

Passive seismic observations on a 65-km telecommunication DAS cable in shallow waters along the Texas Gulf Coast

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Summary

Distributed acoustic sensing on existing telecommunication fibers enables dense, large-aperture seismic observations in shallow marine environments. We analyze passive recordings from a 65 km submarine telecom cable along the Texas Gulf Coast. The wavefield is dominated by ocean gravity waves and Scholte waves, producing strong spatially variable noise. A prominent peak near ~ 0.16 Hz lies within the secondary microseism band and follows ocean-wave dispersion, indicating a primarily ocean-driven origin. Frequency-wavenumber analysis separates ocean-wave, Scholte-wave, and teleseismic components due to their distinct dispersion behavior. After separation, coherent teleseismic surface waves are recovered along the full cable length. The extracted signals show strong phase consistency with nearby onshore broadband recordings, confirming that the cable records true seismic motion despite intense shallow-water noise. Spatial amplitude stripping correlates with seabed stiffness variations, indicating sensitivity to near-seafloor mechanical properties. These observations demonstrate that well-coupled submarine DAS cables provide reliable seismic measurements and diagnostic sensitivity to seabed properties, supporting future imaging and monitoring applications.

Introduction

Distributed acoustic sensing (DAS) enables dense, large-aperture seismic measurements using existing telecommunication fibers. Submarine DAS deployments have demonstrated the ability to record regional and teleseismic wavefields and to characterize marine environments (Williams et al., 2019; Spica et al., 2020; Cheng et al., 2021). Active-source experiments further show that ocean-bottom DAS arrays can function as effective receivers for conventional imaging surveys (Raknes et al., 2025). Recent studies also indicate that seabed properties can strongly modulate recorded DAS amplitudes and spatial noise patterns (Bakulin et al., 2026).

Here we analyze passive data recorded on a shallow-water telecommunication DAS cable along the Texas Gulf Coast. Unlike many previously reported submarine DAS deployments, this experiment samples a coastal environment where ocean-wave energy strongly dominates the recorded wavefield. Using a teleseismic earthquake as a reference signal, we examine the structure of the wavefield and show how dense spatial sampling enables separation of ocean-wave, Scholte-wave, and seismic components. The dataset also provides insight into seabed mechanical

variability and receiver behavior, with further analyses explored in companion studies.

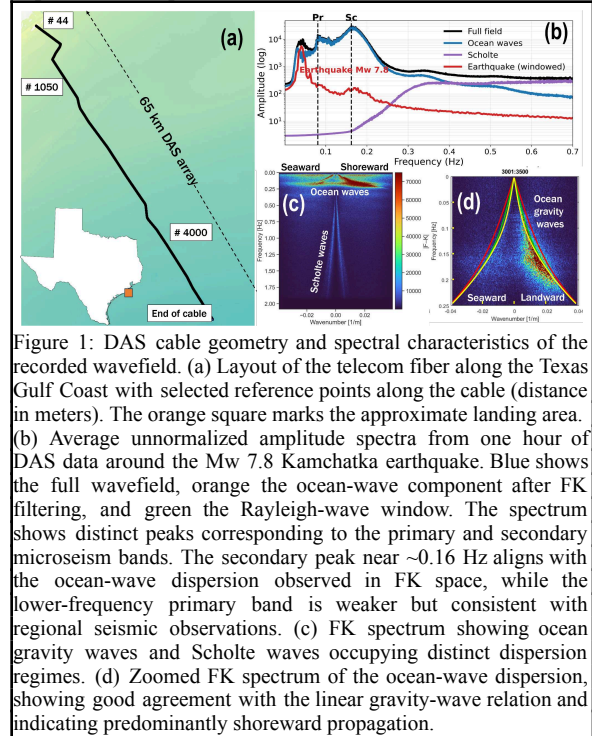


Figure 1: DAS cable geometry and spectral characteristics of the recorded wavefield. (a) Layout of the telecom fiber along the Texas Gulf Coast with selected reference points along the cable (distance in meters). The orange square marks the approximate landing area. (b) Average unnormalized amplitude spectra from one hour of DAS data around the Mw 7.8 Kamchatka earthquake. Blue shows the full wavefield, orange the ocean-wave component after FK filtering, and green the Rayleigh-wave window. The spectrum shows distinct peaks corresponding to the primary and secondary microseism bands. The secondary peak near ~ 0.16 Hz aligns with the ocean-wave dispersion observed in FK space, while the lower-frequency primary band is weaker but consistent with regional seismic observations. (c) FK spectrum showing ocean gravity waves and Scholte waves occupying distinct dispersion regimes. (d) Zoomed FK spectrum of the ocean-wave dispersion, showing good agreement with the linear gravity-wave relation and indicating predominantly shoreward propagation.

Telecommunication DAS, Texas Coast Field Test

The dataset analyzed in this study was recorded on an existing telecommunication fiber-optic cable deployed along the Texas Gulf Coast. The cable forms a continuous sensing array approximately 65 km long extending from the shoreline into shallow marine waters. A DAS interrogator installed onshore records axial strain along the fiber in passive mode. With 12.76 m channel spacing, the system forms a dense linear array providing large spatial aperture for observing the coastal wavefield (Figure 1a).

The spectral structure of the recorded wavefield is shown in Figure 1b. Ocean-generated energy dominates the spectrum, with peaks in the primary and secondary microseism bands. The secondary peak near ~ 0.16 Hz aligns with the ocean-wave dispersion observed in FK space (Figure 1c,d) and is also present at the HKT broadband station, while the primary band is weaker and more intermittent offshore but observed at the HKT station. Similar spectral structure and peak frequencies have been reported in Gulf of Mexico broadband OBS and HKT

Gulf Coast Telecom DAS Performance

comparisons (Pulliam et al., 2003), indicating consistent microseism behavior across independent sensor types. The array records stable signals down to ~ 0.01 Hz and below, demonstrating strong low-frequency sensitivity of the telecom DAS system.

The frequency-wavenumber representation (Figure 1c) reveals two dominant components: ocean gravity waves and Scholte waves propagating along the seafloor. These occupy distinct regions of the FK domain and exhibit different dispersive behavior. A zoomed view of the ocean-wave energy (Figure 1d) shows dispersion closely following the theoretical linear gravity-wave relation and indicates predominantly shoreward propagation. This band follows ocean-wave dispersion, indicating direct coupling to the ocean-wave field.

Raw DAS records along the cable are shown in Figure 2. The wavefield displays strong spatial variability dominated by ocean-wave noise, producing vertical striping along offshore sections. This striping reflects variations in seabed stiffness (Bakulin et al., 2026), where stronger ocean-wave energy masks the signal and weaker zones allow intermittent visibility. As a result, the teleseismic Rayleigh wave is clearly visible onshore, where ocean-wave noise is absent, and only intermittently visible offshore.

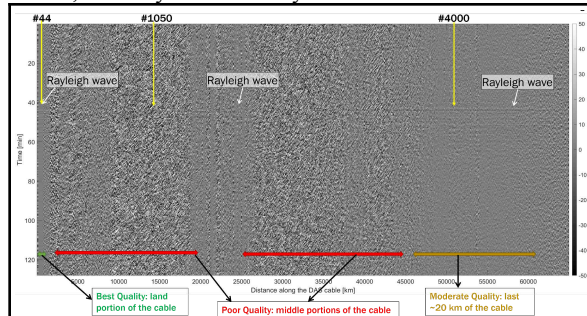


Figure 2: Two-hour DAS record along the ROA telecom cable showing the arrival of teleseismic Rayleigh waves from the Mw 7.8 Kamchatka earthquake. The data exhibit strong spatial variability along the cable, dominated by ocean-wave noise that produces characteristic vertical striping patterns. Three representative channels used later for analysis are marked by yellow lines: a quiet on-land section (#44), a noisier mid-cable section (#1050), and a quieter offshore section about 50 km away (#4000). The teleseismic Rayleigh wave arrival (white arrow) becomes alternately visible and obscured along the cable, emerging clearly in quieter segments (on land and near the far end of the cable) but largely disappearing beneath strong ocean-wave noise in the noisy middle section.

The broadband recordings demonstrate stable sensing down to roughly 0.01 Hz, and potentially lower, confirming strong low-frequency sensitivity of the telecom DAS array.

Land-marine transition of the recorded wavefield

An instructive feature of the dataset is the short transition from land to shallow marine conditions along the cable,

illustrated in Figure 3 around the arrival of the Mw 7.8 teleseismic event. In the on-land segment, the Rayleigh wave is clearly observed as a coherent surface-wave arrival with little interfering energy. Although the cable remains trenched at comparable depth along its length, the wavefield changes abruptly upon entering shallow water. The seismic signal persists beneath the record, but its visibility is strongly reduced due to increasing ocean-wave energy. The shallow marine environment is dominated by low-velocity ocean-wave signals that mask seismic arrivals and introduce strong spatial variability.

This contrast indicates that the observed differences are controlled primarily by the ambient wavefield rather than installation conditions. While coherent seismic energy remains present along the full cable, ocean-wave noise in shallow water significantly reduces its visibility, highlighting the need for wavefield separation.

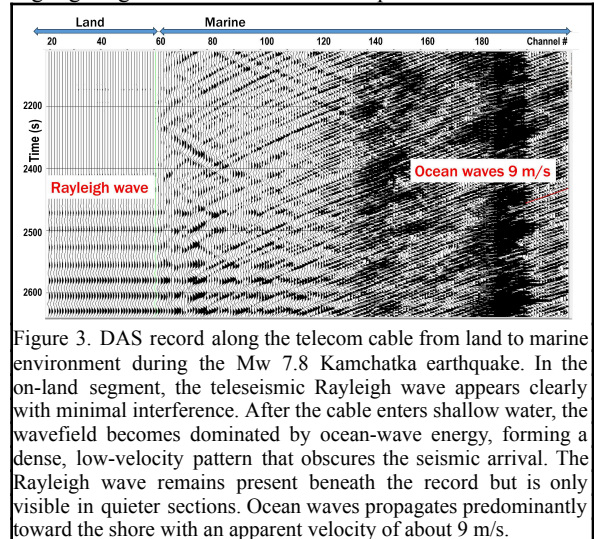


Figure 3: DAS record along the telecom cable from land to marine environment during the Mw 7.8 Kamchatka earthquake. In the on-land segment, the teleseismic Rayleigh wave appears clearly with minimal interference. After the cable enters shallow water, the wavefield becomes dominated by ocean-wave energy, forming a dense, low-velocity pattern that obscures the seismic arrival. The Rayleigh wave remains present beneath the record but is only visible in quieter sections. Ocean waves propagate predominantly toward the shore with an apparent velocity of about 9 m/s.

Wavefield separation

Different apparent velocities observed in the FK spectra (Figure 1c-d) indicate that the dominant wavefield components occupy separate regions of the frequency-wavenumber domain. Ocean gravity waves and Scholte waves exhibit distinct dispersions and propagation velocities, allowing separation using FK-based filtering following the approach of Bakulin et al. (2026). An example is shown in Figure 4, which presents a zoom of ~ 400 channels over a 50 s interval around the teleseismic arrival. The upper panel shows the full wavefield dominated by ocean-wave energy, while the lower panels illustrate the separated components: (B) ocean waves, (C) Scholte waves, and (D) the extracted teleseismic Rayleigh wave.

Ocean waves behave similarly to very low-velocity ground roll, with apparent velocities near 10 m/s. The dominant

Gulf Coast Telecom DAS Performance

energy near ~ 0.16 Hz falls within this ocean-controlled band, although its spectral position corresponds to the secondary microseism frequency. With dominant frequencies around 0.16 Hz, their wavelength is roughly 60 m. The DAS channel spacing of 12.76 m therefore samples the wavefield with about five spatial samples per wavelength, enabling reliable FK separation.

After removing the ocean-wave component, the seismic signal becomes clearly visible. More than 90-95% of the recorded energy is associated with ocean-wave processes, highlighting both the challenge of shallow-water DAS observations and the effectiveness of dense spatial sampling for isolating seismic signals.

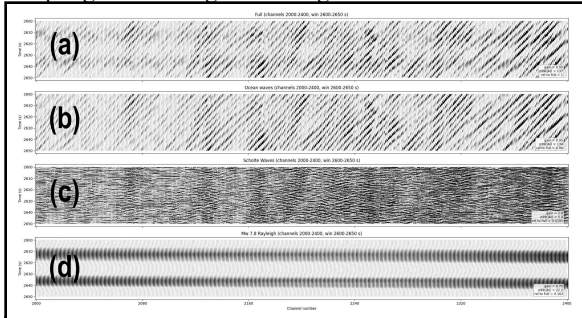


Figure 4: Zoomed DAS waveform over ~ 400 channels and ~ 50 s illustrating separation of the main components. (A) Full waveform dominated by ocean-wave energy. (B) Ocean waves isolated after FK filtering, propagating shoreward with apparent velocity ~ 10 m/s. (C) Scholte waves extracted after removing the ocean component. (D) Teleseismic Rayleigh wave from the Mw 7.8 Kamchatka earthquake after removing ocean and Scholte energy, revealing a clean surface-wave arrival. Traces are shown with independent amplitude scaling for each panel.

Comparison with a nearby broadband station

To place the DAS observations in a broader seismic context, we compare the extracted wavefield with recordings from the HKT broadband seismic station located onshore near Houston, about 120 km from the cable landing station. Figure 5 shows this comparison. The upper panels display the vertical component and the horizontal component rotated along the cable direction at HKT. Three representative DAS channels are shown below: one from the onshore segment, one from the noisy mid-cable section (#1050), and one from the far offshore section (#4000). Each DAS channel is shown before and after wavefield separation. The land channel already shows the Rayleigh arrival clearly, whereas the mid-cable channel is dominated by ocean-wave noise in the raw data. After processing, the Rayleigh wave becomes clearly visible. The offshore channel near the far end of the cable shows intermediate noise conditions but recovers a clear Rayleigh arrival after processing, demonstrating that useful seismic signal is preserved across the entire cable length. In all cases the processed DAS traces display coherent arrivals consistent with the signal recorded at HKT. In addition to waveform

similarity, the HKT recordings exhibit the same primary and secondary microseism peaks over the same time interval, confirming that these spectral features are not specific to the cable.

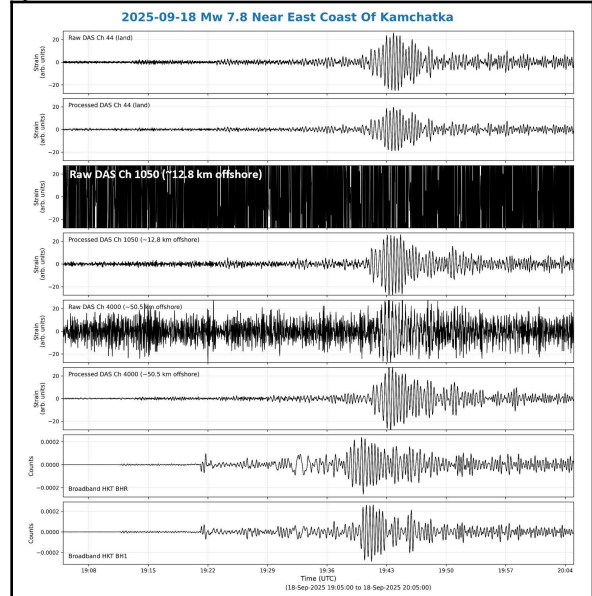


Figure 5: DAS and broadband comparison for the Mw 7.8 Kamchatka earthquake. Three representative DAS channels are shown: an on-land section, a mid-cable offshore section, and a far offshore section. For each location, raw DAS records are shown together with processed traces after removal of ocean-related noise. The processed DAS data reveal a coherent Rayleigh-wave arrival that is consistently observed along the full cable length, including sections where it is largely obscured in the raw records. The improvement is most pronounced in the mid-cable region, where strong ocean-wave energy dominates the unprocessed data. For comparison, recordings from the nearby HKT broadband station are shown, including the vertical component and the horizontal component rotated along the cable direction. After processing, the DAS waveforms show strong phase similarity with the rotated HKT component across all three locations, confirming consistent seismic response and timing along the cable. Separation uses a two-stage FK filter (ocean then Scholte), yielding a substantial increase in effective signal-to-noise ratio.

Figure 6 shows a zoomed comparison between the DAS records and HKT waveforms. The HKT horizontal component is rotated along the cable direction to approximate the DAS sensitivity. After minor alignment, the records display strong phase similarity. An earlier packet, likely Love-wave energy, is strongest on horizontal components, followed by the Rayleigh wave.

These results demonstrate that although shallow-water DAS records are dominated by ocean-wave noise, simple FK-based processing can recover coherent teleseismic signals. In this experiment, the separation increases the effective signal-to-noise ratio by up to ~ 40 dB, producing

Gulf Coast Telecom DAS Performance

waveforms consistent with nearby broadband seismic observations.

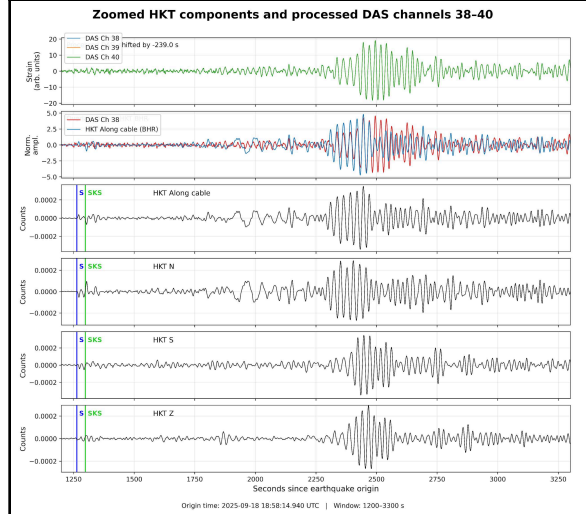


Figure 6: Comparison of broadband station HKT waveforms and processed DAS channels (38–40) for the Mw 7.8 Kamchatka teleseismic event. The top panels show processed DAS channels. The second panel compares a DAS trace with the HKT horizontal component rotated along the cable direction. The lower panels show HKT components, including the along-cable horizontal, N, S, and Z components. Traces are slightly time-aligned to facilitate visual comparison. The earlier surface-wave packet, interpreted as Love-wave energy, is strongest on horizontal components and along-cable motion and is largely absent on the vertical component. The later packet corresponds to the Rayleigh wave, which shows stronger vertical motion and is consistently observed in the DAS response. The DAS waveforms closely match the rotated HKT component, confirming coherent phase behavior across independent sensors.

Discussion

The Gulf Coast telecommunication DAS experiment demonstrates that an existing shallow-water fiber cable can function as a well-coupled, large-aperture seabed seismic receiver array. The cable is well trenched and mechanically coupled to the seafloor. Spatial striping along the array reflects amplitude modulation by seabed stiffness variations (Bakulin et al., 2026) and influences seismic arrival visibility.

Ocean-wave energy accounts for more than 90% of the recorded wavefield in this shallow-water environment, spanning both primary and secondary microseism bands. Despite this strong background, coherent seismic signals remain detectable along the full 65 km cable and down to ~ 0.01 Hz. Dense spatial sampling enables effective wavefield separation, as ocean gravity waves, Scholte waves, and teleseismic signals occupy distinct regions in the frequency-wavenumber domain. Sequential FK filtering isolates the seismic component, improving signal-to-noise ratio by ~ 25 –40 dB and revealing arrivals that are largely obscured in the raw data.

The recovered teleseismic wavefield shows good agreement with recordings from the nearby broadband station HKT, confirming that the submarine DAS cable records coherent seismic motion despite the challenging shallow-water noise environment. In addition, the extracted Rayleigh-wave signal exhibits spatial amplitude modulation that correlates with variations in seabed stiffness along the cable (Bakulin et al., 2026). This observation further supports the interpretation that seabed mechanical properties play a key role in controlling the recorded DAS response.

Strong Scholte waves are also clearly observed along the cable and provide a useful diagnostic of shallow seabed conditions. Their dispersion contains information about near-seafloor shear properties and could potentially be used for geotechnical characterization of marine sediments without the need for dedicated active-source experiments.

The experiment therefore provides a comprehensive field-scale dataset for evaluating submarine DAS performance in shallow-water environments, spanning wavefield characterization, receiver behavior, and seabed mechanical effects. This framework establishes a baseline for subsequent specialized analyses of signal detectability, repeatability, and seabed property inversion derived from the same dataset.

Conclusions

We show that a shallow-water telecommunication DAS cable can provide high-quality seismic data and function as a well-coupled ~ 65 km aperture seabed receiver array. Although the wavefield is dominated by ocean-wave noise, dense spatial sampling enables separation of ocean waves, Scholte waves, and teleseismic energy, recovering coherent seismic arrivals consistent with nearby broadband observations. Existing submarine telecommunication fibers can therefore serve as large-aperture seismic observatories while also recording ocean-driven processes, including signals linked to shallow seabed mechanical properties through Scholte-wave behavior and spatial amplitude modulation.

The results also suggest that dense DAS measurements can inform the design of nodal ocean-bottom acquisitions, particularly by diagnosing persistent noise on vertical and horizontal components that remains difficult to resolve with sparse node spacing.

Overall, the dataset demonstrates robust performance across the full cable length and highlights the potential of telecom DAS for geotechnical characterization, environmental monitoring, and future seismic imaging and monitoring applications, including integration with active-source surveys.

Gulf Coast Telecom DAS Performance

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