Decrease in High-Frequency Background Seismic Noise after the COVID-19 Lockdown at a Suburban Site Outside Washington DC

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Abstract

The global slowdown in human activity brought on by the COVID-19 virus in early 2020 has resulted in a measurable decrease in high-frequency background seismic noise at many sites around the world (Lecocq et al., 2020). We measure and interpret this decrease in noise at a Raspberry Shake station (RAC22) outside Washington DC. We processed the vertical channel data starting January 1, 2020 by bandpass filtering in the primary noise band of 6-18 Hz, and computing the signal envelopes using Gaussian smoothing windows of widths 15 minutes and 4 hours. The resulting envelopes show the diurnal cycles of human activity, the decrease in levels on weekends and holidays, and the overall decrease after the March 15 lockdown. We compare these measurements with non-seismic measurements of human activity and use a model of traffic noise from nearby roads to identify the likely noise source.

Station RAC22, 28 km W of DC

RAC22 is located ~26 km west of Washington DC. The site is 1.7 km north of a major highway, RT 66. Pre-shutdown weekday signal velocity peaks were ~0.4 µmeters/s with additional peaks of 0.5 µmeters/s during the morning and evening rush hours. After the March 15 shutdown, weekday peaks decreased to ~0.2 µmeters/s with no apparent rush hour peaks, a decrease of ~50%. Nighttime lows before and after the shutdown are both ~0.05 µmeters/s. Acoustic measurements at RAC22 show a post lockdown

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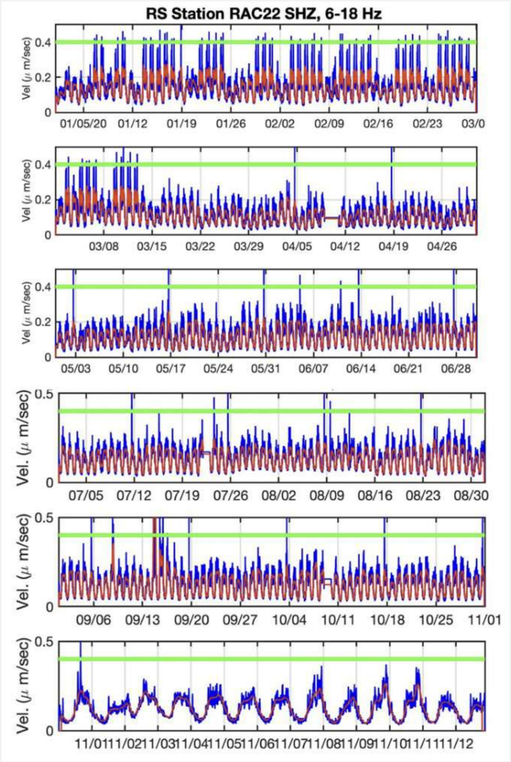
Observations



Blue curve is 15-minute Gaussian smoothing filter, red curve is 4-hour filter. 50% decrease in background seismic noise after the March 15 lockdown. Noise has remained low to this day.

Rush Hours, Before and After Lockdown

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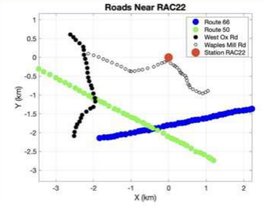
Mobility Data and Traffic Modeling

Apple Mobility Index shows a 50% decrease in traffic after March 15 but a recovery to the baseline after early June. This metric does not correlate well with the seismic data. Using a statistical traffic model based on average vehicle size, speed, the number of road lanes, digitized tracks for four roads, and a simple propagation model (1/sqrt(R), vel 2.5 km/s, f = 10 Hz, Q = 20), we conclude that RT 66 is the primary source of the ambient noise at RAC22. Back propagating 0.4 µmeters/s level to the highway, we estimate a source level of 2 µmeters/s, typical for mid to large size trucks.

Apple Mobility Data for Fairfax County

Deciphering Local Traffic Noise



- Source levels (SL) for a given road proportional to average vehicle weight/size, average speed squared, and number of lanes, mix of large vs small vehicles
  - *Route 66, 8 lanes, 60 MPH*
  - *Route 50, 6 lanes, 50 MPH*
  - *West Ox Road, 4 lanes, 40 MPH*
  - *Waples Mill Road, 2 lanes, 30 MPH*
- Received level ~ SL x $D^{-1/2}$ x $e^{-\omega D/v/(2Q)}$
- freq = 10 Hz, Q = 25, V = 2.5 km/sec

Estimated Signal Levels at RAC22

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Summary and Next Steps

Why is it Important to Understand Seismic Noise?

- We try to install seismic stations in quiet areas, but as station density increases we have to utilize noisy sites
- Seismic stations in noisy locations can still be used for important studies, like site amplification, as well as identifying station noise characteristics so that the data from these sites can be properly filtered and used in earthquake monitoring.
- Seismic stations in noisy schools still serve an important educational function, as well as providing station density in urban areas.
- The time history of the noise helps us disambiguate noise sources.
- Understanding noise sources can help us interpret noise tomography.
- Seismic noise monitoring is more site specific than cellular phone activity monitoring.
- Enables passive situational awareness.

Specific Findings

- After the March 15 local lockdown, day time background noise in the band 6-18 Hz decreased by 50%
- Nighttime noise levels did not change
- Temporal variations in noise correlating with rush hours point to traffic noise as the source
- Modeling based on road locations and traffic volumes point to Route 66 as the primary source, at a distance of 1.7 km
- Apple Mobility Index for the area dropped after the lockdown but has returned to baseline, contrary to noise measurements.

Next Steps

- Correlate ground truth with seismic data using a web cam and traffic counter.
- Obtain traffic volume data from the county.