



Thomas H. W. Goebel

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Professional appointments

Researcher, Seismological Laboratory

University of California, Santa Cruz, USA, September 2018 - present

Postdoctoral Scholar, Seismological Laboratory

University of California, Santa Cruz, USA, September 2015 – August 2018

Postdoctoral Scholar, Seismological Laboratory

California Institute of Technology, USA, August 2013 – August 2015

Consultant and Technical Advisory Board Member, Induced seismicity consortium (ISC)

University of Southern California, USA, June 2013 – December 2015

Visiting positions

Humboldt Fellow, *Karlsruhe Institute of Technology (KIT), Germany, June – December 2016*

Visiting Scholar, *Swiss Federal Institute of Technology (ETH), Zürich, May - July 2012*

Visiting Scholar, *German Research Centre for Geoscience (GFZ), Potsdam, Sept. – Dec. 2010*

Education

Ph.D. Geophysics, *University of Southern California*

August 2008 - August 2013

B.Sc. Geological Sciences, *Freie Universität Berlin, Germany*

April 2005 - September 2007

Applied Geophysics, *Technical University – Bergakademie Freiberg, Germany*

October 2004 - March 2005 (transferred, course work applied)

Teaching experience

Current and upcoming

Lecturer, Spring 2019

Introduction to Scientific Computing, EART119, University of California, Santa Cruz

Lecturer, Fall 2018, Summer 2019

Earthquakes, EART11 (online), University of California, Santa Cruz

Past teaching assignments

Lecturer, Fall 2018 (two weeks)

'Fricción y la física de terremotos' (friction and earthquake mechanics), two weeks intensive course in Spanish, Universidad Nacional de El Salvador, Santa Ana, El Salvador

Lecturer, Winter 2016, Summer 2017

Geomechanics and advanced seismicity analysis: Application to reservoir characterization two-day intensive course, University of Southern California, Los Angeles, California



one-day intensive course, *Society of Petroleum Engineers*, Bakersfield, California
Lecturer, Spring 2017 (one week)
Introduction to seismological data analysis in python, *University of California, Santa Cruz*
Teaching Assistant, 2008 – 2012 (4 semesters)
Process of Change in Science (Honors – Core 103),
Earthquakes (GE – Geol 240), *University of Southern California*, Los Angeles, California

Awards and fellowships

Editor's Citation for Excellence in Refereeing

Journal of Geophysical Research, American Geophysical Union 2017

Humboldt Research Fellowship

Karlsruhe Institute of Technology, Germany, June - December 2016

Think-Swiss Research Fellowship

Swiss Federal Institute of Technology (ETH-Zürich), May - July 2012 (2 months)

Best Student Presentation Award

Seismological Society of America, Annual Meeting, Memphis, Tennessee, April 2011

Outstanding Teaching Assistant Award

Department of Earth Sciences, University of Southern California, Spring 2010

Work experience

Applied Geophysics Consultant

Induced Seismicity Consortium, University of Southern California, August 2014–March 2016

Initiated and supervised research projects and Ph.D. students, conducted research in applied seismology, co-organized meetings, presented results, conducted seismic survey

Field Assistant

University of Southern California and University of Southern Florida, Spring 2012

Installed GPS stations to constrain crustal deformation in Baja California, Mexico

Research Assistant

German Research Centre for Geoscience, GFZ-Potsdam, Summer 2007 (3 month)

Prepared and conducted rock mechanics experiments, analyzed data, presented results

Intern and Field Assistant

Eastern Atlas – Geophysical Exploration, Berlin, Germany, 2006 - 2007 (3 month)

Participated in geophysical exploration (geomagnetic and ground penetrating radar) campaigns with focus on archaeological sites



Publications

Since 2012, I have published 20 peer-reviewed articles and 3 extended abstract.

Selected publications

2018

- 20 **T.H.W. Goebel** & E.E. Brodsky, "The spatial footprint of injection wells in a global compilation of induced earthquake sequences", *Science*, 361 (6405), 899-904
- 19 S.M. Hosseini, **T.H.W. Goebel**, B. Jha, F. Aminzadeh "A probabilistic approach to injection-induced seismicity assessment for different reservoir types and pressure-diffusion models", *Geophys. Res. Letts.*, doi: 10.1029/2018GL07552
- 18 X. Chen, J. Haffener, **T.H.W. Goebel**, X. Meng, Z. Peng, J.C. Peng, "Temporal correlations between seismic moment and injection volume for an induced earthquake sequence in Central Oklahoma", *J. Geophys. Res.*, doi:10.1002/2017JB014694

2017

- 17 **T.H.W. Goebel**, J. Walter, K. Murray & E.E. Brodsky. "Comment on: How will induced seismicity in Oklahoma respond to decreased saltwater injection rates", *Science Advances* doi:10.1126/sciadv.1700441.
- 16 J. Davidsen, G. Kwiatek, E.-M. Charalampidou, **T.H.W. Goebel**, S. Stanchits, M. Rueck & G. Dresen. "Triggering processes in rock fracture: On the importance of large-scale heterogeneities", *Physical Review Letters*, 119.
- 15 **T.H.W. Goebel**, G. Kwiatek, T.W. Becker, E.E. Brodsky & G. Dresen, "What allows seismic events to grow big?: Insights from *b*-value and fault roughness analysis in laboratory stick-slip experiments", *Geology*, doi:10.1130/G39147.1
- 14 **T.H.W. Goebel**, M. Weingarten, J. Haffener, X. Chen & E.E. Brodsky. "The 2016 Mw5.1 Fairview, Oklahoma earthquakes: Evidence for long-range poroelastic triggering at >40 km from fluid disposal wells", *Earth Planetary Science Lett.*, 472, 50-61.

2016

- 13 N. van der Elst, M. Page, D.A. Weiser, **T. Goebel** & S.M. Hosseini. "Induced earthquake magnitudes are as large as (statistically) expected", *J. Geophys. Res.*, 121 (6), 4575-4590.
- 12 **T.H.W. Goebel**, E. Hauksson, A. Plesch & J. Shaw, "Detecting significant stress drop variations in large micro-earthquake datasets: A comparison between a convergent step-over in the San Andreas Fault and the Ventura thrust fault system, southern California", *Pure Appl. Geophys.* doi:10.1007/s00024-016-1326-8
- 11 **T.H.W. Goebel**, S.M. Hosseini, F. Cappa, E. Hauksson, J.-P. Ampuero, F. Aminzadeh & J.B. Saleeby. "Wastewater disposal and earthquake swarm activity at the southern end of the Central Valley, California", *Geophys. Res. Letts.*, 43, 1-8, doi:10.1002/2015GL066948.

2015

- 10 **T.H.W. Goebel**, E. Hauksson, F. Aminzadeh & J.-P. Ampuero. "An objective method for the assessment of fluid injection induced seismicity and application to tectonically active regions in central California", *J. Geophys. Res.*, 120, 1-20, doi:10.1002/2015JB011895.
- 9 **T.H.W. Goebel**, E. Hauksson, P. M. Shearer & J.P. Ampuero. "Stress drop heterogeneity within tectonically complex regions: A case study of San Geronio pass, Southern California", *Geophys. J. Int.*, 202(1), 514-528, doi: 10.1093/gji/ggv160.
- 8 **T.H.W. Goebel**. "Comparing seismicity rates and fluid injection operations in Oklahoma and California: Implications for upper crustal stresses", *The Leading Edge, Special Volume: Injection-induced seismicity*, eds. Robert Habiger, Gregory Beroza, 34(6), 640-648.



- 7 E. Hauksson, **T.H.W. Goebel**, J.-P. Ampuero & Elizabeth Cochran. "A century of oilfield operations and earthquakes in the greater Los Angeles basin, southern California", *The Leading Edge*, 34(6), 650-656, doi: 10.1190/tle34060650.1.

2014

- 6 G. Kwiatek, **T.H.W. Goebel**, & G. Dresen. "Seismic moment tensor and *b*-value variations over successive seismic cycle in laboratory stick-slip experiments", *Geophys. Res. Letts.*, 41 (16), doi:10.1002/2014/GL060159.
- 5 **T.H.W. Goebel**, T. W. Becker, C. G. Sammis, G. Dresen, & D. Schorlemmer. "Off-fault damage and acoustic emission distributions during the evolution of structurally-complex faults over series of stick-slip events", *Geophys. J. Int.*, 197 (3), doi: 10.1093/gji/ggu074.
- 4 **T.H.W. Goebel**, T. Candela, C. G. Sammis, T. W. Becker, & G. Dresen. "Seismic event distributions and off-fault damage during frictional sliding of saw-cut surfaces with predefined roughness", *Geophys. J. Int.*, 196 (1), 612-625.

2013

- Thesis **T.H.W. Goebel**. "Microseismicity, fault structure & the seismic cycle. Insights from laboratory stick-slip experiments", *Thesis (Ph.D.)*, University of Southern California. (2013) 204 p, ISBN: 9781303467219, <http://gradworks.umi.com/35/98/3598217.html>
- 3 **T.H.W. Goebel**, D. Schorlemmer, T. W. Becker, G. Dresen, & C. G. Sammis. "Acoustic emissions document stress changes over many seismic cycles in analog experiments", *Geophys. Res. Letts.*, 40 (10), doi:10.1002/grl.50507.
 - 2 **T.H.W. Goebel**, C. G. Sammis, T. W. Becker, G. Dresen, & D. Schorlemmer. "A comparison of seismicity characteristics and fault structure in stick-slip experiments and nature", *Pure Appl. Geophys.*, doi:10.1007/s00024-013-0713-7.

2012

- 1 **T.H.W. Goebel**, T. W. Becker, D. Schorlemmer, S. Stanchits, C. G. Sammis, E. Rybacki & G. Dresen, "Identifying fault heterogeneity through mapping spatial anomalies in acoustic emission statistics", *J. Geophys. Res.*, 117 (B3), doi:10.1029/2011JB008763.

Extended abstracts

Y.-X. Zhang, **T.H.W. Goebel**, Z. Peng, C. Williams, M. Yoder, J. Rundle (2017), "Earthquakes and Multi-hazards around the Pacific Rim, Vol. 1: Introduction", *Pure Appl. Geophys.*, 174, 2195-2198

T.H.W. Goebel, F. Aminzadeh, J. Haffener & X. Chen. "Statistical seismicity analysis methods for the detection of fault activation during fluid injection", *Society of Exploration Geophysicists*, annual meeting 2016, Dallas Texas

Manuscripts submitted or in preparation (pre-print available)

J. Davidsen, **T.H.W. Goebel**, G. Kwiatek, S. Stanchits, J. Baro and G. Dresen, "Triggering cascades and compression events in rock fracture experiments" *J. Geophys. Res.*, (in prep.)

G. Dresen, G. Kwiatek and **T.H.W. Goebel**, "Preparatory processes before stick-slip failure on smooth and rough laboratory fault surfaces" *J. Geophys. Res.*, (in prep.)

T.H.W. Goebel, Z. Rosson, E.E. Brodsky, J. Walter "Aftershock deficiency in regions with rapid induced seismicity mitigation in Oklahoma" *Earth Planet. Sc. Lett.*, (in prep.)

N. Wetzler, E. Shalev, I. Kurzon, V. Lyakhovskiy, **T. Goebel**, E. Brodsky, "The July 4th 2018 Mw 4.5 Sea of Galilea earthquake triggered by groundwater extraction", (in prep.)



Presentations and invited seminar talks

Since 2008, I have given more than 50 presentations (>20 invited and one plenary talk).

Selected presentations

- T.H.W. Goebel, G. Kwiatek, T.W. Becker, E.E. Brodsky, G. Dresen (2018), Fault roughness, stress and seismicity statistics in stick-slip experiments, *UC Berkeley Seismolab Seminar*, October 2nd, 2018.
- T.H.W. Goebel, E.E. Brodsky (2018), What is the maximum spatial reach of fluid-injection operations?: Examining seismicity decay and poroelastic effects around injection wells, *Caltech Seismo-Lab Seminar*, Pasadena, April 20th, 2018
- T.H.W. Goebel, G. Kwiatek, T.W. Becker, E.E. Brodsky, G. Dresen (2017), What allows seismic events to grow big? Insights from *b*-value and fault roughness analysis in stick-slip experiments, *USGS Earthquake Physics Seminar*, Menlo Park, USA, June 14th, 2017.
- T.H.W. Goebel, M. Weingarten, J. Haffener, X. Chen & E.E. Brodsky (2016b), The 2016 Mw5.1 Fairview, Oklahoma earthquakes: Evidence for long-range poroelastic triggering at >40 km from disposal wells, *Ecole Normale Supérieure*, Paris, France, October 25th, 2016.
- T.H.W. Goebel, J. Haffener, X. Chen & E.E. Brodsky (2016a), Distant earthquake triggering by fluid injection operations in Colorado, Oklahoma and California, *German Center for Geosciences*, Potsdam, July 5th, 2016.
- T.H.W. Goebel, E. Hauksson, P. Shearer, J. Shaw, A. Plesch (2015c) Stress drop variations in San Geronimo Pass and Ventura Basin, Hewett Club Seminar, *UC Riverside*, Dec. 1st, 2015
- T.H.W. Goebel, J.-P. Ampuero, E. Hauksson, J. Saleeby, M. Hosseini, F. Aminzadeh and F. Cappa (2015b), Seismogenic response to fluid injection in California hydrocarbon basins: The role of permeability structure and implications for crustal stresses, *USGS Earthquake Physics Seminar*, Menlo Park, USA, September 9th, 2015.
- T.H.W. Goebel, E. Hauksson, J.-P. Ampuero, F. Aminzadeh (2015a), Differences in fluid injection induced seismicity in California and Oklahoma and implications for crustal stresses, *Earthquake Physics Seminar, University of Southern California*, January 21st, 2015.
- T.H.W. Goebel, E. Hauksson, J.-P. Ampuero, F. Aminzadeh (2014c), Waste water injection and induced seismicity in central California, *USEA Informational Briefing on subsurface technology, engineering challenges, R&D opportunities*, Washington D.C., October 30, 2014.
- T.H.W. Goebel, E. Hauksson, J.-P. Ampuero, F. Aminzadeh, F. Cappa, J.B. Saleeby (2014b), Waste water injection induced seismicity in naturally-active, seismogenic regions in central California, *Southern California Earthquake Center annual meeting, Conference Proceedings*, v03, p. 113 (plenary talk).
- T.H.W. Goebel, F. Aminzadeh (2014a), Identifying induced seismic events in active tectonic regions, *IGPP Seminar*, UC Santa Cruz, CA, April 11, 2014.
- T.H.W. Goebel, T. W. Becker, D. Schorlemmer, C. G. Sammis, G. Dresen (2012b), Properties of faults inferred from seismicity statistics during stick-slip experiments. *Caltech, Seismo-Lab Seminar*, Dec. 14, 2012, Pasadena, California.
- T.H.W. Goebel, T. W. Becker, D. Schorlemmer, C. G. Sammis, G. Dresen (2012a), Stress driven variations in micro-seismicity during laboratory stick-slip tests, *Lamont-Doherty Earth-Observatory Seminar*, Jan. 12, 2012, Palisades, New York.
- T.H.W. Goebel, T. W. Becker, D. Schorlemmer (2011), Fault heterogeneity and *b*-value mapping, *Swiss Seismological Service Seminar*, June 27, 2011, ETH-Zurich, Switzerland.



Service, activities and professional memberships

Advised Students

Mehran Hosseini, Petroleum Engineering, USC, Ph.D. 2018
Primary Advisor, Prof. Fred Aminzadeh
Zach Rosson, Geophysics, University of Oklahoma, M.Sc., expected: 2019
Primary Advisor, Dr. Jake Walter
Andrew Quartuccio, Mathematics, UC Santa Cruz, B.A., expected: 2020

Editor

Pure and Applied Geophysics (Guest Editor, 3 volumes)
Seismological Research Letters (Associate Editor)

Reviewer

Geology, Geochem. Geophys. Geosys., Phys. Earth Planet. Int., Pure Appl. Geophys.,
Bull. Seis. Soc. Am., J. Geophys. Res., Nature Comm., Geophys. Res. Lett., Earth
Planet. Sc. Lett., PNAS

Session Convener

11 sessions at AGU, SSA and EGU between 2014 and 2018

Proposal Review Panel Member (2 panels)

United States Geological Survey, National Earthquake Hazards Reduction Program

Faculty Adviser

Bridges at Caltech (Bridges International), California Institute of Technology, 07/2014 to
08/2015

Advised leaders of Christian student association for international students and
scholars, support and transitional help for new international students

Voluntary Work

Youth with a Mission, El Salvador - 8/2017 to 11/2017; 9/2018

Nutrition, construction and education programs in underprivileged neighborhoods of
San Salvador

Lecture: "La subida dramática de sismicidad inducida en el centro de Estados
Unidos", Ministerio de Medio Ambiente y Recursos Naturales, San Salvador

Laboratory rock mechanics and induced seismicity lectures (Spanish), Universidad El
Salvador, Santa Ana

Memberships

Seismological Society of America (SSA), American Geophysical Union (AGU), Society
of Exploration Geophysicists (SEG), American Association of Petroleum Geologists
(AAPG)

