Zachary E. Ross

1200 E. California Blvd., MS 252-21
Pasadena, CA 91125-2100
Phone: (626) 395-6958; E-mail: zross@caltech.edu

Education

2016	Ph.D., Geophysics, University of Southern California Thesis Advisor: Prof. Yehuda Ben-Zion
2011	M.S., Civil Engineering, California Polytechnic State University, San Luis Obispo
2009	B.S., Physics, University of California, Davis

Professional Appointments

2025-	Professor of Geophysics, California Institute of Technology
2021-	William H. Hurt Scholar, California Institute of Technology
2019-2025	Assistant Professor of Geophysics, California Institute of Technology
2016-2019	Postdoctoral Scholar in Geophysics, California Institute of Technology
2011-2016	Graduate Student Researcher, University of Southern California

Honors and Awards

2024	Researcher profile in *National Geographic,* special vol. "The AI Revolution"
2022	Packard Fellow, David and Lucile Packard Foundation
2022	Kavli Fellow, National Academy of Sciences
2022	CAREER Award, National Science Foundation
2021	William H. Hurt Scholar (endowed professorship for junior faculty), Caltech
2019	Keiiti Aki Early Career Award, American Geophysical Union
2019	AGU Editors' Citation for Excellence in Refereeing
2019	High Performance Computing Innovation Excellence Award, Hyperion Research
2016	University Ph.D. Achievement Award, University of Southern California
2011	Graduation with Distinction, Cal Poly, San Luis Obispo

Patents

Zhu, W., Biondi, E., Li, J., Yin, J., **Ross, Z. E.**, and Z. Zhan, 2023-02-08. "Seismic Phase Arrival-Time Picking On Distributed Acoustic Sensing Data Using Semi-Supervised Learning".

Publications (Peer-Reviewed)

Legend: *Graduate Student, ^Postdoctoral Scholar, †Undergraduate Student

In review:

[91] *Wilding, J. D., Wang, T. A., Liu, Y.-K., and **Z. E. Ross**. Cascading magmatic unrest and aseismic faulting in the Aegean Sea enabled by elastic stress relay, *submitted*.

[90] *Kong, C., Gurnis, M., and **Z. E. Ross**. Forward and Inverse Mantle Convection with Neural Operators, *submitted*.

[89] **Ross, Z. E.**, Wilding, J. D., Azizzadenesheli, K., and A. Kato. SPIDER: Scalable Probabilistic Inference for Differential Earthquake Relocation, *submitted.*

[88] *Gao, A. F., Wilding, J. D., Biondi, E., Bouman, K. L., and **Z. E. Ross**. High-resolution Eikonal imaging and uncertainty quantification of the Kilauea caldera, *submitted.*

[87] ^Ramirez, E. E., Stock, J. M., **Ross, Z. E.**, Vidal-Villegas, J. A., Núñez-Leal, M. A., Ramírez-Hernández, J. Northern Baja California, Mexico, Seismicity Illuminated with Deep Learning Phase Picking and Associator, *submitted.*

[86] ^Chen, Z., McPhillips, D., Scharer, K., and **Z. E. Ross**. Large-scale 3D Semantic Mapping Using Structure-from-Motion and Segmentation Mosaicking Algorithms, *submitted.*

[85] ^Ragon, T., Gao, A. F., and **Z. E. Ross**. DeepGEM-EGF: A Bayesian strategy for joint estimates of source-time functions and empirical Green's functions, *submitted*

Published:

[84] *Shi, Y., **Ross, Z. E.**, Asimaki, D., and K. Azizzadenesheli. Mesh-Informed Neural Operator: A Transformer Generative Approach, *Trans. Machine Learning Research*, https://openreview.net/forum?id=K8qAuRfv0G.

[83] *Shi, Y., **Ross, Z. E.**, Asimaki, D., and K. Azizzadenesheli. Stochastic Process Learning via Operator Flow Matching, *NeurIPS 2025, *Spotlight Paper**

[82] *Zou, C., **Ross, Z. E.**, Clayton, R. W., Lin, F.-C., and K. Azizzadenesheli. Ambient Noise Full Waveform Inversion with Neural Operators, *J. Geophys. Res. Solid Earth, in press*

[81] Kong, Q., Zou, C., Choi, Y., Matzel, E. M., Azizzadenesheli, K., **Ross, Z. E.**, Rodgers, A. J., and R. W. Clayton. Reducing Frequency Bias of Fourier Neural Operators In 3D Seismic Wavefield Simulations Through Multi-Stage Training, *Seismol. Res. Lett.*, https://doi.org/10.1785/0220250085

[80] ^Poggiali, G., Chiaraluce, L., **Ross, Z. E.**, Zhu, W., and C. Marone. A High Resolution Machine-Learning Earthquake Catalog to Characterize Fault Geometry and Source Mechanics: the Altotiberina Fault Case Study, *Bull. Seismol. Soc. Am.*, https://doi.org/10.1785/0120250072

[79] Zheng, H., Chu, W., Zhang, B., Wu, Z., Wang, A., Feng, B., Zou, C., Sun, Y., Kovachki, N., **Ross, Z. E.**, Bouman, K., and Y. Yue (2025). InverseBench: Benchmarking Plug-and-Play Diffusion Models for Scientific Inverse Problems*, ICLR 2025, *Spotlight Paper**

[78] *Atterholt, J., Wilding, J. D., and **Z. E. Ross** (2024). The Evolution of Fault Orientation in the 2019 Ridgecrest Earthquake Sequence with a New Long-Term Catalog of Seismicity and Moment Tensors, *Geophys. J. Int*.

[77] *Shi, Y., Gao, A. F., **Ross, Z. E.**, and K. Azizzadenesheli (2024). Universal Functional Regression with Neural Operator Flows, *Trans. Machine Learning Research*, https://openreview.net/forum?id=rHL329Xa3X.

[76] *Wilding J. D. and **Z. E. Ross** (2024). Rift zone architecture and inflation-driven seismicity of Mauna Loa volcano, *J. Geophys. Res. Solid Earth.* 129, e2024JB029726. https://doi.org/10.1029/2024JB029726

[75] *Zou, C., Azizzadenesheli, K., **Ross, Z. E.**, and R. W. Clayton (2024). Deep Neural Helmholtz Operators for 3D Elastic Wave Propagation and Inversion, *Geophys. J. Int*., doi: 10.1093/gji/ggae342

[74] Sirorattanakul, K., Wilding, J. D., Acosta, M., Li, Y., **Ross, Z. E.**, Bourne, S. J., van Elk, J., and J.-P. Avouac (2024). Bursts of fast propagating swarms of induced earthquakes at the Groningen gas field, *Seismol. Res. Lett*., https://doi.org/10.1785/0220240107

[73] *Wilding, J. D. and **Z. E. Ross** (2024). Insights on the state of stress in the mantle beneath Pahala, Hawai`i, *Volcanica*, 7 (1), 1-19, https://doi.org/10.30909/vol.07.01.0119

[72] *Shi, Y., Lavrentiadis, G., Asimaki, D., **Ross, Z. E.**, and K. Azizzadenesheli (2024). Broadband Ground Motion Synthesis via Generative Adversarial Neural Operators: Development and Validation, *Bull. Seismol. Soc. Am.* 114 (4): 2151–2171, https://doi.org/10.1785/0120230207

[71] **Ross, Z. E.** (2024), Insights on the dip of fault zones in Southern California from modeling of seismicity with anisotropic point processes, *Seismica*, *3*(1), https://doi.org/10.26443/seismica.v3i1.1092

[70] *Atterholt, J. and **Z. E. Ross** (2024). Finite Source Properties of Large Strike-Slip Earthquakes, *Geophys. J. Int*., 236 (2), 889–903, https://doi.org/10.1093/gji/ggad459

[69] ^Sun, H., **Ross, Z. E.**, Zhu, W., and K. Azizzadenesheli (2023). Phase Neural Operator for Multi-Station Picking of Seismic Arrivals. *Geophys. Res. Lett.*, 50, e2023GL106434. https://doi.org/10.1029/2023GL106434

[68] ^Zhu, W., Biondi, E., Li, J., Yin, J., **Ross, Z. E.**, Zhan, Z (2023). Seismic Arrival-time Picking on Distributed Acoustic Sensing Data using Semi-supervised Learning, *Nature Communications,* 14 (1), 8192, https://doi.org/10.1038/s41467-023-43355-3

[67] Rahman, M. A., **Ross, Z. E.**, and K. Azizzadenesheli (2023). U-NO: U-shaped Neural Operators, *Transactions on Machine Learning Research*, 2835-8856, https://openreview.net/forum?id=j3oQF9coJd

[66] Cochran, E. S., Page, M., van der Elst, N. J., **Ross, Z. E.**, and D. T. Trugman (2023). Fault Roughness at Seismogenic Depths and Links to Earthquake Behavior. *The Seismic Record*; 3 (1): 37–47, https://doi.org/10.1785/0320220043

[65] *Yang, Y., Gao, A. F., Azizzadenesheli, K., Clayton, R. W., and **Z. E. Ross** (2023). "Rapid Seismic Waveform Modeling and Inversion With Neural Operators," in *IEEE Transactions on Geoscience and Remote Sensing*, vol. 61, pp. 1-12, 2023, Art no. 5906712, doi: 10.1109/TGRS.2023.3264210.

[64] *Muir, J. B., and **Z. E. Ross** (2023). Aseismic forcing during the 2016-2020 Cahuilla swarm sequence determined with a deep Gaussian process model. *Geophys. J. Int.*, ggad074, https://doi.org/10.1093/gji/ggad074

[63] *Wilding, J. D., Zhu, W., **Ross, Z. E.**, and J. M. Jackson (2022). The magmatic web beneath Hawai'i, *Science*, 379 (6631), 462-468, doi: 10.1126/science.ade5755

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[59] *Wilding, J. D. and **Z. E. Ross** (2022). Aftershock moment tensor scattering. *Geophysical Research Letters*, 49, e2022GL098473. https://doi.org/10.1029/2022GL098473

[58] *Atterholt, J. and **Z. E. Ross** (2022). Bayesian framework for inversion of second-order stress glut moments: application to the 2019 Ridgecrest Sequence Mainshock, *J. Geophys. Res.: Solid Earth*, e2021JB023780, doi: 10.1029/2021JB023780

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[56] *Liu, Y.-K., **Ross, Z. E.**, Cochran, E. S., and N. Lapusta (2022). A unified perspective of seismicity and fault coupling along the San Andreas Fault, *Science Advances*, 8 (8), eabk1167, doi: 10.1126/sciadv.abk1167
[55] ^Smith, J. D., **Ross, Z. E.**, Azizzadenesheli, K., and J. B. Muir (2022). HypoSVI: Hypocenter inversion with Stein variational inference and Physics Informed Neural Networks, *Geophys. J. Int.*, 228, 698–710 doi: 10.1093/gji/ggab309.
[54] *Gao, A. F., Castillo, J., Yue, Y., **Ross, Z. E.**, and K. L. Bouman (2021). DeepGEM: Generalized Expectation-Maximization for Blind Inversion. *Advances in Neural Information Processing Systems*, 34, 11592-11603
[53] *Yang, Y., *Gao, A. F., *Castellanos, J. C., **Ross, Z. E.**, Azizzadenesheli, K., and R. W. Clayton (2021). Seismic wave propagation and inversion with Neural Operators, *The Seismic Record*, 1 (3), 126-134, https://doi.org/10.1785/0320210026
[52] ^Li, B. Q., Smith, J. D., and **Z. E. Ross** (2021). Basal nucleation of ascending swarms in Long Valley Caldera, *Science Advances*, 7 (35), eabi8368, doi: 10.1126/sciadv.abi8368.
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[50] *Stephenson, O. L, Koehne, T., Zhan, E., Cahill, B. E., Yun, S.-H., **Ross, Z. E.**, and M. Simons (2021). Deep Learning-based Damage Mapping with InSAR Coherence Time Series, *IEEE Trans. Geosci. Rem. Sens.*, doi: 10.1109/TGRS.2021.3084209.
[49] **Ross, Z. E.**, and E. S. Cochran (2021). Evidence for latent crustal fluid injection transients in Southern California from long-duration earthquake swarms, *Geophys. Res. Lett.*, 48 (12), e2021GL092465, doi: 10.1029/2021GL092465.
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[46] Hauksson, E., Olson, B., Grant, A., Andrews, J. R., Chung, A. I., Hough, S., Kanamori, H., McBride, S. K., Michael, A., Page, M., **Ross, Z. E.**, Smith, D. E., Valkaniotis, S (2021). The Normal Faulting 2020 Mw5.8 Lone Pine Eastern California Earthquake Sequence, *Seismol. Res. Lett*, doi:10.1785/0220200324.
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[44] ^Smith, J. D., Azizzadenesheli, K, and **Ross, Z. E.** (2020). EikoNet: Solving the Eikonal equation with Deep Neural Networks, *IEEE Trans. Geosci. Rem. Sens.*, 59 (12), 10685-10696, doi: 10.1109/TGRS.2020.3039165.
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[39] †Zhang, X., *Jia, Z., **Ross, Z. E.**, and R. W. Clayton (2020). Extracting dispersion curves from ambient noise correlations using deep learning, *IEEE Trans. Geosci. Rem. Sens.*, doi: 10.1109/TGRS.2020.2992043 [arXiv:2002.02040]

[38] Cochran, E. S., Skoumal, R. J., McPhillips, D., **Ross, Z. E.**, and K. M. Keranen (2020). Activation of optimally- and unfavorably-oriented faults in a uniform local stress field during the 2011 Prague, Oklahoma, sequence, *Geophys. J. Int*, ggaa153, doi: 10.1093/gji/ggaa153.

[37] Trugman, D. T., **Ross, Z. E.**, and P. A. Johnson (2020). Imaging Stress and Faulting Complexity Through Earthquake Waveform Similarity, *Geophys. Res. Lett.*, e2019GL085888, doi:10.1029/2019GL085888.

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[35] **Ross, Z. E.**, Trugman, D. T., Azizzadenesheli, K., and A. Anandkumar (2020). Directivity Modes of Earthquake Populations with Unsupervised Learning, *J. Geophys. Res-Solid Earth*, 125 (2), e2019JB018299, doi: 10.1029/2019JB018299

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[28] Kanamori, H. and **Z. E. Ross** (2018). Reviving m_B. *Geophys. J. Int.*, 216 (3), doi:10.1093/gji/ggy510.

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Publications (Non-Refereed)

Ross, Z. E., Zhu, W., and K. Azizzadenesheli (2023). Neural mixture model association of seismic phases. arXiv:2301.02597

Sun, H., Yang, Y., Azizzadenesheli, K., Clayton, R. W., and **Z. E. Ross** (2022). Accelerating Time-Reversal Imaging with Neural Operators for Real-time Earthquake Locations. arXiv:2210.06636

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Ross, Z. E., 2016. Applying automated techniques to large seismic datasets for systematic analyses of phases, source, and structure, Ph.D Dissertation, University of Southern California.

Ross, Z. E., 2011. Probabilistic Fault Displacement Hazard Analysis for Reverse Faults and Surface Rupture Scale Invariance, Master's Thesis, California Polytechnic State University, San Luis Obispo.

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Invited Presentations

[53] *Harvard University, October 2025.*
[52] *Earthquake Research Institute, University of Tokyo*, May 2025
[51] *Distinctive Voices Lecture, Beckman Center, National Academy of Sciences*, January 2025.
[50] *Earthquake Research Institute, University of Tokyo*, April 2024.
[49] *Machine Learning in Solid Earth Geoscience, Santa Fe, NM,* January 2024.
[48] *Committee on Seismology and Geodynamics, National Academy of Sciences*, November 2023.
[47] *University of California, Berkeley, Berkeley Seismological Laboratory Seminar*, August 2023.
[46] *American Geophysical Union*, December 2023.
[45] *ERC TECTONIC Workshop: Earthquake Physics and Applications of Machine Learning to Tectonic Faulting*, Rome, Italy, September 2023.
[44] *Earthquake Research Institute*, *University of Tokyo*, December 2022.
[43] *Seismological Laboratory Centennial Celebration*, November 2022.
[42] *Kavli Frontiers of Sciences, 3rd Japanese-American-German FOS*, *Beckman Center of the National Academies of Sciences and Engineering*, Sept 2022.
[41] *University of California, Los Angeles, Departmental Colloquium*, May 2022
[40] *American Geophysical Union, New Orleans, LA,* December 2021
[39] *Sala Baldini, Rome, Physics of Earthquake Faulting: Machine Learning to Illuminate Earthquake Precursors and Predict Laboratory Earthquakes*, September 2021.
[38] *Rice University, Earth, Environmental and Planetary Sciences Department Seminar*. November 2021.
[37] *Center for Nonlinear Studies, Los Alamos National Laboratory*, *Machine Learning in Solid Earth Geoscience,* March 2021.
[36] *University of Toronto, Geophysics seminar*. February 2021.
[35] *Michigan State University*, *Computational Mathematics, Science and Engineering Colloquium,* October 2020.
[34] *Earth2Earth UK-wide Zoom Seminar*, October 2020.
[33] *University of Utah*, *Distinguished Lecture Series,* September 2020.
[32] *Deformation and Tectonics (DeTect) Zoom Seminar series,* September 2020.
[31] *American Geophysical Union*, December 2020.
[30] *Geological Society of America*, October 2020.

[29] *Center for Nonlinear Studies, Los Alamos National Laboratory, Machine Learning in Solid Earth Geoscience*, Santa Fe, NM, March 2020. (canceled due to COVID-19).
[28] The structural architecture of fault zones and its role in earthquake physics, *University of California, Los Angeles, Tectonics Seminar,* November 2019.
[27] Searching for hidden earthquakes in Southern California, *Committee on Seismology and Geodynamics, National Academy of Sciences*, Washington DC, October 2019
[26] How deep learning is transforming earthquake seismology, *IST seminar, Dept. of Computing and Mathematical Sciences, Caltech*, October 2019.
[25] The structural architecture of fault zones at depth, *IRIS SAGE/GAGE*, Portland, October 2019
[24] The structural architecture of fault zones and its relation to earthquake physics, *Distinguished Lecturer Series, University of Utah*, October 2019.
[23] Earthquakes and the era of artificial intelligence, *Jet Propulsion Laboratory*, Pasadena, CA, September 2019.
[22] Earthquakes and the era of artificial intelligence, *Earthquake Research Institute, University of Tokyo*, Tokyo, Japan, August 2019.
[21] Earthquakes and the era of artificial intelligence, *Geological Survey of Japan, AIST*, Tsukuba, Japan, August 2019
[20] A Deep Learning Pipeline for Earthquake Detection, *StatSei11*, Hakone, Japan, August 2019.
[19] A Deep Learning Pipeline for Earthquake Detection, *Seismological Society of America Annual Meeting*, Seattle, WA, April 2019.
[18] A Deep Learning Pipeline for Earthquake Detection, *Machine Learning in Solid Earth Geoscience*, Santa Fe, NM, March 2019.
[17] A deep learning approach to seismic phase association, *American Geophysical Union*, Washington, D.C., December 2018.
[16] Detection of earthquakes, phases, and first-motion polarities with deep learning, *International Induced Seismicity Workshop*, Banff, Canada, October 2018.
[15] How big data and artificial intelligence are transforming seismology, *GPS Division Seminar, California Institute of Technology*, October 2018.
[14] Detecting millions of earthquakes in Southern California with template matching, *Southern California Earthquake Center*, Palm Springs, CA, September 2018.
[13] Earthquakes and artificial intelligence, *Berkeley Seismological Laboratory, UC Berkeley,* Berkeley, CA September 2018.
[12] Earthquakes and artificial intelligence, *United States Geological Survey, Golden*, Golden, CO, July 2018.
[11] Detecting millions of earthquakes in Southern California with template matching, *ETH Zurich*, June, 2018.
[10] Generalized seismic phase detectors with deep learning, *Seismological Society of America Annual Meeting*, Miami, FL, May, 2018.
[9] Generalized seismic phase detectors with deep learning, *Lawrence Livermore National Laboratory*, Livermore, CA, April 2018.
[8] Connecting fault zone structure and earthquake source processes, *IGPP Seminar, Scripps Institution of Oceanography*, San Diego, CA, January 2018.
[7] Aftershocks driven by afterslip and fluid pressure sweeping through a fault-fracture mesh. *American Geophysical Union*, New Orleans, LA, December 2017.

[6] Connecting fault zone structure and earthquake source processes, *University of California, Los Angeles,* Los Angeles, CA, October 2017.
[5] Using GPU clusters to detect millions of earthquakes in southern California with template matching. *Stanford University*, Stanford, CA, February 2017.
[4] Toward reliable automated estimates of earthquake source properties of body wave spectra. *American Geophysical Union*, San Francisco, CA, December 2016.
[3] Applying automatic techniques to large seismic datasets for comprehensive studies of regional and fault zone environments. Department of Earth and Planetary Sciences, *University of California, Santa Cruz*, Santa Cruz, CA, October 2015.
[2] Applying automatic techniques to large seismic datasets for comprehensive studies of regional and fault zone environments. Seismolab Seminar*, California Institute of Technology*, Pasadena, CA, April 2015.
[1] Automatic detection and picking of direct P, S and fault zone head & trapped waves. Tectonics Seminar, *Department of Earth and Space Sciences, UCLA*, Los Angeles, CA, January 2015.

Ph.D. students
Siavash Rahimi (2025-present; CMS)
Soyeon Park (2024-present; GPS)
Chenxi Kong (2023-present; GPS)
Rajani Shrestha (2023-present; GPS)
Caifeng Zou (2022-present; GPS)
Yaozhong Shi (2022-present; MCE, joint with D. Asimaki)
Valeria Villa (2021-present; GPS)
Yan Yang (2021-2023; GPS)
John Wilding (2020-present; GPS)
James Atterholt (2019-2024; GPS)
Angela Gao (2019-2025; main advisor K. Bouman in CMS)
Ben Strozewski (2019-2022; GPS)
Yuan-Kai Liu (2019-2022; GPS)

Postdoctoral Scholars
Taiyi Wang (2024-present) Incoming Assistant Professor, University of Texas, Austin
Huiyun Gao (2024-present)
Zhi-ang Chen (2023-present)
Hongyu Sun (2022-2024), Assistant Professor, University of Texas, El Paso
Greg Lavrentiadis (2022-2025), Assistant Professor, SUNY Buffalo. (Main: Domniki Asimaki)
Weiqiang Zhu (2021-2023), Assistant Professor, University of California, Berkeley
Manuel Florez-Torres (2019-2022) Assistant Professor, Universidad Industrial de Santander
Erik Ramirez (2021-2022), Researcher, Universidad Autónoma de Baja California
Jonathan Smith (2019-2021), Principal Research Scientist, British Antarctic Survey
Bing Li (2019-2021), Assistant Professor, University of Western Ontario

Visiting Scholars
Shinya Katoh (2024), Earthquake Research Institute, University of Tokyo
Hiromichi Nagao (2023), Earthquake Research Institute, University of Tokyo

Giulio Poggiali (2022), INGV, Roma, Italy