Tristan Montoya

tristan.montoya@alumni.utoronto.ca
tmontoya@uni-koeln.de

tjbmontoya.com

EDUCATION

University of Toronto — Toronto, Canada
Doctor of Philosophy (PhD), Aerospace Science and Engineering — *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 — Ottawa, Canada
Bachelor of Engineering (BEng), Mechanical Engineering — *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, discontinuous Galerkin and spectral-element methods, 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. *11^{th} International Conference on Computational Fluid Dynamics*, Maui, United States, July 2022. **Awarded best student paper**.

CONFERENCE PRESENTATIONS (EXCLUDING ABOVE PROCEEDINGS)

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^{th} 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

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

Nonlinear Numerics Inc. Ottawa, Canada
President *May 2025 – Present*
Research, software development, and consulting services for advanced 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 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

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 Montréal, Canada
Undergraduate Researcher, Department of Mechanical Engineering *May 2016 – August 2016*
Project: Robust deformation of unstructured grids using radial basis functions and linear elasticity
Advisor: Siva Nadarajah

Carleton University Ottawa, Canada
Undergraduate Researcher, Department of Mechanical and Aerospace Engineering *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

TEACHING EXPERIENCE

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

SUPERVISION OF GRADUATE AND UNDERGRADUATE RESEARCH

Paula Weiß, University of Cologne Cologne, Germany
MSc, Mathematics (co-supervised with Gregor Gassner and Benedict Geihe) *August 2024 – Present*
Project: High-order vertical discretizations for nonhydrostatic atmospheric models

Fabian Höck, University of Cologne Cologne, Germany
MSc, Mathematics (co-supervised with Gregor Gassner and Benedict Geihe) *April 2024 – Present*
Project: A discontinuous Galerkin method for moist atmospheric dynamics with rain

Ruilin (Jerry) Bai, University of Toronto Toronto, Canada
BASc, Engineering Science (co-supervised with David Zingg) *September 2020 – December 2020*
Project: Optimization of summation-by-parts operators for minimal solution error

Yewon Lee, University of Toronto Toronto, Canada
BASc, Engineering Science (co-supervised with David Zingg and Masayuki Yano) *May 2019 – August 2019*
Project: Comparative evaluation of energy- and entropy-stable discontinuous Galerkin and summation-by-parts methods

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 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

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; 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

Programming languages	Julia, Python (including NumPy and SciPy), C, C++, , MATLAB, Fortran, LaTeX
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	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