Imaging Seismic Attenuation across the Northern Los Angeles Basins with Dense Arrays

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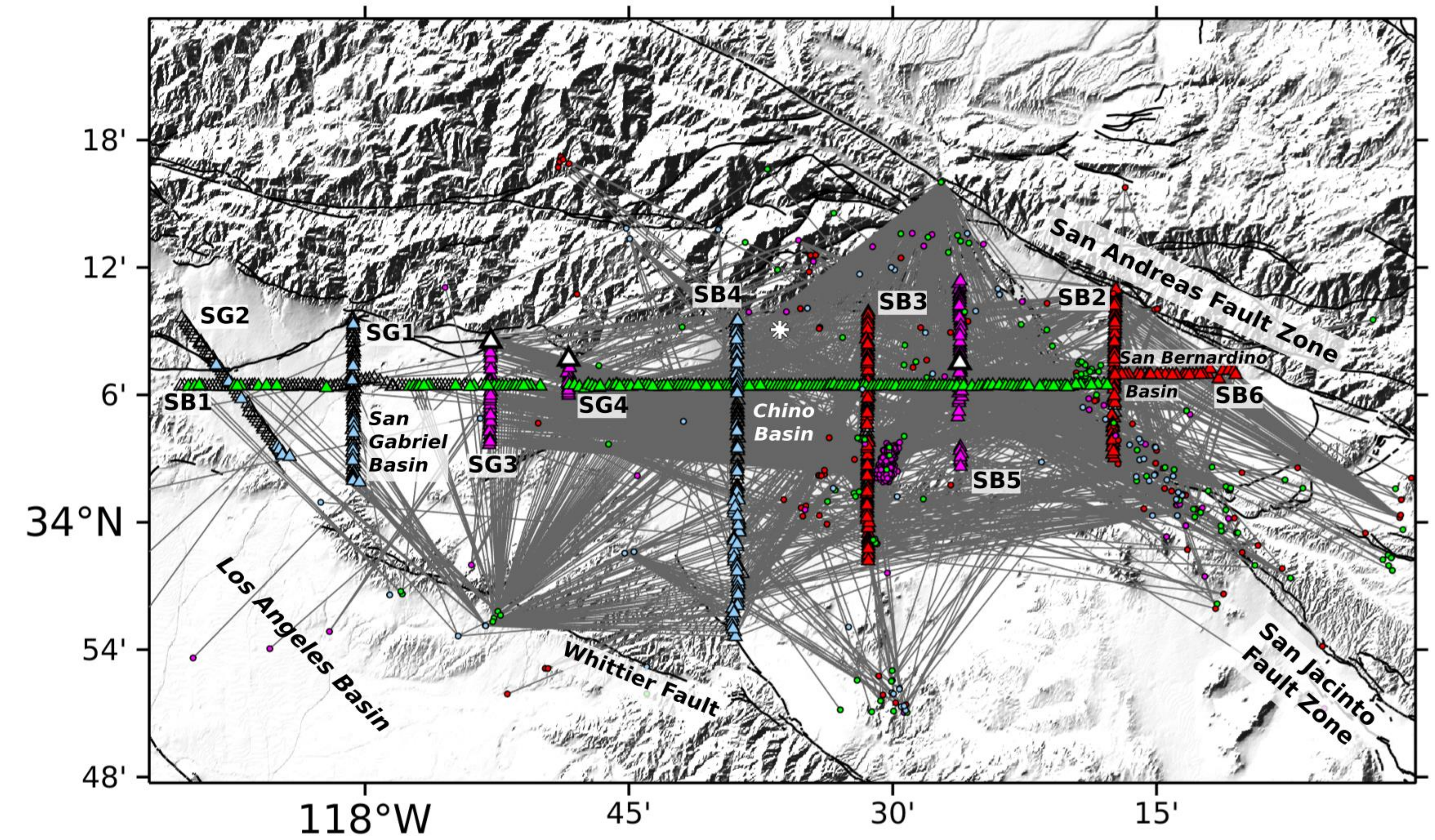
1. Introduction

- In high seismic hazard regions, an accurate attenuation model is critical for predicting site response and seismic wavefield amplitudes along the path. Fault zones and fine-scale crustal heterogeneities can be detected by combining seismic attenuation with velocity tomography.
- The northern basins of the Los Angeles area (San Gabriel, Chino, and San Bernardino basins) are characterized by complex fault networks and sedimentary layers that can focus and trap seismic energy from a large earthquake on the southern San Andreas fault.
- The SCEC CVM-H v15.1 and CVM-S 4.26 Earth models provide P and S wave velocities for Southern California but lack attenuation. As part of the Basin Amplification Seismic Investigation (BASIN) experiment, a 3D shear wave velocity model based on ambient noise cross-correlation (Li et al., 2022) and a 3D model of the basin depths that integrates gravity data (Villa et al., 2022) have been developed.
- What's next? Seismic attenuation tomography of the Southern California region comprising the San Gabriel, Chino, and San Bernardino basins.

2. BASIN dataset

- In the northern Los Angeles region, the BASIN experiment deployed 10 dense nodal arrays that each recorded continuously for ~30 days providing a dataset of >1500 local earthquakes.
- We have applied a signal-to-noise ratio selection criterion to the waveforms in the time window containing the P and S phases, and the coda.
- The epicentral distances are limited to <40 km because larger epicentral distances across sedimentary basins may cause wave reverberations that could bias the attenuation estimate.
- The final dataset (Fig. 1) comprises 20484 data: 1500 earthquakes of magnitude <3, recorded by 688 stations.



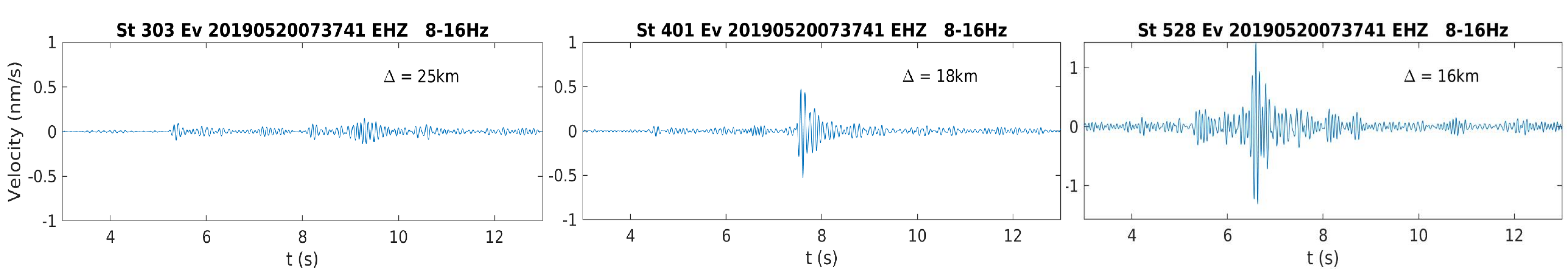


Figure 1. Top Panel: epicentral location of local earthquakes (colored dots) recorded by the BASIN seismic receivers (colored triangles) and the corresponding ray paths (grey lines). Bottom panels: earthquake (white asterisk in the map) recorded at three stations (white triangles) from the SG3, SG4, and SB5 seismic lines.

3. Seismic Attenuation

- The overall coda quality factor is given by:

$$Q_{tot}^{-1} = Q_{sc}^{-1} + Q_i^{-1}$$

where Q_{sc}^{-1} and Q_i^{-1} are the quality factors due to the scattering loss and the absorption, respectively.

- Scattering --> ***Peak Delay***: defined as the time lag between the maximum of the envelope and either the arrival time or the origin time of the event (Takahashi et al., 2007). It's a direct measurement of multiple forward scattering due to the presence of small-scale heterogeneities.
- Absorption --> ***Coda quality factor:*** Coda waves are the wave train following a crustal phase (e.g., a direct S wave). The Q_c method measures the decay of the envelope from a given lapse time relative to the event origin time.
- The analysis is performed in the frequency bands 2-4 Hz, 4-8 Hz, 8-16 Hz using MuRAT3D (De Siena et al., 2014; Reiss et al., 2022). Peak Delay and Q_c imaging are based on regionalization and inversion procedures, respectively.

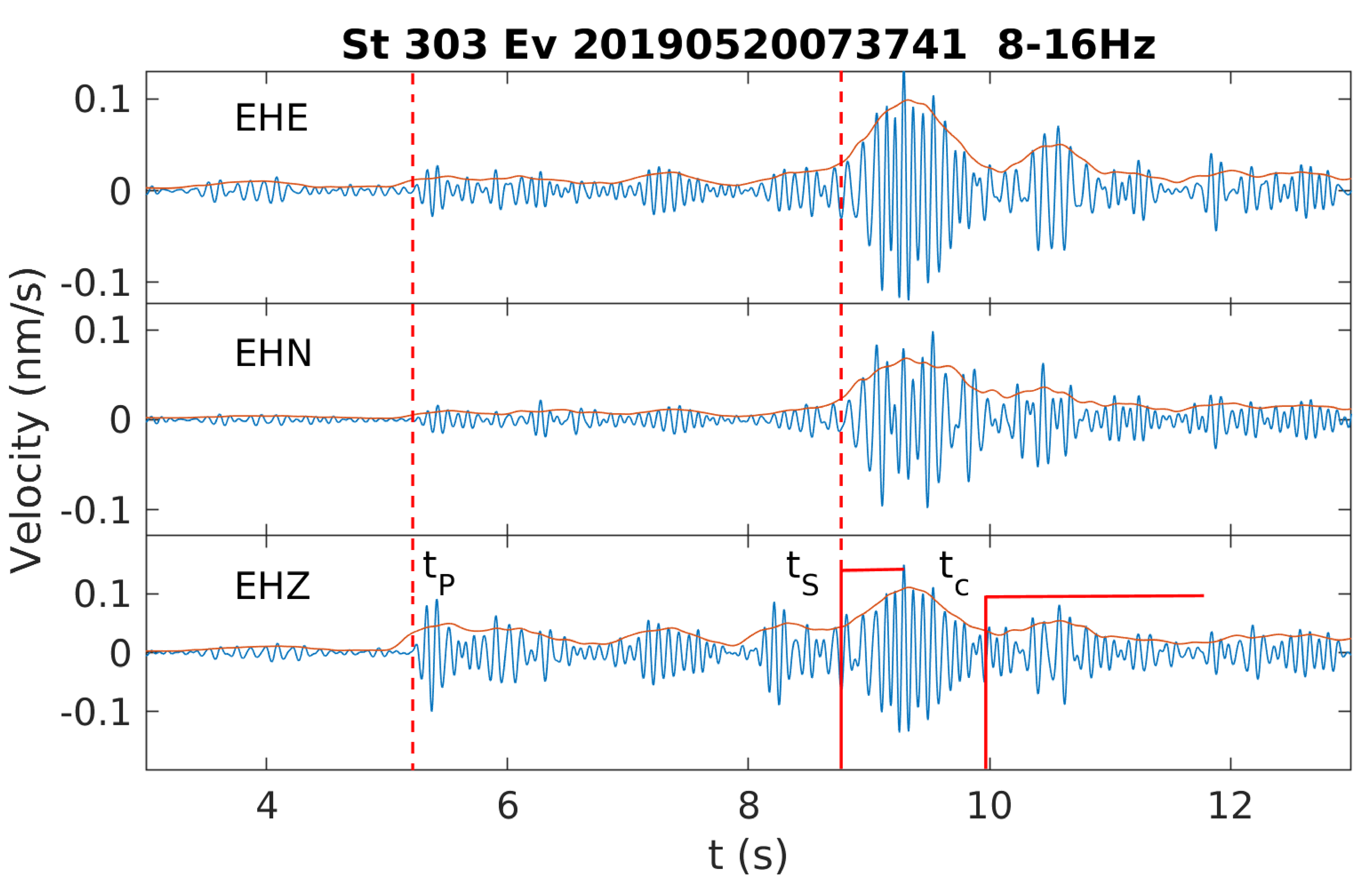


Figure 2. Examples of three component waveforms, filtered in the frequency band 8-16 Hz. t_P, t_S, t_c indicate the P and S phases, and the coda waves time window. The seismic envelope is shown for each component (orange line).

Summary

- Attenuation parameters (frequency and amplitude-dependent) have shown their potential in imaging material properties (e.g., fractures, fluids).
- Figure 1 shows our initial dataset for applying attenuation tomography as described in Section 3. The waveforms were selected based on event-station distance and a signal-to-noise selection criterion.
- We present the method for the estimation of the scattering parameter and the intrinsic attenuation.
- Applying attenuation tomography in this region is crucial for improving ground motion predictions from a large earthquake rupture on the southern San Andreas fault.

References

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Acknowledgments

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