

## 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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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

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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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**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](#). *9<sup>th</sup> 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.

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\*Presenting author.

## INVITED TALKS

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**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

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### **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)

*March 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**

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**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**

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**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**

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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 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

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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

### **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

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### **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

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

## CITIZENSHIP

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Canada, France