TCCS
Texas Consortium for Computational Seismology

Fall 2024 Newsletter

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Texas Consortium for Computational Seismology • The University of Texas at Austin

Welcome to the 28th *TCCS Newsletter*!

The Texas Consortium for Computational Seismology is a joint initiative of the Bureau of Economic Geology (BEG) and the Oden Institute for Computational Engineering and Science at The University of Texas at Austin. Its mission is to address the most critical and challenging research problems in computational geophysics as experienced by the energy industry while educating the next generation of research geophysicists and computational scientists.

Fall Meeting

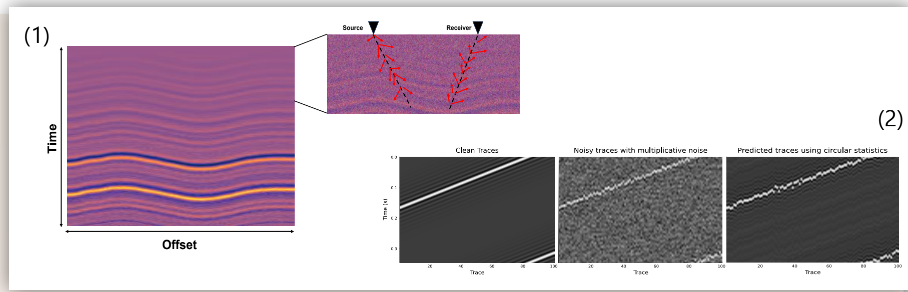
The Fall 2024 Research Meeting of the Texas Consortium for Computational Seismology will take place in Austin on November 7–8. Hosted by the Bureau of Economic Geology, it will be held at the University of Texas at Austin, J.J. Pickle Research campus.

Representatives of participating companies are invited to register for the meeting by following the link at https://tccs.beg.utexas.edu/.

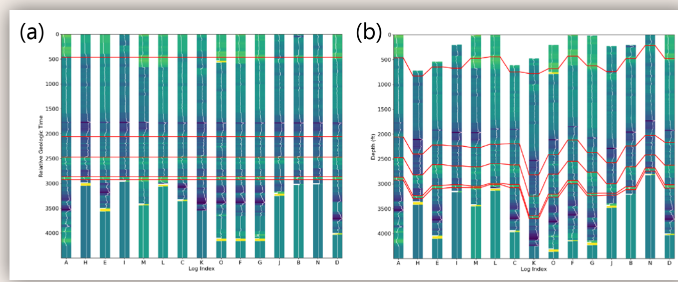
Presentations at IMAGE 2024

Tuesday, August 27	8:00–8:25	SMT 1: Advanced Seismic Modeling in Frequency Domain and Attenuative Media	**J. Badger**, **A. Bakulin**, and **S. Fomel**	Scalable, efficient, and adaptive simulation of frequency-domain wave propagation
	8:25–8:50	SMT 1: Advanced Seismic Modeling in Frequency Domain and Attenuative Media	**J. Badger**, **A. Bakulin**, and **S. Fomel**	Advancing subsurface modeling: Towards accurate and efficient simulation of topography, heterogeneity, and attenuation in the frequency domain
	10:20–12:00	AAS P2: Reservoir Property Estimation 1	**C. Li**, and S. Bhattacharya	Seismic amplitude variation with angle response of hydrogen-saturated rock: Implications on subsurface monitoring
	10:20–12:00	IPS P1: Automatic and Monitoring using Machine Learning/Artificial Intelligence	J. Qiao, J. Li, Y. Xue, W. Xu, and **Y. Chen**	High precision microseismic phase picking and monitoring based on advanced deep learning
	1:20–3:00	IPS P3: Fractures and Induced Seismicity	**Y. Chen**, A. Savvaidis, O. Saad, D. Siervo, D. Huang, Y. Chen, I. Grigoratos, **S. Fomel**, and C. Breton	Complete detection of small earthquakes uncovers intricate relation between injection and seismicity
	3:40–5:20	CO^2 P2: Site Selection and Monitoring 1	S. Bhattacharya, S. Bakhshian, and **S. Swaminadhan**	A new workflow to assess the feasibility of CO^2 plume monitoring by time-lapse seismic modeling: A case study from the Decatursite, United States
Wednesday, August 28	8:50–9:15	RC 1: Methods for Fracture Characterization	J. Lee, **Y. Chen**, R. Dommisse, and A. Savvaidis	Rock physics attribute analysis for identifying brittle zones in upper delaware basin formations
	8:50–9:15	SP 5: Seismic Data Interpolation and Regularization 3	**Y. Chen**, H. Wang, C. Li, and O. Saad	Pushing the limit of 5D interpolation using deep learning
	10:20–12:00	ACQ P2: Denoise and Deblending	**A. Bakulin**, I. Silvestrov, and D. Neklyudov	Beneficial impacts of receiver arrays on suppressing seismic speckle noise from near-surface heterogeneities: A reflection of 3D seismic acquisition practices in the Middle East
	10:20–12:00	ACQ P2: Denoise and Deblending	**Y. Chen**, M. Zhou, and **R. Abma**	3D deblending for marine towed-streamer data
	10:20–12:00	BH P2: Deep Learning Applied to Wellbore Log Data	**H. Corzo-Pola**; S. Saleh, and **S. Fomel**	Near-optimal correlation sequences using reinforcement learning with deep Q-networks
	10:20–12:00	DAS P4: Surface Cable Applications	**Y. Chen**, H. Wang, R. Min, and Y. Chen	Recovering the invisible signals for urban traffic monitoring using distributed acoustic sensing
	10:20–12:00	SP P11: Noise Removal 1	**A. Rohatgi**, **A. Bakulin**, and **S. Fomel**	Phase pilot recovery: A foundation for mitigating speckle scattering noise in seismic data
	1:20–3:00	TL P1: Acquisition and Processing 2	**A. Bakulin**, I. Silvestrov, and H. Al Salim	Statistical imaging through strongly scattering near-surface with path summation techniques
	3:40–5:20	NS P11: Seismic Imaging and Inversion 1	**A. Bakulin**, I. Silvestrov, M. Protasov, and D. Neklyudov	Statistical imaging through strongly scattering near-surface with path summation techniques
Thursday, August 29	8:00–9:40	DAS P5: Processing and Quality Control 1	Y. Cui, U. Bin Waheed, and **Y. Chen**	Background noise suppression for DAS-VSP data using attention-based deep image prior
	8:50–9:15	ACQ 3: Survey Design and Modeling	A. Rabaan, A. Tura, **A. Bakulin**, and I. Silvestrov	Quantitative assessment tools for objective-based optimization of seismic acquisition geometry selection
	9:15–9:40	ACQ 3: Survey Design and Modeling	**A. Bakulin**, and I. Silvestrov	Approximate yet essential: Advocating for a comprehensive seismic acquisition equation to guide single-sensor adoption
	10:20–12:00	TL P4: Improvements in Time-Lapse Analysis 2	**S. Gao**, **S. Fomel**, and **Y. Chen**	Generating high-quality labels for deep learning CO^2 monitoring using local orthogonalization
	10:20–12:00	RP P4: CO^2 Sequestration Applications 1	**S. Swaminadhan**, S. Bhattacharya, and **S. Fomel**	Effects of fluid saturation models on seismic response in carbon dioxide monitoring
	11:35–12:00	ACQ 4: Compressive Sensing	**R. Abma**	The application of simultaneous source technology to conventional acquisition
	1:20–3:00	FWI P9: Cycle Skipping	**T. Masthay**, and **B. Engquist**	Hyperbolic wasserstein distance for full-waveform inversion
	1:20–3:00	SP P22: Noise Removal 2	**S. Swaminadhan**, S. Bhattacharya, and **S. Fomel**	Residual noise attenuation of post-stack seismic data using t-p-x decomposition
	2:35–3:00	IPS 3: Induced Seismicity	**Y. Chen**, O. Saad, A. Savvaidis, F. Zhang, Y. Chen, D. Huang, H. Li, and F. Zanjani	Massive focal mechanisms from deep learning in West Texas
	3:10–3:00	SP 14: Novel Solutions and Advanced Technologies 2	**A. Rohatgi**, **A. Bakulin**, and **S. Fomel**	Analyzing the impact of additive and multiplicative noise on seismic data analysis
	4:25–4:50	SP 15: Imaging Signal Enhancement	S. Saleh, and **S. Fomel**	Sparse-spike deconvolution revisited: thin-layer solution via reinforcement learning
Friday, August 30	9:50–10:30	W-13: Operating at Low-Cost: Autonomous Sources and Long-Term Monitoring	**A. Bakulin**	Geophysical use cases for long-term monitoring
	10:30–10:50	W-2: Advancements and the Road Ahead in 4D Seismic	**A. Bakulin**	How measuring SNR can help optimize your monitoring project
	2:05–2:25	W-6: Distributed Fiber-Optic Sensing in Applied Geophysics	**Y. Chen**	Deep learning for advanced DAS data processing and compression
	2:20–2:40	W-12: Memorial Seismic Deblending and Simultaneous Sourcing	**R. Abma**	Self-simultaneous source acquisition, accuracy, and deblending

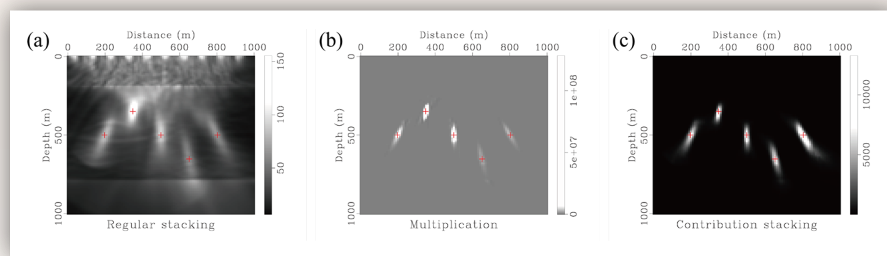
Research Highlights



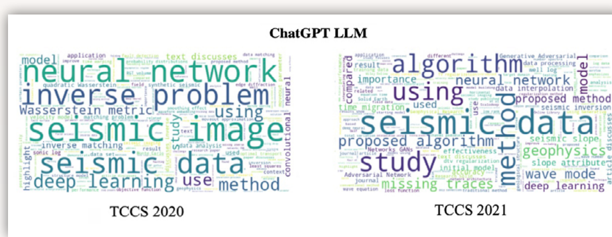
Akshika Rohatgi has been working on understanding the near-surface heterogeneities that cause seismic waves to scatter, leading to severe distortions in seismic signals (Figure 1). This kind of noise, known as "seismic speckle noise," destroys the seismic signal's phases. The phase spectrum provides essential information about the time-domain structure of the signal, and phase-only reconstruction tends to preserve the events' location. Circular statistics can be used to predict the phases in the frequency domain and quantify the amount of speckle noise in seismic data. Figure 2 shows the reconstruction of reflectors affected by seismic speckle noise using circular mean analysis to correct the phases.



Hector Corzo Pola has been working on finding near-optimal well-log correlation sequences using reinforcement learning with deep Q-learning agents. In automatic sequential well-log correlation, the correlation quality depends on the order in which logs are aligned. The number of possible correlation sequences increases factorially, making an exhaustive evaluation of every possible correlation sequence's quality computationally unfeasible for many wells. Instead of evaluating all possible sequences, deep Q-learning agents learn how to follow near-optimal correlation sequences from a random subset of correlation sequences. The figure shows Teapot Dome's gamma-ray logs: a) as sorted and aligned by a deep Q-learning agent, and b) as they were before alignment, but with the correlation markers from the previous step mapped to their proper depth.



Rui Gong has been working on time reversal imaging for passive seismic source localization, using back-propagated wavefields with an appropriate imaging condition. Traditional imaging conditions, such as regular stacking, offer low resolution. Although the multiplication imaging condition provides higher resolution, it can be unstable and may lose physical meaning. Contribution stacking, a weighted non-stationary summation method, assumes that the wavefields from one receiver should approximately equal the sum of wavefields from others, leading to significantly improved localization with resolution comparable to that of multiplication. The figures show localization results in a three-layer model using (a) regular stacking, (b) multiplication, and (c) contribution stacking.



Shirley Mensah has been working on applying ChatGPT Large Language Modales (LLM) to the analysis of UT Austin research publications to streamline and enhance the extraction of meaningful insights from the publications. By leveraging advanced natural language processing techniques, the LLM can automatically summarize, categorize, and extract keywords from a large corpus of research papers. The LLM identifies key themes and trends across years of publications, enabling researchers to navigate and analyze the growing body of literature efficiently. The figure shows word clouds of extracted keywords done by the LLM: a) TCCS 2020 Research Word Clouds and b) TCCS 2021 Research Word Clouds, highlighting the most frequently occurring research terms that give insight into the fields of research being conducted throughout the years.

Papers Accepted and Published 2023–2024

http://www.beg.utexas.edu/tccs/publications

Accepted

A. Bakulin, Neklyudov, D., and I. Silvestrov, 2024, The impact of receiver arrays on suppressing seismic speckle scattering noise caused by the meter-scale near-surface heterogeneity: Geophysics, accepted.

Y. Chen, A. Savvaidis, S. Fomel, Y. Chen, O. Saad, H. Wang, Y. Oboué, L. Yang, and W. Chen, 2024, Denoising of distributed acoustic sensing seismic data: Seismological Research Letters, accepted.

S. Liu, C. Birnie, A. Bakulin, A. Dawood, I. Silvestrov, and T. Alkhalifah, 2024, A self-supervised scheme for ground roll suppression: Geophysical Processing, accepted.

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Y. Chen, A. Savvaidis, O. Saad, D. Siervo, D, Huang, Y. Chen, S. Fomel, I. Grigoratos, C. Breton, 2024, Thousands of induced earthquakes per month in West Texas detected Using EQCCT: Geosciences, v. 14, 114.

B. Engquist, K. Ren, and Y. Yang, 2024, Adaptive state-dependent diffusion for derivative-free optimization: Communications on Applied Mathematics and Computation, v. 6, 1241–1269.

S. Fomel and J. Claerbout, 2024, Streaming prediction-error filters: Geophysics, v. 89, F89–F95.

Z. Geng, S. Fomel, Y. Liu, Q. Wang, Z. Zheng, and Y. Chen, 2024, Streaming seismic attributes: Geophysics, v. 89, A7–A10.

H. Kaur, J. Sun, M. Aharchaou, A. Baumstein, and S. Fomel, 2024, Deep learning framework for true amplitude imaging: Effect of conditioners and initial models: Geophysical Prospecting, v. 72, 92–106.

C. Li, G. Liu, X. Chen, Z. Li, S. Fomel, and Y. Chen, 2024, Joint reconstruction and multiple attenuation using one-step randomized-order damped rank reduction method: IEEE Transactions on Geoscience and Remote Sensing, v. 62, 5921611.

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Y. Oboué, Y. Chen, S. Fomel, W. Zhong, and Y. Chen, 2024, An advanced median filter for improving the signal-to-noise ratio of seismological datasets: Computers and Geosciences, v. 182, 105464.

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Y. Sun, Silvestrov, A., Bakulin, A., 2024, An efficiency-improved GPU algorithm for the 2 + 2 + 1 method in nonlinear beamforming: Journal of Geophysics and Engineering, 21 (4), 1138–1152.

L. Yang, S. Fomel, S. Wang, X. Chen, O. Saad, and Y. Chen, 2024, Salt3DNet: A self-supervised learning framework for 3D salt segmentation: IEEE Transactions on Geoscience and Remote Sensing, v. 62, 5913115.

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L. Yang, S. Fomel, S. Wang, X. Chen, Y. Sun, and Y. Chen, 2024, Interpretable unsupervised learning framework for multi-dimensional erratic and random noise attenuation: IEEE Transactions on Geoscience and Remote Sensing, v. 62, 5911820.

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A. Aldawood, Shaiban, A., Alfataierge, E., and A. Bakulin, 2023, Acquiring and processing deep dual-well DAS walkaway VSP in an onshore desert environment: The Leading Edge 42 (10), 676–682.

A. Bakulin, D. Neklyudov, and I. Silvestrov, 2023, Seismic time-frequency masking for suppression of seismic speckle noise: Geophysics, v. 88, V371–V385.

A. Bakulin., Ramdani, A., Neklyudov, D., and I. Silvestrov, 2023, Meter-scale geologic heterogeneity in the near surface explains seismic speckle scattering noise: The Leading Edge, 42 (10), 654–724.

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Y. Chen, A. Savvaidis, and S. Fomel, 2023, Dictionary learning for single-channel passive seismic denoising: Seismological Research Letters, v. 94, 2840–851.

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K. Gadylshin, I. Silvestrov, and A. Bakulin, 2023, Deep-learning-based local wavefront attributes and their application to 3D prestack data enhancement: Geophysics, v. 88, V277–V289.

H. Kaur, S. Fomel, and N. Pham, 2023, Automated hyperparameter optimization for simulating boundary conditions for acoustic and elastic wave propagation using deep learning: Geophysics, v. 88, WA309–WA318.

H. Kaur, N. Pham, S. Fomel, Z. Geng, L. Decker, B. Gremillion, M. Jervis, R. Abma, and S. Gao, 2023, A deep learning framework for seismic facies classification: Interpretation, v. 11, T107–T116.

H. Kaur, Q. Zhang, P. Witte, L. Liang, L. Wu, S. Fomel, 2023, Deep learning based 3D fault detection for carbon capture and storage: Geophysics, v. 88, IM101–IM112.

O. Saad, Y. Chen, A. Savvaidis, S. Fomel, X. Jiang, D. Huang, Y. Oboué, S. Yong , X. Wang, X. Zhang, and Y. Chen, 2023, Earthquake forecasting using big data and artificial intelligence: a 30-week real case study in China: Bulletin of the Seismological Society of America, v. 113, 2461–2478.

O. Saad, Y. Chen, D. Siervo, F. Zhang, A. Savvaidis, G. Huang, N. Igonin, S. Fomel, and Y. Chen, 2023, EQCCT: A production-ready EarthQuake detection and phase picking method using the Compact Convolutional Transformer: IEEE Transactions on Geoscience and Remote Sensing, v. 61, 4507015.

O. Saad, S. Fomel, R. Abma, and Y. Chen, 2023, Unsupervised deep learning for 3D interpolation of highly incomplete data: Geophysics, v. 88, WA189–WA200.

I. Silvestrov, Bakulin, A., Aldawood, A., Hemyari, E., and A. Egorov, 2023, Improving shallow and deep seismic-while-drilling with a downhole pilot in a desert environment: Geophysics, 88(1), D1–D12

I. Silvestrov, A. Egorov, and A. Bakulin, 2023, Evaluating imaging uncertainty associated with the near surface and added value of vertical arrays using Bayesian seismic refraction tomography: Journal of Geophysics and Engineering, v. 20, 751–762.

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L. Yang, S. Fomel, S. Wang, X. Chen, W. Chen, O. Saad, and Y. Chen, 2023, Denoising of distributed acoustic sensing data using supervised deep learning: Geophysics, v. 88, WA91–WA104.

L. Yang, S. Fomel, S. Wang, X. Chen, W. Chen, O. Saad, and Y. Chen, 2023, Porosity and permeability prediction using transformer and periodic long short term network: Geophysics, v. 88, WA293–WA308.

L. Yang, S. Wang, X. Chen, W. Chen, O. Saad, X. Zhou, N. Pham, Z. Geng, S. Fomel, and Y. Chen, 2023, High-fidelity permeability and porosity prediction using deep learning with the self-attention mechanism: IEEE Transactions on Neural Networks and Learning Systems, v. 34, 3429–3443.

TCCS Staff

The TCCS team includes people from seven different countries (China, Ghana, India, Mexico, Russia, Sweden, and the USA). Our research staff consists of three principal investigators, research scientists, and students.

Raymond Abma (Visiting Scientist)	Björn Engquist (PI)	Tyler Masthay (Ph.D. 8th year)
Jacob Badger (Post-doc)	Sergey Fomel (PI)	Shirley Mensah (Ph.D. 2nd year)
Andrey Bakulin (PI)	Rebecca Gao (Ph.D. 5th year)	Akshika Rohatgi (Ph.D. 2nd year)
Yangkang Chen (Research Scientist)	Rui Gong (Ph.D. 2nd year)	Yiran Shen (Ph.D. 8th year)
Hector Corzo-Pola (Ph.D. 2nd year)	Chao Li (Post-doc)	Sujith Swaminadhan (Ph.D. 2nd year)

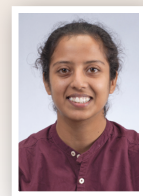
For more information, see http://www.beg.utexas.edu/tccs/staff

TCCS Sponsors

TCCS appreciates the support of its 2024 sponsors: Aramco, BP, Chevron, ConocoPhillips, Petrobras, PetroChina, Sinopec, and TGS.

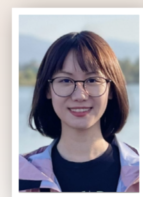
Research Award

The *Interpretation*'s Editorial Board selects an outstanding paper as the Best Paper in *Interpretation* each year. This year's award is given to the TCCS team led by Harpreet Kaur for **A deep learning framework for seismic facies classification (2023)**. Harpreet's co-authors are Nam Pham, Sergey Fomel, Zhicheng Geng, Luke Decker, Ben Gremillion, Michael Jervis, Ray Abma, and Shuang Gao.



Welcoming Dr. Shujuan Mao

Dr. Shujuan Mao has joined the Department of Earth and Planetary Sciences of the Jackson School of Geosciences as a Tenure-Track Assistant Professor. Her research focuses on using and developing seismic techniques, including passive seismic interferometry and time-lapse imaging, for studying the spatiotemporal evolution of shallow fluid systems. Her work has applications in geothermal energy exploitation, carbon capture and storage, and volcanic unrest. **https://www.shujuanmao.com/**



Geoscience Hackathon

The Jackson School of Geosciences at UT Austin, with the support of UT's Open-Souce Program Office, is organizing a Geoscience Hackathon on October 4–6, 2024. The topic of the hackathon is computational reproducibility. Teams of students will work under the guidance of mentors to translate previously published historically significant geoscience papers into a reproducible format. A panel of judges will evaluate the team projects and award prizes.

Dark Fiber Studies for Passive Monitoring at Gulf Coast

TCCS is launching Dark Fiber Studies to explore using existing dark fibers for continuous passive seismic monitoring along the Gulf Coast. This project will leverage both onshore and offshore fiber networks to monitor subsurface changes with high temporal resolution. The focus includes detecting seismic events, imaging subsurface structures, and monitoring temporal changes in seismic properties using passive seismic interferometry. The research will also benchmark dark fiber data against traditional broadband seismometers, such as those in the TexNet network. These studies will span up to two years, with one year of recording in the Gulf Coast region. Current TCCS members are invited to participate through optional tiers, with the first meeting and update expected in Fall 2024.