

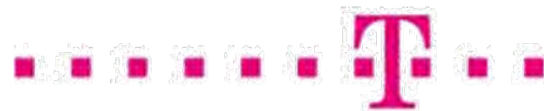
# Smartphones and Twitter for Earthquakes

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Lawrence Livermore National Laboratory

Prepared by LLNL under Contract DE-AC52-07NA27344.  
This is document number LLNL-PRES-830566.

# MyShake and Android Earthquake Alerting System



Deutsche Telekom, Inc.  
Silicon Valley Innovation Center

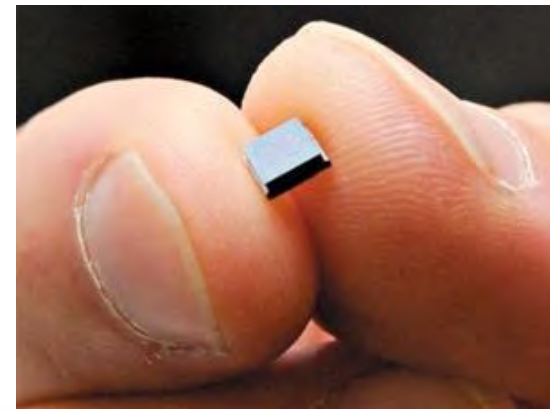


GORDON AND BETTY  
**MOORE**  
FOUNDATION



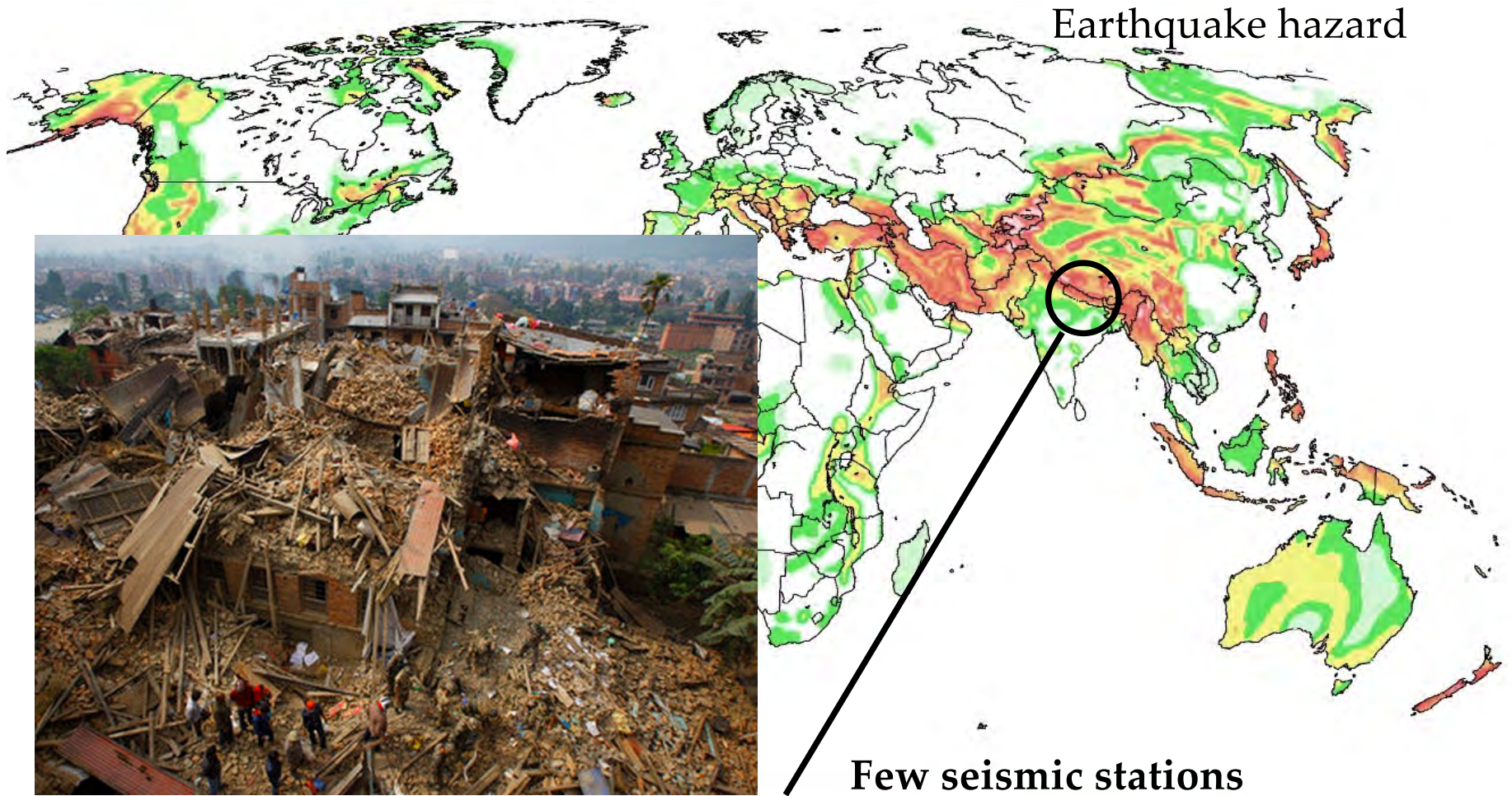
**Cal OES**  
GOVERNOR'S OFFICE  
OF EMERGENCY SERVICES





# A global test

for a global hazard



Katmandu, Nepal  
April 2015, M7.9: 8000 fatalities

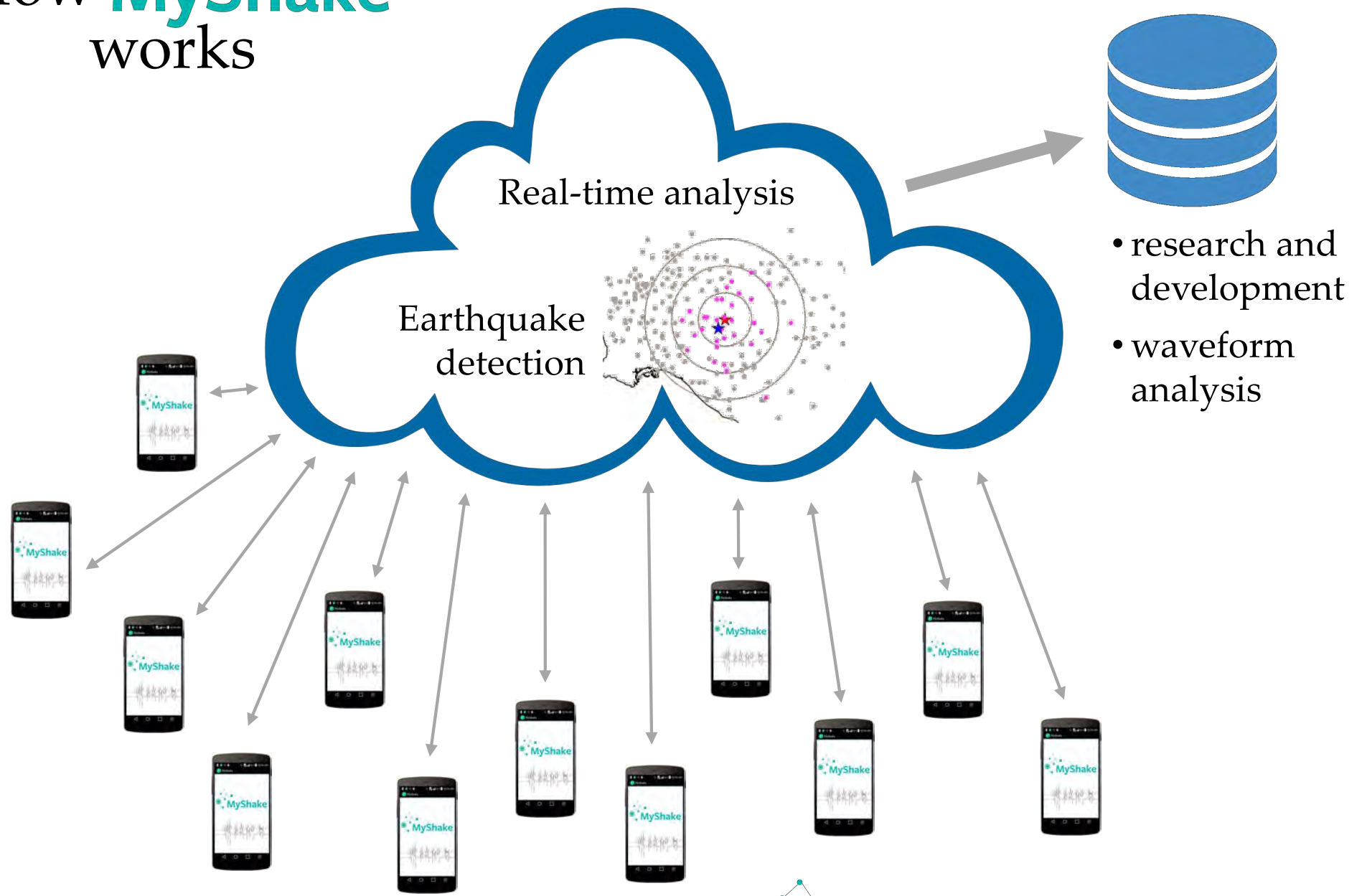
Few seismic stations  
**6 million** smartphones



# Early warning system



# How **MyShake** works



download the free app  **MyShake.berkeley.edu**



# How **MyShake** works

## Real-time analysis phone/cloud

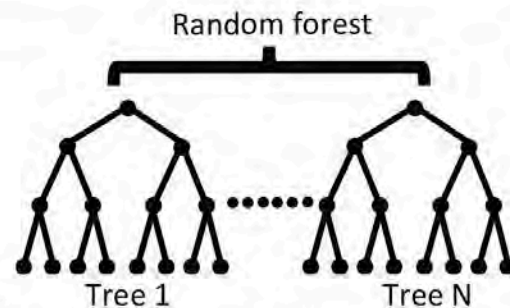
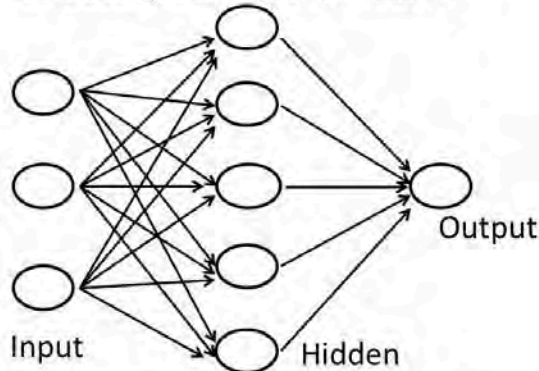
A real-time clustering algorithm - DBSCAN running in cloud to confirm earthquake from multiple phone triggers in a region

Cloud server

An artificial neural network (ANN) classifier on the phone to classify earthquake motion



MyShake users



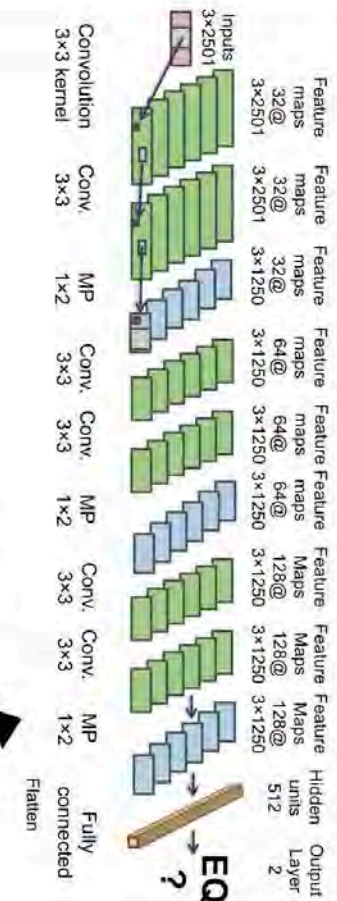
A random forest regressor is running in real-time to estimate the magnitude from the PGA value and distance in the trigger message

## Data analysis on database

Databases



waveforms



A convolutional neural network (CNN) is running on the waveform database to pick the waveforms from earthquakes



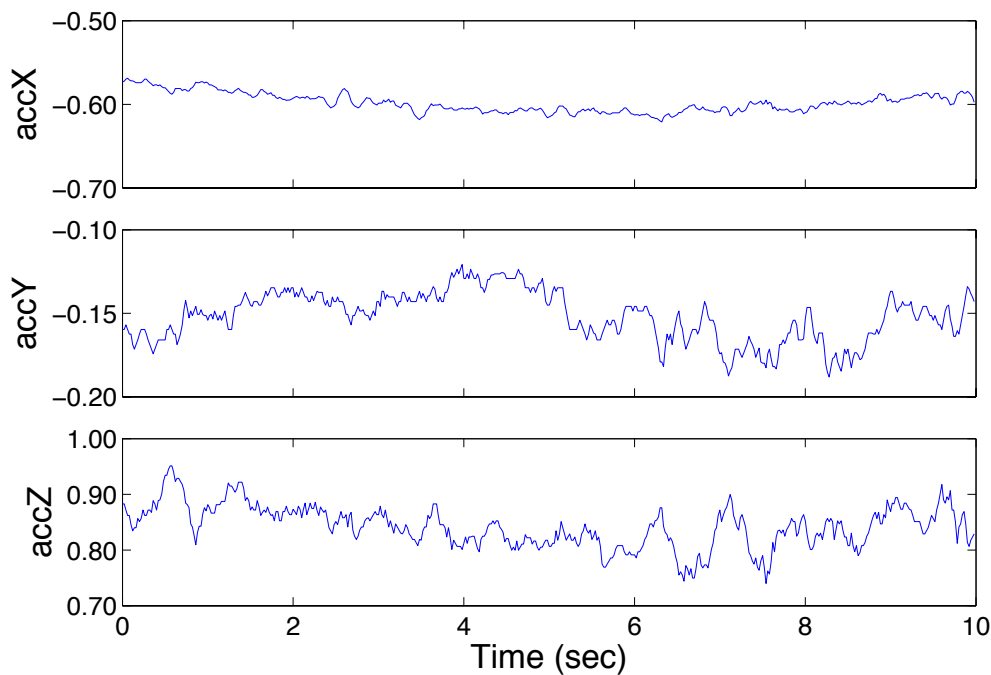
Is this an Earthquake?



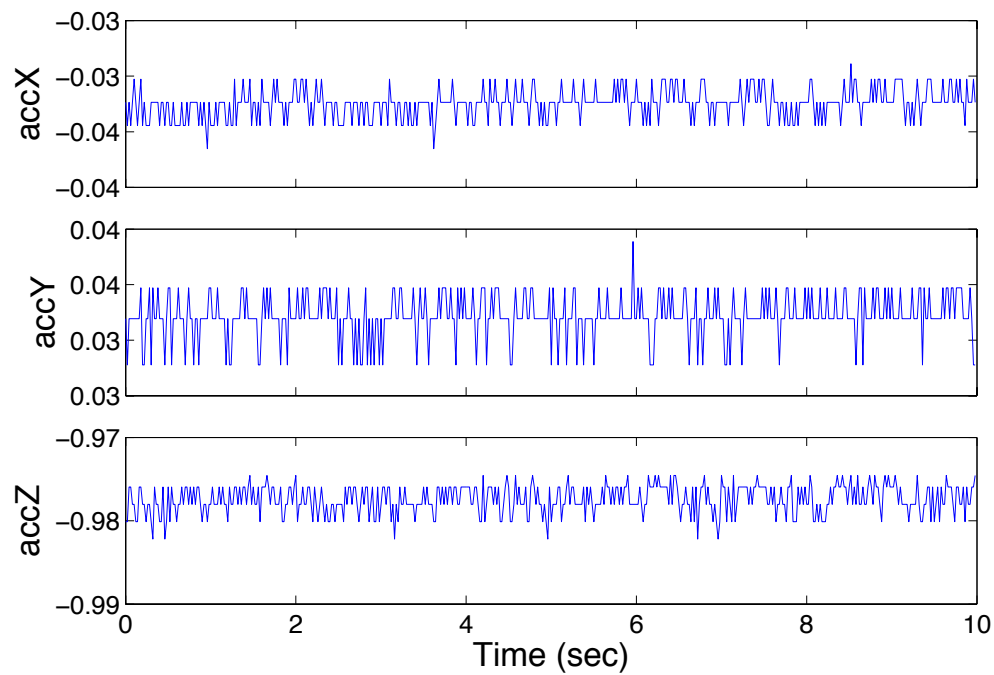




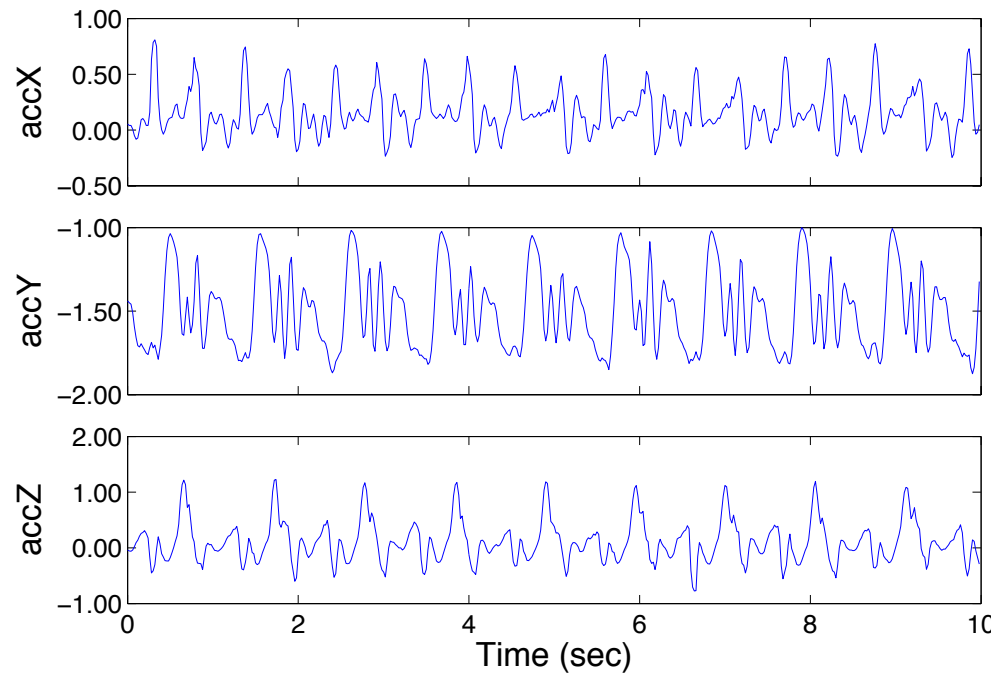
Raw Acceleration for bus



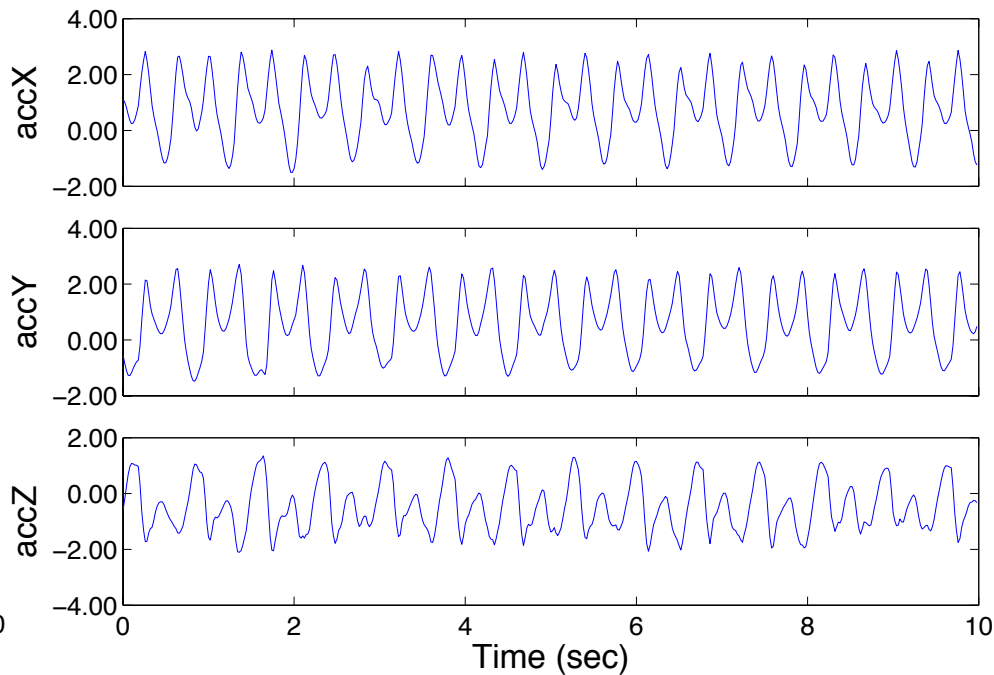
Raw Acceleration for desk

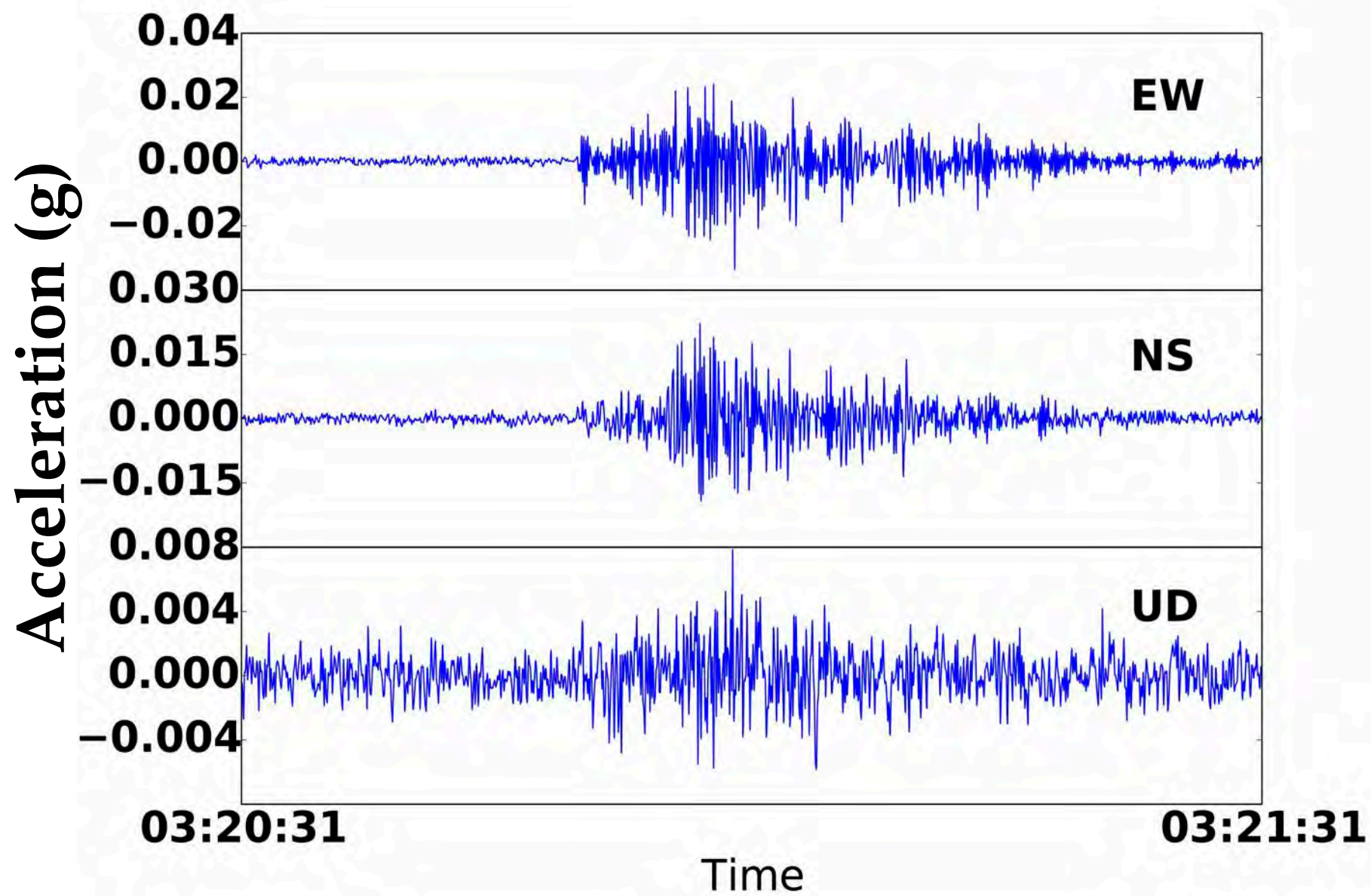


Raw Acceleration for Walk



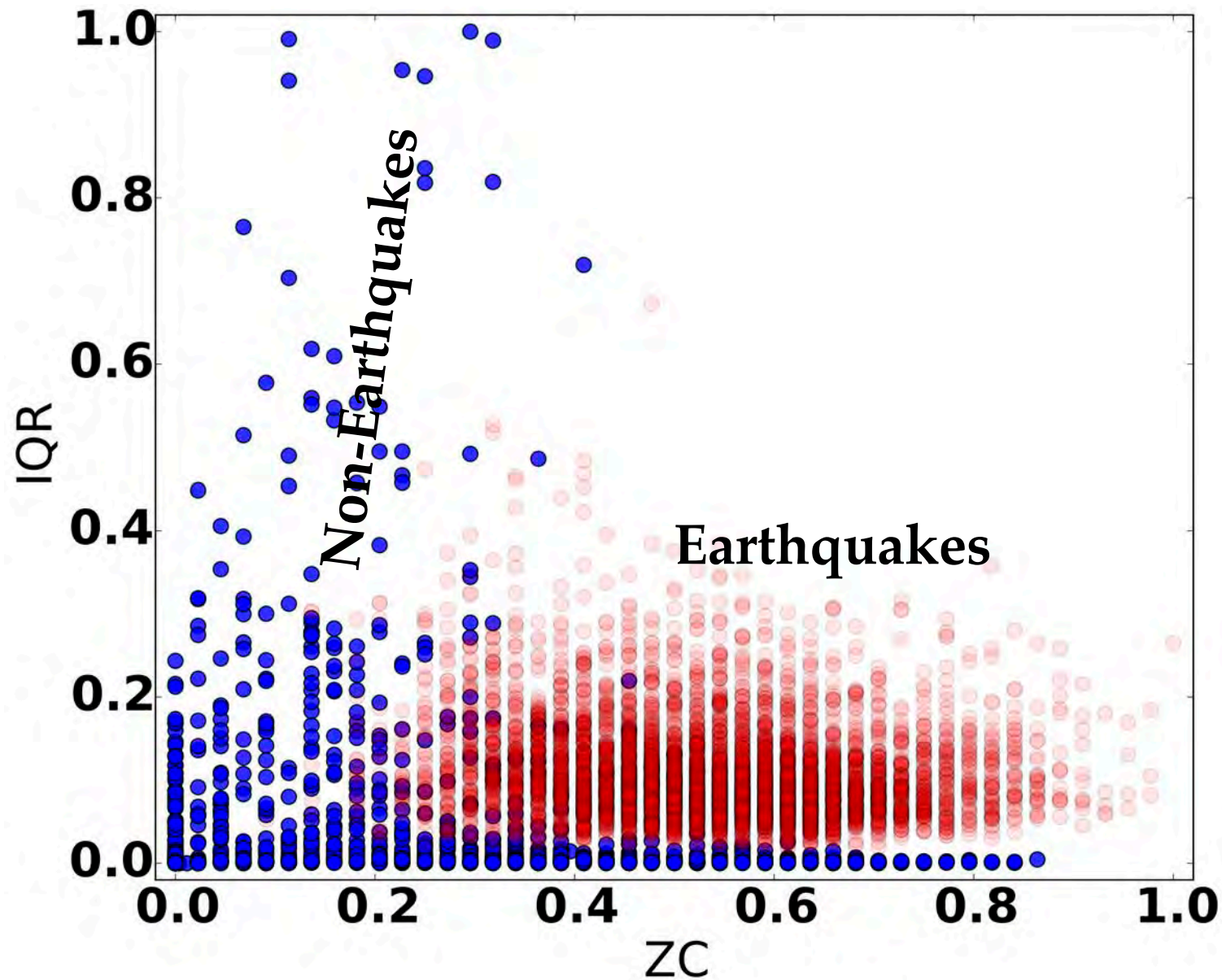
Raw Acceleration for run







# Classification

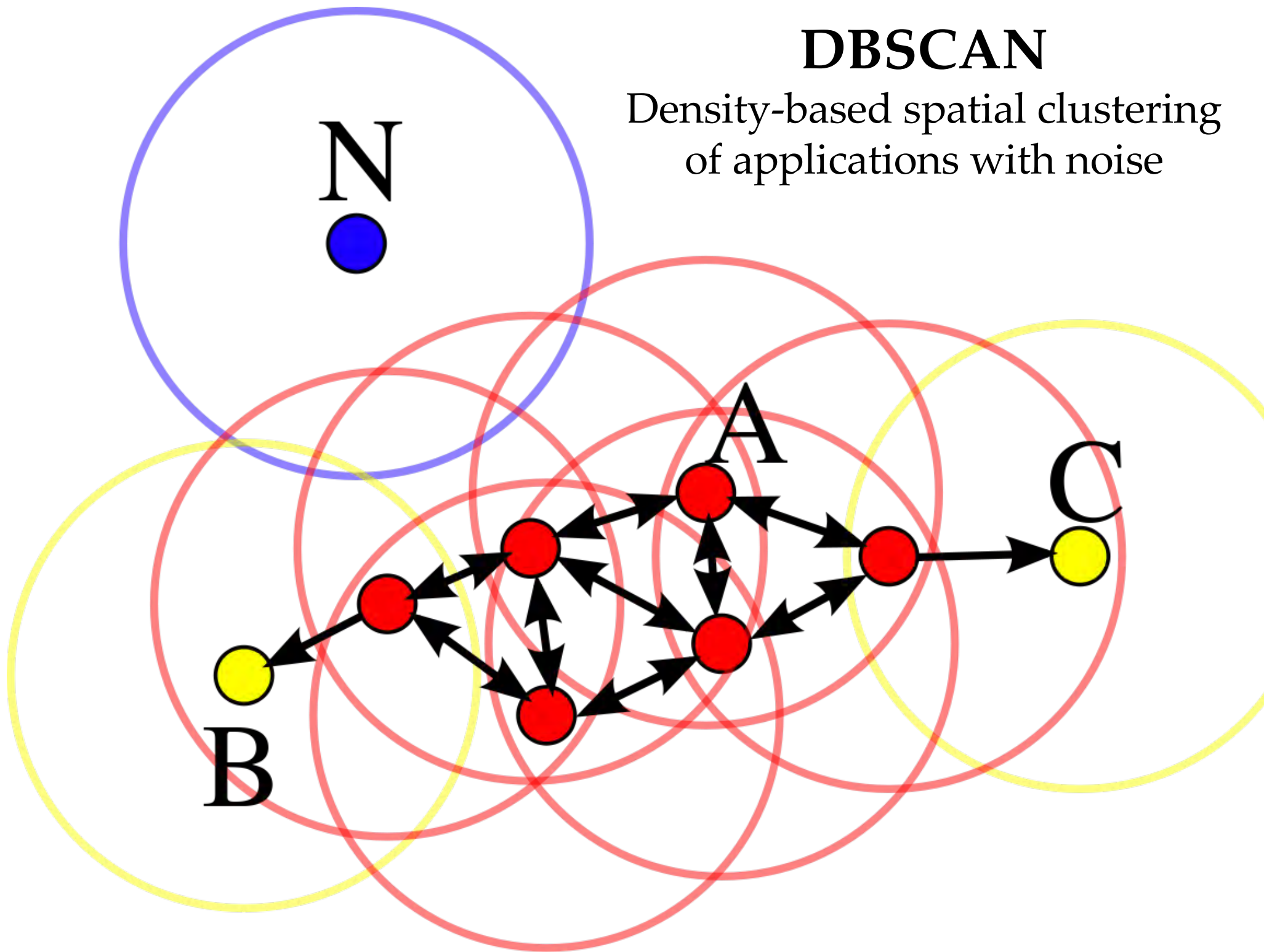


# A network of MyShakers



# DBSCAN

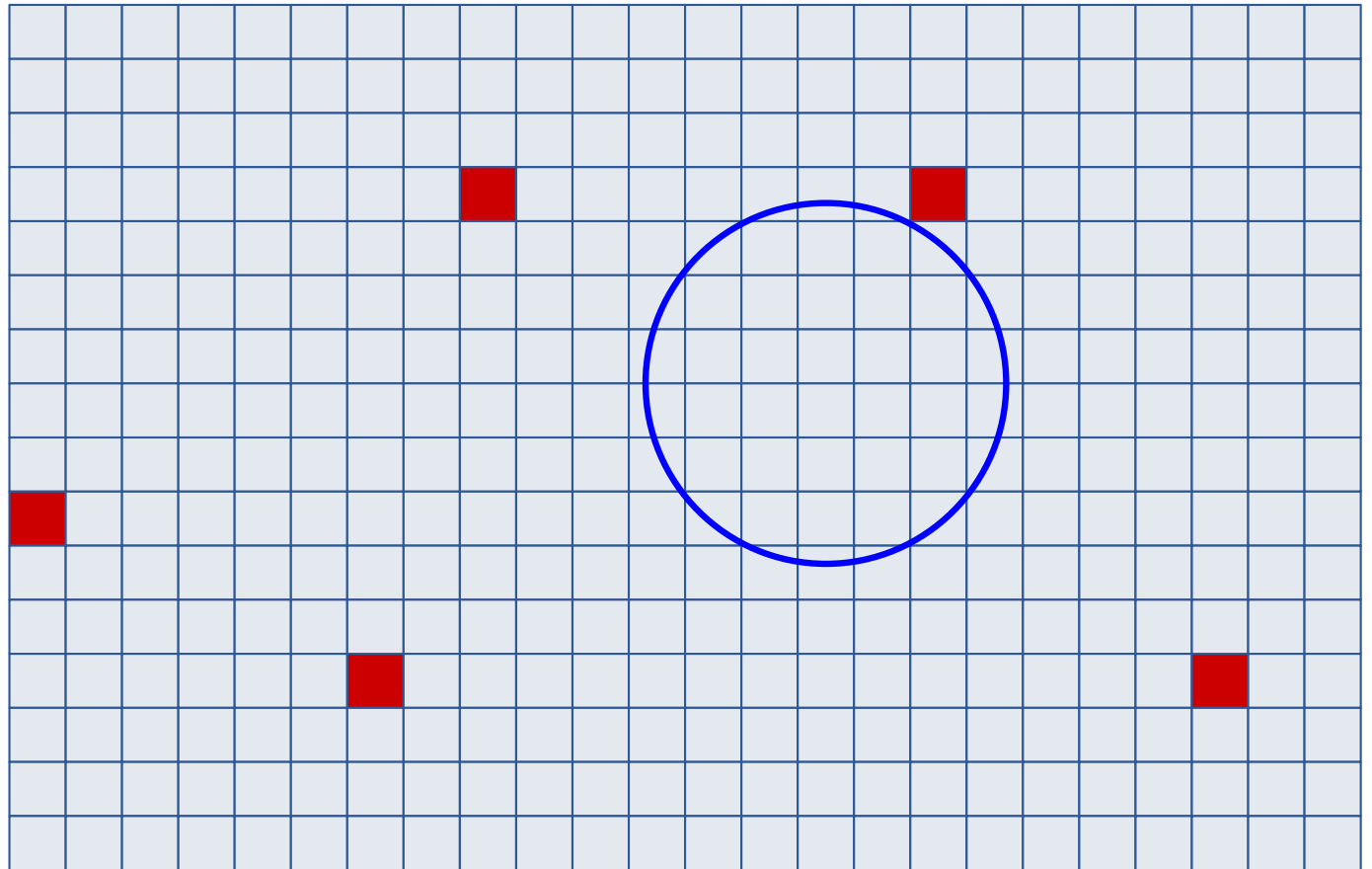
Density-based spatial clustering  
of applications with noise





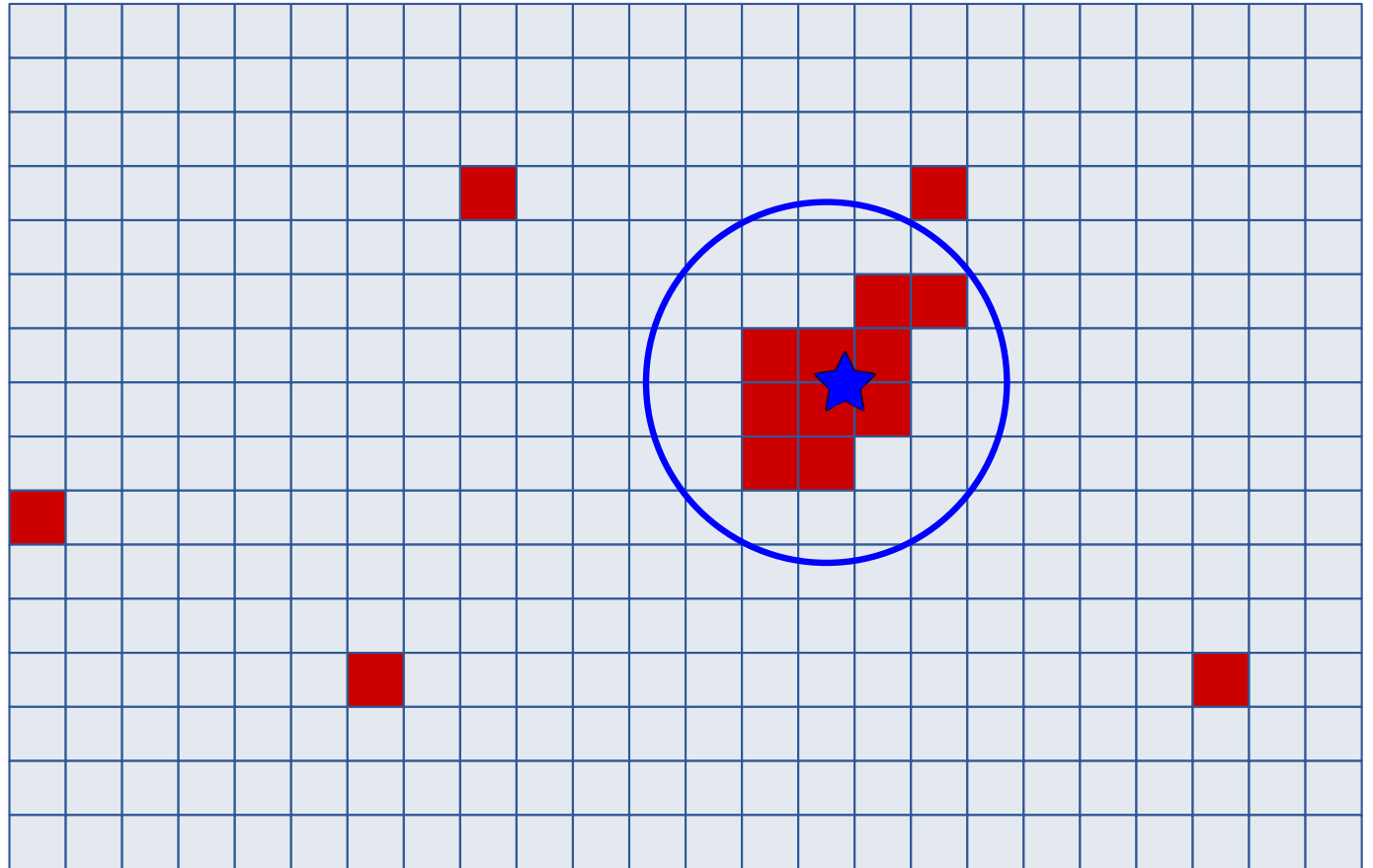
# Using MGRS grid cells

**Random**



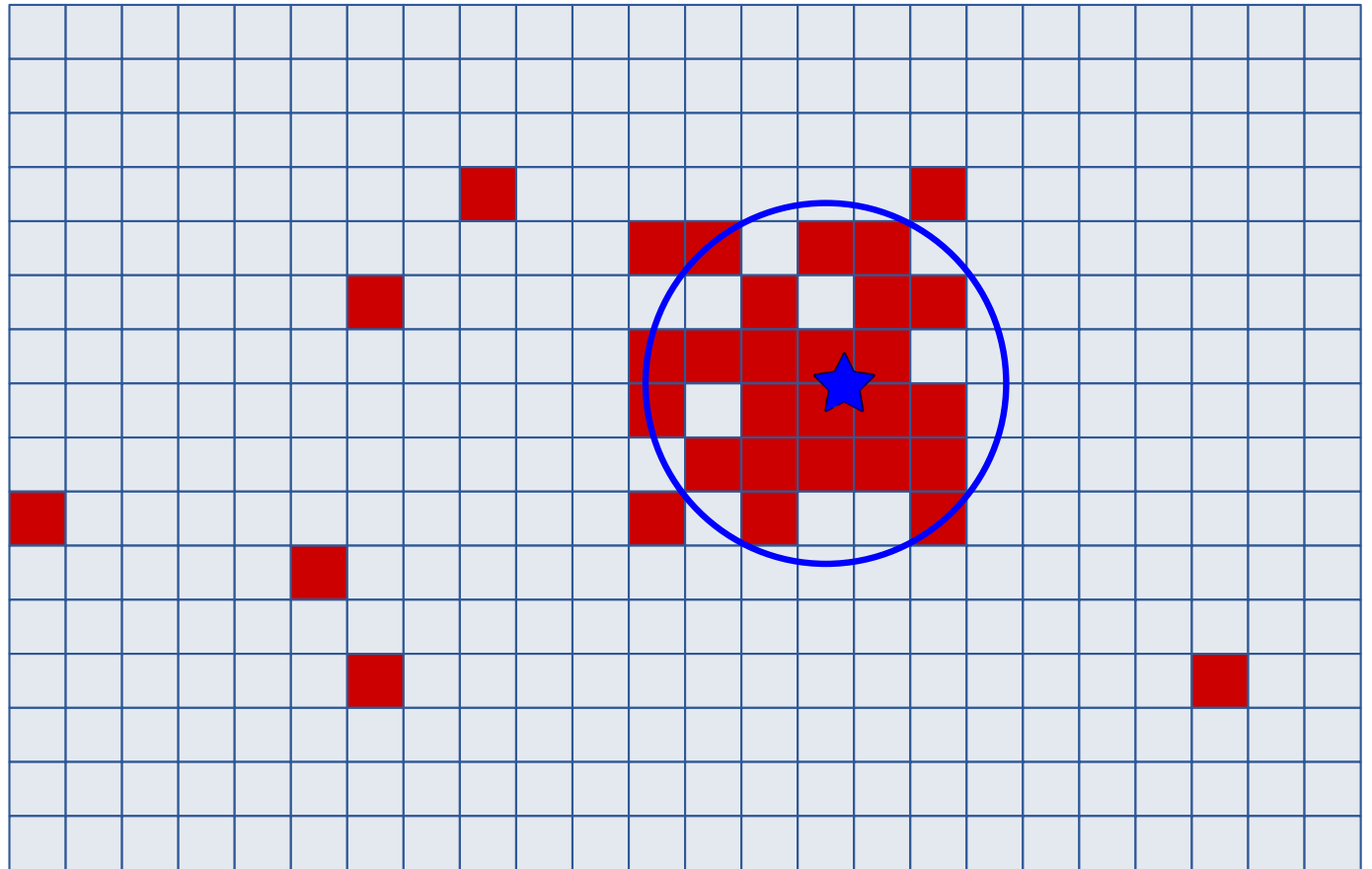
# Using MGRS grid cells

**Earthquake**



# Using MGRS grid cells

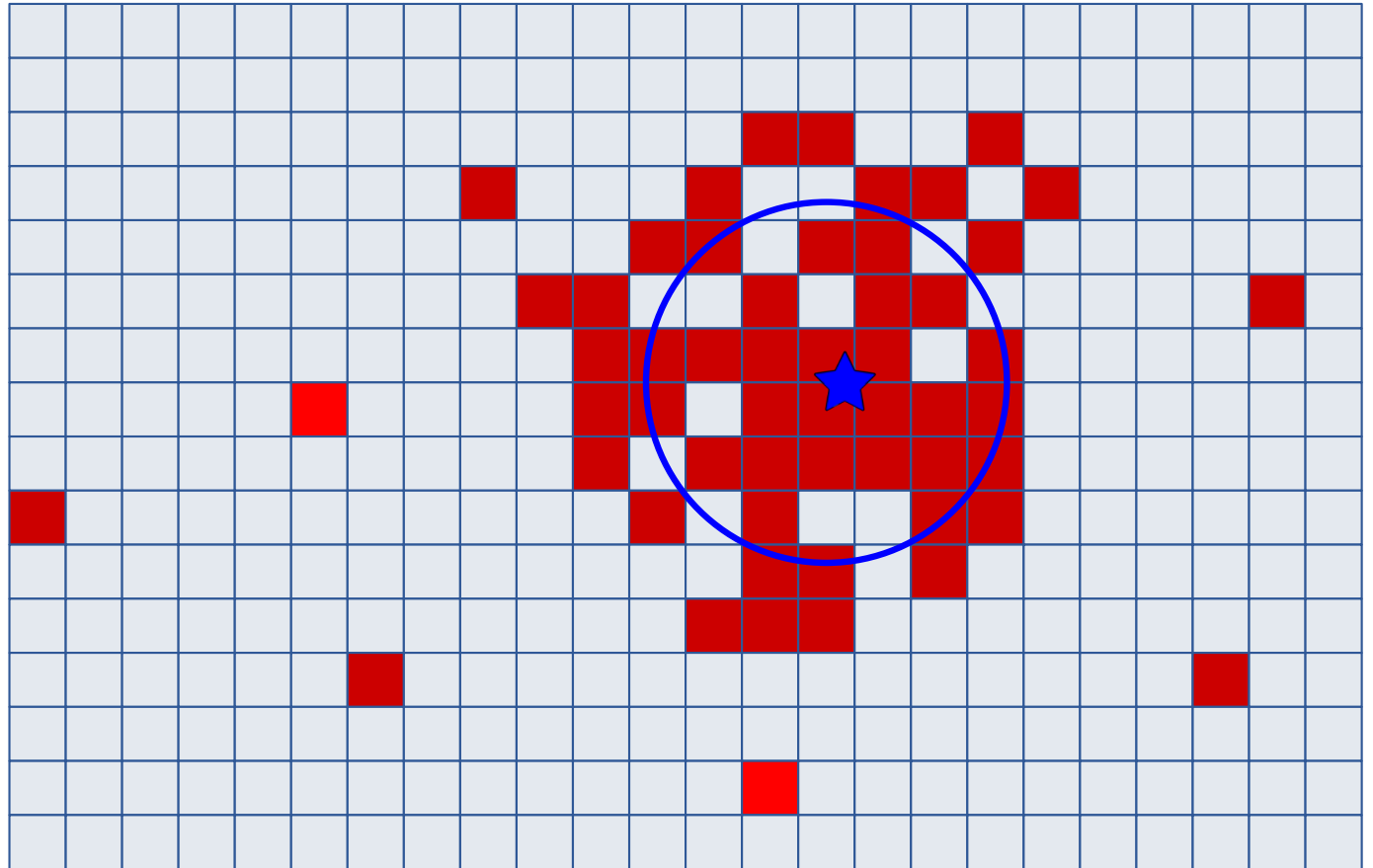
**Earthquake**



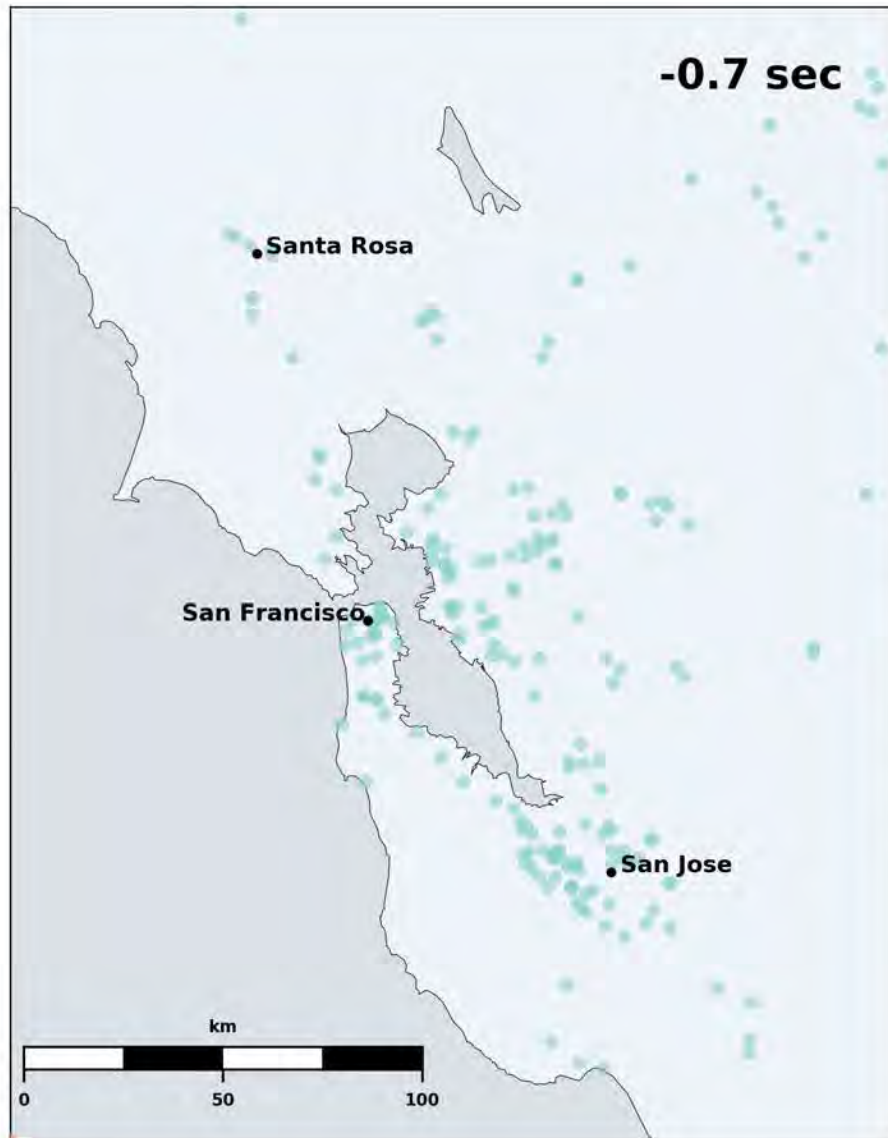


# Using MGRS grid cells

# Earthquake



# Berkeley earthquake



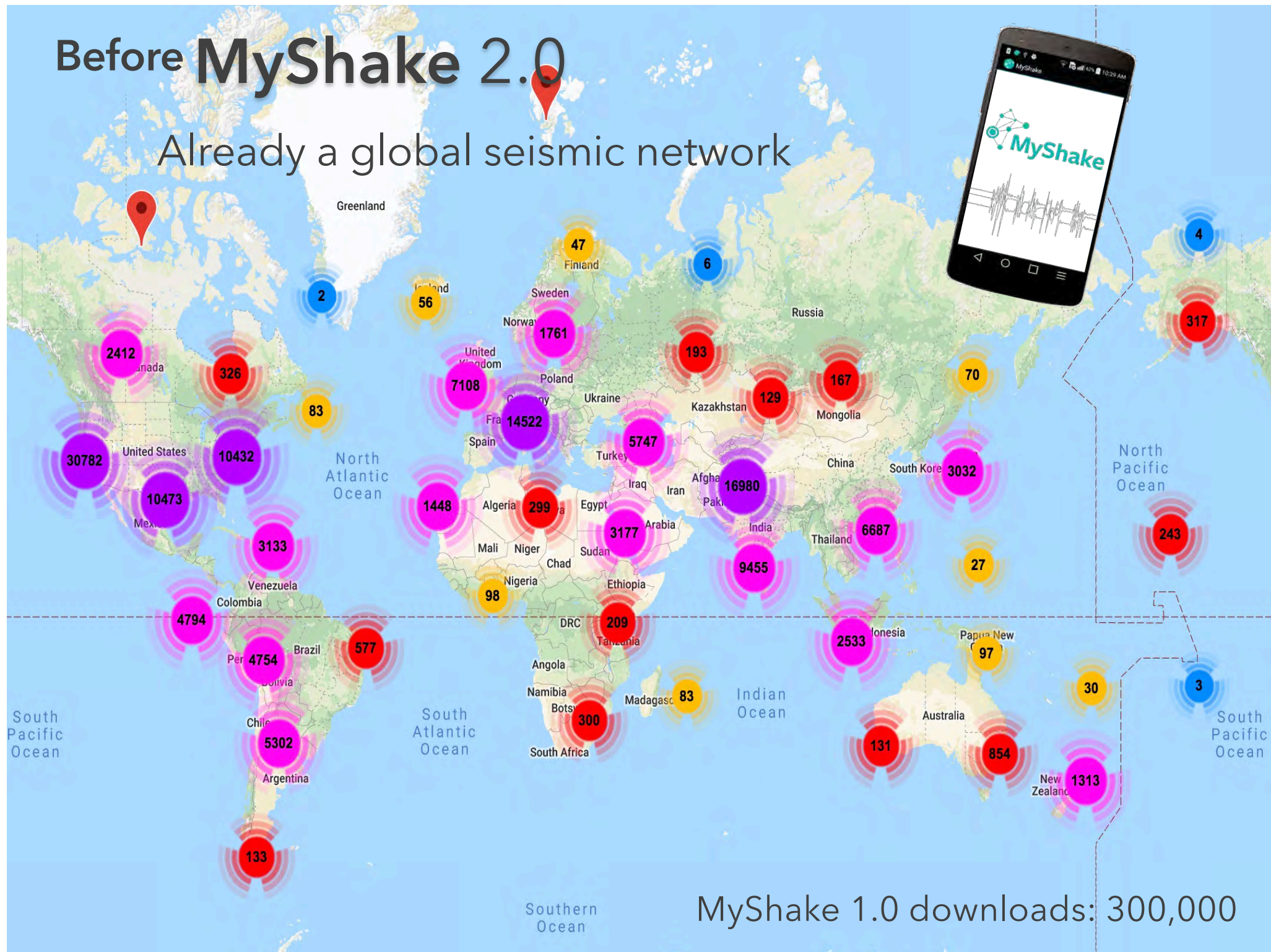
Time(UTC) 2018-01-04 10:39:37  
Time(Local) 2018-01-04 02:39:37  
Triggers 0

**M4.4 Berkeley**  
**Depth 12.3 km**

- MyShake phone
- Triggered phone
- Used for location
- True earthquake location
- Estimated earthquake location
- P-wave front
- S-wave front
- Limit of shaking intensity 4

# Before MyShake 2.0

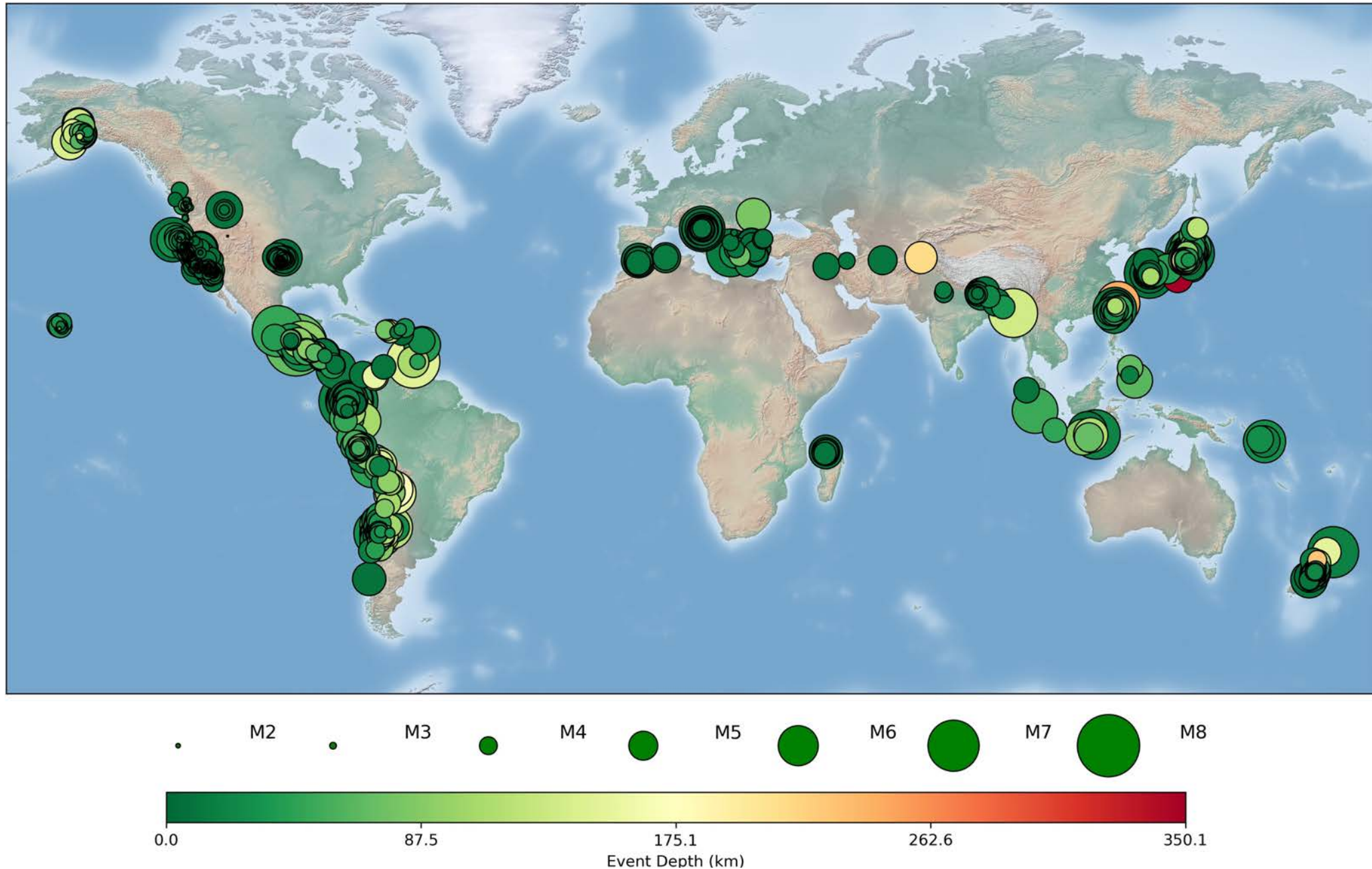
Already a global seismic network





Earthquakes recorded: **1000+** to date  
(usable seismic waveforms)

M1.7 to M7.8  
Surface to 350 km depth





# android

## Earthquake Alerts

Two elements announced:

1. Alerts delivered to all Android phones across California

M4.5 beneath Los Angeles:  
alert delivered to  
**2.2 million** people

2. Phones now being used to detect earthquakes globally  
...with the goal to deliver alerts



## the earthquake team

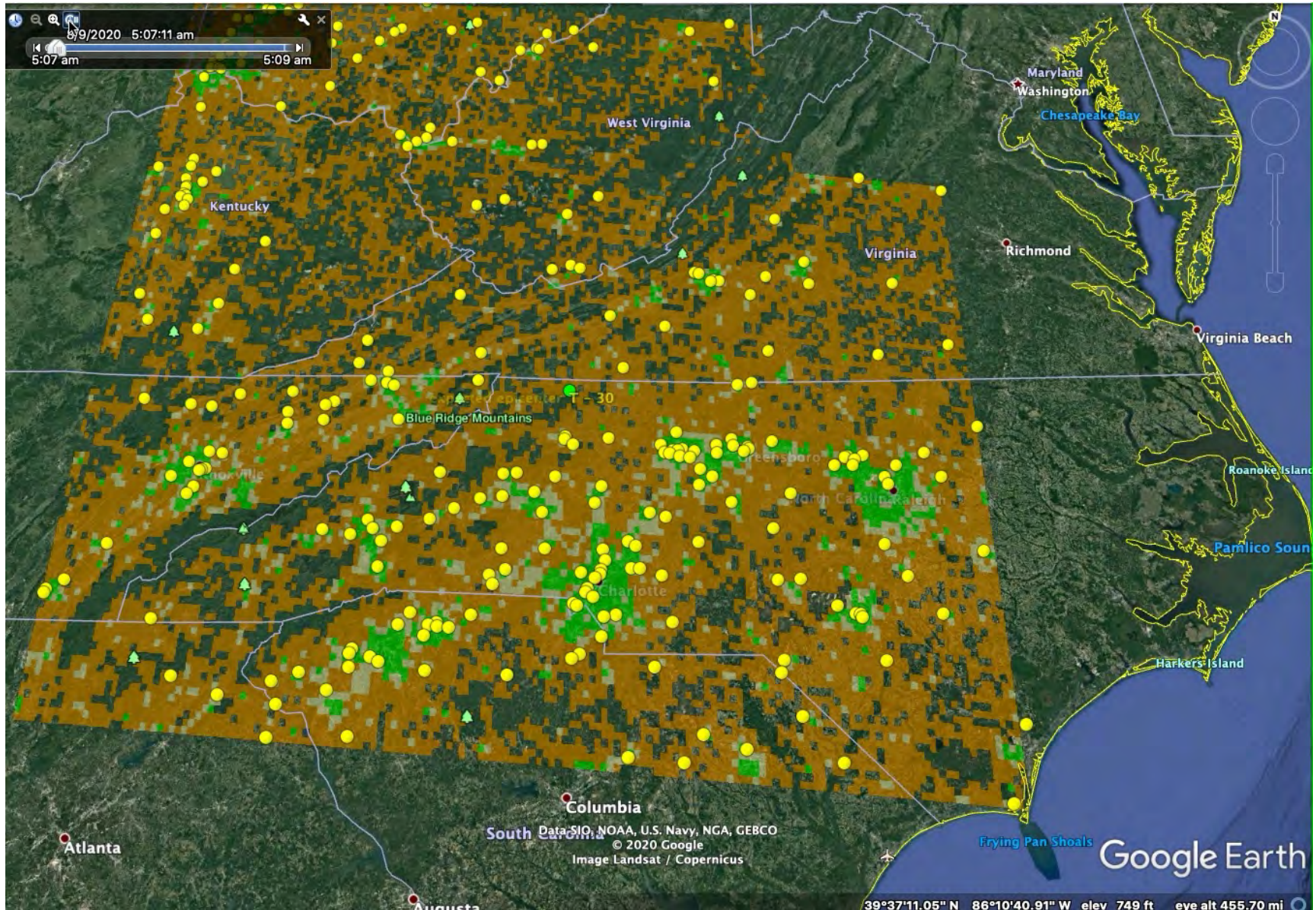
Marc Stogaitis  
Alexei Barski  
Steve Malkos  
Robert Bosch  
Patrick Robertson  
Tajinder Gadh  
Youngmin Cho  
Summer Jiang  
Boone Spooner  
Richard Allen  
Qingkai Kong  
Greg Wimpey  
Yiwen Chen  
Stark Zhu

Google blog - August 11, 2020

Earthquake detection and early alerts, now on your Android phone

# Phone detections

M5.1– North Carolina – Aug 9, 2020





# An Analysis of Twitter Responses to the 2019 Ridgecrest Earthquake Sequence

Tao Ruan\*, Qingkai Kong<sup>†</sup>, Yawen Zhang\*, Sara K. McBride<sup>‡</sup> and Qin Lv\*

\*Department of Computer Science, University of Colorado Boulder, Boulder, Colorado, USA

<sup>†</sup>Berkeley Seismology Lab, University of California Berkeley, Berkeley, California, USA

<sup>‡</sup>United States Geological Survey, Menlo Park, California, USA



Tao Ruan  
Ph.D student



Yawen Zhang  
Ph.D student



Sara McBride  
USGS



Christine Qin  
Professor

# Data we worked on



**Ava DuVernay** ✓

@ava



Been living in Los Angeles all my life. That was the longest earthquake I've ever experienced. Not jerky. Smooth and rolling. But it was loooong. It was so long I thought for the first time ever "Is this the big one?" Damn. Respect Mother Nature. She's the boss.

♡ 58.1K 10:37 AM - Jul 4, 2019



💬 7,803 people are talking about this



**Gabrielle Union** ✓

@itsgabrielleu



The fact that I experienced that longass earthquake while on the toilet at the gym...and immediately blamed the celery juice, is about right. Lordt.

♡ 30.2K 11:02 AM - Jul 4, 2019



💬 2,594 people are talking about this



**Dwayne Johnson** ✓

@TheRock



6.6 is strong. We felt a lil' movement here in the valley, but all good. Prayers to those in D valley, Bakersfield, S Valley, Kern etc. Be safe, stay prepared. [#mothernature](#)

♡ 15.3K 11:09 AM - Jul 4, 2019



💬 2,170 people are talking about this



**Lana Del Rey** ✓

@LanaDelRey



That was a huge one

♡ 83K 10:38 AM - Jul 4, 2019



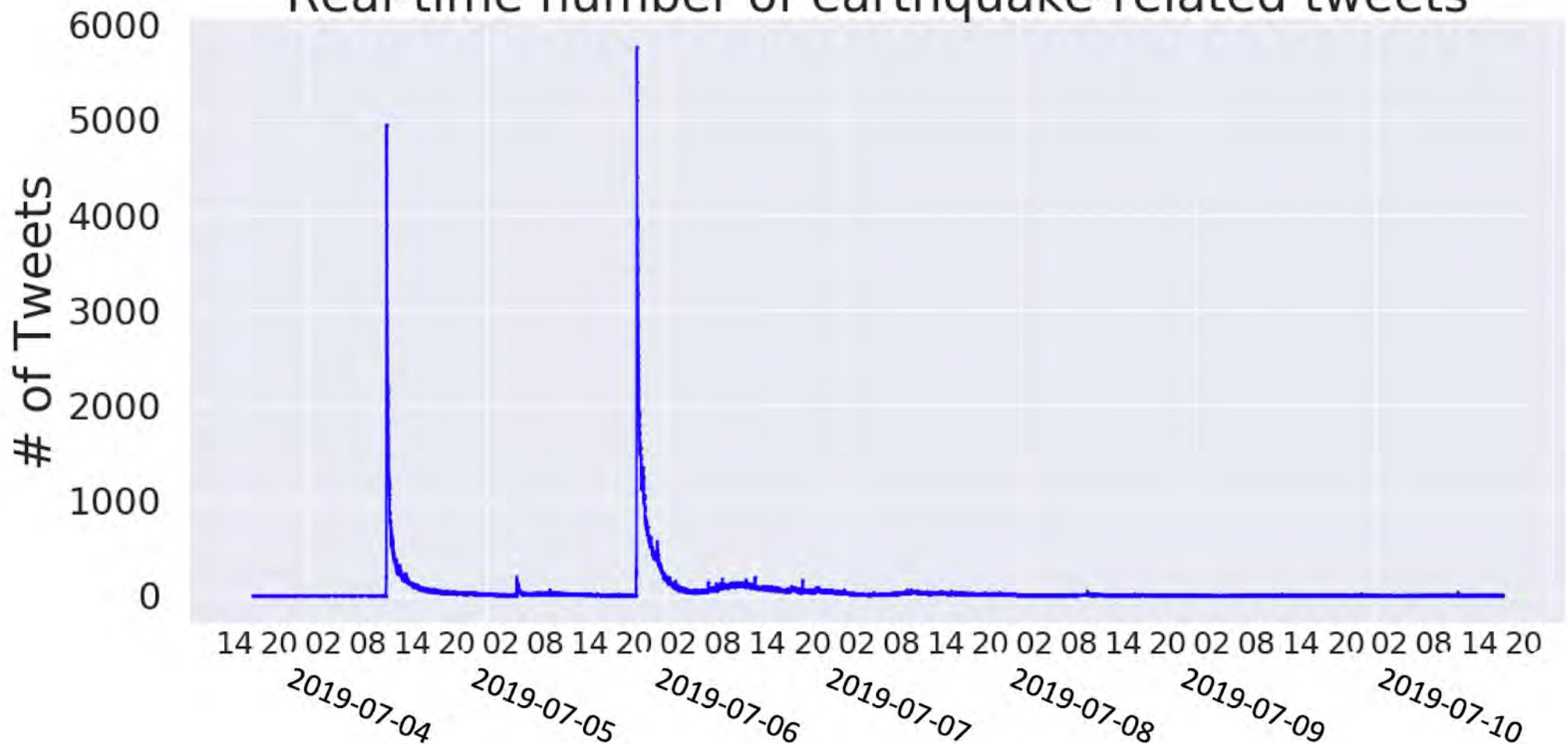
💬 12.9K people are talking about this



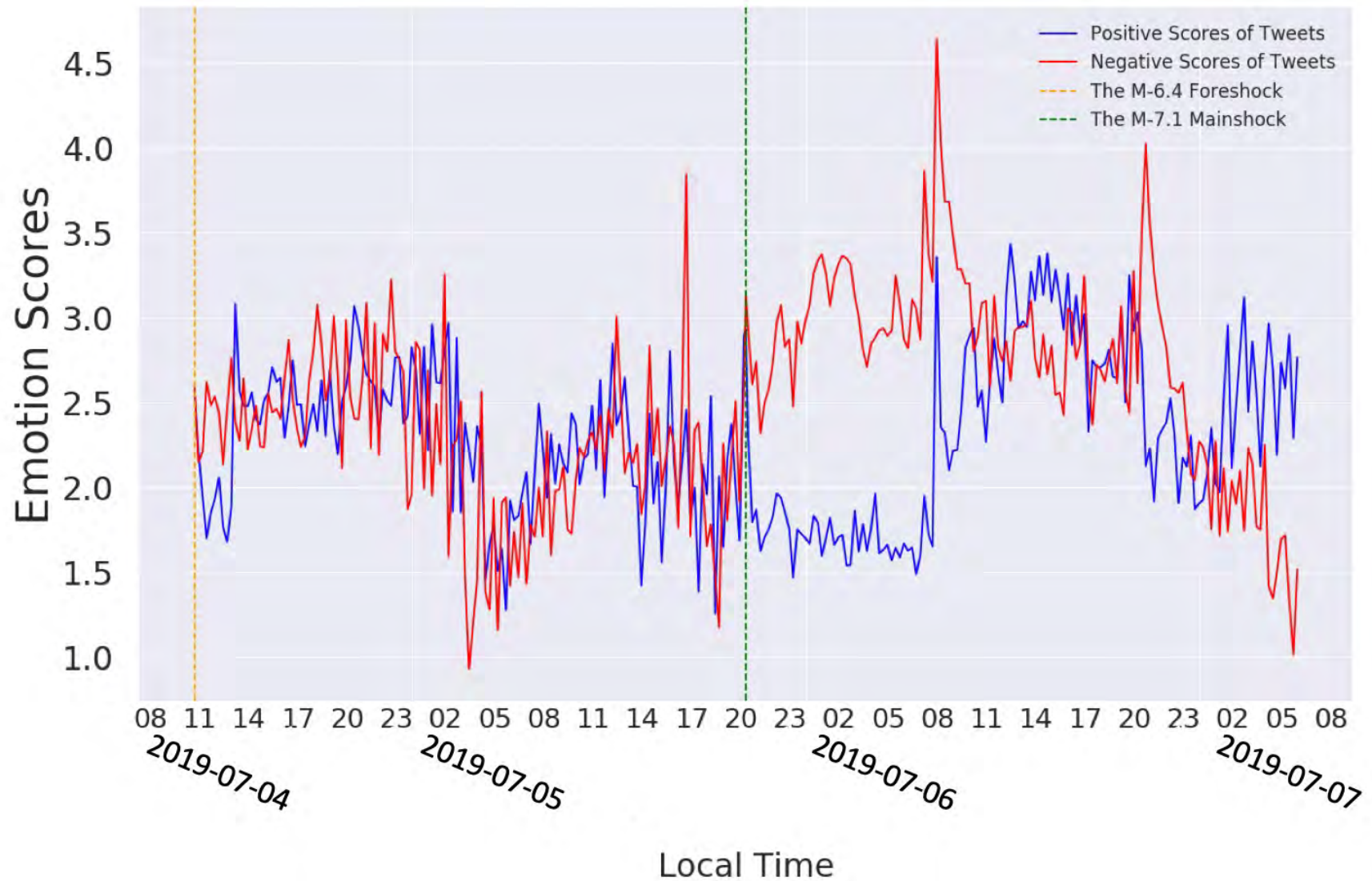


# Clearly see the response

Real-time number of earthquake-related tweets



# Emotion response



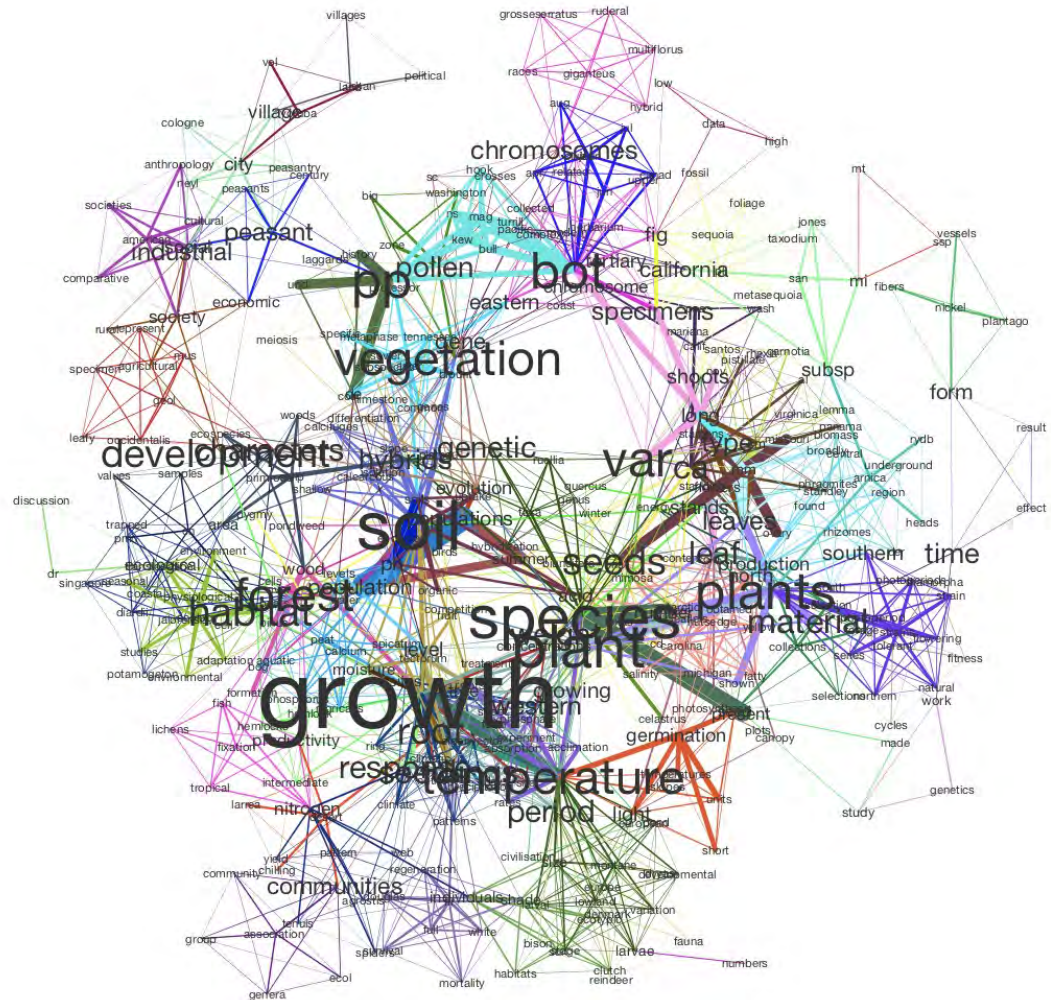
# Topic modeling

- Word Network Topic Model (WNTM)

It is clustering of the words in each document into different topics

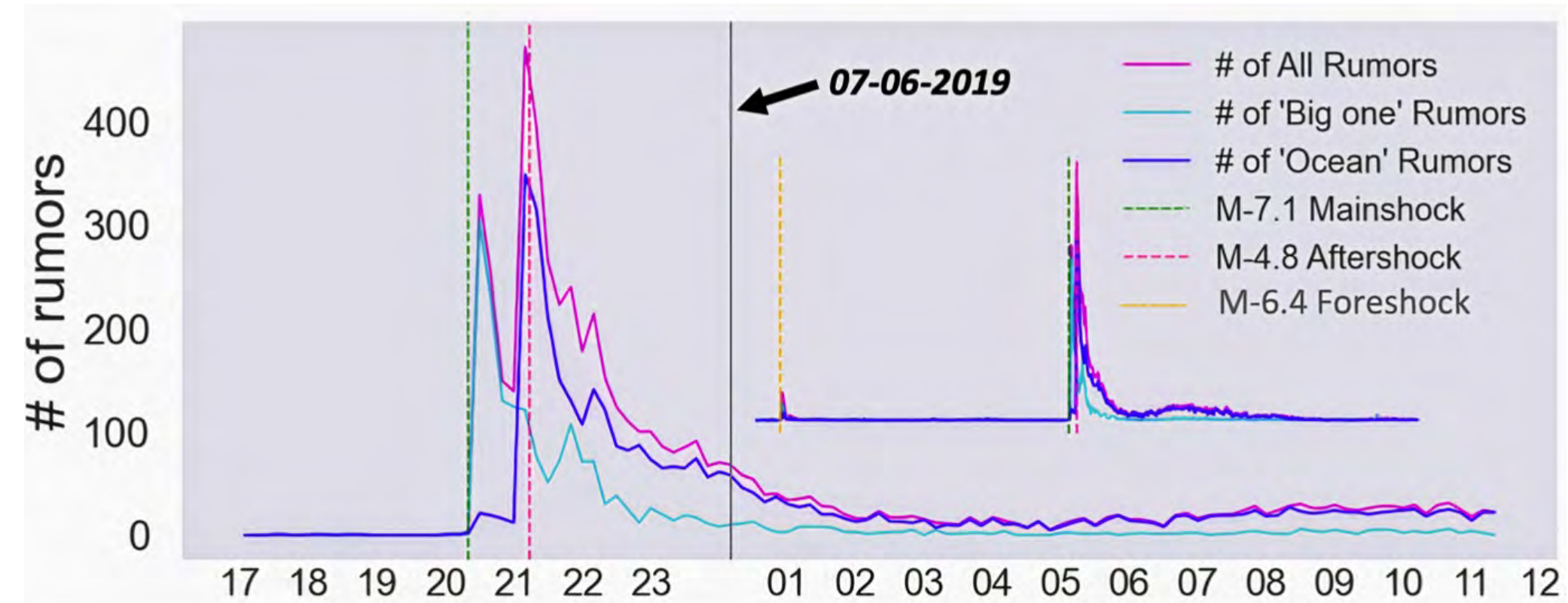
Assumption:

the semantics of two words will be similar if they tend to occur in similar contexts.



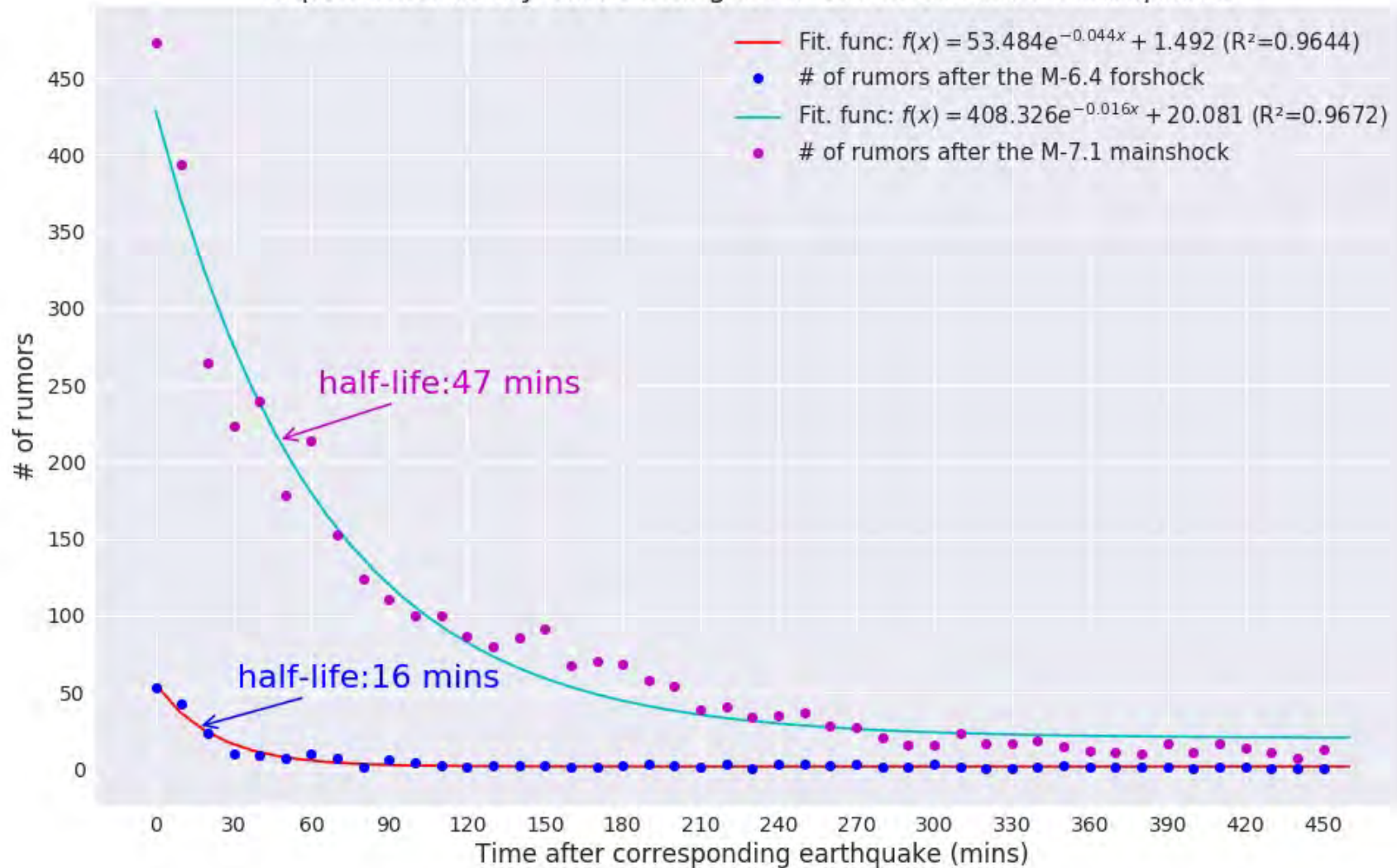


# Rumor analysis



# Rumor life span

Exponential decay curve fitting for # of rumors after earthquakes







Thank you!

