2023 SSA Annual Meeting Sessions

17–20 April 2023 | San Juan, Puerto Rico

New Observations and Modeling of Triggered Seismicity
Normal Faults: From Source to Surface
Numerical Modeling in Seismology: Developments and Applications
Opportunities and Challenges for Machine Learning Applications in Seismology
Opportunities and Challenges in Source Modeling for Seismic Hazard Analysis
Seismology for the Energy Transition
Seismology's Role in Assessing Volcanic Hazard at Multiple Time Scales
ShakeMap-Related Research, Development, Operations, Applications and Uses
Single-Station Passive Exploration Methods: Status and Perspectives
Site-Specific Modeling of Seismic Ground Response: Are We Quantitative Enough to Predict?
Special Session on February 2023 Mw 7.8 Earthquake Sequence in Turkey
Structure and Properties of Subducting Slabs and Deep Earthquakes
Subduction Zone Structure from Trench to Arc
Tectonics and Seismicity of Stable Continental Interiors
The 2020-2021 Southwest Puerto Rico Seismic Sequence: Current State of Knowledge and Implications
The Future of Tsunami Science, Preparedness and Response
Transforming Our Seismological Community Through Inclusive Mentorship and Diverse Narratives
Understanding and Managing Induced Seismicity
Understanding and Modeling the Uncertainties in Earthquake Ground Motions
Understanding Earth Systems with Fiber-Optic Cables
Understanding the Variability in Earthquake Stress Drop Measurements
USGS National Seismic Hazard Models: 2023 and Beyond

2025 Puerto Rico and the U.S. Virgin Islands National Seismic Hazard Model Update

The National Seismic Hazard Model Project (NSHMP) will publish a new Puerto Rico and U.S. Virgin Islands (PRVI) NSHM in 2025. The last update was in 2003, therefore the new update will include over 20-years of new science and engineering data, models and methods. The NSHMP has requested the scientific community bring our attention to published earthquake source and ground motion models (GMMs) that could be included in this update by December 31, 2022. Planned updates for the 2025 PRVI NSHM include new seismicity models, based on an improved Puerto Rico Seismic Network seismicity catalog, updated geologic and geodetic deformation models, NGA-West2 and NGA-Subduction GMMs, site response models and uncertainty estimates.
NSHMs are community- and consensus-based models that are constantly aiming to incorporate the latest data, models and methods available to evaluate and validate hazard assessments as we undertake this updating process. This session will outline the plan and timeline for the 2025 PRVI NSHM Update, feature new source and ground motion data and models that will be considered in the 2025 model, as well as showcase current work being performed in the region that may impact future PRVI NSHM updates. We invite abstracts on new sources and GMMs, risk assessments, building code applications and other policy uses. We also invite abstracts from end users on applications and needs of NSHMs in end user products.

Conveners: Alberto M. López-Venegas, University of Puerto Rico Mayagüez, alberto.lopez3@upr.edu; Allison M. Shumway, U.S. Geological Survey, ashumway@usgs.gov; Jessica A. Thompson Jobe, U.S. Geological Survey, jjobe@usgs.gov; Thomas L. Pratt, U.S. Geological Survey, tpratt@usgs.gov; Victor Huérfano, University of Puerto Rico Mayagüez, victor.huerfano@upr.edu

Above the Seismogenic Zone: Fault Damage and Healing in the Shallow Crust

Fault damage zones provide a window into the inelastic processes and products that result from coseismic stress changes. The spatial extent of fault damage during earthquakes is greatest in the upper-most kilometers of the crust, above the seismogenic zone. Inelastic processes within this volume modify the bulk long-term properties of the shallow crust, increasing local seismic hazard through enhanced shaking. Fault damage zones have attracted the interest of a broad range of geoscientists because of their relevance to fundamental earthquake physics problems, i.e., the earthquake energy balance, strong ground motions and near fault fluid flow. Higher resolution datasets, a growing number of observations and increased computational power have advanced our understanding of the spatial extent, physical properties and time-integrated evolution of the shallow portion of damage zones. Our understanding of fault damage zones, the processes that form them and their feedbacks with various phases of the earthquake cycle is improving; however, there remain many unanswered questions such as the mechanism and rate of fault healing above the seismogenic zone, the role of subsidiary faults on earthquake nucleation and a complete model that extends damage observed at the surface to seismogenic depth. In this session, we welcome contributions and recent advances in the quantitative understanding of the shallow properties of fault damage zones. We are particularly interested in contributions that explore and combine observations, laboratory experiments, numerical modeling and theoretical studies.

Conveners: Ahmed Elbanna, University of Illinois Urbana-Champaign, elbanna2@illinois.edu; Alba M. Rodríguez Padilla, University of California, Davis, arodriguezpadilla@ucdavis.edu; Ashley W. Griffith, Ohio State University, griffith.233@osu.edu; Prithvi Thakur, University of Michigan, prith@umich.edu; Travis Alongi, University of California, Santa Cruz, talongi@ucsc.edu

Active Faults in the Caribbean and Central America

The Caribbean - Central America region is tectonically complex and diverse including convergent, divergent and transform plate boundaries. Numerous damaging historical earthquakes and tsunamis demonstrate the high level of earthquake hazard in the region, yet in many areas the specifics necessary for accurate hazard analysis and earthquake forecasting, such as fault slip rates, fault rupture history, earthquake chronologies and recurrence intervals, and even fault locations remain uncertain. We invite presentations of studies that elucidate any of these factors, including those employing terrestrial or subaqueous earthquake geology, geomorphology, paleoseismology, paleogeodesy or instrumental geodesy, paleotsunami studies, geophysics or seismology, or efforts to map active faults using any technique. Additionally, we accept presentations of work on the interface between earthquake science and society, including risk management, citizen science, and public policy. Submissions emphasizing the contribution of geoscience research to stakeholders in the evaluation of infrastructure resilience in the region are encouraged. Presentations that highlight cutting-edge methods are particularly welcome.

Conveners: Daniel A. Laó-Dávila, Oklahoma State University, daniel.lao_davila@okstate.edu; Belle Philibosian, U.S. Geological Survey, bphilibosian@usgs.gov; Kate Scharer, U.S. Geological Survey, kscharer@usgs.gov; Lorna G. Jaramillo-Nieves, University of Puerto Rico, Rio Piedras, lorna.jaramillo@upr.edu; Alberto M. López Venegas, University of Puerto Rico, alberto.lopez3@upr.edu; Carol Prentice, U.S. Geological Survey, cprentice@usgs.gov; Nathalie Feuillet, Institut de Physique du Globe de Paris, feuillet@ipgp.fr

Advances in Characterizing Seismic Hazard and Forecasting Risk in Hydrocarbon Systems

Unprecedented seismic activity near hydrocarbon development sites has raised questions regarding the physical mechanisms causing induced seismicity and spurred the expansion of hazard mitigation strategies over the past two decades. Adaptive and data-driven strategies for mitigating seismic hazard associated with hydrocarbon production, rely on real-time monitoring of earthquakes, identification of faults, and accurate timely reporting of operational data like downhole pressure. Different kinds of injection and production in operational fields change the reservoir and subsurface stress in space and time. Necessary ancillary data (e.g., sonic logs, 3D seismic data, fault maps, and subsurface pressure) are not always publicly available or reported

in near-real time. Recent advancements in seismic and geodetic data availability and processing afford opportunities for developing high resolution catalogs and monitoring programs. Such data can be used to drive stress simulations and forecasting scenarios for induced seismicity and the real-time characterization of the evolving seismic hazard that enables stakeholders to make informed decisions on mitigation.
We seek diverse contributions focusing on hazard mitigation and risk assessment that span disciplines, including insight into the physics of induced earthquakes, the evolution of host faults and rocks, and case studies of successful mitigation. We encourage submissions that showcase innovative datasets made of deep learning, distributed acoustic sensing and large-N arrays, 3D imaging of faults, and integrated hydrologic and geomechanical modeling linked to production and injection operational data (including carbon capture sites). Presentations on computational, laboratory, and in-situ experiments for understanding fault behavior and fault slip modes under undrained/drained conditions are also encouraged to shed light on hydro-mechanical processes governing the spatiotemporal evolution of micro-seismicity.

Conveners: Alexandros Savvaidis, University of Texas at Austin, alexandros.savvaidis@beg.utexas.edu; Asiye Aziz Zanjani, Southern Methodist University, aazizzanjani@smu.edu; Heather R. DeShon, Southern Methodist University, hdeshon@smu.edu; Jake Walter, University of Oklahoma, Oklahoma Geological Survey, jwalter@ou.edu; Nadine Igonin, University of Texas at Austin, nadine.igonin@beg.utexas.edu

Advances in Marine Seismoacoustics

On land, we are seeing increasing interdependence between seismic and infrasonic or acoustic observations for many important research applications. Continued expansion of seismoacoustic research into the oceans has given rise to a vast expansion of our geophysical reach, sensing and observational capabilities. Both autonomous deep ocean sensing and near-shore cabled arrays have provided significant advances not only for geodynamic modeling but also earthquake and tsunami early warning, extension of global geophysical models and new appreciation of the complex and coupled problem of hydroacoustic and seafloor seismic interactions and phenomena. We invite contributions surrounding all relevant studies addressing marine seismoacoustic issues, including sensor and communications developments, oceanic noise (both hydroacoustic and seismic), marine mammal vocalization and acoustic tomography, propagation and phase conversion, spreading center, transform system and subduction models and observations and fusion of relevant geophysical observations to augment new and existing seafloor seismic data.

Conveners: Charlotte Rowe, Los Alamos National Laboratory, char@lanl.gov; Ethan Williams, Caltech, efwillia@caltech.edu; Kasey Aderhold, Incorporated Research Institutions for Seismology, kasey@iris.edu; Nishath Rajiv Ranasinghe, Los Alamos National Laboratory, ranasinghe@lanl.gov

Advances in Probabilistic Seismic Hazard Analysis and Applications

Probabilistic seismic hazard analysis (PSHA) was established a half-century ago and has since been used for seismic hazard, as the basis for building codes and seismic risk analysis. Significant improvements have been made in both seismic source and ground motion modeling. The modeling of epistemic uncertainty through logic-trees and other tools has allowed modelers to combine diverse ideas to produce more informative hazard estimates.
However, several challenges remain. Despite considerable progress made in the latest decade (e.g., UCERF3), combining different information in the seismic source characterization (e.g., historical seismicity, geodesy, tectonics and paleoseismology) remains problematic. Assumptions about, for example, magnitude scaling, earthquake rates on faults and Mmax are necessary due to incomplete data and lack of understanding and oversimplification of complex earthquake phenomena. On the ground-motion modeling side, an increasing number of hazard analyses incorporate regional and local properties through partially- and non-ergodic models and account for epistemic uncertainties with advanced approaches, such as the ones based on backbone models.
We invite presentations on the developing or updating of national or regional hazard models including site specific hazard studies, as well as the application of them, including but not limited to their application in the building code community and insurance sectors. We also welcome studies on model evaluation such as impact on hazard result by different modeling assumptions. Please note that papers specifically on seismic source modeling should be submitted to “Opportunities and Challenges in Source Modeling for Seismic Hazard Analysis” session.

Conveners: Elliot Klein, FM Global, elliot.klein@fmglobal.com; Harold Magistrale, FM Global, harold.magistrale@fmglobal.com; Marco Pagani, GEM Foundation, marco.pagani@globalquakemodel.org; Matt Gerstenberger, GNS Science, m.gerstenberger@gns.cri.nz; Richard Styron, GEM Foundation, richard.styron@globalquakemodel.org; Sanjay Bora, GNS Science, s.bora@gns.cri.nz; Yufang Rong, FM Global, yufang.rong@fmglobal.com

Advancing Science with Global Seismological and Geophysical Networks

Four decades of globally distributed and openly available very broadband seismic recordings have enabled significant advances in characterizing earthquake sources, mapping the deep structure of the Earth, and understanding the behavior of the atmosphere, hydrosphere, and cryosphere. Long-term deployment has illuminated time-dependent processes and allowed subtle signals to be enhanced and utilized through stacking. At the same time, establishing real-time telemetry at these stations has revolutionized the monitoring capability for large and potentially destructive earthquakes. Central to these activities have been the international partnerships, infrastructure investments, and technological developments that have facilitated, grown, and maintained the availability of low-noise and high-fidelity seismic recordings from almost anywhere in the world. This session will be a forum to highlight impactful current science being done with globally distributed real-time networks, to understand how technological developments can optimize existing resources, to share ideas for expanding networks like the Global Seismographic Network, GeoScope, and others to include other geophysical and environmental observations, to recognize how increased partnerships and collaboration can further grow high-quality station coverage around the world, and to reflect on the common challenges to operating and sustaining these scientific resources. We encourage contributions from the international community of seismologists and related disciplines, instrumentation developers, network and station operators, and other stakeholders.

Conveners: Andrew M. Frassetto, Incorporated Research Institutions for Seismology, andy.frassetto@iris.edu; Colleen Dalton, Brown University, colleen_dalton@brown.edu; David Wilson, Albuquerque Seismological Laboratory, United States Geological Survey, dwilson@usgs.gov; Frederik Tilmann, Helmholtz Center Potsdam, tilmann@gfz-potsdam.de; Martin Vallée, Institut de Physique du Globe de Paris, vallee@ipgp.fr; Robert Busby, Incorporated Research Institutions for Seismology, busby@iris.edu

Collective Impact in Earthquake Science

The earthquake science and engineering community has the opportunity to apply leading edge earthquake research to improve resilience from seismic hazards in an equitable, accessible and sustainable manner. One way to do this is by adopting a collective impact model, which develops a network of community members, organizations and institutions by adopting a common agenda, centralized support, continuous communication, mutually reinforcing activities and shared measurement. In this session, we invite presentations highlighting research from any disciplines with the potential to respond to the needs of vulnerable populations that have been historically underserved by current earthquake science, engineering and public policy. Topics could include 1) community-driven or community-based research results, 2) discoveries advancing our understanding of seismic hazards in areas of low probability but high impact earthquakes (including intraplate and induced earthquakes), 3) strategies for implementing practical, research-inspired solutions for communities, 4) research engaging low-resourced communities or historically marginalized populations, 5) existing efforts to coordinate research and projects for broader community benefits and 6) integration of social science with seismology. We encourage presenters to highlight strategies and efforts to improve inclusivity, diversity, equity and accessibility in seismology.

Conveners: Aaron A. Velasco, University of Texas at El Paso, aavelasco@utep.edu; Alexandros Savvaidis, Bureau of Economic Geology, alexandros.savvaidis@beg.utexas.edu; Manuel Mendoza, University of Colorado, mame3278@colorado.edu; Marianne S. Karplus, University of Texas at El Paso, mkarplus@utep.edu; Michael R. Brudzinski, Miami University, brudzimr@miamioh.edu; Steven Jaume, College of Charleston, jaumes@cofc.edu; Susan Bilek, New Mexico Tech, sbilek@nmt.edu

Constraining Seismic Hazard in the Cascadia Subduction Zone

The Cascadia Subduction Zone is host to a range of significant earthquake and tsunami-related hazards, which have the potential to impact major population centers and coastal communities.

Due to the historically low seismicity in this region, it has been difficult to constrain the hazard and risk to nearby communities from earthquakes and their cascading effects. However, in recent years, our understanding of seismic hazard in Cascadia has progressed thanks to advances in instrumentation and modeling and interdisciplinary collaborations. For example, the M9 Project and Cascadia Coastal Hazards Research Coordination Network have integrated geosciences and structural engineering with social science and public policy planning. These have helped to better characterize CSZ seismic hazards, both from great megathrust earthquakes and from the more frequent low-to-moderate magnitude seismicity occurring on nearby crustal faults and in the subducting slab. Additional multidisciplinary efforts are anticipated over the next few years: the draft SZ4D implementation plan calls for additional long-term instrumentation in the Cascadia Subduction Zone and collaborations resulting from a nascent earthquake science center proposal (Cascadia Region Earthquake Science Center, CRESCENT) aim to understand hazards from an interdisciplinary perspective, with stakeholder input. This session welcomes presentations that address all aspects of earthquake and tsunami hazard in Cascadia, including seismic or geodetic modeling efforts, offshore and onshore observational studies, statistical seismology, probabilistic hazard estimation, early warning and communication and policy planning. We encourage contributions related to intraslab and crustal earthquakes as well as megathrust events.

Conveners: Diego Melgar, University of Oregon, dmelgarm@uoregon.edu; Erin A. Wirth, U.S. Geological Survey, emoriarty@usgs.gov; Leah Langer, U.S. Geological Survey, llanger@usgs.gov; Max Schneider, U.S. Geological Survey, mschneider@usgs.gov; Valerie Sahakian, University of Oregon, vjs@uoregon.edu

Coseismic Ground Failure: Advances in Modeling, Impacts and Communication

Landslides and liquefaction triggered by earthquakes are a diverse set of phenomena that can cause significant impacts and losses across wide areas affected by earthquake shaking. Advances in our ability to model the initiation, displacement or runout, and impacts of ground failure of all types are needed to improve our ability to quantify the magnitude and uncertainty of hazard and risk, as well as predict near-real-time losses for emergency response. To be most useful, these hazard and risk models also need to be effectively communicated to a wide range of technical and general audiences across a wide range of contexts. All coseismic ground failure advances depend on a basis of strong high-quality datasets, both in terms of susceptibility and loading factors and detailed documentation of the occurrence of ground failure in past earthquakes. We welcome all submissions relating to coseismic ground failure, including but not limited to contributions on: regional scale assessment; characterizing uncertainty, or developing ensemble model predictions; studies on the impacts, losses and risk modeling for coseismic ground failure; research or case histories on the best practices and advances in engagement and communication with diverse stakeholder groups; as well as case histories and lessons from recent and historic earthquakes.

Conveners: Alex R. Grant, U.S. Geological Survey, agrant@usgs.gov; Eric Thompson, U.S. Geological Survey, emthompson@usgs.gov; Kate E. Allstadt, U.S. Geological Survey, kallstadt@usgs.gov; Laurie G. Baise, Tufts University, laurie.baise@tufts.edu

Crustal Deformation and Seismic Hazard in Western Canada, Cascadia and Alaska

It is well known that a component of plate boundary deformation is distributed along fault sources located 10s to 100s of km away from the plate interface. However, in many systems the locations, geometries, kinematics and rates of deformation along these faults, and how they interact with the plate interface, are poorly understood. This information is necessary both to understand how plate boundary strain is accommodated across the system and to evaluate the seismic hazard these fault sources pose. This is particularly true of the Cascadian upper plate, Canadian Cordillera and Alaskan margins of western North America, where dense vegetation, rugged terrain, limited instrumentation and locally slow strain rates make assessing fault rupture potential challenging. Over the past decade, there has been significant advances in understanding the deformational and paleoseismic histories of fault structures in Oregon, Washington, Vancouver Island, eastern British Columbia and southeastern Alaska. Much of the most recent work builds upon several decades of prior research — but not all of this work is published or publicly available to researchers and hazard modelers. For this reason, we aim to develop a session to bring researchers together to discuss known and suspected crustal faults in this complex plate boundary zone. In this session, we hope to discuss the current state of knowledge of known or suspected active faults using data sets including but not limited to paleoseismology, seismology, geodesy and modeling of shallow faults in northwestern North America. We aim to bring researchers together to not only share knowledge, but also to help build a community of practice, developing ideas and workflows that can be applied to quantify the deformation rates and hazard of crustal fault in similar tectonic and climatic settings.

Conveners: Christine Regalla, Northern Arizona University, christine.regalla@nau.edu; Lydia Staisch, U.S. Geological Survey, lstaisch@usgs.gov; Richard H. Styron, GEM Foundation, richard.styron@globalquakemodel.org; Tiegan Hobbs, Geological Survey of Canada, thobbs@eoas.ubc.ca

Crustal Imaging of High Seismic Hazard Regions

In high seismic hazard areas, imaging both the elastic and anelastic properties of the medium is key for evaluating deformation processes and the impact of complex fault systems on ground motion amplification. Characterizing crustal features is especially challenging when wave focusing and conversions, or fluid interactions occur such as in geothermal and volcanic areas. Combining attenuation and velocity models is crucial for predicting site response and seismic wavefield amplitudes. This session aims at providing an overview of techniques and applications related to the imaging and validation of seismic velocity and attenuation across various scales ranging from laboratory samples to basin and plate boundary scales. We welcome onshore and offshore passive and active-source seismic studies and studies based on gravity and magnetic data that discuss the characterization of crustal structures, including faults, volcanic and geothermal areas. We aim to gather contributions from velocity and attenuation tomography (t* method, direct wave attenuation, coda waves) and other imaging techniques (e.g., using ambient noise and converted waves). We welcome studies aimed at including these models and other multidisciplinary geophysical and geological data in ground motion modeling, seismic hazard assessments and site response analysis. We also encourage submissions from early-career researchers and studies using innovative methodologies (e.g., machine learning).

Conveners: Chiara Nardoni, Louisiana State University, cnardoni@lsu.edu; Simona Gabrielli, Istituto Nazionale di Geofisica e Vulcanologia, simona.gabrielli@ingv.it; Patricia Persaud, University of Arizona, ppersaud@lsu.edu; Eric Sandvol, University of Missouri, SandvolE@missouri.edu

Deciphering Earthquake Clustering for the Better Understanding of Crustal Deformation Mechanisms

When is the occurrence of earthquakes random and when is it not? How do earthquakes interact and why are interactions stronger in some places? Which physical processes enhance clustering and which do not? More than a century after the first quantitative description of earthquake clustering in aftershock sequences by Omori, clustering has been recognized as the consequence of stress redistribution accompanying deformation in the crust (for example, after a large earthquake). However, high resolution catalogs, application of advanced statistical analyses and numerical modeling in complex fault analogues have started to reveal how earthquake clustering can also emerge from the interplay between fault complexity and physical processes occurring in the lithosphere. The role of transient creep and fault heterogeneity are for example nowadays key factors in controlling the occurrence of time and space synchronization of seismicity. However, much remains to discover about the relationship between the observed spatio-temporal clustering of earthquakes and the driving mechanisms, as well as the host rock properties. In this session we welcome observational, experimental, numerical and theoretical studies tackling the issue of earthquake clustering at different spatial and temporal scales, and which provide interpretation in terms of fault and other crustal mechanisms. Studies focusing on different tectonics settings, and on volcanoes, are welcome, with the aim of shedding new light on the physics of earthquake clustering and understanding the dynamics of complex crustal processes better.

Conveners: Eric Beauce, Lamont-Doherty Earth Observatory, Columbia University, ebeauce@ldeo.columbia.edu; Patricia Martínez Garzón, GFZ Potsdam, patricia@gfz-potsdam.de; Piero Poli, Università di Padova, pieropoli85@gmail.com

De-Risking Deep Geothermal Projects: Geophysical Monitoring and Forecast Modeling Advances

Geothermal energy is an emerging renewable energy source and as a green and sustainable energy can make a significant contribution to the current worldwide challenge to reduce the net atmospheric emissions of greenhouse gases to zero. Geothermal heat extracted from depth in excess of 400 m is defined as deep geothermal energy or Enhanced Geothermal Systems (EGS). EGS usually employ hydraulic fracturing to increase the rock permeability and favor a more efficient exploitation of deep geothermal reservoirs when local geology does not favor natural pathways for fluid circulation. Induced micro-earthquakes in EGS are not therefore undesired by-products but a necessary tool to create effective pathways for fluid migration and heat exchange. Thus, to develop EGS, adaptive, data-driven real-time monitoring and risk analysis of potential seismicity triggered by EGS operations is crucial for assessing the geothermal stimulation effects and demonstrate that safe and sustainable development of deep geothermal energy projects is possible. A current research-oriented EGS laboratory is being developed at the FORGE (Frontier Observatory for Research in Geothermal Energy) geothermal site in Utah, USA. We encourage contributions from FORGE and other different geothermal energy projects and field test sites that focus on geophysical technologies applied to geothermal energy, such as real-time monitoring and characterization of induced seismicity, distributed acoustic sensing, large-N array, active surface seismic, vertical seismic profiling, seismic imaging of faults and fracture zones, laboratory experiments and novel instrumentation. We also welcome submission of abstracts on modelling studies at all scales, seismicity forecasting models, hazard and risk analysis studies as well as presentations dealing with good-practice guidelines and risk assessment procedures that would help in reducing commercial costs and enhancing the safety of future geothermal projects.

Conveners: Annemarie Muntendam-Bos, Delft University of Technology A.G., Muntendam-Bos@tudelft.nl; David Eaton, University of Calgary, eatond@ucalgary.ca; Federica Lanza, Swiss Seismological Service, ETH Zurich, federica.lanza@sed.ethz.ch; Kristine Pankow, University of Utah, kris.pankow@utah.edu; Nori Nakata, Lawrence Berkeley National Laboratory, nnakata@lbl.gov; Ryan Schultz, Stanford University, rjs10@stanford.edu

Detecting, Locating, Characterizing and Monitoring Non-Earthquake Seismoacoustic Sources

Non-earthquake seismoacoustic sources, such as landslides, avalanches, lahars, glacial events, blasts and bolide impacts, are commonly recorded by seismoacoustic monitoring networks. Although most of these sources are not routinely monitored in real-time like earthquakes, the recent surge in seismoacoustic data and ground-based, airborne and satellite imagery makes these post-event detections and characterizations possible. Furthermore, regional networks increasingly incorporate acoustic instrumentation, making acoustic measurements of these events more common. This session focuses on methods that aim to better understand and characterize these sources and to better monitor and mitigate their associated hazards. We encourage presentations that study all types of non-earthquake seismic sources by utilizing seismoacoustic, geodetic and remote sensing techniques on local, regional, and global scales. Relevant topics may include but are not limited to source detection, location, characterization, modeling and classification (including machine learning approaches); precursory signal analysis; monitoring; and hazard mitigation.

Conveners: Ezgi Karasözen, Alaska Earthquake Center, Geophysical Institute, University of Alaska Fairbanks, ekarasozen@alaska.edu; Kate Allstadt, U.S. Geological Survey, kallstadt@usgs.gov; Liam Toney, Alaska Volcano Observatory and Wilson Alaska Technical Center, University of Alaska Fairbanks, ldtoney@alaska.edu

Earth's Structure from the Crust to the Core

Several science priority questions in the community report "A Vision for NSF Earth Sciences 2020-2030" rely on progress in seismological research of Earth's deep interior. This session will cover all aspects of "structural seismology." In particular, we encourage submissions that discuss new or new combinations of seismological data types, as well as advances in global and regional-scale seismic tomography, 3D waveform modeling, array-based approaches and the analysis of correlation wavefields. We hope that this session will highlight new contributions from seismologists to interdisciplinary research of core and mantle dynamics, the role of the mantle transition zone in mantle convection, volcanism in different settings around the world, the structure of subducting slabs, deep lithospheric deformation and processes, lithosphere-asthenosphere interactions and their feedbacks into geohazards.

Conveners: Jeroen Ritsema, University of Michigan, jritsema@umich.edu; Keith Koper, University of Utah, kkoper@gmail.com; Vera Schulte-Pelkum, University of Colorado, vera.schulte-pelkum@colorado.edu

Earthquake Early Warning Optimization and Efficacy

Several elements contribute to the optimization of an Earthquake Early Warning (EEW) system's performance, including: the design of the network, choice of sensors, algorithm refinement and means of communications. The processing of data and the accuracies and latencies this introduces also require analysis to ensure warnings are timely and meaningful. For example, the inclusion of site amplification in estimating intensities and the extent of the potentially impacted region should improve the accuracy of the EEW system; it may, however, slow the distribution of alerts. Additionally, EEW systems can only be effective if people and systems respond appropriately. Technical recipients must have automated systems in place to initiate protective measures, and people need to take safe response actions, such as to Drop, Cover and Hold on. To establish the necessary culture of awareness and preparedness, EEW organizations must work with others, including emergency measures organizations, to ensure a broad, consistent and authoritative EEW education and outreach effort. Such initiatives should include engagement with critical infrastructure operators and take special care to address particularly vulnerable populations, such as low income, new immigrants, Indigenous and elderly. This session invites abstracts on all aspects of optimizing EEW systems, including sensor and communication developments, optimizing methodologies and system assessment and abstracts related to Education, Outreach and Engagement for EEW.

Conveners: Alison L. Bird, Natural Resources Canada, Sidney, alison.bird@nrcan-rncan.gc.ca; Claire Perry, Natural Resources Canada, claire.perry@NRCan-RNCan.gc.ca; Danielle Sumy, Incorporated Research Institutions for Seismology, danielle.sumy@iris.edu; Sara K. McBride, U.S. Geological Survey, skmcbride@usgs.gov

Earthquake Preparation Across Scales: Reconciling Geophysical Observations with Laboratory and Theory

Observing and understanding the physical processes occurring before large earthquakes is fundamental for both scientific purposes and to advance our ability to forecast these catastrophic events. Current physical models of earthquake initiation mainly focus on laboratory experiments and theoretical work. While these studies often describe a distinct nucleation phase, direct field observations of similar preparatory processes based on seismological or geodetic data are still lacking. Nevertheless, recent improvements in monitoring capabilities, density of recording stations, data quality and the development of novel data analysis methods, have increased the spectrum of available observations of processes occurring before large earthquakes. These recent observations, often spanning several spatial and temporal scales, can provide insights into the physical conditions promoting or inhibiting a detectable earthquake preparatory process or fault unrest. In this session we welcome (but we are not limited to) (i) contributions focusing on the observation, analysis and modeling of earthquake preparatory processes from seismological and/or geodetic data covering different spatial and temporal scales, (ii) studies focusing on laboratory scale, theoretical analysis and numerical modeling. For both, we welcome presentations providing novel observations and new insights into the complexities involved in earthquake preparation and initiation and new data analysis (e.g., machine learning, big data, unsupervised analysis) which shed light on earthquake preparation.

Conveners: Gregory McLaskey, Cornell University, gcm8@cornell.edu; Patricia Martinez-Garzon, GFZ Potsdam, patricia@gfz-potsdam.de; Piero Poli, Università di Padova, piero.poli@unipd.it

Earthquake Source Parameters: Theory, Observations and Interpretations

Understanding origin and spatio-temporal evolution of seismicity needs a careful quantitative analysis of earthquake source parameters for large sets of earthquakes in studied seismic sequences. Accurate determination of earthquake hypocenters, focal mechanisms, seismic moment tensors, static stress drop, apparent stress and other earthquake source parameters provides an insight into tectonic stress and crustal strength in the area under study, fault material properties, fault roughness and prevailing fracturing mode (shear/tensile) in the focal zone, and allows investigating earthquake source processes in greater details. In addition, studying relations between static and dynamic source parameters and earthquake size is essential for understanding the self-similarity of rupture processes and scaling laws and for improving our knowledge on ground motion prediction equations.
This session focuses on methodological as well as observational aspects of earthquake source parameters of natural or induced earthquakes in broad range of scales from large natural

earthquakes through reservoir scale microseismicity, to pico- and femto-seismicity from in-situ laboratories and laboratory experiments on rock samples. Presentations of new approaches and methodologies for determination of source characteristics as well as case studies related to analysis of earthquake source parameters in the context of earthquake physics are welcome. We also invite contributions related to scaling of static and dynamic source parameters, to self-similarity of earthquakes and inversions for stress and other physical parameters in the focal zone.

Conveners: German A. Prieto, Universidad Nacional de Colombia, gaprietogo@unal.edu.co; Grzegorz Kwiatek, Deutsches GeoForschungsZentrum, GFZ, grzegorz.kwiatek@gfz-potsdam.de; Pavla Hrubcova, Institute of Geophysics of the Czech Academy of Sciences, pavla@ig.cas.cz; Satoshi Ide, The University of Tokyo, ide@eps.s.u-tokyo.ac.jp; Vaclav Vavrycuk, Institute of Geophysics of the Czech Academy of Sciences, vv@ig.cas.cz

Emerging Developments in Operational Monitoring Systems and Products

Software tools for processing and analyzing geophysical data have continued to evolve along with advancements in monitoring instrumentation and technology. The broad seismic monitoring, assessment and research community must keep up with these advancements in order to quickly and reliably detect events, derive scientific products and distribute this scientific information to a wide array of consumers. In this session we invite presentations that explore emerging developments in operational monitoring systems, interfaces and products. This scope includes, but is not limited to, how various technologies (e.g., cloud-based, orchestration, web services, data streaming) and algorithms or methodologies (e.g., AI/ML, parallel processing) are improving operational monitoring systems for near-real-time processing or rapid delivery of information to human or machine consumers. Abstracts detailing enhancements to code or infrastructure used in the near real-time generation of data products are encouraged. Examples of advancements in monitoring systems via the integration of multiple kinds of data (e.g., geodetic, seismic, DAS, social media, etc.) as well as making software/code, models and interfaces FAIR (findable, accessible, interoperable, and reusable) to a broader scientific community are also important topics of interest.

Conveners: Ellen Yu, Southern California Earthquake Data Center, Caltech, eyu@caltech.edu; Kirstie Haynie, Geologic Hazards Science Center, U.S. Geological Survey, khaynie@usgs.gov; Michelle Guy, Geologic Hazards Science Center, U.S. Geological Survey, mguy@usgs.gov

Exploiting Explosion Sources: Advancements in Seismic Source Physics

Underground, near-surface and/or above ground explosion sources can be used to illuminate the subsurface geologic structure and understand seismo-acoustic signal propagation. Recent work using template matching, waveform modeling for moment tensors, and combining seismo-acoustic data has shown great success in characterizing explosions and discriminating them from earthquakes and other sources. In regions of low natural background seismicity, mine blasting can dominate monitoring catalogs, and identifying and separating these sources from tectonic earthquakes is critical for hazard assessment. The seismo-acoustic signals from intentional and accidental explosions can be used in forensic analysis to study propagation anomalies. Recordings of surface explosions illuminate the geologic structures in aseismic regions and aid in better characterization of the velocity structure. The wavefields that delineate the subsurface structure are being acquired in unprecedented detail with the advent of dense arrays and multi-phenomenology instrumentation. We welcome abstracts in explosion source physics, wave propagation, seismic array design, distributed acoustic sensing (DAS), new sensor technologies, multi-physics data fusion and advanced processing and characterization techniques applied to explosion sources.

Conveners: Catherine M. Snelson, Los Alamos National Laboratory, snelsonc@lanl.gov; Christian Stanciu, Sandia National Laboratories, astanci@sandia.gov; Cleat P. Zeiler, Nevada National Security Site, zeilercp@nv.doe.gov; Colin Pennington, Lawrence Livermore National Laboratory, pennington6@llnl.gov; Elizabeth A. Silber, Sandia National Laboratories, esilbe@sandia.gov; Jenna L. Faith, Los Alamos National Laboratory, jfaith@lanl.gov; William R. Walter, Lawrence Livermore National Laboratory, walter5@llnl.gov

From Earthquakes to Plate Boundaries: Insights into Fault Behavior Spanning Seconds to Millennia

The processes of strain accumulation and release and related topographic evolution happen over disparate timescales – from seconds to millennia and longer. Quantifying and understanding the earthquake cycle in the continental crust and how tectonic strain is expressed at the surface in the landscape thus requires integrating methods that measure deformation at a range of timescales. While geodetic methods record regional infinitesimal strain accumulation over decadal timescales and finite coseismic deformation from individual large events, paleoseismology and tectonic geomorphology measure site-specific or regional-scale strain release over thousands to millions of years. Numerical modeling and analog experiments attempt to replicate processes that can span multiple temporal scales, but they must be validated with observations to ensure they are physically meaningful. In this session, we invite abstracts that integrate observations and methods from different temporal and/or spatial scales to address topics such as: surface rupture and slip distribution patterns in space and time; variations in earthquake timing and recurrence; fault growth, linkage, and scaling; (dis)agreement of geologic and geodetic rates; and tectonic landscape evolution. We welcome contributions from geodesy, earthquake geology, tectonic geomorphology, numerical modeling, analog experiments, and especially contributions with novel approaches to integrating multiple data sources that help further our understanding of strain accumulation and release spanning coseismic to geologic timescales.

Conveners: Austin Elliott, U.S. Geological Survey, ajelliott@usgs.gov; Chris Milliner, California Institute of Technology, milliner@caltech.edu; Nadine Reitman, U.S. Geological Survey, nreitman@usgs.gov; Marion Thomas, Earth Sciences Institute of Paris, Sorbonne Univeristé, marion.thomas@sorbonne universite.fr; Solene Antione, NASA Jet Propulsion Lab, solene.antoine@jpl.nasa.gov

From Sensors and Networks to Site Characterization and Site Response: Coming Full Circle

Recent advances in the fields of site characterization and seismic instrumentation (in terms of sensors and analysis) have introduced a wide range of new approaches that improve our ability to model the influence of near-surface soil and rock formations on ground motion. However, these new approaches are associated with challenges with how to best use and interpret these data. Decisions affecting the quality and quantity of useful ground motion data, encompassing the sensors on which they were recorded, data processing methods, and the choice of site characterization methods at various scales, all affect the accuracy of and uncertainty in the determination of seismic site parameters. These parameters describe the geometry and distribution of earth materials and their properties and are used to predict the "site effect" component of ground motion models used in seismic hazard assessment. Often, however, these downstream applications take for granted the provenance and quality of recorded waveform data and their derivatives, be they earthquake ground motions from seismic networks or site parameters derived from geophysical field campaigns. Our session aims to explore how variation in these operational and analytical decisions affects the modeling of seismic site conditions, site response and ground motion modeling and their uncertainties. We welcome presentations on each stage of ground motion data collection and analysis, from acquisition to analysis, including: recording stations, fieldwork, regional and temporary deployments, assessment of material properties and earth structure, choice of methodologies for carrying out site response analyses and the relationship between uncertainty in site characterization and site response. We encourage submissions from across the globe and at various geospatial scales, especially those pertaining to Puerto Rico and the greater Caribbean/Latin America regions.

Conveners: Albert Kottke, Pacific Gas & Electric, Co., arkk@pge.com; Lisa S. Schleicher, U.S. Geological Survey, Earthquake Science Center, lschleicher@usgs.gov; Olga-Joan Ktenidou, National Observatory of Athens, olga.ktenidou@noa.gr; Sean Ahdi, U.S. Geological Survey, Geologic Hazards Science Center, sahdi@usgs.gov

Future Directions in Physics-Based Ground-Motion Modeling in Preparation for the Fall 2023 Meeting

Modern ground-motion modeling for improved source physics and hazard understanding has been investigated from both simulation-based and data-driven perspectives for quantitative prediction. Significant recent advances in empirical modeling move towards spatially varying, non-ergodic models, while physics-based simulations are broadening their applicability to regions or faults not previously considered. The community needs to move forward together to ensure that these models are realistic and applicable to a larger range of magnitudes of different types of events. To this end, SSA, joint with SSJ, will host a topical meeting entitled "Modern Global Ground-Motion Modeling: Future Directions in Physics-Based Ground-Motion Modeling" in fall 2023. At this meeting, we will bring together international researchers to exchange ideas, compare approaches, and delineate new directions of research for the next decade in the field of physics-based ground-motion modeling and prediction. The conference will be held in Vancouver, Canada on October 9 to 12, 2023. This session is designed as an opportunity to discuss the current status of research on ground motion modeling and make the most effective foci for the discussion during the Fall 2023 Ground Motion meeting. Therefore, this session seeks contributions that elucidate the impact of the new approaches for source and site effects representation on the ground motions and the associated seismic hazard evaluations. Example topics of interest/areas of study include, but are not limited to: evolution and limitations of complex kinematic and dynamic source modeling; new approaches to the modeling of the empirical source characteristics; physical and empirical modeling of side effects; comparisons of physics-based and empirical data-driven approach on the overall prediction accuracy; and, statistical evaluation of the variability of our evaluations and predictions.

Conveners: Annemarie Baltay, Earthquake Science Center, USGS, abaltay@usgs.gov; Hiroshi Kawase, Disaster Prevention Research Institute, Kyoto University, kawase@zeisei.dpri.kyoto-u.ac.jp; Zhigang Peng, Earth and Atmospheric Sciences, Georgia Institute Technology, zpeng@gatech.edu

Geophysical Data Analysis in Cloud Computing Environments

Advancements in instrumentation are increasing the variety, complexity and volume of geophysical datasets. Improvements in cyber infrastructure have been helping to reduce the effort and cost in collecting, storing and sharing large datasets. Utilization of cloud compute and storage resources has the potential to make large temporal and spatial analyses more tractable and for a larger audience. Furthermore, with more data center facilities providing access to datasets in the cloud, the opportunity to process data without transferring it across the internet significantly reduces the operational burden, and potentially cost, of research computation. Cloud computing services, like distributed messaging queues, serverless functions, object storage and container orchestration, expand the options for how research at very large scales can be performed. Open frameworks that can be used in the cloud such as Apache Spark, xarray and Dask, Ray, etc. provide even more options. In this session, we invite researchers, data producers and data providers to share their experiences deploying resources in cloud environments to support or conduct data collection, transformation, analysis, storage and distribution at scale.

Conveners: Chad Trabant, Incorporated Research Institutions for Seismology, chad.trabant@iris.edu; Henry Berglund, UNAVCO, henry.berglund@unavco.org

Ground Truthing Multidimensional Site Response Analyses at Borehole Array Sites

A significant amount of seismic site response research over the past decade has focused on our abilities to replicate recorded ground motions at borehole array sites, where both the input (rock) and output (surface) ground motions are known. When viewed in aggregate, these studies have found that approximately 50% of borehole array sites are poorly modeled using 1D ground response analyses (GRAs). While multidimensional (i.e., 2D and 3D) GRAs are theoretically plausible, 1D GRAs remain by far the most widely used approach for simulating site effects in practice and research. This is partly due to a lack of well-documented and openly accessible case histories that ground truth multidimensional GRAs at borehole array sites. The availability of multidimensional GRA validation studies at borehole array sites could serve as a benchmark for practitioners and researchers to calibrate their own analyses and achieve more reliable seismic hazard assessment and risk mitigation. A current research study is being conducted with collaborators from research and industry to ground truth multidimensional GRAs at the Treasure Island Downhole Array (TIDA). A large-scale, site-specific 3D subsurface model is now available for this site and multidimensional GRAs have proven that site response recorded in the borehole array is influenced by subsurface spatial variability at distances over 1 km away. Several teams have performed multidimensional GRAs for the TIDA site using different commercial and open-source software (e.g., OpenSees, Sesimo-VLab, FLAC, LS-DYNA). We strongly encourage contributions from the different collaborators on this project, as well as from other studies on any aspect of ground truthing multidimensional GRAs. This session will provide an opportunity for researchers and engineers to discuss and constructively compare modeling strategies, boundary conditions, computational time and ground truthing of the numerical results against recorded ground motions.

Conveners: Brady R. Cox, Utah State University, brady.cox@usu.edu; Mohamad M. Hallal, University of California, Berkeley, mhallal@utexas.edu

High-frequency Ground Motion Measurements, Assessments and Predictions

High-frequency ground motion is critical for both seismologists, who can understand the source process, and engineers, who need to design structures with high natural frequency or structures hosting safety-related equipment sensitive to high frequency shaking (e.g., nuclear power plant). Although seismologists consider that high-frequency ground motions include frequencies larger than 1 Hz, while engineers are more interested in frequencies larger than 10 Hz, measuring, analyzing and modeling high-frequency ground motions are necessary for advancing the simulation of ground motions at broader ranges of frequencies and improving ground motion models. Particularly, high-frequency seismic waves tend to be affected by near-surface deposits significantly, hence the appropriate modeling and interpretation of high-frequency ground motions are essential to understand site effects more holistically. Thus, this session invites investigations on an aspects of the assessment of high-frequency ground motions and the improvement of current practices in site response estimations, which may include: (1) the variability in observations of high frequency ground motions, (2) the simulation of high-frequency ground motion, (3) the search of optimal site proxies to characterize site effects affected by shallow or deeper geologic structures, (4) numerical or empirical studies on 2D/3D site effects and the integration of the corresponding results into seismic hazard assessment, (5) site-specific ground motion prediction at high frequencies and its associated uncertainties, (6) in-situ characterization of attenuation, (7) ground motion models with explicit consideration of site attenuation and (8) near-surface and regional attenuation of seismic waves modeled with attenuation parameters such as the high-frequency spectral decay parameter kappa or the seismic quality factor, Q.

Conveners: Albert Kottke, Pacific Gas and Electric Company, albert.kottke@gmail.com; Ashly Cabas, North Carolina State University, amcabasm@ncsu.edu; Chunyang Ji, North Carolina State University, cji3@ncsu.edu; Kenneth Campbell, CoreLogic, ken.w.campbell@comcast.net; Marco Pilz, German Research Center for Geosciences, pilz@gfz-potsdam.de

It's All About Relocation, Relocation, Relocation

The current capability to locate smaller seismic events has been boosted by unprecedented numbers of nodal networks and improved local monitoring throughout the world, yet the challenge still remains to accurately estimate an earthquake's hypocenter. Many relocation algorithms and processing techniques have been implemented to determine absolute and relative locations. The methods of measuring events have not changed significantly but the modern tools and higher sample rates introduce a new opportunity to refine our error estimates. The quantification of error in a location and the tradeoffs between site corrections, velocity model and other constraints applied to the location algorithm are rarely compared across multiple techniques or catalogs. The comparison of historical events and modern relocated events is made more difficult by the changing methods and data availability with time. The quantification of how modern studies deal with such divergence is one that has yet to be strongly examined. As we continue to look at the future of locating smaller seismic events, we want to accurately estimate the hypocenter location while improving our understanding of the historical context of earthquake locations. In this session we invite contributions that are pushing the science of locating earthquakes through new measurement techniques, the development of new location algorithms, the comparison of different methods and comparisons or combinations of the locations of historical and modern catalogs. The goal is to look at the accuracy of modern techniques and understand the errors associated with locating targeted events or event clusters.

Conveners: Cleat Zeiler, Nevada National Security Site, zeilercp@nv.doe.gov; Leiph Preston, Sandia National Laboratory, lpresto@sandia.gov; Michelle Scalise, Nevada National Security Site, scalisme@nv.doe.gov; Moira Pyle, Lawrence Livermore National Laboratory, pyle4@llnl.gov; Ting Chen, Los Alamos National Laboratory, tchen@lanl.gov

Legacy Seismic Data Collections: The Present State of and Future Outlook for Data from the Past

Legacy seismic data were recorded from the late 19th century until the end of the analogue recording era in the late 20th century. Many of these records are still extant today in film and/or paper formats and cover a significant part of the history of seismology. With these data, scientific questions necessitating long-running data such as the “great” earthquakes of the 1960s, above-ground nuclear tests, the earthquake cycle and the effect of climate change can be investigated. However, finding storage to retain this analogue data, making inroads into scanning and extracting digital waveforms and facilitating accessibility continue to be challenges. Due to the diversity of collections and the records which they hold (e.g., media types, number of stations, local vs. global scope), exchanging information about the ways in which data are organized, stored and/or scanned is a prime opportunity for the community. In this way, experiences with one collection that are relevant to others can be identified, plans for the future can be better developed and a more accurate picture of data available globally can be put together.

Conveners: Adam Ringler, USGS Albuquerque Seismological Laboratory, aringler@usgs.gov; Allison Bent, Natural Resources Canada, allison.bent@nrcan-rncan.gc.ca; Paul G. Richards, Columbia University Lamont-Doherty Earth Observatory, richards@ldeo.columbia.edu; Thomas A. Lee, Harvard University, thomasandrewlee@g.harvard.edu

Monitoring Climate Change with Seismology

Climate change is the most pressing global-scale challenge of the coming century. Examples of the immediate and long-term consequences include the intensification of tropical cyclones (as Puerto Rico has experienced in the past several years), accelerated erosion of coastlines, changes in annual precipitation and runoff patterns and the collapse of glaciers and ice caps. Many of these processes are observable with seismology. With decades of archival data predating the satellite era and a globally increasing density of seismic networks, environmental seismology is poised for significant contributions to the modeling and monitoring of climate change. Realizing this largely untapped potential requires formal and persistent monitoring campaigns, accessible data products (including the digitization of legacy seismic datasets) and multi-disciplinary collaborations with the broader climate change research community. This session is seeking abstracts showcasing the implementation or application of environmental seismology to climate change modeling and monitoring. We welcome seismoacoustic studies from all domains impacted by climate change, including processes occurring in the atmosphere, hydrosphere, cryosphere or biosphere. Presentations are also encouraged on the effects of climate change on seismic instrumentation, network operation, velocity structures, ambient noise or other concerns. Also of interest are discussions on how additional data streams could be incorporated at global seismic stations to improve climate monitoring capabilities.

Conveners: Allison Bent, Natural Resources Canada, allison.bent@nrcan-rncan.gc.ca; Michael G. Baker, Sandia National Laboratories, mgbaker@sandia.gov; Robert Anthony, U.S. Geological Survey, Albuquerque Seismic Laboratory, reanthony@usgs.gov; Robert Mellors, Scripps Institution of Oceanography, University of California, San Diego, rmellors@ucsd.edu; Siobhan Niklasson, New Mexico Institute of Mining and Technology, sniklasson@lanl.gov

Multi-Scale Models for Seismic Hazard Analysis

Seismic hazard analysis often requires multi-scale models to capture both regional and local effects at a given site, such as smaller, high-resolution features imbedded in larger-scale structures. Examples include analysis of dam structures, fault damage low-velocity zones and sedimentary basins inside regional models with outer length scales determined by seismic source location or extent of hazard maps. In order to obtain unbiased hazard estimates in the multi-scale models, the smaller-scale features must be merged with the regional models in an optimal fashion. We invite contributions that describe imaging of high-resolution crustal features, methods (including machine learning) for seamless merging of such features with regional models and application/validation of multi-scale models in seismic hazard analysis (e.g., dynamic rupture modeling and wave propagation simulations).

Conveners: Evan Hirakawa, U. S. Geological Survey, ehirakawa@usgs.gov; Kim Olsen, San Diego State University, kbolsen@mail.sdsu.edu; William Stephenson, U. S. Geological Survey, wstephens@usgs.gov

Network Seismology: Recent Developments, Challenges and Lessons Learned

Seismic monitoring is not only an essential component of earthquake response but also forms the backbone of a substantial amount of research into seismic hazards, volcanic processes, the earthquake process and seismotectonics. As such, it is important to continue to develop monitoring networks' abilities to accurately and rapidly catalog earthquakes to ensure networks best serve the public, government and academic communities. Due to the operational environment of seismic monitoring, seismic networks encounter many unique challenges not seen by the research community. In this session, we highlight the unique observations and challenges of monitoring agencies and look to developments that may improve networks' ability to fulfill their missions. Seismic operation centers play a crucial role in collecting seismic data, generating earthquake products including catalogs, warnings and maps of ground shaking. The purpose of the session is to foster collaboration between network operators, inform the wider seismological community of the interesting and challenging problems within network seismology and look to the future on how to improve monitoring capabilities. This session is not only an opportunity for monitoring agencies to highlight new developments in their capabilities, but we also encourage submissions describing new techniques that would benefit network operations for detecting, locating and characterizing earthquakes, particularly in a near real-time environment.

Conveners: Dmitry Storchak, ISC, dmitry@isc.ac.uk; Kris Pankow, University of Utah Seismograph Stations, kris.pankow@utah.edu; Ranate Hartog, PNSN, jrhartog@uw.edu; William Barnhart, U.S. Geological Survey, wbarnhart@usgs.gov; William L. Yeck, U.S. Geological Survey, wyeck@usgs.gov

New Methods and Models for More Informative Earthquake Forecasting

The increasing availability and quality of geophysical datasets, including high-resolution earthquake catalogs, fault information and interseismic strain data, has enabled the creation of statistical and physics-based seismicity models that underpin probabilistic seismic hazard analyses (PSHA). Beyond PSHA, new methods developed by the statistical and machine learning (ML) communities have been shown to add predictive skill for forecasting large earthquakes and aftershock activity. These new methods, hypotheses and models can be prospectively tested and compared within the framework of the Collaboratory for the Study of Earthquake Predictability (CSEP). We invite contributions that develop novel methodology or applications in analyzing and modeling seismicity datasets. In particular, we encourage contributions from researchers who are developing and testing models for long-term earthquake forecasting, Operational Earthquake Forecasting (OEF) and Operational Aftershock Forecasting (OAF). Example submissions may include models based on ML-derived catalogs, new hypotheses explaining what controls earthquake probabilities, quantitative analyses evaluating the predictive abilities of seismicity models or new approaches to evaluating probabilistic earthquake forecasts.

Conveners: Leila Mizrahi, ETH Zurich, leila.mizrahi@sed.ethz.ch; Jose A. Bayona, University of Bristol, jose.bayona@bristol.ac.uk; Max Schneider, United States Geological Survey, mschneider@usgs.gov; Nicholas J. van der Elst, United States Geological Survey, nvanderelst@usgs.gov; William H. Savran, Southern California Earthquake Center, wsavran@usc.edu

New Observations and Modeling of Triggered Seismicity

After a large earthquake occurs the seismic rate increases in its epicenter's surroundings in the form of aftershocks. This is the most recognized form of triggered seismicity. However, many questions still remain open regarding the physics of aftershocks, including the aftershock's maximum magnitude, their spatio temporal distribution, the effects of fluid in the aftershock region, and the role of the stress changes caused by previous mainshocks. Furthermore, observations show that other forms of seismicity can be also triggered, including slow-slip events, tectonic tremor, volcanic seismicity and icequakes. In addition, seismicity – both slow and fast – can be triggered dynamically thousands of kms from the source event.
In this session we invite contributions focused on new observations and the numerical or theoretical modeling of the different types of triggering of seismicity, in the near-field and the far-field (remote triggering). Understanding the different processes that can trigger seismicity, as well as the type of seismic events that can be triggered, is essential towards gaining a better understanding of the physics of earthquakes.

Conveners: Abhijit Ghosh, University of California, Riverside, aghosh@ucr.edu; Debi Kilb, University of California, San Diego, dkilb@ucsd.edu; Esteban J. Chaves, OVSICORI, Universidad Nacional, Costa Rica, estevan.j.chaves@una.cr; Hector Gonzalez-Huizar, CICESE, Mexico, hgonzalez@cicese.mx

Normal Faults: From Source to Surface

High-resolution earthquake-related surface displacement measurements from optical data or field studies are useful to determine co-seismic off-fault deformation. These data serve as an input into fault-slip inversion studies and to validate dynamic rupture models, rendering the measurements of surface displacement a proxy for the fault structure at depth. While this approach can be valid in the strike-slip setting, many earthquakes occur on basin-bounding normal faults where most of the damage is concealed by the sedimentary deposits. In addition, inherent asymmetry of normal dipping faults has been shown to lead to distinct dynamic rupture behaviours, such as reduced or enhanced shallow coseismic slip. The resulting surface deformation may, therefore, reflect the propagation of the rupture through the basin-fill rather than the basement rocks, potentially altering the style and the magnitude of the final displacement. To relate the surface deformation to the subsurface structure of normal faults, we aim to explore the connection between the surface deformation created by large-magnitude normal events and the geometry of the associated subsurface structures. In this session, we would like to bring together studies which collect high-resolution measurements of surface displacement from remote sensing, subsurface geophysics, as well as kinematic and dynamic rupture models and laboratory experiments. We hope to address the question of how representative the surface deformation created during normal earthquakes is of the subsurface structure of normal fault zones.

Conveners: Alice-Agnes Gabriel, University of California San Diego, LMU Munich, alice-agnes.gabriel@geophysik.uni muenchen.de; Lucia Andreuttiova, University College London, lucia.andreuttiova.16@ucl.ac.uk; Thomas M. Mitchell, University College London, tom.mitchell@ucl.ac.uk; Zachary E. Ross, Caltech, zross@caltech.edu

Numerical Modeling in Seismology: Developments and Applications

We equally invite both contributions to numerical-modeling methods/algorithms and applications. Progress in seismology is unthinkable without continuous developments of theory and numerical-modeling methods. Recent developments include faithful rheological and geometrical complexity of the Earth's interior, earthquakes and other important seismological phenomena, time-space discretization, optimizations of computational algorithms and computer codes, optional balance between accuracy and efficiency. Recent methodological progress in numerical modeling in seismic exploration poses a useful challenge for numerical modeling also in earthquake seismology.
New observations and data from local dense networks make it possible for numerical modeling to considerably contribute to our understanding of rupture dynamics, seismic wave propagation, earthquake ground motion including non-linear behavior, seismic noise and earthquake hazard. We especially welcome applications to compelling observational issues in seismology.

Conveners: Alice-Agnes Gabriel, Scripps Institution of Oceanography, UC San Diego, algabriel@ucsd.edu; Emmanuel Chaljub, Université Grenoble Alpes, emmanuel.chaljub@univ-grenoble-alpes.fr; Jozef Kristek, Comenius University in Bratislava, kristek@fmph.uniba.sk; Martin Galis, Comenius University in Bratislava, martin.galis@uniba.sk; Peter Moczo, Comenius University Bratislava, moczo@fmph.uniba.sk; Wei Zhang, Southern University of Science and Technology, zhangwei@sustech.edu.cn

Opportunities and Challenges for Machine Learning Applications in Seismology

Owing to the increase in the availability of large amounts of high-quality open-source data, in recent years, we observed a successful surge in Machine Learning (ML) applications in Seismology. For instance, ML has largely been adopted in earthquake detection; seismic phase picking, in generating high-resolution earthquake catalogs, in discrimination and classification of seismic events, in earthquake early warning, in seismicity forecasting, in ground motion modeling and simulation, as well as in seismic inversion. Today, traditional ML techniques, such as CNN and LSTM networks trained over very large datasets, are successfully employed in operational conditions. Nonetheless, efficient training with small and imbalanced datasets, as well as extrapolation to new data are among the challenges that are still unresolved. On one hand, advanced ML techniques such as attention layers, autoencoders and transformers provide accurate and faster alternatives. On the other hand, physics-informed learning attempts to solve the mathematical problem using neural networks or kernel-based approaches, nourished by real world data. Moreover, ML techniques are adopted to improve existing predictive tools, in a non-intrusive way. However, a thorough investigation of those data driven techniques is demanded, in both existing and new research branches of seismology, before their deployment as operational models. In this session, we invite contributions that explore the potential of ML for seismology. In particular, we are interested in studies focusing on developing state-of-the-art ML models for seismology and earthquake engineering, ML investigations of new research areas, and works highlighting issues related to methodologies in ML, data quantity and quality. Furthermore, we welcome contributions on research topics including null hypothesis testing, open databases for collaborative research, architecture framework, software packages and development of research capabilities.

Conveners: Claudia Q. Cartaya, Frankfurt Institute for Advanced Studies, quinteros@fias.uni-frankfurt.de; Filippo Gatti, CentraleSupélec, Université Paris-Saclay, filippo.gatti@centralesupelec.fr; Florent Aden, GNS Science, f.aden@gns.cri.nz; Kiran k. Thingbaijam, GNS Science, k.thingbaijam@gns.cri.nz; Nishtha Srivastava, Frankfurt Institute for Advanced Studies, FIAS, srivastava@fias.uni-frankfurt.de; Quentin Brissaud, NORSAR Norwegian Seismic Array, quentin@norsar.no

Opportunities and Challenges in Source Modeling for Seismic Hazard Analysis

Evaluating earthquake rates is critical to assess seismic hazards for a variety of applications including national building codes, catastrophe risk modeling and site-specific studies for critical facilities. To accomplish this, recent national and regional seismic hazard models have used interdisciplinary approaches that combine geological, geodetic and seismological models. Often, fault-based models are complemented with distributed (or smoothed) seismicity models derived from earthquake catalogs, especially in regions where knowledge of the fault network is largely incomplete. Some efforts have begun to incorporate physics-based (dynamic) earthquake models, which produce synthetic catalogs spanning hundreds of thousands of years. In active areas, there are complicated cases where different seismotectonic regimes are present, such as subduction zones (interface and intraslab sources) juxtaposed with crustal sources. Some other frontiers include complex multi-fault ruptures, models for earthquake occurrences (Poissonian versus non-Poissonian rates) and region-specific source scaling properties. In this context, there is an impetus for integrated approaches that take advantage of different datasets to deliver a consistent model of earthquake rates, their spatial distribution and potential rupture mechanisms. In this session, we welcome contributions that are focused on the advancements in the development of source models, with new methods, datasets and/or hypotheses. Research topics pertinent to this session include but are not limited to: distributed seismicity models, magnitude-frequency distributions, models for earthquake occurrences, time-dependent seismicity, active fault models, region-specific source scaling properties, inversion of slip-rates, simulated seismicity and synthetic catalogs and subduction sources. We also look forward to region-specific investigations that provide useful case studies.

Conveners: Andrea L. Llenos, U.S. Geological Survey, allenos@usgs.gov; Andrew J. Michael, U.S. Geological Survey, ajmichael@usgs.gov; Andy Nicol, University of Canterbury, andy.nicol@canterbury.ac.n; Chris Rollins, GNS Science, c.rollins@gns.cri.nz; Delphine Fitzenz, Risk Management Solutions Inc., delphine.fitzenz@rms.com; Kiran Kumar S. Thingbaijam, GNS Science, k.thingbaijam@gns.cri.nz; Marco Pagani, GEM Foundation, marco.pagani@globalquakemodel.org; Matt C. Gerstenberger, GNS Science, m.gerstenberger@gns.cri.nz

Seismology for the Energy Transition

The energy transition can help mitigate climate changes by progressively shifting from fossil-based energies to low- or zero-carbon energies, such as wind, solar, hydropower, hydrogen, geothermal, nuclear and marine energies, etc. Decarbonization of the energy sector is crucial for achieving the net-zero goal. Approaches such as geologic carbon storage can enable decarbonization of some energy sources, such as coal- and natural gas-fired power plants, oil refineries, cement plants and bioenergy production facilities. The development of new seismic technologies will play a crucial role in the energy transition. We invite contributions from research exploring applications of advanced seismic approaches and techniques to the energy transition process, particularly for subsurface characterization, monitoring and infrastructure surveillance. We welcome submissions of abstracts on computational, laboratory experimental and field-scale studies.

Conveners: Erkan Ay, Shell, erkan.ay@shell.com; Lianjie Huang, Los Alamos National Laboratory, ljh@lanl.gov; Ting Chen, Los Alamos National Laboratory, tchen@lanl.gov; Verónica R. Rodríguez, Lawrence Berkeley National Laboratory, vrodrigueztribaldos@lbl.gov; Yingcai Zheng, University of Houston, yzheng24@central.uh.edu

Seismology's Role in Assessing Volcanic Hazard at Multiple Time Scales

Dangerous volcanoes not only pose an ongoing threat to nearby settlements, but also to regional economies and global connectivity. Inter-eruption repose periods vary by orders of magnitude and can directly impact the perceived monitoring requirements. Seismology has always been arguably the greatest monitoring tool during active eruption cycles, but can also contribute to change detection in times of repose, offering a potential alarm bell well in advance of a new eruptive cycle. We invite contributions of your research into volcanic seismicity at all time scales, in the context of contributing to interdisciplinary, dynamic hazard assessments for volcanoes of concern.

Conveners: Charlotte A. Rowe, Los Alamos National Laboratory, char@lanl.gov; Francisco Nunez-Cornu, Universidad de Guadalajara, pacornu77@gmail.com; Glenn Thompson, University of South Florida, thompsong@usf.edu; Jolante van Wijk, Los Alamos National Laboratory, jolantevanwijk@lanl.gov; Wendy McCausland, U.S. Geological Survey, wmccausland@usgs.gov

ShakeMap-Related Research, Development, Operations, Applications and Uses

ShakeMap-related research and development encompass a wide range of ground motion, macroseismic, path and site, spatial sampling, finite fault, directivity and various other innovations. All these efforts are crucial for recovering the most accurate ground motion field. Critical uses of the shaking estimates include earthquake response, loss estimation, engineering forensics, financial decision-making, ground failure and loss model calibration and communication of earthquake effects to the public. This session explores and encourages contributions concerning ShakeMap-related research and development, such as GMM selection and development, validation of ground motion and intensity relations, site amplification and geospatial analyses (along with uncertainties) pertinent to ShakeMap. We also encourage updates on innovative operational tools, APIs, and web pages, and presentations on new ShakeMap-related applications and products, formats and web rendering. We also urge presentations on more general research, operations or applications related to ShakeMap. Such applications include but are not limited to earthquake scenarios, risk assessment, loss estimation, earthquake response tools, engineering and other analyses utilizing ShakeMap ground motion estimates and associated uncertainty information.

Conveners: Bruce Worden, U.S. Geological Survey, cbworden@contractor.usgs.gov; Carlo Cauzzi, ORFEUS & SED@ETH Zürich, carlo.cauzzi@sed.ethz.ch; David J. Wald, U.S. Geological Survey, wald@usgs.gov; Eric Thompson, U.S. Geological Survey, emthompson@usgs.gov; Hadi Ghasemi, Geoscience Australia, hadi.ghasemi@ga.gov.au; Nick Horspool, GNS Science, n.horspool@gns.cri.nz

Single-Station Passive Exploration Methods: Status and Perspectives

The physical conditions of subsoil are related to the surface seismic response and may control it. To understand and mitigate the effects that cause damage, it is necessary to characterize the velocity structure in tens or hundreds of meters. To do this, it is required to analyze and confront the results of different geophysical methods together since the distribution of physical properties in depth occurs at different scales. Ambient seismic noise methods can be ideally suited as exploration methods. So far, there are many advances using station arrays and case studies using a single station are quickly emerging. In this session, all those works showing the advantages of high-resolution ambient seismic noise techniques for the subsoil velocity structure are welcome. We will discuss the advancement of microtremor arrays to the limitations and advantages of the HVSR method. Comparing results with other geophysical techniques will enrich the definition of application and development perspectives. We encourage presentations that illustrate the solution to problems related to seismic amplification, terrain subsidence, landslides, the presence of discontinuities, etc.

Conveners: José Francisco Sánchez Sesma, Universidad Nacional Autónoma de México, sesma@unam.mx; José Piña Flores, Universidad Nacional Autónoma de México, jpf@unam.mx; Martín Cárdenas Soto, Universidad Nacional Autónoma de México, martinc@unam.mx

Site-Specific Modeling of Seismic Ground Response: Are We Quantitative Enough to Predict?

The effects of shallow geological layers and interfaces (within the upper 1-2 km) on the seismic-induced ground motion recorded at the ground surface have been the focus of numerous studies over the past few decades. Though the physics governing the main aspects of site effects (also referred to as “site response” or simply “site amplification”) is relatively well understood, amplification at many actual sites is too complex to be fully described by a set of differential equations under certain initial conditions. Also, ergodic amplification equations, embedded in ground motion models, can only provide average estimates of amplification, and bias is expected in a site-specific posterior application.
This session encompasses a broad range of approaches used in site characterization and their downstream effects on site response analyses and seismic hazard and risk assessments. Topics of interest include active- /passive-source geophysical surveys (e.g., single-/multi-station surface-based array methods, down-/cross hole methods, seismic interferometry, etc.), soil nonlinearity, numerical or empirical studies on 2D/3D site effects. Studies comparing data collection techniques at the same site and those integrating a variety of datasets are also encouraged. We also invite contributions on the development and/or implementation of state-of-the-art methods in inverse problems, statistical interference techniques and uncertainty and variability quantification, to improve the characterization of near-surface site conditions. Studies on improving our current practice in ground response assessment through the use of Artificial Intelligence (AI) (e.g., database development, benchmarking different AI models and model transferability) are particularly welcome.

Conveners: Andres Olivar Castano, University of Potsdam, andres.olivar-castano@uni-potsdam.de; Chuanbin Zhu, Department of Civil and Natural Resources Engineering, University of Canterbury, chuanbin.zhu@gfz-potsdam.de; Hiroshi Kawase, Disaster Prevention Research Institute, University of Kyoto, kawase.hiroshi.6x@kyoto-u.ac.jp; Marco Pilz, German Research Center for Geosciences – GFZ, pilz@gfz-potsdam.de

Special Session on February 2023 Mw 7.8 Earthquake Sequence in Turkey

This late-breaking session will focus on the February 2023 Mw 7.8 Earthquake Sequence in Turkey.

Conveners: Xyoli Pérez-Campos, Universidad Nacional Autónoma de México; Elizabeth Vanacore, University of Puerto Rico at Mayagüez

Structure and Properties of Subducting Slabs and Deep Earthquakes

Subduction zones are among the most seismically active regions on Earth. Subducting slabs can affect the convection of the Earth's mantle and the geochemical evolution of the Earth. However, subducting slabs have complex structures and dynamics in terms of their geometry, age, deformation history, stress state, volatile content, thermal structure and seismicity behavior. Most deep earthquakes (depth > 70 km) in the mantle occur in subducting slabs. They are further categorized as intermediate-depth earthquakes (70-350 km depth) and deep-focus earthquakes (350-700 km depth). The cause of deep earthquakes is still a major scientific puzzle. In this session, we invite contributions that address the structure and properties of subducting slabs and deep earthquakes. We seek to bring together researchers from a wide range of studies including observations, laboratory experiments, numerical modeling and theoretical analyses. Novel ideas/models/approaches and/or unusual datasets/observations are especially welcome. Broader scientific issues to be addressed may include slab structure, the distribution of volatile content and stress state in subducting slabs and deep seismogenesis, as well as interactions between these topics.

Conveners: German Prieto, Universidad Nacional de Colombia, gaprietogo@unal.edu.co; Man Xu, The University of Chicago, mxu@cars.uchicago.edu; Shanna Chu, U.S. Geological Survey, schu@usgs.gov; S. Sindhusuta, The University of Illinois Chicago, sindh2@uic.edu; Qiushi Zhai, California Institute of Technology, qzhai@caltech.edu

Subduction Zone Structure from Trench to Arc

Subduction zones are dynamic tectonic environments that generate destructive natural hazards, produce large orogenic systems, create and modify continental crust, recycle volatiles and sediments into the interior and drive mantle convection. Many of these processes occur at depths of < 120 km, roughly from the oceanic trench to the magmatic arc - a key focus area of the broader Earth Science community as evidenced by community-driven programs such as EarthScope, GeoPRISMS and SZ4D. Our understanding of these processes is predicated on direct observations through increasingly more refined and comprehensive seismic images of the incoming plate, the downgoing slab, the mantle wedge and the overriding plate, which we can use to infer subsurface properties such as rock composition, in situ melt percentage and water content. For this session, we invite contributions from the broadly defined seismic imaging community at the basin scale to the crustal and mantle scale. Seismic imaging techniques can include, but are not limited to tomographic techniques, including refraction, surface wave, teleseismic, full waveform and adjoint tomography, as well as active source reflection imaging, distributed acoustic sensing, noise interferometry, attenuation studies, and scattered wave imaging. In particular, we invite contributions that integrate across scales and across shorelines, jointly interpret multiple techniques and/or focus on improving our interpretation of seismic wavespeeds in the crust and mantle to better understand tectonic processes and geologic structures in subduction zone settings.

Conveners: Daniel E. Portner, Arizona State University, dportner@asu.edu; Harm Van Avendonk, University of Texas at Austin, harm@ig.utexas.edu; Jonathan R. Delph, Purdue University, jdelph@purdue.edu; Lindsay L. Worthington, University of New Mexico, lworthington@unm.edu

Tectonics and Seismicity of Stable Continental Interiors

Earthquakes in stable continental interiors far from active plate boundaries, such as in central and eastern North America, northern Europe, Australia and parts of Asia, are perhaps the least understood. Nevertheless, advances in intraplate seismicity are being achieved through a variety of approaches. Examples include local and national-scale seismic monitoring efforts that increase completeness of earthquake catalogs, detection algorithms that identify ever-smaller earthquakes from existing data, imaging of subsurface faults using relocated seismicity and seismic tomography, studies that constrain historical slip on such faults, quantification of geodetic, geomorphologic and elevation changes and through improved measurements of local stresses. In parallel with these efforts, ongoing ground motion studies continue to improve our understanding of source, path, and site response characteristics unique to intraplate regions. This session seeks diverse contributions related to intraplate earthquake hazards with goals of describing seismicity, identifying and characterizing active faults and/or deformation in stable continental interiors, deciphering long-term earthquake histories, assessing potential ground motion impacts, constraining models of kinematics and geodynamic properties and understanding the mechanisms that cause enigmatic intraplate earthquakes. Contributions regarding recent earthquake sequences in stable continental interiors, such as those in South Carolina, are especially welcome.

Conveners: Anji Shah, USGS, ashah@usgs.gov; Jessica T. Jobe, USGS, jjobe@usgs.gov; Miguel Neves, Georgia Tech, mjgfgn3@gatech.edu; Oliver S. Boyd, USGS, olboyd@usgs.gov; Will Levandowski, Tetra Tech, Inc., bouldergeophysics@gmail.com; Zhigang Peng, Georgia Tech, zpeng@gatech.edu

The 2020-2021 Southwest Puerto Rico Seismic Sequence: Current State of Knowledge and Implications

The island of Puerto Rico is situated in the northeastern corner of the Caribbean basin, where active geological features around the island reflect the current tectonic environment of an oblique collision between the Caribbean and North American plates. Although microseismic activity occurs daily, only occasional small events are felt by the general population. In Puerto Rico, for exactly 102 years prior to the year 2020, the people of Puerto Rico were unaware of what was to live in a seismically prone area. The January 7th, 2020 Mw6.4 earthquake and ensuing seismic aftershock activity in Southwestern Puerto Rico served as a wake-up call to the entire population, forcing them to realize how vulnerable the island is to seismic activity. Seismic monitoring and research carried out in the region for the past decades were instrumental to classify the seismic risk and provided limited knowledge of the tectonics of the region. However, it was all the co/post-seismic activity, geodetically-determined crustal monitoring, and marine geophysical surveys performed during the past couple of years that allowed us to learn more about the rupture process, the current kinematics, and related effects. With this session, we seek to unite all efforts and contributions related to the January 7th, 2020 earthquake and layout all the findings with the goal of providing the current state of knowledge and a venue to discuss a seismic sequence known for releasing a complex rupture process and an atypical aftershock behavior. We look forward to all contributions on seismic assessment of the rupture process, relocations, aftershock forecasts, post-seismic deformation, and secondary triggered phenomena such as landslides, liquefaction, and tsunami that are related to the Southwest Puerto Rico 2020-2021 seismic sequence.

Conveners: Alberto M. Lopez, University of Puerto Rico, Mayagüez, alberto.lopez3@upr.edu; Christa von Hillebrandt, International Tsunami Information Center, christa.vonh@noaa.gov; Daniel A. Laó-Dávila, Oklahoma State University, daniel.lao_davila@okstate.edu; Elizabeth Vanacore, Puerto Rico Seismic Network – UPRM, elizabeth.vanacore@upr.edu; Gisela Baéz-Sánchez, Puerto Rico Seismic Network – UPRM, gisela.baez1@upr.edu; James Joyce, University of Puerto Rico – Mayagüez, james.joyce@upr.edu; Margarita Solares-Colón, University of Oregon, msolares@uoregon.edu; Stephen K. Hughes, University of Puerto Rico – Mayagüez, kenneth.hughes@upr.edu; Victor Húerfano, Puerto Rico Seismic Network, victor@prsnmail.uprm.edu

The Future of Tsunami Science, Preparedness and Response

Significant advances in observations, modeling, response, and communication of tsunamis have taken place over the last two decades, often as part of the assessment and improvement process following damaging events. Optimizing risk reduction from future tsunami events requires a full community effort across many disciplines. Much work remains to better characterize global tsunami hazards, both in advance for mitigation and preparedness and in real time with improved observation and forecasting systems. At all stages, hazards need to be translated into potential risk and impacts. Here, we highlight improvements in tsunami science and their pairing with equally important improvements in tsunami preparedness, risk communication, and decision support. Looking forward, the community aims to utilize technical expertise from social scientists and work with an emphasis on social equity to better serve historically marginalized populations. Contributions to this session can span the full spectrum of tsunami work and include: improvements in modeling, assessments of past events, estimation of vulnerabilities and exposure, new measurement techniques, communication of hazards and risk, early warning and rapid or real-time forecasts, and any other relevant tsunami science, engineering, operations, preparedness, or outreach topics.

Conveners: Diego Melgar, University of Oregon, dmelgarm@uoregon.edu; Summer J. Ohlendorf, National Oceanic and Atmospheric Administration, summer.ohlendorf@noaa.gov;

Yajie Lee, ImageCAT, yjl@imagecatinc.com; Elyssa Tappero, Washington Emergency Management Division, elyssa.tappero@mil.wa.gov

Transforming Our Seismological Community Through Inclusive Mentorship and Diverse Narratives

Future generations, responsible for moving the field of geosciences forward, should be envisioned from a social and gender equality perspective, reflecting and embracing diversity to build capacities and novel solutions beyond current schemas. The Seismological Society of America Annual meeting provides an extraordinary platform for connecting scientists from diverse backgrounds to students interested in a research career that will have an impact in making the seismology community more inclusive. This session aims to (1) foster a just, equitable and inclusive research community within the SSA, (2) expose underrepresented minorities (URM) to careers in geophysics and seismology and (3) form a mentorship network for URM students and early-career professionals. This session will focus on connecting individuals across a wide range of backgrounds to support the SSA and engage with URMs and marginalized groups to promote career growth and the advancement of geophysics and seismology, establishing sustainable and long-term connections between individuals in the community by creating an environment that facilitates the building of collaborative mentor-mentee relationships and career-pathways. We invite researchers and students interested in networking/mentoring to present their research and/or career path to engage with the SSA community. We encourage presentations from all career levels to present their scientific research that are also interested in providing and adding their narrative about their experiences with mentorship and/or working with underrepresented groups and/or individuals or how they navigated their research and/or career path in their field.

Conveners: Aaron A. Velasco, University of Texas at El Paso, aavelasco@utep.edu; Esteban J. Chaves, Volcanological and Seismological Observatory of Costa Rica, esteban.j.chaves@una.ac.cr; Katherine Scharer, US Geological Survey, kscharer@usgs.gov; Kevin Kwong, Los Alamos National Lab, kbkwong@lanl.gov; Richard A. Alfaro-Diaz, Los Alamos National Laboratory, raalfarodiaz@lanl.gov

Understanding and Managing Induced Seismicity

Earthquakes caused by anthropogenic operations pose serious risks: either in terms of their potential for economic/human losses or their ability to place moratoriums on resource development. While induced seismicity is one of the major impediments for many resource/energy projects, to date, limited attention has been paid to improving the management of induced earthquakes. Solutions to induced seismicity will be multi-disciplinary and require an approach that includes monitoring the development of induced seismicity, characterizing the geophysical principles involved in fault reactivation, assessing the geological conditions for fault susceptibility, testing operational mitigatory actions, designing regulatory controls, and clear communication of stakeholder concerns. In this spirit, our session invites abstract submissions from all facets of induced seismicity. These studies could include physical/statistical modeling that delve into describing how/why these events occur, laboratory measurements that infer analogs between modeling and observation, hazard/risk assessments that provide management strategies or regulatory/industry perspectives on successful mitigation/avoidance strategies. Overall, the successful management of induced earthquakes will require an integrated understanding of all these aspects. Toward this goal of better understanding and managing induced seismicity, we welcome studies from various scales and regions that could facilitate an integrated understanding of the above aspects.

Conveners: Margaret Glasgow, University of New Mexico, mglasgow@unm.edu; Mohammad J. A. Moein, Freie Universität Berlin, mohammad.moein@fu-berlin.de; Ruijia Wang, Southern University of Science and Technology, ruijia.wang@ualberta.ca; Ryan Schultz, Stanford University, rjs10@stanford.edu

Understanding and Modeling the Uncertainties in Earthquake Ground Motions

Understanding and modeling uncertainties in earthquake ground motions are significant tasks of scientific interest and societal relevance. Variability in earthquake rupture and the physical mechanisms controlling it, as well as linear and nonlinear effects on seismic wave propagation from source to site, are fundamental scientific questions that have not been fully answered, and which may vary across regions. Ground-motion uncertainty is of significant interest for many earthquake hazard applications, though it is not always accounted for consistently. Perhaps the most sophisticated treatment of uncertainty occurs for probabilistic seismic hazards analysis, which partitions uncertainty into two components—a natural (aleatory) variability and knowable (epistemic) uncertainty that can be determined with more information. As the increasing number of available ground-motion records and simulations are utilized in the development of nonergodic ground-motion models, key questions addressing uncertainty have arisen: What is the natural variability of earthquake rupture, what controls it and can we identify repeatable features for use in predictive models? What source parameters (e.g., stress drop, rupture speed) and mechanisms relating to wave propagation (e.g., site and path effects including attenuation and amplification) are well constrained and appropriate for predictive models? Can physics-based modeling reproduce observed ground-motion variabilities? How should hazard analyses partition epistemic uncertainty and aleatory variability? How should approaches to partly or fully nonergodic seismic hazard analyses differ at different spatial scales (local, regional, national)? We encourage abstract submissions relating to fundamental and applied research or case studies in engineering and policy regarding the causes and treatment of earthquake ground-motion uncertainties.

Conveners: Fabrice Cotton, GFZ Potsdam, fcotton@gfz-potsdam.de; Grace Parker, U.S. Geological Survey, gparker@usgs.gov; Morgan P. Moschetti, U.S. Geological Survey, mmoschetti@usgs.gov; Olga-Joan Ktenidou, National Observatory of Athens, olga.ktenidou@gmail.com

Understanding Earth Systems with Fiber-Optic Cables

In the last decade, significant technological advances have been made in distributed sensing. This technology turns fiber-optic cables into arrays of sensors recording physical signals with an unprecedented spatio temporal resolution. In the Earth sciences, Distributed Acoustic Sensing (DAS, measuring seismic and acoustic waves), Distributed Temperature Sensing (DTS, measuring temperature), and Distributed Strain Sensing (DSS, measuring deformation) have been widely used to better understand and monitor the solid Earth, glaciers, rivers, oceans, ecosystems, and urban environments. We invite contributions on any recent development in the fields of application, instrumentation, and theory of distributed optical fiber geophysics. These may include, but are not limited to, theoretical and methodological aspects of fiber-optic sensing, comparison and analysis of DAS/DTS/DSS records with other types of seismological/geophysical measurements, potential combination of distributed sensing with conventional geophysical networks, applications for imaging and monitoring the solid Earth and the hydrosphere, detection and characterization of natural and anthropological signals, and algorithms/techniques to handle and process the large amounts of data recorded by DAS/DTS.

Conveners: Brad Lipovsky, University of Washington, bpl7@uw.edu; Ettore Biondi, California Institute of Technology, ebiondi@caltech.edu; Loïc Viens, Los Alamos National Lab, lviens@lanl.gov; Xiaowei Chen, Texas A&M, xiaowei.chen@tamu.edu

Understanding the Variability in Earthquake Stress Drop Measurements

Stress drop is a fundamental earthquake source parameter that in theory relates the average slip on a fault to rupture area, and in practice characterizes the high frequency seismic radiation. It is a key parameter in earthquake ground motion modeling, rupture simulation and source physics analysis. However, stress drops are notoriously variable and difficult to measure; estimates by different researchers using different methods or datasets yield inconsistent values which mask physical trends. We seek to bring together all interested researchers to compare and validate stress drop estimates, source characterization and high-frequency ground motion. We particularly encourage studies of the 2019 Ridgecrest Earthquake Sequence, any studies focused on the comparison of multiple methods, and studies aimed at quantifying the uncertainties in stress drop estimates. We hope to understand the physical controls and methodological reasons for similarity or differences in stress drops, so that they can be used reliably by the earthquake science community.

Conveners: Annemarie Baltay, USGS Earthquake Science Center, abaltay@usgs.gov; Colin N. Pennington, Lawrence Livermore National Laboratory, pennington6@llnl.gov; Ian Vandevert, Scripps Institution of Oceanography, ivandevert@ucsd.edu; Kevin Mayeda, Air Force Technical Applications Center, kevin.mayeda@us.af.mil; Meichen Liu, University of Michigan, meichenl@umich.edu; Rachel Abercrombie, Boston University, rea@bu.edu; Shanna Chu, USGS Earthquake Science Center, schu@usgs.gov; Taka'aki Taira, University of California, Berkeley, taira@berkeley.edu; Trey Knudson, Stanford University, trey05@stanford.edu

USGS National Seismic Hazard Models: 2023 and Beyond

The USGS National Seismic Hazard Models (NSHMs) are a bridge between best-available earthquake science and public policy. By the end of 2023, the National Seismic Hazard Model Project (NSHMP) will publish a 50-State NSHM, focusing on updates to the conterminous U.S., Alaska and Hawaii. The Puerto Rico and U.S. Virgin Islands NSHM will be updated by the end of 2025 (see 2025 Puerto Rico and the U.S. Virgin Islands National Seismic Hazard Model Update Technical Session), and updates to the Guam and Northern Mariana Islands and American Samoa and Neighboring South Pacific Islands NSHMs are tentatively scheduled to be completed by the end of 2026. Looking ahead to all future NSHM updates, we would like to consider new data, methods and models. For this session, we invite contributions on topics that will influence future seismic hazard models, including but not limited to: seismicity catalogs, declustering and smoothed seismicity models, geologic and geodetic deformation models, multi-fault ruptures, improved representation and quantification of epistemic uncertainty, new ground motion models (GMMs), including non-ergodic models, incorporation of physics-based (3D simulation) GMMs, basin effects, site response, directivity and time dependence. We also invite contributions on the use of NSHMs for scenario development, risk assessment for both buildings and infrastructure, and other applications of risk mitigation including those within the insurance industry. We are also interested in contributions that highlight potential impacts of hazard modeling uncertainties on downstream applications.

Conveners: Emel Seyhan, Risk Management Solutions (RMS), emel.seyhan@rms.com; Jason M. Altekruse, USGS Geologic Hazards Science Center, jaltekruse@usgs.gov; Kishor S. Jaiswal, USGS Geologic Hazards Science Center, kjaiswal@usgs.gov; Mark D. Petersen, USGS Geologic Hazards Science Center, mpetersen@usgs.gov; Peter M. Powers, USGS Geologic Hazards Science Center, pmpowers@usgs.gov; Sanaz Rezaeian, USGS Geologic Hazards Science Center, srezaeian@usgs.gov