The impact of the COVID-19 lockdown measures on the seismic monitoring in the Bucharest (Romania) metropolitan area

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Introduction

Above 1 Hz, the seismic noise is mainly generated by different human and industrial activities presenting a pronounced variability between daytime and nighttime as well as between working-days and weekends. The year 2020 has witnessed an unprecedented disruption in anthropic activities in many cities around the globe caused by the 2019 coronavirus disease (COVID-19) and having a direct effect on seismic noise recorded by seismic stations (Figure 1, Figure 2 and Figure 3).

It all started with a tweet!

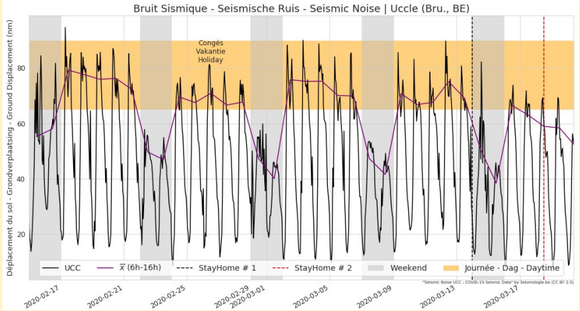

Figure 1. Ground displacement (in nm) at station UCCLE in Brussels, Belgium. The seismic noise reduction is observed after the 1st Stay-at-Home order and is becoming more pronounced after the 2nd Stay-at-Home order (Twitter, @Seismologie_be)

A large community of seismologists around the world started to analyse data from seismic stations in their countries (Figure 2).

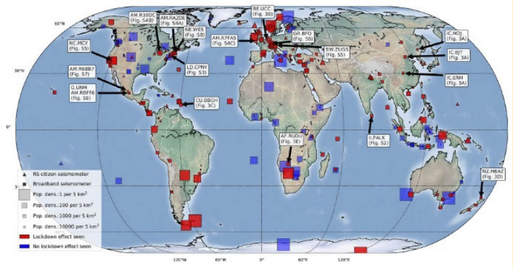

Figure 2. Lockdown effects observed at seismic stations around the globe. Symbol size is scaled by the inverse of population density (after Lecocq et al., 2020a, Science).

From global to local scale

Data and Method

To study the seismic noise variations, we analyse the continuous recordings from the vertical component of accelerometer sensors of the stations (**21**) within the Bucharest metropolitan area (Figure 3) that cover the time period from March 4, 2019 to September 27, 2020. We used the **displacement root-mean-square (DRMS)** in the frequency domain of interest.

Results

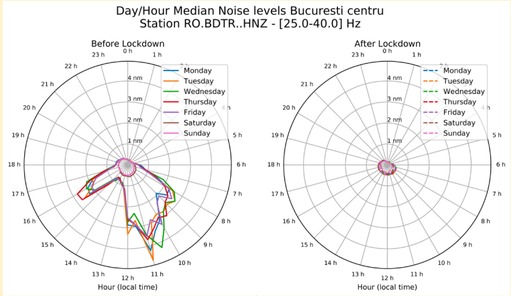

Figure 5. 24-hour clock plots showing average displacement variation for each day of the week and for the period before and during lockdown at station BDTR.

Station **BDTR** is located in a kindergarten in Bucharest. The seismic noise level dropped after the lockdown **80%** in the frequency band **25-40 Hz** (Figure 5).

Station **BSTR** is sited downtown Bucharest in one of the busiest areas of the city. The seismic noise level dropped after the lockdown **18%** in the frequency band **2-8 Hz** (Figure 4).

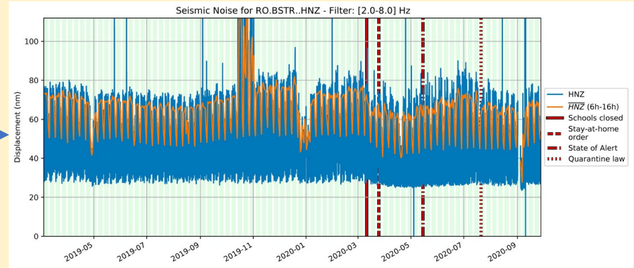

Figure 4. Lockdown effects on seismic noise at station BSTR - evolution of DRMS for the March 2019 - September 2020 period based on displacement data in the band 2-8 Hz.

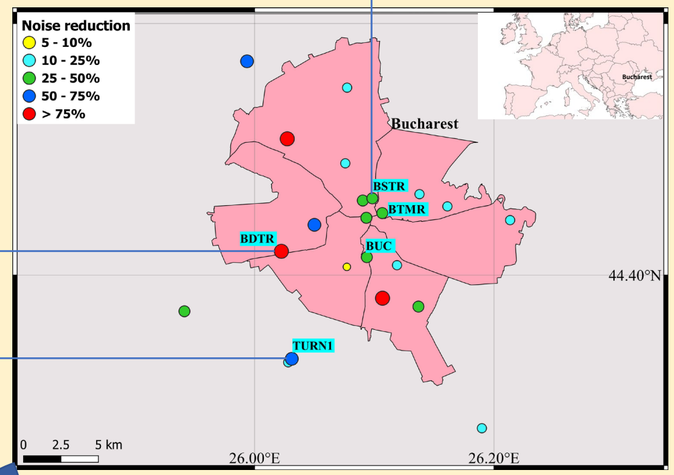

Figure 3. Percent change in DRMS at stations in Bucharest during the period March 25-April 23, 2020 (right after the stay-at-home order entered into force) with respect to the interval February 10 - March 10, 2020.

The comparison between noise time series and community mobility data provided by Google and Apple shows rather good similarities between the two data sets, indicating that the changes in seismic noise can be used to track the human activity in urban areas (Figure 7).

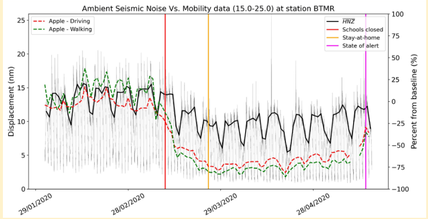

Figure 7. Changes in DRMS at station BTMR compared to Apple's mobility data.

Station **TURN3** is deployed on the 10th floor of the Institute of Atomic Physics building in Magurele, a city close to Bucharest. The seismic noise level dropped after the lockdown **62%** in the frequency **band 25-40 Hz** (Figure 6).

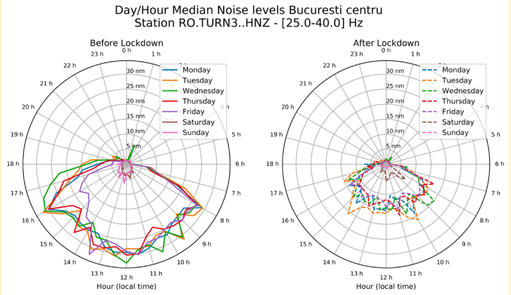

Figure 6. Lockdown effects shown on 24-hour clock plots at the station TURN3 for the frequency bands 25-40 Hz

The noise reduction caused by the measures taken to mitigate the COVID-19 pandemic can influence the seismic monitoring of local events, by improving the detection capability of stations in noisy urban environments (Figure 8).

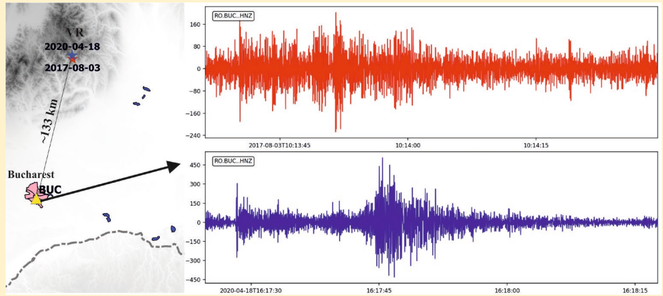

Figure 8. Illustration of the increased earthquake detection capability at station BUC in Bucharest: (left) - map showing the epicenter locations of two intermediate-depth Vrancea earthquakes (2017-08-03, ML=3.8, H=117 km - red star and 2020-04-18, ML=3.8, H=118 km - blue star) and the location of the accelerometer (BUC); (right) - waveforms recorded by the BUC station (red trace for the event before the lockdown and blue trace for the event within the lockdown)

The results have been submitted for publication to Solid Earth.

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