

# Robin John Armstrong

## CONTACT INFORMATION

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## EDUCATION

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### Cornell University

*PhD, Applied Mathematics. Advisor: Anil Damle, Dept. of Computer Science.*

August 2021 – Present

*Ithaca, NY*

### Cornell University

*MS, Applied Mathematics. Advisor: Anil Damle, Dept. of Computer Science.*

August 2021 – May 2024

*Ithaca, NY*

### University of Massachusetts Amherst

*BS, Mathematics (Summa Cum Laude).*

September 2017 – May 2021

*Amherst, MA*

## RESEARCH INTERESTS

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Numerical linear algebra, data assimilation, covariance estimation, computational methods for geoscience.

## PUBLICATIONS

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- Robin Armstrong and Ian Grooms, “Data Assimilation With An Integral-Form Ensemble Square-Root Filter,” *arXiv preprints*, arXiv:2503.00253.  
Submitted to the *Journal of Computational Physics*.
- Robin Armstrong and Anil Damle, “Collect, Commit, Expand: Efficient CPQR-Based Column Selection for Extremely Wide Matrices,” *arXiv preprints*, arXiv:2501.18035, 2025.  
Submitted to the *SIAM Journal on Scientific Computing*.
- Robin Armstrong, Alex Buzali, and Anil Damle, “Structure-Aware Analyses and Algorithms for Interpolative Decompositions,” *arXiv preprints*, arXiv:2310.09452, 2023.  
To appear in the *SIAM Journal on Scientific Computing*.

## PRESENTATIONS

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- International Linear Algebra Society, June 2025, Kaohsiung, Taiwan (Upcoming).  
“Identifying and Estimating Dynamical Covariance Matrices with Hierarchical Rank Structure.”
- SIAM Dynamical Systems Conference, May 2025, Denver, CO (Upcoming).  
“A Quadrature Technique for Efficient Kalman Filtering with Model-Space Covariance Localization.”
- International Symposium on Data Assimilation, March 2024, Online.  
“An Integral-Form Ensemble Square-Root Filter with Efficient and Precise Model-Space Localization.”
- SIAM Computational Science and Engineering Conference, March 2025, Fort Worth, TX.  
“A Quadrature Technique for Efficient Kalman Filtering with Model-Space Covariance Localization.”
- American Meteorological Society Annual Meeting, January 2025, New Orleans, LA.  
“A Quadrature Technique for Ensemble Kalman Filtering with Efficient and Precise Covariance Localization.”
- Mid-Atlantic Numerical Analysis Day, November 2024, Temple University, Philadelphia, PA.  
“Collect, Commit, Expand: A Strategy for Faster CPQR-Based Column Selection on Short, Wide Matrices.”
- SIAM NNP Section Conference, November 2024, Henrietta, NY.  
“Collect, Commit, Expand: A Strategy for Faster CPQR-Based Column Selection on Short, Wide Matrices.”
- Student Colloquium in Applied Mathematics, October 2024, Cornell University, Ithaca, NY.  
“Lessons From a Difficult Eigenvalue Problem.”
- JCSDA Science Cookies Series, July 2024, Boulder, CO.  
“A Quadrature Technique for Model-Space Localization.”

- Data Assimilation Research Centre Seminar Series, May 2024, University of Reading, Reading, UK (Remote).  
“A Quadrature Method for Ensemble Kalman Filtering with Model Space Localization.”
- AGU Ocean Sciences Meeting, February 2024, New Orleans, LA.  
“MARBL-DART: An Ensemble System for Biogeochemical Data Assimilation and Parameter Estimation.”
- Student Applied Dynamics Seminar, February 2024, Cornell University, Ithaca, NY.  
“Kalman Filtering for Weather Prediction.”
- Scientific Computing and Numerics Seminar, November 2023, Cornell University, Ithaca, NY.  
“The Randomized Golub-Klema-Stewart Algorithm.”
- Teaching Seminar, October 2022, Cornell University, Ithaca, NY.  
“The Challenges of Mathematical Language.”
- Data Science for Democracy Workshop, June 2022, Johns Hopkins University, Baltimore, MD.  
“Predicting COVID-19 Vaccine Uptake in the United States” (joint talk with Princess Allotey, Erik Bergland, Eddie Mitchell, and Nikki Wang).
- SUMS Math and Illusion Symposium, March 2021, Brown University, Providence, RI (Remote).  
“Uncertainty Quantification with  $\alpha$ -Divergence.”

## RESEARCH

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### Graduate Student Researcher

January 2022 - Present

Cornell University, Center for Applied Mathematics

Ithaca, NY

- Rank-structured covariance matrix estimation: developing numerical methods for high-dimensional covariance matrix estimation from sparse samples by leveraging ranks structure. Additionally, developing theory to determine when covariance matrices associated with dynamical systems possess rank structure. Joint work with Anil Damle (Cornell Univ. Dept. of Computer Science) and Sam Otto (Cornell Univ. Dept. of Mechanical and Aerospace Engineering). Results to be presented at the 26th Conference of the International Linear Algebra Society
- Data assimilation: developing a novel technique for Kalman filtering with model-space covariance localization using techniques from Krylov subspace iteration and numerical quadrature. Applications in numerical weather prediction. Joint work with Ian Grooms (Univ. of Colorado Dept. of Applied Mathematics) and Chris Snyder (NSF NCAR Mesoscale and Microscale Meteorology Laboratory). Presented results at the American Meteorological Society 2025 annual meeting.
- Fast matrix factorizations: designed an accelerated column-pivoted QR factorization algorithm that exploits problem-specific column norm distributions. Applications in electronic structure theory, spectral clustering, and Gaussian mixture models. Joint work with Anil Damle (Cornell Univ. Dept. of Computer Science). Results submitted to SIAM Journal on Scientific Computing, preprint available as arXiv:2501.18035.
- Randomized numerical linear algebra: conducted a theoretical error analysis and experimental assessment of RGKS, a novel algorithm for column subset selection using the randomized singular value decomposition. Joint work with Anil Damle (Cornell Univ. Dept. of Computer Science) and Alex Buzali (Harvard Univ. School of Eng. and Applied Sciences). Results to appear in SIAM Journal on Scientific Computing, preprint available as arXiv:2310.09452.

### Visitor, National Center for Atmospheric Research

May 2024 - July 2024

MMM Visiting Scholar Program

Boulder, CO

- Developed operational data assimilation code for the Joint Effort in Data Assimilation Integration (JEDI). Implemented a quadrature-based ensemble Kalman filter with model-space covariance localization.
- Results to be presented at the American Meteorological Society 2025 annual meeting.
- Supervisor: Chris Snyder (NSF NCAR Mesoscale and Microscale Meteorology Laboratory).

### Visitor, National Center for Atmospheric Research

August 2023 - February 2024

CISL and CGD Visiting Scholar Programs

Remote

- Finished development of MARBL-DART that was initiated during the summer 2023 internship.
- Presented work at the AGU Ocean Sciences 2024 meeting.
- Supervisors: Moha Gharamti (NSF NCAR Data Assimilation Research Section) and Dan Amrhein (NCAR Climate and Global Dynamics).

### Intern, National Center for Atmospheric Research

May 2023 - August 2023

Summer Internships in Parallel Computational Science (SIParCS)

Boulder, CO

- Began development of MARBL-DART, an ensemble data assimilation system for optimizing the parameters of the Marine Biogeochemistry Library (MARBL) using the Data Assimilation Research Testbed (DART).
- Participated in weekly professional development sessions covering topics in science communication, proposal writing, and diversity, equity, and inclusion (DEI).
- Supervisors: Moha Gharamti (Data Assimilation Research Section) and Dan Amrhein (Climate and Global Dynamics).

## Undergraduate Honors Thesis

January 2020 - December 2020

*University of Massachusetts Amherst, Dept. of Mathematics and Statistics*

*Amherst, MA*

- Examined uncertainty quantification inequalities derived from variational representations of divergences between probability measures. Contributed a generalization of previously existing results on Kullback-Leibler divergences to a wider class of  $\alpha$ -divergences, thereby extending the applicability of these results to heavy-tailed probability distributions.
- Supervisors: Luc Rey-Bellet, Markos Katsoulakis, and Jeremiah Birrell (Dept. of Mathematics and Statistics).

## TEACHING

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### Teaching Assistant

August 2020 - May 2023

*Cornell University and University of Massachusetts Amherst*

*Ithaca, NY and Remote*

- At Cornell University: MATH 2940, Linear Algebra for Engineers (Fall 2021, Fall 2022), MATH 1106, Modeling with Calculus for the Life Sciences (Spring 2022), MATH 4130, Honors Introduction to Analysis I (Spring 2023). At UMass Amherst: MATH 300, Fundamental Concepts of Mathematics (Fall 2020).

## SUMMER SCHOOLS AND WORKSHOPS

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### Gene Golub SIAM Summer School

July - August 2024

*Escuela Politécnica Nacional*

*Qito, Ecuador*

- Two-week summer school focused on randomized and iterative methods for large-scale inverse problems.
- Daily lectures by field experts on theory and algorithms for inverse problems and numerical linear algebra.

### Data Science for Democracy Workshop

June 2022

*Johns Hopkins University, SNF Agora Institute*

*Baltimore, MD*

- Participated in a two-week workshop applying data science to public health, democracy, and civic engagement.
- Worked with county-level geographic datasets to understand demographic factors influencing vaccine hesitancy.

## AWARDS AND HONORS

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- UMass Amherst CHC Honors Research Grant.
- Phi Beta Kappa and Phi Kappa Phi at UMass Amherst.