

# The Silence of Canadian Cities

## The Seismology Impact of the Covid19 Lockdown



S004: Social Seismology: The Effect of COVID-19 Lockdown Measures on Global Seismic Noise I

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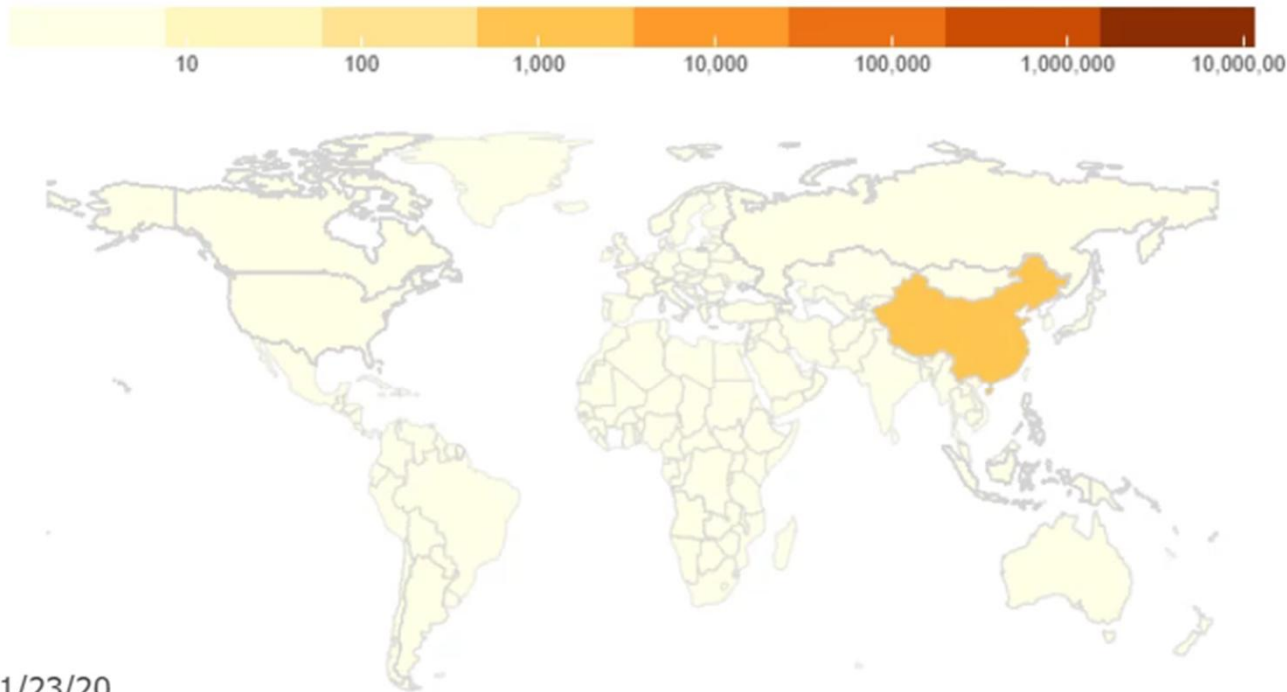
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**AGU FALL MEETING**

Online Everywhere | 1-17 December 2020

# Spread of COVID19 Cases Across the World



**First Canadian Case:**  
**25 January 2020**

**First Community Transmission Case  
in Canada:**  
**5 March 2020**

# Canada: COVID 19 Lockdown Timeline

**11 March 2020:**

**WHO declares COVID19 as a pandemic**



**13 March 2020:**

*Quebec*



**17 March 2020:**

*Alberta, Ontario, Prince Edward Island, Yukon*



**18 March 2020:**

*British Columbia, Saskatchewan, Newfoundland and Labrador, North West Territories, Nunavut*

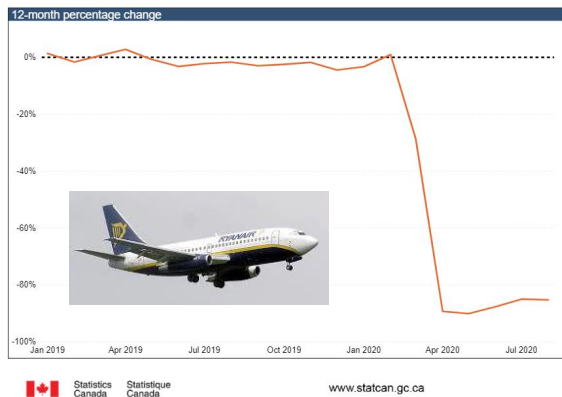


**Canada - US border closed**

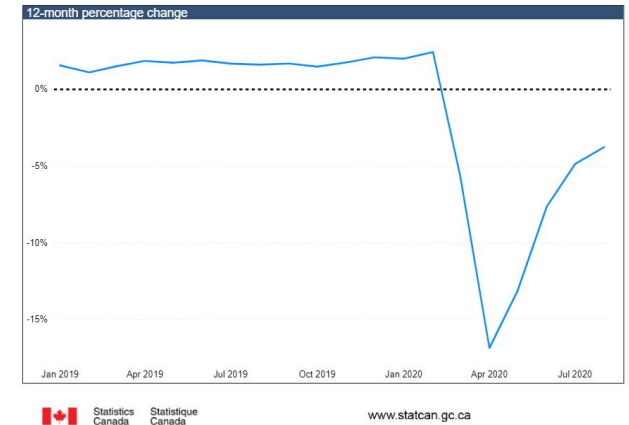


# Canada: Socio-Economic Impact of COVID 19

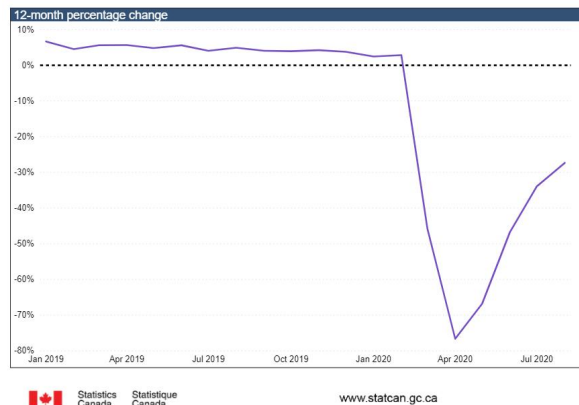
## Transportation Air Travel



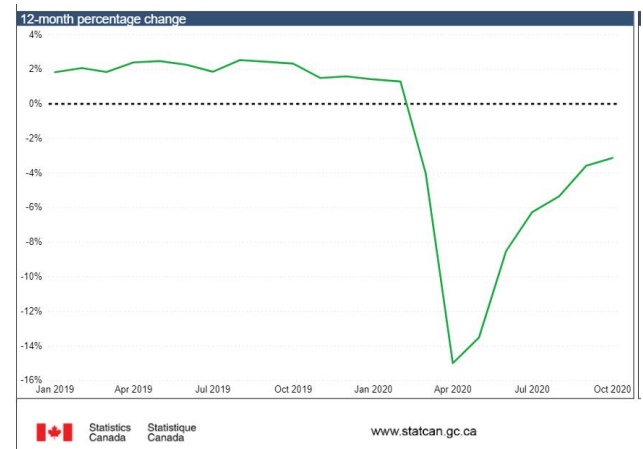
## Gross Domestic Product



## Employment



## Entertainment Restaurants



Source: Statistics Canada. <https://www.statcan.gc.ca/>

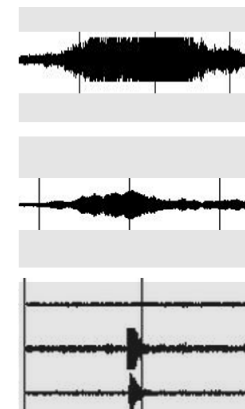
# Goal: Measure the Impact of COVID 19 Lockdown on Seismic Vibrations in Canada

## Seismic Vibrations Near Cities

- Before Lockdown (*pre 11 March 2020*)
- During Lockdown (*post 11 March 2020*)

## Seismic Vibrations

- Near Cities
- Away from Cities



• Train Signal

• Cruise Ship Signal

• Mining / Explosion

# Canadian National Seismograph Network

- Network of over 200 seismographs
- Operated by the Natural Resources Canada and Universities Network



*Seismographs operated by Natural Resources Canada*

Source: Natural Resources Canada Website

[https://earthquakescanada.nrcan.gc.ca/pprs-pprp/pubs/GF-GI/GEOFACT\\_SeismographsInCanada.pdf](https://earthquakescanada.nrcan.gc.ca/pprs-pprp/pubs/GF-GI/GEOFACT_SeismographsInCanada.pdf)

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# Selection Criteria for Seismic Stations

1. **Proximity:** be located within 60 kms of a city center to record anthropogenic activities: *construction, transportation, entertainment...*
2. **Operational:** should be active before and during the lockdown period
3. **Open Data:** should be transmitting live data accessible to all
4. **Representation:** locations should be spread over Canada

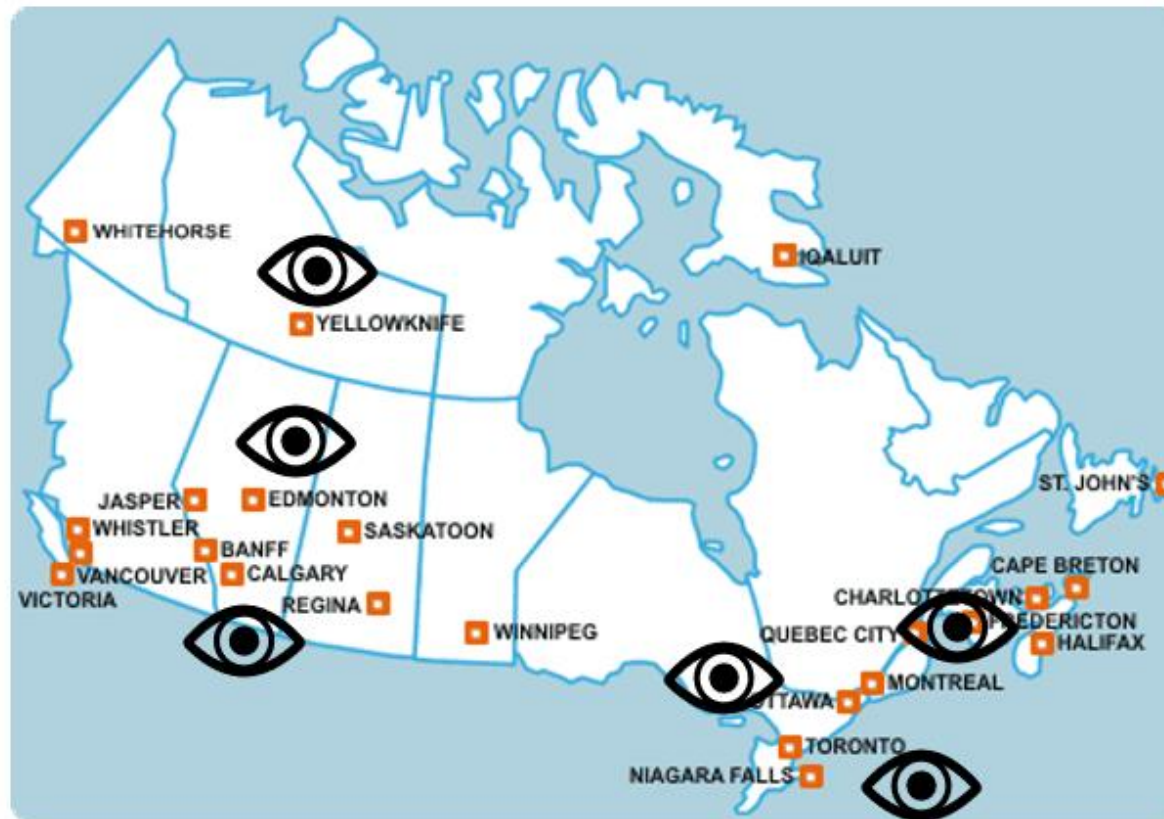
# Six Seismic Stations in 4 Provinces Selected

Period of Study: 15 December 2019 to 13 June 2020 (6 months)

Province	City	City Population	Seismic Station	Distance to City Centre
Alberta	Calgary	1.6 million	TD022	23 kms
	Edmonton	1.5 million	TD002	60 kms
North West Territory	Yellowknife	0.02 million	YKAW1	8 kms
Ontario	Ottawa	1.4 million	OTT	4 kms
	Toronto	6.2 million	TORO	6 kms
Quebec	Montreal	4.2 million	MNTQ	5 kms



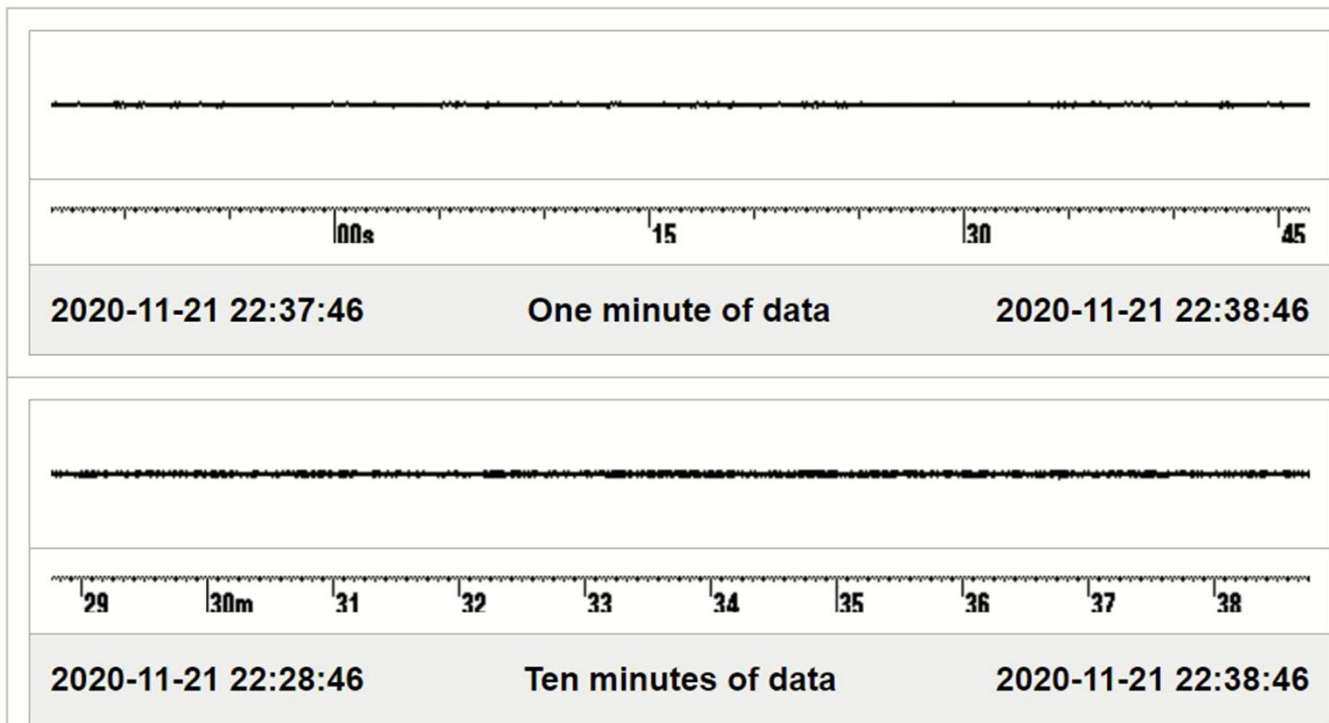
# Location of Canadian Seismic Stations Monitored for the Study



Seismic Station Monitored

# Raw Waveform Data from Seismic Stations

MNTQ [Montreal, QC, CA]



**Axis of vibration :**  
Z-Axis (HHZ)

**Sampling Rate :**  
100 samples / second

**Samples per day:**  
8,640,000

**Samples for study period  
per seismic station:**  
1.5 billion samples

# Data Format, Data Source and Libraries

**Data Format:** MSEED (Mini Standard for the Exchange of Earthquake Data)  
*contains only waveform data and used for time series data analysis*

**Data Source:** Incorporated Research Institutions for Seismology (IRIS)

<https://ds.iris.edu/ds/nodes/dmc/data/types/>

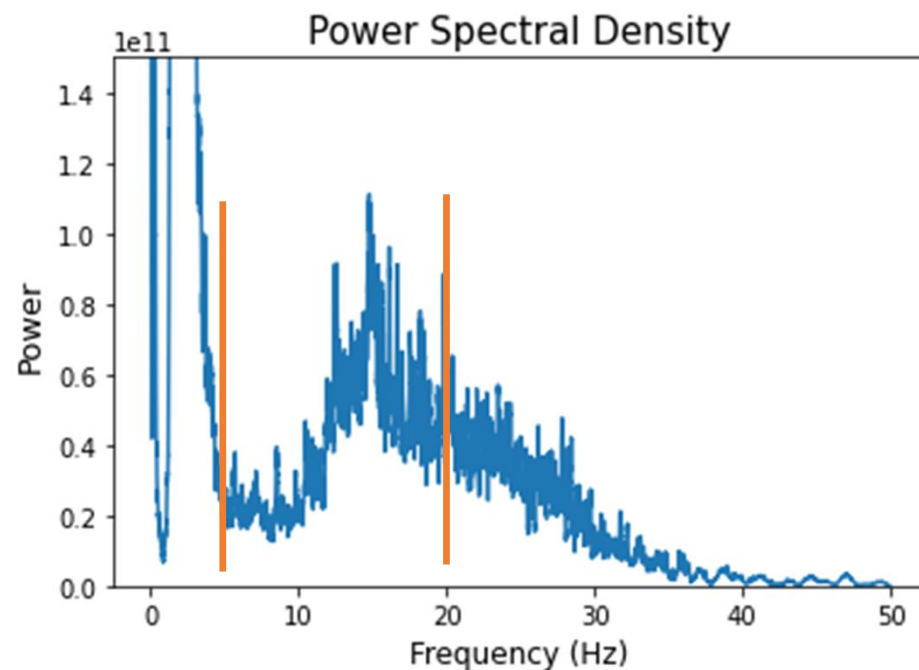
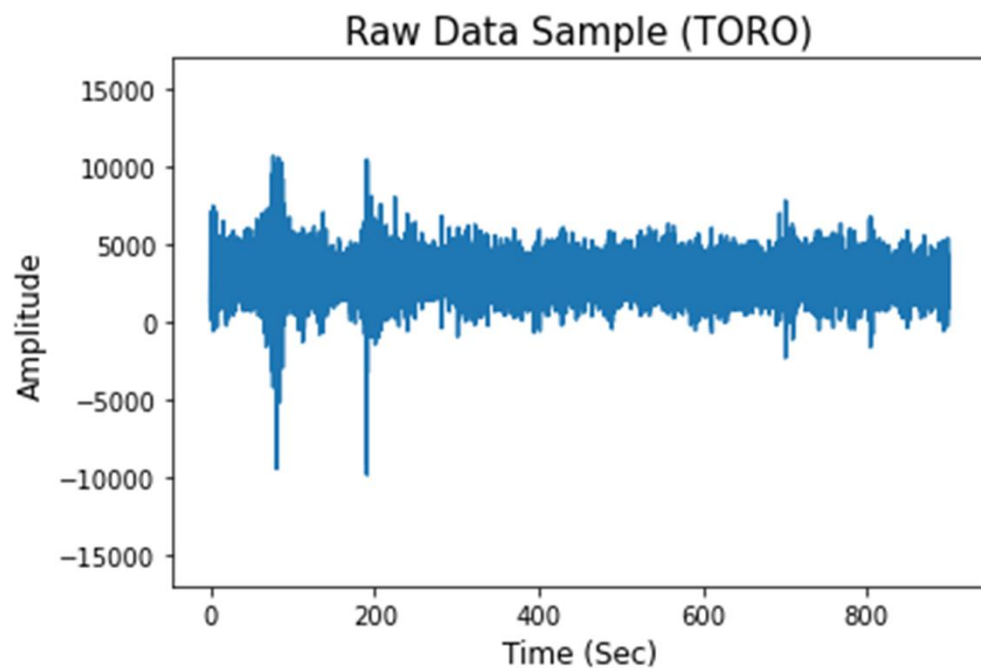


**Python library:** ObsPy to download and process MSEED files



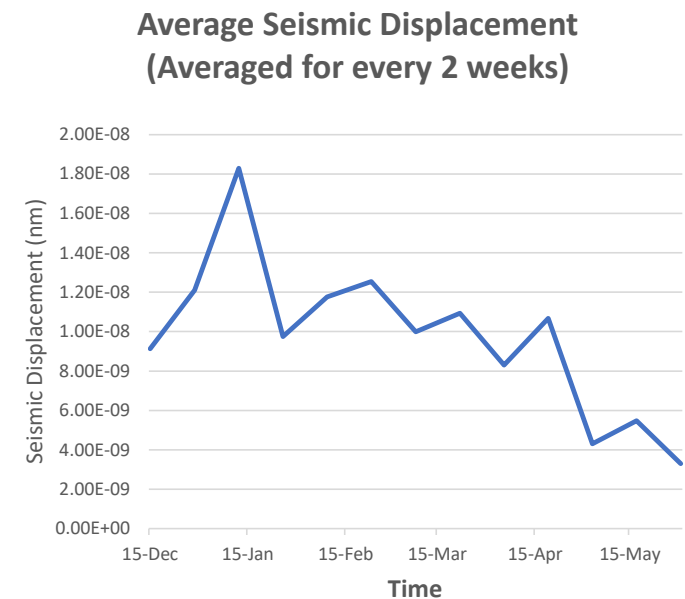
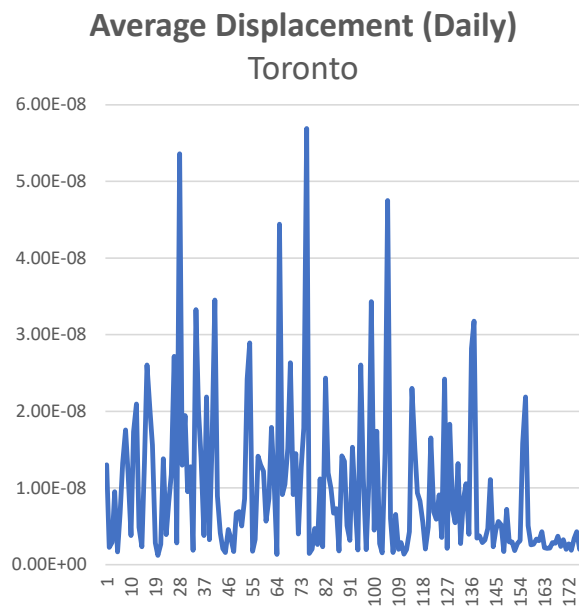
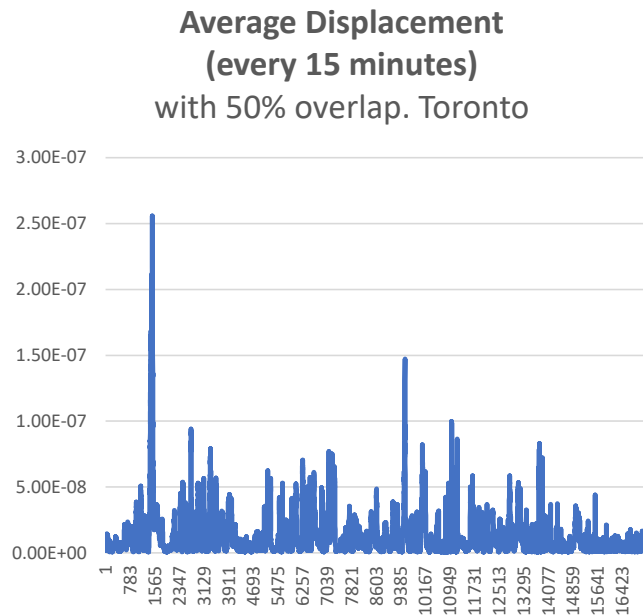
# Waveform Data to Power Spectral Density

Focus on anthropogenic signals in seismic range (4 to 20 Hz)



*9.5 billion lines of seismic data used for Analysis*

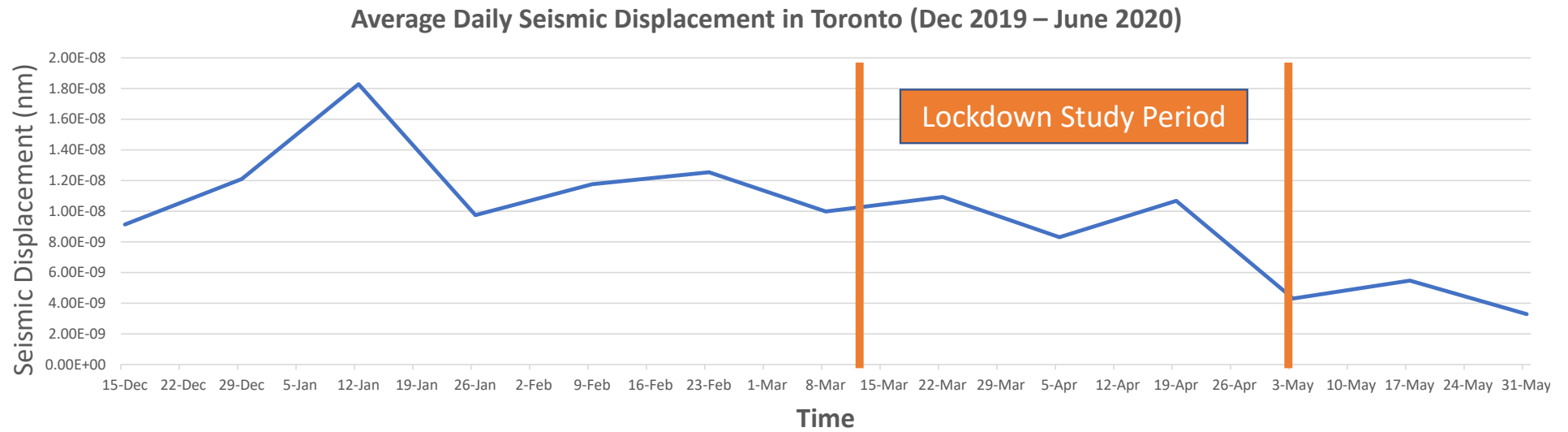
# PSD Processing – Overlapping and Averaging



- The RMS (average displacement) was calculated for each 15-minute period inside the main Power Spectral Densities (PSD) files, with an overlap of 50%. The same is done for each 24-hour period in the data
- Tutorial by Thomas Lecocq ([github.com/ThomasLecocq/SeismoRMS](https://github.com/ThomasLecocq/SeismoRMS)) was adapted for the trend analysis

# Toronto, ON

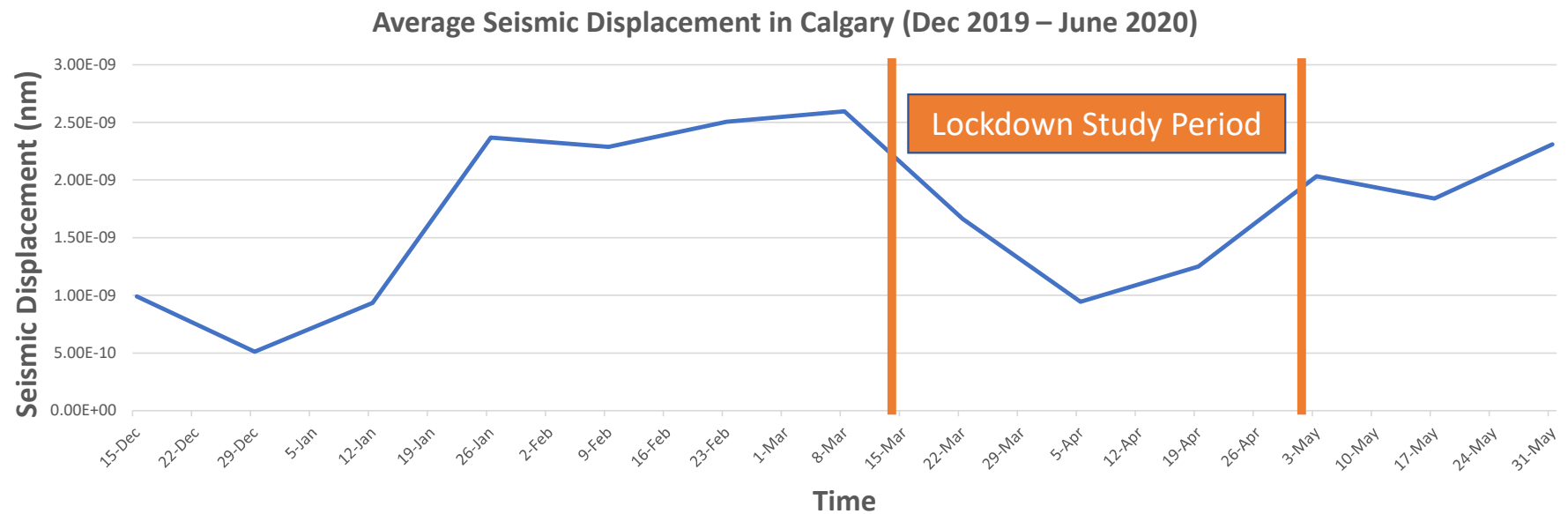
34 % decrease in seismic vibrations during lockdown



Station: TORO  
Channel: HHZ

# Calgary, AB

31% decrease in seismic vibrations during lockdown

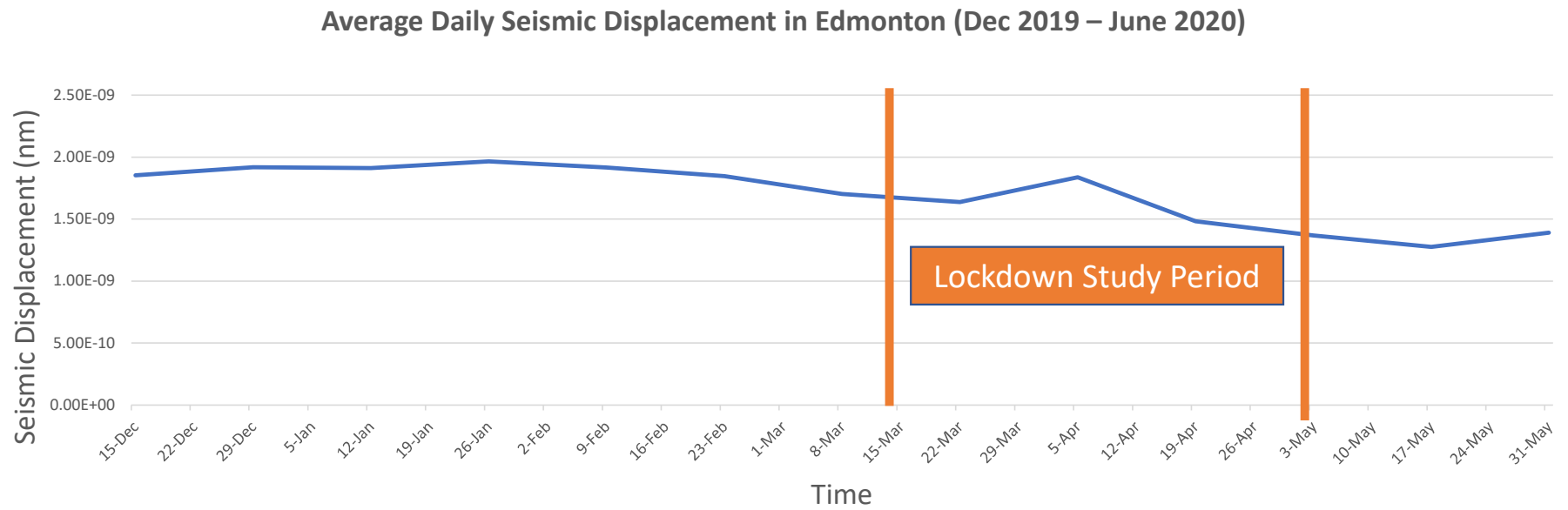


Station: TD022

Channel: HHZ

# Edmonton, AB

14% decrease in seismic vibrations during lockdown



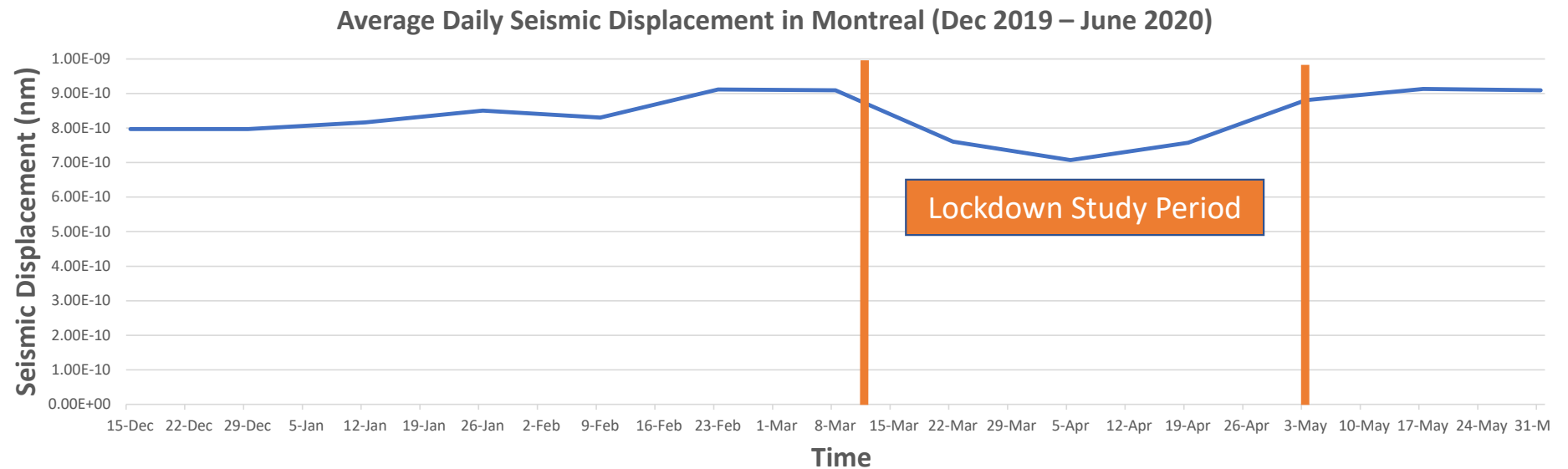
Station: TD002

Channel: HHZ



# Montreal, QC

34 % decrease in seismic vibrations during lockdown

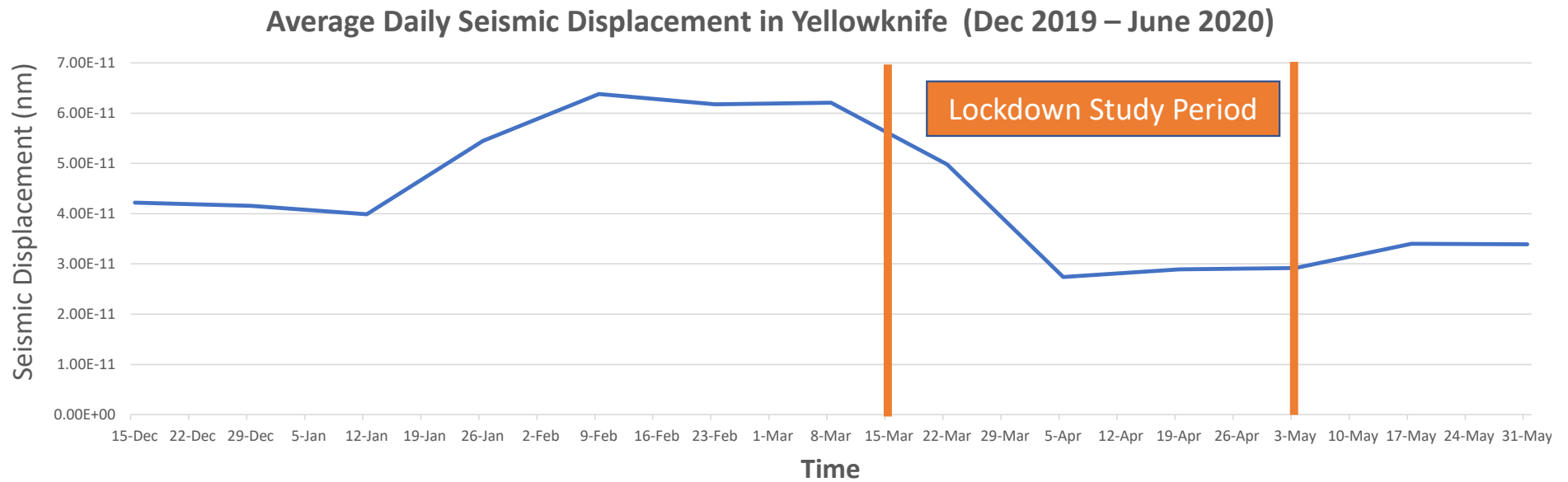


Station: MNTQ

Channel: HHZ

# Yellowknife, NWT

44 % decrease in seismic vibrations during lockdown

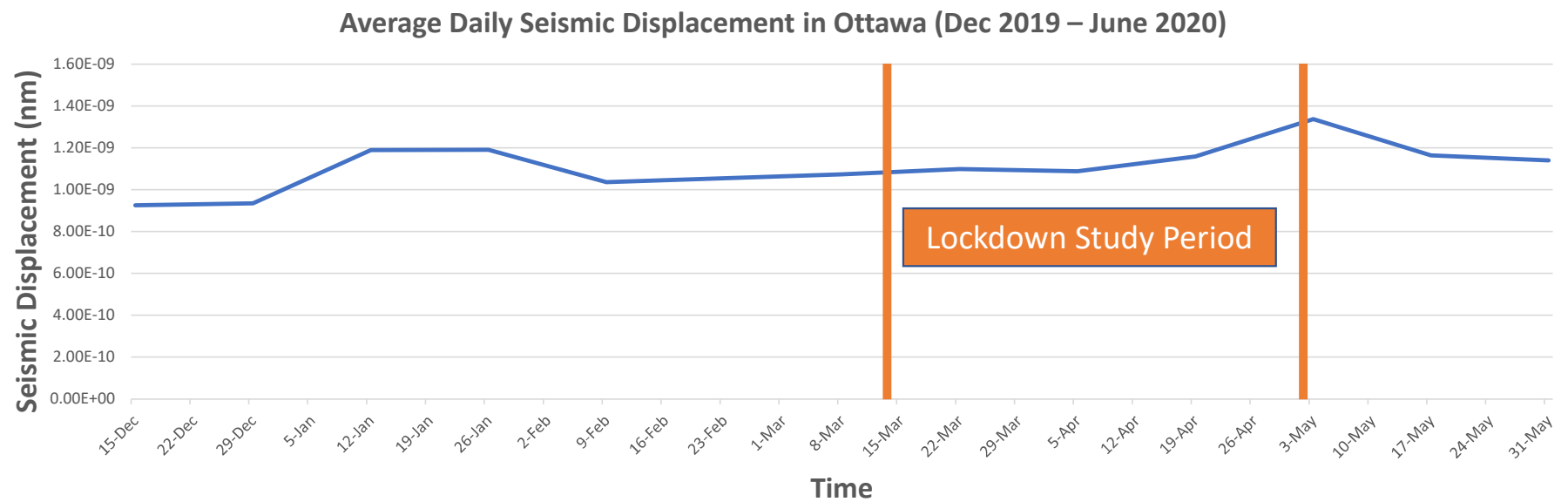


Station: YKAW1

Channel: HHZ

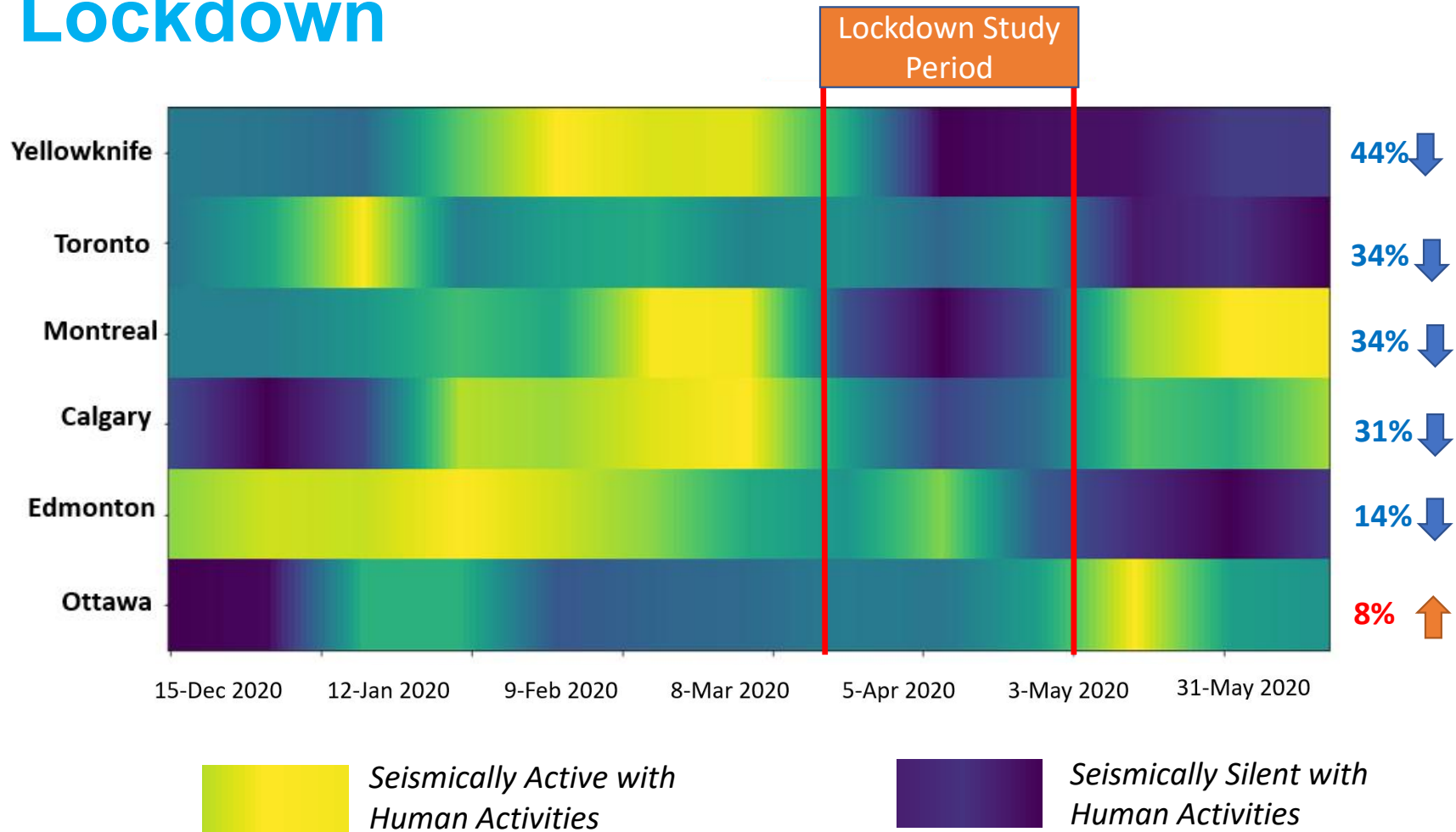
# Ottawa, ON

8% increase in seismic vibrations during lockdown



Station: OTT  
Channel: HHZ

# Seismic Silence of Canadian Cities during Lockdown



Data Validation from Ground Measurement

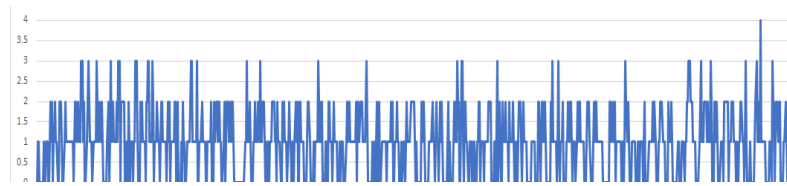
# Toronto Traffic: 50% decrease during Lockdown



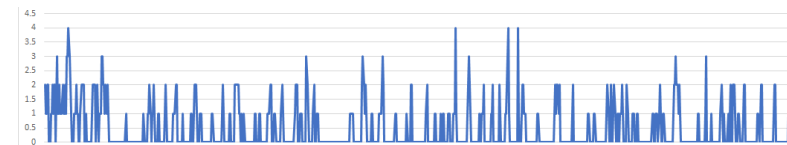
Applying Machine Learning on Live Video Data



Before Lockdown



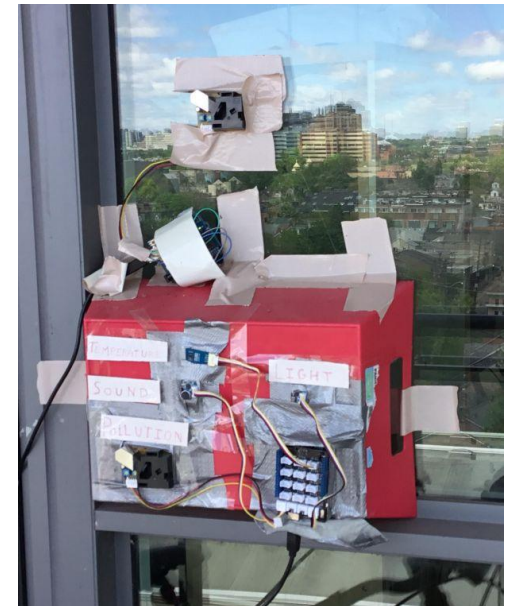
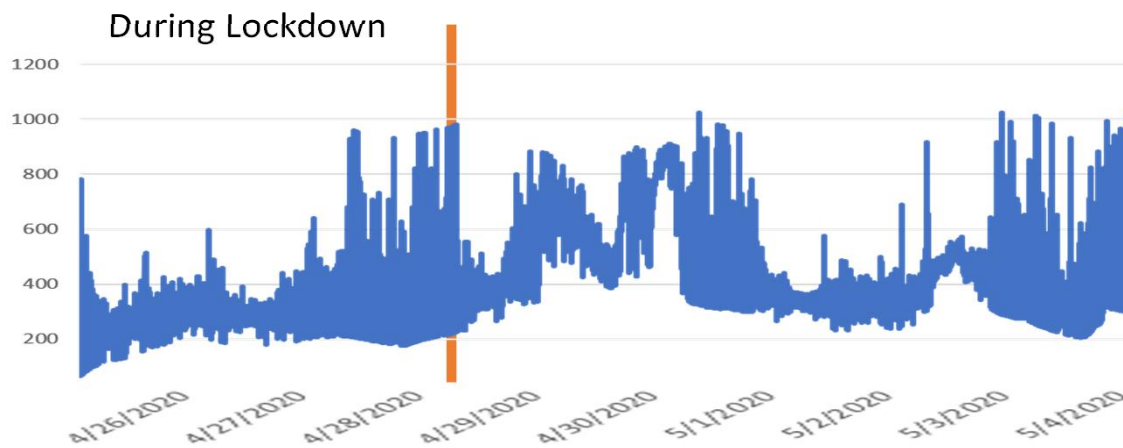
During Lockdown



Live Street Traffic Video  
Analysis using Convolutional  
Neural Network Algorithm

## Data Validation from Ground Measurement

# Toronto Street Sound: 30% decrease during Lockdown



Home-built Sound, Light and Pollution Sensor to gather data during COVID 19 Lockdown

# Pandemics and Urban Seismology



Surgical lockdowns: based on localities, time and actors

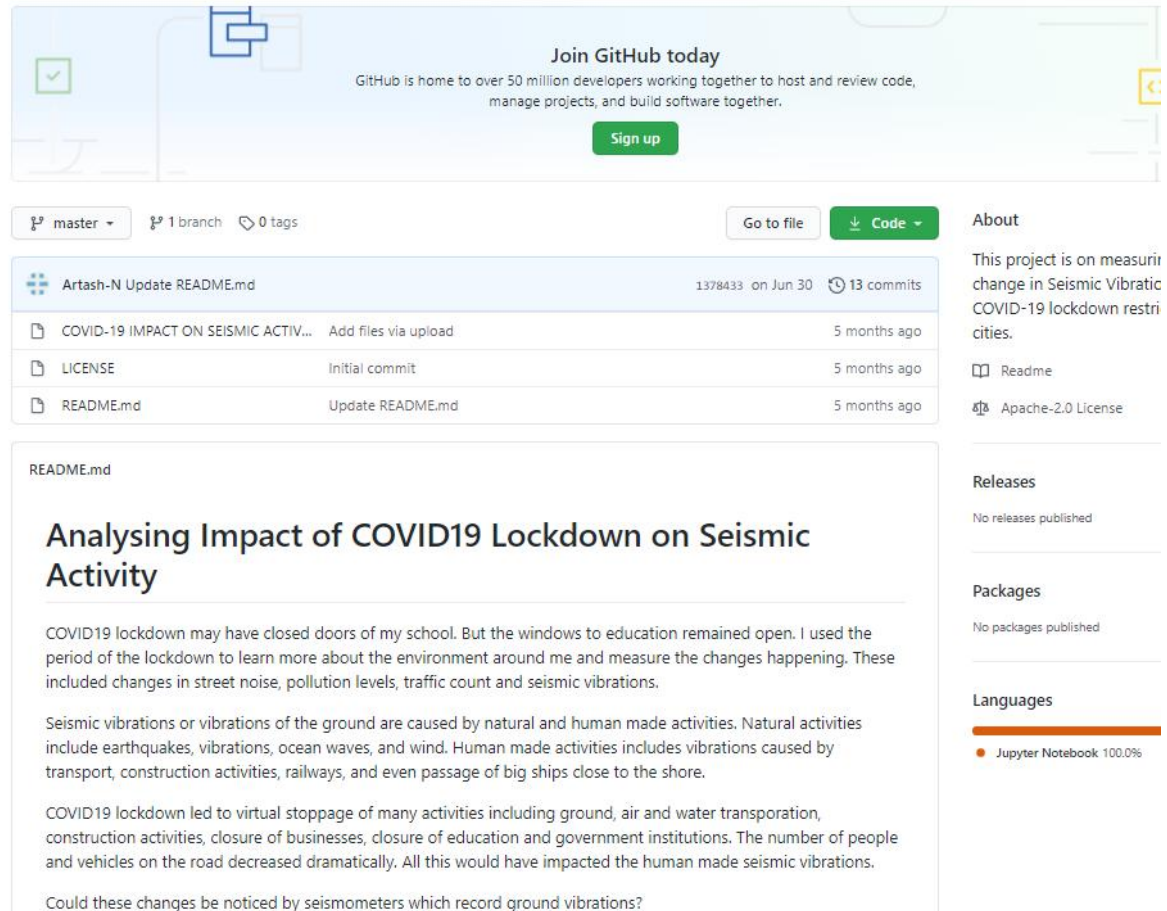


Monitor physical distancing measures

# Online Tutorial

To Calculate Changes in  
Seismic Vibrations for  
any city

<https://github.com/Artash-N/COVID19-Impact-on-Seismic-Activity>



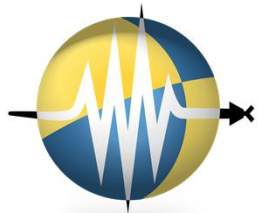
The screenshot shows the GitHub repository page for 'Artash-N/COVID19-Impact-on-Seismic-Activity'. At the top, there is a banner for 'Join GitHub today' with a 'Sign up' button. Below the banner, the repository name 'Artash-N Update README.md' is displayed, along with the commit hash '1378433', the date 'on Jun 30', and '13 commits'. A table lists the files in the repository:

File	Commit	Time
COVID-19 IMPACT ON SEISMIC ACTIV...	Add files via upload	5 months ago
LICENSE	Initial commit	5 months ago
README.md	Update README.md	5 months ago

Below the file list, the 'README.md' content is shown. It starts with the title 'Analysing Impact of COVID19 Lockdown on Seismic Activity'. The text describes how the COVID19 lockdown may have closed doors of schools but kept education open, and how the author used the lockdown period to learn about the environment and measure changes in street noise, pollution levels, traffic count, and seismic vibrations. It also explains that seismic vibrations are caused by natural and human-made activities, and that the lockdown led to a virtual stoppage of many activities, including ground, air, and water transportation, construction, and business closures, which would have impacted human-made seismic vibrations. The text concludes with the question: 'Could these changes be noticed by seismometers which record ground vibrations?'.

On the right side of the repository page, there are sections for 'About', 'Releases', 'Packages', and 'Languages'. The 'About' section states that the project is on measuring change in seismic vibrations due to COVID-19 lockdown restrictions. The 'Releases' section shows 'No releases published'. The 'Packages' section shows 'No packages published'. The 'Languages' section shows 'Jupyter Notebook 100.0%'.



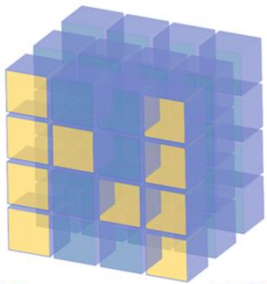


# ObsPy

A Python Framework for Seismology



# pandas



# NumPy



## PYTHON 3



# TensorFlow

## Conclusion

- Seismic vibrations decreased in most Canadian cities. Decreased over 30% in 4 cities
- Decrease was due to stoppage in human activity and was validated by ground measurements

## Limitations

- Seismic stations located at different distances from the city center
- Types of lockdowns and enforcements differed: by city, by province and health department



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