

# MELISSA BUTLER

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## RESEARCH INTERESTS

Computational and Applied Mathematics, Modeling, Data Science, Scientific Computing, Machine Learning, Network Science, Anomaly Detection, Random Matrix Theory, Human Mobility Patterns

## EDUCATION

PhD in Mathematics | University of Wyoming Anticipated Graduation May 2026

- \* Dissertation: Anomaly detection algorithms for human mobility and other complex networks
- \* Committee: Dr. Dane Taylor (Chair/Advisor), Dr. Victor Ginting, Dr. Bryan Shader, Dr. Long Lee, Dr. Chen Xu

MS in Mathematics | University of Wyoming December 2022

- \* Concentration: Numerical Methods and Mathematical Modeling

BS in Mathematics | University of Wyoming May 2019

- \* Minor: Computer Science
- \* Concentration: Scientific Computing and Differential Equations

## PUBLICATIONS

- \* M. Butler, A. Khan, F. Afrifa, Y. Hu, and D. Taylor (2026) *Multilayer networks characterize human-mobility patterns by industry sector for the 2021 Texas winter storm*. Accepted to NPJ Complexity. <https://arxiv.org/abs/2509.03642>
- \* M. Butler, A. Khan, F. Afrifa, Y. Hu, and D. Taylor (2026) *Multilayer networks characterize human-mobility patterns by industry sector for the 2021 Texas winter storm*. In preparation.
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## RESEARCH AND PROJECTS

PhD Research | University of Wyoming

*Community Detection in Complex Networks*, Dane Taylor (Advisor). Extend current spectral analysis methods from random matrix theory to realistic network modeling for complex networks. Specifically, apply nonnegative matrix factorization to various stochastic block matrices that encode a network to isolate and identify small anomalous communities in human mobility data provided by *SafeGraph*.

MS Research | University of Wyoming

*Uncertainty in Boundary Values of Richards Equation*, Victor Ginting (Advisor). A finite volume method is used to derive numerical approximate solutions for the boundary value problem for Richards Equation, governing semi-saturated fluid flow. The uncertainty of surface precipitation is quantified by introducing Brownian Motion to a Neumann boundary condition and analyzing the total water mean, standard deviation, and statistical distribution.

Graduate Course Projects | University of Wyoming

*Metalearning for Machine Learning Optimization*. I created machine learning algorithms to optimize selection of ML learner, data preparation, and hyperparameter selection.

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*Physics Informed Neural Networks for Initial Value Problems.* I adapted code to create a PINN for solving initial value problems and research current literature for PINN's.

*Finite Element Method for Solving Two-point Boundary Value Problems.* I worked in collaborative group to create object oriented software in MATLAB for solving BVP's.

*Conjugate Gradient Method.* I implemented the conjugate gradient method using C++ and applied it to differential equations.

## PRESENTATIONS

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September 25, 2025	"Characterizing anomalous human mobility patterns during the 2021 Texas winter storm," Wyoming Computing Symposium: AI For WY Industries, Laramie, WY
June 24, 2025	"Characterizing anomalous human mobility patterns during the 2021 Texas winter storm," 2025 USGIS Symposium, Navigating the Geospatial Frontier: Future Directions for Academia and Its Partners, Laramie, WY
October 15, 2024	"Characterizing anomalous human mobility patterns during the 2021 Texas winter storm," I-GUIDE Forum 2024, Convergence Science and Geospatial AI for Environmental Sustainability, Jackson, WY
March 12, 2022	"Quantifying uncertainty in Richards equation through Brownian Motion," SIAM 18 <sup>th</sup> Front Range Applied Mathematics Student Conference, Denver, CO (virtual participation)

## SOFTWARE AND COMPUTING EXPERTISE

### Languages

Python	Anomaly Detection in Networks, Machine Learning, Data Science
C++	Finite Volume Method, Stochastic Gradient Decent, Iterative Techniques
MATLAB	Finite Element Method, Scientific Computing Techniques
OpenMP	Parallel Computing, Decentralized Computing Network
Mathematica	Mathematical Modeling

### Professional Development Workshops

20???	<i>Conference workshops???</i>
2022	<i>Fundamentals of Accelerated Computing with CUDA C/C++</i> NVIDIA Deep Learning Institute
2022	<i>Fundamentals of Deep Learning</i> NVIDIA Deep Learning Institute
2022	<i>Parallel Computing Workshop</i> MATLAB

## GRADUATE COURSEWORK

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2023 - 2024	Random Matrix Theory for Anomaly Detection, Combinatorial Matrix Theory, Advanced Topics in AI, Computational Methods III, Practical Applications of Machine Learning, Machine Learning for Fluid Dynamics
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2021 – 2022 Multiscale Modeling, Permutation Groups, Introduction to Machine Learning, Advanced High Performance Computing, Computational Methods II, Functional Analysis, Bayesian Numerical Analysis, Real Variables

2019 – 2020 Stochastic Processes, Advanced Partial Differential Equations, Computational Methods I, Introduction to High Performance Computing, Abstract Algebra, Advanced Linear Algebra, Methods of Applied Mathematics, Complex Variable

## TEACHING EXPERIENCE

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2024-Present Undergraduate Research Mentor | University of Wyoming  
Topic: Network science for human mobility patterns

2020-2023 Instructor of Record | University of Wyoming  
Courses: Differential Equations, Calculus I, Math Apps for Business, Trigonometry

2018-2023 Teaching Assistant | University of Wyoming  
Courses: Scientific Computing, Calculus II, College Algebra

2017-2023 Tutor | University of Wyoming  
Center for Assistance in Statistics and Mathematics (CASM)

## REFERENCES

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Dane Taylor, Ph.D., Associate Professor, Department of Mathematics and Statistics, University of Wyoming  
[dane.taylor@uwyo.edu](mailto:dane.taylor@uwyo.edu)

Victor Ginting, Ph.D., Professor, Department of Mathematics and Statistics, University of Wyoming  
[vginting@uwyo.edu](mailto:vginting@uwyo.edu)

Yingjie Hu, Ph.D., Director of Graduate Studies, Associate Professor, Department of Geography, University at Buffalo  
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