SSA 2024 Photonic Seismology Speakers and Topics
Vancouver, British Columbia, Canada, 7-10 October 2024

Featured Speakers

- Jonathan Ajo-Franklin, Rice University
- Biondo Biondi, Stanford University
- Fabrice Cotton, GFZ Postdam
- Andreas Fichtner, ETH Zurich
- Allen Husker, California Institute of Technology
- Philippe Jousset, GFZ Potsdam
- Voon Hui Lai, Australian National University
- Jeff McGuire, U.S. Geological Survey
- Giuseppe Marra, National Physical Laboratory
- Eileen Martin, Colorado School of Mines
- Meghan Miller, Australian National University
- Danica Roth, University of Colorado, Boulder
- Connie Stewart, California State Polytechnic University, Humboldt
- Tieyan Zhu, Penn State University

Topics

The content will be organized broadly in **the following topic areas**:

An Innovative Photonic Vision of Volcanoes and Geothermal Systems

The structure and dynamics of volcanoes and geothermal systems can benefit from a new vision: fiber-optic sensing. Fiber-optic sensing single point sensors (such as rotational sensors and gyroscopes), fiber Bragg arrays, and distributed fiber-optic sensing have been recently used to improve our knowledge of the subsurface features and mechanisms driving the phenomena occurring within volcanic and geothermal systems. Whether temperature, strain, or chemical sensing, these new tools help us to highlight unknown structural features of the complex plumbing systems of the earth, with a clear reduction of cost for exploration. Monitoring of such systems is also facilitated as deployment on existing telecommunication and dedicated fibers is becoming easier, and the instruments' sensitivities are enhanced at both high and low frequencies. The session aims to provide an innovative vision of volcanic and geothermal areas with contributions to the exploration and monitoring of these systems in various environments, such as boreholes, underwater, and acidic and high-temperature conditions. We welcome diverse applications related to volcano/geothermal seismicity and tremor, related landslides, and volcanic glaciers that employ new sensing and processing technologies such as machine learning and artificial intelligence. We aim in particular at attracting contributions on the long-term deformation of volcanoes or geothermal systems due to magma, gas, and tectonic processes, as seen with fiber optic and photonic tools to offer geoscientists a new vision of Earth processes leading to new knowledge, better resource management, hazard assessment, as well as for more sustainable energy solutions and risk mitigation.

Earthquake Characterization Using Fiber-optic Cables

Photonic seismology has grown into an exciting topic within observational seismology over the last decade. The flexibility of how and where a fiber optic cable can be deployed provides significant opportunities for both novel network designs and a broad spectrum of short-term and long-term monitoring applications, addressing temporal and spatial resolution as well as sensing needs. Despite this growth in interest, we are still, as a community, trying to understand both what the current limitations are and how far we can push these limits. Fundamental differences exist between earthquake records from fiber optic cables and traditional seismometers. While the differences in physical measurements require adaptation to extract meaningful signal characteristics, the continuous spatial measurements provide new opportunities for novel signal processing techniques that can take advantage of the vast quantities of recorded data. The high resolution offered by optical fiber presents an opportunity to enhance observations, facilitating a deeper understanding of earthquake physics. Existing telecom networks have repurposed their fiber and underwater cables for seismological applications. These networks have been used to demonstrate the potential for earthquake-related studies including, earthquake detection and location, magnitude estimation and stress drop, focal mechanisms, fault rupture processes, and imaging Earth structure. In this session, we encourage contributions that showcase the latest research and technological innovations that are pushing the frontiers of earthquake characterization and analysis through fiber optics. We are interested in contributions focused on novel methods, applications, network designs, and case studies that can enrich our understanding of earthquake processes and contribute to the evolution of photonic seismology.

Exploring the Frontier of Environmental Processes using Fiber-optic Sensing

Fiber-optic sensing offers unique capabilities for capturing high-resolution data across spatial and temporal scales, making it particularly valuable for studying dynamic environmental systems. This session aims to explore the unprecedented opportunities and advancements in monitoring enabled by Distributed Acoustic Sensing (DAS) and other fiber sensing technologies, transforming our understanding of environmental processes. We seek contributions from researchers and practitioners working on cutting-edge applications of seismological and acoustic fiber optic techniques that showcase their unique capacities to unravel complex environmental dynamics of the cryosphere, geosphere, atmosphere, hydrosphere, and biosphere. Example topics may include but are not limited to: mass movement (landslides, rockfalls, debris flows, lahars); hydrologic processes (groundwater, open-water waves/tides, floods, turbulence, sediment transport), cryospheric (avalanches, icequakes, ice calving/fracture/deformation, glacial hydrology/sliding), atmospheric and oceanic phenomena (microseisms, weather, gravity waves); as well as methodological developments (spatio-temporal imaging, how environmental changes affect fiber-optic sensing operations and data quality, advances in logistical techniques for deployments in harsh environments). Contributors are encouraged to share their research findings, methodologies, and case studies that showcase the versatility and potential of fiber-optic sensing in advancing environmental process monitoring. This session provides a platform for cross-disciplinary discussions, bringing together experts from seismology, acoustics, hydroacoustics, fiber optics, and a wide range of Earth and environmental sciences. Submit your abstract to be part of this transformative session, where fiber-optic sensing technologies take center stage in reshaping our ability to monitor and interpret environmental seismo-acoustic signals.

Filling the Data Gap: Ocean-bottom Sensing with Fiber-optic Cables

Are we at the beginning of a new era for Earth monitoring?

Our ability to monitor our planet has been continuing to expand over the last several decades, with ever improving sensing capabilities both on land and from space. In contrast, the bottom of the oceans remains largely unmonitored to this day. As the oceans account for 70% of the Earth's surface, the lack of permanent ocean-bottom sensors results in a huge data gap. However, the giant network of optical fiber cables at the bottom of the oceans, which enabled the digital revolution over the last 30 years, could now be the key to a new revolution. By turning seafloor cables into arrays of environmental sensors, many research groups around the world are expanding our monitoring capabilities from land to the bottom of the oceans. Crucially, this can be achieved without requiring new seafloor installations. This session will explore the state of the art in the emerging field of ocean-bottom fiber-optic sensing, covering a number of science areas, from seismology to oceanography and acoustics. We invite contributions on optical interferometry, distributed acoustic sensing (DAS), and other techniques that enable short and long-range sensing over seafloor cables, as well as applications of ocean-bottom sensing from monitoring offshore earthquakes and subsurface imaging to detecting marine mammal vocalizations and measuring ocean temperature changes. In addition to the talks, the session will include engaging discussions on the exciting possibilities, the challenges, and the future outlook of cable-based ocean-bottom sensing.

How to Scale Up

Fiber optic sensing technologies hold immense promise for advancing geophysical studies. Distributed Acoustic Sensing (DAS) has demonstrated remarkable capabilities in studying surface and subsurface processes with unprecedented resolution and over extended periods, even in challenging environments. Emerging technologies like phase transmission and state of polarization (SoP) offer the potential for continental or oceanwide scale monitoring with continuously improving data quality. Yet, to fully leverage the potential of fiber sensing for geophysical applications, several key steps must be taken. This includes facilitating access to existing fibers and streamlining the installation of new fibers in both onshore and submarine environments. Overcoming challenges in telemetry, real-time monitoring, and data transportation is crucial, as proven by many ongoing efforts underway to address these obstacles. Additionally, ensuring common standards for metadata and providing user-friendly software interfaces are essential for encouraging broader use and analysis of fiber optic sensing datasets, especially as they become more accessible to the public. While advancements in photonics technology have led to faster algorithms, there is a need to develop techniques and infrastructure tailored to fully exploit the richness of fiber optic sensing datasets such as DAS and enable greater synergy among scientists. As new techniques such as SoP and projects such as smart cables emerge, it will be important for the geophysical community to embrace these innovations and integrate them effectively into existing practices. This session will feature a series of short talks followed by a panel-style discussion, exploring these topics, presenting new and emerging solutions, and addressing open challenges in deploying fiber-optic sensing technologies to the next level.

Real-Time Monitoring and Warning with Fiber Optic Seismology

Real-time warning systems that rapidly detect and characterize earthquakes are increasingly operational around the world with the mission to provide accurate forecasts of both damaging shaking and tsunami warnings. These early warning systems rely on real-time seismic and geodetic data to provide seconds to minutes of warning. The inherent ability of fiber optic-based measurements to cover large spatial scales with instantaneous telemetry of data, including from offshore locations, provides a key motivation to investigate the potential to apply these methods to warning systems. In recent years, fiber optic sensing has rapidly evolved in scale and sophistication, and much effort is being spent harnessing these improvements for real-time applications. In this session, we welcome contributions dealing with a variety of topics, including both scientific and technical aspects of real-time fiber sensing. Scientific aspects may include real-time demonstrations and performance assessments of various algorithms, assessment of the limitations and feasibility, combining fiber optics with traditional sensing technologies, and new approaches for robust, strong shaking and long-period measurements. Technical aspects may include real-time data processing strategies, ensuring robust data streams, and developing effective partnerships with fiber owners and manufacturers of sensing equipment. Additionally, studies aimed at understanding the overall costs of system operation, including data management, are invited. We encourage forward-looking submissions that are aimed at identifying ways to make progress toward improving real-time warning systems through the adoption of fiber optic-based technologies.

Sensing Technologies and their Latest Developments

Optical fiber communication networks are one of the largest global infrastructures humans have ever built, providing a vast web of cables spanning across the globe. Current sensing modalities under exploration in this context can imply fully distributed measurements (such as Distributed Acoustic Sensing, DAS) or end-to-end measurements such as State of Polarization (SoP) and phase measurements. Distributed measurements have the advantage of providing an unprecedented level of spatiotemporal details, while end-to-end measurements leverage mostly the re-use of data so far discarded by the optical fiber transceivers. Hybrid schemes involving, e.g., the use of loop-back channels already available in fiber-optic repeaters are also currently under exploration. By gaining more insight and combining these sensing modalities wisely, the possibilities ahead are extremely broad and, so far, largely unexplored. This session aims to understand the current progress in fiber-optic measurement technologies for seismology, from the first principles to the more general aspects of their application. Submissions are welcome on all topics related to (1) progress in DAS, SoP, and phase schemes, including loop-back configurations; (2) novel architectures enabling compatibility of communications and sensing on the same infrastructure; (3) prospects of finding new applications in the edges of current array seismology.

Urban Seismology

More than half the world’s population lives in cities, and an additional 2.5 billion people are expected to move to cities by 2050. The cities of the future must support thriving human communities but also reduce their carbon footprint and be resilient to the new challenges presented by climate change. Seismic data can provide invaluable information to achieve these goals by cost-effective continuous monitoring of the subsurface, the built environment, and the impact of human activities. Potential monitoring applications range from managing geologic hazards and water resources by time-lapse subsurface imaging and analysis of local and regional seismicity to cost-effective monitoring of urban infrastructure such as bridges and tunnels. The potential value of urban seismology has been recently enhanced by the development of new acquisition technologies such as autonomous nodes and fiber optic sensing, which, combined with cloud/edge computing, enable the creation and management of large-scale, dense seismic networks. In particular, repurposing unused fiber-optic telecommunication networks as massive arrays of seismic sensors enables continuous imaging and monitoring of the urban subsurface at unprecedented resolution with minimum effort, providing opportunities for a wide range of new urban seismic studies. The future realization of the potential value of leveraging fiber-optics sensing technologies for urban seismology depends on developing new data acquisition strategies, processing algorithms, computational tools, and interpretation workflows. We welcome contributions on all aspects of using fiber-optic sensing technologies in urban seismology, ranging from advances in instrumentation to algorithmic development, modeling studies, and new field experiments. Applications include, but are not limited to, characterization and mitigation of geologic hazards, urban hydrogeophysics, monitoring energy development and storage activities, traffic monitoring, and any other application contributing to advancing urban resilience and sustainable development.