Spring 2022 Newsletter

www.beg.utexas.edu/tccs/

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

Welcome to the 22nd *TCCS Newsletter*!

The Texas Consortium for Computational Seismology is a joint initiative of the Bureau of Economic Geology and the Oden Institute for Computational Engineering and Sciences at The University of Texas at Austin. Its mission is to address the most important 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

TCCS will deliver the Spring 2022 report individually to each sponsoring company in online meetings, starting from April 15.

The regular in-person meetings will resume in fall 2022 with a meeting in Austin.

TCCS Sponsors

TCCS appreciates the support of its 2022 sponsors: BP, Chevron, ConocoPhillips, Equinor, ExxonMobil, Petrobras, PetroChina, Saudi Aramco, Sinopec, Shell, and TGS.

New Member

We welcome PetroChina as a new member of the consortium!

PetroChina

Hope to See You in Houston

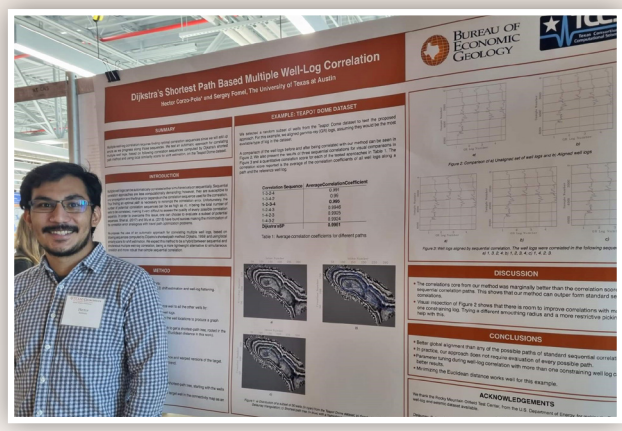
TCCS has submitted nine expanded abstracts to the **2022 IMAGE meeting in Houston**. The submitted papers fall into different subject areas: machine learning and advanced data analytics, inversion algorithms, borehole geophysics and geomechanics, seismic data processing, and seismic theory.

SEG | AAPG image
International Meeting for Applied Geoscience & Energy

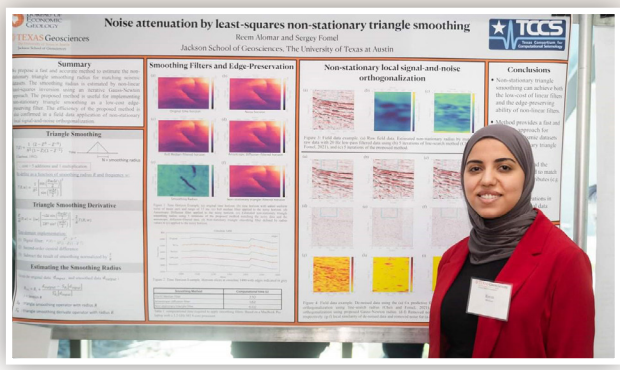
Spring 2022 Jackson School Research Symposium

Each spring semester, students of the Jackson School of Geosciences at UT Austin present their research in a day-long poster competition. Throughout the day, faculty, research scientists, and industry representatives evaluate the posters. The goal of the symposium is to provide cross-disciplinary collaboration among graduate students, undergraduate students, and faculty and research scientists at the Jackson School. The event is sponsored by ConocoPhillips.

In 2022, Reem Alomar won the second prize among undergraduate students for her presentation **"Noise Attenuation by Least-Squares Non-Stationary Triangle Smoothing."**



Héctor Corzo Pola with his poster "Dijkstra's Shortest Path Based Multiple Well-Log Correlation."



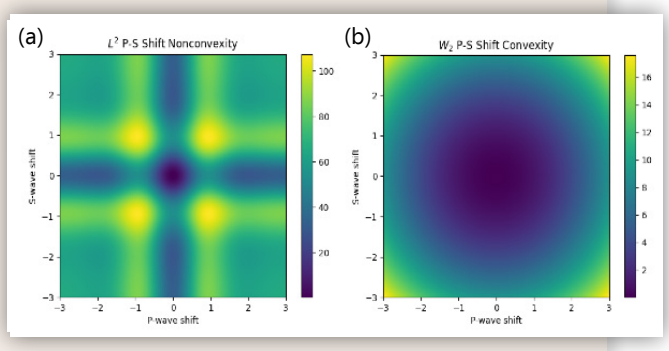
Reem Alomar with her poster "Noise Attenuation by Least-Squares Non-Stationary Triangle Smoothing."

Professional Award

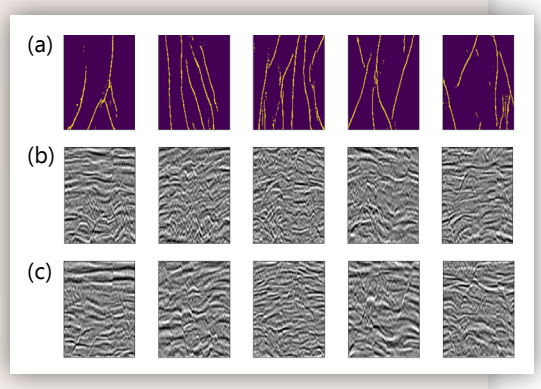
Sergey Fomel is being awarded by SEG with an honorary membership. Such membership is "conferred upon persons who, by unanimous vote of the Honors and Awards Committee and the Board of Directors, have made distinguished contributions, which warrants exceptional recognition, to exploration geophysics or a related field or to the advancement of the profession of exploration geophysics through service to the Society." The award ceremony will take place at the IMAGE conference in Houston.

Research Highlights

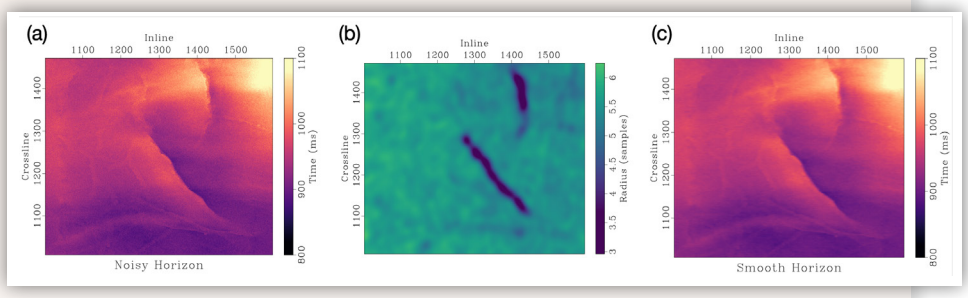
Tyler Masthay has been working on the application of optimal transport to elastic full-waveform inversion for source detection. The Wasserstein-2 metric, a form of optimal transport metric, is attractive for full-waveform inversion due to its convexity with respect to shifts and dilations. This property does not hold for the L_2 misfit. Pictured here is a comparison of the Wasserstein-2 and L_2 differences between a reference waveform and a shifted version of that waveform. The horizontal axis shows the P-wave shift and the vertical axis the S-wave shift. In this example, we see a nonconvex L_2 landscape and a convex Wasserstein-2 landscape, showing the potential of Wasserstein-2 for mitigating cycle skipping.



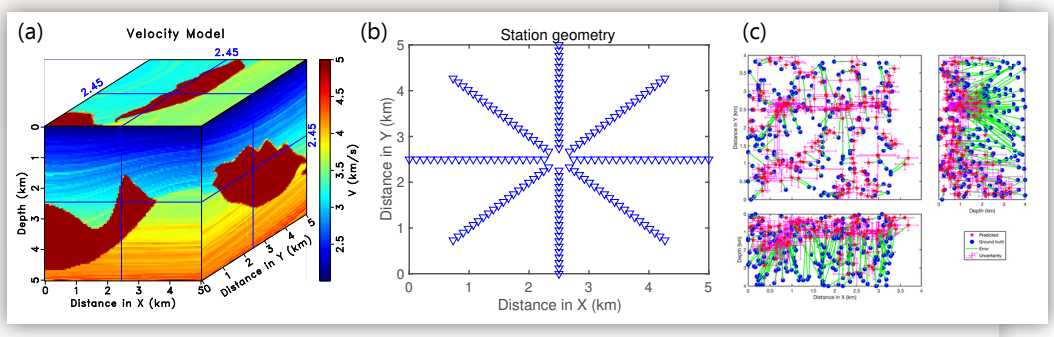
Nam Pham has been working on generating seismic images with corresponding fault labels using generative adversarial networking (GAN). The method has two steps: generating fault systems and generating seismic images with faults as a condition. The model generating seismic images also learns characteristics of seismic images with an encoder. During inference, it takes the field seismic data as an input and generates seismic images that have characteristics of training images and field data. The proposed method can be used to augment the training data for a neural network to pick faults in seismic images. (a) Generated fault systems. (b) Generated seismic images using shallow sections of field data as style. (c) Generated seismic images using deep sections of field data as style.



Reem Alomar has been working on a fast and accurate method to estimate the nonstationary triangle smoothing radius for matching seismic data sets. The analytical derivative of the smoothing operator is used to compute the gradient for inversion in an iterative Gauss-Newton approach. The figure shows an application of the proposed method to implement nonstationary triangle smoothing as a low-cost edge-preserving filter. A time horizon with added random noise is displayed in (a). The result of applying a nonstationary triangle filter defined by nonstationary radius values in (b) is displayed in (c).



Yangkang Chen has been working on an efficient real-time microseismic source localization method based on machine learning. The manually or automatically picked arrival-time differences between different stations and a reference station after a microseismic event and the actual station locations are fed into the well-trained model for a fast and accurate location prediction. The proposed method is efficient enough to be widely applied for the real-time monitoring of hydraulic fracturing. The figure shows a synthetic test of the new RFloc3D method: (a) Velocity model. (b) Acquisition geometry. (c) Uncertainty analysis result. 100 independent tests are repeated for 200 events to evaluate the uncertainty of the RFloc3D method considering the errors in the velocity model and arrival-time picking.



Papers Accepted and Published 2021–2022

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

Accepted

Z. Geng, L. Liang, T. Ding, and I. Zharkov, 2022, RSTT: Real-time Spatial Temporal Transformer for space-time video super-resolution. CVPR, accepted.

Z. Geng, Z. Hu, X. Wu, and S. Fomel, 2022, Semi-supervised salt segmentation using Mean Teacher: Interpretation, accepted.

G. Huang, X. Chen, O. Saad, and Y. Chen, S. Fomel, A. Savvaidis, and Y. Chen, 2022, High-resolution and robust microseismic grouped imaging and grouping strategy analysis: Geophysical Prospecting, accepted.

O. Saad, Y. Chen, A. Savvaidis, S. Fomel, and Y. Chen, 2022, Real-time earthquake detection and magnitude estimation using vision transformer: Journal of Geophysical Research - Solid Earth, accepted.

O. Saad, Y. Chen, D. Trugman, M. S. Soliman, L. Samy, A. Savvaidis, M. A. Khamis, A. G. Hafez, S. Fomel, and Y. Chen, 2022, Machine learning for the fast and reliable source-location prediction in earthquake early warning: IEEE Geoscience and Remote Sensing Letters, accepted.

H. Wang, Y. Chen, O. Saad, W. Chen, Y. Oboue, L. Yang, S. Fomel, and Y. Chen, 2022, A MATLAB code package for 2D/3D local slope estimation and structural filtering: Geophysics, accepted.

H. Wang, Y. Chen, Y. A. S. I. Oboué, R. Abma, Z. Geng, S. Fomel, and Y. Chen, 2022, Simultaneous reconstruction and denoising of extremely sparse 5-D seismic data by a simple and effective method: IEEE Transactions on Geoscience and Remote Sensing, accepted.

L. Yang, S. Wang, X. Chen, W. Chen, O. Saad, X. Zhou, N. Pham, Z. Geng, S. Fomel, and Y. Chen, 2022, High-fidelity permeability and porosity prediction using deep learning with the self-attention mechanism: IEEE Transactions on Neural Networks and Learning Systems, accepted.

S. Zu, H. Cao, S. Fomel, and Y. Chen, 2022, Robust local slope estimation by deep learning: Geophysical Prospecting, accepted.

Published 2022

Y. Chen, O. Saad, A. Savvaidis, Y. Chen, and S. Fomel, 2022, 3D microseismic monitoring using machine learning: Journal of Geophysical Research - Solid Earth, v. 127, e2021JB023842.

L. Decker and S. Fomel, 2022, A probabilistic approach to seismic diffraction imaging: Lithosphere, v. 2021, 6650633.

L. Decker and S. Fomel, 2022, A variational approach for picking optimal surfaces from semblance-like panels: Geophysics, v. 87, U93–U108.

Z. Geng, Z. Zhao, Y. Shi, X. Wu, S. Fomel, and M. Sen, 2022, Deep learning for velocity model building with common-image gathers: Geophysical Journal International, v. 228, 1054–1070.

H. Kaur, A. Sun, Z. Zhong, and S. Fomel, 2022, Time-lapse seismic data inversion for estimating reservoir parameters using deep learning: Interpretation, v. 10, T167–T179.

N. Pham and W. Li, 2022, Physics-constrained deep learning for ground-roll attenuation: Geophysics, v. 87, V15–V27.

Published 2021

Y. Chen and S. Fomel, 2021, Nonstationary local signal-and-noise orthogonalization: Geophysics, v. 86, V409–V418.

Y. Chen, S. Fomel, H. Wang, and S. Zu, 2021, 5D dealiased seismic data interpolation using nonstationary prediction-error filter: Geophysics, v. 86, V419–V429.

Y. Chen, O. Saad, G. Huang, Y. Chen, A. Savvaidis, S. Fomel, and N. Pham, 2021, SCALODEEP: a highly generalized deep learning framework for real-time earthquake detection: Journal of Geophysical Research - Solid Earth, v. 126, e2020JB021473.

Y. Chen, O. Saad, X. Liu, and S. Fomel, 2021, A compact program for 3D passive seismic source-location imaging: Seismological Research Letters, v. 92, 3187–3201.

S. Fomel and H. Kaur, 2021, Wave-equation time migration: Geophysics, v. 86, 1JF–V89.

G. Huang, X. Chen, J. Li, O. Saad, Y. Chen, S. Fomel, C. Luo, and H. Wang, 2021, The slope attribute regularized high-resolution prestack seismic inversion: Surveys in Geophysics, v. 42, 625–671.

H. Kaur, S. Fomel, and N. Pham, 2021, A fast algorithm for elastic wave-mode separation using deep learning with generative adversarial networks (GANs): Journal of Geophysical Research - Solid Earth, v. 126, e2020JB021123.

H. Kaur, N. Pham, and S. Fomel, 2021, Seismic data interpolation using deep learning with generative adversarial networks: Geophysical Prospecting, v. 69, 307–326.

N. Pham and S. Fomel, 2021, Uncertainty and interpretability analysis of encoder-decoder architecture for channel detection: Geophysics, v. 86, O49–O58.

Y. Shi, X. Wu, and S. Fomel, 2021, Interactively tracking seismic geobodies with a deep learning flood-filling network: Geophysics, v. 86, A1–A5.

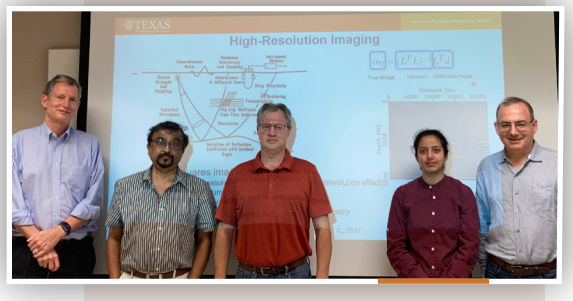
TCCS Staff

The TCCS group consists of people from five countries. Our research staff includes two principal investigators, seven Ph.D. students, one M.S. student, one undergraduate student, and two visiting scientists:

Raymond Abma (Visiting Scientist)
Reem Alomar (B.S., 4th year)
Yangkang Chen (Research Scientist)
Héctor Corzo Pola (M.S., 2nd year)
Björn Engquist (PI)
Sergey Fomel (PI)
Rebecca Gao (Ph.D., 2nd year)
Zhicheng Geng (Ph.D., 5th year)
Ben Gremillion (Ph.D., 3rd year)
Mike Jervis (Visiting Scientist)
Harpreet Kaur (Ph.D., 5th year)
Tyler Masthay (Ph.D. 5th year)
Nam Pham (Ph.D., 3rd year)
Yiran Shen (Ph.D., 5th year)

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

Testimonials



Harpreet Kaur

Joining TCCS and pursuing a Ph.D. under the guidance of Professor Fomel has been one of the best decisions of my life. Having moved to the States with many expectations, I was highly impressed with the unique research environment that TCCS offers. The multidisciplinary domain of TCCS that encourages collaboration between researchers from geoscience, computational science, and mathematics was not only resourceful but even helped me grow as a geoscientist. It was particularly uplifting for a newcomer to amalgamate into this wonderful group that cherishes integrity, curiosity, creativity, and fosters independent thinking amongst its researchers. Professor Fomel always encouraged me to work on challenging research problems and learn from the experts in different fields. Through these experiences, I gained valuable insights into the intricate details of different projects. The close industrial collaborations at TCCS also proved vital in my quest to better understand the impact of my research projects. The unparalleled computational resources at TACC empowered me to efficiently scale up the ideas. I feel fortunate to be a part of TCCS and I believe that the experiences that I gained during my time here will remain as a learning curve that I wish to pursue and associate with even after the end of my term.

Zhicheng Geng

It was the best decision in my life to join TCCS, and I will never regret it. Dr. Fomel is a perfect supervisor, collaborator, and researcher. He makes significant contributions to the geophysics community through Madagascar, in which you can find the spirit of reproducibility and brilliant ideas everywhere. I will continue to benefit in my future career from what I learned from him during the past five years. Being part of TCCS, I am fortunate enough to work with colleagues who are so creative, productive, and talented. We together create an encouraging, motivating, and collaborative research environment, which builds the foundation of TCCS's success.

Ph.D. Dissertations

Name	Year	Title	Current Employer
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 Data Analysis Problems	Chevron
Yunzhi Shi	2020	Deep Learning Empowers the Next Generation of Seismic Interpretation	Amazon Web Services
Yunan Yang	2018	Optimal Transport for Seismic Inverse Problems	Cornell University
Dmitrii Merzlikin	2018	Diffraction Imaging by Path-Summation Migration	Schlumberger
Zhiguang Xue	2017	Regularization Strategies for Increasing Efficiency and Robustness of Least-Squares RTM and FWI	CGG
Yanadet Sripanich	2017	Seismic Anisotropy Analysis Using Muir-Dellinger Parameters	PTTEP
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	Occidental Petroleum
Christina Frederick	2014	Numerical Methods for Multiscale Inverse Problems	New Jersey Institute of Technology
Vladimir Bashkardin	2014	Phase-Space Imaging of Reflection Seismic Data	BP
Siwei Li	2014	Imaging and Velocity Model Building with Linearized Eikonal Equation and Upwind Finite-Differences	Chevron
Jack Poulson	2012	Fast Parallel Solution of Heterogeneous 3D Time-Harmonic Wave Equations	Hodge Star Scientific Computing
Xiaolei Song	2012	Application of Fourier Finite Differences and Lowrank 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

Ben Gremillion	2019	Seismic Data Interpolation with Shaping Inversion to Zero Offset and Least-Squares Flattening	The University of Texas at Austin
Nam Pham	2019	Automatic Channel Detection Using Deep Learning	The University of Texas at Austin
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	Improbable
Ryan Swindeman	2015	Iterative Seismic Data Interpolation Using Plane-Wave Shaping	Enthought
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	Saudi 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	Saudi Aramco
Tharit Tangkijwanichakul	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

QAe9506