Welcome to the 29th *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.

TCCS Sponsors

TCCS appreciates the support of its 2025 sponsors: Aramco, BP, Chevron, ConocoPhillips, ExxonMobil, Petrobras, and TGS.

Spring Meeting

The Spring 2025 Research Meeting of the Texas Consortium for Computational Seismology will occur in Houston on April 24–25, 2025. Hosted by the Bureau of Economic Geology, it will be held at the Bureau's Houston Research Center.

Hope to see you in Houston

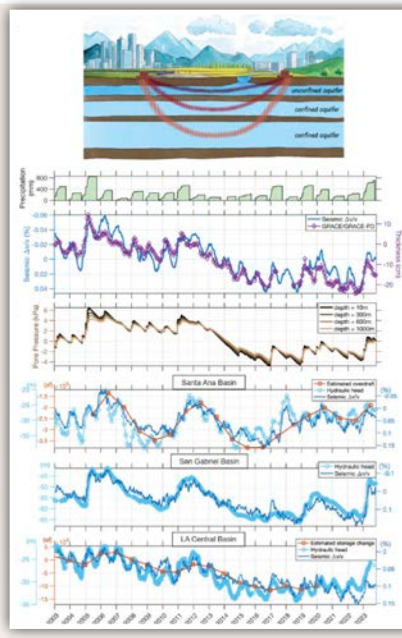
SEG | AAPG IMAGE
International Meeting for Applied Geoscience & Energy

TCCS has submitted 12 abstracts to the 2025 IMAGE Meeting in Houston.
The subjects will be:

- Geophysical Technologies: Distributed Acoustic Sensing, TimeLapse, Acquisition, Full-Waveform Inversion, Seismic Processing, Near Surface
- Geological Technologies: Structure, Tectonics, and Geomechanics
- Recent Advances and Road Ahead

Depth-dependent seismic sensing through coda-wave imaging

Shujuan Mao, who joined UT Jackson School of Geosciences as an Assistant Professor in 2024, is partnering with TCCS to advance seismic monitoring of subsurface fluid systems. Her research focuses on developing and applying advanced seismic methods, particularly coda-wave interferometry, to enable 4D time-lapse seismic imaging of the subsurface. This approach promises breakthroughs in water and energy resource management by transforming passive seismic data into a continuous, depth-dependent 4D sensing system. The method is relevant for monitoring shallow and deep reservoirs for groundwater, carbon storage, geothermal energy, and hydrocarbon extraction. Check out her paper on depth-dependent seismic sensing of groundwater recovery, published in *Science* in February 2025.



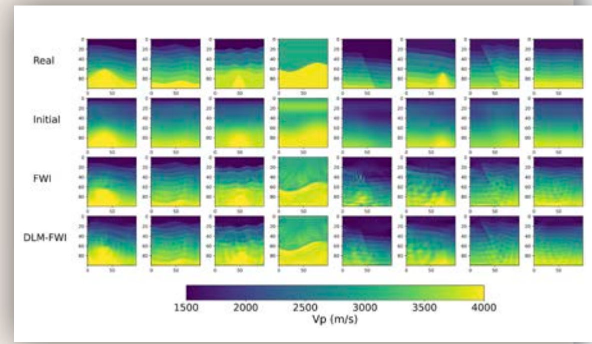
Seismic and hydrogeological monitoring from 2003 to 2023. (A) Seismic sensing across aquifers. (B–C) Precipitation and regional water changes from seismic and satellite data. (D) Modeled pore pressure. (E–G) Basin-specific seismic velocity changes, hydraulic head, and storage estimates in Santa Ana, San Gabriel, and LA Central Basins.

Bureau H_2 Test at the Devine Site

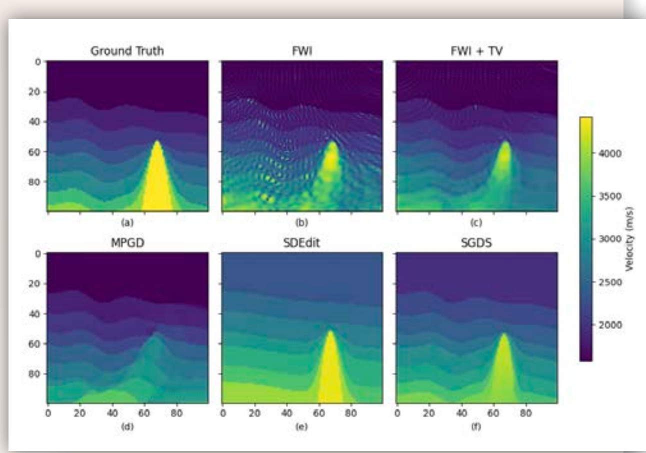
In a collaboration between TCCS and $GeoH_2$, Andrey Bakulin led an ultra-dense 3D surface seismic and 3D VSP survey to characterize the shallow Olmos Sandstone in preparation for future hydrogen injection monitoring. Using a 7.5 × 7.5 m receiver grid and a dense source layout, the team achieved high-resolution imaging of weak reflectors typically obscured by near-surface noise. This benchmark dataset enables detailed mapping of fluid migration pathways and informs the design of optimized, sparse 4D monitoring strategies.

Research Highlights

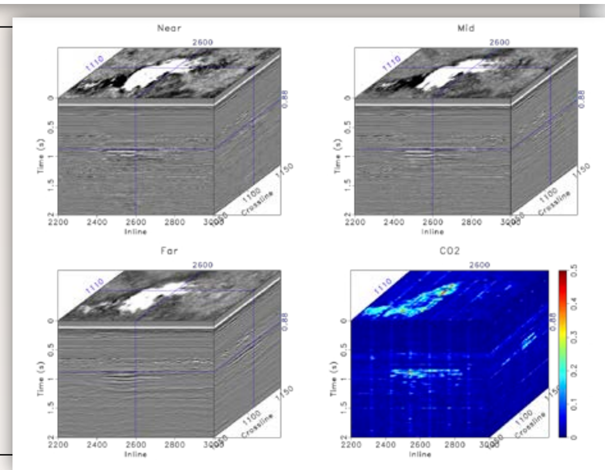
Chao Li has been working on data-driven, deep-learning-based full-waveform inversion (FWI). Incorporating deep learning matching (DLM) into FWI incorporates multiple convolutional neural networks (CNNs) to construct an adaptive matching filter for pinpointing discrepancies between synthetic and observed data. The figure shows the newly built velocity model dataset and the corresponding inversion results of classic FWI compared to DLM-FWI. DLM-FWI weakens dependence on the initial model and can recover model complexities, such as undulating structures, foldings, and faults.



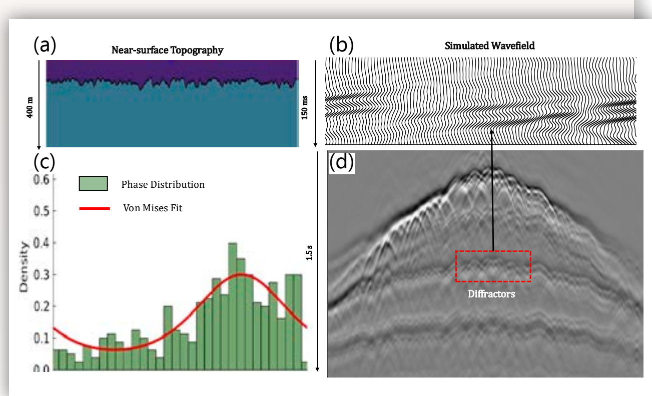
Yiran Shen has been working on a novel seismic inversion framework that integrates Full Waveform Inversion (FWI) with pre-trained diffusion generative models to improve subsurface velocity model recovery. Three posterior sampling strategies—Manifold-Preserving Guided Diffusion (MPGD), Guided Image Synthesis with SDEdit, and Split Gibbs Diffusion Sampling (SGDS)—combine FWI's physical constraints with diffusion models' data-driven priors. Numerical experiments on complex synthetic geological models demonstrate that all three approaches outperform conventional FWI. Notably, SGDS yields the most accurate and structurally faithful reconstructions by alternating between FWI and diffusion in a cyclic refinement scheme.



Sujith Swaminadhan has been working on deep-learning-based methods to estimate CO_2 saturation directly from seismic angle stacks. By leveraging the ability of neural networks to capture complex relationships, this method achieves accurate saturation estimates with a low computational cost. Preliminary results demonstrate its potential for generating saturation maps to support efficient seismic time-lapse monitoring. Incorporating additional inputs, such as porosity, improves the prediction accuracy. Tests on real data from the Sleipner field highlight the feasibility of applying a network trained on synthetic datasets to real CO_2 monitoring applications.



Akshika Rohatgi's has been analyzing seismic signal distortions caused by near-surface heterogeneities, which generate complex wave scattering and speckle noise. Phase analysis in the spectral domain, with phase coherence serving as a signal reliability indicator, helps in understanding and mitigating these effects. Figure A shows the near-surface velocity model perturbed with the near-surface topography. The simulated wavefield (Figures B and D) reveals a significant distortion from propagation effects caused by reflections traveling through the rough near-surface boundary. These transmission-induced distortions impact both deep and shallow reflections by generating diffractions along the reflection wave paths. When diffractions coalesce and become indistinguishable, they transition to speckle noise and phase randomization (Figure C), with the spread increasing at higher frequencies.



Papers Accepted and Published 2024–2025

tccs.beg.utexas.edu/publications

Accepted

Y. Chen, A. Savvaidis, S. Fomel, Y. Chen, O. Saad, H. Wang, Y. Oboue, L. Yang, and W. Chen, 2025, Denoising of distributed acoustic sensing seismic data: Seismological Research Letters, accepted.

C. Li, S. Fomel, Y. Chen, R. Dommisse, A. Savvaidis, 2025, FaultVitNet: An vision transformer assisted network for 3D fault segmentation: Journal of Geophysical Research–Machine Learning and Computation, accepted.

L. Yang, S. Fomel, S. Wang, W. Li, J. Meng, C. Li, and Y. Chen, 2025, HCTNet: Robust prestack seismic inversion using a hybrid convolutional transformer: Geophysics, accepted.

Published 2025

A. Bakulin, I. Silvestrov, R. Smith, and P Golikov, 2025, Smart DAS uphole acquisition system: bridging the gap between surface seismic and borehole geophysics for imaging and monitoring in complex near-surface environments, Geophysical Monograph Series, v 289, p.109–131.

C. Li, G. Liu, Z. Wang, Z. Li, S. Fomel, and Y. Chen, 2025, Simultaneous off-the-grid deblending and data reconstruction via unsupervised deep learning: IEEE Transactions on Geoscience and Remote Sensing, v. 63, 5909311.

C. Li, G. Liu, L. Yang, S. Fomel, and Y. Chen, 2025, Robust bidirectional Q-compensated denoising for seismic data with adaptive structural regularization: IEEE Transactions on Geoscience and Remote Sensing, v. 63, 5906711.

S. Mao, W. L. Ellsworth, W. Zheng, and W. C. Beroza, 2024, Depth-dependent seismic sensing of groundwater recovery from the atmospheric-river storms of 2023. Science387, no. 6735 (2025): 758–763.

Published 2024

A. Aldawood, A. Samarin, A. Shaiban, and A. Bakulin, 2024, Virtual Shear Checkshot from a Densely Sampled DAS Walkaway VSP in a Desert Environment, First Break, v. 42, 37–43.

A. Bakulin, D. Neklyudov, and I. Silvestrov, 2024, The impact of receiver arrays on suppressing seismic speckle scattering noise caused by meter-scale near-surface heterogeneity: Geophysics, v. 89, V551–V561.

C. Birnie, S. Liu, A. Aldawood, A. Bakulin, I. Silvestrov, and T. Alkhalifah, 2024, Self-supervised denoising at low signal-to-noise ratios: a seismic-while-drilling application, The Leading Edge, v. 7, 436–443.

S. Carney, M. Dussinger, and B. Engquist, 2024, On the nature of the boundary Resonance error in numerical homogenization and its reduction: Multiscale Modeling & Simulation, v. 22, 811–835.

Y. Chen, A. Savvaidis, S. Fomel, Y. Chen, O. Saad, H. Wang, Y. Oboue, L. Yang, and W. Chen, 2024, Denoising of distributed acoustic sensing seismic data: Seismological Research Letters, v. 94, 457–472.

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.

C. Li, G. Liu, X. Chen, Z. Wang, S. Fomel, and Y. Chen, 2024, Warped-mapping based multi-gather joint prestack Q estimation: IEEE Transactions on Geoscience and Remote Sensing, v. 62, 5920209.

S. Liu, C. Birnie, A. Bakulin, A. Dawood, I. Silvestrov, and T. Alkhalifah, 2024, A self-supervised scheme for ground roll suppression: Geophysical Processing, v. 72, 2580–2598.

Y. Oboue, Y. Chen, S. Fomel, and Y. Chen, 2024, Protecting the weak signals in distributed acoustic sensing data processing usinwg local orthogonalization: the FORGE data example: Geophysics, v. 89, V103–V118.

Y. Oboue, 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.

N. Pham and S. Fomel, 2024, Seismic data augmentation for automatic fault picking using deep learning: Geophysical Prospecting, v. 72, 125–141.

A. I. Ramdani, A. Perbaw, A. Bakulin, and V. Vahrenkamp, 2024, 3D geophysical image translated into photorealistic virtual outcrop geology using generative adversarial networks, The Leading Edge, v. 43, 102–116.

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

L. Yang, S. Fomel, S. Wang, X. Chen, Y. Chen, 2024, Deep learning with soft attention mechanism for small-scale ground roll attenuation: Geophysics, v. 89, WA179–WA193.

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.

L. Yang, S. Fomel, S. Wang, X. Chen, Y. Chen, and Y. Chen, 2024, SLKNet: An attention-based deep learning framework for downhole Distributed Acoustic Sensing (DAS) data denoising: Geophysics, v. 86, WC69–WC89.

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.

C. Li, G. Liu, F. Li, and Z. Wang, 2024, Robust joint adaptive multiparameter waveform inversion with attenuation compensation in viscoacoustic media. Geophysics, v. 89, R231–R246.

C. Li, G. Liu, Z. Wang, L. Shi, and Q. Wu, 2024, Robust Q-compensated multidimensional impedance inversion using seislet-domain shaping regularization. Geophysics, v. 89, R109–R120.

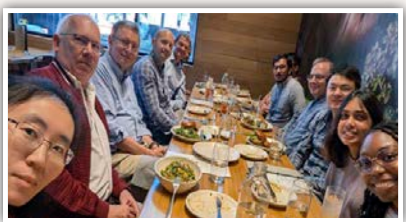
Z. Wang, G. Liu, C. Li, L. Shi, and Z. Wang, 2024, Random noise attenuation of 3D multicomponent seismic data using a fast adaptive prediction filter. Geophysics, v. 89, V263–V280.

TCCS Staff

The TCCS team includes researchers and students from eight countries, led by three principal investigators and supported by research scientists.

Raymond Abma (Visiting Scientist)
Roy Burnstad (Research scientist)
Tolulope Agbaje (Ph.D. 2nd year)
Dhary Alrushaid (B.S. 4th year)
Andrey Bakulin (PI)
Yangkang Chen (Research Professor)
Björn Engquist (PI)
Sergey Fomel (PI)
Rebecca Gao (Ph.D. 5th year)
Chao Li (Post-doc)
Shirley Mensah (Ph.D. 2nd year)
Sabrina Reichert (Ph.D. 2nd year)
Akshika Rohatgi (Ph.D. 2nd year)
Yiran Shen (Ph.D. 8th year)
Sujith Swaminadhan (Ph.D. 2nd year)

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



Celebrating Rebecca's award over TCCS lunch with Baker Hughes' David Katz and Santi Randazzo.

JSG Hackathon

The first Geoscience Hackathon, organized by the Jackson School of Geosciences and the Open-Source Program Office at UT Austin, was held on October 4–6, 2024. ConocoPhillips and Sandia National Labs sponsored the event and its theme was computational reproducibility. Around 20 students split into teams and worked on creative projects that reproduced and extended computational results from previously published classic geoscience papers.

A panel of external judges evaluated the results. Team Surfers, mentored by Yangkang Chen and including Akshika Rohatgi from TCCS, won the First Place Award for their project on physics-informed neural networks. https://www.jsg.utexas.edu/geoscience-hackathon/

Ph.D. Dissertations

Name	Year	Title	Current Employer
Tyler Masthay	2025	Optimal Transport for Elastic Source Inversion	Stellar Science
Nam Pham	2022	Deep Learning for Automatic Geophysical Interpretation with Uncertainty	SLB
Zhicheng Geng	2022	Deep Learning For Pattern Recognition In Seismic Reflection Data	Amazon
Harpreet Kaur	2022	Improving Accuracy and Efficiency of Seismic Data Analysis Using Deep Learning	Amazon
Luke Decker	2021	Parameter Selection in Seismic Processing Problems	Chevron
Yunzhi Shi	2020	Deep Learning Empowers the Next Generation of Seismic Interpretation	Amazon
Yunan Yang	2018	Optimal Transport for Seismic Inverse Problems	Cornell University
Dmitrii Merzlikin	2018	Diffraction Imaging by Path- Summation Migration	SLB
Yanadet Sripanich	2017	Seismic Anisotropy Analysis Using Muir-Dellinger Parameters	PTTEP
Zhiguang Xue	2017	Regularization Strategies for Increasing Efficiency and Robustness of Least-Squares RTM and FWI	Meta
Junzhe Sun	2016	Seismic Modeling and Imaging in Complex Media Using Low-Rank Approximation	Meta
Yangkang Chen	2015	Noise Attenuation in Seismic Data from the Simultaneous-Source Acquisition	The University of Texas at Austin
Parvaneh Karimi	2015	Seismic Interpretation Using Predictive Painting	Oxy
Vladimir Bashkardin	2014	Phase-Space Imaging of Reflection Seismic Data	BP
Christina Frederick	2014	Numerical Methods for Multiscale Inverse Problems	New Jersey Institute of Technology
Siwei Li	2014	Imaging and Velocity Model Building with Linearized Eikonal Equation and Upwind Finite-Differences	SensorEra
Jack Poulson	2012	Fast Parallel Solution of Heterogeneous 3D Time-Harmonic Wave Equations	Hodge Star
Xiaolei Song	2012	Application of Fourier Finite Differences and Low-Rank Approximation Method for Seismic Modeling and Subsalt Imaging	BP
Paul Tsuji	2012	Fast Algorithms for Frequency-Domain Wave Propagation	Lawrence Livermore National Laboratory
William Burnett	2011	Multiazimuth Velocity Analysis Using Velocity-Independent Seismic Imaging	ExxonMobil

M.S. Theses

Hector Corzo Pola	2023	Near-Optimal Correlation Sequences using Q-Learning and Shortest-Path Trees	The University of Texas at Austin
Ben Gremillion	2019	Seismic Data Interpolation with Shaping Inversion to Zero Offset and Least-Squares Flattening	Hess
Nam Pham	2019	Automatic Channel Detection Using Deep Learning	SLB
Sean Bader	2018	Seismic and Well Log Data Integration Using Data-Matching Techniques	EOG
Mason Phillips	2017	Geophysical Data Registration Using Modified Plane-Wave Destruction Filters	DownUnder Geosolutions
Kelly Regimbal	2016	Improving Resolution of NMO Stack Using Shaping Regularization	Onward
Ryan Swindeman	2015	Iterative Seismic Data Interpolation Using Plane-Wave Shaping	Noonlight
Luke Decker	2014	Seismic Diffraction Imaging Methods and Applications	Chevron
Shaunak Ghosh	2013	Multiple Suppression in the t-x-p Domain	CGG
Salah Alhadab	2012	Diffraction Imaging of Sediment Drifts in Canterbury Basin	Aramco
Yihua Cai	2012	Spectral Recomposition and Multicomponent Seismic Image Registration	Shell

B.S. Honors Theses

Reem Alomar	2022	Seismic Data Analysis by Least-Squares Non-Stationary Triangle Smoothing	Aramco
Tharit Tangki-jwanichakul	2021	Chain of Operators for Inverse Hessian Estimation in Least-Squares Migration	PTTEP
Sarah Greer	2018	A Data Matching Algorithm and Its Applications in Seismic Data Analysis	MIT
Lubna Barghouty	2013	Surface-Related Multiple Elimination and Velocity-Independent Imaging of a 2D Seismic Line from the Viking Graben Dataset	MIT
Yanadet Sripanich	2013	An Efficient Algorithm for Two-Point Seismic Ray Tracing	PTTEP