (BEng), Mechanical Engineering

Ottawa, Canada

September 2014 – June 2018

Capstone project: Performance analysis and numerical optimization of a supercritical carbon dioxide Brayton cycle

RESEARCH INTERESTS

Numerical analysis and scientific computing focused on nonlinear hyperbolic and advection-dominated systems of partial differential equations; specific topics include robust structure-preserving high-order methods using summation-by-parts operators, dynamical systems and control-theoretic approaches to adaptive simulations, integration of physics-based simulation with data-driven models, open-source scientific software development, efficient implementation on modern computer hardware, as well as applications in computational fluid dynamics, numerical weather prediction, climate modelling, and plasma physics

PUBLICATIONS IN PEER-REVIEWED JOURNALS

T. Montoya and D. W. Zingg, [Efficient entropy-stable discontinuous spectral-element methods using tensor-product summation-by-parts operators on triangles and tetrahedra](#). *Journal of Computational Physics* 516, article no. 113360, 2024.

T. Montoya and D. W. Zingg, [Efficient tensor-product spectral-element operators with the summation-by-parts property on curved triangles and tetrahedra](#). *SIAM Journal on Scientific Computing* 46(4), pp. A2270–A2297, 2024.

T. Montoya and D. W. Zingg, [A unifying algebraic framework for discontinuous Galerkin and flux reconstruction methods based on the summation-by-parts property](#). *Journal of Scientific Computing* 92(3), article no. 87, 2022.

PUBLICATIONS IN CONFERENCE PROCEEDINGS

T. Montoya* and D. W. Zingg, [Stable and conservative high-order methods on triangular elements using tensor-product summation-by-parts operators](#). *11th International Conference on Computational Fluid Dynamics*, Maui, United States, July 2022. **Awarded best student paper.**

CONFERENCE PRESENTATIONS (EXCLUDING ABOVE PROCEEDINGS)

T. Montoya* and D. W. Zingg, [Efficient entropy-stable discontinuous spectral-element methods in collapsed coordinates for hyperbolic systems on curved triangular and tetrahedral meshes](#). *Canadian Applied and Industrial Mathematics Society Annual Meeting*, Kingston, Canada, June 2024.

T. Montoya* and D. W. Zingg, [Efficient entropy-stable tensor-product spectral-element methods on simplices](#). *9th European Congress on Computational Methods in Applied Sciences and Engineering*, Lisbon, Portugal, June 2024.

T. Montoya* and D. W. Zingg, [Efficient tensor-product spectral-element methods with the summation-by-parts property on triangles and tetrahedra](#). *SIAM Conference on Computational Science and Engineering*, Amsterdam, Netherlands, February 2023.

T. Montoya* and D. W. Zingg, [Unified analysis of discontinuous Galerkin and flux reconstruction methods based on the summation-by-parts property](#). *International Conference on Spectral and High-Order Methods* (online), July 2021.

T. Montoya* and D. W. Zingg, [Unified analysis of high-order methods based on the summation-by-parts property: Application to discontinuous Galerkin and flux reconstruction discretizations](#). *SIAM Conference on Computational Science and Engineering* (online), March 2021.

*Presenting author.

INVITED TALKS

T. Montoya,* An entropy-stable discontinuous spectral-element method for the spherical shallow water equations in covariant form. University of Waterloo Numerical Analysis and Scientific Computing Seminar, Waterloo, Canada, February 2025.

T. Montoya, A. M. Rueda-Ramírez, G. J. Gassner, J. Markert,* M. Baldauf, and D. Reinert, ICON-DG: Gearing up the ICON model with smarter discretizations. *WarmWorld General Assembly*, Bremerhaven, Germany, October 2024.

T. Montoya* and D. W. Zingg, Provably stable tensor-product discontinuous spectral-element methods on triangular and tetrahedral unstructured grids. Ansys, Inc. (online), July 2024.

T. Montoya* and D. W. Zingg, Entropy-stable tensor-product discontinuous spectral-element methods on curved triangles and tetrahedra. Rice University (online), March 2024.

T. Montoya* and D. W. Zingg, Efficient and robust spectral-element methods on triangles using tensor-product summation-by-parts operators. *NASA Advanced Modeling and Simulation Seminar Series* (online), October 2022.

T. Montoya* and S. Nadarajah, Robust deformation of unstructured grids. Bombardier Aerospace, Montréal, Canada, August 2016.

PROFESSIONAL EXPERIENCE

Nonlinear Numerics Inc.

Founder and President

Research, software development, and consulting services for advanced scientific and engineering simulation in industry, academia, and government

Ottawa, Canada

May 2025 – Present

University of Toronto

Research Fellow, Institute for Aerospace Studies

Academic research and student mentorship on high-order methods for computational fluid dynamics

Toronto, Canada (remote)

April 2025 – Present

University of Cologne

Research Fellow, Department of Mathematics and Computer Science

Academic research and student mentorship on high-order methods for numerical weather prediction and climate modelling

Cologne, Germany (remote)

January 2025 – Present

University of Cologne

Postdoctoral Researcher, Department of Mathematics and Computer Science

Project: Robust split-form and entropy-stable discontinuous spectral-element methods for the ICON-DG atmospheric dynamical core; collaboration with the Deutscher Wetterdienst (DWD) and German Aerospace Center (DLR) as part of the “Smarter” module of the [WarmWorld](#) project for kilometre-scale climate predictions at exascale, which is funded by the German Federal Ministry of Education and Research (BMBF)

Advisor: Gregor Gassner

Cologne, Germany

January 2024 – January 2025

National University of Singapore

Visiting Researcher, Department of Mechanical Engineering

Project: Koopman operator approaches to data-driven stability analysis of numerical methods

Advisor: Gianmarco Mengaldo

Singapore

August 2022

University of Toronto

Graduate Researcher, Institute for Aerospace Studies

Project: Provably stable discontinuous spectral-element methods with the summation-by-parts property for conservation laws on general unstructured grids

Advisor: David Zingg

Toronto, Canada

September 2018 – December 2023

University of Toronto

Undergraduate Researcher, Institute for Aerospace Studies

Projects: Optimization of finite-difference operators with the summation-by-parts property on non-uniform nodal distributions; comparison of continuation methods for steady aerodynamic flows

Advisor: David Zingg

Toronto, Canada

May 2017 – August 2017

McGill University*Undergraduate Researcher, Department of Mechanical Engineering***Project:** Robust deformation of unstructured grids using radial basis functions and linear elasticity**Advisor:** Siva Nadarajah

Montréal, Canada

May 2016 – August 2016

Carleton University*Undergraduate Researcher, Department of Mechanical and Aerospace Engineering***Projects:** Optimal estimation of uncertain parameters in computer models of welding processes; novel interpolation techniques for stress and strain tensor fields using quaternions**Advisor:** John Goldak

Ottawa, Canada

May 2015 – August 2015

TEACHING EXPERIENCE

University of Cologne*Scientific Computing: Introduction to the Simulation of Atmospheric Flows (14722.0023)*

Assisted in the development and delivery of a new graduate-level mathematics course on modern numerical methods for atmospheric dynamics; contributed to curriculum design and preparation of lecture notes, and was responsible for the creation and supervision of the final project, in which students implement a discontinuous Galerkin solver for the spherical shallow water equations and assess its effectiveness for a series of standard atmospheric test problems

Cologne, Germany

April 2024 – July 2024

SUPERVISION OF GRADUATE AND UNDERGRADUATE RESEARCH

Paula Weiß, University of Cologne*MSc, Mathematics (co-supervised with Gregor Gassner and Benedict Geihe)***Project:** High-order vertical discretizations for nonhydrostatic atmospheric models

Cologne, Germany

August 2024 – Present

Fabian Höck, University of Cologne*MSc, Mathematics (co-supervised with Gregor Gassner and Benedict Geihe)***Project:** A discontinuous Galerkin method for moist atmospheric dynamics with rain

Cologne, Germany

April 2024 – Present

Ruilin (Jerry) Bai, University of Toronto*BASc, Engineering Science (co-supervised with David Zingg)***Project:** Optimization of summation-by-parts operators for minimal solution error

Toronto, Canada

September 2020 – December 2020

Yewon Lee, University of Toronto*BASc, Engineering Science (co-supervised with David Zingg and Masayuki Yano)***Project:** Comparative evaluation of energy- and entropy-stable discontinuous Galerkin and summation-by-parts methods

Toronto, Canada

May 2019 – August 2019

AWARDS AND SCHOLARSHIPS

Best Student Paper, International Conference on Computational Fluid Dynamics	2022
Ontario Graduate Scholarship	2019 – 2020, 2022 – 2023
Kenneth Molson Fellowship	2021 – 2022, 2022 – 2023
Queen Elizabeth II Graduate Scholarship in Science and Technology	2020 – 2021, 2021 – 2022
Douglas Patton Hogg Memorial Award	2021
NSERC Canada Graduate Scholarship - Master's	2018 – 2019
University Medal (highest academic standing of any Bachelor of Engineering graduate)	2018
Canadian Society for Mechanical Engineering Gold Medal	2018
Rajesh Ahluwalia Memorial Scholarship	2017 – 2018
NSERC Undergraduate Student Research Award	2015, 2017
McGill University Summer Undergraduate Research in Engineering Award	2016
Allan Buchanan Undergraduate Scholarship	2015 – 2016
Deans' Honour List	2014 – 2018
Faculty Scholarship	2014 – 2018

OPEN-SOURCE SOFTWARE CONTRIBUTIONS AS PRINCIPAL DEVELOPER

TrixiAtmo.jl

<https://github.com/trixi-framework/TrixiAtmo.jl>

Julia package extending the [Trixi.jl numerical framework](#) for conservation laws to enable the solution of atmospheric flow problems using a high-order discontinuous spectral-element dynamical core

StableSpectralElements.jl

<https://github.com/tristanmontoya/StableSpectralElements.jl>

Julia framework for energy-stable and entropy-stable discontinuous spectral-element methods on general element types based on multidimensional and tensor-product formulations; emphasis on dispatched strategies for matrix-based and matrix-free operator evaluation

GHOST: Generalized High-Order Solver Toolbox

<https://github.com/tristanmontoya/GHOST>

Python implementation of discontinuous Galerkin and flux reconstruction schemes in one or two spatial dimensions with various design choices

OTHER SIGNIFICANT OPEN-SOURCE CONTRIBUTIONS

Trixi.jl

<https://github.com/trixi-framework/Trixi.jl>

Added support for two-dimensional meshes in three-dimensional ambient space to enable the numerical solution of partial differential equations on surfaces

NodesAndModes.jl

<https://github.com/jlchan/NodesAndModes.jl>

Added high-order symmetric quadrature rules on triangular and tetrahedral elements

SERVICE

Centre for Computational Science and Engineering

Toronto, Canada

Lab Representative, Computational Aerodynamics

December 2021 – June 2024

Member of the student organizing committee for an interdepartmental group of researchers at the University of Toronto across various disciplines of computational science and engineering

Canadian Science Fair Journal

<https://csfjournal.com/>

Editor, Physics and Mathematics Section

June 2022 – March 2024

Volunteer editor and mentor for an open-access online publication showcasing science projects by children and youth at primary and secondary schools across Canada

Reviewer for Scientific Journals and Conferences

Journal of Parallel and Distributed Computing, Advances in Continuous and Discrete Models, JuliaCon 2025

TECHNICAL SKILLS

Programming languages

Julia, Python (including NumPy and SciPy), C, C++, , MATLAB, Fortran, \LaTeX , Bash

Development tools

Unix shell (including advanced scripting), Git, GNU Make, Anaconda, Jupyter/Pluto notebooks, VS Code, Vim, Emacs, Slurm

High-performance computing

Shared-memory parallelism (OpenMP, multithreading), distributed-memory parallelism (MPI), matrix-free algorithms, SIMD vectorization

Computer-aided engineering

Computational fluid dynamics (Ansys Fluent, Ansys CFX, Ansys ICEM CFD), thermal and structural finite-element analysis (Ansys Mechanical), computer-aided design (SolidWorks, OnShape, CATIA, Creo Parametric, Inventor)

OTHER ACTIVITIES

Music (performing guitarist/bassist), cycling, alpine skiing (former ski instructor), non-fiction reading

CITIZENSHIP

Canada, France