Seismological Society of America
Annual Meeting 2022
Technical Sessions

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- Adjoint Waveform Tomography: Methods and Applications
- Advances in Earthquake Early Warning: Research and Development
- Advances in Earthquake Geology: Spatiotemporal Variations in Fault Behavior from Geology and Geodesy
- Advances in Geophysical Sensing
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- Fault Damage Zones: What We Know and Do Not
- Fiber Optic Seismology: Understanding Earth Structure and Dynamics with Distributed Sensors
- From Desktops to HPC & Cloud: Emerging Strategies in Large-scale Geophysical Data Analysis
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- Frontiers in Marine Seismology
- Imaging, Monitoring and Induced Seismicity: Applications to Energy and Storage
- Improving Strong-motion Data, Products and Services: From Waveform Quality to Open Dissemination
- Insights from Earthquakes in and Around Alaska in the 20 Years Since the Denali Fault Earthquake
- Investigating Nonlinear Source and Near-source Dynamics from Earthquake and Explosive Sources

- Machine Learning Techniques for Sparse Regional and Teleseismic Monitoring
- Modeling, Collecting and Communicating Post-earthquake Hazard and Impact Information
- Multi-scale Dynamics of Complex Earthquake Faulting and Seismic Wave Propagation
- Network Seismology: Recent Developments, Challenges and Lessons Learned
- New Developments in Physics- and Statistics-based Earthquake Forecasting
- Numerical Modeling in Seismology: Developments and Applications
- Observations and Modeling of the 2021 Haiti Earthquake
- The Re-interpretation of Quaternary Faults near Tehran Based on Paleo Mega Lake of Rey Theory
- Rethinking PSHA: Are We Using Appropriate Inputs for the End Goal?
- Searching for Fault Creep Over a Range of Timescales
- Seismo-acoustics Applications to Forensics and Novel Monitoring Problems
- Seismo-geodetic Approaches for Seismic and Tectonic Processes
- Shakes in Lakes: Frontiers in Lacustrine Paleoseismology
- Site Response Characterization in Seismic Hazard Analysis
- Structure and Seismogenesis of Subducting Slabs
- Tectonics and Seismicity of Intraplate Regions
- Things That Go Bump: Identifying and Characterizing Non-Earthquake Seismo-Acoustic Sources
- Using Data and Experience to Improve Geohazards Communication
- What Controls the Style of Fault Slip in Subduction Zones?

50-State Update of the USGS National Seismic Hazard Models

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. (last updated in 2018) and Alaska (last updated in 2007) models. The update to the Hawaii model, published in 2021, will be included as part of the 50-State NSHM update. The NSHMP has been developing and evaluating new data and models over the past year and has held a number of public workshops to present early input models to the scientific community for feedback. Planned updates for the 50-State NSHM include better representation of epistemic uncertainties, new seismicity models, updated geologic and geodetic deformation models, improved treatment of segmentation and multi-fault ruptures, NGA-Subduction GMMs, incorporation of physics-based (3D simulation) GMMs, modified location of the CEUS and WUS attenuation boundary, basin effects and site response models. In addition, the NSHMP plans to develop a research NSHM that may include directivity, non-ergodic aleatory uncertainty in GMMs and time dependence models. In early 2022, the NSHMP will hold a multi-day public workshop to present the draft model for the 50-State NSHM update.

This session will outline the next steps in finalizing the 2023 50-State NSHM and explore the implications of the draft model. NSHMs are community consensus-based models that are constantly aiming to leverage from the latest data, models and tools available at the time to evaluate and to validate hazard assessments as we undertake an updating process. We invite abstracts on implications, sensitivities and uncertainties of new sources and GMMs that are being considered for the draft model, research model, 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

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Adjoint Waveform Tomography: Methods and Applications

Adjoint waveform tomography and full waveform inversion methods are providing new models of Earth structure. These methods use numerical 3D wave propagation to determine the sensitivity of waveform misfits to sub-surface structure and involve iterative inversion strategies that require complex workflows. As such, they are data and computationally intensive and benefit from recent developments in full waveform solvers and high-performance computer systems.

This session solicits presentations on adjoint waveform tomography and full waveform inversion, including contributions on theoretical and methodological developments as well as applications on reservoir, local, regional and global scales.

Conveners

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Advances in Earthquake Early Warning: Research and Development

Earthquake Early Warning (EEW) systems are able to provide a few to tens of seconds of warning for incoming strong ground motions after the rupture of a significant earthquake has initiated. For effective EEW, the rapid assessment of and alerting for an evolving earthquake is necessary, requiring action based on small increments of data. The ‘brains’ of EEW systems are constantly being improved in terms of speed and accuracy, through aspects such as updates to algorithms, the addition of novel data sources, the incorporation of additional earthquake physics and more. Increased processing capabilities also allows for more computational intensive measures to be considered.

This session invites submissions on any aspect of the development or improvement of an EEW system, which may include: algorithm development and performance review, improved detection/discrimination techniques, the use of data sources beyond traditional seismic stations, social and physical science perspectives on alerting logic, methods of reducing missed or false alerts or new approaches to EEW from around the world.

Conveners

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Advances in Earthquake Geology: Spatiotemporal Variations in Fault Behavior From Geology and Geodesy

Field and remote sensing observations of recent ruptures at the Earth's surface highlight variable rupture geometries, surface slip distributions, zones of distributed or off-fault deformation and fault zone damage. The extent to which these complex and heterogenous patterns are consistent or variable between earthquakes is a fundamental question in earthquake science and remains largely unknown. Meanwhile, advances in numerical and analog modeling and laboratory experiments expand our ability to study strain accumulation and release and the landscape response through multiple earthquake cycles. Additionally, advances in geochronology allow us to better constrain earthquake timing and slip rates, enabling higher resolution comparisons of spatial and temporal patterns of slip within a fault zone. In this session, we encourage abstracts that investigate spatial and temporal patterns (including their causes and uncertainties) in strain accumulation and release spanning coseismic to geologic timescales to address questions such as: 1) How variable or consistent are patterns of surface slip and distributed deformation from one earthquake to the next and along ruptures?; 2) How do we infer geologic rates based on limited geodetic records?; 3) How does earthquake timing and recurrence cluster through space and time?; 4) Are observations from single events representative of earthquake and fault behavior over geologic timescales?; 5) How applicable are observations and findings across fault systems? We welcome contributions that present new observations or theories on the patterns and variability in earthquake rupture from field (paleoseismology, tectonic geomorphology), remote sensing (geodesy) or modeling (numerical or analog simulations or laboratory experiments) studies in any tectonic setting that will further our understanding of fault behavior over modern to geologic timescales.

Conveners

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Advances in Geophysical Sensing

Seismological studies depend on the capability to measure ground motion resulting from the passage of seismic waves. Similarly, geodetic studies of tectonic and volcanic deformation are underpinned by measurements of changes in the shape of the Earth. Advances in observational geophysics rely on improvements in the quality of measurements and innovations that extend the types and ranges of phenomena observed. These advances both drive and are driven by development of theoretical and computational approaches to interpret observations. Recent years have seen considerable efforts to improve the quality of geophysical sensing. New techniques have been developed that complement established approaches by measuring new quantities and improving the quality and density of observations. Existing sensing techniques have been improved by reducing instrument self-noise, expanding bandwidth, improving calibrations for sensitivity and drift and developing compact and rugged instruments with lower power requirements for easier operation in the field. Dense multi-element networks in a variety of settings may use arrays of inexpensive sensors developed initially for consumer electronics purposes. There are often particular challenges to operating instruments in hostile locations such as the oceans, polar regions, volcanoes, other planets or very remote sites on Earth that have spurred technical advances. Methods of removing environmental noise from observations have been critical to improving geophysical observations, particularly within the oceans, but atmospheric and hydrological noise can also be important.

This session will provide an opportunity for scientists, engineers and instrument developers to discuss recent advances in the full range of sensors and sensing techniques for seismology, geodesy and related fields and explore potential applications of emerging sensing capabilities and future scientific needs and challenges.

Conveners

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Advances in Geospatial Modeling of Seismic Hazards

Geospatial modeling analyzes spatial relationships and patterns of geographic features on sociocultural and physical processes. Recent developments in geospatial modeling of seismic hazards have benefited from the rapid growth of multi-source data (e.g., seismic waveform, remote sensing images, GPS time series) and advances in modeling techniques (e.g., machine learning and deep learning). These have opened up the possibility of performing seismic hazard assessment at different phases, such as pre-earthquake planning and post-earthquake reconnaissance. In addition, the spatial distribution pattern of different types of geographic features on seismic hazards and its temporal variation provide the possibility of investigating the driving mechanism of seismic hazards. We welcome contributions of recent advances in and applications of geospatial modeling on various types of seismic hazards (e.g., shaking, landslide, liquefaction), including (but not limited to) geospatial data collection, processing and management, data mining, artificial intelligence in geospatial modeling and spatiotemporal analysis.

Conveners

Weiwei Zhan, Tufts University (weiwei.zhan@tufts.edu)
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Laurie G. Baise, Tufts University (laurie.baise@tufts.edu)
Chuanbin Zhu, GFZ German Research Centre for Geosciences (chuanbin.zhu@gfz-potsdam.de)

Advances in Seismoacoustic Methods for Explosion Monitoring

National and global security are ongoing missions whose needs are supported significantly through seismoacoustic research and development. In particular, seismic and acoustic research relevant to the detection and description of explosions – their source properties, coupling, explosive yield, phase generation and ground and atmospheric wavefield propagation – is critically important to the ability to discern anthropogenic explosion activity and assess its importance to the monitoring effort. We invite contributions relevant to the challenging field of seismoacoustic explosion monitoring, with a special focus on smaller sources, noise mitigation strategies, machine learning and deep learning applications, cloud computing, laboratory to local to teleseismic scale analyses and observations and new approaches to models and model validation.

Conveners

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Advances in the Use of Seismic and Acoustic Methods to Constrain Physical Processes at Volcanoes

Recent advances in instrumentation technology have enabled scientists to deploy progressively denser networks of seismo-acoustic sensors for longer periods of time at locations closer to volcanic systems than was previously possible. Recordings from these networks have enabled researchers to glean new insights into surface and sub-surface processes that produce seismo-acoustic signals at volcanoes, insights that hold promise for improved monitoring and real-time hazard assessment. Furthermore, advances in data processing and the development of new techniques enable both new discoveries in legacy datasets and the promise of new monitoring tools. We invite submissions to this session that describe novel studies at volcanic systems involving seismic and/or infrasonic instrumentation, with particular emphasis on results that would be applicable to the monitoring and understanding of Cascade Range volcanoes.

Conveners

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Alicia Hotovec-Ellis, U.S. Geological Survey (ahotovec-ellis@usgs.gov)
Barrett Johnson, University of Washington (bnjo@uw.edu)
Seth Moran, U.S. Geological Survey (smoran@usgs.gov)

Advancing Multi-scale Evaluations of Seismic Attenuation

Understanding and quantifying seismic attenuation is key to advancing seismic hazard assessments at different spatial scales. At regional scales, the seismic quality factor Q captures path attenuation with consideration of the different wave phases (e.g., P-wave or S-wave) and attenuation mechanisms (e.g., anelasticity and/or scattering). At local scales (e.g., at a given site of interest), the empirical high-frequency spectral decay parameter kappa and its site-specific component characterize the near-surface attenuation. However, the description of seismic wave propagation is not easy especially when it comes to amplitudes. The crust and especially the shallower layers can be very variable leading to wave focusing effects or wave conversions. Furthermore, seismic source phenomena, local site amplifications or the responses of the recording instrument itself can hinder the identification of attenuation. All these reasons in connection with different measurement techniques makes it difficult to identify a unique parameter that captures seismic attenuation mechanisms at multiple scales.

This session aims to gather recent advances in physics-based or empirical modeling related to the quantification of seismic attenuation. We welcome studies focused on, but not limited to: 1) the variability and uncertainty associated with seismic attenuation measurements (e.g., the errors associated with in-situ measurements of Q, the computation bias in kappa and potential tradeoffs between kappa and source); 2) the physics-based explanation behind seismic attenuation parameters (e.g., identification of scattering versus intrinsic attenuation contributions); 3) the link among different attenuation parameters (such as kappa, Q and material damping ratio; scattering and intrinsic attenuation) at various scales and 4) challenges associated with their integration into ground motion modeling, seismic hazard assessments and site response analysis.

Conveners

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Characteristics, Hazards and Evolution of the Gorda Region of the Cascadia Subduction Zone
The Gorda region of the Cascadia subduction zone (CSZ) extends from the Mendocino triple junction to Southern Oregon. It is one of the most seismically active regions of the contiguous 48 states. This region is marked by two transitions: 1) that from the strike-slip tectonics of the San Andreas transform system to the CSZ and 2) that from the seismically active deformation zone associated with the Gorda plate to the relatively intact Juan de Fuca plate.

We welcome presentations addressing the tectonics in the Southern Cascadia region, as well as discussion of the tsunami, ground shaking and fault rupture hazards from the region's seismicity. We also encourage contributions on the major uncertainties in estimating risk and how new technologies may contribute to a better understanding of the area.

Conveners
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Rick I. Wilson, California Geological Survey (rick.wilson@conservation.ca.gov)

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 (zero-net emissions target). Geothermal heat extracted from depth in excess of 400m is defined as deep geothermal energy. Enhanced Geothermal Systems (EGS) 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 are crucial for assessing the geothermal stimulation effects and demonstrating 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 EGS 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 modeling 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

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Development, Enhancement and Validation of Seismic Velocity Models
3D velocity and anelastic attenuation models are critical to generate useful ground motion estimates as well as many other applications. Community Velocity Models (CVMs) have been developed for these purposes in different regions. However, the potential for these CVMs to contribute to new advances in seismic hazard analysis depends on their accuracy, flexibility (e.g., meshing capabilities) and accessibility (e.g., software, efficiency).

We solicit submissions describing the development, enhancement and validation of seismic velocity and anelastic attenuation models. Among other topics, we are interested in: 1) uncertainty estimation of the velocity models as well as the resulting ground motion predictions; 2) studies on techniques for including variable-resolution features, surface topography, small-scale heterogeneities and (frequency-dependent) anelastic attenuation; 3) procedures for including multi-scale features such as fault damage zones, near-surface weathering layers, geotechnical information and other geophysical and geological data and 4) case studies for validating existing or new enhancements, for example through 3D waveform tomography, to CVMs.

Conveners
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Distributed Deformation from Surface Fault Rupture
Distributed deformation or secondary surface fault rupture are a concern for many projects that lie within some distance of principal active faults. Attempts to model the probability of distributed ruptures and amounts of distributed deformations have considered style of faulting, fault geometry, distance from the principal fault, geologic and tectonic structural setting and whether the distributed deformations are geometrically connected to principal ruptures or dynamically triggered. Attempts to understand the causes and mechanisms of distributed fault rupture deformations have application not only to hazard assessment of engineered structures and hazard policy but also to our understanding of the shallow slip deficit, particulate vs. rock mechanics and earthquake rupture forecasting. This session invites speakers to present recent research on distributed deformations associated with surface fault rupture and participate in a broad discussion on how to understand, study and manage these deformations.

Conveners
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Steve Thompson, Lettis Consultants Inc. (thompson@lettisci.com)
Chris Milliner, California Institute of Technology (milliner@caltech.edu)

Diversity, Equity and Inclusion in Seismology

Geosciences is one of the least diverse fields and will remain so if actions are not taken to address issues of racism, sexism, homophobia and inaccessibility. In this session, we welcome participants to present on efforts undertaken to improve the diversity, equity, and inclusion of seismology, geodesy and the broader geoscience community.

We particularly encourage contributions that will include specific issues, for example: best practices for partnerships with indigenous communities, workforce development including the recruitment and retention of individuals from underrepresented groups or issues related to field safety for underrepresented individuals. Recent developments to diversify, retain and provide career development for student and early career scientists in seismology, geodesy and the broader geoscience community will be highlighted.

Conveners

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Drop Cover and Hold On! ShakeAlert: Past, Present and Future

Over the last five years ShakeAlert has become a fully operational system on the West Coast of the US. Data is currently imported from US, Canadian and Mexican networks into ShakeAlert servers in California, Oregon and Washington and since May 2021, public alerts have been available in all three states. Since SSA last met in person, station buildout has progressed rapidly and data contributions have increased from other sources such as the neighboring state of Nevada. The existing Earthquake Early Warning (EEW) system in British Columbia is soon to be supplemented by a nation-wide system targeting higher-risk regions of Canada.

This session will focus on the current state of practice of the ShakeAlert system with emphasis on network operations, the possible wider expansion of ShakeAlert and lessons learned from recent events (e.g. Lone Pine, Westmoreland, Antelope Valley). We also encourage abstracts related to the role of EEW in engineering to assess the current status of ShakeAlert on the West Coast of North America and of EEW operations worldwide.

Conveners

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Earthquake Source Processes at Various Scales: Theory and Observations
The recurrence time, ground motion and the spatiotemporal evolution of natural, anthropogenic-induced and laboratory earthquakes are strongly influenced by processes that involve the frictional and mechanical properties of the fault systems, as well as the regional and local stress field where these events nucleate. Understanding and characterizing static and dynamic earthquake source parameters is crucial for improving hazard assessment and earthquake forecasts. Similarly, understanding the various scaling relationships of these parameters and their interactions between seismic and aseismic slip modes is important for further advancing hazard estimates. This session focuses on highlighting forefront studies that aim to improve understanding of earthquake source processes and its related complexities. From theory and numerical modeling to large-scale observations at different tectonic regimes, we encourage contributions on research that explore earthquake source physics in a broad range of magnitudes and time scales.

Conveners
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Valerie Sahakian, University of Oregon (vjs@uoregon.edu)
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Taka’aki Taira, University of California, Berkeley Seismological Laboratory (taira@berkeley.edu)

Earthquakes in the Urban Environment

The relentless urbanization and associated concentration of people and infrastructure in earthquake-prone environments brings increased focus on the local to site-specific assessment of seismic risk. Seismic hazard and risk in urban areas need to be addressed by considering all the elements that can affect the intensity of shaking and distribution of losses, considering close proximity to even moderate events and the multi-event degradation of structures. Seismic measurements in urban areas can be difficult due to abundant ambient noise, scattered energy from built structures and foundations and modified near-surface conditions. Array studies also can be difficult due to limited space and access issues. In this session, we invite presentations on earthquake studies using data processing, empirical, analytical or numerical models, which integrate urban aspects into the research of seismic hazard and risk. Topics could include studies on the source parameters of shallow earthquakes, nearby induced seismicity, attenuation in the near-field, approaches to model and mitigate dynamic seismic hazards and risks, wave propagation in a complex urban environment, ground motion spatial variability, 2D versus 3D site responses and site-city or soil-structure interactions. We also encourage presentations on recent instrumental and data processing developments in urban environments (e.g., optical fiber technology, low-cost sensors, rotation, N-arrays), along with studies on dynamic urban exposure, dealing with seismic structural health monitoring, rapid loss assessment and/or early warning systems. Similarly, we hope to include recent and innovative developments on proxies for predicting the consequences of seismic ground motion and improving the spatial distribution forecasting of earthquake losses on cities.

Conveners

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The Effects of Sedimentary Basins on Earthquake Ground Motions

The manifestation of ground shaking intensities at the surface of sedimentary basins during an earthquake is a complex phenomenon that is depends on a variety of factors, which include basin structure (shape and depth), depositional history (e.g., sediment type and layering) and characteristics of the seismic event (e.g., magnitude, directivity and azimuth). Sedimentary basins also underlie many urban settings where the potential for the amplification of strong ground motions, especially at long periods, may lead to a substantially elevated risk profile for the residing population and the built environment. As the number of long-period large-scale structures increases worldwide, estimation and realistic modeling of long-period ground motions become important considerations in seismic design. However, there is still a lack of simple guidelines for the selection of strong ground motion recordings containing surface waves and for considering their complex characteristics (such as dispersion) in engineering analysis procedures.

In this session, we seek contributions that will elucidate the impact of sedimentary basins on ground motions and the associated seismic hazards. Example topics of interest/areas of study include advances in characterizing basin structure, improving Earth models at multiple scales, performing high-fidelity 3D numerical simulations to investigate basin site response, identifying basin effects on ground motions and incorporating representative features into ground motion models. We also encourage presentations related to modeling long-period surface-wave propagation within basins, rotational motions (i.e., rocking and torsion), long-duration excitation and relevant risk to long-period structures.

Conveners

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Everything Old Is New Again – Resurging Use of Analog Data

Efforts to understand Earth dynamics often depend on our ability to interpret past behaviors of complex systems. Much of this observational data was collected during the pre-digital era and is difficult to discover and access. The seismological community benefits greatly from these continuous observations that have been collected, at some locations, for over a century. When subject to analysis using modern methods, analog seismic data can reveal new insights and have the potential to enable discoveries in many fields. These include not only seismotectonics and seismic hazard, but also Earth structure, induced seismicity, ambient noise, tsunamis, landslides, volcanoes and effects associated with climate change. This data set is being rediscovered and progress continues many fronts in advancing its use.

To that end, we invite presentations from a wide range of activities that advance the preservation and discovery and illustrate the value of legacy seismic data. We seek presentations from users and maintainers of data on addressing issues concerning preservation and access as well as efforts to create standards to enhance search and discovery, improve usability and enable access. Presentations on new and successfully adapted and applied techniques demonstrating the utility of these data are strongly encouraged. Contributions may include but are not limited to, studies of seismicity, natural hazards, seismotectonics, Earth structure and climate signatures as well as studies that advance the preservation of records through scanning and vectorization and efforts towards understanding and establishing metadata standards needed to successfully use legacy data.

Conveners

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Exploring Earthquake Source Dynamics and Wave Propagation Properties in Tectonic and Lab Environments

Current, challenging research issues include complex earthquake rupturing and the impact of physical state of media on wave propagation. Therefore, this session will cover recent advancements in the understanding of dynamics in both complex tectonic and controlled lab environments. Our understanding of earthquake source physics remains restricted due to the scarcity of documented seismic rupture along complex fault systems, which makes short-term and long-term forecasting difficult. The two most crucial concepts to understand are rupturing processes and modification waves passing through heterogeneous media. Laboratory experiments exploring real tectonic scenarios might be a feasible way for understanding and comparing earthquake source physics. Using shear rock experiments as an earthquake analogue coupled with a state-of-the-art high frequency acoustic monitoring system, various researchers have demonstrated in the past that accelerations recorded in the kilohertz range on centimeter-sized samples were self-similar to those expected at the kilometric scale for a large earthquake. Recent advances in laboratory imaging of spontaneous dynamic ruptures have allowed us to visualize and quantify stress reduction at the free surface, and its impact on friction for fault-slip histories that are similar to natural thrust and normal earthquakes. Therefore, we are open to an extensive variety of seismological studies such as moment tensor analysis, seismic tomography, frictional parameters, fault dimension assessment, fault geometry, wave attenuation characteristics, etc.

Conveners

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Extraterrestrial Seismology: Seismology from Mars, the Moon and Everywhere
The InSight mission landed on Mars on 26 November 2018 and was the first to place an ultra-sensitive broadband seismometer on the surface of another planet. The mission has now reached the milestone of 1000 sols on Mars, and the Marsquake Service is frequently reporting new marsquakes. Researchers from the InSight team are making new observations and inferences regarding the structure of Mars' core, upper mantle and crust and other recent work.

Meanwhile, on the Moon, new work is happening or being planned. The Farside Seismic Suite, a NASA mission to Schrödinger Crater, was selected for flight in the mid-2020s. The Lunar Geophysical Network is in formulation for NASA's New Frontiers 5 Announcement of Opportunity and would place four geophysical stations around the Moon. Other space agencies are also interested in deploying instruments to determine the structure of the Moon. Chang'e 4 uses ground-penetrating radar to learn more about the shallow structure of the farside of the Moon. Other potential seismic targets include Venus, where researchers are beginning to consider studying venusquakes with infrasound, and icy ocean moons, where seismometers could be deployed to study icequakes and even the rocky interior.

We invite contributions on any aspect of planetary seismology. Contributions from Mars, the Moon, Venus, Mercury, icy moons, the Sun, comets, asteroids and even stars or exoplanets are all welcome. We're interested in data-driven or theoretical work, and we would also love to hear about new mission proposals, instruments and concepts.

Conveners
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Fault Damage Zones: What We Know and Do Not

Fault damage zones accommodate the bulk of the inelastic deformation produced during earthquakes, modify the long-term properties of the shallow crust and increase local seismic hazard through enhanced shaking. Because of their relevance to the earthquake energy balance problem, their influence on ground motions and their impact on fluid pathways near faults, damage zones have garnered the interest of a broad disciplinary range of geoscientists. Over the past two decades, increasing resolution and availability of observations, together with improvements in numerical modeling capabilities, have advanced our understanding of the spatial extent, physical (mechanical) properties and long-term evolution of damage zones. Though the understanding of fault damage zones is improving there remain many unanswered questions such as the mechanism and role of fault healing, the importance of lithology, the effect of fault maturity and the bulk damage zone rheology over time.

In this session, we welcome recent advances in the quantitative understanding of damage zones from observations, numerical models and laboratory studies. We are particularly interested in studies spanning the complete earthquake cycle, experimental studies and work bridging observations from various methods. As part of pushing our understanding of damage zones forward, we invite contributors to identify the outstanding questions in their research and potential directions that will address them, especially those requiring a collaborative, cross-disciplinary approach.

Conveners

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Fiber Optic Seismology: Understanding Earth Structure and Dynamics with Distributed Sensors
Distributed Acoustic Sensing (DAS) is rapidly becoming a popular tool for seismological research, contributing to a new understanding of earth structure and its influence on wave propagation and seismic source mechanisms. DAS is enabling Large-N array seismology in novel and unique spaces. Examples of recent deployments have explored microseismicity in enhanced geothermal systems (EGS), regional scale earthquakes, the near-field source physics of underground explosions, ocean wave propagation and acoustics, glacier surface and basal processes, near-surface structure in urban areas and mass movements including landslides and avalanches. The main advantages of DAS for seismology include, but are not limited to, dense recording, wide spatial extent of virtual sensors, time-lapse repeatability and the unique opportunity to leverage existing fiber infrastructure in the form of telecommunication cables ("dark fiber"). Researchers are rapidly expanding the range of DAS applications, techniques and analysis methods. Because DAS measurements are a single-component projection of the strain (or strain-rate) wavefield along the direction of the fiber, there is a need to develop a fundamental theoretical framework to cope with this new measurement. Methods have been proposed for relating DAS measurements to traditional seismic recordings using geophones and seismometers, however much work remains in translating and matching both the phase and amplitude information between the instruments. The high spatial resolution and broadband nature of DAS furthermore allows for new data analysis methods or the adaptation of existing Large-N methods to strain recording. Large data volumes generated with DAS are also amenable to the application of machine learning for addressing data management, processing and interpretation challenges. Additionally, DAS measurements can be paired with complementary optical based measurements (i.e. distributed temperature or strain sensing), thereby gaining unique subsurface and process understanding.

We invite contributions from research related to all aspects of fiber-optic sensing methods in seismology and geophysics, including but not limited to: advancements in optical engineering; developments in theoretical and methodological aspects of fiber-optic sensing; novel processing and data handling approaches; case studies from recent and ongoing fiber-optic sensing experiments; comparisons between non-inertial and inertial instruments and insights gained from fiber-optic sensing measurements in the context of other types of seismological/geophysical datasets.

Conveners
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From Desktops to HPC & Cloud: Emerging Strategies in Large-scale Geophysical Data Analysis
As the availability of geophysical data continues to grow in volume and variety, many aspects of research data collection, access and processing are evolving to allow full use of large data sets. Processing large data volumes is not unique to geophysics and there exist many modern, open source languages (e.g. Python, Julia), data containers (e.g. HDF5, Zarr) and computational frameworks (e.g. Apache Spark, xarray and Dask, Ray), that can be leveraged and allow researchers to focus more on the domain-specific issues. Access to computational resources, such as HPC and cloud computing, continue to become more accessible and affordable. Specialized hardware, such as GPUs, are increasingly available in both academic and commercial computing environments and make efforts such as large scale waveform template matching possible. New computing models, like serverless architectures and Kubernetes container orchestration, expand the ways in which research can be performed. The combination of available software and computational resources increase accessibility to a new scale of inquiry, making large-scale research in seismology, infrasound, geodesy and geophysics in general more tractable than ever before. In this session, we invite researchers, data producers and data providers to share work in data-hungry applications, approaches to large data collection, storage and access and experiences with processing platforms and architectures.

Conveners
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Jonathan K. MacCarthy, Los Alamos National Laboratory (jkmacc@lanl.gov)

Frontiers in Earthquake and Tsunami Science - Model Integration, Recent Advances, Ongoing Questions
Over the last several decades, the subduction zone science community has accumulated a wealth of geophysical and geological data on earthquakes and tsunamis. This has enabled the creation of more realistic and diverse numerical models of earthquake and tsunami hazards. However, critical questions about earthquake rupture characteristics, tsunami inundation extents, paleoseismic proxies and more remain unresolved. In this session we solicit presentations on recent advances in modeling earthquake rupture scenarios with particular focus on the use of iterative modeling across coseismic deformation and resultant tsunami inundation. Modeling studies incorporating real-time, historic or reconstructed data constraints (geophysical and/or geological) are expressly welcome.

In this session we hope to highlight advances in the field of earthquake and tsunami science and outline the steps needed to move towards more integrated models and filling important knowledge gaps. Such gaps may include limited geologic and/or geophysical data constraints, needs for improved modeling methodology, etc. We hope participants view this session as a community discussion on continued improvement of earthquake and tsunami science.

Conveners
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Frontiers in Marine Seismology
Understanding of geohazards and Earth structure continues to be advanced with the development and use of marine technologies and new analysis techniques. Whether investigating the formation and evolution of structures in ocean basins, refining the controls on and potential impact of megathrust earthquake slip behavior along subduction zones or tracking the seismicity along oceanic transform faults, mid-ocean ridges, seafloor or island volcanoes and undersea landslides, marine geophysical observations will be key to answering the science questions prioritized by the community in reports like "A Vision for NSF Earth Sciences 2020-2030: Earth in Time" (National Academies of Sciences, Engineering and Medicine, 2020).

This session encourages abstract submissions related to all aspects of marine seismology, particularly in the collection and use of observations through ocean bottom seismographs to record natural and controlled sources. Presentations are also encouraged on related marine geophysical topics such as marine electromagnetic instrumentation and imaging, seafloor geodesy, moored and unmoored hydroacoustic sensors and use of underwater fiber optics, as well as on integration of offshore and onshore technologies and techniques.

Conveners
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Imaging, Monitoring and Induced Seismicity: Applications to Energy and Storage
The character and evolution of both natural and induced fracture networks in the deep subsurface remains critical for utilization in both energy (e.g., EGS) and storage (e.g., CO2 or nuclear waste) applications. Additionally, the interactions between induced fractures and the natural structural heterogeneities (i.e., those that govern subsurface flow) remain enigmatic at most meaningful scales. Recent advancements have afforded the research community the opportunity to develop high resolution characterization and monitoring techniques using seismic methods at intermediate to full scale field applications. Additionally, model advancements have allowed for detailed studies of these interactions, although many critical parameters remain poorly constrained. In deep crystalline settings the rock fabric, complex structure, and sometimes severe seismic anisotropy often create challenging characterization environments. In terms of monitoring, energy and storage applications are frequently 4D problems, where the character of the reservoir evolves throughout the active injections (e.g., stress evolution). In these long-term operational scenarios, it is paramount that seismic imaging and characterization approaches be developed and streamlined to provide useful and timely information to operators. Finally, new observations regarding induced seismicity are illuminating complexities beyond stress reduction via increased pore pressures (e.g., thermo-poro-elastic stressing). Improved understanding of these processes bears significantly on seismic hazard assessments. Given the unique challenges to deep subsurface seismic investigations, we invite submissions detailing methods, observations, and modeling studies related to seismic imaging, monitoring and induced seismicity in fractured crystalline rocks and other relevant geologic media applied to energy production or waste storage.

Conveners
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Improving Strong-motion Data, Products and Services: From Waveform Quality to Open Dissemination

Engineering seismology and earthquake engineering require high-quality and easily accessible earthquake waveform data and associated station and event metadata. Providers of event-based waveform data (often referred to as 'strong-motion data' for simplicity) and services worldwide are continuously improving the portfolio of available services in order to meet the expectations of a broad range of users, that includes both scientists and engineering practitioners. Users and funding agencies expect the data, products and services to be open and FAIR (Findable, Accessible, Interoperable, Reusable). While web interfaces remain the preferred way to discover available data, access is increasingly via web services that allow integration in automated processing workflows and enhanced interaction with large datasets. The traditional boundary between weak and strong ground motion records has become blurred, as on-scale weak motion data is proving to be useful in many applications where strong motions would have only been used in the past. In this context, ensuring a high quality of event-based waveform data and metadata is a need and at the same time a challenge. In this session we welcome contributions from the communities of strong-motion/event-based data providers at both a local/national level and an international level to promote knowledge transfer and expert discussion on the strategies to improve earthquake waveform data, metadata and the associated products and services. Topics include: station and waveform quality, station and event metadata curation and integration, new processing algorithms and needs, new data types, formats and open dissemination strategies.

Conveners

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Insights from Earthquakes in and Around Alaska in the 20 Years Since the Denali Fault Earthquake

This year will mark 20 years since the 3 November 2002 M7.9 Denali Fault Earthquake. The last two decades have seen a number of intriguing and important earthquakes across Alaska, as well as an explosion in the amount of seismic and geodetic instrumentation and data to study them. Notable Alaska earthquakes over the last two decades include the largest earthquake in the United States since 1965 (2021 M8.2 Chignik), the largest intraslab earthquake in the United States (2014 M7.9 Little Sitkin earthquake in the western Aleutians), an earthquake that at least partially filled the enigmatic Shumagin seismic gap (2020 M7.8 Simeonof), the complex Gulf of Alaska earthquake in 2018 and two damaging events in Cook Inlet (2016 Iniskin and 2018 Anchorage). Additional large earthquakes have occurred nearby in the North Pacific region, including the 2012 M7.8 Haida Gwaii earthquake offshore Canada and the 2017 M7.8 earthquake north of the Komandorsky Islands. Meanwhile, observational capabilities have grown dramatically due to the EarthScope program, significant components of which have been incorporated into long-term network capabilities, the continuing enhancement of InSAR measurements and the growth in the number of near-field strong motion recordings.

This session welcomes presentations on all aspects of earthquakes in Alaska and the north Pacific, including western Canada and the Russian Far East. We welcome geological, geodetic and seismological studies, modeling efforts, hazard assessments and integrative studies that address earthquakes in this region and their hazard, seismotectonics and mechanics of fault systems.

Conveners

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Derek Schutt, Colorado State University (derek.schutt@colostate.edu)
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Investigating Nonlinear Source and Near-source Dynamics from Earthquake and Explosive Sources

Earthquakes and explosive sources can produce complex wavefields and fracture patterns via nonlinear properties and initial conditions (geometry and material). Additionally, near-source properties such as the pre-stress regime, material strength, frictional processes, anisotropy, topography and other heterogeneities can add to that complexity in nonlinear and unintuitive ways. Such properties can affect the nonlinear deformation during an event, impacting the resultant ground motion, plastic deformation, fracture distribution, spall and the generation of seismic waves seen beyond the nonlinear volume. Determining the cause-and-effect relationships between earthquake and explosion source media properties and observations is an area of active and challenging research. This session is intended to highlight recent advances in our understanding of nonlinear dynamics for fault and explosive sources. We are open to a wide range of studies related to numerical, experimental and observational findings that may include heterogeneities in source geometry, pre-stress regime, topography and material properties. Numerical models that feature algorithms (single or coupled) to robustly model nonlinear time-dependent source properties (e.g., frictional processes, high frequency waves, initial pressure pulses and fracturing) and their effects are especially welcome. We also encourage contributions from research topics that explore impact, volcanic, nuclear and chemical explosive sources.

Conveners

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Carene Larmat, Los Alamos National Laboratory (carene@lanl.gov)
Zhou Lei, Los Alamos National Laboratory (zlei@lanl.gov)
Chandan K. Saikia, Air Force Technical Applications Center (chandan.saikia@us.af.mil)
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Machine Learning Techniques for Sparse Regional and Teleseismic Monitoring

Applying Machine-learning (ML) applications to seismic processing problems is increasingly becoming standard for local and near regional networks. However, sparser global and continental scale regional networks present additional challenges that require further development for such methods to be effective. These challenges include the detection and identification of additional phase types (such as local, regional and teleseismic P and S arrivals). Overlap among all arrival types and network sparsity often prevent the direct application of many local and dense network approaches (e.g. those that rely on moveout patterns). Another difference is the broader use of seismic arrays at some networks, such as the International Monitoring System, which provide processing challenges as well as more input features for ML algorithms than are available at most smaller networks. We invite presentations on methods that can enhance the performance of steps commonly taken in both retrospective and near-real-time network processing, such as signal detection, phase identification, event detection/association, event location, event validation, magnitude estimation, event type classification and repeat event tracking, with a focus on methods that reduce analyst workloads, especially during large aftershock sequences. We also invite presentations that combine multiple steps or reimagine processing into novel pipelines enabled by data science methods and/or high performance computing capabilities. The goal of this session is to highlight recent work that improves large scale, sparse network processing and to motivate discussion of new research directions that can address these challenges.

Conveners

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Modeling, Collecting and Communicating Post-earthquake Hazard and Impact Information
Effective and timely post-earthquake response and recovery require a continuous flow of accurate, updated assessments to key decision-makers from a variety of disparate sources. Users know that each source has its own limitations and uncertainties, though there are always challenges in quantifying and communicating them. In the case of the 2021 M7.2 Haiti earthquake, compounding the difficulty in assessing the immediate shaking damage were reports of widespread landslides that added uncertainty as to the cause of remotely assessed physical changes. Further changes resulted from tropical storm rainfall and flooding that began soon after the event. This earthquake emphasized the benefits and importance of modeled hazard and loss estimates, remotely sensed observations and information gathered locally and assessed remotely. Field assessments by numerous international teams were limited due to Haiti's governmental limitations, security concerns and other on-the-ground challenges.

In this session, we solicit studies of all means of contributing to post-event situational awareness for decision-makers, responders and aid agencies, be it from physical or empirical modeling, ground-truth or remotely sensed data collection, or combinations of thereof. We are also intent on gathering experience or evidence of best practices in communicating actionable information and their uncertainties for the 2021 Haiti and other events. Analyses that consider the complexity of response and recovery from simultaneous, cascading and multi-hazard events are particularly welcome.

Conveners
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Eric Fielding, NASA Jet Propulsion Laboratory (eric.j.fielding@jpl.nasa.gov)
Haeyoung Noh, Stanford University (noh@stanford.edu)
Susu Xu, SUNY Stonybrook (susu.xu@stonybrook.edu)
Kate E. Allstadt, U.S. Geological Survey (kallstadt@usgs.gov)

Multi-scale Dynamics of Complex Earthquake Faulting and Seismic Wave Propagation
The complexity of earthquake rupture and the parameters that control such behavior is an active area of investigation that includes many challenging research topics. This session will highlight recent advances in rupture dynamics on complex fault systems and their comparison with different types of available observations. We are interested in a wide range of investigations related to numerical, experimental and observational fault rupture studies that examine the effects of fault geometry, fault roughness, frictional parameters, topography, creeping mechanisms, stress asperities, off-fault material properties and plasticity, bi-material interfaces and wedge structures along subduction zones. We also encourage contributions on research that explores links between earthquake source physics, tsunami generation/propagation and ground motion variability.

Conveners
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Roby Douilly, University of California, Riverside (roby.douilly@ucr.edu)
Christodoulos Kyriakopoulos, University of Memphis (ckyrkpls@memphis.edu)
Eric L. Geist, U.S. Geological Survey (egeist@usgs.gov)
Ruth Harris, U.S. Geological Survey (harris@usgs.gov)
David D. Oglesby, University of California, Riverside (david.oglesby@ucr.edu)

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, 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 and 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
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Kris L. Pankow, University of Utah (pankowseis2@gmail.com)
Renate Hartog, University of Washington (jrhartog@uw.edu)

New Developments in Physics- and Statistics-based Earthquake Forecasting
The increasing availability of geophysical datasets, including high-resolution earthquake catalogs, fault information and interseismic strain data, has enabled the creation of statistics- and physics-based seismicity models that underpin probabilistic seismic hazard analyses. Recently, data acquisition has further improved from machine learning (ML) techniques, which paves the way for potentially more informative earthquake forecasts. Earthquake forecasting models express a wide range of hypotheses regarding the occurrence of earthquakes, which can be tested within the framework of the Collaboratory for the Study of Earthquake Predictability (CSEP). We welcome contributions that help uncover the main advantages and limitations of statistical and physics-based seismicity models, identify informative forecasting methods and improve our understanding of the earthquake generation process. Submissions may include forecasting models based on ML-derived catalogs, new hypotheses explaining what controls earthquake potential or evaluations of the predictive skills of earthquake-rate forecasts.

Conveners
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William H. Savran, Southern California Earthquake Center (wsavran@usc.edu)
Leila Mizrahi, ETH Zürich (leila.mizrahi@sed.ethz.ch)

Numerical Modeling in Seismology: Developments and Applications
We invite both methodological contributions and useful applications. Progress in seismology is unthinkable without continuous development of numerical-modeling methods. Recent methodological development includes faithful rheological and geometrical complexity of the Earth, 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 in earthquake seismology.

New observations and data make applications of numerical modeling very important for understanding 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
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Observations and Modeling of the 2021 Haiti Earthquake
The August 14, 2021 Mw7.2 Nippes, Haiti earthquake ruptured along the Enriquillo-Plantain Garden Fault Zone (EPGFZ), about 100 km west of the devastating 2010 Mw7.0 Leogane, Haiti earthquake. The EPGFZ is part of a system of strike slip and thrust faults that comprise the transpressive boundary between the North American and Caribbean plate. In this session, we plan to highlight observations and models of this rupture sequence, informing the ongoing debate on how this complex fault system partitions strain as it transitions from subduction to strike-slip regimes. In bringing together the latest observations and models of the 2021 earthquake, we hope to forge new perspectives on ongoing seismic hazards in the region.

We welcome all abstract submissions related to observations and models of the 2021 earthquake. This includes rupture imaging, relocated aftershock sequences, field observations, surface rupture observations, ground failure observations, landslide observations, rupture modeling and hazard modeling. Submissions with retrospective analyses of the 2010 earthquake that shed light on the broader context of the earthquake sequence are also welcome.

Conveners
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Roby Douilly, University of California, Riverside (robyd@ucr.edu)

The Re-interpretation of Quaternary Faults near Tehran Based on Paleo Mega Lake of Rey Theory

In the last half-century, morphological escarpments in the south of Tehran have been considered active Quaternary faults. This issue has an impressive effect on the seismic code of Tehran with a 15 million population. But what will happen if we are wrong?

During the last decade, relocating the tectonic data in this area has revealed a great secret about the seismicity of Iran. In fact, it is now assumed that all of the southern Tehran faults are remains of an ancient lake known as “Paleo Mega Lake of Rey” (PAMELA), which would displace Paleo mega lake of Chad in Africa as the largest. This lake formerly covered the Great Kavir, Lut, Hamoun (between Iran and Afghanistan) and Kharan (Pakistan) deserts. This idea will transform the seismicity level of this area. We are currently at a critical juncture where large-scale multidisciplinary efforts are being launched to better understand PAMELA. At the moment, the area remains enigmatic in terms of the separation of Quaternary fault escarpment from the shoreline escarpment.

A goal of this session is to motivate discussions on the identification of PAMELA scarps and their effect on Iranian seismic code changes. Additionally, the Lake sediments (clay) are known to be the reason for subsidence incidents. Thus, focusing on the relationship between PAMELA and subsidence is the next goal of the session. Due to the large size of the study area (some parts of Iran, Afghanistan and Pakistan), radar data will be the best tool to detect the anomalies. Also worth mentioning is the fact that PAMELA dried up during the Holocene, and there are several active faults around this Lake. Our next goal is to examine the effect of the Lake's drying on upsetting the crustal isostasy. This issue can be the main reason for the reactivation of faults. The last goal is to draw a comparison between PAMELA and Mega Chad in terms of their link with fault activation, subsidence rate and so on.

Conveners

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Rethinking PSHA: Are We Using Appropriate Inputs for the End Goal?

Probabilistic seismic hazard assessments (PSHA) are widely used in building codes and other standards and guidelines in determination of seismic loads for seismic resistant design. Many types of input go into PSHA, such as an earthquake catalogues (requiring a robust assessment of earthquake magnitudes, locations, depths, etc.), active fault information (geometry, sense of motion on the fault, recurrence and slip rate estimates, etc.) and prediction of strong ground motion through ground motion models (GMMs), which can be empirical. GMMs require large amounts of recorded strong motion or analytical data and simulations that may have varying degrees of sophistication. In addition, PSHA is increasingly conducted for multiple ground conditions rather than being pegged to a “reference” site condition characterized in terms of Vs30. In this session we discuss how to rethink and improve some of these inputs, keeping in mind the end goal of determining seismic loads for engineering design. To that end, we welcome contributions related to topics including but not limited to: improvements in moment magnitude calculations and magnitude conversions; earthquake relocations; how to improve upon declustering earthquake catalogues for PSHA purposes; how to incorporate our current knowledge in active faults into PSHA, particularly in places where that knowledge is sparse; whether we can move beyond “active” and “stable” crustal GMMs to adequately capture the variation in attenuation characteristics for shallow crustal earthquakes; objective vs. subjective decision making in selecting GMMs and how simulations can help resolve some important issues around ground motion characterization in PSHA.

Conveners

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Searching for Fault Creep Over a Range of Timescales
Creep is well-expressed on fast slipping faults in developed areas (ex: the Hayward fault, California). In the absence of fault creep, geoscientists often assume that all fault slip over historic and geologic time scale is accommodated seismically. However, this assumption is not currently testable as the broader earthquake hazard community does not have well-developed methods for distinguishing seismic from aseismic transient displacement in the geologic record. The impacts of this assumption on hazard assessment are likely profound. How much does interseismic creep contribute to periodic, quasi-periodic, random or clustered earthquake recurrence? What is the impact on the spatio-temporal distribution of microseismicity, geologic slip rate calculations and earthquake rupture forecasting?

This session seeks to understand geologic, geodetic, seismologic, numerical and physical modeling insights into including the following: 1) What are observations of creep in the geodetic, paleoseismic and geologic record?; 2) When does shallow aseismic occur during the seismic cycle?; 3) Does lithology impact the distribution and preservation of creep?; 4) Do fault zone mechanical and physical properties control creeping versus seismic behavior?; 5) What do creeping faults teach us about seismogenic faults? and 6) What is missed in hazard by misidentifying aseismic as coseismic slip? We invite contributions that aim to answer these or other questions for creeping faults.

Conveners
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Seismo-acoustics Applications to Forensics and Novel Monitoring Problems
Anthropogenic and animal activities generate detectable acoustic, infrasonic and seismic signals. Both temporary and permanent sensor deployments provide seismo-acoustic data that we can use to monitor, locate, identify and characterize such activities. For example: the COVID-19 pandemic lockdowns reduced seismic noise values globally; industrial facility activity generates seismo-acoustic signals that characterize machinery operation; and trail and road traffic produces seismic signals that both quantify traffic parameters and provide data for subsurface imaging. We require innovative analysis techniques to better extract the seismo-acoustic signals of anthropogenic and animal activities and to convert these signals to useful knowledge.

We welcome submissions on collection and analysis of seismo-acoustic data and techniques including but not limit to (1) seismo-acoustic monitoring of animal, domestic and industrial activities; (2) acoustic and seismic analyses of chemical, ammunition, or vapor explosions; (3) multi-signature fusion of seismo-acoustic data with other geophysical signatures; (4) source analyses of anthropogenic and animal activities; (5) special geophysical considerations of human-made environments that can bias source parameter estimates; (6) leveraging unconventional data streams for association and source location that include social media posts and (7) machine learning applications to acoustic and seismic signals.

Conveners
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Seismo-geodetic Approaches for Seismic and Tectonic Processes
Geodetic tools have become routine in studies of tectonic plate motions, ground deformation, dynamic seismic observations, earthquake early warning and short-/long-term seismic hazard projections. Geodesy complements seismic observations by increasing the spatial resolution of seismic source models, spatially and temporally characterizing tectonic deformation and providing additional constraints on seismic processes. Advances to geodetic data processing and its incorporation in evolving seismological methods contribute to faster and more reliable seismic and disaster-mitigation applications.

This session welcomes contributions in the field of seismo-geodesy. We invite abstracts relating to any geodetic tool (e.g., GNSS, InSAR, strain, etc.) demonstrating new applications, improvements or analyses of tectonic deformation, specific earthquakes or sequences or other seismic processes with geodetic observations. We encourage submissions that illustrate the complementary nature of geodetic methods to their seismological counterparts, providing a comprehensive picture of a given seismic or tectonic process.

Conveners
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Shakes in Lakes: Frontiers in Lacustrine Paleoseismology
Lacustrine paleoseismology studies show that lakes can provide superior records of earthquake shaking for hazard analysis and understanding earthquake behavior. Earthquake-induced strong ground motions can result in the mobilization and redeposition of sediments in lakes. Thus, records of earthquake shaking can extend thousands of years with near annual resolution and be sensitive to earthquakes with Modified Mercalli Intensities as low as IV½. These advantages can provide a much more complete record of earthquake shaking than traditional paleoseismic records from trenches or coastal marshes, although single-lake records are generally agnostic of the seismic source. Uniquely, lakes can record earthquake shaking from seismic sources that cannot be directly examined, such as intraslab or intraplate events. And multi-lake records in some regions show high potential for resolving source faults.

We invite presentations on all aspects of the emerging field of lacustrine paleoseismology and potential uses of these records. We encourage presentations on the following topics: tectonic settings and types of lake environments, the discrimination between earthquake and climatically induced turbidites, the links between deposit characteristics and shaking parameters (MMI, duration, PGA), the evaluation of seismic sources and the novel ways of including these data in hazard evaluation.

Conveners
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Site Response Characterization in Seismic Hazard Analysis

Ergodic ground motion models (GMMs) represent site response (SR) as a function of explanatory variables, such as V S30 (time-averaged shear wave velocity in the top 30 m). Such SR models make the ergodic assumption that any sites with the same values of explanatory variables will have the same SR. However, it is well known that the SR at a given site (non-ergodic site response, NESR) can significantly differ from that estimated by the ergodic SR model. Moreover, when applied to scenarios for which the empirical observations are sparse (e.g. V S30 > 1500 m/s), ergodic SR estimates from the GMMs could be systematically biased. To perform site response characterization (SRC) for a site of interest, 1D ground response analyses (GRA) are often performed, requiring SR input parameters such as a V S profile to derive a model-based NESR (M-NESR). An alternative approach uses ground motion recordings at the site of interest to perform SRC and derive an empirical NESR (E-NESR), without the need to perform GRA or make assumptions on GRA model and input parameters.

This session solicits a broad range of approaches used for SRC. Topics of interest include active-/passive geophysical surveys (e.g., linear/2D, single-/multi-station surface-based array methods, down-/cross-hole methods, seismic interferometry, etc.) to develop M-NESR, studies using site-specific recordings to derive E-NESR, the use of machine learning in SRC and studies comparing results from different techniques and their associated epistemic uncertainties. Of special interest are studies performing SRC outside the applicable range of ergodic GMMs (e.g. V S30 > 1500 m/s); studies on improving current practice in SRC, e.g., the search of optimal SR proxy (beyond V S30 or site dominant frequency); 2D/3D site effects; SR uncertainty and variability; soil nonlinearity; the effect of topography and fractured rocks on ground motion amplification and attenuation and integration of site effects into seismic hazard analysis.

Conveners

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Structure and Seismogenesis of Subducting Slabs
Sinking slabs provide the major force that drives Earth's interior dynamics and plate tectonics. They also carry volatiles such as water and CO_2 into the deep mantle and impact the geochemical evolution of the Earth. Deep earthquakes (depth > 70 km) are absent in the mantle except in subducting slabs, mantle wedges, or regions of continental convergence. They can be further categorized as intermediate-depth earthquakes (70-350 km depth) and deep-focus earthquakes (350-700 km). Their causes and mechanisms remain a major scientific puzzle.

In this session, we invite contributions that characterize the structure and properties of subducting slabs, as well as new findings about deep earthquakes. We welcome observational, theoretical and numerical modeling results, as well as those from laboratory and field studies. New ideas and/or unusual observations, supported by numerical modeling, on how to study slabs and deep earthquakes are also welcome. Relevant techniques may include, but are not limited to seismic imaging, waveform inversion, seismic anisotropy, moment tensors, precise location of deep earthquakes and their statistical behaviors. Broader scientific issues to be addressed may include constraints on deep seismogenesis, slab structure and stress in subducting slabs, as well as interactions between these topics.

Conveners
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Tectonics and Seismicity of Intraplate Regions

Far from active plate boundaries, in stable continental interiors of central and eastern North America, northern Europe, Australia, parts of Asia, as well as in some offshore regions, tectonic deformation and seismicity are poorly known. New understandings of intraplate tectonic activity and associated seismicity are being achieved through a variety of approaches. Some take advantage of recent local, regional or national-scale geophysical experiments, using various technologies to monitor or image both onshore and offshore regions. Detailed studies of individual recent earthquakes or sequences and new methods of identifying smaller earthquakes from existing data have provided insights into subsurface faulting. Moreover, advances are being made in measuring historical slip on faults and estimating recurrence intervals. Our understanding has also increased from investigations of geodetic, geomorphologic and elevation changes and through improved measurements of local stresses. Complementing these approaches are studies that focus on ground motion attenuation and local site responses in continental interior regions, highlighting the impact intraplate earthquakes can have on seismic hazard assessments.

This session seeks diverse contributions related to intraplate earthquakes with goals of describing seismicity, identifying and characterizing active faults and/or deformation in stable continental interiors or offshore regions, 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.

Conveners

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Things That Go Bump: Identifying and Characterizing Non-Earthquake Seismo-Acoustic Sources

Although earthquakes are well known sources of seismic and acoustic energy, there are many others that produce such signals, which can occasionally perplex scientists: explosions, underground cavity collapses, landslides, volcanic activity and human activities (planned and accidental), to name just a few. This session focuses on improvements in methods to detect these types of sources and identify what causes them amid the background of the Earth's seismicity. We seek studies that can better characterize these sources in terms of their location, size and physics with a goal of better explaining what happened to produce such signals. Many techniques have been used over the years to accomplish this task including: seismic/acoustic energy partitioning; moment tensor characterization through waveform modeling; P/S, low/high frequency, Rayleigh/Love and other types of seismic amplitude ratios; as well as many types of magnitude ratios such as m_b:M_s and M_L:M_c. The successful methods vary greatly with source to receiver distance and frequency content in ways that are not completely understood. More recently waveform correlation methods have had great success in identifying repeated sources and can be used to drive down detection levels for such events. Most recently, when appropriate training data are available, machine learning and methods are being explored for these purposes. In this session we seek studies on all types of non-earthquake seismic acoustic sources and the methods used to find and describe them.

Conveners

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Using Data and Experience to Improve Geohazards Communication

Effective communication of potential and unfolding geohazards and the science that underpins our understanding of these hazards is critical for delivering accurate information to various stakeholders, including religious, community and government leaders, scientists, emergency responders and managers, and the interested and at-risk public. While good communication techniques are paramount in any science communication, geohazards communication requires special considerations and different groups, organizations and universities may play different (but key) roles in the communication process.

This session aims to 1) explore research-based evidence and case studies of communicating about geohazards through various types of media and to different communities, 2) share lessons learned and best practices for communicating geohazards in the public sphere and 3) facilitate community-wide discussion about how we can more accurately, effectively and responsibly communicate geohazards science to a broad audience using various media and communications partnerships.

Conveners

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What Controls the Style of Fault Slip in Subduction Zones?

The heterogeneous structure of the plate boundary fault zone has a first-order impact on the style of fault slip that occurs at the subduction interface, both within the megathrust and neighboring regions of the seismogenic zone where slow earthquakes occur. For example, subducting seamounts appear to control the segmentation of the megathrust; at a smaller scale, tremor-generating seismic asperities are spatially stationary across multiple slow slip events that each have their own unique rupture evolution. Other controls on structure such as lithology, elevated pore fluid pressures and changing stress states can also play a role in determining faulting style. The outstanding question we would like to address is: what is the impact of subducting plate interface structure on the broad spectrum of faulting that is observed?

We seek abstracts that shed light on the impact of such fault structure (including but not limited to heterogeneity, lithology, pore fluid pressure and stress state) on the mode of fault slip. We welcome abstracts focused on individual aspects of structure and faulting dynamics, including but not limited to geophysical imaging, earthquake source, and numerical modeling studies, whose connections will be explored within the greater context of the session. Our hope is that this session will build off of, and contribute to, the momentum surrounding the community-driven Subduction Zones in 4 Dimensions (SZ4D) initiative.

Conveners

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