Spring 2018 Newsletter

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

Welcome to the 15th *TCCS Newsletter*!

The Texas Consortium for Computational Seismology is a joint initiative of the Bureau of Economic Geology (Bureau) and the Institute for Computational Engineering and Sciences (ICES) 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.

TCCS Sponsors

TCCS appreciates the support of its 2018 sponsors:

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Spring Meeting

The Spring 2018 Research Meeting of the TCCS will take place in Houston on April 19–20. Hosted by the Bureau, it will be held at the Bureau's Houston Research Center.

Representatives of participating companies are invited to register for the meeting at: http://www.beg.utexas.edu/tccs/.

See You in Anaheim in October

TCCS has submitted 19 expanded abstracts to the 2018 SEG Annual Meeting in Anaheim. The submitted papers fall into eight different subject areas: Anisotropy; Borehole Geophysics; Full Waveform Inversion; Interpretation; Machine Learning, Seismic Processing: Migration; Seismic Processing: Multiples, Noise and Regularization; and Seismic Velocity Estimation.

Professional Awards

TCCS presented 19 talks at the 2017 SEG Annual Meeting in Houston. Three of them—given by **Sean Bader** ("Semiautomatic seismic well ties and log data interpolation") and **Dmitrii Merzlikin** ("Diffraction-based migration velocity analysis using double-path summation" and "Oriented anisotropy continuation using shifted hyperbola traveltime approximation"—were recognized and included in a list of the top 39 papers presented at the convention.

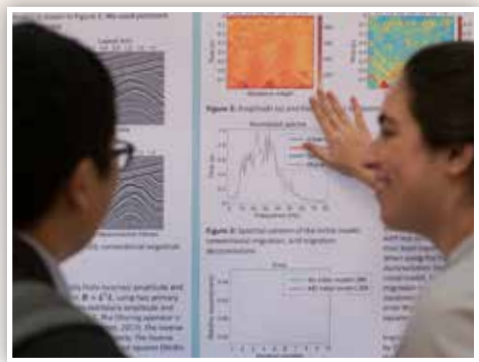
New Sponsors

TCCS welcomes its new sponsor Anadarko. TCCS is also grateful to NVIDIA Corporation, who has granted the TITAN Xp Graphics Card to TCCS to promote machine learning research.

Spring 2018 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 evaluated by faculty, research scientists, and industry representatives. The goal of the Symposium sponsored by ConocoPhillips, is to promote cross-disciplinary collaboration among graduate students, undergraduate students, and faculty/research scientists at the Jackson School. This year, **Sean Bader** won 2nd place in the Late Career Masters Student division with his poster "Missing well log data interpolation and semiautomatic seismic well ties using data matching techniques."

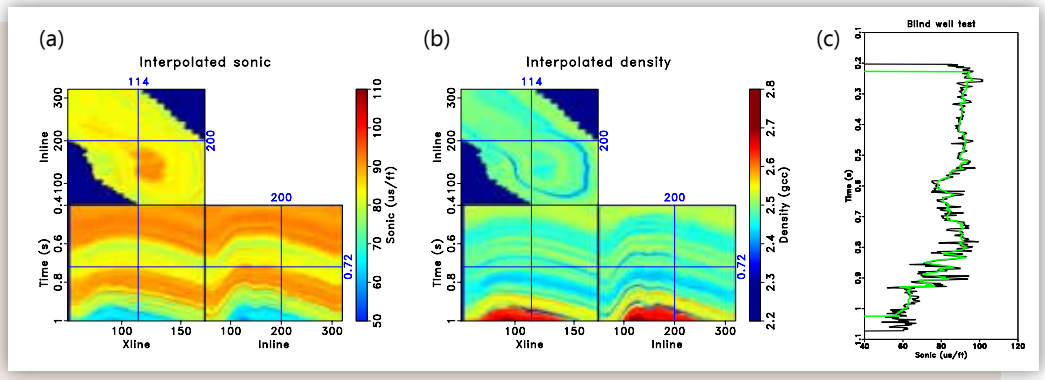
Dmitrii Merzlikin presenting his poster "Oriented anisotropy continuation using shifted hyperbola travel time approximation" to judge Dana Thomas (GeoFORCE).



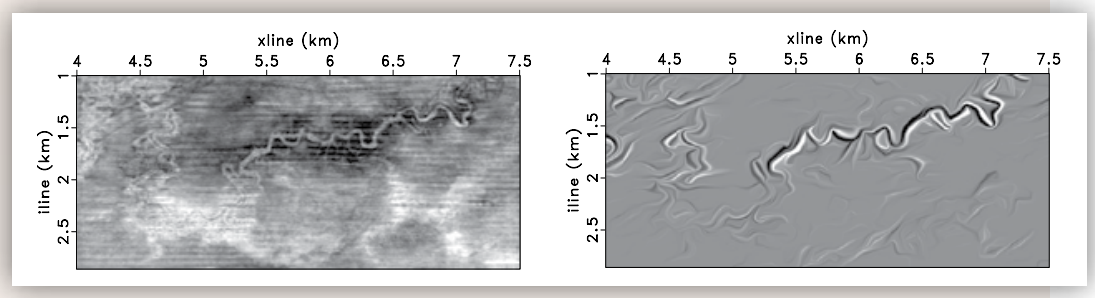
Sarah Greer (right) presenting her poster "Migration deconvolution using non-stationary matching" to a fellow student.

Research Highlights

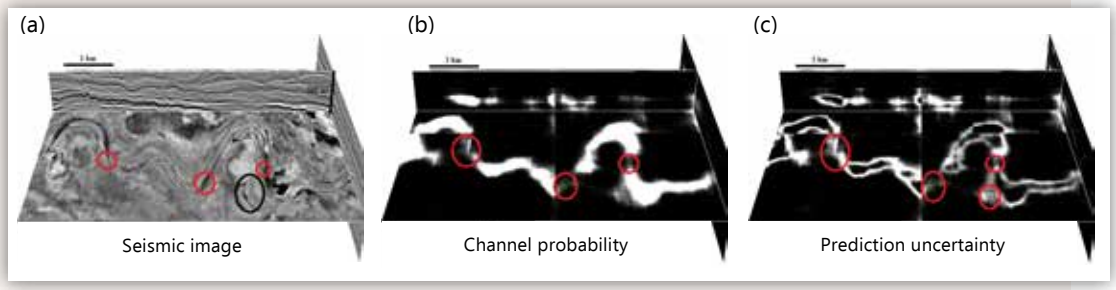
Sean Bader has been focusing on methods for integrating well-log and seismic data. This method estimates missing well-log information, automatically ties wells to seismic data, and generates log-property volumes using data-matching techniques. The workflow honors both well-log and seismic data, and the accuracy of multiple seismic well ties can be verified using blind well tests. The figures show a global sonic volume, density volume, and the result from performing a blind well test to verify the approach using several wells and a 3D seismic dataset.



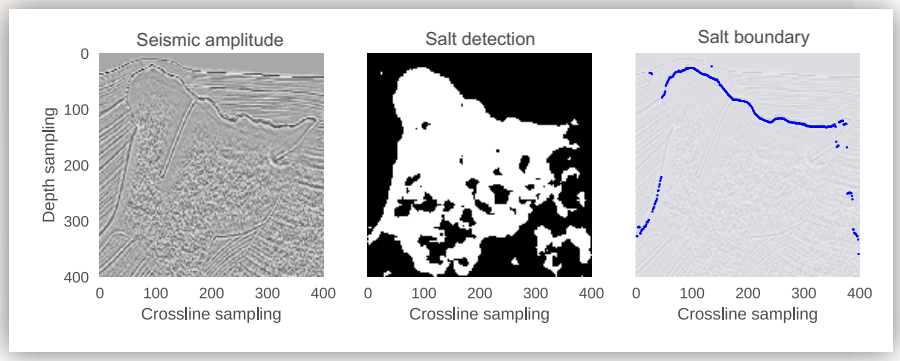
Dmitrii Merzlikin has been working on least-squares diffraction imaging. He developed an approach to denoise and emphasize edge diffractions by combining sparsity constraints and anisotropic smoothing to penalize the model using shaping regularization. The left figure shows a conventional image of an ultra-high resolution (P-cable) dataset acquired in the Gulf of Mexico to characterize the shallow subsurface. The right figure shows the result of the proposed method: channel edges and faults are denoised and emphasized.



Nam Pham has been working on automatic channel detection in seismic images using an encoder–decoder convolutional neural network which automatically learns useful features for channel detection after training on a synthetic dataset. Without the need for any other precomputed seismic attributes, the model successfully identifies channel bodies in the field dataset. Prediction uncertainty is computed simultaneously and can help the interpreter judge the results.



Yunzhi Shi has been focusing on deep-learning techniques applied to the problem of salt-body detection in seismic images. A multilayer convolutional neural network is trained to perform salt body classification as an image segmentation. This method based on deep learning provides an end-to-end automatic salt-body detection approach in seismic images. With a limited amount of manually prepared training samples, the model successfully generalizes to interpreted seismic slices and produces accurate salt-body detection results compared with manual interpretation.



Papers Accepted and Published 2017–2018

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

Accepted

B. Engquist and Y. Yang, 2018, Seismic imaging and optimal transport: Communications in Information and Systems.

B. Engquist and Y. Yang, 2018, Seismic inversion and the data normalization for optimal transport: Methods and Applications of Analysis.

Z. Xue, S. Fomel, and J. Sun, 2017, Increasing resolution of reverse-time migration using time-shift gathers: Geophysical Prospecting.

Published 2018

Y. Chen and S. Fomel, 2018, EMD-Seislet transform: Geophysics, v. 83, A27–A32.

S. Greer and S. Fomel, 2018, Matching and merging high-resolution and legacy seismic images: Geophysics, v. 83, V115–V122.

Y. Sripanich and S. Fomel, 2018, Fast time-to-depth conversion and interval velocity estimation with weak lateral variations: Geophysics, v. 83, S227–S235.

G. Wu, S. Fomel, and Y. Chen, 2018, Data-driven time-frequency analysis of seismic data using nonstationary Prony method: Geophysical Prospecting, v. 66, 85–97.

X. Wu, S. Fomel, and M. Hudec, 2018, Fast salt boundary interpretation with optimal path picking: Geophysics, v. 83, 045–053.

Z. Xue, J. Sun, S. Fomel, and T. Zhu, 2018, Accelerating full waveform inversion with attenuation compensation: Geophysics, v. 83, A13–A20.

Z. Xue, X. Wu, and S. Fomel, 2018, Predictive painting across faults: Interpretation, v. 6, T449–T455.

Y. Yang and B. Engquist, 2018, Analysis of optimal transport and related misfit functions in full-waveform inversion: Geophysics, v. 83, A7–A12.

Y. Yang, B. Engquist, J. Sun, and B. Hamfeldt, 2018, Application of optimal transport and the quadratic Wasserstein metric to full-waveform inversion: Geophysics, v. 83, R43–R62.

Published 2017

H. Chen, H. Zhou, Q. Zhang, and Y. Chen, 2017, Modeling elastic wave propagation using k-space operator-based temporal high-order staggered-grid finite-difference method: IEEE Transactions on Geoscience and Remote Sensing, v. 55, 801–815.

L. Decker, D. Merzlikin, and S. Fomel, 2017, Diffraction imaging and velocity analysis using oriented velocity continuation: Geophysics, v. 82, U25–U35.

B. Engquist, C. Frederick, Q. Huynh, and H. Zhou, 2017, Seafloor identification in sonar imagery via simulations of Helmholtz equations and discrete optimization: Journal of Computational Physics, v. 338, 477–492.

P. Karimi, S. Fomel, and R. Zhang, 2017, Creating detailed subsurface models using predictive image-guided well-log interpolation: Interpretation, v. 5, T279–T285.

D. Merzlikin and S. Fomel, 2017, Analytical path-summation imaging of seismic diffractions: Geophysics, v. 82, S51–S59.

D. Merzlikin, T. A. Meckel, S. Fomel, and Y. Sripanich, 2017, Diffraction imaging of high-resolution 3D P-cable data from the Gulf of Mexico using azimuthal plane-wave destruction: First Break, v. 35, 35–41.

M. Phillips and S. Fomel, 2017, Plane-wave Sobel attribute for discontinuity enhancement in seismic images: Geophysics, v. 82, WB63–WB69.

Y. Sripanich, S. Fomel, A. Stovas, and Q. Hao, 2017, 3D generalized nonhyperboloidal moveout approximation: Geophysics, v. 82, C49–C59.

Y. Sripanich, S. Fomel, J. Sun, and J. Cheng, 2017, Elastic wave-vector decomposition in heterogeneous anisotropic media: Geophysical Prospecting, v. 65, 1231–1245.

A. Stovas and S. Fomel, 2017, The modified generalized moveout approximation, a new parameter selection: Geophysical Prospecting, v. 65, 687–695.

J. Sun, S. Fomel, Y. Sripanich, and P. Fowler, 2017, Recursive integral time extrapolation of elastic waves using low-rank symbol approximation: Geophysical Journal International, v. 211, 1478–1493.

J. Sun, and T. Zhu, 2017, Strategies for stable attenuation compensation in reverse-time migration: Geophysical Prospecting, v. 66, 498–511.

B. Tong, I. Tsvankin, and X. Wu, 2017, Waveform inversion for attenuation estimation in anisotropic media: Geophysics, v. 82, WA83–WA93.

X. Wu, 2017, Building 3D subsurface models conforming to seismic structural and stratigraphic features: Geophysics, v. 82, IM21–IM30.

X. Wu, 2017, Directional structure-tensor based coherence to detect seismic channels and fault: Geophysics, v. 82, A13–A17.

X. Wu, 2017, Structure-, stratigraphy-, and fault-guided regularization in geophysical inversion: Geophysical Journal International, v. 210, 184–195.

X. Wu and G. Caumon, 2017, Simultaneous multiple well-seismic ties using flattened synthetic and real seismograms: Geophysics, v. 82, IM13–IM20.

X. Wu and X. Janson, 2017, Directional structure tensors in estimating seismic structural and stratigraphic orientations: Geophysical Journal International, v. 210, 534–548.

X. Wu and Z. Zhu, 2017, Methods to enhance seismic faults and construct fault surfaces: Computers & Geosciences, v. 107, 37–48.

Z. Xue, H. Zhu, and S. Fomel, 2017, Full waveform inversion using seislet regularization: Geophysics, v. 82, A43–A49.

R. Zhang and S. Fomel, 2017, Time variant wavelet extraction with spectral decomposition for seismic inversion: Interpretation, v. 5, SC9–SC16.

TCCS Staff

The TCCS group consists of scientists from five countries who are united in their goal to advance science. Research staff includes two principal investigators, six Ph.D. students, three M.S. students, a postdoc, a B.S. student, a senior research fellow, and a visiting scholar. The team includes the following:

Sean Bader (M.S. 2nd year)
Luke Decker (Ph.D. 2nd year)
Björn Engquist (PI)
Sergey Fomel (PI)
Zhicheng Geng (Ph.D. 1st year)
Sarah Greer (B.S. 4th year)
Ben Gremillion (M.S. 1st year)
Harpreet Kaur (Ph.D. 1st year)

TCCS group: *first row from left to right:* Yunzhi Shi, Ben Gremillion, Sarah Greer, Xinming Wu, Sergey Fomel, Harpreet Kaur, Yunan Yang, Jessica Rowling (Administrative Associate), Nam Pham; *second row from left to right:* Yuhan Sui, Zhicheng Geng, Dmitrii Merzlikin, Sean Bader, Karl Schleicher, Luke Decker (photo by Sarah Greer).

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

Dmitrii Merzlikin (Ph.D. 4th year)
Nam Pham (M.S. 1st year)
Karl Schleicher (Senior Research Fellow)
Yunzhi Shi (Ph.D. 3rd year)
Yuhan Sui (Visiting Scholar)
Yunan Yang (Ph.D. 5th year)
Xinming Wu (Postdoc)

Testimonial

Zhiguang Xue with his dissertation committee *from left to right:* Björn Engquist, Omar Ghattas, Sergey Fomel, Zhiguang Xue, Mrinal Sen, and James Zhang (Saudi Aramco).

Zhiguang Xue

TCCS is an encouraging, creative, and highly productive research group, and group members aim at addressing important and challenging problems in geophysics. I feel so fortunate to have joined it and to be surrounded by exceptional students and researchers. Dr. Fomel is so nice, approachable, and knowledgeable, and from him I can always get answers to my questions. Group members use Madagascar—an open-source software package created and managed by Dr. Fomel—to carry out research work. The employment of Madagascar has greatly improved our productivity and professionalization, and has given our research work very good continuity and reproducibility. Besides technical skills, I also learned many other things from Dr. Fomel and his students: superior research habits, collaborative spirit, and a positive attitude toward work and life. After four and a half years with TCCS, I found that I have learned much more than I expected. I am so grateful to Dr. Fomel and colleagues in the group for creating a tremendously supportive, helpful, and encouraging environment. I would say that joining TCCS is one of the best decisions I have made in my life.

Ph.D. Dissertations

Name	Year	Title	Current Employer
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	Utrecht University
Junzhe Sun	2016	Seismic Modeling and Imaging in Complex Media Using Low-Rank Approximation	ExxonMobil
Yangkang Chen	2015	Noise Attenuation in Seismic Data from the Simultaneous-Source Acquisition	Oak Ridge National Laboratory
Parvaneh Karimi	2015	Seismic Interpretation Using Predictive Painting	PGS
Christina Frederick	2014	Numerical Methods for Multiscale Inverse Problems	Georgia 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	Google
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	Sandia National Laboratory
William Burnett	2011	Multiazimuth Velocity Analysis Using Velocity-Independent Seismic Imaging	ExxonMobil

M.S. Theses

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	ExxonMobil
Ryan Swindeman	2015	Iterative Seismic Data Interpolation Using Plane-Wave Shaping	BHP Billiton
Luke Decker	2014	Seismic Diffraction Imaging Methods and Applications	The University of Texas at Austin
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

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