Supplemental Material for

Seismic noise recorded by telecommunication fiber optics reveal the impact of COVID-19 measures on human activities

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This Supplemental Material contains text including (1) the calculation of the seismic noise changes and (2) the details of Google mobility data we used (Text S2). Figure S1 and S2 provide two more results of temporal seismic noise changes at different locations (Ch 204 and Ch 1491).

Supplemental Text:

Text S1-S2

Supplemental Figures:

Figure S1: Noise changes at Ch 204 in the frequency range of 0.01-1 Hz, 1-10 Hz, 10-50 Hz and 50-100 Hz.

Figure S2: Noise changes at Ch 1491 in the frequency range of 0.01-1 Hz, 1-10 Hz, 10-50 Hz and 50-100 Hz.

Text S1. Calculation of the RMS noise level

To quantify seismic noise in different frequency bands, we calculated the noise power spectral density (PSD) in each 5-minute window using McNamara's method (McNamara, 2004). We first detrend the raw data and convert raw DAS measurements to strain rate (nanostrain/s) by multiplying a scaling factor of 11.6 (nanostrain/radian) (Zhu et al., 2021). We then computed spectrograms, $A(f)$, by discrete Fourier transform. The PSD estimate, $P(f)$ is the square of the spectrogram with a normalization factor:

$$\boldsymbol{P(f) = \frac{2\Delta t}{N}|A(f)|^2}, \tag{1}$$

where Δt is the sampling interval (0.004 sec) and N is the number of data samples in each time series segments. The PSD estimates for each hour were obtained by averaging 12 segment PSDs. In this way, for each hour, we got a PSD estimate at each channel.

Then we calculated the RMS (root-mean-square) strain rate e_{rms} to represent the noise power by taking the square-root of the integral of the power spectrum over four interested frequency bands, 0.1-1Hz, 1-10 Hz, 10-50 Hz and 50-100 Hz:

$$\boldsymbol{e_{rms} = \sqrt{\int_{f_{min}}^{f_{max}} P(f)df}}, \tag{2}$$

Then the time-lapse noise change is defined as follows:

$$\boldsymbol{N_{TL} = \frac{e_{rms} - e_{rms}^{baseline}}{e_{rms}^{baseline}} \times 100}\%. \tag{3}$$

The baseline noise level $e_{rms}^{baseline}$ as the reference is selected in the time period of 8 am to 6 pm and is averaged over a week of the spring semester (February 3-7, 2020).

Text S2. Mobility Data

The mobility data we used are from Community mobility reports in Centre County, PA, released by Google (Google, 2020). The reports chart daily percentage changes of visits by geography, across different categories of places such as retail and recreation, groceries and pharmacies, parks, transit stations, workplaces, and residential. The baseline is the median value during Jan 3-Feb 6, 2020. For a college town like State College, the most common social activities are school activities and transportation. In our study, we pick out “transit stations” category (Mobility trends for places like public transport hubs such as subway, bus, and train stations) as Transport and “workplaces” (Mobility trends for places of work) category as Workplaces.

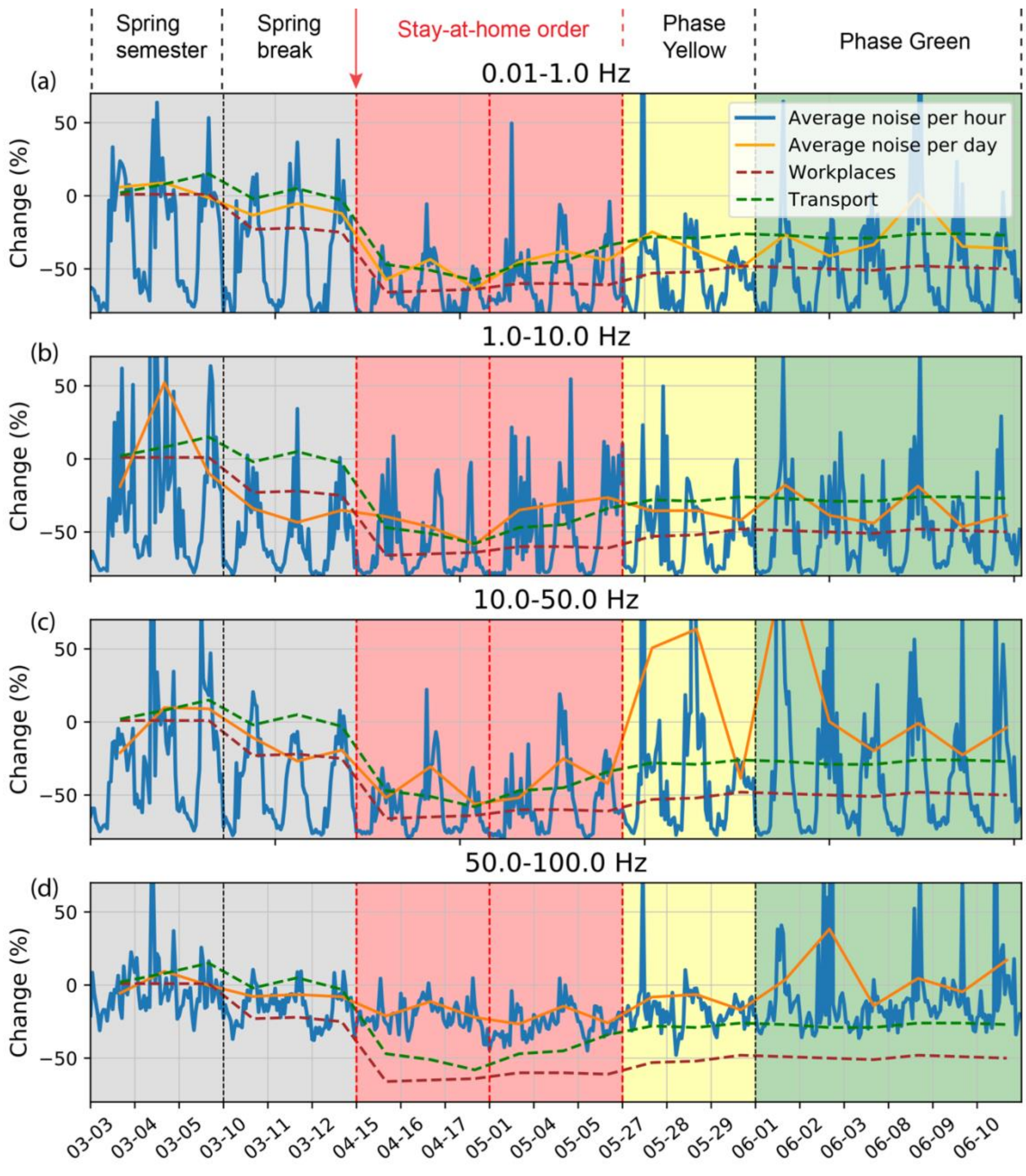

Figure S1. Noise changes at Ch 204 in the frequency range of (a) 0.01-1 Hz, (b) 1-10 Hz, (c) 10-50 Hz and (d) 50-100 Hz. The daily average noise change (orange) as well as the mobility data provided by Google (dashed line) are plotted

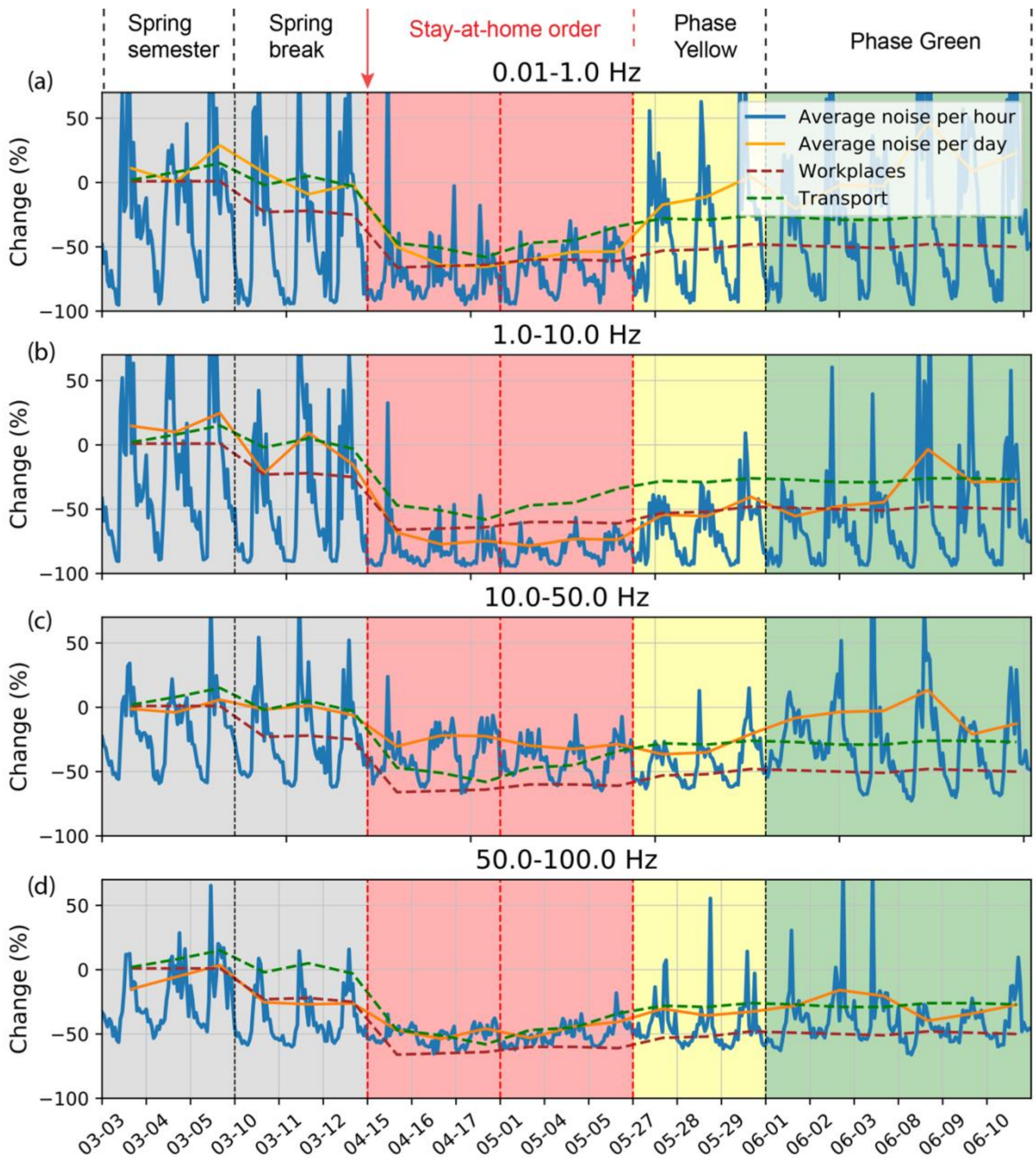

Figure S2. Noise changes at Ch 1491 in the frequency range of (a) 0.01-1 Hz, (b) 1-10 Hz, (c) 10-50 Hz and (d) 50-100 Hz. The daily average noise change (orange) as well as the mobility data provided by Google (dashed line) are plotted

References From the Supplemental Material

McNamara, D. E. (2004). Ambient Noise Levels in the Continental United States. *Bulletin of the Seismological Society of America*, 94(4), 1517–1527. https://doi.org/10.1785/012003001

Google (2020). COVID-19 Community Mobility Reports. Available at: https://www.google.com/covid19/mobility/ (accessed: 25 September 2020).

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