

Seismic noise reduction in MeSO-net during COVID-19 pandemic

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Japanese society has been forced to change due to COVID-19 pandemic started in 2020. Japanese people were requested to stay home when the state of emergency was declared in April 2020. The number of commuters was decreased by introducing remote working. Such changes in social activities have been visualized through location information of smartphones. We report that seismic noise at high frequency (>1 Hz) in Metropolitan Seismic Observation network (MeSO-net) also records social activity changes due to COVID-19.

It has been known that seismic stations record noise generated by social activities at frequency higher than 1 Hz. The noise level is usually higher on weekdays than on weekends, on daytime than on night, which corresponds to social activeness. The noise level becomes lower during long holidays, such as new-year holidays, which also corresponds to social activeness. However, we have not had opportunities to compare seismic noise level with any quantitative indexes of social activities. This study compares seismic noise level with population data around train stations, which is published during COVID-19 pandemic as an opportunity.

The seismic noise level varies temporally at several timings. Its first small drop was occurred at the beginning of March, which corresponds to when schools were shut down. A larger drop was recorded when the Governors of the Tokyo metropolitan area requested citizens to stay home (the end of March 2020) and when the state of emergency was declared for the Tokyo metropolitan area by the government (8th April 2020). The noise reduction reached 10-20% at most in many stations. On the middle of May 2020, the noise level in turn started to increase, which occurred before the state of emergency was lifted on the end of May. The noise level recovered to that of normal years in June at many stations, though the noise level at some stations (especially at central Tokyo) are kept at ~5 % lower than that of normal years. The state of emergency was declared again on 8th Jan 2021, though seismic noise level just shows a slight drop.

The observed temporal changes in seismic noise level are correlated with social activeness visualized through the location information of smartphones. We refer population data around train stations published by Agoop corp. According to their data, population drops occurred at the same timing when seismic noise level reduction occurred. Population recovery at the middle of May also corresponds to seismic noise-level recovery. On the other hand, there are also several inconsistencies between population data and the seismic noise level. For example, population after the state of emergency in 2020 was lifted did not recover to that before COVID-19 pandemic started, though seismic noise level was recovered at many stations. Population after new-year holiday is fewer than that before the holiday, though the seismic noise level just shows a slight decrease. These observations suggest that, although the primary noise source at high frequency is social activities, the population data does not directly reflect activeness of seismic noise source.

Seismic noise source is considered to be mobility such as cars and trains and machine vibrations in buildings and factories. However, we do not understand how they actually contribute to the observed

seismic noise. There should be various indexes for social activities other than the population data we referred in this study. Data mining with such various indexes will enables us to develop a social monitoring method through seismic data.

Keywords: Seismic noise, COVID-19, Social activity