Session:
Plenary Session: New and exotic approaches for Acquiring, Analyzing, and Modeling in Geophysics.

Title:
Crossing the shoreline with fiber-optic Distributed Acoustic Sensing (DAS) in Monterey Bay

Authors:
Nathaniel J Lindsey, Jonathan Ajo-Franklin, T. Craig Dawe, Horst Rademacher, Aleksei Titov, Julia Correa, Verónica Rodríguez Tribaldos, Feng Cheng

Abstract:
Emerging fiber-optic Distributed Acoustic Sensing (DAS) technology coupled to existing telecommunications cables provides unprecedented access to geophysical array data at the meterscale over tens of linear kilometers. Unlike classic inertial seismometers and geodetic strainmeters, DAS instrument response is largely uncalibrated, specifically at the low frequencies relevant to the earth science community. We are quantifying DAS instrument response in the field and laboratory, and also applying DAS to answer different earth science questions. During March 2018, we conducted a DAS experiment with a buried fiber-optic cable typically used for data transfer to and from a scientific cabled observatory offshore Monterey Bay, called the Monterey Accelerated Research System (MARS) node. During a 4-day period of MARS node maintenance the MARS cable was repurposed as an evenly-spaced ~10,000-component, 20-kilometer-long DAS array. Full wavefield observation of a M3.4 earthquake that occurred 45-km inland near Gilroy, CA illuminated multiple recently-mapped and previously unmapped submarine fault zones. In the nearshore water of the MARS cable, the dominant noise was found to match the predicted seafloor pressure field induced by shoaling ocean surface waves, otherwise known as the primary ocean microseism. Frequency-wavenumber decomposition of the incoming and outgoing wavefield components validated the Longuet-Higgins-Hasselmann theory that bi-directional ocean wind-waves setup by the coast reflection undergo nonlinear wave mixing to cause the secondary microseisms, even when the outgoing energy is only 1% of the incoming energy. DAS amplitudes track sea state dynamics during a storm cycle in the Northern Pacific, correlating with features of local bay buoy and onshore broadband seismometer data streams. We observe additional noise patterns at higher and lower frequencies consistent with previous point sensor observations of post-low-tide tidal bores, storm-induced sediment transport, infragravity waves, and breaking internal waves. The number of geophysical interactions observed over this brief four-day recording evidences the introduction of an important new technique for seafloor science.

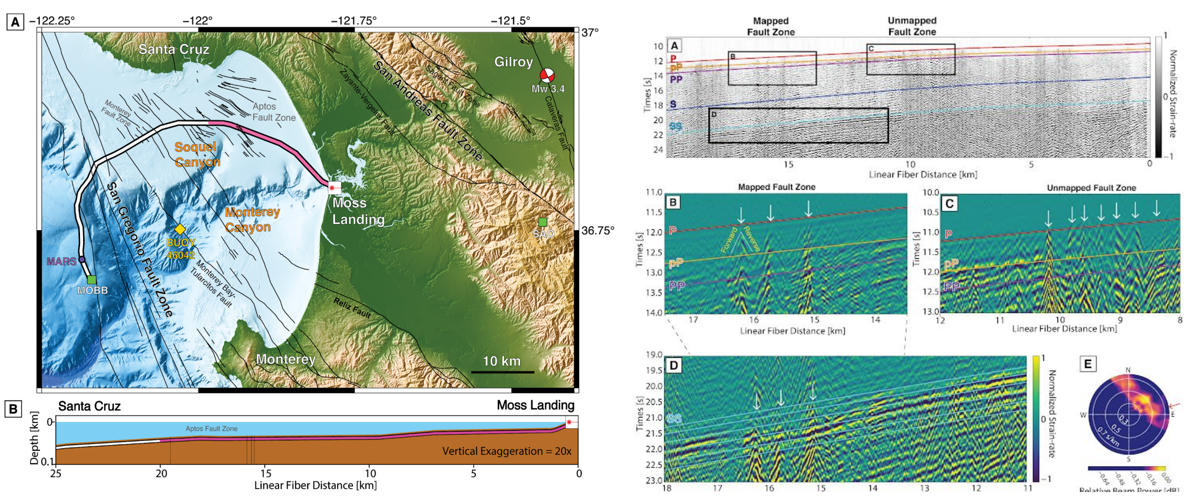

Figure. [left] A) Map of Monterey Bay, CA shows the 52-km MARS cable (pink portion used for DAS), mapped faults, M3.4 2018-Mar-11 Gilroy earthquake (star), auxiliary broadband seismometers (green squares), NOAA buoy 46042 (yellow diamond), and major bathymetric features. B) Cartoon cross-section of illuminated MARS cable array illustrates that the MARS cable is buried 1-m below the seafloor under 20 - 50 m of water. Note the mapped fault locations around 16 and 19 km linear fiber distance. [right] A) DAS observations of the M3.4 2018-Mar-11 Gilroy earthquake shown on map made from 0 - 20 km along the MARS cable, beginning at Moss Landing. P, pP, PP, S and SS phase arrivals are consistent with predicted arrivals (colored lines) using cable geometry. B-D) Insets from (A) show discrete secondary scattering in the forward and reverse directions propagating with an apparent velocity of 200-600 m/s away from submarine faults (white arrows) and SS wavefront delay. Lines show predicted constant phase arrivals immediately following the first SS wavefront. E) Time-domain beamforming solution for a horizontal slowness range of 0.05 - 0.8 s/km (apparent velocity = 1.25 - 20 km/s) shows how energy arrives from east-northeast-north azimuths. Red arrow shows backazimuth from cable midpoint.