Using Social Media to Aid in the Refinement and Understanding of Seismic and Acoustic Ground Truth Information

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CTBT:
SCIENCE AND
TECHNOLOGY
2017 CONFERENCE

Vienna, Austria
June 27, 2017

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Outline

- Motivation

- Initial findings

- Integration of social media with seismic and infrasound data

- Example data sets

- Conclusions

- Future work

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Motivation

- Investigate validity of social media applications as an information source for non-earthquake seismic occurrences

  - Location (Lat./Lon.)

  - Approximate time of Event

  - Type of event? (i.e. explosion, meteor, bomb, etc…)

https://xkcd.com/723/
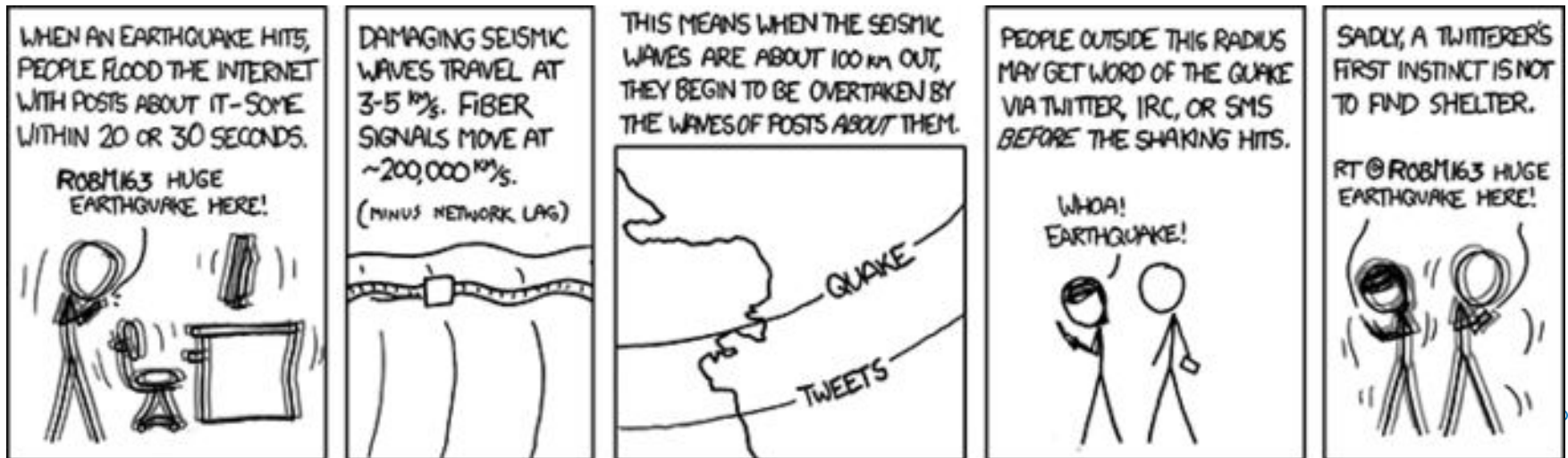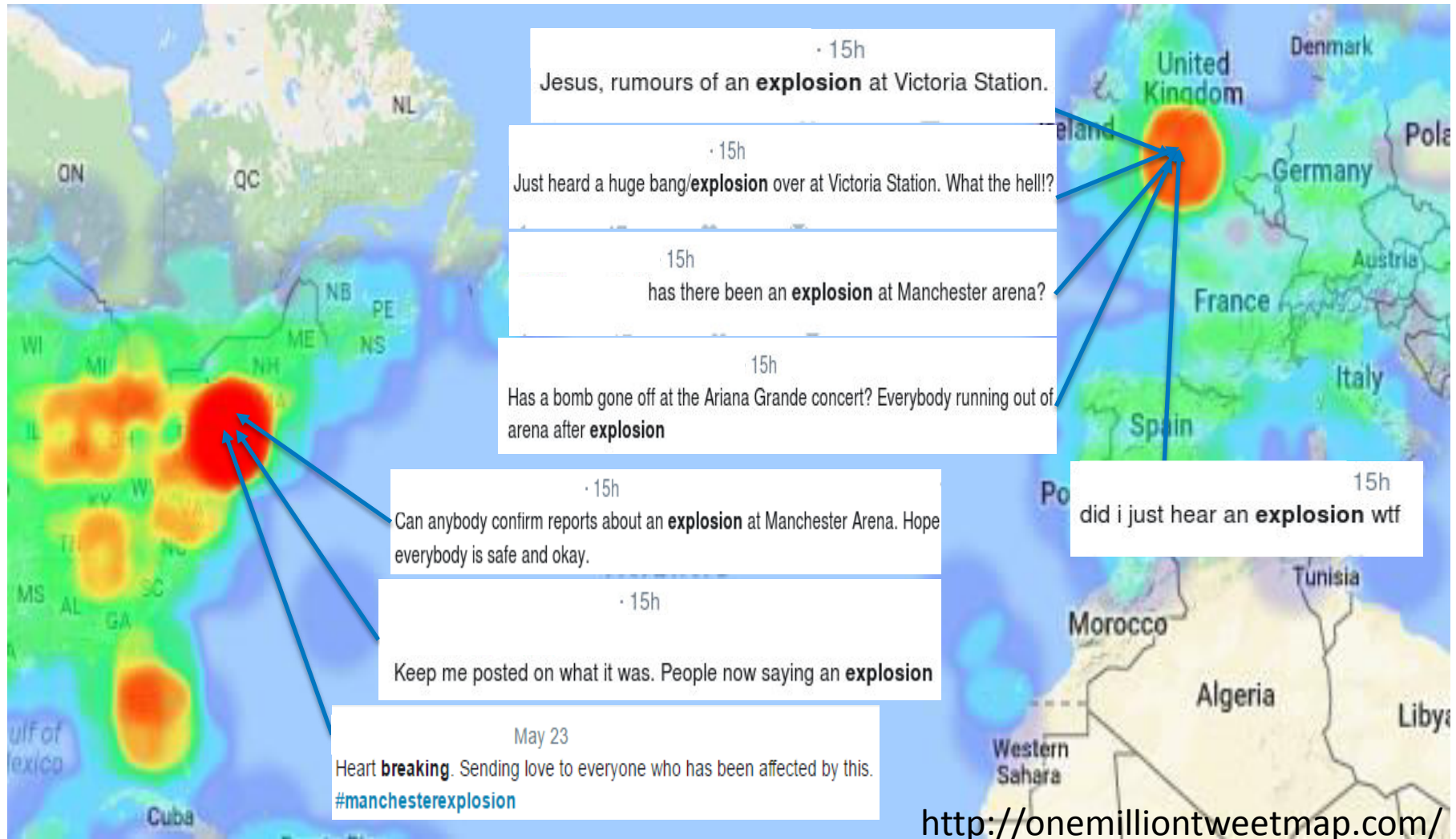
Initial Findings

- Only about 1 – 2% of social media users allow application to use location

- Users provide important information in regard to origin time, location and give clues about what the event is
  - Reliability?

- Many users repost to emphasize an event
  - Social media posts can drastically increase in a short amount of time
  - Photographs & news reports are often reposted
    - Multiple, repeated posts are not helpful for this purpose

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Anatomy of a Social Media Posting

```
{"created_at":"Tue May 23 12:20:09 +0000 2017",
"id":866992143965061133,
"text":"Manchester Arena: police raid flat and arrest 23-year-old man over arena
bombing that killed"
"user":{
"location":"Madrid",
"description":"Reading!",
  "followers_count":155,
  "location":"Madrid",
  "favourites_count":14,
  "created_at":"Mon Oct 17 20:21:17 +0000 2011",
  "utc_offset":7200,
  "time zone":"Madrid",
"geo_enabled":false,
  "lang":"en",
},
"geo":null,
"coordinates":null,
"place":null,
"contributors":null,
"is_quote_status":false,
"retweet_count":0,
"place":null, lse,
"retweeted":false,
"is_quote_status":false,
"retweeted":false,
```

- Twitter used as an example, other social media sites have similar construction of postings
- Considerable amount of information contained in a single posting
- What information can we extract from a message?

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Geographic Distribution – Heat Map

Jesus, rumours of an **explosion** at Victoria Station.
· 15h

Just heard a huge bang/**explosion** over at Victoria Station. What the hell!?
· 15h

has there been an **explosion** at Manchester arena?
15h

Has a bomb gone off at the Ariana Grande concert? Everybody running out of arena after **explosion**
15h

did i just hear an **explosion** wtf
15h

Can anybody confirm reports about an **explosion** at Manchester Arena. Hope everybody is safe and okay.
· 15h

Keep me posted on what it was. People now saying an **explosion**
· 15h

Heart **breaking**. Sending love to everyone who has been affected by this. #manchesterexplosion
May 23

http://onemilliontweetmap.com/
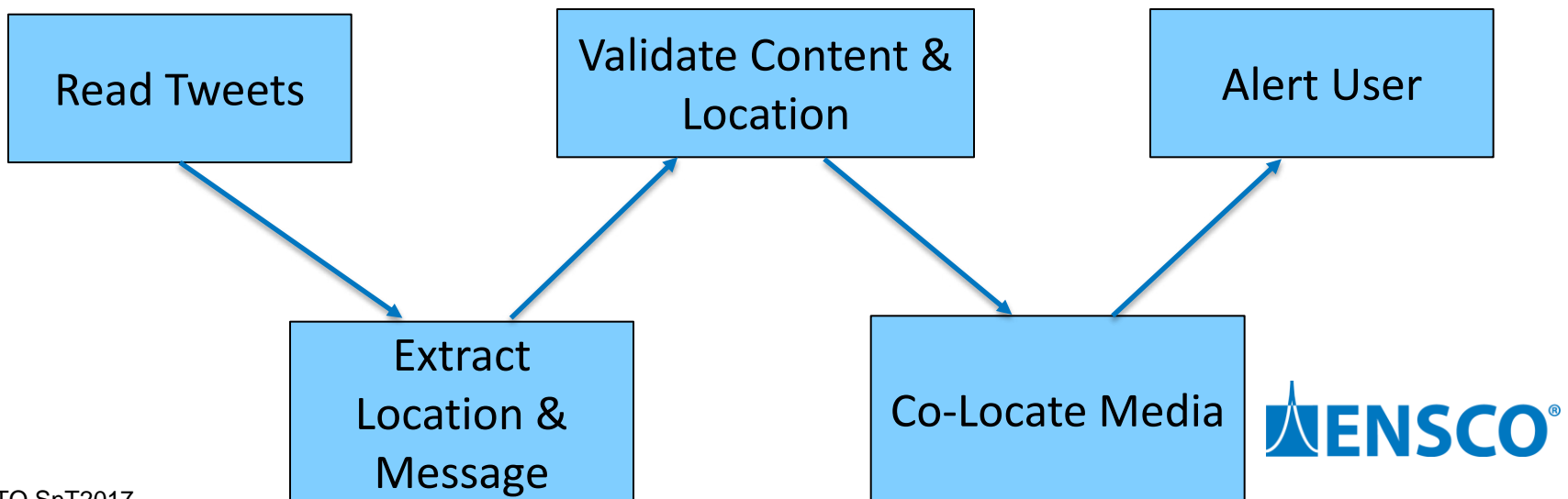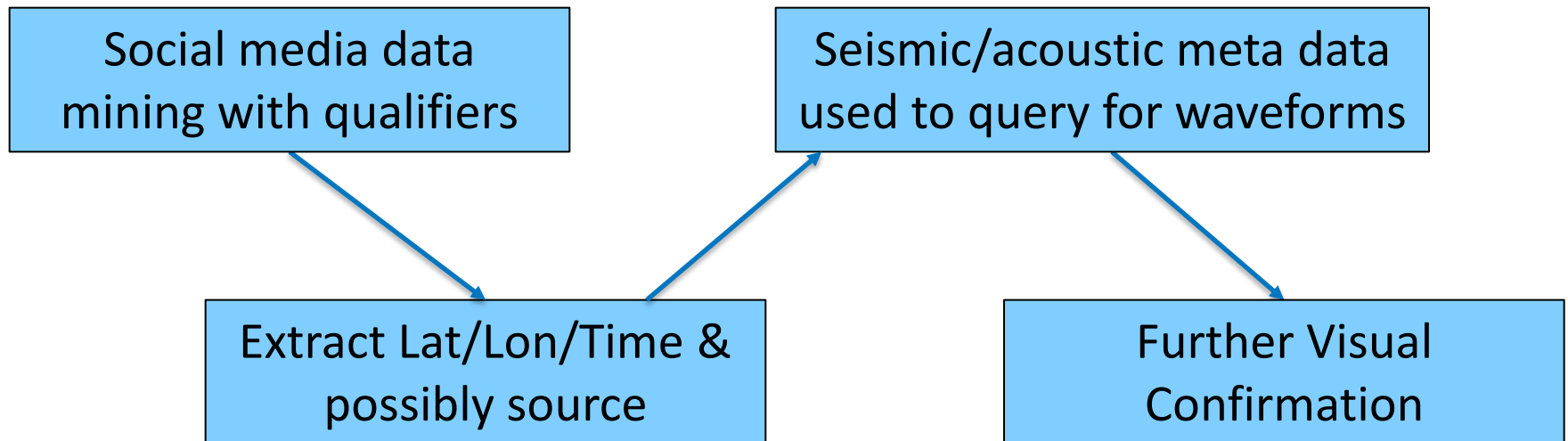
# of Posts

0-2   5-6   >10

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Evaluation of Messages to Extract Key Data

- Multiple parameters, in various languages, are varied to create the optimum query
  - Explosion, Bomb, Bolide, Meteor, etc…
- Test that location is within 1 degree and time < 4 hours determine an event has occurred
  - Co-locating media posts using location and place names
- Reposts/empty posts/ favorited posts/ blocked users rejected
- Message text scanned for associated terms and blocked terms rejected
- Generate bulletin of relevant events and notify users

```
Read Tweets  →  Extract Location & Message  →  Validate Content & Location  →  Co-Locate Media  →  Alert User
```

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Processing Flow

- Adjudication of media information can be complex because of reposting & favorites
- Identification of location is key, utilize geocoding and entity extraction when necessary
- Once criteria are met, initiate data gathering on public published interfaces

Social media data mining with qualifiers	Seismic/acoustic meta data used to query for waveforms

Extract Lat/Lon/Time & possibly source	Further Visual Confirmation

- Visual confirmation to determine seismic event may not be available

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Terrorist Bomb Explosion Kabul Afghanistan May 31, 2017

{"latitude":29.377472,"longitude":60.478443,"time":"Wed May 31 03:54:19 +0000 2017","location":"Kabul, Afghanistan","msg":"Breaking: huge **#explosion** heard in #Kabul. Stay safe."}

{"created_at":"Wed May 31 03:55:23 +0000 2017","text":"Massive **explosion** just shattered all the windows and glass in our bureau #Kabul,"location":"Afghanistan"}}

{"created_at":"Wed May 31 03:56:47 +0000 2017","id":869507879715438592,"id_str":"869507879715438592","text":"#Break **#Explosion** in Kabul PD11","location":"Kabul Afghanistan"}}

- Obtained messages relating to a possible explosion on May 31st in Kabul

- Incorporated social media meta-data to seismic datacenter query

- Seismic data were retrieved in minutes
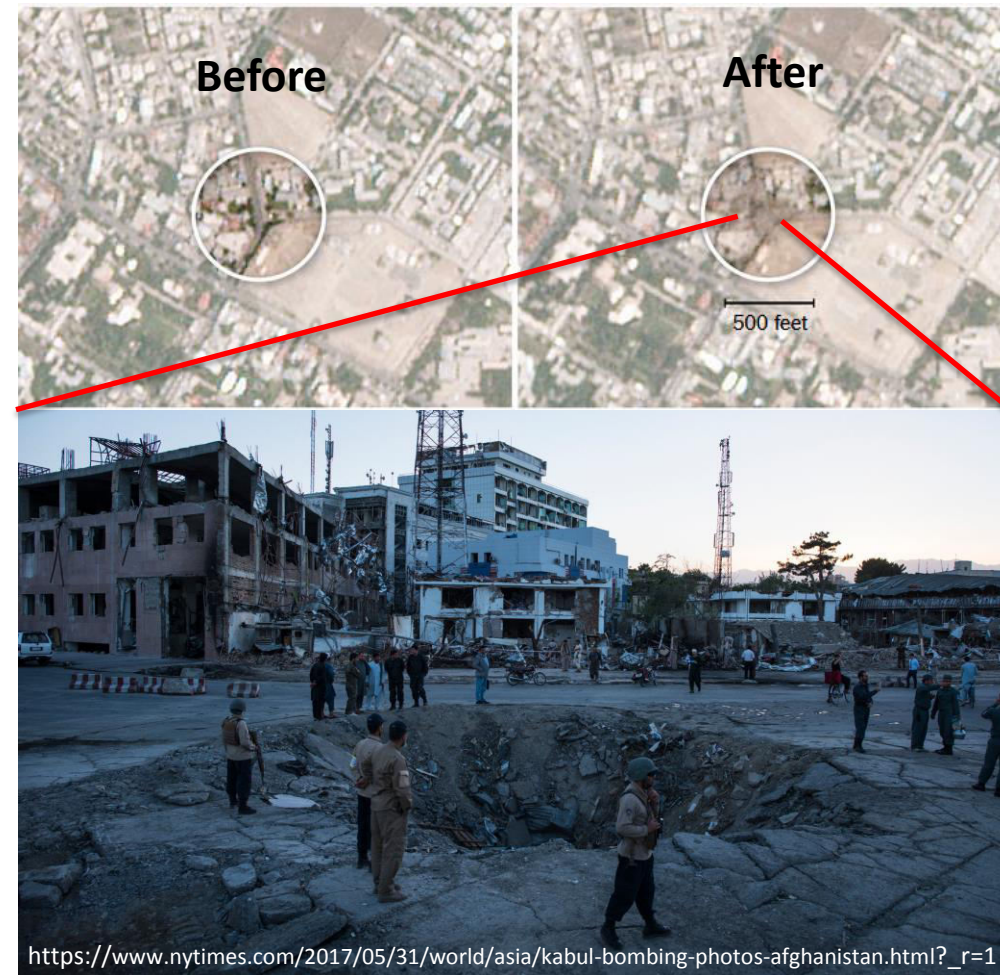
Located Event Origin time: 03:52:18 GMT
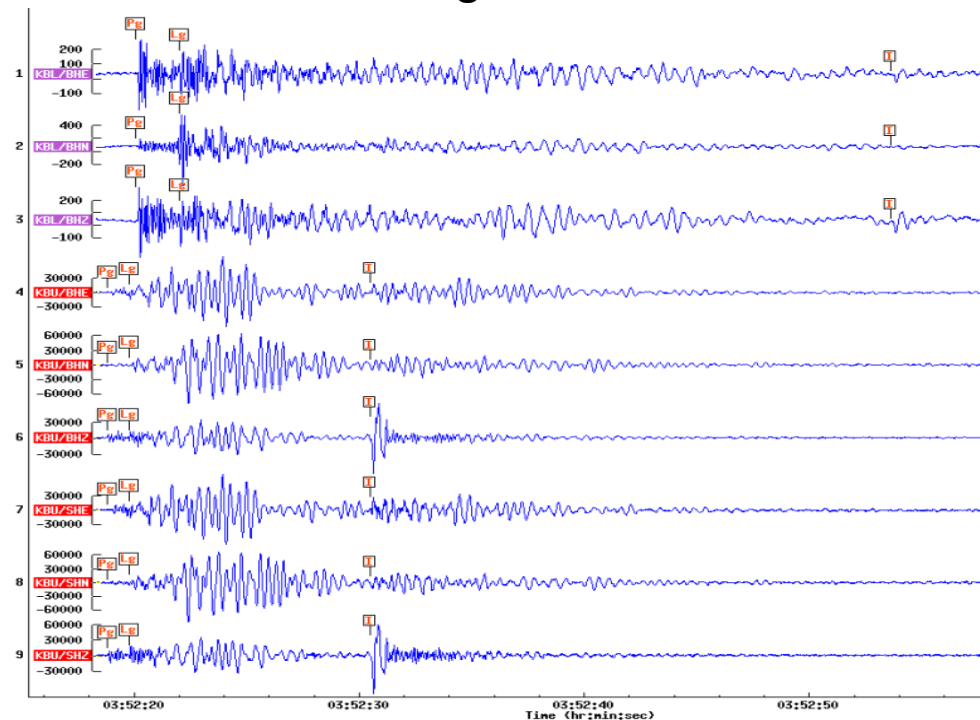
Kabul May 31, 2017 Continued

- Original messages occurring within ~ 2 minutes of determined origin time

- Reposting of messages commences at ~8 minutes

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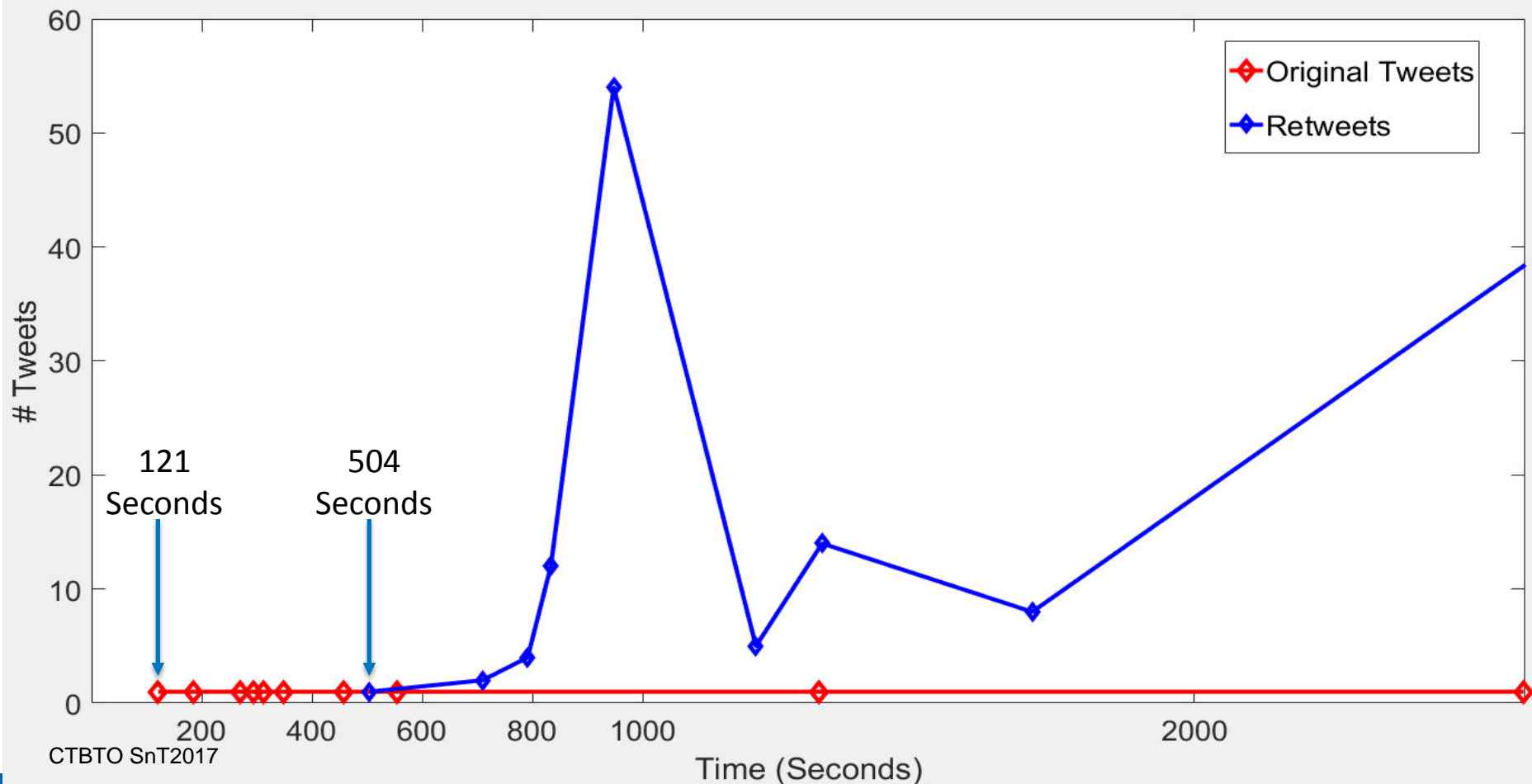
Using News Media for Visual Confirmation

- Use media sources in conjunction with seismic data to confirm location and type of event

Before

After

500 feet

https://www.nytimes.com/2017/05/31/world/asia/kabul-bombing-photos-afghanistan.html?_r=1

Kabul

N

Seismic Location

Blast

~830m

Shahre Naow

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Gas Explosion
Marengo, Illinois, USA June 11, 2017

- Mixed reports of Earthquake versus Explosion

Jun 11 → 09:54:52

The whole house just shook and we heard it as well... Was that just an earthquake? Haven't felt one in years...

Jun 11 → 09:55:29

Did an #earthquake just hit NW Illinois?

· Jun 11 → 09:57:33

I think we just had an earthquake

· Jun 11 → 10:16:01

Or it was a house explosion apparently so that's a good way to start the day

Jun 11 → 10:28:11

Wish these sites, accounts, and apps for places that had an #earthquake would tell me that what we felt was in fact an earthquake!

Jun 11 → 10:30:58

Huge explosion here about 35 minutes ago. No idea what it was other than ay some distance perhaps several miles.

· Jun 11 → 10:35:28

Any coverage on house explosion in **Marengo** at about 4:52 AM today? The boom/jolt was felt as far as West Dundee and SE Rockford

Jun 11 → 10:56:06

Noise I reported earlier was from **Marengo**, 4 miles away. Scene of explosion: m.facebook.com/photo.php?fbid...
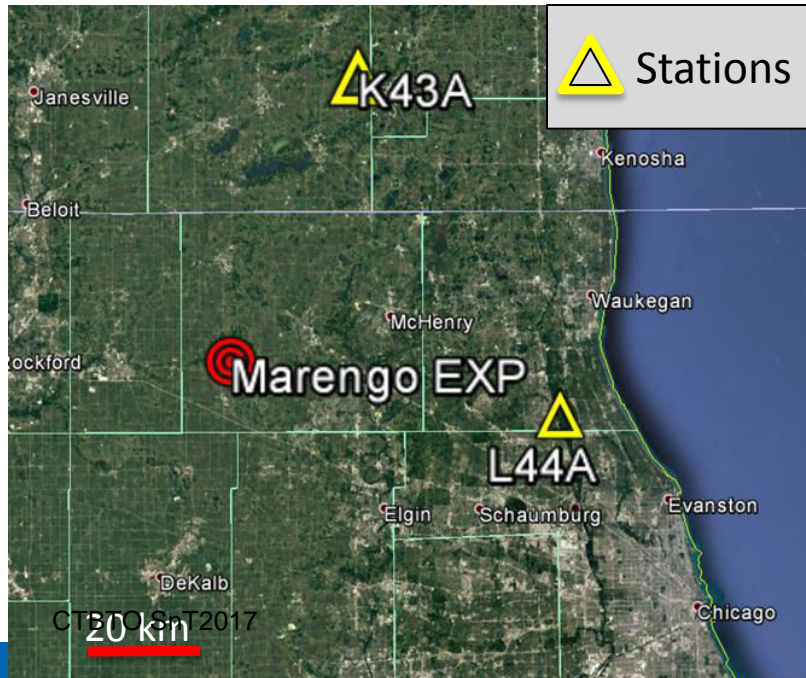
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- Explosion terminology came in secondary to Earthquake references
- Only acoustic arrival ('I' phase) recognized
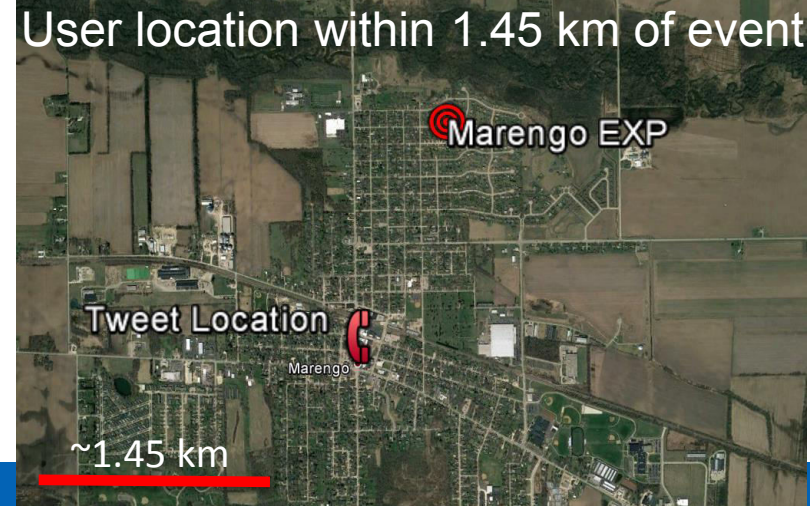- Indication of non-coupled source
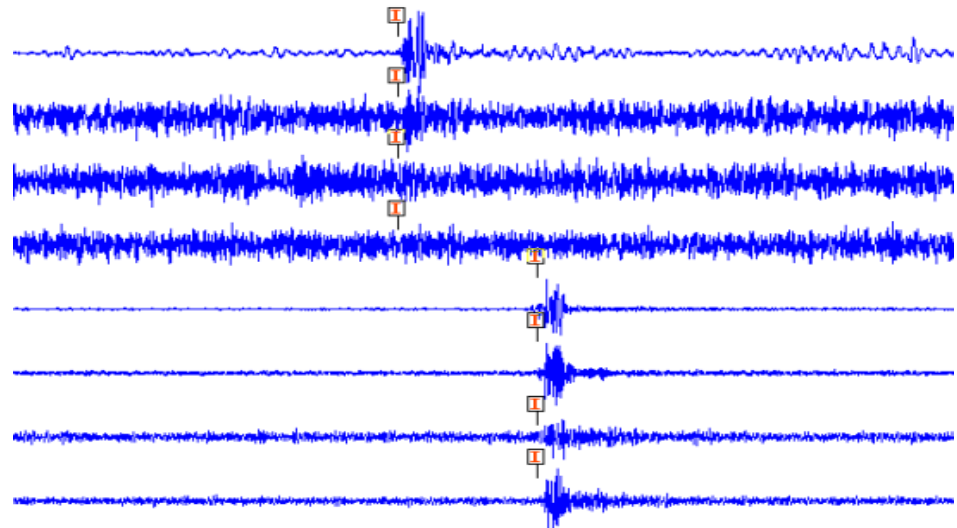
Extracting Supplemental Information

Imagery obtained from news media aids in the discovery of the source location

After

N

Source: http://www.dailyherald.com/news/20170611/drone-photos-show-descruction-to-Marengo-homes-after-explosion

Before

N

Source: Google Earth

K43A

⚠ Stations

Janesville
Kenosha
Beloit
Waukegan
McHenry
Rockford
Marengo EXP
L44A
Elgin Schaumburg Evanston
DeKalb
Chicago

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20 km

Using acoustic travel time of 300m/s get origin time of ~09:49:06 GMT △ ~5.75 min from first post

User location within 1.45 km of event

Marengo EXP

Tweet Location

Marengo

~1.45 km

Conclusions

- Added value of using social media data sets
  - Can provide independent information about a seismo-acoustic event
  - Location Refinement
- Ability to tailor queries to seismo-acoustic event of interest (Explosions, Bombs, Bolides etc…)
- Approach was successful in constraining origin time for:
  - Kabul Afghanistan, May 31, 2017 explosion
  - Marengo, IL, USA, June 11, 2017 gas explosion
- Take advantage of search capabilities to retroactively query for terms such as earthquake or shaking
- Process can be applied to various social media outlets

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Future work

- Integrate geocoding and entity extraction from social media text to better constrain location

- Using social media posts to prompt automatic retrieval of waveforms

- Incorporate user interface for visual representation of the social media data for each event

- Use suspected origin time from social media to populate seismo-acoustic data with respective arrivals

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Questions?