

Ali Siahkoohi

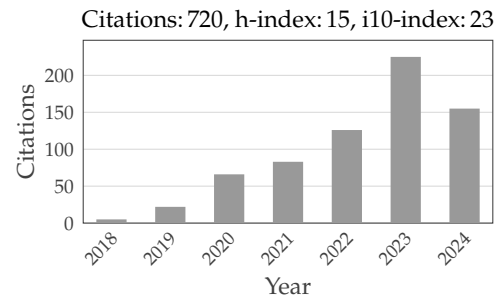
Simons Postdoctoral Fellow
Dept. of Comp. Applied Math. & Operations Research
Rice University

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Last updated: June 26, 2024

Research Interests and Highlights

My research in scientific machine learning aims to overcome barriers to fully unlocking AI's potential in computational science. I develop scalable, data-driven methods that integrate strengths from both fields to tackle challenging problems in computational science and engineering. Keywords defining my current research include: generative models, scientific machine learning, computational imaging, and uncertainty quantification.

Over the past years, I have published 38 peer-reviewed articles, including 17 first-author papers in high-impact journals and conference proceedings, such as *NeurIPS*, *ICML*, *ICLR*, *Interspeech*, *MIDL*, *SPIE*, *TMLR*, and *Geophysics*.



Academic Appointments

Rice University
Simons Postdoctoral Fellow
Department of Computational Applied Mathematics & Operations Research
Jointly hosted by Maarten V. de Hoop and Richard G. Baraniuk

August 2022 – Present
Houston, TX, USA

Education

Georgia Institute of Technology
Ph.D. in Computational Science and Engineering (minor in Applied Math.)
Advised by Felix J. Herrmann

August 2022
Atlanta, GA, USA

University of Tehran
M.Sc. in Geophysics

March 2016
Tehran, Iran

Sharif University of Technology
B.Sc. in Electrical Engineering

August 2013
Tehran, Iran

Publications

Google Scholar profile: <https://scholar.google.com/citations?user=sxRMqYIAAAAJ&h>

In Preparation & Under Review

- P5. P. M. Mayer, L. Luzi, A. Siahkoohi, D. H. Johnson, and R. G. Baraniuk. Removing bias from maximum likelihood estimation with model autophagy. Preprint arXiv:2405.13977; under review by *NeurIPS*, 2024
- P4. L. Baldassari, A. Siahkoohi, J. Garnier, K. Sølna, and M. V. de Hoop. Taming score-based diffusion priors for infinite-dimensional nonlinear inverse problems. Preprint arXiv:2405.15676; under review by *NeurIPS*, 2024
- P3. R. Orozco, A. Siahkoohi, M. Louboutin, and F. J. Herrmann. ASPIRE: Iterative amortized posterior inference for Bayesian inverse problems. Preprint arXiv:2405.05398; under review by *Inverse Problems*, 2024

- P2. A. Siahkoohi, R. Morel, R. Balestrieri, E. Allys, G. Sainton, T. Kawamura, and M. V. de Hoop. Martian time-series unraveled: A multi-scale nested approach with factorial variational autoencoders. Preprint arXiv:2305.16189, 2024
- P1. R. Orozco, P. Witte, M. Louboutin, A. Siahkoohi, G. Rizzuti, B. Peters, and F. J. Herrmann. InvertibleNetworks.jl: A Julia package for scalable normalizing flows. Preprint arXiv:2312.13480; under review by *Journal of Open Source Software*, 2023

Journal Publications

- J6. L. Luzi, P. M. Mayer, J. Casco-Rodriguez, A. Siahkoohi, and R. G. Baraniuk. Boomerang: Local sampling on image manifolds using diffusion models. *Transactions on Machine Learning Research*, 2024
- J5. M. Louboutin, Z. Yin, R. Orozco, T. J. Grady II, A. Siahkoohi, G. Rizzuti, P. A. Witte, O. Møyner, G. J. Gorman, and F. J. Herrmann. Learned multiphysics inversion with differentiable programming and machine learning. *The Leading Edge*, 42(7):474–486, 2023
- J4. Y. Zhang, Z. Yin, O. López, A. Siahkoohi, M. Louboutin, R. Kumar, and F. J. Herrmann. Optimized time-lapse acquisition design via spectral gap ratio minimization. *Geophysics*, 88(4):A19–A23, 2023
- J3. A. Siahkoohi, G. Rizzuti, R. Orozco, and F. J. Herrmann. Reliable amortized variational inference with physics-based latent distribution correction. *Geophysics*, 88(3):R297–R322, 2023
- J2. A. Siahkoohi, G. Rizzuti, and F. J. Herrmann. Deep Bayesian inference for seismic imaging with tasks. *Geophysics*, 87(5):S281–S302, 2022
- J1. A. Siahkoohi, M. Louboutin, and F. J. Herrmann. The importance of transfer learning in seismic modeling and imaging. *Geophysics*, 84(6):A47–A52, 2019

Peer-Reviewed Conference Proceedings

- C32. S. Alemohammad, J. Casco-Rodriguez, L. Luzi, A. I. Humayun, H. Babaei, D. LeJeune, A. Siahkoohi, and R. G. Baraniuk. Self-consuming generative models go MAD. In *The Twelfth International Conference on Learning Representations*, 2024
- C31. L. Luzi, D. LeJeune, A. Siahkoohi, S. Alemohammad, V. Saragadam, H. Babaei, N. Liu, Z. Wang, and R. G. Baraniuk. Titan: Bringing the deep image prior to implicit representations. In *IEEE International Conference on Acoustics, Speech and Signal Processing*, pages 6165–6169, 2024
- C30. L. Baldassari, A. Siahkoohi, J. Garnier, K. Sølna, and M. V. de Hoop. Conditional score-based diffusion models for Bayesian inference in infinite dimensions. In *Advances in Neural Information Processing Systems*, volume 36, pages 24262–24290, 2023
- C29. A. Siahkoohi, R. Morel, M. V. de Hoop, E. Allys, G. Sainton, and T. Kawamura. Unearthing InSights into Mars: Unsupervised source separation with limited data. In *Proceedings of the 40th International Conference on Machine Learning*, volume 202, pages 31754–31772, 2023
- C28. R. Orozco, M. Louboutin, A. Siahkoohi, G. Rizzuti, T. van Leeuwen, and F. J. Herrmann. Amortized normalizing flows for transcranial ultrasound with uncertainty quantification. In *Medical Imaging with Deep Learning*, volume 227, pages 332–349, 2023
- C27. R. Orozco, A. Siahkoohi, M. Louboutin, and F. J. Herrmann. Refining amortized posterior approximations using gradient-based summary statistics. In *5th Symposium on Advances in Approximate Bayesian Inference*, 2023
- C26. R. Orozco, A. Siahkoohi, G. Rizzuti, T. van Leeuwen, and F. J. Herrmann. Adjoint operators enable fast and amortized machine learning based Bayesian uncertainty quantification. In *Medical Imaging 2023: Image Processing*, volume 12464, page 124641L, 2023
- C25. Y. Zhang, Z. Yin, O. Lopez, A. Siahkoohi, M. Louboutin, and F. J. Herrmann. 3D seismic survey design by maximizing the spectral gap. In *Third International Meeting for Applied Geoscience & Energy*, 2023
- C24. A. Siahkoohi, M. Chinen, T. Denton, W. B. Kleijn, and J. Skoglund. Ultra-low-bitrate speech coding with pretrained Transformers. In *Proceedings of Interspeech*, pages 4421–4425, 2022

- C23. A. Siahkoohi, M. Louboutin, and F. J. Herrmann. Velocity continuation with Fourier neural operators for accelerated uncertainty quantification. In *Society of Exploration Geophysicists Technical Program Expanded Abstracts*, pages 1765–1769, 2022
- C22. M. Louboutin, P. Witte, A. Siahkoohi, G. Rizzuti, Z. Yin, R. Orozco, and F. J. Herrmann. Accelerating innovation with software abstractions for scalable computational geophysics. In *Society of Exploration Geophysicists Technical Program Expanded Abstracts*, pages 1482–1486, 2022
- C21. Z. Yin, A. Siahkoohi, M. Louboutin, and F. J. Herrmann. Learned coupled inversion for carbon sequestration monitoring and forecasting with Fourier neural operators. In *Society of Exploration Geophysicists Technical Program Expanded Abstracts*, pages 467–472, 2022
- C20. Y. Zhang, M. Louboutin, A. Siahkoohi, Z. Yin, R. Kumar, and F. J. Herrmann. A simulation-free seismic survey design by maximizing the spectral gap. In *Society of Exploration Geophysicists Technical Program Expanded Abstracts*, pages 15–20, 2022
- C19. A. Siahkoohi, R. Orozco, G. Rizzuti, and F. J. Herrmann. Wave-equation based inversion with amortized variational Bayesian inference. In *EAGE Deep learning for seismic processing: Investigating the foundations workshop*, 2022
- C18. R. Orozco, A. Siahkoohi, G. Rizzuti, T. van Leeuwen, and F. J. Herrmann. Photoacoustic imaging with conditional priors from normalizing flows. In *NeurIPS Workshop on Deep Learning and Inverse Problems*, 2021
- C17. A. Siahkoohi, G. Rizzuti, M. Louboutin, P. Witte, and F. J. Herrmann. Preconditioned training of normalizing flows for variational inference in inverse problems. In *3rd Symposium on Advances in Approximate Bayesian Inference*, 2021
- C16. A. Siahkoohi and F. J. Herrmann. Learning by example: Fast reliability-aware seismic imaging with normalizing flows. In *Society of Exploration Geophysicists Technical Program Expanded Abstracts*, pages 1580–1585, 2021
- C15. R. Kumar, M. Kotsi, A. Siahkoohi, and A. Malcolm. Enabling uncertainty quantification for seismic data preprocessing using normalizing flows (NF)—An interpolation example. In *Society of Exploration Geophysicists Technical Program Expanded Abstracts*, pages 1515–1519, 2021
- C14. G. Rizzuti, A. Siahkoohi, P. A. Witte, and F. J. Herrmann. Parameterizing uncertainty by deep invertible networks, an application to reservoir characterization. In *Society of Exploration Geophysicists Technical Program Expanded Abstracts*, pages 1541–1545, 2020
- C13. M. Zhang, A. Siahkoohi, and F. J. Herrmann. Transfer learning in large-scale ocean bottom seismic wavefield reconstruction. In *Society of Exploration Geophysicists Technical Program Expanded Abstracts*, pages 1666–1670, 2020
- C12. A. Siahkoohi, G. Rizzuti, and F. J. Herrmann. Weak deep priors for seismic imaging. In *Society of Exploration Geophysicists Technical Program Expanded Abstracts*, pages 2998–3002, 2020
- C11. A. Siahkoohi, G. Rizzuti, and F. J. Herrmann. Uncertainty quantification in imaging and automatic horizon tracking—A Bayesian deep-prior based approach. In *Society of Exploration Geophysicists Technical Program Expanded Abstracts*, pages 1636–1640, 2020
- C10. A. Siahkoohi, G. Rizzuti, and F. J. Herrmann. A deep-learning based Bayesian approach to seismic imaging and uncertainty quantification. In *European Association of Geoscientists & Engineers Conference and Exhibition Extended Abstracts*, 2020
- C9. F. J. Herrmann, A. Siahkoohi, and G. Rizzuti. Learned imaging with constraints and uncertainty quantification. In *NeurIPS Deep Inverse Workshop*, 2019
- C8. A. Siahkoohi, R. Kumar, and F. J. Herrmann. Deep-learning based ocean bottom seismic wavefield recovery. In *Society of Exploration Geophysicists Technical Program Expanded Abstracts*, pages 2232–2237, 2019
- C7. A. Siahkoohi, D. J. Verschuur, and F. J. Herrmann. Surface-related multiple elimination with deep learning. In *Society of Exploration Geophysicists Technical Program Expanded Abstracts*, pages 4629–4634, 2019

- C6. G. Rizzuti, A. Siahkoohi, and F. J. Herrmann. Learned iterative solvers for the Helmholtz equation. In *European Association of Geoscientists & Engineers Conference and Exhibition Extended Abstracts*, 2019
- C5. A. Siahkoohi, M. Louboutin, R. Kumar, and F. J. Herrmann. Deep convolutional neural networks in prestack seismic—two exploratory examples. In *Society of Exploration Geophysicists Technical Program Expanded Abstracts*, pages 2196–2200, 2018
- C4. A. Siahkoohi, R. Kumar, and F. J. Herrmann. Seismic data reconstruction with generative adversarial networks. In *European Association of Geoscientists & Engineers Conference and Exhibition Extended Abstracts*, 2018
- C3. A. Siahkoohi and A. Gholami. Sparsity promoting least squares migration for laterally inhomogeneous media. In *7th EAGE Saint Petersburg International Conference and Exhibition*, 2016
- C2. M. S. Ebrahimi, M. H. Daraei, J. Rezaei, and A. Siahkoohi. A novel utilization of wireless sensor networks as data acquisition system in smart grids. In *Materials Science and Information Technology*, volume 433-440, pages 6725–6730, 2012
- C1. A. Najafi, A. Siahkoohi, and M. B. Shamsollahi. A content-based digital image watermarking algorithm robust against JPEG compression. In *IEEE International Symposium on Signal Processing and Information Technology*, pages 432–437, 2011

Theses

- T2. A. Siahkoohi. *Deep generative models for solving geophysical inverse problems*. PhD thesis, **Georgia Institute of Technology**, 2022
- T1. A. Siahkoohi. *Sparsity promoting least-squares migration for laterally inhomogeneous media*. Master’s thesis, **University of Tehran**, 2016

Technical Reports

- R3. M. Louboutin, A. Siahkoohi, R. Wang, and F. J. Herrmann. Low-memory stochastic backpropagation with multi-channel randomized trace estimation. Technical Report arXiv:2106.06998, Georgia Institute of Technology, 2021
- R2. A. Siahkoohi, G. Rizzuti, P. A. Witte, and F. J. Herrmann. Faster uncertainty quantification for inverse problems with conditional normalizing flows. Technical Report arXiv:2007.07985, Georgia Institute of Technology, 2020
- R1. A. Siahkoohi, M. Louboutin, and F. J. Herrmann. Neural network augmented wave-equation simulation. Technical Report arXiv:1910.00925, Georgia Institute of Technology, 2019

Talks

Invited Talks

- | | | |
|------|--|---|
| T22. | CNRS, Université Montpellier
Low-cost uncertainty quantification for large-scale inverse problems
RhEoVOLUTION Group (Dr. Andréa Tommasi) | January 2023
Virtual oral presentation |
| T21. | Workshop on Subsurface Uncertainty Description and Estimation
Reliable amortized variational inference with conditional normalizing flows via
physics-based latent distribution correction
International Meeting for Applied Geoscience & Energy | August 2022
Oral presentation |
| T20. | Intelligent illumination of the Earth Workshop
Fast and reliability-aware seismic imaging with conditional normalizing flows
King Abdullah University of Science and Technology | June 2021
Virtual oral presentation |
| T19. | Advances in Seismic Imaging and Inversion Mini-symposium
Unsupervised data-guided uncertainty analysis in imaging and horizon
tracking | October 2020
Virtual oral presentation |

Contributed Talks

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|------|---|-------------------------------------|
| T18. | International Conference on Machine Learning | July 2023 |
| | Unearthing InSights into Mars: Unsupervised source separation with limited data | Poster presentation |
| T17. | Symposium on Advances in Approximate Bayesian Inference | July 2023 |
| | Refining amortized posterior approximations using gradient-based summary statistics | Poster presentation |
| T16. | Geo-Mathematical Imaging Group Partners Meeting, Rice University | May 2023 |
| | Martian time-series unraveled: A multi-scale nested approach with factorial variational autoencoders | Oral presentation |
| T15. | Geo-Mathematical Imaging Group Partners Meeting, Rice University | May 2023 |
| | Unearthing InSights into Mars: Unsupervised source separation with limited data | Oral presentation |
| T14. | International Meeting for Applied Geoscience & Energy | August 2022 |
| | Velocity continuation with Fourier neural operators for accelerated uncertainty quantification | Oral presentation |
| T13. | Chrome Media Team, Google | December 2021 |
| | Low-bitrate speech coding with Transformers | Virtual oral presentation |
| T12. | ML4SEISMIC Partners Meeting, Georgia Institute of Technology | November 2021 |
| | Multifidelity conditional normalizing flows for physics-guided Bayesian inference | Virtual oral presentation |
| T11. | ML4SEISMIC Partners Meeting, Georgia Institute of Technology | November 2021 |
| | Uncertainty quantification in imaging and automatic horizon tracking—A Bayesian deep-prior based approach | Virtual oral presentation |
| T10. | Society of Exploration Geophysicists International Exposition and Annual Meeting | September 2021 |
| | Learning by example: Fast reliability-aware seismic imaging with normalizing flows [Link to video] | Virtual oral presentation |
| T9. | Symposium on Advances in Approximate Bayesian Inference | January 2021 |
| | Preconditioned training of normalizing flows for variational inference in inverse problems [Link to video] | Prerecorded short oral presentation |
| T8. | European Association of Geoscientists & Engineers Annual Conference & Exhibition | December 2020 |
| | A deep-learning based Bayesian approach to seismic imaging and uncertainty quantification | Virtual oral presentation |
| T7. | Society of Exploration Geophysicists International Exposition and Annual Meeting | October 2020 |
| | Uncertainty quantification in imaging and automatic horizon tracking—A Bayesian deep-prior based approach [Link to video] | Virtual oral presentation |
| T6. | Society of Exploration Geophysicists International Exposition and Annual Meeting | October 2020 |
| | Weak deep priors for seismic imaging [Link to video] | Virtual oral presentation |
| T5. | Society of Exploration Geophysicists Student Chapter, Georgia Tech | February 2020 |
| | A deep-learning based Bayesian approach to seismic imaging and uncertainty quantification | Oral presentation |
| T4. | HotCSE Seminar, CSE Department, Georgia Institute of Technology | November 2019 |
| | Learned imaging with constraints and uncertainty quantification | Oral presentation |
| T3. | Society of Exploration Geophysicists International Exposition & Annual Meeting | September 2019 |
| | Deep-learning based ocean bottom seismic wavefield recovery | Oral presentation |
| T2. | Society of Exploration Geophysicists International Exposition & Annual Meeting | September 2019 |
| | Surface-related multiple elimination with deep learning | Oral presentation |
| T1. | Society of Exploration Geophysicists International Exposition & Annual Meeting | October 2018 |
| | Deep convolutional neural networks in prestack seismic—two exploratory examples | Poster presentation |

Professional Service

Editorial Service

- ▶ **Journal of Mathematics** 2023 – Present
Guest Editor
Special issue on Applied Mathematics in Inverse Problems and Uncertainty Quantification

Conference Organization

- ▶ **Deep Learning and Inverse Problems Workshop (NeurIPS)** 2024
Workshop Organizer
- ▶ **International Meeting for Applied Geoscience & Energy** 2022
Session Chair

Technical Program Committee Member and Reviewer

- ▶ Neural Information Processing Systems (NeurIPS) 2023 – 2024
- ▶ Advances in Approximate Bayesian Inference (AABI) 2023 – 2024
- ▶ Structured Probabilistic Inference & Generative Modeling (ICML workshop) 2023 – 2024
- ▶ International Conference on Machine Learning (ICML) 2024
- ▶ International Conference on Learning Representations (ICLR) 2024
- ▶ Artificial Intelligence and Statistics Conference (AISTATS) 2024
- ▶ International Speech Communication Association (Interspeech) 2023
- ▶ Deep Generative Models for Health (NeurIPS workshop) 2023
- ▶ International Meeting for Applied Geoscience & Energy 2023

Journal Reviewer

- ▶ IEEE Transactions on Neural Networks and Learning Systems
- ▶ IEEE Geoscience and Remote Sensing Letters
- ▶ IEEE Transactions on Geoscience and Remote Sensing
- ▶ Notices of the American Mathematical Society (AMS)
- ▶ Remote Sensing
- ▶ Journal of Geophysical Research – Solid Earth
- ▶ Geophysical Prospecting
- ▶ Geophysics
- ▶ Geosciences
- ▶ Entropy

Teaching Experience

Rice University Fall 2022
Instructor for 18 lectures Houston, TX, USA
Numerical Analysis I

Georgia Institute of Technology Spring 2022
Teaching Assistant Atlanta, GA, USA
Computational Foundations of Machine Learning

Georgia Institute of Technology Fall 2019
Teaching Assistant Atlanta, GA, USA
Imaging with Data-Driven Models

Georgia Institute of Technology
Teaching Assistant
Numerical Analysis I

Fall 2018
Atlanta, GA, USA

Sharif University of Technology
Teaching Assistant
Digital Signal Processing

Spring 2011
Tehran, Iran

Sharif University of Technology
Teaching Assistant
Signals and Systems

Spring 2011
Tehran, Iran

Sharif University of Technology
Teaching Assistant
Linear Algebra

Spring 2010
Tehran, Iran

Internship

Google
Research Intern (cf. publication C24)
Chrome Media Team

August 2021 – December 2021
San Francisco, CA, USA