

Henry Adams

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ACADEMIC EMPLOYMENT

Assistant Professor at the Colorado State University Department of Mathematics, 2015–present.

Visiting Assistant Professor at the Duke University Department of Mathematics, 2014–2015

Postdoctoral Fellow at the Institute for Mathematics and its Applications, 2013–2015.

EDUCATION

Stanford University, Ph.D. Mathematics, August 2013.

Advisor: Gunnar Carlsson.

Thesis: *Evasion paths in mobile sensor networks*

Stanford University, B.S. Mathematics with honors and distinction, 2007.

Thesis: *Spaces of range image patches*. Minor in Economics.

GRANTS, AWARDS, AND FELLOWSHIPS

2019–2021 NSF Grant #1934725, *DELTA: Descriptors of Energy Landscapes by Topological Analysis*, NSF Harnessing the Data Revolution (HDR): Institutes for Data-Intensive Research in Science and Engineering Frameworks (I-DIRSE-FW), Co-Principal Investigator (PI is Professor Aurora Clark, Washington State University). The DELTA project advances topological data analysis and machine learning algorithms for the study of data sets of the energy landscapes of chemical systems. This grant provides research funding three Colorado State graduate students: one semester each per year, plus summers. \$1,600,000 grant, of which \$201,804 is for my team at Colorado State.

2019 Simons Collaboration Grant for Mathematicians, on *Reconstruction via metric thickenings*, \$42,000 grant. [Declined when I became ineligible due to the grant above.]

2017–2019 DARPA-BAA-16-42 “Prometheus” grant, *Geometric, Topological and Dynamic Features of Early Warning of Contagious Respiratory Infection*. Senior Investigator (PI is Professor Michael Kirby, Colorado State University). The Prometheus program aims to develop a molecular host prognostic assay to determine infectious disease contagiousness, focused specifically on the early prognosis of pathogen transmission potential. \$174,000 grant.

2019 Research in Pairs Grant from the Mathematical Research Institute of Oberwolfach, on *Quantifying topology via metric thickenings*, with Florian Frick and Žiga Virk.

2015 Research in Pairs Grant from the Mathematical Research Institute of Oberwolfach, on *Behavior of geometric complexes as the scale increases*, with Michał Adamaszek.

2012–2013 Ric Weiland Graduate Fellowship, Stanford University.

RESEARCH

My research interests are in topology, geometry, data analysis, machine learning, and sensor networks. More specific subfields of interest include applied topology, computational topology and geometry, metric geometry, and combinatorial topology. In particular, I advance the study of Vietoris–Rips and

Čech simplicial complexes, Vietoris–Rips and Čech metric thickenings, applications of topology to data analysis and machine learning, and applications of topology to sensor networks.

Mathematical Press

32. *How do I ... develop an online research seminar?* Notices of the American Mathematical Society, Volume 67, Number 8, September 2020.
31. *Topological data analysis of collective motion*, with Maria-Veronica Ciocanel, Chad M. Topaz, and Lori Ziegelmeier, SIAM News, January/February Issue, 2020.

Preprints (* denotes graduate student coauthor, • denotes undergraduate student coauthor)

30. *Efficient evader detection in mobile sensor networks*, with Deepjyoti Ghosh*, Clark Mask•, William Ott, and Kyle Williams*, 2021.
29. *Lions and contamination, triangular grids, and Cheeger constants*, with Leah Gibson• and Jack Pfaffinger•. Submitted and available at arXiv:2012.06702, 2021.
28. *Capturing dynamics of time-varying data via topology*, with Lu Xian•, Chad Topaz, and Lori Ziegelmeier. Submitted and available at arXiv:2010.05780, 2020.
27. *Representations of energy landscapes by sublevelset persistent homology: An example with n-alkanes*, with Joshua Mirth*, Yanqin Zhai*, Johnathan Bush*, Enrique G Alvarado*, Howie Jordan*, Mark Heim*, Bala Krishnamoorthy, Markus Pflaum, Aurora Clark, and Y Z. Submitted and available at arXiv:2011.00918, 2020.
26. *Support vector machines and Radon's theorem*, with Brittany Carr* and Elin Farnell. Submitted and available at arXiv:2011.00617, 2020.
25. *The persistent homology of cyclic graphs*, with Ethan Coldren• and Sean Willmot•. Submitted and available at arXiv:1812.03374, 2020.
24. *Vietoris–Rips complexes of regular polygons*, with Samir Chowdhury*, Adam Jaffe•, and Bonginkosi Sibanda•. Available at arXiv:1807.10971, 2020.

Refereed Journal Papers (* denotes graduate student coauthor, • denotes undergraduate student coauthor)

23. *Metric thickenings and group actions*, with Mark Heim* and Chris Peterson. Accepted to appear in the Journal of Topology and Analysis, 2021.
22. *Metric thickenings, Borsuk–Ulam theorems, and orbitopes*, with Johnathan Bush* and Florian Frick. Mathematika 66:79–102, 2020.
21. *On homotopy types of Vietoris–Rips complexes of metric gluings*, with Michał Adamaszek, Ellen Gasparovic, Maria Gommel*, Emilie Purvine, Radmila Sazdanovic, Bei Wang, Yusu Wang, Lori Ziegelmeier. Journal of Applied and Computational Topology, 4:425–454, 2020.
20. *Multidimensional scaling on metric measure spaces*, with Mark Blumstein and Lara Kassab*. Rocky Mountain Journal of Mathematics, 50:397–413, 2020.
19. *A torus model for optical flow*, with Johnathan Bush*, Brittany Carr*, Lara Kassab*, and Joshua Mirth*. Pattern Recognition Letters, 129:304–310, 2020.
18. *Metric thickenings of Euclidean submanifolds*, with Joshua Mirth*. Topology and its Applications, 254:69–84, 2019.
17. *On Vietoris–Rips complexes of ellipses*, with Michał Adamaszek and Samadwara Reddy•. Journal of Topology and Analysis, 11:661–690, 2019.

16. *Metric reconstruction via optimal transport*, with Michał Adamaszek and Florian Frick. *SIAM Journal on Applied Algebra and Geometry*, 2:597–619, 2018.
15. *Persistence images: A stable vector representation of persistent homology*, with Sofya Chepushtanova, Tegan Emerson*, Eric Hanson, Michael Kirby, Francis Motta, Rachel Neville*, Chris Peterson, Patrick Shipman, and Lori Ziegelmeier. *Journal of Machine Learning Research*, 18(8):1–35, 2017.
14. *The Vietoris–Rips complexes of a circle*, with Michał Adamaszek. *Pacific Journal of Mathematics*, 290:1–40, 2017.
13. *Random cyclic dynamical systems*, with Michał Adamaszek and Francis Motta. *Advances in Applied Mathematics*, 83:1–23, 2017.
12. *Nerve complexes of circular arcs*, with Michał Adamaszek, Florian Frick, Chris Peterson, and Corrine Previte-Johnson. *Discrete & Computational Geometry*, 56:251–273, 2016.
11. *Evasion paths in mobile sensor networks*, with Gunnar Carlsson. *International Journal of Robotics Research* 34:90–104, 2015.
10. *Nudged elastic band in topological data analysis*, with Atanas Atanasov and Gunnar Carlsson. *Topological Methods in Nonlinear Analysis*, 45:247–272, 2015.
9. *On the nonlinear statistics of range image patches*, with Gunnar Carlsson. *SIAM Journal on Imaging Sciences* 2:110–117, 2009.

Book chapters (* denotes graduate student coauthor)

8. Chapter on *Topological data analysis*, with Johnathan Bush* and Joshua Mirth*, in the book *Data Science for Mathematicians*, editor Nathan Carter, Chapman & Hall/CRC, New York (2020), DOI 10.1201/9780429398292.

Refereed Proceedings / Transactions (* denotes graduate student coauthor, • denotes undergraduate student coauthor)

7. *An adaptation for iterative structured matrix completion*, with Lara Kassab* and Deanna Needell. Accepted to appear in the 54th Asilomar Conference on Signals, Systems and Computers, 2020.
6. *Operations on metric thickenings*, with Johnathan Bush* and Joshua Mirth*. In: Spivak, D., Vicary, J. (eds), *Applied Category Theory*, *Electronic Proceedings in Theoretical Computer Science* 328:1–15, 2020.
5. *A fractal dimension for measures via persistent homology*, with Manuchehr Aminian, Elin Farnell, Michael Kirby, Chris Peterson, Joshua Mirth*, Rachel Neville, and Clayton Shonkwiler. In: Baas N., Carlsson G., Quick G., Szymik M., Thaulé M. (eds), *Topological Data Analysis*. *Abel Symposia*, Springer vol 15:1–32, 2020.
4. **[Conference version of reference 19 above]** *On the nonlinear statistics of optical flow*, with Johnathan Bush*, Brittany Carr*, Lara Kassab*, and Joshua Mirth*. *Proceedings of Computational Topology in Image Context*, LNCS volume 11382:151–165, 2019.
3. **[Conference version of reference 21 above]** *Vietoris–Rips and Čech complexes of metric gluings*, with Michał Adamaszek, Ellen Gasparovic, Maria Gommel*, Emilie Purvine, Radmila Sazdanovic, Bei Wang, Yusu Wang, Lori Ziegelmeier. *Proceedings of the 34th International Symposium on Computational Geometry*, 3:1–3:15, 2018.
2. *Sweeping costs of planar domains*, with Brooks Adams• and Colin Roberts•. In Erin W Chambers, Brittany T Fasy, and Lori Ziegelmeier, eds., *Research in Computational Topology*, pages 71–92, AWM Springer series, volume 13, 2018.

1. *Javaplex: A research software package for persistent (co)homology*, with Andrew Tausz and Mikael Vejdemo-Johansson. In Han Hong and Chee Yap, editors, *Proceedings of International Congress on Mathematical Software, Lecture Notes in Computer Science 8592*: 129–136, 2014. Software available at <http://appliedtopology.github.io/javaplex>.

Invited Research Talks

2021 May, *Persistence images: A stable vector representation of persistent homology* Minisymposium on Topological Signal Processing at the SIAM conference on the Dynamical Systems, online.

2021 May, *Descriptors of Energy Landscapes using Topological Analysis (DELTA)*, Minisymposium on Multi-Scale Statistical Descriptors of Materials at the SIAM Conference on Mathematics Aspects of Materials Science, online.

2021 May, Workshop on *Topology in Data Science*, 54th Spring Topology and Dynamical Systems Conference, rescheduled for online.

2021 May, *Bridging applied and quantitative topology* Virtual Workshop on Topological Data Analysis: Theory and Applications, hosted by the University of Western Ontario and the Tutte Institute.

2021 Apr, *Representations of energy landscapes by sublevelset persistent homology: An example with n-alkanes*, American Chemical Society symposium on Graph theory underpinning new domains of physical chemistry, online.

2021 Jan, *Descriptors of Energy Landscapes using Topological Analysis (DELTA)*, AMS Special Session on Combinatorial Approaches to Topological Structures and Applications, Joint Mathematics Meetings, Washington DC, online.

2021 Jan, *Evasion paths in mobile sensor networks*, AMS Special Session on Applied Topology, Joint Mathematics Meetings, Washington DC, online.

2021 Jan, *Applied topology: From global to local*, AMS Special Session on Geometry in the Mathematics of Data Science, Joint Mathematics Meetings, Washington DC, online.

2020 Oct, *Bridging applied and quantitative topology*, Topology and Dynamics Seminar, University of Florida, Gainesville FL, online.

2020 July, *Metric reconstruction via optimal transport*, Workshop on Optimal Transport, Topological Data Analysis, and Applications to Shape and Machine Learning, Mathematical Biosciences Institute – The Ohio State University, online.

2020 June, *Borsuk-Ulam theorems and Vietoris-Rips complexes*, Workshop on Topological Data Analysis, as part of the Thematic Program on Toric Topology and Polyhedral Products, Fields Institute, Toronto, Canada, online.

2020 June, *Descriptors of Energy Landscapes using Topological Analysis (DELTA)*, Mathematics of Data Science Virtual Lecture Series. Rescheduled from the Special Session on Mathematics of Data Science, AMS Sectional Meeting, Tufts University, MA.

2020 June, *Applied topology: From global to local*, Mathematics of Data and Decisions at Davis (MADDD) Seminar, UC Davis, CA, online.

2020 June, *From persistent homology to machine learning*, SIAM Conference on Mathematics of Data Science (MDS20), for the Minisymposium on Topological Image Analysis, Cincinnati OH, online.

2020 May, *Vietoris-Rips complexes and Borsuk-Ulam theorems*, Online Algebraic Topology Seminar (OATS).

2020 Mar, *Computational topology and energy landscapes*, National Meeting of the American Chemical Society, *Graph Theory Underpinning New Domains of Physical Chemistry* symposium, Philadelphia, PA. Talk changed to an online slide submission.

2020 Jan, Minicourse on *Geometric complexes in applied topology*, Winter School on Geometric and Topological Data Analysis at CIMAT, in Guanajuato, Mexico.

2020 Jan, *Vietoris–Rips thickenings of spheres*, AMS Special Session on *Vietoris-Borsuk-Rips Homotopy*, Joint Math Meetings, Denver, CO.

2019 Sep, *An introduction to applied topology*, Applied Mathematics Colloquium, University of Colorado, Boulder, CO.

2019 July, *Persistent homology*, Summer School on Data Science for Dynamical Systems, Lorentz Center, Leiden University, Netherlands. Three talk lecture series, along with an afternoon software tutorial session.

2019 May, *An introduction to applied topology software*, NSF-CBMS Conference and Software Day on Topological Methods in Machine Learning and Artificial Intelligence, College of Charleston, SC. Also led a week-long research conversation group, and an afternoon-long coding sprint on real-life applied topology examples for beginners.

2019 Apr, *Metric reconstruction via optimal transport*, Arches Topology Conference, Hurricane, UT.

2019 Jan, *Metric reconstruction via optimal transport*, AMS Special Session on Topological Data Analysis: Theory and Applications, Joint Mathematics Meetings, Baltimore, MD.

2018 Nov, *An introduction to applied topology*, Symposium of Physics and Mathematics FCFM-IFM at the University of Michoacan, Morelia, Mexico.

2018 Nov, *An introduction to applied topology*, Department Colloquium, Texas State University, San Marcos, TX.

2018 Nov, *Metric reconstruction via optimal transport*, Topology Seminar, Texas State University, San Marcos, TX.

2018 Nov, *Metric reconstruction via optimal transport*, Upstate New York Topology Seminar (UNYTS), University of Albany, NY.

2018 Nov, *An introduction to applied and computational topology*, Data Science Seminar, University of Tennessee, TN.

2018 Apr, *Metric reconstruction via optimal transport*, Lafayette-Lehigh Geometry-Topology Seminar, PA.

2018 Apr, *An introduction to applied topology*, Undergraduate colloquium, Lafayette College, PA.

2018 Mar, *Evasion paths in mobile sensor networks*, Department Colloquium, Williams College.

2018 Jan, *The theory of Vietoris–Rips complexes*, AMS special session on Topological Data Analysis, Joint Mathematics Meetings in San Diego, CA.

2017 Dec, *Evasion paths in mobile sensor networks*, Topological data analysis of exclusion zones, Edinburgh, Scotland.

2017 Oct, *Metric reconstruction via optimal transport*, Applied Algebraic Topology Research Network, Online Seminar.

2017 May, *Metric reconstruction via optimal transport*, 58th Cascade Topology Seminar, University of British Columbia.

2017 Mar, *The theory of Vietoris–Rips complexes*, Applied Topology Seminar, Brown University, RI.

2017 Feb, *Vietoris–Rips complexes of circles, ellipses, and higher-dimensional spheres*, Topology, Geometry, and Data Analysis seminar, Ohio State University, OH.

2017 Jan, *Metric reconstruction via Vietoris–Rips complexes and optimal transport*, Florida International University Winter Conference on Geometry, Topology, and Applications, Miami, FL.

2017 Jan, *An introduction to applied and computational topology*, Florida International University Winter Conference on Geometry, Topology, and Applications, Miami, FL.

2016 Oct, *An introduction to computational topology*, Computer Science Department Colloquium, Colorado State University, CO.

2016 Oct, *The theory of Vietoris–Rips complexes: What is known and what is open?*, Mini-symposium on Applied and Computational Topology at the SIAM Central States Section Meeting, University of Arkansas at Little Rock, AR.

2016 July, *What is topology, and how is it applied to data analysis?*, Front Range Computational & Systems Biology Symposium, Colorado State University, CO.

2016 Jan, *Vietoris–Rips complexes of circles and ellipses*, AMS Special Session on Applied and Computational Topology, Joint Meetings, Seattle, WA.

2015 Oct, *Introduction to Javaplex software for persistent homology*, Applied Algebraic Topology Research Network, Student Online Seminar Series.

2015 July, *Introduction to Javaplex software for persistent homology*, Young Topologists' Meeting, EPFL, Lausanne, Switzerland.

2015 Apr, *The Vietoris–Rips complexes of a circle*, University of Rochester Data Science Colloquium, NY.

2015 Mar, *The Vietoris–Rips complexes of a circle*, Applied Algebraic Topology Research Network, Online Seminar Series.

2015 Jan, *The Vietoris–Rips complexes of a circle*, Department Colloquium, Colorado State University, CO.

2014 Nov, *The Vietoris–Rips complexes of a circle*, Geometry and Topology Seminar, Tulane University, LA.

2014 Nov, *The Vietoris–Rips complexes of a circle*, Applied Topology Seminar, University of Pennsylvania, PA.

2014 Oct, *The Vietoris–Rips complexes of a circle*, Department Colloquium, University of North Carolina at Greensboro, NC.

2014 Sept, *The Vietoris–Rips complexes of a circle*, Geometry and Topology Seminar, North Carolina State University, NC.

2014 Mar, *Evasion paths in mobile sensor networks*, IMA Workshop on Topological Systems: Communication, Sensing, and Actuation, University of Minnesota, MN.

2013 Nov, *Evasion paths in mobile sensor networks*, Rocky Mountain Algebraic Combinatorics Seminar, Colorado State University, CO.

2013 Aug, *Evasion paths in mobile sensor networks*, SIAM Conference on Applied Algebraic Geometry, Colorado State University, CO.

2013 July, *Evasion paths in mobile sensor networks*, IM PAN (Institute of Mathematics, Polish Academy of Sciences) Applied Topology, Będlewo, Poland.

2013 June, *Evasion paths in mobile sensor networks*, MSRI Workshop on Algebraic Topology, Berkeley, CA.

2013 June, *Evasion paths in mobile sensor networks*, Ayasdi Topology Day, Palo Alto, CA.

2013 May, *Evasion paths in mobile sensor networks*, CompTop Seminar, Stanford University, CA.

2012 Aug, *Evasion paths in mobile sensor networks*, Special Session on Applied and Computational Topology at MAA MathFest, Madison, WI.

2012 July, *Evasion paths in mobile sensor networks*, Algebraic Topology: Applications and New Directions, Stanford University, CA.

2012 July, *Evasion paths in mobile sensor networks*, Minisymposium on Applied Algebraic Topology at SIAM Annual Meetings, Minneapolis, MN.

2012 Mar, *Evasion paths in mobile sensor networks*, Schloss Dagstuhl Seminar on Applications of Combinatorial Topology to Computer Science, Dagstuhl, Germany.

2012 Jan, *Evasion paths in mobile sensor networks*, AMS Special Session on Computational and Applied Topology, Joint Meetings, Boston, MA.

2011 Oct, *Evasion paths in mobile sensor networks*, SIAM Conference on Applied Algebraic Geometry,

North Carolina State University, NC.

2011 Oct, *Nudged elastic band in topological data analysis*, SIAM Conference on Applied Algebraic Geometry, North Carolina State University, NC.

2011 June, *Introduction to Jvavplex software for persistent homology*, AMS Mathematical Research Community on Computational and Applied Topology, Snowbird, UT.

2011 Jan, *Introduction to JPlex software for persistent homology*, AMS Short Course on Computational Topology, Joint Meetings, New Orleans, LA.

2010 Jan, *Nudged elastic band in topological data analysis*, CompTop Seminar, Stanford University.

2010 Jan, *Nudged elastic band in topological data analysis*, AMS-SIAM Special Session on Applications of Algebraic Geometry, Joint Meetings, San Francisco, CA.

2009 Aug, *Introduction to JPlex software for persistent homology*, CSRI Workshop on Combinatorial Algebraic Topology, Sandia National Laboratories, Santa Fe, NM.

2009 June, *Topological data analysis: Understanding optical flow*, IMA Short Course on Applied Algebraic Topology, University of Minnesota, MN.

2009 June, *Introduction to JPlex software for persistent homology*, IMA Short Course on Applied Algebraic Topology, University of Minnesota, MN.

Invited Panels

2020 Sep, Panelist for the Virtual Department of Energy (DOE) Basic Energy Sciences (BES) Chemical Sciences, Geosciences, and Biosciences (CGSB) Data Science Workshop. On Panel 3: *Understanding Topology of Chemical Data*.

2020 Jan, Panelist for *Next Steps: Mathematics Departments and the Explosive Growth of Computational and Quantitative Offerings in Higher Education*, AMS Committee on Education Panel, JMM, Denver, CO.

Departmental Talks and Expository Talks

2021 Jan, *Coffee break chat on data science*, Data Science Seminar, Colorado State University.

2020 Sep, *Fair Division*, Data Science Seminar, Colorado State University.

2020 May, *Borsuk-Ulam theorems into higher-dimensional codomains*, Rocky Mountain Algebraic Combinatorics Seminar, Colorado State University.

2020 Feb, *Persistent homology, zigzag persistence, and quiver representations*, Topology Seminar, Colorado State University.

2020 Feb, *Neighborly polytopes and the sparsity-promoting L^1 norm*, Data Science Seminar, Colorado State University.

2020 Jan, *An introduction to persistent homology*, Descriptors of Energy Landscapes by Topological Analysis (DELTA), Online Seminar.

2019 Nov, *An introduction to Morse theory*, Descriptors of Energy Landscapes by Topological Analysis (DELTA), Online Seminar.

2019 Oct, *An introduction to applied topology*, Data Science Seminar, Colorado State University.

2019 Sep, *An introduction to matroids*, Topology Seminar, Colorado State University.

2019 Sep, *Applying to academic jobs*, Department of Mathematics, Colorado State University.

2019 June, *An introduction to applied topology*, an REU at CU Boulder.

2019 Mar, *The waist inequality*, Topology Seminar, Colorado State University.

2018 Nov, *Lovász' proof of the Kneser conjecture*, Topology Seminar, Colorado State University.

- 2018 May, *Using homotopy colimits to understand infinite simplicial complexes*, Topology Seminar, Colorado State University.
- 2018 April, *An introduction to homotopy colimits*, Topology Seminar, Colorado State University.
- 2017 Oct, *Vietoris–Rips complexes of the circle*, Topology Seminar, Colorado State University.
- 2017 Oct, *Sperner’s lemma and fair division*. Colorado State University Math Club.
- 2017 Sept, *An introduction to Vietoris–Rips complexes*, Topology Seminar, Colorado State University.
- 2016 Oct, *Cyclic polytopes and nerve complexes*, Rocky Mountain Algebraic Combinatorics Seminar, Colorado State University.
- 2015 Oct, *Evasion paths in mobile sensor networks*, Colorado State University Pattern Analysis Lab.
- 2015 Sept, *Random cyclic dynamical systems*, Rocky Mountain Algebraic Combinatorics Seminar, Colorado State University.
- 2015 Feb, *Evasion paths in mobile sensor networks*, Duke University Graduate & Faculty Seminar.
- 2014 Oct, *Vietoris–Rips complexes*, Duke University Graduate & Faculty Seminar.
- 2014 May, *The Vietoris–Rips complexes of a circle*, IMA Postdoc Seminar, University of Minnesota.
- 2013 Dec, *Introduction to discrete Morse theory*. Student Topology Seminar, University of Minnesota.
- 2013 Oct, *What is the Vietoris–Rips complex for evenly spaced points around a circle?*, IMA Postdoc Seminar, University of Minnesota.
- 2013 July, *Applied topology*. Stanford University Mathematics Camp, Guest Lecture Series, Stanford University.
- 2012 March, *Evasion paths in mobile sensor networks*, Graduate Student Colloquium, Stanford University.
- 2011 July, *Applied topology*. Stanford University Mathematics Camp, Guest Lecture Series, Stanford University.
- 2010 May, *Coverage problems in sensor networks*. Stanford Undergraduate Mathematical Organization, Speaker Series, Stanford University.

TEACHING

Colorado State University

- DSCI (Data Science) 475, Topological Data Analysis, Spring 2021. **Developed as a new course.**
- Math 366, Introduction to Abstract Algebra, Spring 2021, 2020, 2019.
- Math 510, Linear Programming and Network Flows, Fall 2020.
- Math 301, Introduction to Combinatorial Theory, Fall 2019, 2018, 2016, 2015.
- Math 571, Topology II, Spring 2018.
- Math 570, Topology I, Fall 2017.
- Math 580A2, Topological Data Analysis, Spring 2017. **Developed as a new course.**
- Math 435, Projects in Applied Mathematics, Spring 2017 and 2016.
- Math 472, Introduction to Topology, Fall 2016.

Development of new courses at Colorado State University

- DSCI 475 – Introduction to Topological Data Analysis. I developed this class as an elective for the new Data Science major. This class has been fully approved as a new class by CSU, and I am teaching it for the first time in Spring 2021. The class studies topological techniques for analyzing high-dimensional or complex data. The shape of data may reflect patterns within; e.g. connected components may corre-

spond to groupings, or a circular shape may correspond to periodic behavior. Topics include clustering, dendrograms, a visual introduction to topology, data modeling and visualization, and selected topics from nonlinear dimensionality reduction, graph-based models of data, Reeb graphs, multi-scale approaches to data, and persistent homology.

- Math 580a2 – Applied Topology. I developed and taught (in Spring 2017) a 1-credit topics course on Applied Topology. The class began with an intuitive introduction to topology, and we then moved into applications in the realm of data analysis. As our main tool we studied persistent homology, which we computed using the software package Javaplex. This class was targeted not only at mathematics graduate students, but also at computer science graduate students and members of the Colorado State GAUSSI (Generating, Analyzing, and Understanding Sensory and Sequencing Information) program.

Duke University

Math 431, Introduction to Analysis, Spring 2015.

Outreach Teaching

Minicourse on *Geometric complexes in applied topology* at the TDA workshop at CIMAT, in Guanajuato, Mexico, January 2020.

Two week course on *Computational Topology* at the Universidad de Costa Rica, Summer 2017.

One week minicourse on *Computational Topology* at the REU program Summer@ICERM 2017.

Instructor, Stanford Summer Engineering Academy Math 41 and 51, Summer 2012.

The goal of the Stanford Summer Engineering Academy is to attract women and minority students to engineering majors. I taught a course on calculus and a course on linear algebra.

In 2011 I received the Stanford Centennial Teaching Assistant Award.

ADVISING

I am interested in making academia more welcoming, more open, more transparent, more accessible, and less intimidating.

Graduate Student Advisees

1. Joshua Mirth, Department of Mathematics. PhD in Summer 2020 and Masters in Fall 2017. Currently a Postdoctoral Fellow at Michigan State University.
2. Johnathan Bush, Department of Mathematics. Masters in Fall 2018. Current PhD student, 5th year.
3. Lara Kassab, Department of Mathematics. Masters in Spring 2019. Current PhD student, 4th year. Amazon Research intern in Summer 2021.
4. Brittany Carr, Department of Mathematics. Masters in Spring 2019. Current PhD student, 4th year. NASA Research intern in Summer 2019
5. Mark Heim, Department of Mathematics (co-advised by Chris Peterson). Masters in Spring 2020. Current PhD student, 3rd year.
6. Lander Ver Hoef, Department of Mathematics (co-advised by Emily King). Current PhD student, 2nd year.
7. Michael Moy, Department of Mathematics. Current Masters student, 2nd year. NASA Research intern in Summer 2020.

In addition to the committees chaired above, I have also served as a member on 12 MS and 4 PhD completed committees, and am currently a member on 3 MS and 14 PhD committees.

Undergraduate student advisees

An undergraduate research project was my entrance into research mathematics, and I believe strongly in the importance of mentoring undergraduate students.

Ty Jensen, Sophia Ressler, Taylor Rogers, Caroline Wendt, *Laplacian eigenmaps of the circle*, 2020–present.

Leah Gibson and Jack Pfaffinger, research paper *Lions and contamination, triangular grids, and Cheeger constants*, 2020–present.

Natalie Burke, bachelor's thesis *An exploration in Perron's theorem*, 2019–2020.

Lu Xian from Macalester College; main advisor is Professor Lori Ziegelmeier. Research paper *Persistent crocker plots*, 2018–present.

Ethan Coldren, bachelor's thesis *On Vietoris-Rips complexes of planar curves* and research paper *The persistent homology of cyclic graphs*, 2018–2019.

Sean Willmot, research paper *The persistent homology of cyclic graphs*, 2017–2019.

Adam Jaffe (Stanford University) and Bonginkosi Sibanda (Brown University), via the Summer@ICERM 2017 program. Research paper *Vietoris–Rips complexes of regular polygons*, 2017–present.

Samadwara Reddy via the Duke PRUV Fellowship. Bachelor's thesis *The Vietoris–Rips complexes of finite subsets of an ellipse of small eccentricity* and research paper *On Vietoris–Rips complexes of ellipses*, 2015–2017.

Colin Roberts, bachelor's thesis *Sweeping costs of simply-connected domains* and research paper *Sweeping costs of planar domains*, 2016–2017.

Brooks Adams, research paper *Sweeping costs of planar domains*, 2016–2017.

John Obuch, undergraduate research paper *Crystallization processes in 1-D*, 2016.

Honors option for 4 students (Natalie Burke, Math 301, Fall 2019; Isabella Zapata, Math 366, Spring 2019; Leah Gibson, Math 301, Fall 2018; Andrea Vigil, Math 301, Fall 2015).

External examiner: 2019, Williams College, Senior Honors Thesis, Zhiqi Li

I write letters of recommendation for many of my official and unofficial advisees (letters for 24 people in 2020, 28 people in 2019, 19 people in 2018, 16 people in 2017).

SERVICE AND OUTREACH

Service leadership in applied topology

Co-Director of the IMA-sponsored Applied Algebraic Topology Research Network (AATRN), 2016–present, which features an online research seminar series (two such series in summer 2020 in response to the pandemic). We hosted 71 talks total in 2020. Recordings of our seminar are available at our YouTube Channel, which has **over 200 hour-long videos, over 1,580 YouTube subscribers, and averages over 12 hours watched per day**. We have also helped four conferences record their videos and post them online.

Author and maintainer of tutorials for the Javaplex and JPlex software packages for applied topology.

Committees at Colorado State University

Data Science Major Committee Member, College of Natural Sciences, 2016–2018. I served as one of two representatives from the math department in meetings to help our college create a new data science major. As an off-shoot of this role, I created the DSCI (Data Science) 475 class titled Introduction to Topological Data Analysis.

Departmental Action Team (DAT) for improving our undergraduate mathematics program, Department of Mathematics, 2017–2018.

Graduate Curriculum Investigation Committee, Department of Mathematics, 2020–present.

Diversity, Equity, and Inclusion Committee, Department of Mathematics, 2020–present.

Seminar organization at Colorado State University

Co-Coach for the Putnam Mathematical Competition at Colorado State University, 2015–present. Our practice seminar meets both fall and spring semesters.

Advisor for the Mathematical Contest in Modeling team at Colorado State University, 2016–2017.

Co-organizer of Colorado State University’s Topology Seminar, 2015–present.

Co-organizer of Colorado State University’s Pattern Analysis Lab, 2016–present.

Conference organization

Co-organized the week-long *ICERM Topical Workshop on Applied mathematical modeling with topological techniques*, with Maria D’Orsogna, Rachel Neville, Jose Perea, Chad Topaz, 2019.

Co-organized the week-long *TRIPODS Summer Bootcamp on Topology and Machine Learning* at ICERM, with Jeffrey Brock, Melissa McGuirl, Bjorn Sandstede, Yitzchak Solomon, 2018.

Mini-symposia organized:

2020, AMS special session on *Applied Topology* at the Joint Mathematics Meetings in Denver CO, with Mikael Vejdemo–Johansson.

2018, Minisymposium on *Applied and Computational Topology* at the SIAM Central States Section Meeting, University of Oklahoma, with Mehmet Aktas, Wenwen Li, and Murad Ozaydin.

2018, 7th Annual Minisymposium on Computational Topology at Computational Geometry Week, Budapest, Hungary, with Ellen Gasparovic and Katharine Turner.

2018, AMS special session on *Topological Data Analysis* at the Joint Mathematics Meetings in San Diego CA, with Mikael Vejdemo–Johansson.

2017, Minisymposium on *Symmetric Simplicial Complexes and Polytopes* at the SIAM Conference on Applied Algebraic Geometry, Atlanta GA, with Florian Frick.

2017, Special session on *Recent Advances in Applied Algebraic Topology* at the AMS Spring Western Sectional Meeting, Washington State University, with Bala Krishnamoorthy.

2016, Minisymposium on *Applied and Computational Topology* at the SIAM Central States Section Meeting, University of Arkansas at Little Rock, with Patrick Shipman.

Conference program committees:

2020, Symposium on Computational Geometry (SoCG), Multimedia Exposition Track Committee Member, Zürich, Switzerland.

2019, Program committee member for the IEEE ICMLA Special Session on Topological Data Analysis in Machine Learning, Boca Raton, Florida.

Refereeing

I have reviewed grants for the Simons Foundation Collaboration Grants for Mathematicians, for the NSF Computer and Information Science and Engineering (CISE) Research Initiation Initiative (CRII), for the NSF Computational and Data-Enabled Science and Engineering (CDS&E) Office of Advanced Cyberinfrastructure (OAC), for the Mathematics Division at the US Army Research Office (ARO), for the Austrian Science Fund, for Banf International Research Station conference proposals, for the Section Activity Grants Committee for the Rocky Mountain Section of the Mathematical Association of America, and for an internal grant at Wilkes University.

Reviewer for *Mathematical Reviews* (MathSciNet), *zbMATH*, and a referee for many mathematics and computer science journals (26 reviews in 2020, 20 reviews in 2019, 14 reviews in 2018, 13 reviews in

2017): Discrete & Computational Geometry, SIAM Journal on Applied Algebra and Geometry, Algebraic & Geometric Topology, Proceedings of the National Academy of Sciences, Journal of Applied and Computational Topology, Symposium on Computational Geometry, Foundations of Computational Mathematics, Journal of Topology & Analysis, Homology, Homotopy and Applications, Proceedings of the Royal Society A, Topological Methods in Nonlinear Analysis, Journal of Mathematical Biology, Acta Applicandae Mathematicae, Computational Geometry: Theory and Applications, Journal of Chemical Physics, Journal of Neuroscience Methods, Journal of Learning Analytics, Neurocomputing, AWM-IMA Springer volume, PCMI book chapter, Forum Mathematicum, Abel Symposia (Springer).

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