

## EDUCATION

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**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

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Structure-preserving numerical methods for hyperbolic and advection-dominated partial differential equations; efficient algorithms for high-performance scientific computing; open-source simulation software development; scientific and engineering applications including geophysical fluid dynamics, aerodynamics, electromagnetics, and plasma physics

## SUBMITTED PREPRINTS

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T. Montoya, A. M. Rueda-Ramírez, and G. J. Gassner, [Entropy-stable discontinuous spectral-element methods for the spherical shallow water equations in covariant form](#). Preprint, arXiv:2509.08790 [math.NA], 2025.

## PUBLICATIONS IN PEER-REVIEWED JOURNALS

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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

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

## CONFERENCE PRESENTATIONS (EXCLUDING ABOVE PROCEEDINGS)

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**Entropy-stable discontinuous Galerkin methods for the spherical shallow water equations in flux form**. *International Conference on Spectral and High-Order Methods*, Montréal, Canada, July 2025.

**Entropy-stable discontinuous spectral-element methods for the shallow water equations on the sphere**. *Southern Ontario Numerical Analysis Day*, Hamilton, Canada, May 2025.

**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.

**Efficient entropy-stable tensor-product spectral-element methods on simplices**. *9<sup>th</sup> European Congress on Computational Methods in Applied Sciences and Engineering*, Lisbon, Portugal, June 2024.

**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.

**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.

**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.

## INVITED TALKS

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**Robust split-form and entropy-stable high-order methods for next-generation atmospheric dynamics.** Canadian Meteorological Centre, Environment and Climate Change Canada, Dorval, Canada, August 2025.

**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.

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

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

**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.

**Robust deformation of unstructured grids.** Bombardier Aerospace, Montréal, Canada, August 2016.

## PROFESSIONAL EXPERIENCE

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**Nonlinear Numerics Inc.** Ottawa, Canada  
President May 2025 – Present  
Specialized research, software development, and consulting services for scientific and engineering simulation in industry, academia, and government

**University of Toronto** Toronto, Canada (remote)  
*Research Fellow, Institute for Aerospace Studies* March 2025 – Present  
Academic research and student mentorship on high-order methods for computational fluid dynamics

**University of Cologne** Cologne, Germany (remote)  
*Research Fellow, Department of Mathematics and Computer Science* January 2025 – Present  
Academic research and student mentorship on high-order methods for numerical weather prediction and climate modelling

**University of Cologne** Cologne, Germany  
*Postdoctoral Researcher, Department of Mathematics and Computer Science* January 2024 – January 2025  
**Project:** Robust structure-preserving discontinuous spectral-element methods for the ICON-DG atmospheric dynamical core; collaboration with the German Meteorological Service (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

**National University of Singapore** Singapore  
*Visiting Researcher, Department of Mechanical Engineering* August 2022  
**Project:** Koopman operator approaches to data-driven stability analysis of numerical methods  
**Advisor:** Gianmarco Mengaldo

**University of Toronto** Toronto, Canada  
*Graduate Researcher, Institute for Aerospace Studies* September 2018 – December 2023  
**Project:** Provably stable discontinuous spectral-element methods with the summation-by-parts property for conservation laws on general unstructured grids  
**Advisor:** David Zingg

**University of Toronto** Toronto, Canada  
*Undergraduate Researcher, Institute for Aerospace Studies* May 2017 – August 2017  
**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

**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*

Ottawa, Canada

May 2015 – August 2015

**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

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**TEACHING EXPERIENCE**

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

Cologne, Germany

April 2024 – July 2024

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

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**SUPERVISION OF GRADUATE AND UNDERGRADUATE RESEARCH**

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**Paula Weiß, University of Cologne***MSc, Mathematics (co-supervised with Gregor Gassner and Benedict Geihe)*

Cologne, Germany

August 2024 – Present

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

Cologne, Germany

April 2024 – April 2025

**Project:** A discontinuous Galerkin method for moist atmospheric dynamics with rain**Ruilin (Jerry) Bai, University of Toronto***BASc, Engineering Science (co-supervised with David Zingg)*

Toronto, Canada

September 2020 – December 2020

**Project:** Optimization of summation-by-parts operators for minimal solution error**Yewon Lee, University of Toronto***BASc, Engineering Science (co-supervised with David Zingg and Masayuki Yano)*

Toronto, Canada

May 2019 – August 2019

**Project:** Comparative evaluation of energy- and entropy-stable discontinuous Galerkin and summation-by-parts methods

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**AWARDS AND SCHOLARSHIPS**

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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 Carleton 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, Carleton University

2014 – 2018

Faculty Scholarship, Carleton University

2014 – 2018

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**OPEN-SOURCE SOFTWARE CONTRIBUTIONS AS PRINCIPAL DEVELOPER**

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**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

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**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

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**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; assisted in hosting the [2023 CCSE Symposium](#)

**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

## TECHNICAL SKILLS

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**Programming languages** Julia, Python (including NumPy and SciPy), C, C++, , MATLAB, Fortran, L<sup>A</sup>T<sub>E</sub>X

**Development tools** Unix shell (including Bash/zsh/tcsh scripting), Git, GNU Make, Anaconda, Jupyter/Pluto notebooks, VS Code, Vim, Emacs

**High-performance computing** Shared-memory parallelism (OpenMP, multithreading), distributed-memory parallelism (MPI), matrix-free algorithms, SIMD vectorization, job scheduling (Slurm)

**Computer-aided engineering** Applied 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

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

## CITIZENSHIP

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Canada, France