Michael McCabe

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Education

University of Colorado Boulder — Boulder, CO
M.S. in Applied Mathematics — 2019–2022
Ph.D. in Machine Learning and Scientific Computing, Advisor: Jed Brown — 2019–2024

- Dissertation: "Integrating Numerical and Physical Insights for Scientific Deep Learning"

Northwestern University — Evanston, IL
B.A. in Economics and International Studies — 2009–2013

- Capstone: "Analyzing the Impact of *Growth in a Time of Debt* on the Public Discourse on Austerity with Document Similarity Methods"

Work Experience

New York University, New York, NY, *Research Scientist* — 2/2025-Current

- Leads efforts on physical dynamics emulation as part of Polymathic AI collaboration both as researcher and mentor for junior researchers. These efforts are geared towards developing foundation models for physical dynamics by developing architectures and training approaches for learning to forecast in multiple spatiotemporal physical systems simultaneously.

Flatiron Institute, New York, NY, *Research Engineer* — 6/2023-2/2025

- Developed the tools enabling the first generation of foundation models for physical dynamics emulation.
- Led project delivering the largest, highest diversity of physical emulation data to date including more than 15 TB of data sourced from 15 different numerical codes across multiple domains of continuum dynamics.

University of Colorado Boulder, Boulder, CO, *Research Assistant* — 8/2019-6/2024

- Performs research at the intersection of Machine Learning and Scientific Computing. Current projects focus on integrating prior knowledge in the form of differential equations, conservation laws, and invariances into scientific deep learning methods to improve data efficiency and extrapolation capabilities.

Lawrence Berkeley National Lab, Berkeley, CA, *Graduate Researcher* — 5/2022-1/2023

- Examined the failure scenarios in deep learning based global weather models from the perspective of numerical methods and spectral analysis. Identified several key modes of failure and developed architectural improvements to address them resulting in significantly more stable forecasts enabling architectures originally designed for medium-range forecasts (10 days) to be used coherently for seasonal forecasts (3 months) or longer without significant computational cost increases.

Argonne National Lab, Lemont, IL, *Givens Associate* — 5/2020-7/2020

- Developed multi-device RL-based framework for learning to optimize in mixed-precision in JAX.

Ayasdi, Menlo Park, CA, *Data Scientist* — 11/2016-7/2019

- Designed and implemented Machine Learning and Topological Data Analysis pipelines for healthcare, government, and financial services clients using both Ayasdi software and the scientific Python ecosystem.
- Collaborated with product and engineering teams in research and development capacity to develop new platfom capabilities and prioritize candidate features for development.
- Developed an improved optimization framework for a non-convex unsupervised learning problem that exploited the structure of the problem to reduce run-time of a widely used software component to a quarter of the original execution time.

Eccella, New York, NY, *Senior Consultant* 2/2015-11/2016

- Architected large scale data integration projects involving 30+ heterogeneous systems and multiple business organizations from scoping through design, development, testing, and production support.
- Developed automation tools in Python and Java to integrate with enterprise ETL platforms in order to reduce development time on certain data flow mappings by approximately 80%.

Siemens Healthcare, Malvern, PA, *Consultant* 7/2013-2/2015

- Implemented custom C# solutions to tailor software to specific customer needs, particularly with regard to Health Information Exchange integration and cross-enterprise secure messaging.
- Completed more than twenty projects as a lead consultant within first year including managing product betas at multiple hospitals working closely with engineering team to identify potential defects and enable clients to hit Meaningful Use metrics with minimal disruption of existing workflows.

Publications

[1] R. A. Fear, M. Cranmer, P. Mukhopadhyay, and **M. McCabe**, "From vortices to spirals: Physics foundation models learn cross-domain concepts", in *Mechanistic Interpretability Workshop at NeurIPS 2025*, 2025.

[2] R. Koki, **M. McCabe**, D. Kedar, J. Myers-Dean, A. Wade, J. Q. Stewart, C. Kumler-Bonfanti, and J. Brown, "Smokeviz: A large-scale satellite dataset for wildfire smoke detection and segmentation", in *The Thirty-ninth Annual Conference on Neural Information Processing Systems Datasets and Benchmarks Track*, 2025.

[3] **M. McCabe**, P. Mukhopadhyay, T. Marwah, B. R.-S. Blancard, F. Rozet, C. Diaconu, L. Meyer, K. W. K. Wong, H. Sotoudeh, A. Bietti, I. Espejo, R. Fear, S. Golkar, T. Hehir, K. Hirashima, G. Krawezik, F. Lanusse, R. Morel, R. Ohana, L. Parker, M. Pettee, J. Shen, K. Cho, M. Cranmer, and S. Ho, *Walrus: A cross-domain foundation model for continuum dynamics*, 2025. arXiv: 2511.15684 [cs.LG].

[4] R. Morel, F. P. Ramunno, J. Shen, A. Bietti, K. Cho, M. Cranmer, S. Golkar, O. GUGNIN, G. Krawezik, T. Marwah, **M. McCabe**, L. T. Meyer, P. Mukhopadhyay, R. Ohana, L. H. Parker, H. Qu, F. Rozet, K. Leka, F. Lanusse, D. Fouhey, and S. Ho, "Predicting partially observable dynamical systems via diffusion models with a multiscale inference scheme", in *The Thirty-ninth Annual Conference on Neural Information Processing Systems*, 2025.

[5] L. H. Parker, F. Lanusse, J. Shen, O. Liu, T. Hehir, L. Sarra, L. T. Meyer, M. Bowles, S. Wagner-Carena, H. Qu, S. Golkar, A. Bietti, H. Bourfoune, P. Cornette, K. Hirashima, G. Krawezik, R. Ohana, N. Lourie, **M. McCabe**, R. Morel, P. Mukhopadhyay, M. Pettee, K. Cho, M. Cranmer, and S. Ho, "AION-1: Omnimodal foundation model for astronomical sciences", in *The Thirty-ninth Annual Conference on Neural Information Processing Systems*, 2025.

[6] F. Rozet, R. Ohana, **M. McCabe**, G. Louppe, F. Lanusse, and S. Ho, "Lost in latent space: An empirical study of latent diffusion models for physics emulation", in *The Thirty-ninth Annual Conference on Neural Information Processing Systems*, 2025.

[7] **M. McCabe**, B. R.-S. Blancard, L. Parker, R. Ohana, M. Cranmer, A. Bietti, M. Eickenberg, S. Golkar, G. Krawezik, F. Lanusse, M. Pettee, T. Tesileanu, K. Cho, and S. Ho, "Multiple physics pretraining for spatiotemporal surrogate models", in *The Thirty-eighth Annual Conference on Neural Information Processing Systems*, 2024.

[8] R. Ohana*, **M. McCabe***, L. Meyer, R. Morel, F. J. Agocs, M. Beneitez, B. B. Marsha Berger, D. B. F. Stuart B. Dalziel, D. Fortunato, J. A. Goldberg, K. Hirashima, Y.-F. Jiang, S. M. Rich Kerswell, J. M. Miller, P. Mukhopadhyay, S. S. Nixon, J. Shen, R. Watteaux, B. R.-S. Blancard, F. Rozet, L. H. Parker, M. Cranmer, and S. Ho, "The well: A large-scale collection of diverse physics simulations for machine learning", in *The Thirty-eight Conference on Neural Information Processing Systems Datasets and Benchmarks Track*, 2024.

[9] S. Golkar, M. Pettee, M. Eickenberg, A. Bietti, M. Cranmer, G. Krawezik, F. Lanusse, **M. McCabe**, R. Ohana, L. Parker, B. R.-S. Blancard, T. Tesileanu, K. Cho, and S. Ho, "Xval: A continuous number encoding for large language models", in *NeurIPS 2023 AI for Science Workshop*, 2023.

[10] F. Lanusse, L. Parker, S. Golkar, A. Bietti, M. Cranmer, M. Eickenberg, G. Krawezik, **M. McCabe**, R. Ohana, M. Pettee, B. R.-S. Blancard, T. Tesileanu, K. Cho, and S. Ho, "AstroCLIP: Cross-modal pre-training for astronomical foundation models", in *NeurIPS 2023 AI for Science Workshop*, 2023.

[11] **M. McCabe**, B. R.-S. Blancard, L. Parker, R. Ohana, M. Cranmer, A. Bietti, M. Eickenberg, S. Golkar, G. Krawezik, F. Lanusse, M. Pettee, T. Tesileanu, K. Cho, and S. Ho, "Multiple physics pretraining for physical surrogate models", in *NeurIPS 2023 AI for Science Workshop*, Best Paper Award, 2023, https://github.com/PolymathicAI/multiple_physics_pretraining.

[12] **M. McCabe**, P. Harrington, S. Subramanian, and J. Brown, "Towards stability of autoregressive neural operators", *Transactions on Machine Learning Research*, 2023, ISSN: 2835-8856, https://github.com/mikemccabe210/stabilizing_neural_operators.

[13] R. Koki, A. Sheehan, E. Bradley, **M. McCabe**, and J. Brown, "Improving deep learning seismic arrival pickers using wavelet transforms", in *Fall Meeting 2022*, AGU, 2022.

[14] R. Koki, J. Stewart, C. Kumler, and **M. McCabe**, "A deep learning approach for detection, semantic segmentation and density classification of smoke in satellite imagery", in *Fall Meeting 2022*, AGU, 2022.

[15] **M. McCabe** and J. Brown, "Learning to assimilate in chaotic dynamical systems", in *Thirty-Fifth Conference on Neural Information Processing Systems*, 2021, https://github.com/mikemccabe210/amortizedassimilation.

[16] **M. McCabe** and J. Brown, "Using Differentiable Physics for Self-Supervised Assimilation of Chaotic Dynamical Systems", presented at the 2020 Workshop on Differentiable Vision, Graphics, and Physics in Machine Learning at NeurIPS, 2020.

[17] **M. McCabe**, *Mapper Comparison with Wasserstein Metrics*, 2018. arXiv: 1812.06232 [cs.CG], https://github.com/mikemccabe210/mapper_comparison.

Presentations

- **Building foundation models for scientific data** at Brookhaven National Lab — October 2024
  Brookhaven AI/ML Seminar
- **Multiple physics pretraining for physical surrogate models** at Ansys, Inc — September 2024
  Ansys SIG-ML Seminar
- **Pre-training methods for foundation models in physics: AstroCLIP and MPP** — January 2024
  Berkeley Lab – CS/NERSC Seminar
- **Challenges and Opportunities in Learning Physical Dynamics** — October 2023
  Georgia Tech AI/Physics Workshop
- **Numerical Challenges in Large-scale Neural Operators** — July 2023
  NCAR MILES Group Meeting
- **Where Spectral Neural Operators Fail: Lessons from Data-driven Weather Forecasting** — May 2023
  NOAA AI Working Group

- **Data Science in the Healthcare Industry** at Colorado State University — February 2020
  CSU Data Science Seminar
- **Graph Neural Networks in the Physical Sciences** at University of Colorado Boulder — November 2019
  CU Optimization and ML Seminar
- **Fine-grained Segmentation for Population Risk** at HIMSS 2018 — March 2018
  HIMSS Solutions Lab

Technical Skills

Languages:	Python, SQL, C++, Java, Scala, Matlab
Frameworks:	PyTorch, JAX, TensorFlow, SciPy Ecosystem, Spark
Databases:	Oracle, MySQL, MS SQL Server, SQLite, Postgres, HDFS

Scholarships and Awards

- Best Paper Award - NeurIPS 2023 AI for Science Workshop — 2023
- CU Boulder CS Early Career Professional Development Fellowship — 2019
- Ayasdi "Flare" Performance Award — 2018
- Eccella "Eccelarator" Performance Award — 2015
- Siemens "You Answered" Recognition — 2014
- Nominated for Guetzkow Prize for Outstanding Senior Research Paper in International Studies — 2013
- Design Award for Engineering Design and Communication — 2009
- Siemens Foundation Merit Scholarship — 2009–2013

Service

- Reviewer at TMLR — 2024-2025
- Reviewer for AMS Journal for Artificial Intelligence for the Earth Systems — 2023-2025
- Co-organizer "AI-driven discovery in physics and astrophysics" Workshop 2023 — 2023
- Reviewer at NeurIPS — 2021, 2023, 2024
- Reviewer at ICML — 2021, 2022, 2023
- CU Boulder Numerical Computing Reading Group Coordinator — 2020–2022
- CU Boulder CS Department Peer Mentor — 2020–2021
- CU Boulder CS Department Application Feedback Mentor — 2020, 2021
- Volunteer at NeurIPS — 2020
- Volunteer at ICML — 2020
- Volunteer at ICLR — 2020