

## Di Qi

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## Research Interests

- Uncertainty quantification and model reduction strategies
- Data-driven models and machine learning for complex systems
- Theoretical and numerical statistical analysis for turbulent flows
- Filtering, multiscale data analysis, and information theory
- Turbulent diffusion of passive tracers in geophysical flows
- Statistical control methods for complex turbulent systems

## Academic Position

- 2021- Assistant Professor  
DEPARTMENT OF MATHEMATICS, PURDUE UNIVERSITY
- 2017-2021 Postdoctoral Associate  
COURANT INSTITUTE OF MATHEMATICAL SCIENCES, NEW YORK UNIVERSITY  
*Mentor: Andrew J. Majda*

## Education

- 2017 PH.D. in Mathematics/Atmosphere and Ocean Science (with distinction)  
COURANT INSTITUTE OF MATHEMATICAL SCIENCES, NEW YORK UNIVERSITY, NY, USA  
*Advisor: Andrew J. Majda*
- 2012 B.S. in Mathematics (major) and Physics (minor)  
SHANGHAI JIAO TONG UNIVERSITY, SHANGHAI, CHINA  
*Advisor: Shi Jin*

## Thesis

D. Qi, *Strategies for Reduced-Order Models in Uncertainty Quantification of Complex Turbulent Dynamical Systems*. PHD Dissertation, New York University. May 2017.

## Research Publications & Submissions

JOURNAL ARTICLES (\* INDICATES THE CORRESPONDING AUTHOR)

### Submitted & In preparation:

Qi, D.\* and Liu, J.-G. (2023). Oscillating solutions at the continuum limit of the Lorenz '96 systems. *in preparation*.

Mohamad, M.A. and Qi, D. (2023). Modeling extreme events and intermittency in turbulent diffusion models with a mean gradient. *in preparation*.

Qi, D.\* and Liu, J.-G. (2023). High-order moment closure models with random batch method for efficient computation of multiscale turbulent systems. *submitted*.

Covington, J., Qi, D., and Chen, N (2023). Effective statistical control strategies in complex turbulent systems. *submitted*.

Qi, D.\* (2023). Unambiguous models and machine learning strategies for anomalous extreme events in turbulent dynamical systems. *submitted*.

Qi, D.\* and Xie, J.-H. (2023). Weakly nonlinear analysis for zonal jet development and transition to turbulence in two-field Hasegawa-Wakatani models. *submitted*.

Qi, D.\* and Chen, N. (2022). A physics-informed data-driven algorithm for ensemble forecast of complex turbulent systems. *submitted*.

### Published:

Cao, N. and Qi, D. (2023). Nearly-Integrable Flows and Chaotic Tangles in the Dimits Shift Regime of Plasma Edge Turbulence. *Physics of Plasmas, Special Collection on Turbulence in Plasmas and Fluids*, accepted.

Qi, D.\* and Harlim, J. (2023). A Data-Driven Statistical-Stochastic Surrogate Modeling Strategy for Complex Nonlinear Non-stationary Dynamics. *Journal of Computational Physics*, 485, 112085.

Qi, D.\* and Liu, J.-G. (2022). A Random Batch Method for Efficient Ensemble Forecasts of Multi-scale Turbulent Systems. *Chaos: An Interdisciplinary Journal of Nonlinear Science* 33(2), 023113.

Qi, D.\* and Harlim, J. (2022). Machine Learning-Based Statistical Closure Models for Turbulent Dynamical Systems. *Philosophical Transactions of the Royal Society A* 380. no. 2229, 20210205

Qi, D.\* and Vanden-Eijnden, E. (2022). Anomalous Statistics and Large Deviations of Turbulent Water Waves past a Step. *AIP Advances* 12(2), 025016.

Qi, D.\*, Majda, A.J., and Cerfon, A.J. (2020). Dimits shift, avalanche-like bursts, and Solitary propagating structures in the two-field Flux-Balanced Hasegawa-Wakatani model for plasma edge turbulence (Featured article). *Physics of Plasmas*, 27(10), p.102304.

Qi, D.\* and Majda, A.J. (2020). Nonlinear interaction and turbulence transition in the limiting regimes of plasma edge turbulence. *Research in the Mathematical Sciences*, 7(3), 1-32.

Moore, M.N.J., Bolles, C.T., Majda, A. J., and Qi, D. (2020). Anomalous waves triggered by abrupt depth changes: Laboratory experiments and truncated KdV statistical mechanics. *Journal of Nonlinear Science*.

Qi, D.\* and Majda, A.J. (2020). Flux-balanced two-field plasma edge turbulence in a channel geometry. *Physics of Plasmas*, 27(3), p.032304.

Qi, D.\* and Majda, A.J. (2020). Using machine learning to predict extreme events in complex systems. *Proceedings of the National Academy of Sciences*, 117(1), 52-59.

Majda, A.J., and Qi, D.\* (2019). Statistical phase transitions and extreme events in shallow water waves with an abrupt depth change. *Journal of Statistical Physics*, pp. 1-24.

Majda, A.J., and Qi, D.\* (2019). Linear and nonlinear statistical response theories with prototype applications to sensitivity analysis and statistical control of complex turbulent dynamical systems. *CHAOS: An Interdisciplinary Journal of Nonlinear Science*, 29(10), p. 103131.

Qi, D., Majda, A.J., and Cerfon, A.J. (2019). A flux-balanced model for collisional plasma edge turbulence: numerical simulations with different aspect ratios. *Physics of Plasmas*, 26(8), p.082303.

Qi, D.\*, and Majda, A.J. (2019). Zonal jet creation from secondary instability of drift waves for plasma edge turbulence. *Chinese Annals of Mathematics, Series B*, 40(6), pp. 869-890.

Qi, D.\*, and Majda, A. J. (2019). Linking the two-field dynamics of plasma edge turbulence with the one-field balanced model through systematic unstable forcing at low resistivity. *Physics of Plasmas*, 26(5), p. 052108.

Qi, D.\*, and Majda, A.J. (2019). Transient metastability and selective decay for the coherent zonal structures in plasma edge turbulence. *Journal of Nonlinear Science*, pp. 1-43.

Majda, A.J., and Qi, D.\* (2019). Using statistical functionals for effective control of inhomogeneous complex turbulent dynamical systems. *Physica D: Nonlinear Phenomena*, 392, pp. 34-56.

Majda, A.J., Moore, M.N.J., and Qi, D.\* (2019). A statistical dynamical model to predict extreme events and anomalous features in shallow water waves with abrupt depth change. *Proceedings of the National Academy of Sciences*, 116(10), pp. 3982-3987.

Majda, A.J., Qi, D., and Cerfon, A.J. (2018). A flux-balanced fluid model for collisional plasma edge turbulence: model derivation and basic physical features. *Physics of Plasmas*, 25(10), p.102307.

Qi, D.\*, and Majda, A.J. (2018). Rigorous statistical bounds in uncertainty quantification for one-layer turbulent geophysical flows. *Journal of Nonlinear Science*, 28(5), pp. 1709-1761.

Qi, D.\*, and Majda, A.J. (2018). Predicting extreme events for passive scalar turbulence in two-layer baroclinic flows through reduced-order stochastic models. *Communications in Mathematical Sciences*, 16(1), pp.17-51.

Majda, A.J., and Qi, D.\* (2018). Strategies for reduced-order models for predicting the statistical responses and uncertainty quantification in complex turbulent dynamical systems. *SIAM Review*,

60(3), 491–549.

Majda, A.J., and Qi, D.\* (2017). Effective control of complex turbulent dynamical systems through statistical functionals. *Proceedings of the National Academy of Sciences*, 114(22), pp. 5571–5576.

Qi, D.\*, and Majda, A.J. (2017). Low-dimensional reduced-order models for statistical response and uncertainty quantification: barotropic turbulence with topography. *Physica D: Nonlinear Phenomena*, 343, pp. 7–27.

Lee, Y., Majda, A.J., and Qi, D. (2017). Preventing catastrophic filter divergence using adaptive additive inflation for baroclinic turbulence. *Monthly Weather Review*, 145(2), pp. 669–682.

Qi, D.\*, and Majda, A.J. (2016). Low-dimensional reduced-order models for statistical response and uncertainty quantification: two-layer baroclinic turbulence. *Journal of the Atmospheric Sciences*, 73(12), pp. 4609–4639.

Lee, Y., Majda, A.J., and Qi, D. (2016). Stochastic superparameterization and multiscale filtering of turbulent tracers. *Multiscale Modeling & Simulation*, 15(1), pp. 215–234.

Majda, A.J., and Qi, D.\* (2016). Improving prediction skill of imperfect turbulent models through statistical response and information theory. *Journal of Nonlinear Science*, 26(1), pp. 233–285.

Qi, D.\*, and Majda, A.J. (2015). Predicting fat-tailed intermittent probability distributions in passive scalar turbulence with imperfect models through empirical information theory. *Communications in Mathematical Sciences*, 14(6), pp. 1687–1722.

Qi, D.\*, and Majda, A.J. (2015). Blended particle methods with adaptive subspaces for filtering turbulent dynamical systems. *Physica D: Nonlinear Phenomena*, 298, pp. 21–41.

Majda, A.J., Qi, D., and Sapsis, T.P. (2014) Blended particle filters for large-dimensional chaotic dynamical systems. *Proceedings of the National Academy of Sciences*, 111(21), pp. 7511–7516.

## Teaching Experiences

- Fall 2023     *Instructor*  
MA 573. Numerical Solutions of ODEs and dynamical systems  
Department of Mathematics, Purdue University
- Spring 2023     *Instructor*  
MA 510. Vector Calculus  
Department of Mathematics, Purdue University
- Fall 2022     *Instructor*  
MA 35301. Linear Algebra II  
Department of Mathematics, Purdue University
- Spring 2022     *Instructor*  
MA 303: Differential Equations and PDE

Department of Mathematics, Purdue University

- Fall 2019 *Instructor*  
Advanced Topics in Applied Math: Uncertainty Quantification In Turbulent Dynamical Systems  
Courant Institute, New York University
- Fall 2018 *Instructor*  
Advanced Topics in Applied Math: Filtering Turbulent Signals in Complex Systems  
Courant Institute, New York University
- Fall 2016 *Instructor*  
Advanced Topics in Applied Math: Turbulent Dynamical Systems  
Courant Institute, New York University
- Fall 2015 *Co-Instructor*  
Advanced Topics in Applied Math: Quantifying Uncertainty in Complex Turbulent Systems  
Courant Institute, New York University
- Fall 2014 *Co-Instructor*  
Advanced Topics in Applied Math: Filtering Turbulent Signals in Complex Systems  
Courant Institute, New York University

## Students

UNDERGRADUATE STUDENTS:

Yufan Zhou (2023 - current)  
Vlada Volyanskaya (2023 - current)  
Shubham Shrivastava (2023 - current)

## Professional Service

CONFERENCE & WORKSHOPS ORGANIZED:

- 7/2024 *Co-organizer*, World Congress on Computational Mechanics  
Mini-symposium: Hybrid Techniques in Data-Driven Modeling, Forecasting, and Uncertainty Quantification of Transport-Dominated Complex Multiscale Phenomena
- 2/2024 *Co-organizer*, 2024 SIAM conference on Uncertainty Quantification  
Mini-symposium: Statistical and Data-Assisted Modeling Approaches for Forecasting and Uncertainty Quantification of Complex Multiscale Systems in Real-World Applications
- 12/2023 *Co-organizer*, AGU Fall meeting  
Efficient Data-Driven Methods for Multiscale Stochastic Modeling and Uncertainty Quantification
- 8/2023 *Co-organizer*, ICIAM-Tokyo  
Mini-symposium: Combining Machine Learning and Stochastic Methods for Modeling and Forecasting Complex Systems
- 5/2023

*Co-organizer*, 2023 SIAM conference on Dynamical Systems  
Mini-symposium: Reduced Order Modeling and Forecasting in Geophysical Flows and Complex Dynamical Systems

7/2022 *Co-organizer*, 2022 SIAM Annual Meeting  
Mini-symposium: Data-driven Models and Machine Learning Strategies for Complex Dynamical Systems

3/2022 *Co-organizer*, AMS Spring Central Sectional Meeting  
Special Session on Modeling and Forecasting Complex Turbulent Systems

12/2021 *Co-organizer*, AGU Fall Meeting  
Advances in Computational Analysis in Geophysical Processes: Applied Mathematics Perspectives on Prediction, Uncertainty Quantification, and State Estimation

7/2019 *Co-organizer*, ICIAM-Valencia  
Mini-symposium: State estimation, prediction, and uncertainty quantification in geophysics

EDITORIAL WORK:

Guest Editor in Entropy Special Issue on *An Information-Theoretical Perspective on Complex Dynamical Systems*

JOURNAL REFEREE:

Physica D • SIAM Journal on Scientific Computing • Journal of Computational Physics • Multiscale Modeling and Simulation • Research in the Mathematical Sciences • Journal of Plasma Physics • Philosophical Transactions A • Foundations of Data Science • Nonlinear Dynamics • Journal of Engineering Mathematics • The European Physical Journal ST • Entropy • Journal of the Atmospheric Sciences • International Journal for Numerical Methods in Engineering • IEEE Access • Mathematics • Stats • Applied Sciences

REVIEWER FOR MATHEMATICAL REVIEWS (AMS)

SUPERVISING STUDENT RESEARCH:

Ph.D. Thesis Defense Committee of Senwei Liang, Chen Zhang  
Ph.D. Committee Member of Ka-Ying Ho, Xiangyu Liu, Yikai Liu, Zhaoyu Liu

Outstanding Student Presentation Award (OSPA) judge and liaison, American Geophysical Union Fall Meeting, 2021.

## Conferences & Workshops

5/2023 *Statistical reduced-order models and data-driven closure strategies for turbulent systems*, SIAM Conference on Dynamical Systems (DS23), Portland, OR, May 2023.

3/2023 *Reduced-order models and data-driven closure strategies for turbulent systems*, Mathematical Approaches of Atmospheric Constituents Data Assimilation and Inverse Modeling, BIRS, Canada, March 2023

- 12/2022 *Data-driven statistical-stochastic model for effective ensemble forecast of complex systems*, AGU Fall Meeting, Chicago, IL, December 2022.
- 11/2022 *Statistical reduced-order models and data-driven closure strategies for turbulent systems*, Machine Learning for Climate and Weather Applications, IMSI Workshop, Chicago, IL, November 2022.
- 7/2022 *Statistical reduced-order models and closure strategies for turbulent systems*, SIAM Conference on Mathematics of Planet Earth (MPE22), Pittsburgh, PA, July 2022.
- 4/2022 *Reduced-order models and machine learning-based closure for turbulent systems*, SIAM Conference on Uncertainty Quantification (UQ22), Atlanta, GA, April 2022.
- 3/2022 *Predicting extreme events and anomalous statistics of turbulent water waves*, AMS Spring Central Meeting, West Lafayette, IN, March 2022.
- 12/2021 *Statistical reduced-order models and closure strategies for turbulent geophysical flows*, AGU Fall Meeting, New Orleans, LA, December 2021.
- 7/2021 *Suppression of turbulent transport by zonal flows in magnetized plasmas (virtual)*, SIAM Annual Meeting (AN21), July 2021.
- 1/2021 CIB-EPFL workshop: Linear Response: Rigorous Results and Applications (virtual), January 2021.
- 12/2019 *Statistical reduced models for uncertainty quantification of turbulent geophysical flows*, AGU Fall Meeting, San Francisco, CA, December 2019.
- 10/2019 *Transition from drift wave turbulence to coherent zonal structures in plasma edge turbulence*, 61st Annual Meeting of the APS Division of Plasma Physics (DPP), Fort Lauderdale, Florida, October 2019.
- 7/2019 *Statistical reduced models and rigorous analysis for uncertainty quantification of turbulent geophysical flows*, Scientific Grand Challenges and New Perspectives in Applied Mathematics: Ocean, Atmosphere and Climate Sciences, University of Victoria, Canada, July 2019.
- 7/2019 *Reduced-order statistical models for predicting statistical responses and extreme events in geophysics*, International Congress on Industrial and Applied Mathematics, Valencia, Spain, July 2019.
- 5/2019 *Reduced-order statistical models for predicting mean responses and extreme events in barotropic turbulence*, SIAM Conference on Applications of Dynamical Systems (DS19), Snowbird, Utah, May 2019.
- 5/2019 *Rigorous statistical bounds in uncertainty quantification for turbulent geophysical flows*, Workshop on Data Assimilation: Methodology and Applications, Centre de Recherches Mathématiques (CRM), Université de Montréal, Canada, May 2019.
- 3/2019 *Statistical reduced models and rigorous analysis for uncertainty quantification of turbulent geophysical flows*, A Conference to Celebrate the 70th Birthday of Andrew Majda, Courant Institute, New York, NY, March 2019.
- 12/2018

- Statistical bounds for turbulent geophysical flows in uncertainty quantification*, Nonlinear PDEs from Oceanic and Atmospheric Dynamics and Related Topics, Guangzhou, China, December 2018.
- 12/2018 *Rigorous statistical bounds in uncertainty quantification for turbulent geophysical flows*, Applied Mathematics and Statistics Youth Forum, Peking University, Beijing, China, December 2018.
- 7/2018 *Statistical Response in Uncertainty Quantification through Reduced-order Models*, SIAM Annual Meeting, Portland, OR, July 2018.
- 4/2018 *Predicting Statistical Responses and Extreme Events in Turbulent Systems through Low-Dimensional Reduced-Order Models*, SIAM Conference on Uncertainty Quantification, Garden Grove, CA, April 2018.
- 12/2017 *Low-Dimensional Reduced-Order Models for Statistical Response and Uncertainty Quantification in Turbulent Systems*, AGU Fall Meeting, New Orleans, LA, December 2017.
- 5/2017 *Predicting Extreme Events for Passive Scalar Turbulence through Reduced-Order Models*, SIAM Conference on Applications of Dynamical Systems (DS17), Snowbird, Utah, May 2017.
- 12/2016 *Statistical Response in Two-layer Baroclinic Turbulence for Uncertainty Quantification* (Poster), AGU Fall Meeting, San Francisco, CA, December 2016.
- 10/2016 *Low-Dimensional Reduced-Order Models for Statistical Response and Uncertainty Quantification*, MURI 2016 workshop, New York University, October 2016.
- 5/2016 *Preventing Catastrophic Filter Divergence Using Adaptive Additive Inflation for Baroclinic Turbulence* (Poster), The seventh EnKF Data Assimilation Workshop, State College, PA, May 2016.
- 4/2016 *Improving Prediction Skill of Imperfect Turbulent Models through Empirical Information Theory*, SIAM Conference on Uncertainty Quantification, EPFL, Lausanne, Switzerland, April 2016.
- 8/2015 *Blended Particle Filters for Large Dimensional Chaotic Dynamical Systems*, Mathematics of Geophysical Flows and Turbulence, Fudan University, Shanghai, August 2015.
- 8/2015 *Improving prediction skill of imperfect turbulent models through statistical response and information theory*, Mathematics of Geophysical Flows and Turbulence, Fudan University, Shanghai, August 2015.
- 8/2015 *Developing Imperfect Turbulent Models through Statistical Response and Information Theory*, The eighth International Congress on Industrial and Applied Mathematics, Beijing, China, August 2015.
- 6/2014 *Filtering Turbulent Signals in Fourier Space: Fourier Domain Kalman Filter*, Short Course in High Dimensional Filtering, University of Warwick, UK, June 2014.
- 3/2014 *Blended Particle Filters for Large Dimensional Chaotic Dynamical Systems*, SIAM Conference on Uncertainty Quantification, Savannah, Georgia, March 2014.
- 1/2014 *Blended Particle Filters for Large Dimensional Chaotic Dynamical Systems*, MURI 2014 workshop, New York University, NY, January 2014.



## Seminar Talks

- 7/2023 *Reduced-order closure models and ensemble methods for complex multiscale systems*, AI + Math Colloquia, Shanghai Jiao Tong University, July 2023.
- 11/2022 *Reduced-order models and data-driven closure strategies for turbulent systems*, Applied Math & Analysis Seminar, Duke University, November 2022.
- 3/2022 *Statistical reduced-order models and machine learning-based closure strategies for turbulent dynamical systems*, Numerical Analysis Seminar, North Carolina State University, March 2022.
- 3/2022 *Predicting extreme events and anomalous features in complex turbulent systems*, Bridge to Research Seminar, Purdue University, March 2022.
- 11/2021 *Research conservation: stochastic models for turbulence*, PCCRC, Purdue University, November 2021.
- 11/2021 *Statistical reduced-order models and closure strategies for turbulent geophysical flows*, Storm Snacks, EAPS, Purdue University, November 2021.
- 10/2021 *Statistical reduced-order models and closure strategies for turbulent dynamical systems*, Mathematics Colloquium, United States Naval Academy, October 2021.
- 9/2021 *Statistical reduced models and rigorous analysis for uncertainty quantification in turbulent dynamical systems*, CCAM Seminar, Purdue University, September 2021.
- 4/2021 *Creation of coherent zonal structures from selective decay and secondary instability (virtual)*, Applied Analysis Group Seminar, University of Bremen, April 2021.
- 3/2021 *Predicting extreme events and anomalous features using a statistical dynamical model and machine learning (virtual)*, Institute of Natural Sciences, Shanghai Jiao Tong University, March 2021.
- 2/2020 *Predicting extreme events and anomalous features using a statistical dynamical model and machine learning*, Special Data Science Colloquium, Purdue University.
- 1/2020 *Predicting extreme events and anomalous features using a statistical dynamical model and machine learning*, Computational and Applied Mathematics Colloquium, Penn State.
- 1/2020 *Statistical reduced models and rigorous analysis for uncertainty quantification of turbulent dynamical systems*, Mathematics Colloquium, University of Illinois at Urbana-Champaign.
- 12/2019 *Statistical reduced models and rigorous analysis for uncertainty quantification of turbulent dynamical systems*, Mathematics Colloquium, University at Buffalo, SUNY.
- 4/2019 *Statistical reduced models and rigorous analysis for uncertainty quantification of turbulent geophysical flows*, Mathematical Sciences Colloquium, Rensselaer Polytechnic Institute.
- 4/2019 *Creation of coherent zonal structures from selective decay and secondary instability*, Atmosphere Ocean Science Colloquium, Courant Institute.
- 10/2018

*Rigorous statistical bounds in uncertainty quantification for turbulent geophysical flows*, Graduate Student / Postdoc Seminar, Courant Institute.

- 5/2017 *Predicting Extreme Events for Passive Scalar Turbulence through Reduced-Order Models*, CAOS Student Seminar, Courant Institute
- 2/2016 *Low-Dimensional Reduced-Order Models for Statistical Response and UQ*, CAOS Student Seminar, Courant Institute.
- 2/2015 *Improving Prediction Skill of Imperfect Turbulent Models through Statistical Response and Information Theory*, CAOS Student Seminar, Courant Institute.
- 2/2014 *Blended Particle Filter for Large Dimensional Chaotic Dynamical Systems*, CAOS Student Seminar, Courant Institute.
- 10/2013 *Statistical Dynamics For Uncertainty Quantification Of Quadratic System*, CAOS Monday Lunch Seminar.
- 8/2013 *Filtering Linear Systems and Observability*, Summer Discussion Group, Courant Institute.
- 4/2013 *Blended reduced subspace algorithms for uncertainty quantification*, CAOS Student Seminar, Courant Institute.

## Grants & Research Support

*PCCRC Seed Grant*, Purdue University, 2021 – 2023.

## Press Release

- 11/2018 Strategies for Predicting Statistical Responses in Complex Turbulent Systems  
*CAOS News & Research*  
<https://caos.cims.nyu.edu/dynamic/news/10/>

## Honors & Awards

- 2018 New World Mathematics Awards for Doctor Thesis
- 2017 Kurt O. Friedrichs prize for an outstanding dissertation in mathematics, New York University
- 2012–2017 New York University MacCracken Graduate Scholarship, New York University
- 2011 China Undergraduate Mathematical Contest in Modeling (first Class Prize)
- 2010 Mathematical Contest in Modeling (Meritorious Winner)
- 2008–2010 Academic Excellence Scholarship (A class), Shanghai Jiao Tong University
- 2008 Samsung scholarship (1st Class), Shanghai Jiao Tong University