## Hao Hu, Ph. D. in Geophysics

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## Summary

I am a passionate Geophysicist working in energy resources and seismology, with a solid understanding of *seismic* wave propagation, imaging, and inversion. I have both academic and industry research experience which makes me specialize in thinking and solving problems practically.

I have published many peer-reviewed professional papers and conference abstracts, 3 patents (1 commercial license). I have been involved in multiple industry/academia funded projects, e.g., marine seismic imaging, and geothermal/$CO_2$/hydrocarbon fracture characterization. I have been doing research and developing industrial-level seismic imaging programs (CPU/GPU), including acoustic/elastic reverse-time imaging. acoustic/elastic full waveform inversion.

## Research Interests

- Exploration of unconventional/conventional resources, e.g., fossil/geothermal resources, $CO_2$ geological storage, using seismic methods.
- Understanding the subsurface structures, from near-surface to earth's interior, using both active-source seismic and earthquake signals, e.g., high-resolution imaging and inversion;
- Fundamental studies of seismic wave propagation, imaging, inversion, and machine learning.

## Expertise Areas

**Algorithm developments/applications**
- 3D Seismic imaging: marine and land
- Seismic signal processing and inversion
- Proprietary surface wave separation/removal
- Machine learning in seismic studies
- Geothermal/fossil/$CO_2$-storage reservoir characterization

**Fundamental Research**
- Seismic elastic wave modeling, high-resolution imaging, and inversion
- HPC using large-scale GPU/CPU
- Nonlinear signal processing
- Stochastic inversion of heterogeneity
- Seismology

## Professional Appointments

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|---|---|
| Aug 2024- | **Assistant Professor of Geophysics,** School of Geoscience, University of Oklahoma |
| Sep 2022 - | **Senior Research Geophysicist I** TGS, R&D at Houston, As a core researcher and developer for acoustic/elastic Full waveform inversion and reverse-time migration. |
| May 2022 - | **Research Assistant Professor** University of Houston |
| Apr 2015 - Apr 2022 | **Postdoctoral Research Fellow** University of Houston |
| Jun 2013 - Aug 2013 | **Internship** Statoil (Beijing) Technology Service Co., Ltd |

## Education

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|---|---|
| Sep 2009 - Jan 2015 | **Ph. D. in Geophysics** Thesis: Seismic Prestack Depth Migration: Reverse Time Migration and Gaussian Beam Migration. Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing, China. |
| Sep 2005 - Jun 2009 | **B. S. in Geophysics** Yunnan University, Kunming, China. |

## Patents

- Patent (with Y. Zheng) "Nonlinear signal comparison and high-resolution measurement of seismic or acoustic wave dispersion". *One commercial license has been authorized by an industry company.*
- Patent (With Y. Zheng) "Surface wave prediction and removal from seismic data".
- Patent (With Y. Liu) "Seismic prestack migration imaging method", CN102944894B.

## Selected publications:

Faqi Liu, Cosmin Macesanu, **Hao Hu**, Fuchun Gao, Yi Huang, Ge, Zhan, James Sheng, Yang He, Carlos Calderon, Bin Wang, Enhance P wave imaging using elastic dynamic matching FWI, 2024, EAGE extended abstract.

**Hu H.**, Ge Zhan, Faqi Liu, Carlos Cardanons, Bin Wang, 2023, Enhance the subsalt imaging of DAS-VSP using angle-controlled RTM, EAGE extended abstract. Link.

**Hu, H.**, Y. Zheng, L. Huang and K. Gao, 2023, Imaging steeply-dipping faults using angle-controlled decoupled *elastic reverse-time migration* of multicomponent seismic data, **IEEE, TGRS**, PDF.

Wu., B., **H. Hu**, and H. Zhou, 2023, Convolutional Neural Network Assisted Least-Squares Migration, **Surveys in Geophysics**, accepted. Link. PDF.

**Hu, H.,** M. A. Alali, A., Almomin, and Y. Zheng, 2021, 3D Seismic Characterization of Fractures Using *Elastic P-to-S* Double-Beams, **Geophysics**, 86(6): 1-51. Link, PDF

Ding Y., **H. Hu**\*, A. Malallah, M. C. Fehler, L. Huang, and Y. Zheng, 2021, Mapping subsurface karsts and voids using directional *elastic wave packets*, **Geophysics**, 86(6): 1-67. Link, PDF

**Hu, H**., and Y. Zheng, 2020, *Stochastic inversion* of Gaussian random media using transverse coherence functions for reflected waves, **JGR: Solid Earth,** 125(12). Link, PDF

**Hu, H.**, K. Xia, F. Hilterman, and Y. Zhang, 2020, Amplitude-versus-angle analysis of *local angle-domain common image gathers* with prestack Gaussian beam migration of Seismic data**, IEEE, TGRS**, 58(8): 5969-5975. Link, PDF

Wei, Z., **H. Hu**\*, A. Lau and H. W. Zhou, 2019, Characterizing the rock facies using *convolutional neural network* with feature engineering and a data padding strategy, **Pure and Applied Geophysics,** 176(8): 3593-3605. Link, PDF

**Hu, H.,** M. Senkaya and Y. Zheng, 2019, A novel measurement of the *surface wave dispersion* with high and adjustable resolution: Multi-channel nonlinear signal comparison, **Journal of Applied Geophysics**, 160: 236-241. Link, PDF

Eftekhar, R., **H. Hu**\* and Y. Zheng, 2018, Convergence acceleration in scattering series and seismic *waveform inversion* using nonlinear Shanks transformation, **Geophysical Journal International**, 214(3): 1732–1743. Link, PDF

**Hu, H.**, Y. Liu, Y. Zheng, X. Liu and H. Lu, 2016, *Least-squares Gaussian beam* migration, **Geophysics**, 81(3), S87-S100. Link, PDF

## Projects/Grants

| 2022, | Developing the new kernel of elastic/acoustic full-waveform inversion and RTM in the TGS Imaging Research & Development team. |
|---|---|
| 2022, | Optimizing the RTM GPU algorithm and applying it to DAS-VSP in the TGS Imaging Research & Development team. |
| 2021/2022 | Resubmitted. Heterogeneity Signatures of Mantle Phase Changes and their Implications for Thermochemical Mixing of Earth's Interior, to NSF, $900k. PI: Vernon Cormier (UConn), CoPI: Hao Hu, Jin Zhang (Univ. of New Mexico), Lars Stixrude (UCLA), Carolina Lithgow-Bertelloni (UCLA). I am the CoPI ($160k) for 3D seismic elastic modeling and seismic stochastic measurement and inversion of heterogeneity. |
| 2021-  $1.01m, | Seismic elastic double-beam characterization of faults and fractures for CO2 storage site selection, from DOE, PI: Yingcai Zheng, CoPI, Lianjie Huang (Los Alamos National Lab), I am the principal participant in UH. |
| 2021-  $1.12m, | Detecting and characterizing fracture zones using convolutional neural network, Phase II, from DOE, PI: Yingcai Zheng, CoPI, Lianjie Huang (Los |

|          |          |                                                                                       |
|----------|----------|---------------------------------------------------------------------------------------|
|          |          | Alamos National Lab), I am the principal participant in UH.                            |
| 2020-    | $314k,   | Verification of predicated shear wave splitting due to strong seismic anisotropy in subducting slabs, from NSF, PI: Yingcai Zheng, I am the principal participant. |
| 2019-    | $625k,   | Detecting and characterizing fracture zones using convolutional neural network, from DOE, PI: Yingcai Zheng, CoPI: Lianjie Huang (Los Alamos National Lab), I am the principal participant in UH. |
| 2019:    | $1200,   | Postdoc travel grant, UH.                                                              |
| 2019:    | $51k,    | Independent review of Brazilian seismic activity and subsidence – Phase 1. From Braskem, PI (Aibing Li), CoPI (Yingcai Zheng), <span style="color:red">I am the CoPI for Geomechanics modeling.</span> |
| 2018-2019: $460k, | | Development of Fracture characterization, From Aramco Services Company Houston, PI: Yingcai Zheng, I am the principal participant. |
| 2017-2018: $49.6k, | | Super-resolution subsurface and medical imaging, Technology GAP Fund, to commercialize our surface wave patents, from UH. |
| 2016-2017: $87k, | | High-resolution geophysical imaging of subsurface Fractures. 20-20 Reservoirs, PI: Yingcai Zheng, I am the principal participant. |
| 2015-2016: $59k, | | Seismic Inversion of Fracture Parameters Using Multiply Scattered Waves. From Sinopec Tech Houston, PI: Yingcai Zheng, I am the principal participant. |
| 2013-2014: $101k, | | Microseismic monitoring in Shengli oil/field, China. From Shengli oil field research center. PI, Prof. Yike Liu, I am the principal participant for the whole project. |
| 2011-2013: $370k, | | Suppression of surface-related multiples and seismic response of the reservoir in China, South sea. From China National Science Foundation, PI. Prof. Yike Liu, I am the principal participant for marine seismic imaging. |

## Programming Expertise

**C/C+**: independently developed algorithms: e.g., 3D finite-difference acoustic/elastic forward modeling, 3D reverse-time migration, least-squares migration, and Gaussian beam migration, full-wave form inversion.

**Fortran**: independently developed various types of forward modeling algorithms (e.g., acoustic/elastic/decoupled/anisotropic), and elastic reverse-time migration; modified many open-source codes, e.g., specfem3D, Geomechanics modeling.

**Matlab**: independently developed many algorithms (e.g., surface waves, forward modeling and imaging algorithms, signal processing, fracture characterization), GUI design and optimization (CougarSeismic), and acceleration using CPU/GPU.

**Parallel computing**: solid understanding of CPU/GPU HPC from hardware architecture to algorithm; experienced in *MPICH*, *OpenMP*, and *CUDA* (GPU); all computationally-heavy codes are performed on HPC.

**Python**: Numerical calculation, Devito wave solver, Numba, TensorFlow.

**Others**: Shell, Linux, Git.

## Awards and Honors

2023. Research Bright spot for elastic/acoustic wave propagation used in FWI and RTM, TGS.

2019. Postdoctoral travel award, UH.

2014. "Excellent Graduate Student Award" in the Institute of Geology and Geophysics, Chinese Academy of Sciences.

2013. "Excellent paper award" at the 29th Chinese Geophysics Annual Meeting.

## Professional Societies

SEG (Society of Exploration Geophysicists)

EAGE (European Association of Geoscientists and Engineers)

AGU (American Geophysical Union)

## Professional services

I served as a reviewer for over 100 manuscripts in multiple professional journals and conferences,

including Geophysics, Geophysics prospecting, Journal of Applied Geophysics, IEEE TGRS, IEEE GRSL, Geothermics, JGR Planets, AGU books, SEG/IMAGE. I also served as a guest associate editor for the Journal of Frontiers in Earth Science.

# *Full list of publications*

## *Papers in Peer-reviewed Journals (\* corresponding author).*

### Under review/in preparation

46. Sharmila Appini, J. Li., **H. Hu**, N. Creasy, L. Thomsen, Y. Zheng, Prediction of Complex Observed Shear Wave Splitting Patterns at Ryukyu Subduction Zone Using a Strong Intra-slab Anisotropy Model, Seismological Research Letters, under review.

45. Zhehao Li, Hua-Wei Zhou, Boming Wu , **Hao Hu**, and William Sager, Challenges and opportunities in imaging deep seafloor structures with a 2D green seismic survey in the South Atlantic Ocean, in preparation.

44. **Hu, H.**, J. Li, J. Zhang, Y. Zheng, V. Cormier, Amount of Subducted Basaltic Crust at the Core-Mantle Boundary Beneath Japan Revealed by PKPdf and PKPbc Waves, in preparation.

43. **Hu, H.,** Y. Zheng, and O. Yilmaz, NLSC-PAS: a robust novel data-driven surface wave separation method, **The Leading Edge,** in preparation.

### 2023

42. Y. Zheng and **H. Hu**, F. J. Spera, M. Scruggs, G. Thompson, Y. Jin, T. Lapen, S. R. McNutt, K. Mandli, Z. Peng, 2023, D. A. Yuen, Episodic Magma Hammers for the 15 January 2022 Cataclysmic Eruption of Hunga Tonga-Hunga Ha`apai, Geophysical Research Letters 50(8), e2023GL102763. Link. PDF

41. Boming Wu, **Hao Hu**, and Hua-wei Zhou, 2023, Convolutional Neural Network Assisted Least-Squares Migration, **Surveys in Geophysics**, accepted. Link. PDF

40. **Hu H.,** Y. Zheng, L. Huang and K. Gao, 2023, Imaging steeply-dipping faults using angle-controlled decoupled elastic reverse-time migration of multicomponent seismic data, **IEEE, Transactions on Geoscience and Remote Sensing**, 61. Link. PDF.

39. Tang, S., Y. Zheng, H.W Zhou, **H. Hu,** 2023, Earthquake stress drop for a circular crack in an anisotropic medium, **BSSA**, 113(1). Link.

### 2022

38. Zhou, H.W., Z. Zou, W. Zhang, Q. Liu, and **H. Hu**, 2022, Editorial: Reverse Time Imaging in Solid Earth and Exploration Geophysics, **Frontiers in Earth Science**, accepted. Link.

37. David, A. Yuen, Melissa A. Scruggs, Frank J. Spera, Yingcai Zheng, **Hao Hu**, Stephen R. McNutt, Glenn Thompson, Kyle Mandli, Barry R. Keller, Songqiao Shawn Wei, Zhigang Peng, Zili Zhou, Francesco Mulargia, Yuichiro Tanioka, 2022, Under the surface: Pressure-induced planetary-scale waves, volcanic lightning, and gaseous clouds caused by the submarine eruption of Hunga Tonga-Hunga Ha'apai volcano, **Earthquake Research Advances**, Link, PDF.

### 2021

36. Gao, K., L. Huang, Y. Zheng, R. Lin, **H. Hu**, and T. Cladouhos, 2021, Automatic fault detection on seismic images using a multiscale attention convolutional neural network, **Geophysics**, in press. Link**,** PDF

35. **Hu, H.,** M. A. Alali, A., Almomin, and Y. Zheng, 2021, 3D Seismic Characterization of Fractures Using Elastic P-to-S Double-Beams, **Geophysics**, 86(6): 1-51. Link, PDF

34. Ding Y., **H. Hu**\*, A. Malallah, M. C. Fehler, L. Huang, and Y. Zheng, 2021, Mapping subsurface karsts and voids using directional elastic wave packets**, Geophysics**, 86(6): 1-67. Link, PDF

33. Lin, R., **H. Hu**, Y. Ding, L. Huang, K. Gao, and Y. Zheng, 2021, Improving the image quality of high-angle interfaces and subsalt sediments using high-order scattered seismic waves, **Pure and Applied Geophysics**, 178(5):1-15, 10.1007/s00024-021-02741-y. Link, PDF

32. Wo, Y., J. Zong, **H. Hu,** H.W. Zhou and R. Stewart, 2021, Velocity model building for a single-offset VSP data via deformable-layer tomography: A Texas salt dome example, **Geophysics**, 86(4): 1-44. Link, PDF

31. Yi, J., Y. Liu, **H. Hu**, Y. Zhang and Z. Yang, 2021, High-resolution multimode surface-wave dispersion spectrum imaging with a multichannel signal comparison method, **Chinese Journal of Geophysics**. 64(5): 1710-1720, doi: 10.6038/cjg2021O0184. Link, PDF

**2020**

30. **Hu, H**., and Y. Zheng, 2020, Stochastic inversion of Gaussian random media using transverse coherence functions for reflected waves, **Journal of Geophysical Research: Solid Earth,** 125(12), https://doi.org/10.1029/2020JB020385. Link, PDF

29. Thongsang, P., **H. Hu**\*, H.W. Zhou and A. Lau, 2020, Imaging enhancement in angle-domain common-image-gathers using the connected-component labeling method, **Pure and Applied Geophysics,** 177: 4897–4912. Link, PDF

28. Li, D., X. Tian, **H. Hu**, X. Tang, X. Fang and Y. Zheng, 2020, Gaussian beam imaging of fractures near the wellbore using sonic logging tools after removing dispersive borehole waves, **Geophysics**, 85(4): 1-47. Link, PDF

27. Wo, Y., H.W. Zhou, **H. Hu**, Y. Ding and J. Zong, 2020, A Layer-cell Tomography Method for Near-surface Velocity Model Building Using First Arrivals, **Pure and Applied Geophysics**, 1-15. Link, PDF

26. **Hu, H.**, K. Xia, F. Hilterman, Y. Zhang, 2020, Amplitude-versus-angle analysis of local angle-domain common image gathers with prestack Gaussian beam migration of Seismic data, **IEEE, TGRS**, 58(8): 5969-5975. Link, PDF

**2019**

25. **Hu, H**., and Y. Zheng, 2019, Data-driven dispersive surface-wave prediction and mode separation using high-resolution dispersion estimation, **Journal of Applied Geophysics**, 171: 1-10. Link, PDF

24. Li, L., Y. Chen, Y. Zheng, **H. Hu** and J. Wu, 2019, Seismic Evidence for Plume-Slab Interaction by High-resolution Imaging of the 410-km Discontinuity Under Tonga**, Geophysical Research Letters**, 46(23): 13687-13694. Link, PDF

23. Driel, M., S. Ceylan, J. F. Clinton, D. Giardini, R. Weber, P. Lognonn´e, B. Banerdt, M.Drilleau, N. Murdoch, M. Panning, R. Garcia, D. Mimoun, M. Golombek, J. Tromp, M. B¨ose1, I. Daubar, B. Kenda, A. Khan, L. Perrin, A. Spiga, M. S. Boxberg, M. Parath, M. Ditz, A.Lamert, T. M¨oller, S. Zhang, D. Ambrois, J. Ch`eze, F. Peix, H. Alemany, D. Mercerat, J. Balestra, A. Deschamp, C. Twardzik, L. Rolland, S. Mader, L. Marten, C. Schr¨oer, D.Becker, T. Casademont, F. Dethof, D. Essing, K. Grunert, C. Hadziioannou, G. Hein, I.Hochfeld, T. Kilchling, F. Mehrkens, P. Neumann, R. Neurath, R. Steinmann, N.Trumpik, P. Werdenbach-Jarklowski, **H. Hu**, J. Li, Y. Zheng, E. Stutzmann, M. Schimmel,C. Hammer, B. Knapmeyer-Endrun, S. C. St¨ahler, N. Brinkman, S. Kedar, F. Euchner, B.Fernando, M. Tsekhmistrenko, K. Hosseini, C. Haindl, H. Godwin, A. Szenicer, T. Garth, and A. Allam. 2019, Preparing for InSight: Evaluation of the Blind Test for Martian Seismicity, **Seismology Research Letters**, 90(4): 1518-1534. Link, PDF

22. Wei, Z., **H. Hu**\*, A. Lau and H. W. Zhou, 2019, Characterizing the rock facies using convolutional neural network with feature engineering and a data padding strategy, **Pure and Applied Geophysics,** 176(8): 3593-3605. Link, PDF

21. Zhang, Y., A. Li and **H. Hu**, 2019, Crustal structure in Alaska from receiver function analysis, **Geophysical Research Letters**, 46(3): 1284-1292. Link, PDF

20. **Hu, H.,** M. Senkaya and Y. Zheng, 2019, A novel measurement of the surface wave dispersion with high and adjustable resolution: Multi-channel nonlinear signal comparison, **Journal of Applied Geophysics**, 160: 236-241. Link, PDF

## 2018

19. Xia K., F. Hilterman and **H. Hu**, 2018, Unsupervised Machine Learning Algorithm for Detecting and Outlining Surface Waves, **Journal of Applied Geophysics**, 157, 73-86. Link, PDF

18. **Hu, H**., Y. Zheng, X. Fang and M. C. Fehler, 2018, 3D Seismic characterization of fractures with Random spacing Using the Double-Beam Method, **Geophysics**, 83(5): M63-M74. Link, PDF

17. Eftekhar, R., **H. Hu**\* and Y. Zheng, 2018, Convergence acceleration in scattering series and seismic waveform inversion using nonlinear Shanks transformation, **Geophysical Journal International**, 214(3): 1732–1743. Link, PDF

16. Zhou, H. W., **H. Hu,** Z. Zou, Y. Wo and O. Youn, 2018, Reverse time migration: A prospect of seismic imaging, **Earth-Science Reviews**, 179: 207-227. Link, PDF

15. **Hu, H**. and Y. Zheng, 2018, 3D Seismic Characterization of Fractures in a Dipping Layer Using the Double-beam Method, **Geophysics**, .83(2): V123-V134. Link, PDF

## 2017

14. Ding, Y., Zheng, Y., Zhou, H. W., Howell, M., **Hu, H**. and Zhang, Y., 2017. Propagation of Gaussian Wave Packets in complex media and application to fracture characterization, **Geophysical Journal International**, 210(2): 1244-1251. Link, PDF

13. Zheng, Y. and **H. Hu**, 2017, Nonlinear signal comparison and high-resolution measurement of surface wave dispersion, **Bulletin of the Seismological Society of America**, 107(3):1551-1556. Link, PDF

12. Liu, X., Y. Liu, H. Lu and **H. Hu,** 2017, Prestack correlative least-squares reverse time migration, **Geophysics**, 82(2): S159-S172. Link, PDF

## 2016

11. Liu, X., Y. Liu, **H. Hu**, Peng Li and M. Khan; 2016, Imaging of first-order surface-related multiples by reverse-time migration, **Geophysical Journal International**, 208(2): 1077-1087. Link, PDF.

10. Liu, Y., X. Liu, A. Osen, Y. Shao, **H. Hu** and Y. Zheng, 2016, Least-squares reverse time migration using controlled order multiples reflections, **Geophysics**, 81(5): S347-S357. Link, PDF.

9. **Hu, H.**, Y. Liu, Y. Zheng, X. Liu and H. Lu, 2016, Least-squares Gaussian beam migration, **Geophysics**, 81(3), S87-S100. Link, PDF

8. Zheng, Y., A. H. Malallah, M. C. Fehler and **H. Hu**, 2016, 2D full-waveform modeling of seismic waves in layered karstic media, **Geophysics**, 81, T19-T28. Link, PDF

## 2015

7. **Hu, H.**, Y. Liu, A. Osen and Y. Zheng, 2015, Compression of local slant stacks by the estimation of multiple local slopes and the matching pursuit decomposition, **Geophysics**, 80, WD175-187. Link, PDF

6. Liu, Y., **H. Hu**, X. Xie and Y. Zheng, 2015, Reverse time migration of internal multiples for subsalt imaging, **Geophysics**, 80, S175-S185. Link, PDF

5. **Hu, H.**, Y. Wang and X. Chang, 2015, Migration of free-surface-related multiples: removing artefacts using a water-layer model, **Journal of Applied Geophysics**, 112, 147-156. Link, PDF

4. Liu, Y., W. Zhu, L. Mi, J. Zhou and **H. Hu**, 2015, Migration of multiples from the South China sea, **Science China**, 45(2), 482-490. Link, PDF

3. Liu, X., Y. Liu, **H. Hu** and S. Xie, 2015, Focal transformation imaging of first-order multiples, **Chinese Journal of Geophysics**, 58(6), 1985-1997. Link, PDF

## Before 2015

2. Wang, Y., X. Chang and **H. Hu**, 2014, Simultaneous reverse time migration of primaries and free-surface related multiples without multiple prediction, **Geophysics**, 79, S1-S9.

Link, PDF

1. **Hu, H.**, Y. Liu, X. Chang, Y. Wang, X. Du and R. Yang, 2013, Analysis and application on boundary treatment for the computation of reverse-time migration, **Chinese Journal of Geophysics**, 2033-2042. Link, PDF

## *Abstracts in Professional Meetings:*

### 2024

58. Cosmin Macesanu, Faqi Liu, Yi Huang, **Hao Hu**, Carlos Calderon, Implementation aspects of elastic FWI and its application to sparse OBN surveys, in preparing, SEG extended abstract.

57. Ge Zhan, Fuchun Gao, Raheel Malik, Mitch Preston, Cosmin Macesanu, **Hao Hu**, Carlos Calderon, Bin Wang, Denis Kiyashchenko, Jonathan Wall, 2024, Optimizing DAS VSP Value through FWI Imaging, EAGE extended abstract.

56. Faqi Liu, Cosmin Macesanu, **Hao Hu**, Fuchun Gao, Yi Huang, Ge, Zhan, James Sheng, Yang He, Carlos Calderon, Bin Wang, 2024, Enhance P wave imaging using elastic dynamic matching FWI, EAGE extended abstract.

### 2023

55. Yingcai Zheng, **Hao Hu**, Muhammad Nawaz Bugti, Jake Parsons, Lianjie Huang, Kai Gao, Trenton Cladouhos3Characterizing Steam-Filled Fracture Zones at the Soda Lake Geothermal Field Using Seismic Double-Beam Neural Network (DBNN), PROCEEDINGS, 48th Workshop on Geothermal Reservoir Engineering, pp.9, Stanford University, Stanford, California, February 6-8, 2023. Link. PDF

54. **Hao Hu**, Ge Zhan, Faqi Liu, Carlos Cardanons, Bin Wang, 2023, Enhance the subsalt imaging of DAS-VSP using angle-controlled RTM, EAGE extended abstract. Link

53. Yingcai Zheng, Jake Parsons, **Hao Hu,** Lianjie Huang, 2023, Vector Double-Beam Characterization for Discrete Fractures in Geological Carbon Storage Sites, Seismological Society of America Annual Meeting.

### 2022

52. Jake Parsons, Yingcai Zheng, **Hao Hu**, Xinding Fang, Lianjie Huang, 2022, 3D Seismic Wave Modeling and Inversion in Fractured Media for Energy Transition, AGU fall conference.

51. Yingcai Zheng, **Hao Hu**, Frank Spera, Melissa Scruggs, Glenn Thompson, Yuesu Jin, Tom Lapen, Steve McNutt, Kyle Mandli, Zhigang Peng, Dave A. Yuen, 2022, Episodic magma hammer forces causing the recent cataclysmic Hunga Tonga-Hunga Ha'apai eruption, AGU fall conference.

50. Yingcai Zheng, **Hao Hu**, Jiaxuan Li, Jin Zhang, Vernon Cormier, Ru-Shan Wu, Michael Fehler and Thorne Lay, 2022, Volume Fraction of Subducted Basaltic Crust Above the Core-Mantle Boundary Revealed by PKPdf and PKPbc Waves, AGU fall conference.

49. Sharmila Appini, **Hao Hu**, Jiaxuan Li, Yingcai Zheng, 2022, Understanding Backazimuth Dependence of Shear Wave Splitting Patterns of S Waves Transmitted Through Strongly Anisotropic Slabs, AGU fall conference.

48. Zheng, Y., **H. Hu**, F. Spera, M. Scruggs, K. Mandli, Y. Jin, Z. Peng, G. Thompson, S. R. McNutt, D. Yuen, 2022, Early Episodic Eruption Characteristics of the January 2022 Hunga Tonga-Hunga Ha'apai Volcanic Activities, SSA Annual Meeting. Bellevue, WA, April 19-23. Oral Presentation.

47. Zheng, Y., R. Lin, L.A. Thomsen, J.X. Li, **H. Hu**, 2022, An Inclusion Model for the Origin of Slab Anisotropy and the Influence on Earthquake Moment Tensors, SSA Annual Meeting, Bellevue WA, April 19-23. Poster Presentation.

### 2021

46. Zhang, Y., A. Li, **H. Hu**, and Z. Tao, 2021, Love wave tomography with mode separation analysis in Northeastern America, AGU fall conference.

45. Appini, S., Y. Zheng, **H. Hu,** J. Li, 2021, Evaluating intra-slab anisotropy using shear wave splitting patterns at west pacific subduction zones, AGU fall conference.
44. **Hu, H,** Y. Zheng and L. Huang, 2021, Imaging high-angle faults in geothermal fields using multi-component seismic data, AGU fall conference.
43. **Hu, H**, Y. Zheng and L. Huang, 2021, Multicomponent imaging of vertical faults using multiple seismic scattering, Geothermal Rising Conference 2021.
42. Zheng, Y., J. Li, **H. Hu,** K. Gao, L. Huang and T. Cladouhos, 2021. Seismic Double-beam Neural Network Approach to Characterizing Small-Scale Fractures in Geothermal Fields, Geothermal Rising Conference 2021.
41. Zheng Y., J. Li, R. Lin, **H. Hu**, K. Gao and L. Huang, 2021, Physics-Guided Machine Learning Approach to Characterizing Small-Scale Fractures in Geothermal Fields, 46th Workshop on Geothermal Reservoir Engineering, Proceedings, Stanford.
40. Gao K., L. Huang, R. Lin, **H. Hu,** Y. Zheng and T. Cladouhos, 2021, Delineating Faults in the Soda Lake Geothermal Field Using Machine Learning, 46th Workshop on Geothermal Reservoir Engineering, Proceedings, Stanford.

**2020**
39. Zhang Y., A. Li and **H. Hu.,** 2020, Separation of Multi-Mode Waveforms for Love Waves Using a Stacking-and-Stripping Technique, AGU fall conference. Link.
38. **Hu H**. and Y. Zheng, 2020, Inversion of random heterogeneity power spectrum using the transverse coherence functions of reflected waves, AGU fall conference. Link.
37. Lin R., **H. Hu**, Y. Ding, L. Huang, K. Gao, and Y. Zheng, 2020, Improving subsalt sediment imaging and high angle faults using secondary scattered seismic waves, SEG, Expanded abstracts. Link, PDF.
36. Lin R., **H. Hu** and Y. Zheng, 2020, Seismic imaging with weighted stacking of common-image gathers, SEG, Expanded abstracts. Link, PDF.

**2019**
35. **Hu H.,** Y. Zheng and V. F. Cormier, 2019, Probing the Inner Core using near-vertical PKIIKP and frequency dependent amplitude ratio of PKiKP/PcP, AGU fall conference. Link.
34. Zheng Y., P. Given, **H. Hu** and J. Li, 2019, Non-double-couple mechanisms of deep earthquakes and anisotropic rock fabrics of subducting slabs, AGU fall conference. Link.
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