Dr. Mingzhe Li

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Research Profile

I develop topological and optimal-transport methods for comparing, tracking, and summarizing complex scientific data, together with scalable algorithms that make these methods practical on large datasets. My work spans topological data analysis, scientific visualization, high-performance computing, uncertainty visualization, and scientific machine learning, with applications in climate and atmospheric science. My record includes **9 peer-reviewed publications (8 first-authored)**, research appointments at **Lawrence Berkeley and Los Alamos National Laboratories**, and scalable contour-tree algorithms integrated into **Viskores**.

Research areas: scientific visualization; topological data analysis; computational topology; optimal transport; high-performance computing; uncertainty visualization; scientific machine learning.

Academic Appointment

University of Notre Dame, Notre Dame, IN Nov 2025–Present

Postdoctoral Research Fellow, Department of Computer Science & Engineering. Supervisor: Erin W. Chambers.

Education

University of Utah, Salt Lake City, UT Aug 2020–Oct 2025

Ph.D. in Computing (Data Management and Analysis). Advisor: Bei Wang Phillips.

Dissertation: Topological Descriptors for Complex and Scalable Data Analysis: Optimal Transport and Distributed Feature Extraction.

University of Southern California, Los Angeles, CA Jan 2018–Dec 2019

M.S. in Computer Science.

Zhejiang University, Hangzhou, China Sep 2013–Jun 2017

B.Eng. in Computer Science.

Selected Research Contributions

1. Topological Comparison, Tracking, and Structural Uncertainty

Flexible and Probabilistic Topology Tracking IEEE TVCG, 2025

- Developed a partial optimal-transport framework for merge trees that produces partial, probabilistic correspondences between evolving topological features and accommodates unmatched or ambiguous features, including births/deaths and split/merge events; established a stability result for the proposed distance.

MS-COOT: Comparing Morse–Smale Complexes Preprint, 2026

- Co-developed a co-optimal-transport distance that models Morse–Smale complexes as measure hypernetworks and jointly matches critical points and regions. Evaluated the method on five datasets spanning 2D simulations, 3D surfaces, and volumetric data, enabling explicit region-level correspondences and detection of split/merge behavior.

Contour-Tree Barycenters and Uncertainty Visualization IEEE VIS, 2026

- Developed approximate partial-OT barycenters for contour-tree ensembles together with uncertainty encodings for function values, spatial embeddings, and node correspondences, producing interpretable summaries of topological variability in scientific ensembles.

Sketching Merge Trees TopoInVis, 2023

- Combined Gromov–Wasserstein alignment with matrix sketching to compress collections of merge trees into compact basis sets for representative selection, reconstruction, outlier identification, and periodicity analysis.

2. Scalable Topological Computing

Distributed Contour-Tree Analysis IEEE TVCG / VIS, 2024

- Co-developed distributed augmentation, hypersweeps, branch decomposition, and contour extraction for hierarchical contour trees. The implementation achieved up to **98.76× speedup** over the state-of-the-art single-node baseline and supports production scientific analysis through Viskores.

Pre-Simplification for Extreme-Scale Contour Trees IEEE LDAV, 2025

- Introduced a pre-simplification strategy that delivered **1.60–2.58×** additional speedup and enabled **3.87–6.67× larger** data volumes under fixed compute resources. Demonstrated construction of a contour tree with **more than 0.5 trillion nodes** from a **550-billion-element** volume in **under 15 minutes**.

3. Topology for Scientific Discovery

Atmospheric Blocking Detection and Uncertainty Visualization IEEE TVCG / PacificVis TVCG Track, 2026

- Developed geometry-based detection/tracking and uncertainty-aware visual summaries for atmospheric blocking using UKESM climate simulations and ERA5 reanalysis, including contour boxplots, frequency heatmaps, and 3D temporal stacks; demonstrated the workflow on the 2003 European heatwave.

Topology-Driven Low-Level Cloud Tracking TopoInVis, 2025

- Extended probabilistic topology tracking to cloud systems using merge-tree anchors derived from cloud optical depth. Evaluated on two geostationary-satellite datasets and compared against two dedicated cloud trackers and two topology-based general-purpose trackers.

Peer-Reviewed Publications (9 publications; 8 first-authored)

[**P1**] **Mingzhe Li**, Fangfei Lan, Gunther H. Weber, Bei Wang. "Uncertainty Visualization for Approximated Barycenter of Contour Trees Based on Partial Optimal Transport." *IEEE Visualization and Visual Analytics (VIS) Short Paper*, accepted, 2026.

[**P2**] **Mingzhe Li**, Peer Nowack, Bei Wang. "Spatiotemporal Detection and Uncertainty Visualization of Atmospheric Blocking Events." *IEEE Transactions on Visualization and Computer Graphics* (PacificVis 2026 TVCG Journal Track), 32(6):4742–4752, 2026. DOI

[**P3**] **Mingzhe Li**, Dwaipayan Chatterjee, Franziska Glassmeier, Fabian Senf, Bei Wang. "Tracking Low-Level Cloud Systems with Topology." *IEEE Workshop on Topological Data Analysis and Visualization (TopoInVis)*, pp. 89–99, 2025. DOI

[**P4**] **Mingzhe Li**, Hamish Carr, Oliver Rübel, Bei Wang, Gunther H. Weber. "Extremely Scalable Distributed Computation of Contour Trees via Pre-Simplification." *IEEE Symposium on Large Data Analysis and Visualization (LDAV)*, pp. 1–11, 2025. DOI

[**P5**] **Mingzhe Li**, Xinyuan Yan, Lin Yan, Tom Needham, Bei Wang. "Flexible and Probabilistic Topology Tracking with Partial Optimal Transport." *IEEE Transactions on Visualization and Computer Graphics*, 31(10):7951–7969, 2025. DOI

[**P6**] **Mingzhe Li**, Hamish Carr, Oliver Rübel, Bei Wang, Gunther H. Weber. "Distributed Augmentation, Hypersweeps, and Branch Decomposition of Contour Trees for Scientific Exploration." *IEEE Transactions on Visualization and Computer Graphics* (IEEE VIS 2024), 31(1):152–162, 2025. DOI

[**P7**] **Mingzhe Li**, Carson Storm, Austin Yang Li, Tom Needham, Bei Wang. "Comparing Morse Complexes Using Optimal Transport: An Experimental Study." *IEEE Visualization and Visual Analytics (VIS) Short Paper*, pp. 41–45, 2023. DOI

[**P8**] **Mingzhe Li**, Sourabh Palande, Lin Yan, Bei Wang. "Sketching Merge Trees for Scientific Visualization." *IEEE Workshop on Topological Data Analysis and Visualization (TopoInVis)*, pp. 61–71, 2023. DOI

[**P9**] Kamonphop Srisopha, Chukiat Phonsom, **Mingzhe Li**, Daniel Link, Barry Boehm. "On Building an Automatic Identification of Country-Specific Feature Requests in Mobile App Reviews: Possibilities and Challenges." *IEEE/ACM 42nd International Conference on Software Engineering Workshops (ICSEW)*, pp. 494–498, 2020. DOI

Manuscript / Preprint

[**M1**] Guangyu Meng, **Mingzhe Li**, Erin W. Chambers. "MS-COOT: Comparing Morse–Smale Complexes with Co-Optimal Transport." 2026. arXiv:2606.08258

Awards and Honors

Provost's Postdoctoral Fellowship, University of Notre Dame Sep 2025

Research Experience

Lawrence Berkeley National Laboratory, Berkeley, CA Summers 2023 & 2024

Graduate Researcher, Scientific Data Division. Supervisor: Dr. Gunther H. Weber.

- Designed and implemented distributed contour-tree algorithms; conducted large-scale experiments on NERSC Perlmutter; research resulted in the IEEE TVCG/VIS 2024 and IEEE LDAV 2025 papers listed above.

Los Alamos National Laboratory, Los Alamos, NM May–Aug 2022

Graduate Researcher, ISTI. Supervisor: Dr. Li-Ta Lo.

- Collaborated with VTK-m contributors to verify, test, and refactor augmented contour-tree code for large-scale scientific visualization workflows.

Teaching and Mentoring Experience

Teaching summary: instructional roles across **5 courses** spanning algorithms, discrete mathematics, data science, geospatial computing, and advanced scientific visualization.

- **CS 6966 – Advanced Data Visualization**, University of Utah, Guest Lecturer, Apr 2025. Delivered a hands-on "Topology Toolkit Tutorial."
- **MATH 4100 / COMP 5360 – Introduction to Data Science**, University of Utah, Lead Teaching Assistant, Spring 2022. Maintained course materials, designed Python assignments, mentored visualization project teams, and delivered a guest lecture on Git.
- **CS 2100 – Discrete Structures**, University of Utah, Teaching Assistant, Fall 2021. Led weekly problem-solving sessions on logic, proofs, and probability and contributed to homework and quiz design/grading.
- **CSCI 587 – Geospatial Information Management**, University of Southern California, Course Producer, Fall 2019.
- **CSCI 570 – Analysis of Algorithms**, University of Southern California, Course Producer, Fall 2018 and Spring 2019.
- **Graduate mentoring**, University of Notre Dame, 2025–Present. Mentor graduate students on research problem formulation, implementation, experimental design, and scientific communication.

Selected Invited and Conference Presentations

- **Jul 2026 – Workshop on Graph-Based Methods in TDA, Michigan State University.** Poster: "Flexible & Probabilistic Topology Tracking with Partial Optimal Transport"; panelist, Professional Development Panel.
- **May 2026 – Workshop on Foundations of Computational Geometry and Topology, ICERM, Brown University.** Invited talk: "Comparing Morse–Smale Complexes via Co-Optimal Transport."
- **Jun 2025 – Workshop on Topological Data Visualization, University of Iowa.** Invited talk: "Comparing and Tracking Topological Structures via Optimal Transport."
- **Jan 2025 – Graduate Research Symposium, University of Utah.** Invited talk: "Sketching Merge Trees for Scientific Visualization."
- **Oct 2024 – IEEE VIS.** Conference talk: "Distributed Augmentation, Hypersweeps, and Branch Decomposition of Contour Trees for Scientific Exploration."
- **Oct 2023 – TopoInVis & IEEE VIS, Melbourne, Australia.** Conference talks on "Sketching Merge Trees for Scientific Visualization" and "Comparing Morse Complexes Using Optimal Transport: An Experimental Study."

Professional Service

Reviewer for 6 visualization venues / tracks: IEEE Transactions on Visualization and Computer Graphics (2025–2026); IEEE VIS Full Papers (2025–2026); IEEE VIS Short Papers (2025–2026); EuroVis (2025–2026); IEEE PacificVis TVCG Journal Track (2025); ChinaVis (2026).

Industry Experience

Microsoft, Beijing, China May–Aug 2019
Software Engineer Intern, STCA.

- Implemented C/C++ changes for Microsoft Excel to extend long-path file support and updated Document Inspector and Compatibility Checker behavior for legacy-file compatibility.

Desay SV Automotive, Nanjing, China Aug–Nov 2017
Machine Learning Intern, R&D Department.

- Designed and implemented neural-network models for lane recognition from real-world road video, achieving **96% recognition accuracy**.

Technical Skills

Programming and HPC: C/C++, Python, MPI, OpenMP, Linux/HPC, Git, Viskores/VTK-m; distributed algorithms and large-scale scientific visualization.
Research methods: topological data analysis, computational topology, optimal transport, scientific visualization, uncertainty visualization, machine learning; climate and atmospheric data analysis.