Welcome to the 27th *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.

Spring Meeting

The Spring 2024 Research Meeting of the Texas Consortium for Computational Seismology will occur in Houston on April 25–26, 2024. Hosted by the Bureau of Economic Geology, it will be held at the Bureau's Houston Research Center.

Participating company representatives are invited to register for the meeting by following the link at tccs.beg.utexas.edu.

Hope to see you in Houston

TCCS has submitted 14 abstracts to the 2024 IMAGE Meeting in Houston. The papers fall into the following subject areas: Acquisition, AVO, Borehole, FWI, Near Surface, Rock Physics, Seismic Modeling, Seismic Processing, and Time Lapse.

SEG | AAPG image
International Meeting for Applied Geoscience & Energy

New Directions

Following the appointment of Andrey Bakulin as research professor at BEG and co-PI of TCCS, the consortium plans to expand its research into developing acquisition and data analysis techniques aligned with the demands of future energy transitions. This includes rigorous evaluations of signal-to-noise ratios and data repeatability, addressing complex challenges such as managing scattering speckle noise and enhancing quantitative data-driven survey designs. Integrating measurement and acquisition with our analysis efforts aims to improve the efficiency of the entire pipeline from data collection to decision-making. Our strategies will incorporate diverse monitoring approaches, such as DAS-VSP and seismic with trenched DAS, leveraging advanced algorithms and machine learning to optimize data insight extraction.

Spring 2024 Jackson School Research Symposium

Each spring semester, students of the Jackson School of Geosciences at UT Austin present their research in a day-long poster competition. Faculty and industry representatives evaluate the posters. The Symposium aims to provide cross-disciplinary collaboration at the Jackson School.

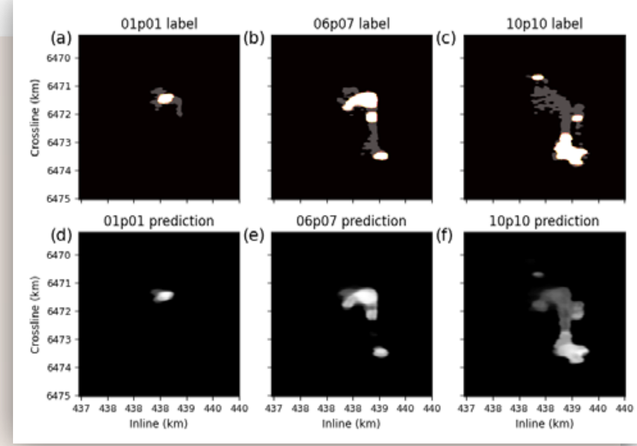
PI Andrey Bakulin and some of the TCCS students at the Jackson School Research Symposium. From left to right: Rui Gong, Akshika Rohatgi, Andrey Bakulin, Sujith Swaminadhan, and Hector Corzo Pola.

TCCS Sponsors

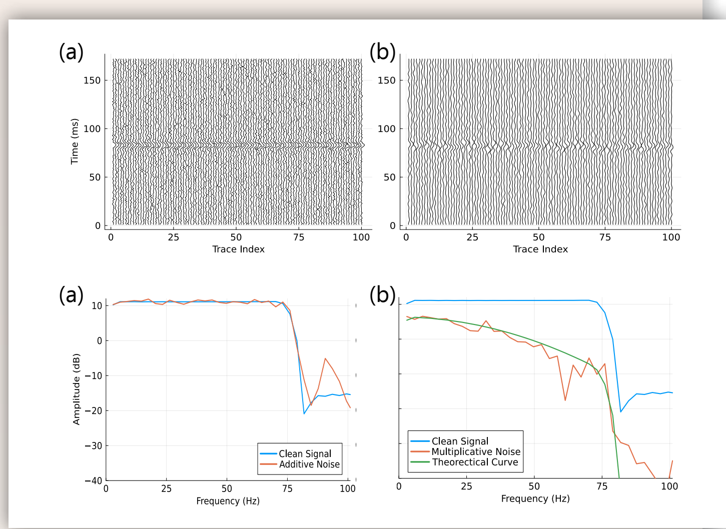
TCCS appreciates the support of its 2024 sponsors: Aramco, BP, Chevron, ConocoPhillips, Petrobras, PetroChina, Sinopec, and TGS.

Research Highlights

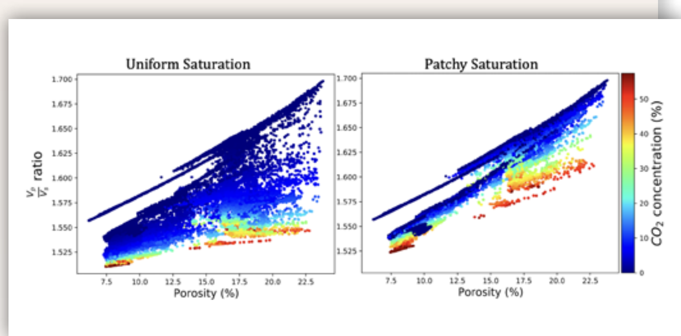
Shuang (Rebecca) Gao has been working on combining local orthogonalization and computer-vision techniques to automatically generate high-resolution labels for both CO_2 plumes and geological features from 4D time-lapse seismic data. The novel deep learning architecture, TLNet, offers segmentation of CO_2 plumes and enhances the model's ability to predict CO_2 distribution. The figure compares ground truth CO_2 labels and corresponding predictive results at a depth for the years 2001, 2007, and 2010 for the Sleipner CCS project.



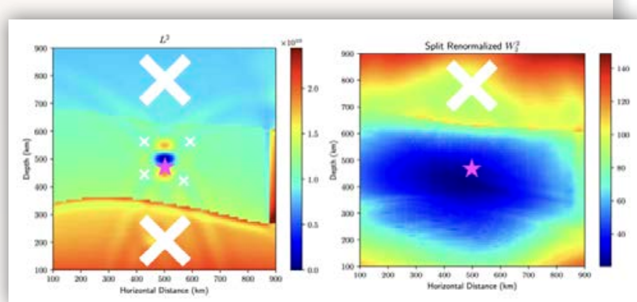
Akshika Rohatgi has been working on multiplicative noise, also known as seismic speckles. While seismic noise has conventionally been considered additive noise, in recent years, multiplicative speckle noise has been recognized as caused by small-scale scattering in the near-surface. Theoretical analysis and numerical experiments show that while stacking-based processing can effectively neutralize additive noise, it struggles against the complexities of multiplicative noise. Figure (1a) shows an ensemble of 100 traces with additive noise (1b) shows traces with multiplicative noise characterized by standard deviations π/3 for phase perturbations and 4 ms for residual static, both noises have SNR of -1.2 dB for consistency. Figure 2 shows how stacking restores the signal amplitude for additive noise but fails for multiplicative noise.



Sujith Swaminadhan has been studying the effects of fluid saturation in carbon dioxide monitoring, utilizing previous 100-year reservoir simulation study results for Decatur CCS project. Two end-member saturation models were studied: uniform saturation, where the fluids are evenly distributed within the pore space, and patchy saturation, characterized by heterogeneous fluid distribution. The model-driven results exhibit substantial variations in the amplitude of seismic response for the same amount of carbon dioxide in the subsurface. The more realistic patchy saturation model appears to produce less uncertain results as compared to those obtained from the uniform saturation model.



Tyler Masthay has been working on application of the optimal transport to elastic full-waveform inversion for source detection. The Wasserstein-2 metric, an optimal transport metric, is attractive for full-waveform inversion due to its convexity with respect to shifts and dilations. This property does not hold for the L^2 misfit. Pictured here is a comparison of the Wasserstein-2 and L^2 optimization landscapes as a function of source location, all else equal, with a curved-layer velocity model. The magenta star denotes the global minimum, and white X denotes local minima. While both landscapes are nonconvex for this example, the Wasserstein-2 landscape adds significant convexification with less local minima, showing its potential for mitigating cycle skipping.



Papers Accepted and Published 2023–2024

tccs.beg.utexas.edu/publications

Accepted

- 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: Geosciences, accepted.
- B. Engquist, K. Ren, and Y. Yang, 2024, Adaptive state-dependent diffusion for derivative-free optimization: Communications on Applied Mathematics and Computation, accepted.

Published 2024

- 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.
- Y. Oboue, Y. Chen, S. Fomel, and Y. Chen, 2024, Protecting the weak signals in distributed acoustic sensing data processing using 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.
- O. Saad, Y. Chen, D. Siervo, F. Zhang, A. Savvaidis, G. Huang, N. Igonin, S. Fomel, and Y. Chen, 2024, 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.
- 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, 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. Bakulin, D. Neklyudov, and I. Silvestrov, 2023, Seismic time-frequency masking for suppression of seismic speckle noise: Geophysics, v. 88, V371–V385.
- Y. Chen, Y. Chen, S. Fomel, A. Savvaidis, O. Saad, and Y. Oboue, 2023, Pyekfmm: a python package for 3D fast-marching-based traveltime calculation and its applications in seismology: Seismological Research Letters, v. 94, 2050–2059.
- Y. Chen and S. Fomel, 2023, 3D true-amplitude elastic wave-vector decomposition in heterogeneous anisotropic media: Geophysics, v. 88, C79–C89.
- Y. Chen, S. Fomel, and R. Abma, 2023, Joint deblending and source time inversion: Geophysics, Geophysics, v. 88, WA27–WA35.
- Y. Chen, A. Savvaidis, and S. Fomel, 2023, Dictionary learning for single-channel passive seismic denoising: Seismological Research Letters, v. 94, 2840–2851.
- Y. Chen, A. Savvaidis, S. Fomel, Y. Chen, O. Saad, Y. Oboue, Q. Zhang, and W. Chen, 2023, Pyseistr: a python package for structural denoising and interpolation of multi-channel seismic data: Seismological Research Letters, v. 94, 1703–1714.
- Y. Chen, A. Savvaidis, Y. Chen, O. Saad, and S. Fomel, 2023, Enhancing earthquake detection from distributed acoustic sensing data by coherency measure and moving-rank-reduction filtering: Geophysics, v. 88, WC13–WC23.
- Y. Chen, A. Savvaidis, S. Fomel, Y. Chen, O. Saad, H. Wang, Y. Oboue, L. Yang, W. Chen, 2023, Denoising of distributed acoustic sensing seismic data using an integrated framework: Seismological Research Letters, v. 94, 457–472.
- Y. Chen, A. Savvaidis, S. Fomel, O. Saad, and Y. Chen, 2023, RFloc3D: a machine learning method for 3D real-time microseismic source location using P- and S-wave arrivals: IEEE Transactions on Geoscience and Remote Sensing, v. 61, 5901310.
- 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. Oboue, S. Yong , X. Wang, X. Zhang, and Y. Chen, 2023, Earthquake forecasting using big data and artificial intelligence: a 30-weeks real case study in China: Bulletin of the Seismological Society of America, v. 113, 2461–2478.
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- 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, 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.
- L. Yang, S. Fomel, S. Wang, X. Chen, Y. Chen. 2023, Denoising distributed acoustic sensing (DAS) data using unsupervised deep learning: Geophysics, v. 88, V317–V332.
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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 consists of people from seven different countries (China, Ghana, India, Mexico, Russia, Sweden, and the USA). Our research staff includes three principal investigators, research scientists, and students.

Raymond Abma (Visiting Scientist)
Andrey Bakulin (PI)
Yangkang Chen (Research Scientist)
Héctor Corzo Pola (Ph.D. 1st year)
Björn Engquist (PI)
Sergey Fomel (PI)
Rebecca Gao (Ph.D. 4th year)
Rui Gong (Ph.D. 1st year)
Chao Li (Post-doc)
Tyler Masthay (Ph.D. 7th year)
Shirley Mensah (Ph.D. 1st year)
Akshika Rohatgi (Ph.D. 1st year)
Yiran Shen (Ph.D. 7th year)
Sujith Swaminadhan (Ph.D. 1st year)

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

Machine Learning Certificate

Starting in Fall 2024, the Jackson School of Geosciences will offer a "Stackable Certificate Program on Machine Learning" and "Data Analytics in Geosciences" to any UT Austin degree-seeking graduate students.

Students will learn to use modern data analytics tools and machine learning to solve Earth science problems involving large volumes of data, such as climate modeling, seismic imaging, earthquake forecasting, and satellite mapping. Through this certificate program, students will also acquire proficiency in Python coding.

See https://www.jsg.utexas.edu/ai-certificate for more information.

Ph.D. Dissertations

Name	Year	Title	Current Employer
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

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