

Welcome to the 30th 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 2025 Research Meeting of the Texas Consortium for Computational Seismology will take place in Austin on October 20–21. 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 2025

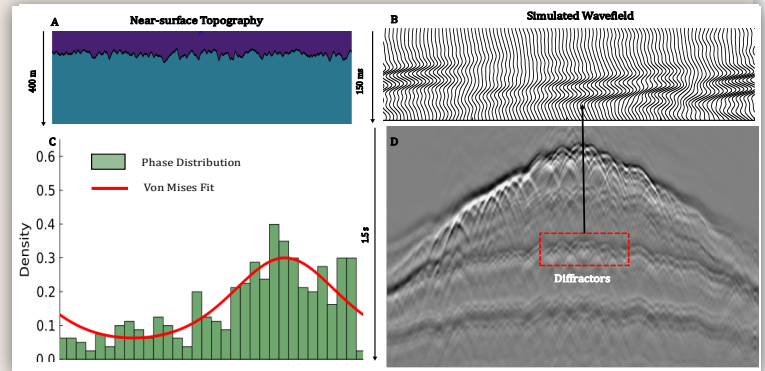


Tuesday, August 26	10:20–10:40	SS 6: Passive Seismic Rising 2	H. Li*, J. Liu, S. Mao, S. Yuan, R. Clapp, and B. Biondi	Daily elastic full-waveform inversion for continuous groundwater monitoring with Stanford DAS array
	10:20–12:00	TL P1: 4D Seismic Acquisition and Processing 1	A. Bakulin*, S. Swaminadhan, M. Shuster, and B. Gurevich	Instrumenting the Devine site as a field laboratory for hydrogen injection: characterization and monitoring feasibility assessment
	11:35–11:55	DAS 2: Theory and Simulation	A. Bakulin*, J. Badger, and S. Fomel	No-compromise 3D finite-element modeling of borehole DAS data
	1:20–3:00	NS P2: Noise and Uncertainty in Near Surface Seismic Analysis	A. Rohatgi*, A. Bakulin, S. Fomel, and J. Badger	Impact of near-surface topography on reflection distortions: From diffractions to speckle noise
	1:20–3:00	SP P3: Seismic Data Interpolation, Regularization and Deblending	R. Abma	Simultaneous source separation: Accuracy and algorithms
	3:40–4:00	SS 17: Geophysics for Urban Spaces and Infrastructure 2	S. Mao*, G. Beroza, and W. Ellsworth	Leveraging passive seismic monitoring for urban water and energy sustainability
	3:40–5:20	FWI P6: Machine Learning 3	Y. Shen*, Y. Chen, and B. Engquist	Diffusion generative model for full waveform inversion
	4:05–4:25	SS 18: Recent Advances and the Road Ahead: Hot Topics in Geoscience 2	S. Fomel	Linear and nonlinear operators in seismic data analysis
Wednesday, August 27	4:30–4:50	SS 16: Monitoring of the Near Surface Earth	S. Mao*, W. Ellsworth, Y. Zheng, and G. Beroza	4D monitoring of natural and managed aquifer recharge via seismic interferometry
	10:20–12:00	FWI P7: Novel Approaches and Workflows 1	C. Li*, S. Fomel, and Y. Chen	Deep learning full waveform inversion with dynamic matching filtering
	10:20–12:00	TL P2: Analysis using Machine Learning 1	S. Swaminadhan*, S. Fomel, and S. Bakhshian	Estimation of carbon dioxide saturation from angle stacks using deep learning
	10:20–12:00	STGM P1: Faults, Fractures, and Fluids 4	T. Agbaje* and S. Fomel	Deep learning-based approach to mapping fault density on seismic data
	10:45–11:05	SP 6: Deblending	R. Abma	The accuracy of deblending low-frequency signals
	1:20–3:00	SMT P4: Seismic Modeling in Different Media	Y. Cui, U. Waheed*, C. Song, and Y. Chen	Leveraging Kolmogorov-Arnold Network empowered Fourier Neural Operator to solve eikonal equation
	3:40–5:20	SP P12: Case Studies 2	A. Rohatgi*, A. Bakulin, and S. Fomel	Seismic phase spectral analysis: Field-data insights from circular statistics
	4:05–4:25	SP 8: Seismic Data Interpolation and Reconstruction	C. Li*, O. Saad, and Y. Chen	Simultaneous off-the-grid reconstruction and denoising: A label free deep learning framework
Thursday, August 28	8:00–8:20	INT 1: Machine Learning in Assisting Geological Interpretation	C. Li*, S. Fomel, Y. Chen, R. Dommisse, and A. Savvaids	3D fault detection using vision transformer with a hybrid-attention mechanism
	8:00–8:20	ACQ 3: Survey Design and Compressive Sensing 2	A. Titova*, M. Wakin, and A. Tura	Floating window Fourier transform and its applications for estimating spectra
	8:50–9:10	SP 9: Novel Solutions and Emerging Technologies	A. Rohatgi*, A. Bakulin, and S. Fomel	Theory of seismic phase analysis using circular statistics
	10:45–11:05	TL 3: Analysis using Machine Learning 2	S. Gao*, S. Fomel, and Y. Chen	Labeling CO ₂ plumes via deep learning
	11:35–11:55	ACQ 4: Land Seismic Challenges and Opportunities 2	A. Bakulin*, A. Chatenay, S. Swaminadhan, R. Burnstad and M. Shuster	Ultra-dense nodal 3D seismic for high-resolution characterization the Devine injection field laboratory

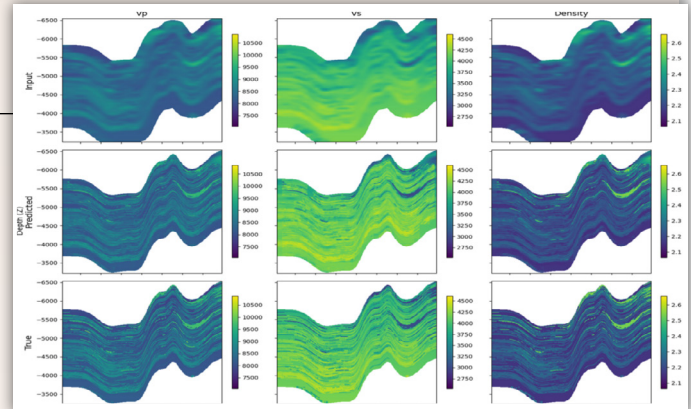
Research Highlights



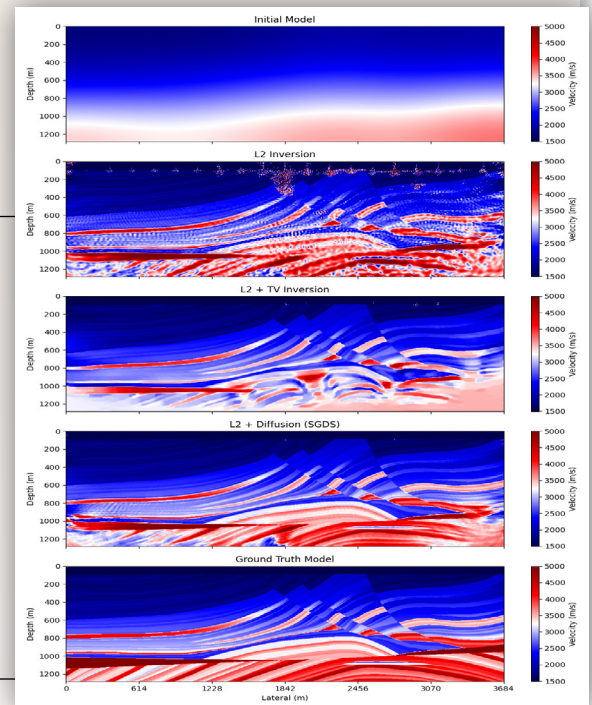
Akshika Rohatgi has been studying seismic signal distortions caused by near-surface heterogeneities. Phase analysis in the spectral domain, with phase coherence serving as a signal reliability indicator, helps in understanding and reducing these effects. Figure A shows a velocity model with near-surface heterogeneities. The simulated wavefield (Figures B and D) displays 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 creating diffractions along the reflection wave paths. When diffractions merge and become indistinguishable, they turn into speckle noise and phase randomization (Figure C).



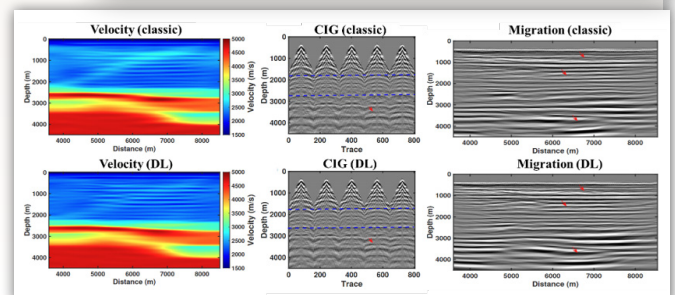
Rebecca Gao has been developing an integrated workflow for monitoring CO₂ storage using seismic data and machine learning tools. Facies-based geologic models and fluid substitution help generate synthetic time-lapse velocity models and multi-angle reflectivity gathers that capture the evolution of injected CO₂. These gathers can be inverted using the Hybrid Convolutional Transformer Network (HCTNet) to recover P-wave velocity, S-wave velocity, and density at much higher resolution than the coarse, low-frequency input models. A sensitivity analysis shows that high-angle reflections provide the clearest diagnostic signals of CO₂ saturation. The figure illustrates this dual contribution: HCTNet transforms low-resolution inputs into elastic property predictions, while high-angle differences highlight the seismic response to CO₂.



Yiran Shen has been evaluating the effectiveness of diffusion-based priors in full waveform inversion (FWI). Traditional L2 inversion often faces issues like strong artifacts, noise amplification, and cycle skipping, which can lead to unrealistic velocity updates. Adding TV (total variation) regularization can help mitigate these problems, but it may also cause oversmoothing and loss of important details. In contrast, the proposed approach uses a diffusion model prior through Split Gibbs Diffusion Sampling (SGDS), learning the low-dimensional manifold of plausible geological velocity models from training data. This prior knowledge enables the inversion to produce sharper velocity contrasts, clearly define complex interfaces, and better capture sharp geological features such as salt boundaries and faults.



Chao Li has been developing a deep-learning (DL) based full-waveform inversion (FWI) method to improve inversion accuracy and reduce dependence on a good initial model. Neural networks act as nonstationary and nonlinear filters to enhance data fitting and adaptively decrease the amplitude and phase differences between predicted and observed data in an unsupervised way. The figure shows a field data example. With a poor initial model, the proposed DL-based FWI outperforms traditional FWI in achieving higher accuracy, as shown by improvements in CIGs (common image gathers) and reflection images.



Accepted	A. Bakulin, S. Swaminadhan, R. Burnstad, J. Badger, M. Shuster, M. Delshad, and M. Hotan, 2025, Engineering 4D seismic monitoring: A data-driven blueprint from the Devine hydrogen test site: The Leading Edge, accepted. S. Gao, S. Fomel, and Y. Chen, 2025, Improving fluid-induced time-lapse seismic monitoring using local orthogonalization: Geophysics, accepted. A. Rohatgi, A. Bakulin, and S. Fomel, 2025, Data-driven analysis of seismic phase using circular statistics: The Leading Edge, 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, S. Fomel, Y. Chen, R. Domisse, A. Savvaidis, 2025, FaultVitNet: An vision transformer assisted network for 3D fault segmentation: Journal of Geophysical Research–Machine Learning and Computation, v. 2, e2024JH000488. 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, 2025, Depth-dependent seismic sensing of groundwater recovery from the atmospheric-river storms of 2023. Science, no. 6735 (2025): 758–763. 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, v. 90, NO. 4, N17–N32.
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 and Simulation, v. 22, 811–835. Y. Chen, A. Savvaidis, S. Fomel, Y. Chen, O. Saad, H. Wang, Y. Oboue, L. Yang, and W. 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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. 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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.

TCCS Staff

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

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For more information, see <https://tccs.beg.utexas.edu/staff>

TCCS Sponsors

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

Research Award

Xinming Wu is a 2025 recipient of the SEG Virgil Kauffman Gold Medal, and will be presented with this award at the IMAGE conference in Houston. The medal is awarded to a person who has made an outstanding contribution to the advancement of the science of geophysical exploration as manifested during the previous five years. Xinming is recognized for developing revolutionary artificial intelligence (AI) and machine learning methods for seismic interpretation the work he started while a visiting Ph.D. student and a postdoc at TCCS in 2015–2019. He is currently a professor at USTC (University of Science and Technology of China).



Geoscience Hackathon

The Jackson School of Geosciences at UT Austin, with the support of UT's Open-Source Program Office, is organizing an annual Geoscience Hackathon on October 10–12, 2025. This year's theme is "Change Over Time," covering shifts in Earth's systems from real-time monitoring to cumulative changes over millions of years. Teams will be guided by mentors and build computational models to track these changes. A panel of judges will evaluate the projects and award prizes. <https://www.jsg.utexas.edu/geoscience-hackathon/>



TCCS launches Gulf Coast Offshore Monitoring

TCCS is proud to announce the start of Gulf Coast Offshore Monitoring, with recording commencing in September 2025. The study will use 70 km of shallow-water telecom DAS to detect seismic events and apply coda-wave interferometry to monitor subtle subsurface changes. A 12-month recording window will run to August 2026. During this time, TCCS is also seeking partners to conduct an airgun survey to evaluate active-source monitoring with DAS and to deploy and assess both transmitting and blind ocean-bottom nodes for sparse, sensitive monitoring to advance the combined DAS + node offshore monitoring use case. We thank FiberSense for their partnership in this study.

