Ali Siahkoohi

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

alisk@rice.edu
https://alisiahkoohi.github.io
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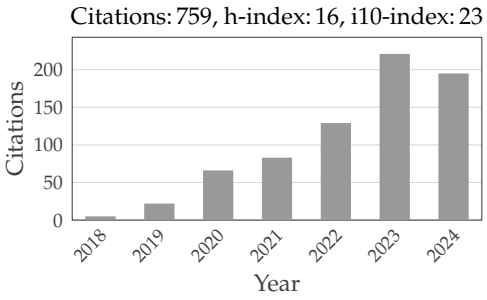
Research Interests and Highlights

My research in *scientific machine learning*, under the mentorship of Maarten V. de Hoop and Richard G. Baraniuk, lies at the intersection of computational science and artificial intelligence, focusing on developing scalable, data-driven methods that leverage the strengths of both fields to address challenging, large-scale problems in computational science and engineering. Keywords defining my current research interests include: computational science, deep learning, generative models, and uncertainty quantification.



Over the past years, I have published 39 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.

Education

Georgia Institute of Technology — August 2022
Ph.D. in Computational Science and Engineering (minor in Applied Math.) — Atlanta, GA, USA
Advised by Felix J. Herrmann

University of Tehran — March 2016
M.Sc. in Geophysics — Tehran, Iran

Sharif University of Technology — August 2013
B.Sc. in Electrical Engineering — Tehran, Iran

Academic Appointments

Rice University — August 2022 – Present
Simons Postdoctoral Fellow — Houston, TX, USA
Department of Computational Applied Mathematics & Operations Research
Jointly hosted by Maarten V. de Hoop and Richard G. Baraniuk

Awards

Rice University — June 2024
George R. Brown School of Engineering — Houston, TX, USA
Future Faculty Fellows Award

Publications

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

In Preparation & Under Review

P4. A. Siahkoohi, R. Morel, R. Balestriero, 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; under review by ***IEEE Transactions on Neural Networks and Learning Systems***, 2024
[pdf] [code] [slides] [bib]

P3. 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
[pdf] [bib]

P2. 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
[pdf] [bib]

P1. 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
[pdf] [code] [bib]

Journal Publications

J7. 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. ***Journal of Open Source Software***, 9(99):6554, 2024
[pdf] [code] [link] [bib]

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
[pdf] [code] [link] [bib]

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
[pdf] [link] [bib] [featured in Seismic Soundoff]

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
[pdf] [link] [bib]

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
[pdf] [slides] [code] [link] [bib] [featured in Geophysics Bright Spots]

J2. A. Siahkoohi, G. Rizzuti, and F. J. Herrmann. Deep Bayesian inference for seismic imaging with tasks. ***Geophysics***, 87(5):S281–S302, 2022
[pdf] [code] [link] [bib]

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
[pdf] [code] [link] [bib]

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
[pdf] [extended pdf] [poster] [link] [bib] [featured in the news [1, 2, 3, 4, 5, 6, 7, 8, 9, 10]]

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
[pdf] [code] [link] [bib]

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
[pdf] [slides] [poster] [code] [link] [bib] [featured as a Spotlight presentation]

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
[pdf] [slides] [poster] [code] [link] [bib]

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
[pdf] [link] [bib]

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
[pdf] [link] [bib]

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
[pdf] [link] [bib]

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
[pdf] [poster] [bib]

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
[pdf] [link] [bib]

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
[pdf] [slides] [code] [link] [bib]

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
[pdf] [slides] [link] [bib]

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
[pdf] [slides] [code] [link] [bib]

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
[pdf] [slides] [code] [link] [bib]

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
[pdf] [slides] [code] [link] [bib]

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
[pdf] [poster] [link] [bib]

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
[pdf] [slides] [code] [link] [bib]

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
[pdf] [slides] [code] [link] [bib]

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
[pdf] [code] [link] [bib]

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
[pdf] [slides] [code] [link] [bib]

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
[pdf] [slides] [code] [link] [bib]

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
[pdf] [slides] [code] [link] [bib]

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
[pdf] [slides] [code] [link] [bib]

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
[pdf] [slides] [code] [link] [bib]

C9. F. J. Herrmann, A. Siahkoohi, and G. Rizzuti. Learned imaging with constraints and uncertainty quantification. In ***NeurIPS Deep Inverse Workshop***, 2019
[pdf] [slides] [poster] [link] [bib]

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
[pdf] [code] [slides] [link] [bib]

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
[pdf] [slides] [link] [bib]

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
[pdf] [slides] [link] [bib]

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

[pdf] [poster] [link] [bib]

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
[pdf] [slides] [link] [bib]

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
[pdf] [link] [bib]

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
[pdf] [link] [bib]

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
[pdf] [link] [bib]

Theses

T1. A. Siahkoohi. *Deep generative models for solving geophysical inverse problems*. PhD thesis, **Georgia Institute of Technology**, 2022
[pdf] [slides] [link] [bib]

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
[pdf] [code] [link] [bib]

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
[pdf] [link] [bib]

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
[pdf] [code] [link] [bib]

Selected Research Proposal Experience

Topological deep learning, causal inference, and data-driven forecasting for subsurface multiscale multiphysics systems Awarded in 2022

- Funding Source: Department of Energy In Progress
- Principal Investigator: Maarten V. de Hoop
- **Contribution**: Led the effort to write the annual progress report June 2024

Learning and forecasting complex fault dynamics – Predictability of earthquakes Submitted in 2024

- Funding Source: National Science Foundation Under Review
- Principal Investigator: Maarten V. de Hoop
- **Contribution**: Developing ideas and writing for one of the four research thrusts March 2024
  - Structure in data, clustering, lattice theory, and diffusion models

Scientific ML-supported subsurface characterization in physical function spaces Awarded in 2024
- Funding Source: Occidental Petroleum Corporation In Progress
- Principal Investigator: Maarten V. de Hoop
- **Contribution**: Developing ideas and writing for two of the four research thrusts November 2023
  - Score diffusion, nonlinear operators, and uncertainty quantification in function spaces
  - Unsupervised, factorial data decomposition and hidden signals: Reservoir characterization below salt, denoising, and monitoring

Exploring the local geometry of deep networks Awarded in 2023
- Funding Source: Office of Naval Research (DURIP) In Progress
- Principal Investigator: Richard G. Baraniuk
- **Contribution**: Developing ideas and writing for a research objective within one of the three research thrusts May 2023
  - The geometry of deep probabilistic models

Professional Service

Editorial Service

- **Acta Geophysica** 2024 – Present
  Associate Editor
  Applied Geophysics section
- **Journal of Mathematics** 2023 – Present
  Guest Editor
  Special issue on Applied Mathematics in Inverse Problems and Uncertainty Quantification

Conference Organization

- **Annual AAAI Conference on Artificial Intelligence** 2025
  Program Chair
- **International Meeting for Applied Geoscience & Energy** 2022
  Session Chair

Technical Program Committee Member and Reviewer

- International Conference on Learning Representations (ICLR) 2024 – 2025
- 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
- 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 2024
Substitute Instructor Houston, TX, USA
Department of Computational Applied Mathematics & Operations Research
Numerical Analysis

Rice University Fall 2022
Substitute Instructor (18 lectures) Houston, TX, USA
Department of Computational Applied Mathematics & Operations Research
Numerical Analysis I

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

Georgia Institute of Technology Fall 2019
Teaching Assistant Atlanta, GA, USA
School of Computational Science and Engineering
Imaging with Data-Driven Models

Georgia Institute of Technology Fall 2018
Teaching Assistant Atlanta, GA, USA
School of Computational Science and Engineering
Numerical Analysis I

Sharif University of Technology Spring 2011
Teaching Assistant Tehran, Iran
Department of Electrical Engineering
Digital Signal Processing

Sharif University of Technology Spring 2011
Teaching Assistant Tehran, Iran
Department of Electrical Engineering
Signals and Systems

Sharif University of Technology Spring 2010
Teaching Assistant Tehran, Iran
Department of Electrical Engineering
Linear Algebra

Talks

Invited Talks

T22. **CNRS, Université Montpellier** January 2023
Low-cost uncertainty quantification for large-scale inverse problems Virtual oral presentation
RhEoVOLUTION Group (Dr. Andréa Tommasi)

T21. **Workshop on Subsurface Uncertainty Description and Estimation** August 2022
Reliable amortized variational inference with conditional normalizing flows via physics-based latent distribution correction Oral presentation
International Meeting for Applied Geoscience & Energy

T20. **Intelligent illumination of the Earth Workshop** June 2021
Fast and reliability-aware seismic imaging with conditional normalizing flows Virtual oral presentation
King Abdullah University of Science and Technology

T19. **Advances in Seismic Imaging and Inversion Mini-symposium** October 2020
Unsupervised data-guided uncertainty analysis in imaging and horizon tracking Virtual oral presentation
The 3rd Annual Meeting of the SIAM Texas–Louisiana Section

Contributed Talks

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 Virtual oral presentation
[Link to video]

T9. **Symposium on Advances in Approximate Bayesian Inference** January 2021
Preconditioned training of normalizing flows for variational inference in inverse problems Prerecorded short oral presentation
[Link to video]

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 Virtual oral presentation
[Link to video]

T6. **Society of Exploration Geophysicists International Exposition and Annual Meeting** October 2020
Weak deep priors for seismic imaging Virtual oral presentation
[Link to video]

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

Industry Research Experience

Google — August 2021 – December 2021
Research Intern (cf. publication C24) — San Francisco, CA, USA
Chrome Media Team