Listening to Manchester: using Raspberry Shake seismometers in urban environments to monitor traffic

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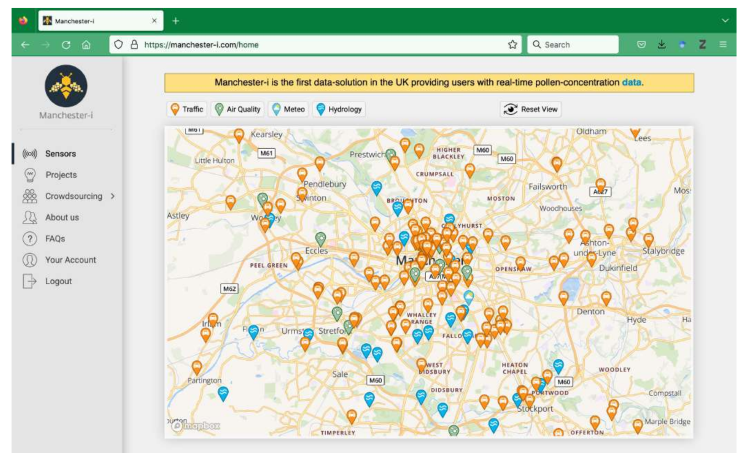
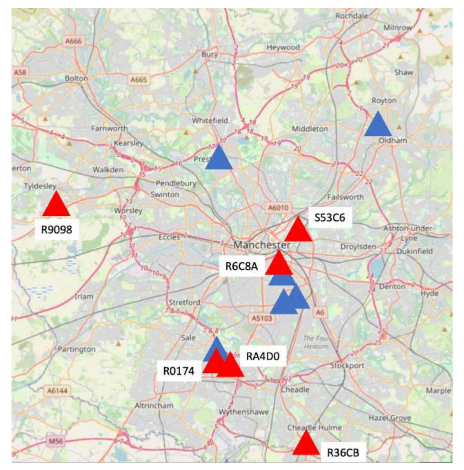
Listen to Manchester

Context

Why Manchester? Why Raspberry Shakes?





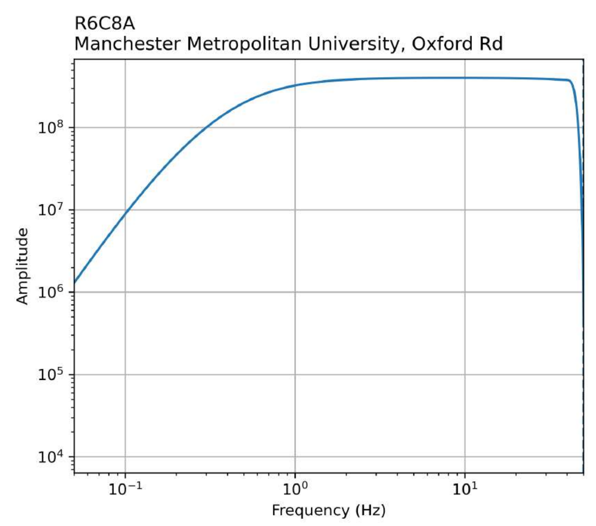
Greater Manchester extends over 1000 km² and is home to nearly 3 million people.

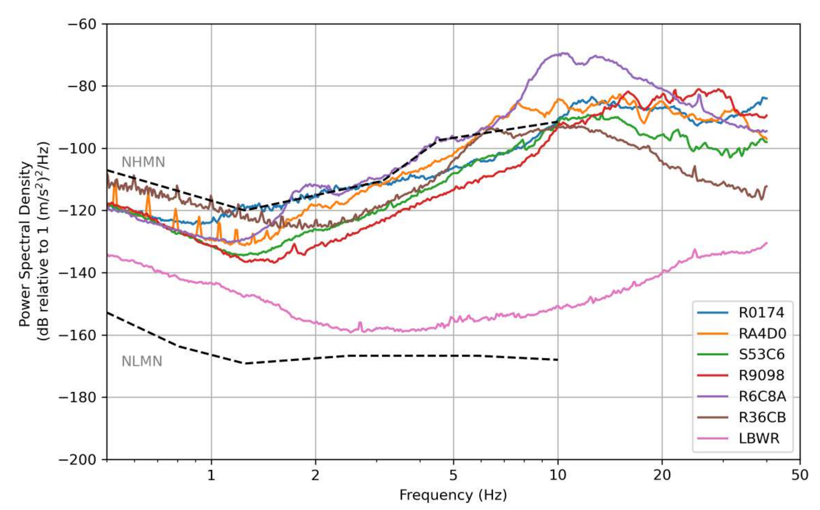
The Manchester Urban Observatory runs the manchester-i network of sensors for traffic, air quality and hydrology – all with publicly available data.

Prior to the Listen to Manchester project, there were no citizen science Raspberry Shake seismometers in the area.

The frequency response of Raspberry Shake seismometers is skewed towards the high end (> 0.5 Hertz).

This can be problematic for earthquake seismology, but most ambient – i.e., **anthropogenic** – 'noise' is in the range 1 to 40 Hertz.



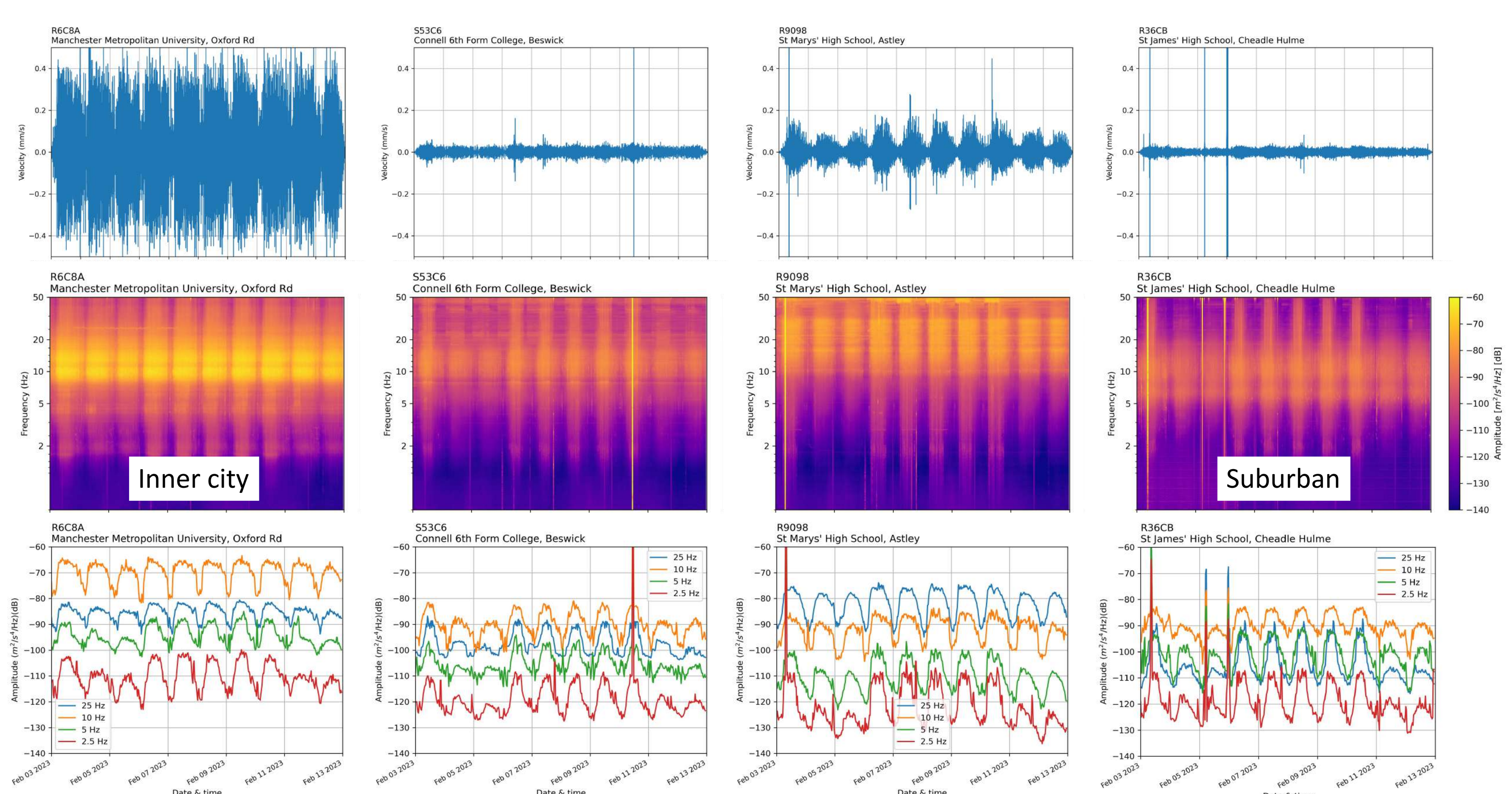


Target audience: School pupils & teachers

Time series, waves & vibrations, and Python coding

Data from the installed network of Raspberry Shakes is being used in primary and secondary schools to help teach Physics, Maths, Geography and Coding.

Data from different locations provide stark contrasts in anthropogenic 'noise' (signal!) in the frequency range 1 to 40 Hertz.



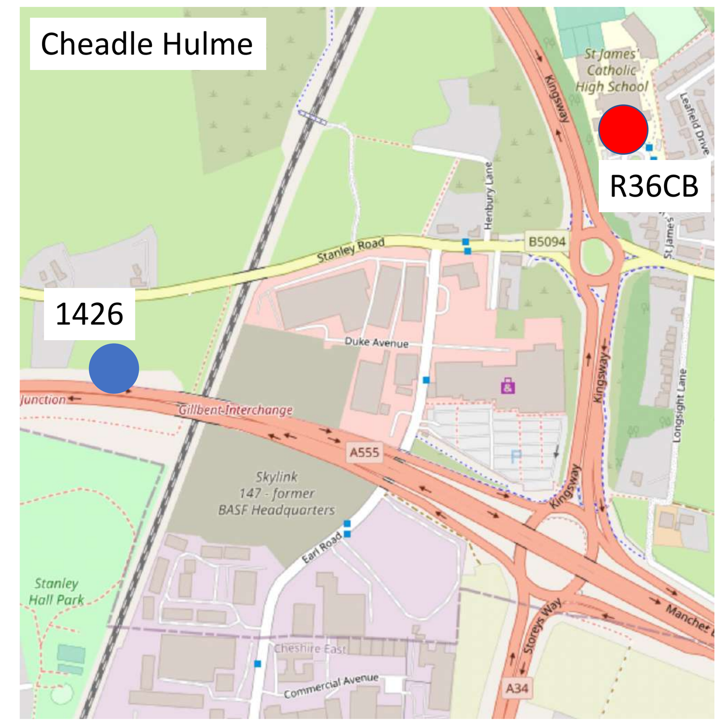
Classroom exercises involve the use of seismograms (with high-pass filters, top), spectrograms of power (middle), and selected frequencies of power amplitude (bottom).

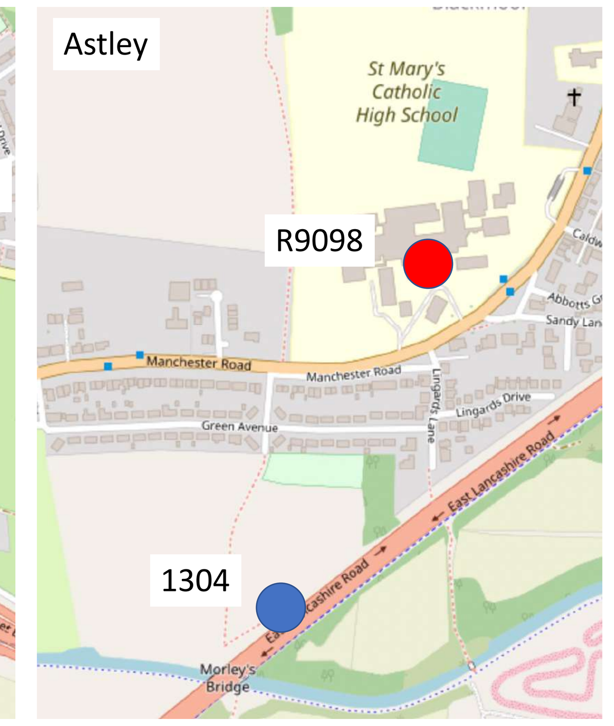
By providing a mixture of local data relevant to the area around the school, and data from other sites across the city, the students benefit by comparing vibrations measured on the same set of instruments.

Diurnal patterns over periods of weeks can be compared from urban to suburban locations, and on a shorter timescale, crowd responses at individual football matches can be studied (cf. Diaz, 2016; Denton et al., 2018).

Target audience: Local authority (GMCA)

Traffic camera count comparisons with seismometers

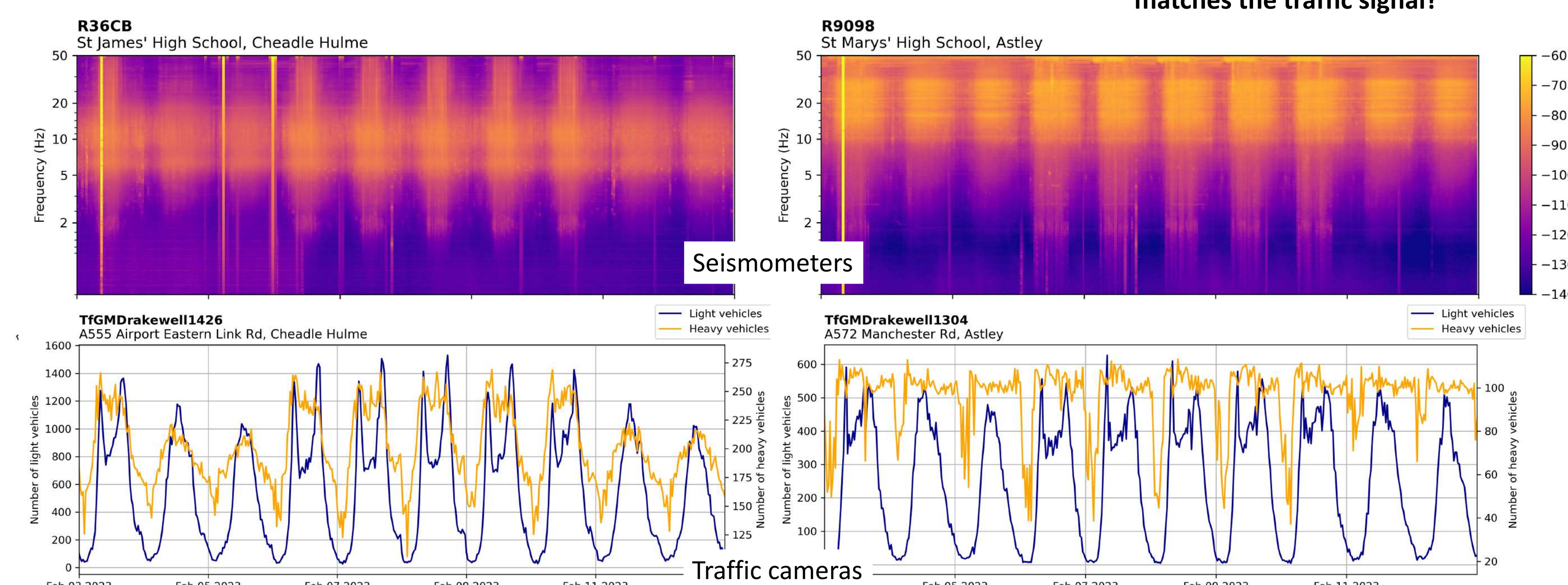




Co-location of Raspberry Shake seismometers (red dots) close to existing traffic cameras (blue) enables detailed comparisons of time series.

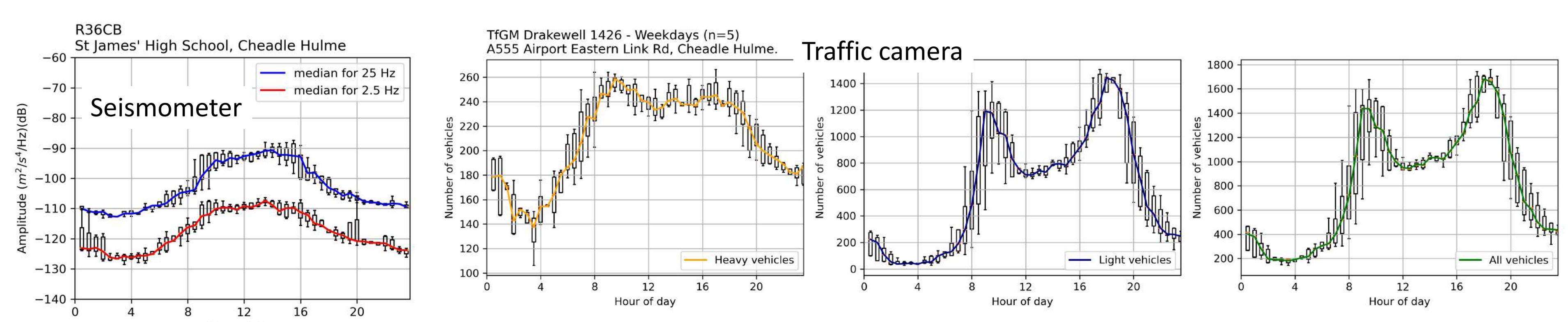
Transport for Greater Manchester (TfGM) Drakewell cameras operate 24/7, sampling at 5-minute intervals, and can identify different vehicle types: i.e., cars, small vans, lorries, buses etc.

Q: Can we use cost-effective seismometers to quantify the traffic load? Which part of the frequency spectrum most closely matches the traffic signal?

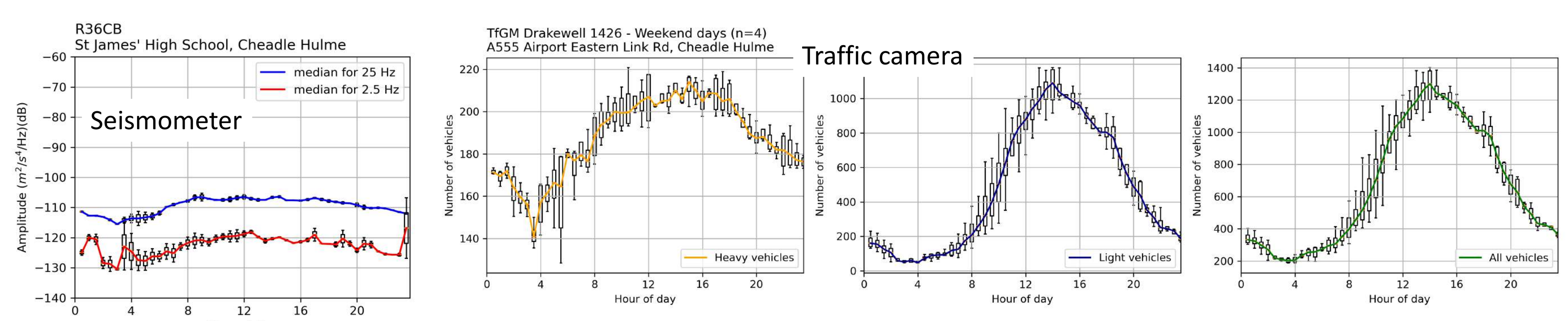


Diurnal variations in the seismometer response are clearly mirrored in the traffic camera time series data. Note the distinct daily patterns for light (cars & vans) versus heavy vehicles (lorries, buses) in the camera data. Light vehicles show clear morning and afternoon 'rush hours', but these are not so clear for heavy vehicles. Weekends are also distinct from weekdays, with changes in overall amplitude and 'shape' over a 24 hour period.

Following Green et al. (2018), we can examine the statistical variations in amplitude over 24 hours – with separate plots for weekdays and weekends + Bank Holidays. Examples from Cheadle Hulme are shown below.

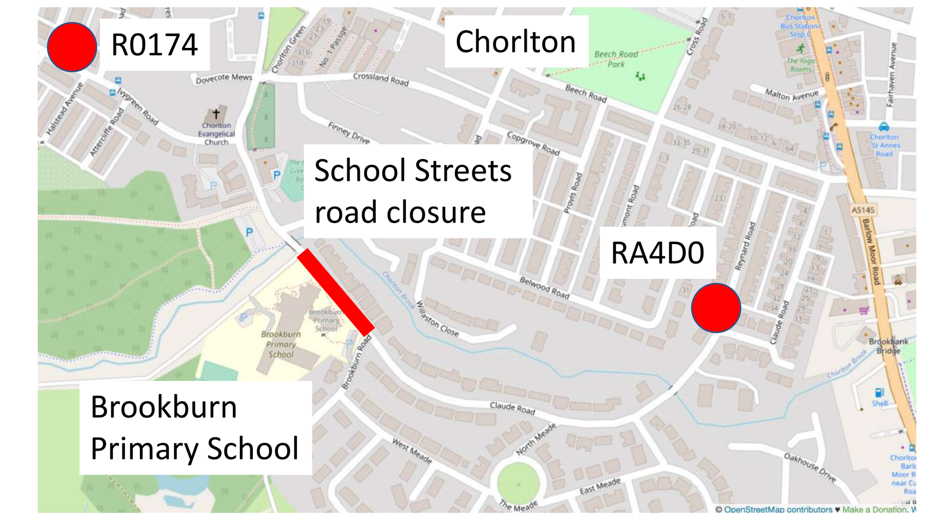


For weekdays, the distinct rush hour peaks observed in the traffic camera time series data are not apparent in the seismometer response, at either 25 or 2.5 Hertz. However, the broad plateau of the heavy vehicle camera counts between 08:00-19:00 is closer to the shape of the seismometer response. For weekends, traffic camera counts and seismometer power amplitudes are consistently lower. The seismometer response at 2.5 Hertz more closely matches the heavy vehicle variation.



Target audience: Residents & parents

School Streets closures to promote active travel

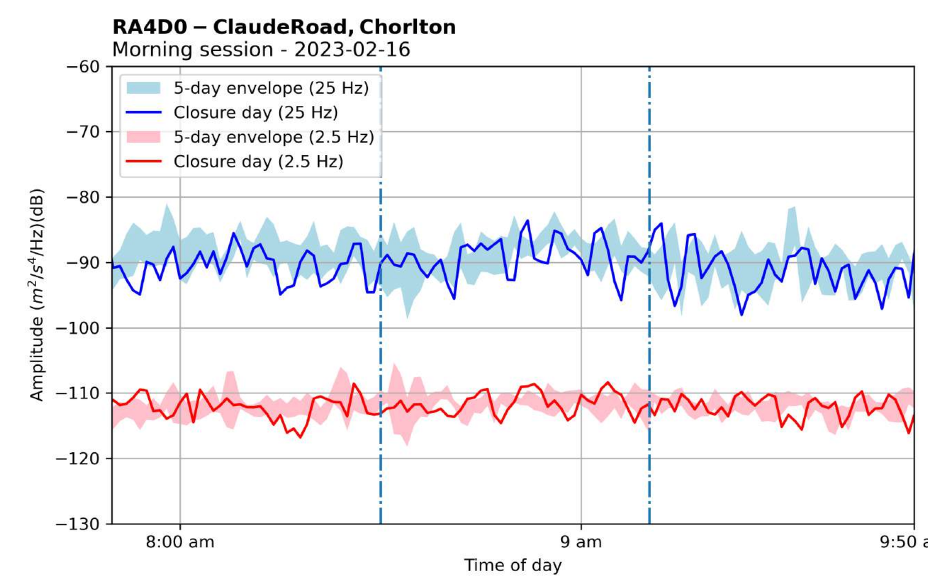


Greater Manchester Combined Authority and local councils have started School Street pilot projects, including one in Chorlton. The road outside Brookburn Primary School is closed twice a day (8:30-9:10 and 15:10-15:50) to reduce vehicle traffic and promote active travel to/from school.

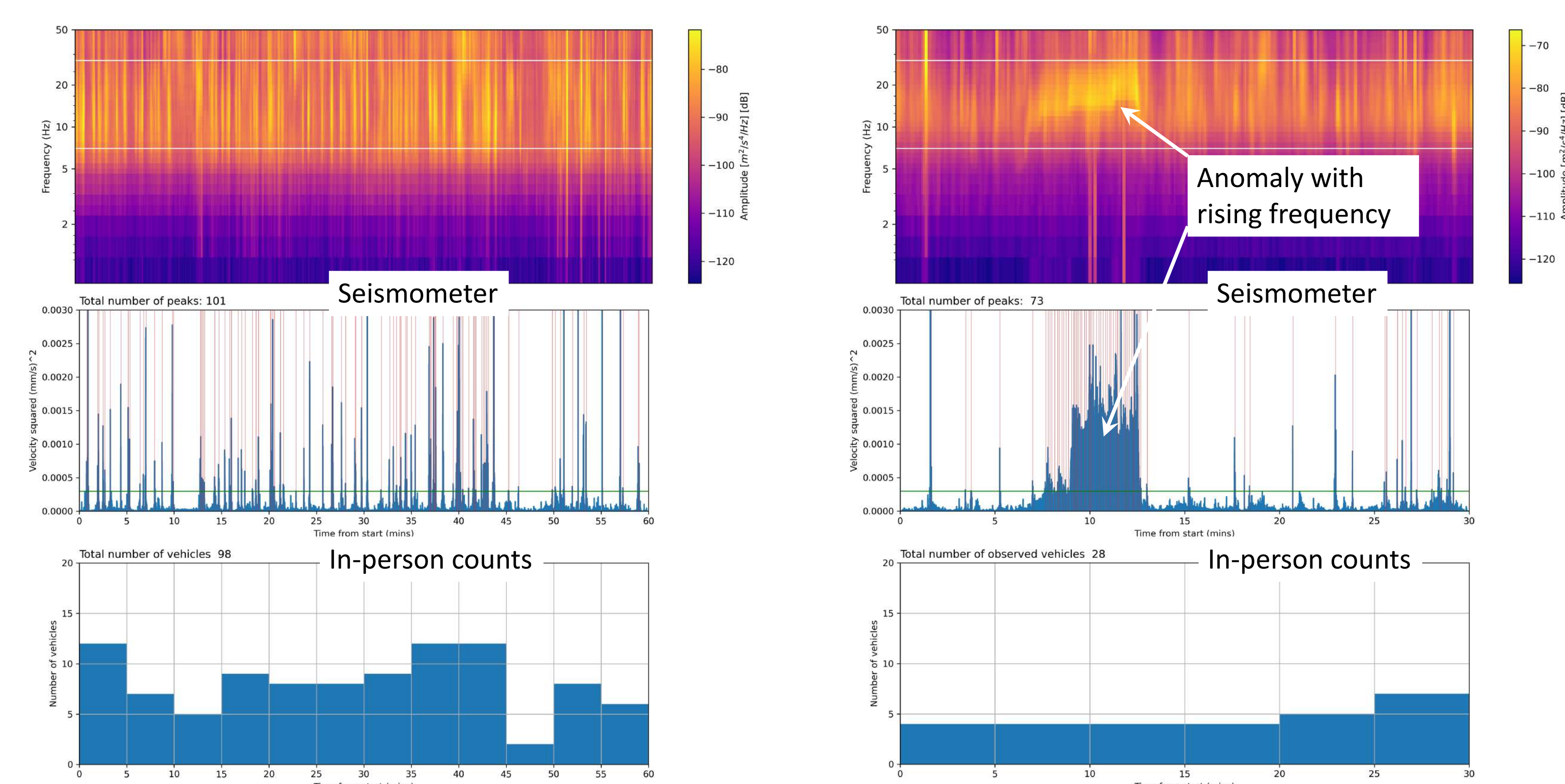
Some residents were concerned that closures would displace traffic elsewhere, so in the absence of any traffic cameras 2 seismometers were installed at each end of the street.

We compare power amplitudes for a 5-day period with no road closures to the signal recorded on the day of each closure, at two selected frequencies (25 and 2.5 Hertz).

To date (after 6 road closure days), there have been no increases in 'noise' recorded by the seismometers, and we infer that traffic is not increasing at the limits of the closed road.



Before the pilot project began, we compared the seismometer response over 30-60 minute intervals to in-person traffic counts performed by volunteer parents. The correlation is good and the peaks in spectrogram correlate clearly with the counts. Local anomalies due to domestic appliances (e.g., washing machines?) can contaminate the seismometer data.



Summary

Findings so far…

Around Manchester, nearly one third of CO_2 emissions are from transport (BEIS, 2020), and air quality near roads (NO_2 and PM2.5) is also known to be poor (DEFRA, 2017; TfGM, 2016). Monitoring traffic in this region is both useful and urgent.

By using geophysical instruments (i.e., citizen science Raspberry Shake seismometers), the **Listen to Manchester** project has shown how methods from solid earth science such as signal processing, time series analysis, and general seismology can be applied to topical issues in environmental science.

By demonstrating these links to different groups in the Greater Manchester area, **Listen to Manchester** is highlighting the positive contributions by geoscientists in tackling the climate emergency and the energy transition. The ubiquity of open data and open source code builds public confidence in the analyses, from school students, to local authorities and residents.

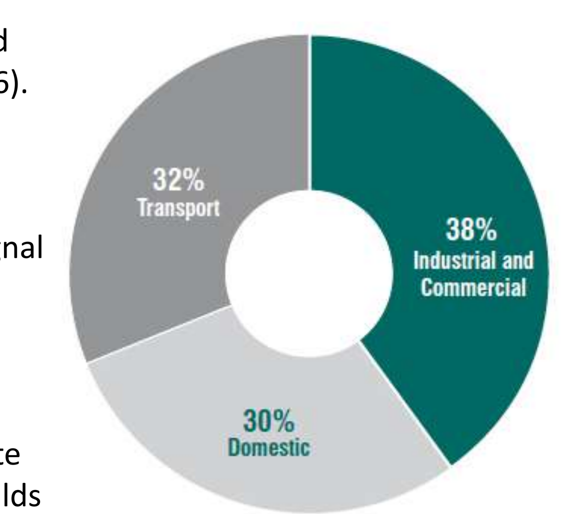


Figure 1: Manchester Emissions by sector 2018. BEIS 2020 Local Authority and Regional CO_2 Statistics