Web-based macroseismic intensity study in Turkey: entries in Ekşi Sözlük

Deniz Ertuncay[1], Laura Cataldi[1], and Giovanni Costa[1]

[1]University of Trieste, Department of Mathematics and Geosciences, via E.Weiss 4, 34128 Trieste, Italy

Correspondence: Deniz Ertuncay (dertuncay@units.it)

Abstract. Ekşi Sözlük is one of the most visited websites in Turkey. Registered users of the website share their knowledge about any topic. In this study, we collect the user entries on the topics of 20 earthquakes in Turkey and the surrounding area. Entries with city and district level information are converted to intensity values. ~~Shape~~ Shake maps of the earthquakes are created by using a ground motion to intensity conversion equation. User entries and created shake maps are compared. It is found that entries correlate with the predicted intensities. It is also found that local soil conditions and building types have an amplifier effect on entries in the web site. Several entries in the earthquake topics have magnitude estimations. Difference between predicted and observed intensities also vary with distance. Users are able to predict the magnitudes of the earthquakes with $\pm$ 0.54 misfit. This study shows that Ekşi Sözlük has a potential to be a reliable source of macroseismic intensity for the earthquakes in Turkey, if the felt reports ~~have been~~ are collected with a predetermined format.

1 Introduction

Many national seismic data providers (Agencija Republike Slovenije Za Okolje - ARSO, 2020; British Geological Survey, 2020; Sbarra et al., 2010; Swiss Seismological Service, 2020; Zentralanstalt für Meteorologie und Geodynamik — ZAMG, 2020) along with international organizations (European-Mediterranean Seismological Centre (EMSC) Bossu et al. (2017), United States Geological Survey (USGS) Wald et al. 2012) collect web-based macroseismic survey data. Various questions are asked in form of a questionnaire to the individuals who are willing to share their experience after an earthquake. The answers are then converted to macroseismic intensity scales, and felt maps are created as an end product of the earthquake. The data may be collected continuously as in EMSC and USGS as well as after a specific earthquake (Bossu et al., 2008, 2015; Goltz et al., 2020; Liang et al., 2017).

In Turkey, Disaster and Emergency Management Presidency of Turkey (AFAD) is the only data collector for macroseismic intensity. However, felt reports of AFAD are rare and lack location information. On the other hand, Turkish data providers were the 7th largest data providers (3rd in Europe) to EMSC in 2018.

Social media data are used also for earthquake science (Crooks et al., 2013; Earle et al., 2010, 2012; Mendoza et al., 2010; Robinson et al., 2013). Integration of multi language social media data provides additional information about the earthquake location in near real time (Zielinski et al., 2012). Twitter was used in Sichuan earthquake to have rapid information about the earthquake (Li and Rao, 2010). In 2011 Tohoku earthquake, Twitter provided rapid spread of information about the earthquake

(Miyabe et al., 2012). Arapostathis et al. (2018) revealed that intensity maps created using Twitter data has high correlation with predicted intensity maps for 2017 Lesbos earthquake. Fayjaloun et al. (2020) integrated Twitter data with strong-motion recordings to compare felt area predicted by shake maps and real observations in France.

Internet users in Turkey are also sharing their experiences on earthquake in other websites such as Ekşi Sözlük (www.eksisozluk.com). Ekşi Sözlük is a collaborative dictionary. To be a full member of the website, newly registered users are required to write 10 entries in existing topics. Then the entries are analyzed according to the rules of the site. By doing that Ekşi Sözlük provides relatively reliable information to the visitors. It was the 14th most visited website in Turkey in 2019 (Alexa Internet, 2020). Even though there are entries with other languages, the main language used on the website is Turkish. Users of the website create topics for earthquakes that they have felt and also for major earthquakes occurring around the world.

In this study, we have collected entries from various major earthquakes in western Turkey. Entries which provide city and district information are analyzed. Macroseismic intensity maps are created for the earthquakes by using the magnitude information. Analyzed entries are compared with predicted intensities. Furthermore we collect the magnitude guesses of the users and compare them with the real results.

2 Data

Earthquake information of origin time, magnitude, latitude, longitude and depth of the events are gathered from EMSC and Kandilli Observatory and Earthquake Research Institute Regional Earthquake-Tsunami Monitoring Center. These information are used for the shake map creation (Section 3) and distance calculation between the epicenter and districts of the entries.

To analyze the entries in the earthquake topics, 20 titles with the highest number of entries for earthquakes that have occurred in western Turkey and the surrounding area are selected (Table 1). Western Turkey is chosen due to higher access to the internet (Turkish Statistical Institute, 2019). Entries that provide location information in district levels are filtered. These entries are labelled according to the modified Mercalli-Cancani-Sieberg (MCS) scale (Sieberg, 1930). MSC scale is a way of describing the effect of an earthquake. Intensity of an earthquake can be determined for a site of interest. Unlike the magnitude of an earthquake, intensity value (I) can be change depending on various parameters such as epicentral distance, local soil conditions, and building type. For instance, I (MSC) class 1 which is the lowest class means that the earthquake is not felt except by very few under especially favorable conditions whereas class 12 which is the highest class means a total destruction. Several entries also provide a guess of the magnitude of the earthquake.

Topics are created almost immediately after the arrival of S waves which produce bigger amplitudes than P waves. In other words, it creates larger ground motions, hence it is easier to be noticed by humans. Several topics are created for some earthquakes that are widely felt in many regions. Moderators of the website combine the topics into the proper topic title which is in general the date of the earthquake and the nearest major city or the name of the sea to the epicenter. Topics are created with the same format, which is provided below:

10-aralik-2019-balikesir-depremi–6277350

day-month-year-location-earthquake–topicID

When an aftershock is felt, the entries indicate the existence of an aftershock. In these cases, we subdivided the earthquake to multiple earthquakes by adding a number to the end of the topicID. Several MCS labels, along with the entry, can be seen below:

Topic: 20-aralik-2018-yalova-depremi–5881852

Entry: “I felt it in Gebze (Kocaeli) but I was the only one.

Lights are not swinging, none of my family members have felt it."

I (MCS):1

Topic: 20-subat-2019-canakkale-depremi–5947040

Entry: “I felt it strongly. I think it was M4.4 . . .

I (MCS):2

Topic: 30-kasim-2018-yalova-depremi–5861331

Entry: “I thought my neighbor downstairs hit the ceiling of their

apartment with a hammer . . . "

I (MCS):3

Topic: 26-eylul-2019-istanbul-depremi–6191375

Entry: “We saw the rattling windows not only in our office building

but also on the neighboring building. I tried to walk forward but instead

I staggered backwards . . . "

I (MCS)4

Topic: 6-subat-2017-canakkale-depremi–5296414

Entry: “We felt it stronly. We evacuated the office building."

I (MCS):5

Topic: 26-eylul-2019-istanbul-depremi–6191375

Entry: “I was at Avcılar. I saw falling parts from a building . . . "

I (MCS):6

Hereafter, earthquakes are represented by their topicID. In Table 2, we present information about the entries. 5392358 is excluded from further analysis due to lack of entries.

3 Method

For each event, analyzed entries are compared with reference instrumental intensity values. Instrumental intensity is a forecast of the macroseismic intensity and is ~~obtained~~ calculated as a function of input ground motion parameters. Instrumental intensity is defined following the methodology from Cataldi et al. (in prep.).

First, ~~the empirical relationship between intensity and PGV and PGA values is estimated on a different~~ instrumental intensity is defined using an independent dataset, relative to 90 ~~($M_l > 3.4$)~~ events occurred in Italy between 1972 and 2016, with local magnitude over 3.4. The definition consists of extracting an empirical relationship between observed intensity and ground motion parameters, namely the peak ground velocity (PGV) and peak ground acceleration (PGA). PGV and PGA are observed from ground motion records. Integration and/or differentiation of the seismic record is done depending on the seismic recorder and then the two parameters are measured. Ground motion parameter values are extracted from the dataset (Gallo et al., 2014) and are correlated with expert-assessed intensity values taken from the Italian Macroseismic Database (Locati et al., 2016). The regression is performed using Gaussian Naïve Bayes (GNB) classifiers. This methodology provides a full probability distribution over integer intensity classes. In other words, for each input parameter value, probability of occurrence is calculated for I classes. The intensity forecast is then taken as the class with the highest associated probability.

Second, a piece-wise function, relating ground motion values to intensity, is extracted from the GNB results obtained for the Italian dataset, so that each forecasted ~~intensity class (I)~~ I class is associated to a specific range of ground motion parameter values. For ~~PGA and PGV~~ PGV and PGA, the used intervals are presented in Table 3.

As for the events reported in Table 1, ~~peak ground velocity (PGV) and peak ground acceleration (PGA)~~ PGV and PGA values are calculated from information on seismic origins using ground motion prediction equations ~~. These values~~ (GMPEs). GMPEs are set of equations that allow us to predict the ground motion parameters based on various earthquake and site-related information. Values obtained through GMPEs are then assigned to the corresponding I class according to Table 3. The PGA-based function is used for events with $M_w < 5$, the PGV-based one is used for events with $M_w > 5$.

4 Results

All topics are analyzed with the methods explained in Section 2 and Section 3. 4 of them are represented in this section. ~~Maps of all the earthquakes can be found at of the study.~~ We compare the computed intensities with the entries; and we also compare them with the EMSC felt report maps. Furthermore, magnitude guesses are compared with the measured magnitudes.

4.1 12 June 2017 Lesbos Earthquake

12 June 2017 Lesbos earthquake, $M_w = 6.2$, (topicID: 5388936) had occurred south of Lesbos island and was felt largely in Turkey. İzmir is the closest city to epicenter of the earthquake, thus topic is created as 12 June 2017 İzmir earthquake in Ekşi Sözlük. There are 151 of entries with city and district information. Farthest felt entry is from Pursaklar district ($\approx$580 km) of Ankara (MCS = 1). Entry with largest MCSs are from Konak ($\approx$80 km), Karaburun districts (27 km) of İzmir and ~~Yunusemre~~ Yunus Emre district ($\approx$85 km) of Manisa (Fig. 1). In Karaburun district, user overbalanced during the earthquake with many others inside the government office. Cracks on walls and columns of the buildings are reported in two entries. Intensity map has strong correlation with the labelled maximum MCS scale. Minimum MCSs are hard to interpret since some of the entries contain only words such as "strongly felt", which is labelled as MCS = 2. Such entries lowered the average MCSs. Hence we preferred to rely on maximum MCS labels.

A large amount of entries are written in İstanbul (Fig. 2). Almost all districts of the city have maximum MCS of 2 except Avcılar district which has 3. This can be linked ~~with~~ to the loose soil of Avcılar district of İstanbul. Avcılar district was affected by the $M_w = 7.4$ İzmit earthquake of 1999. More than 10 % of the buildings were either destroyed or damaged in the earthquake (Tezcan et al., 2002). It is due to the amplified shaking and soft sediments in the district (Tezcan et al., 2002; Ergin et al., 2004; Akarvardar et al., 2009).

There are 635 felt reports at AFAD for the earthquake. It is hard to interpret the data due to lack of location information of the earthquake. There are intensity values of 11 in several reports which is highly unlikely for magnitude 6.2 earthquake. EMSC have 755 felt reports for the earthquake (Fig. 1). Intensities in EMSC are larger than the ones in Ekşi Sözlük. There are intensity 5 reports in far away cities such as İstanbul and Sofia which is unlikely. Furthermore, there are various intensity 10+ in EMSC in İzmir. However, there is no report that supports such destruction in İzmir. Various masonry buildings have cracks on their walls but none of them have collapsed (9 Eylül, 2017).

4.2 25 August 2019 Ankara Earthquake

25 August 2018 Ankara earthquake, $M_l = 3.5$, (topicID: 6155192) had occurred south of ~~Kecioren~~ Keçiören district of Ankara and was felt locally in the city (Fig. 3). There are 129 entries with city and district information. Depth of the earthquake is measured as 5 km. Even though there are large number of magnitude 3.5 earthquakes in Turkey, this was felt by many inhabitants since hypocenter was located beneath the city of Ankara and the earthquake had a shallow hypocentral depth. Due to the shallow depth, almost all districts provided relatively higher maximum MCS values.

There is no felt report in AFAD for the earthquake. There are 205 felt reports in EMSC (Fig. 3). Intensity measures of Ekşi Sözlük and EMSC are highly correlated for the earthquake.

4.3 26 September 2019 İstanbul Earthquake

26 August 2019 İstanbul earthquake, $M_w = 5.6$, (topicID: 6191375) had occurred south of Silivri district of İstanbul and was felt largely in İstanbul and the surrounding cities (Fig. 3). There are 233 entries with city and district information. A minaret of

a mosque in Avcılar district of İstanbul was collapsed (Hürriyet, 2019) and more than 450 buildings were damaged (Anadolu Agency, 2019). The earthquake provided the largest dataset with 233 comments with district level information on 12 cities. It is due to the fact that İstanbul is the most crowded city in Turkey and the earthquake happened in the daytime (13:59 local time).

In Silivri, ~~Buyukcekmece~~ Büyükçekmece and Avcılar districts, maximum MCS from the entries are labelled as 6. Intensity map predicts the MCS 4.5 for Avcılar district. Local soil conditions as explained in Section 4.1 may have a role on the exaggerated intensities in entries written in Avcılar.

In Beşiktaş district, maximum MCS of 5 is given in 3 entries. All of them are due to the evacuation of the buildings. Two of these entries are from high-rise office buildings, which probably caused extra panic due to the swing of the tall buildings. The evacuation also influenced by panic is also one of the reasons for the maximum MCS of 5 that is given to the entries from Fatih, Beyoğlu and Kadıköy districts. In Kartal district, MCS = 5 is due to the fallen objects from shelves.

There are 70 felt reports in AFAD for the earthquake with maximum intensity of 6, which is also the case in Ekşi Sözlük. In EMSC (Fig. 4) there are 2027 felt reports. In İstanbul, intensities are reported slightly higher with respect to Ekşi Sözlük. However, it is important to keep in mind that felt report in EMSC is designed for this purpose, whereas in Ekşi Sözlük, entries are written in free format. In general, EMSC and Ekşi Sözlük are correlated in Büyükçekmece and Avcılar districts. On the other hand, intensities are at least one grade lower in Ekşi Sözlük with respect to EMSC. There are large intensity values in cities such as Eskişehir ($d >$200 km) and Denizli ($d >$350 km). Large intensities in such far away distances for a $M_w = 5.6$ earthquake are unlikely.

4.4 10 October 2019 Yalova Earthquake

10 August 2019 Yalova earthquake, $M_w = 4.0$, (topicID: 6208576) had occurred north of Yalova and was felt in İstanbul and the surrounding cities (Fig. 5). There are 68 entries with city and district information. Most of the entries are coming from Kartal district of İstanbul and Gebze district of Kocaeli. In Gebze, maximum MCS is 5, which is due to the evacuation of a building with panic. The rest of the entries in Gebze are claiming 2 and 3. MCS scale is highly subjective on an individual's feelings on earthquakes. Thus, users in Ekşi Sözlük are writing their feelings without using any guidelines. As in this example, unexpectedly high MCSs may occur.

There is no felt report in AFAD for the earthquake. There are 1371 felt reports in EMSC (Fig. 5). Intensity measures of Ekşi Sözlük and EMSC are correlated in Gebze, Kartal, Kadıköy and Kücükçekmece districts. There are more datapoints in EMSC than in Ekşi Sözlük, which provides more information in different regions of the area, especially in the city of Yalova. There are several unexpectedly high intensity values for İstanbul in EMSC.

4.5 Magnitude Guesses

Users in Ekşi Sözlük also provide magnitude information depending on their feelings. We include entries without location information. In various entries, the magnitude is guessed with a semi-infinite range, such as "…it was at least 4.8" in 20 February 2019 Dardanelles earthquake (topicID: 5947040), or it is guessed within a full range, such as "…it is between 2-3

. . . ” in 10 December 2019 Balıkesir earthquake (topicID: 6277350). In semi-definite guesses, given edge value is considered. The average of the range is used when it is provided.

Measured magnitudes along with the user guesses can be seen in Fig. 6. The average misfit between guessed magnitudes and measured magnitudes is 0.54. We also examine the earthquakes with at least two guesses. Misfit is calculated, again, 0.54. However, it is important to keep in mind that, guesses with range are averaged and various guesses are semi-definite.

5 Discussion and Conclusion

In this study, we gather entries from earthquake topics in Ekşi Sözlük. In the topics, users discuss the earthquake and their experiences. We filter the entries with city and district level information that can be converted to MCS scale. When there is an aftershock, it is discussed in the same topic on the website. In such incidences, we divide the topic into sub topics.

In total 27 earthquakes are chosen for the analysis. Intensity maps are created for the earthquakes and correlation between the predicted intensities and the entries which were converted to intensity values are roughly interpreted. The values are mapped to the districts of Turkey due to lack of precise location information. Interpretation is done over maximum MCSs. Uncertainty of the data points in terms of location varies depending on the epicenter of the earthquake and the positioning of the governmental district.

To have an insight of the relation between the predicted MCS and observed MCS, a rough relation between the two parameters and the distance is analysed. Observation points are labelled with their districts. However, the district is most likely to have more than one intensity inside its border depending on the epicentral distance from the earthquake and the border of the district (Gebze district in Fig. 5 has 3 different MCS values inside its border). To overcome this problem, we have calculated the centroid point of each district and treated the district as a point.

We have calculated the residuals of MSC differences between the predicted and observed values (Fig 7). To do that, we binned the distance between the epicenter and the centroid points with $10\,\mathrm{km}$ intervals from $0\,\mathrm{km}$-$100\,\mathrm{km}$. We combined more distant points with +$100\,\mathrm{km}$ label. Weighted average of average MSCs are used for the residual calculations. Asymmetric errors are calculated by using the minimum and maximum MSC value for each bin and the predicted MSC. If all data points have the same MSCs, then errors are not calculated. A line is fitted to residuals when more than one data is associated in different bins.

It is found that residuals tend to increase with increasing distance. In longer distances, MSC values are more likely to be 1. When there is an entry which states the feeling of the earthquake, it is more likely to have MSC value of 2. This is due to the fact that it is hard to distinguish between MCS 1 to MCS 2 by analyzing the entries. Lack of resolution in terms of expression of the experience limits our distinction levels of intensity. The website is not dedicated to provide exact information on earthquakes.

Furthermore, population distribution of districts are mostly heterogeneous. An example can be seen in Section 4.3. Silivri district of İstanbul has all of its EMSC data from the coastline. However, its centroid position is located in northern part of the district, for which MSC value is one integer lower with respect to the highly populated coastal area.

In 10 October 2019 Yalova Earthquake, aftershocks (6208576-2, 6208576-3, 6208576-4) mostly have 1 of residuals. City of İstanbul and Kocaeli have many reports with MSC = 2. However, all the centroid points of the districts is in MSC = 1 area.

Despite not having the exact location and subjective feelings of the users, it is found that the district with loose soils have relatively bigger maximum MCS values. Avcılar district in İstanbul has the highest MCS value (MCS = 3) for the Lesbos earthquake (Section 4.1) in the city. In the İstanbul earthquake (Section 4.3), Avcılar also has the highest MCS (MCS = 6) with respect to other districts with the same epicentral distance. Avcılar district has suffered during 1999 İzmit earthquake due to the amplified shaking and soft sediments in the district (Tezcan et al., 2002; Ergin et al., 2004; Akarvardar et al., 2009).

Entries that are written from high-rise buildings were affected more due to these buildings' tendency to amplify the motions of longer periods (eg. Beşiktaş district in the İstanbul earthquake). Another reason for higher intensities with respect to the predicted ones, is the evacuation of buildings, even if it is not necessary. There are unexpectedly high intensity values in various districts both in İstanbul and Yalova earthquakes.

In 20 August 2019 Ankara earthquake (6148327), there is a large gap between the predicted and observed MSCs. It is due to the fact that people of city of Ankara are not used to feel an earthquake with respect to seismically active cities such as İzmir, İstanbul and Yalova. Moreover, the epicenter of the earthquake is close to the city center.

Effect of epicentral depth in small earthquakes can be seen in Ankara earthquake (Section 4.2). Districts of Sincan, ~~Yeni Mahalle~~Yenimahalle, Mamak and Çankaya have at least one degree higher maximum MCS than the predicted ones.

We also analyzed the magnitude guesses in entries with the measured magnitudes. Users of the website try to guess the magnitudes, most probably, by comparing their experiences with previous earthquakes. Users live in seismically active regions such as ~~Istanbul~~İstanbul, Dardanelles and ~~Izmir~~ İzmir are more likely to feel more earthquakes that are occurred in different epicentral distances and magnitudes. On the other hand, users live regions with lower seismicity, eg. Ankara, do not have large number of experiences. Users lives in the latter case may think that when they feel an earthquake it must be a major one since they do not know the feeling of low magnitude earthquake. Even though there are good matches in some of the earthquakes, in most of the cases magnitudes are guessed with 0.54 misfit.

In conclusion, entries in Ekşi Sözlük can provide intensity distribution of earthquakes with limits. Entries are written in free form which creates uncertainties in the MSC labeling process. Entries do not reveal the exact position of the data provider which makes it hard to analyze the differences between observed and predicted MSC values. Despite the limitations, gathered data have similarities with the predictions. The website can provide near real-time intensity information after an earthquake.

5.1 Future work

Ekşi Sözlük has a potential to provide a wide variety of information through collaboration with the scientific community. Fast response time of the users may be useful for having early information about the intensity distribution. In case of a collaboration, a questionnaire can be embedded to the earthquake topics, which would homogenise the data that users write as entries. Depending on the privacy policy of the website and allowance of a higher precision data in terms of location and building information of the users, high resolution intensity maps can be created.

Code and data availability. Python codes that are used to retrieve the user comments, dataset and intensity maps can be found in http://github.com/dertuncay/Web-base-macroseismic-intensity-study-in-Turkey.

Author contributions. Deniz Ertuncay analyzed the entries in Ekşi Sözlük website and determined the intensity values. Laura Cataldi created shake maps and Deniz Ertuncay visualized the intensity values collected from Ekşi Sözlük and EMSC to create figures. Results are interpreted by all authors.

Competing interests. The authors declare that they have no conflict of interest.

Acknowledgements. We would like to thank to Enrico Magrin who was a part of SeisRaM working group of Department of Mathematics and Geosciences in University of Trieste (currently works at Istituto Nazionale di Oceanografia e di Geofisica Sperimentale) for his help on the calculation of intensities and Hafize Başak Bayraktar from University of Napoli Federico II department of Structures for Engineering and Architecture for sharing district level polygons of Turkey. We also would like to thank all users of Ekşi Sözlük for sharing their experiences on the website. Finally we would like to thank Selen Caner Ertuncay for proofreading the manuscript.

References

Agencija Republike Slovenije Za Okolje - ARSO: Environmental Agency of the Republic of Slovenia, http://www.arso.gov.si/potresi/vprašalnik/, 2020.

Akarvardar, S., Feigl, K. L., and Ergintav, S.: Ground deformation in an area later damaged by an earthquake: Monitoring the Avcilar district of Istanbul, Turkey, by satellite radar interferometry 1992–1999, Geophysical Journal International, 178, 976–988, 2009.

Alexa Internet: Top Websites Ranking, https://www.similarweb.com/top-websites/turkey, 2020.

Anadolu Agency: İstanbul'da 5.8 büyüklügünde deprem (in Turkish), https://www.aa.com.tr/tr/turkiye/istanbulda-5-8-buyuklugunde-deprem/1594875, 2019.

Arapostathis, S. G., Lekkas, E., Kalabokidis, K., Drakatos, G., Xanthopoulos, G., Spyroy, N., and Kalogeras, I.: Developing seismic intensity maps from twitter data; the case study of Lesvos Greece 2017 earthquake: Assessments, improvements and enrichments on the methodology, Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci, 42, W4, 2018.

Bossu, R., Mazet-Roux, G., Douet, V., Rives, S., Marin, S., and Aupetit, M.: Internet users as seismic sensors for improved earthquake response, Eos, Transactions American Geophysical Union, 89, 225–226, 2008.

Bossu, R., Laurin, M., Mazet-Roux, G., Roussel, F., and Steed, R.: The importance of smartphones as public earthquake-information tools and tools for the rapid engagement with eyewitnesses: A case study of the 2015 Nepal earthquake sequence, Seismological Research Letters, 86, 1587–1592, 2015.

Bossu, R., Landès, M., Roussel, F., Steed, R., Mazet-Roux, G., Martin, S. S., and Hough, S.: Thumbnail-based questionnaires for the rapid and efficient collection of macroseismic data from global earthquakes, Seismological Research Letters, 88, 72–81, 2017.

British Geological Survey: BGS E-Mail Earthquake Questionnaire, http://www.earthquakes.bgs.ac.uk/questionnaire/EqQuestIntroA.html, 2020.

Cataldi, L., Tiberi, L., and Costa, G.: A new estimation of MCS intensity for Italy from high quality accelerometric data, using GMICEs and Gaussian Naïve Bayes Classifiers, in prep.

Crooks, A., Croitoru, A., Stefanidis, A., and Radzikowski, J.: # Earthquake: Twitter as a distributed sensor system, Transactions in GIS, 17, 124–147, 2013.

Department of Engineering of Dokuz Eylul University: 12 Haziran 2017 İzmir Karaburun (Ege Denizi) Depremi Değerlendirme Raporu (in Turkish), http://www.jeofizik.org.tr/resimler/ekler/74cb68517e1d6f3_ek.pdf?tipi=1&turu=H&sube=4, 2017.

Earle, P., Guy, M., Buckmaster, R., Ostrum, C., Horvath, S., and Vaughan, A.: OMG earthquake! Can Twitter improve earthquake response?, Seismological Research Letters, 81, 246–251, 2010.

Earle, P. S., Bowden, D. C., and Guy, M.: Twitter earthquake detection: earthquake monitoring in a social world, Annals of Geophysics, 54, 2012.

Ergin, M., Özalaybey, S., Aktar, M., and Yalcin, M.: Site amplification at Avcılar, Istanbul, Tectonophysics, 391, 335–346, 2004.

Fayjaloun, R., Gehl, P., Auclair, S., Boulahya, F., Marthe, S. G., and Roulle, A.: Integrating strong-motion recordings and Twitter data for a rapid shakemap of macroseismic intensity, International Journal of Disaster Risk Reduction, p. 101927, 2020.

Gallo, A., Costa, G., and Suhadolc, P.: Near real-time automatic moment magnitude estimation, Bulletin of earthquake engineering, 12, 185–202, 2014.

Goltz, J. D., Park, H., Quitoriano, V., and Wald, D. J.: Human Behavioral Response in the 2019 Ridgecrest, California, Earthquakes: Assessing Immediate Actions Based on Data from "Did You Feel It?", Bulletin of the Seismological Society of America, 110, 1589–1602, 2020.

Hürriyet: Fuat Oktay'dan İstanbul depremi sonrası önemli açıklamalar (in Turkish), https://www.hurriyet.com.tr/gundem/fuat-oktaydan-istanbul-depremi-sonrasi-onemli-aciklamalar-41338943, 2019.

Li, J. and Rao, H. R.: Twitter as a rapid response news service: An exploration in the context of the 2008 China earthquake, The Electronic Journal of Information Systems in Developing Countries, 42, 1–22, 2010.

Liang, W.-T., Lee, J.-C., Chen, K. H., and Hsiao, N.-C.: Citizen earthquake science in Taiwan: from science to hazard mitigation, Journal of Disaster Research, 12, 1174–1181, 2017.

Locati, M., Camassi, R. D., Rovida, A. N., Ercolani, E., Bernardini, F. M. A., Castelli, V., Caracciolo, C. H., Tertulliani, A., Rossi, A., Azzaro, R., et al.: DBMI15, the 2015 version of the Italian Macroseismic Database, Istituto Nazionale di Geofisica e Vulcanologia, 2016.

Mendoza, M., Poblete, B., and Castillo, C.: Twitter under crisis: Can we trust what we RT?, in: Proceedings of the first workshop on social media analytics, pp. 71–79, 2010.

Miyabe, M., Miura, A., and Aramaki, E.: Use trend analysis of twitter after the great east japan earthquake, in: Proceedings of the ACM 2012 conference on Computer Supported Cooperative Work Companion, pp. 175–178, 2012.

Robinson, B., Power, R., and Cameron, M.: A sensitive twitter earthquake detector, in: Proceedings of the 22nd international conference on world wide web, pp. 999–1002, 2013.

Sbarra, P., Tosi, P., and De Rubeis, V.: Web-based macroseismic survey in Italy: Method validation and results, Natural Hazards, 54, 563–581, 2010.

Sieberg, A.: Scala MCS (Mercalli-Cancani-Sieberg), Geologie der Erdbeben, Handbuch der Geophysik, 2, 552–555, 1930.

Swiss Seismological Service: Did You Feel an Earthquake? Report an Earthquake, http://www.seismo.ethz.ch/en/earthquakes/did-you-feel-an-earthquake/, 2020.

Tezcan, S. S., Kaya, E., Bal, I. E., and Özdemir, Z.: Seismic amplification at Avcılar, Istanbul, Engineering structures, 24, 661–667, 2002.

Turkish Statistical Institute: Information and Communication Technology (ICT) Usage in Households and by Individuals, http://www.turkstat.gov.tr/PreTablo.do?alt_id=1028, 2019.

Wald, D. J., Quitoriano, V., Worden, C. B., Hopper, M., and Dewey, J. W.: USGS "Did You Feel It?" internet-based macroseismic intensity maps, Annals of Geophysics, 54, 2012.

Zentralanstalt für Meteorologie und Geodynamik — ZAMG: Central Institute for Meteorology and Geodynamics of Austria, https://www.zamg.ac.at/cms/de/geophysik/bebenbericht/index.php, 2020.

Zielinski, A., Bügel, U., Middleton, L., Middleton, S., Tokarchuk, L., Watson, K., and Chaves, F.: Multilingual analysis of twitter news in support of mass emergency events., in: ISCRAM, Citeseer, 2012.

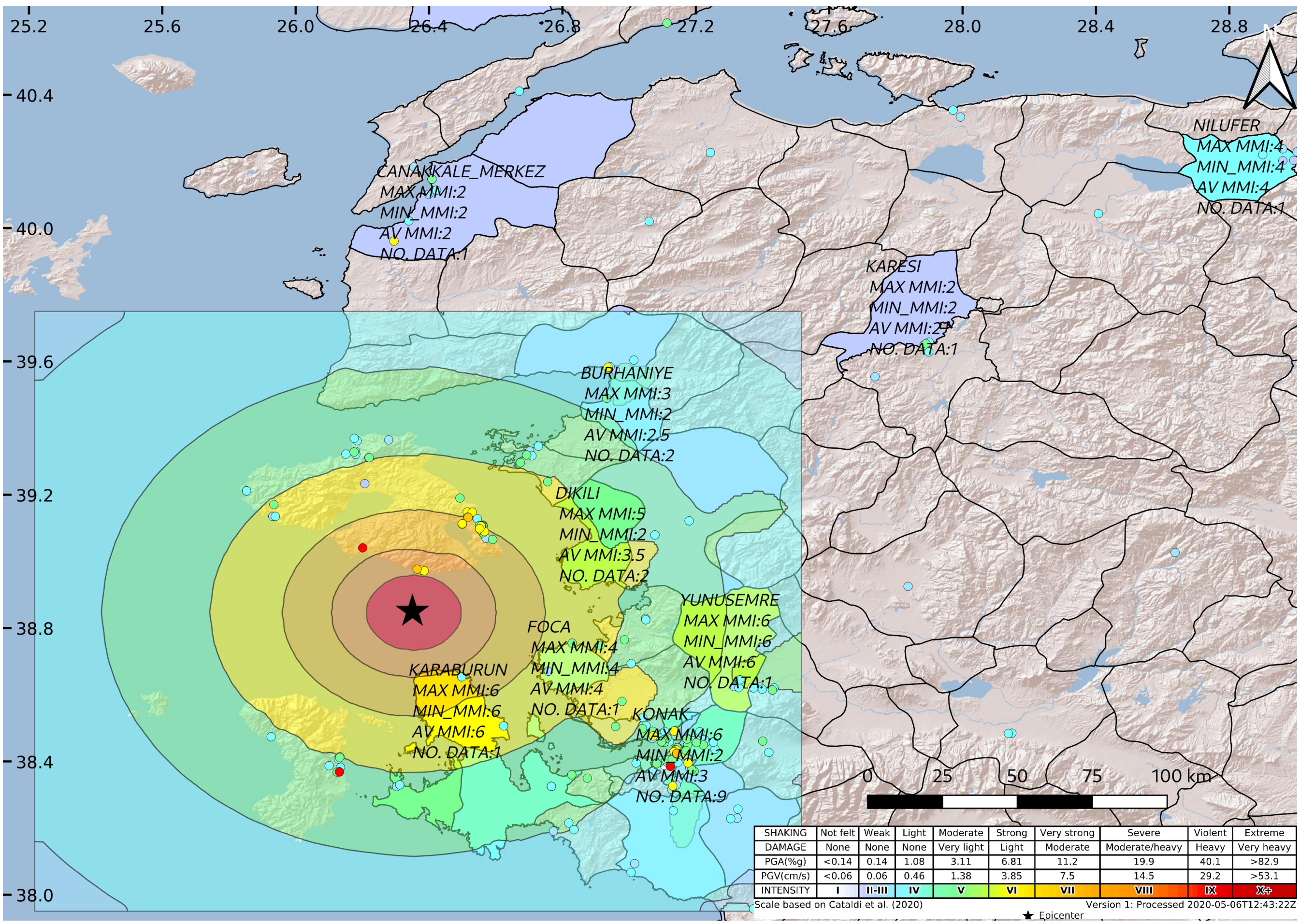


Figure 1. Intensity map of 12 June 2017 Lesbos earthquake with labelled entries. Entries are plotted to district level polygons since the exact location of data providers are unknown. Felt reports of the earthquake submitted to EMSC on top of the labelled entries (created using QGIS).

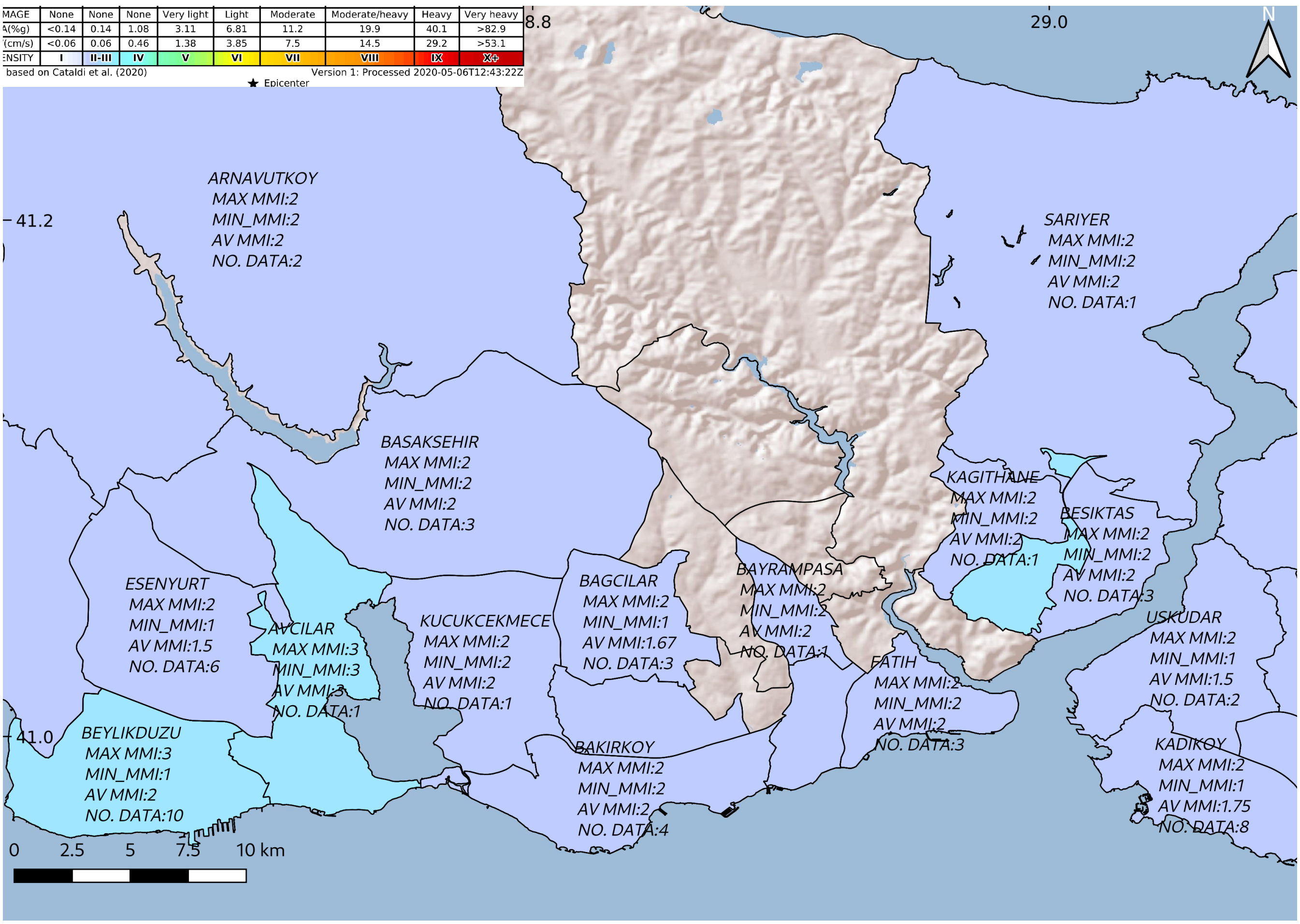


Figure 2. Intensity map of 12 June 2017 Lesbos earthquake with labelled entries in West side of İstanbul. Entries are plotted to district level polygons (created using QGIS.

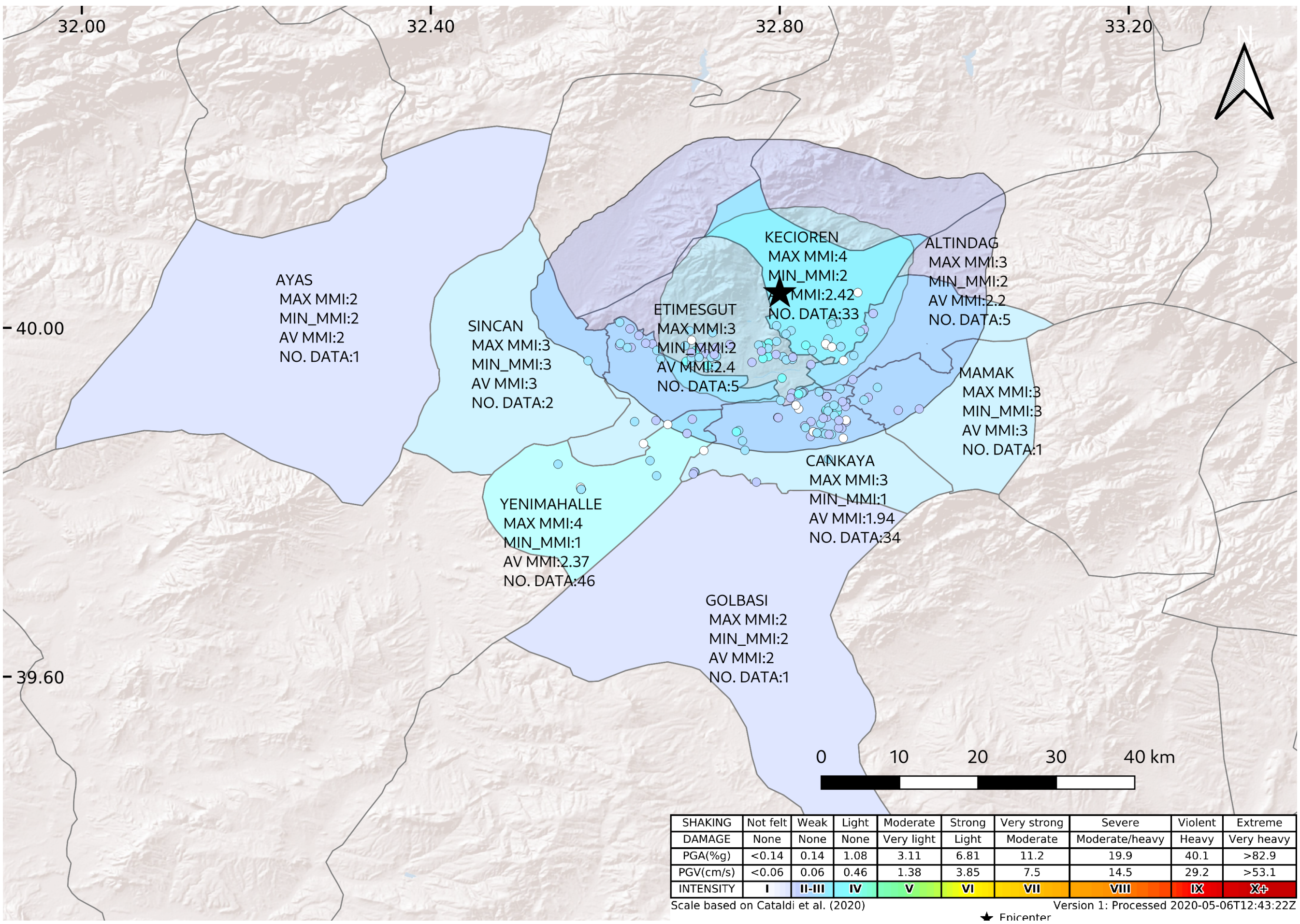


Figure 3. Intensity map of 25 August 2019 Ankara earthquake with labelled entries. Entries are plotted to district level polygons. Felt reports of the earthquake submitted to EMSC on top of the labelled entries (created using QGIS.

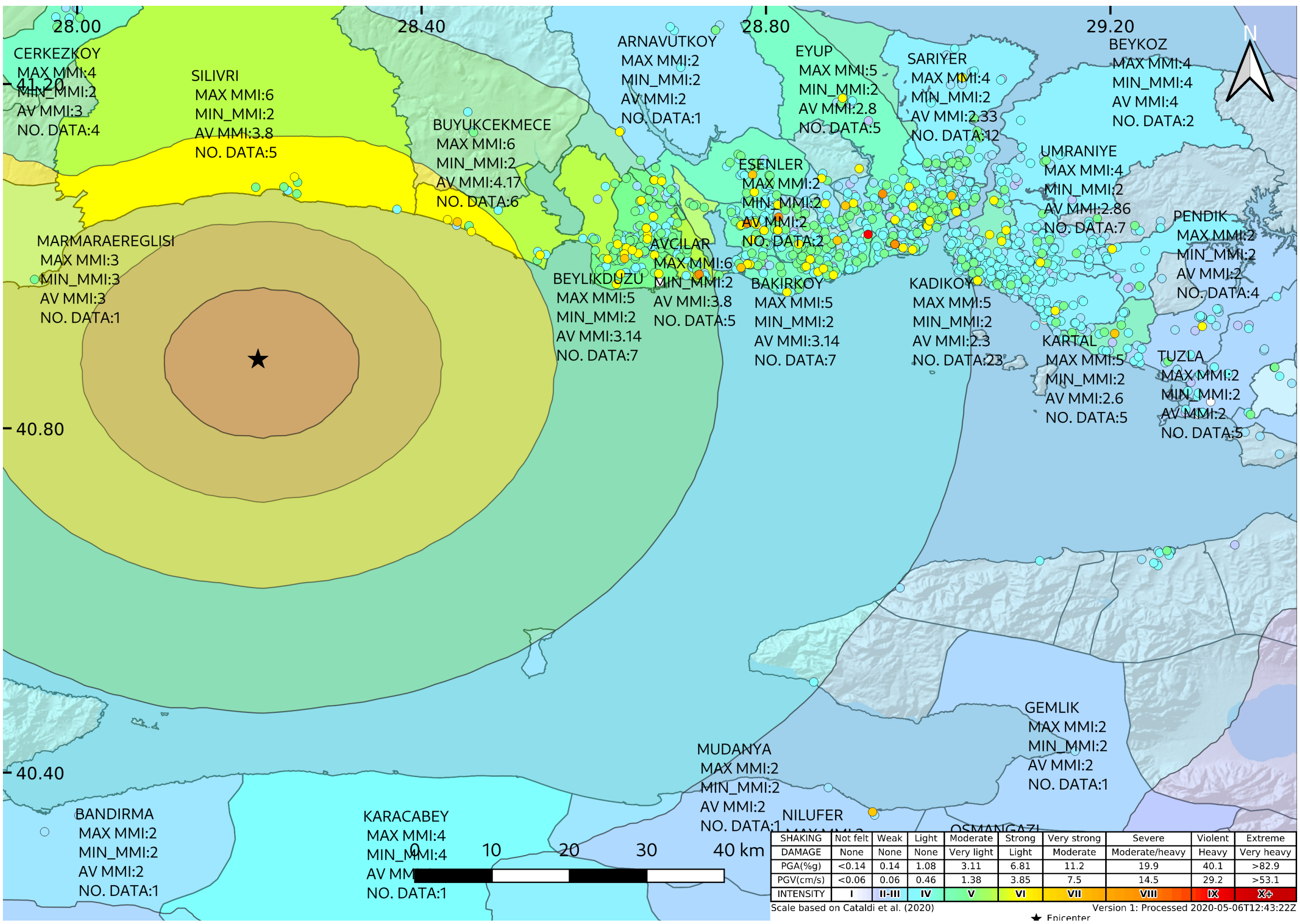
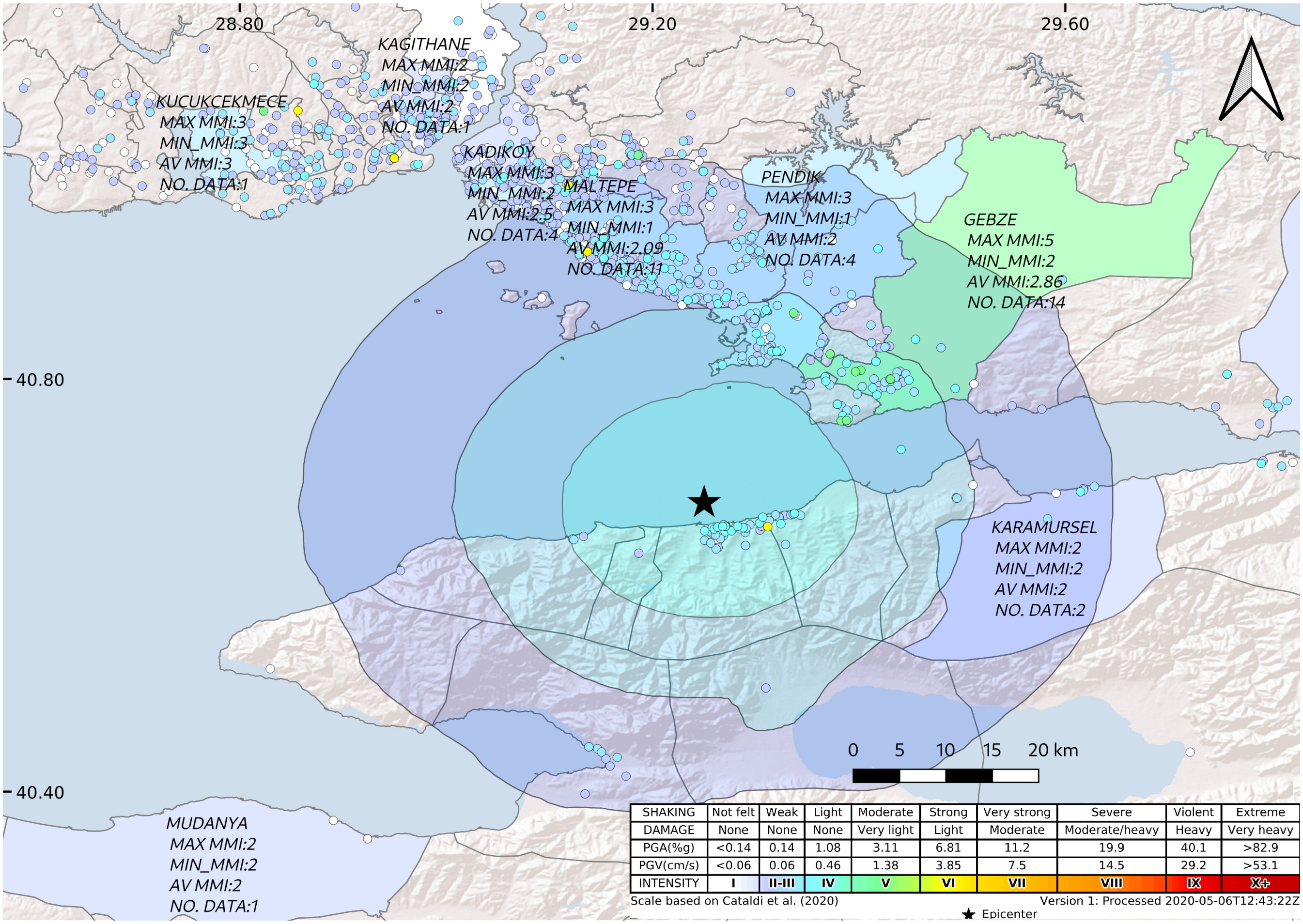


Figure 4. Intensity map of 26 September 2019 İstanbul earthquake with labelled entries. Entries are plotted to district level polygons. Felt reports of the earthquake submitted to EMSC on top of the labelled entries (created using QGIS.



SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
DAMAGE	None	None	None	Very light	Light	Moderate	Moderate/heavy	Heavy	Very heavy
PGA(%g)	<0.14	0.14	1.08	3.11	6.81	11.2	19.9	40.1	>82.9
PGV(cm/s)	<0.06	0.06	0.46	1.38	3.85	7.5	14.5	29.2	>53.1
INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Figure 5. Intensity map of 10 October 2019 Yalova earthquake with labelled entries. Entries are plotted to district level polygons. Felt reports of the earthquake submitted to EMSC on top of the labelled entries (created using QGIS.

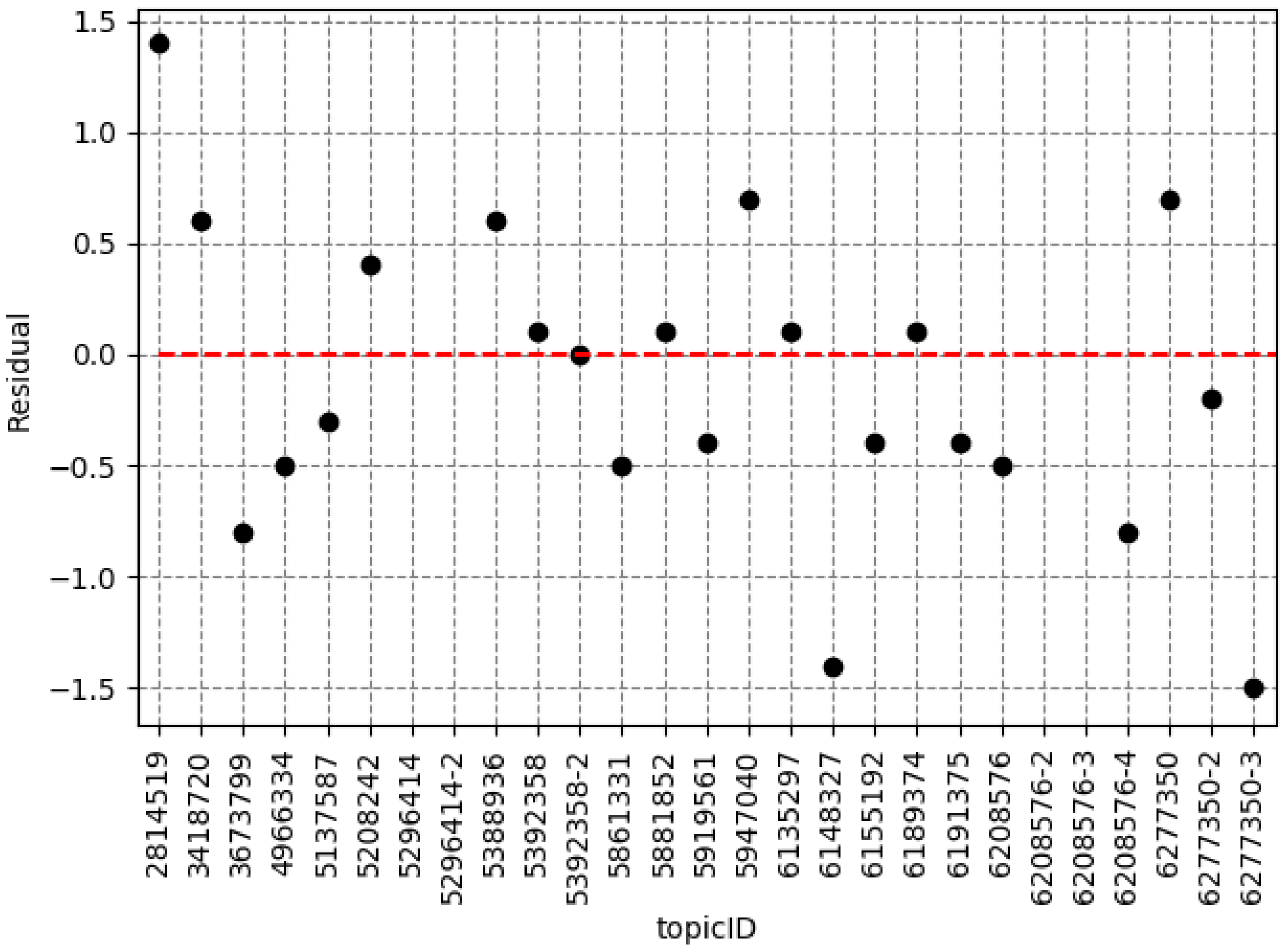


Figure 6. Residuals of measured magnitudes of the earthquakes (Table 1) with average magnitude guesses from users. Earthquakes without any guesses are blank (created using Matplotlib library of Python).

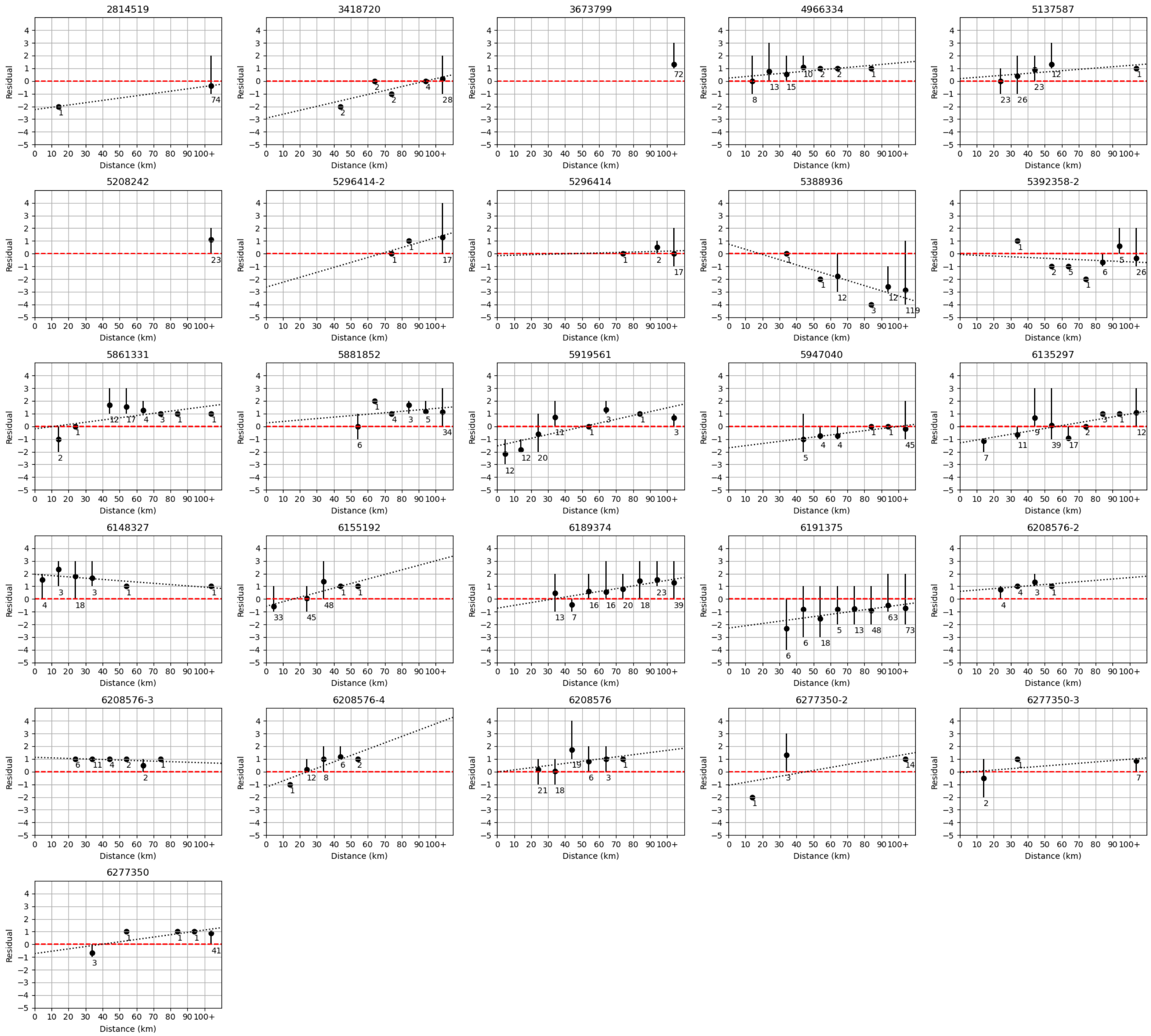


Figure 7. Residuals of predicted and observed MSCs. Red dashed line represents the baseline. Black circles are the residual of weighted average of the bin. Vertical black lines are the residuals from predicted MSCs and minimum and maximum MSCs that are observed in the bin. Black dotted line is the fitted line to the residual of weighted averages. Number of data points inside bins are provided beneath each bin point with data (created using Matplotlib library of Python).

Table 1. Topics of various earthquakes in Ekşi Sözlük. First entry, additionally, gives the information of the creation time of the topic. Δt is the time between the origin time of the earthquake and the creation of topic of the earthquake. Entries do not have the 'second' information for the time. Magnitudes are moment magnitude (M_w) unless otherwise stated.

Topic	Origin Time	First Entry	Δt (min)	Magnitude	Event Latitude	Event Longitude	Depth (km)
19-mayis-2011-simav-depremi–2814519	19/05/2011 20:15:22	19/05/2011 20:15	<= 1	5.7	39.14	29.1	8
7-haziran-2012-tekirdag-depremi–3418720	06/07/2012 20:54:26	06/07/2012 20:55	<= 1	5.1	40.85	27.92	14
8-ocak-2013-ege-denizi-depremi–3673799	01/08/2013 16:16:06	01/08/2013 16:17	<= 1	5.7	39.65	25.48	8.4
16-kasim-2015-istanbul-depremi–4966334	16/11/2015 15:45:43	16/11/2015 15:46	<= 1	3.9	40.83	28.76	7.7
25-haziran-2016-yalova-depremi–5137587	25/06/2016 05:40:11	25/06/2016 05:41	<= 1	4.1	40.7	29.21	9
15-ekim-2016-istanbul-depremi–5208242	15/10/2019 08:18:32	15/10/2019 08:19	<= 1	4.9	42.19	30.71	10
6-subat-2017-canakkale-depremi–5296414	02/06/2017 03:51:39	02/06/2017 03:54	>1	5.3	39.56	26.02	6
6-subat-2017-canakkale-depremi–5296414-2	02/06/2017 10:58:00	02/06/2017 10:59	<= 1	5.1	39.51	26.07	6
12-haziran-2017-izmir-depremi–5388936	06/12/2017 12:28:39	06/12/2017 12:29	<= 1	6.2	38.85	26.35	10
17-haziran-2017-izmir-depremi–5392358	17/06/2017 03:40:36	17/06/2017 03:42	>1	4.6	38.91	26.22	9
17-haziran-2017-izmir-depremi–5392358-2	17/06/2017 19:50:04	17/06/2017 19:54	>1	5.2	38.85	26.44	7
30-kasim-2018-yalova-depremi–5861331	30/11/2018 02:36:35	30/11/2018 02:37	<= 1	4	40.58	28.98	9
20-aralik-2018-yalova-depremi–5881852	20/12/2018 06:34:25	20/12/2018 06:35	<= 1	4.4	40.6	29.97	8
25-ocak-2019-izmir-depremi–5919561	25/01/2019 20:20:33	25/01/2019 20:21	<= 1	4.2	38.58	27.1	18
20-subat-2019-canakkale-depremi–5947040	20/02/2019 18:23:27	20/02/2019 18:24	<= 1	5	39.62	26.43	8
8-agustos-2019-izmir-depremi–6135297	08/08/2019 08:39:07	08/08/2019 08:39	<= 1	4.6	38.02	26.85	6
20-agustos-2019-ankara-depremi–6148327	20/08/2019 02:07:35	20/08/2019 02:08	<= 1	3.2(ml)	39.89	33.04	10
25-agustos-2019-ankara-depremi–6155192	25/08/2019 18:42:26	25/08/2019 18:42	<= 1	3.5(ml)	40.04	32.8	5
24-eylul-2019-istanbul-depremi–6189374	24/09/2019 08:00:22	24/09/2019 08:00	<= 1	4.5	40.88	28.21	4
26-eylul-2019-istanbul-depremi–6191375	26/09/2019 10:59:24	26/09/2019 11:00	<= 1	5.6	40.88	28.21	5
10-ekim-2019-yalova-depremi–6208576	10/10/2019 16:52:03	10/10/2019 16:52	<= 1	4	40.68	29.25	13.9
10-ekim-2019-yalova-depremi–6208576-2	10/10/2019 17:04:39	10/10/2019 17:04	<= 1	3.1(ml)	40.7	29.26	5
10-ekim-2019-yalova-depremi–6208576-3	10/10/2019 17:09:40	10/10/2019 17:10	<= 1	3.3(ml)	40.7	29.25	2
10-ekim-2019-yalova-depremi–6208576-4	10/10/2019 19:32:07	10/10/2019 19:32	<= 1	3.7(ml)	40.69	29.26	12
10-aralik-2019-balikesir-depremi–6277350	12/10/2019 20:14:02	12/10/2019 20:15	<= 1	4.6	39.45	29.93	8
10-aralik-2019-balikesir-depremi–6277350-2	12/10/2019 20:24:05	12/10/2019 20:24	<= 1	4.3	39.44	29.91	11.3
10-aralik-2019-balikesir-depremi–6277350-3	12/10/2019 20:46:18	12/10/2019 20:47	<= 1	4	39.44	29.9	14.3

Table 2. Table of extracted information from entries of each topicID. Number of entries with city and district information along with the MCS value is represented by No of Entry. Unique number of cities and districts of these cities are given by No of City and No of District, respectively. Maximum MCS, minimum MCS and average MCS of these entries are represented by Max MCS, Min MCS and Av MCS, respectively. Entries with magnitude guesses regardless of location information are given in No of Mag.

topicID	No of Entry	No of City	No of District	Max MCS	Min MCS	Av MCS	No of Mag
2814519	78	11	37	5	2	2.65	2
3418720	38	4	28	4	1	2.18	1
3673799	73	6	33	4	2	2.30	3
4966334	51	2	23	5	2	2.53	4
5137587	85	5	21	4	1	2.68	6
5208242	26	4	15	3	1	2.12	6
5296414	20	6	14	4	1	2.10	0
5296414-2	20	6	14	5	1	2.40	0
5388936	151	12	60	6	1	2.26	9
5392358	3	1	3	2	2	2.00	1
5392358-2	46	7	22	5	1	1.98	9
5861331	42	4	23	4	2	2.48	3
5881852	53	4	27	4	1	2.21	2
5919561	63	3	18	4	1	2.37	13
5947040	62	7	38	4	1	1.90	5
6135297	101	6	32	5	1	2.17	16
6148327	30	1	6	4	1	2.87	7
6155192	129	1	9	4	1	2.27	5
6189374	152	5	41	5	1	2.59	9
6191375	233	12	57	6	1	2.74	1
6208576	68	3	18	5	1	2.15	15
6208576-2	12	3	10	3	1	2.00	0
6208576-3	25	2	12	2	1	1.96	0
6208576-4	29	3	10	3	1	2.10	2
6277350	47	8	26	3	1	1.94	10
6277350-2	19	7	13	5	1	2.16	1
6277350-3	10	3	8	5	1	2.20	1

Table 3. Table of PGA and PGV value intervals for calculation of I; values are taken from (Cataldi et al., in prep.).

I	1	2	3	4	5	6	7	8	9	10
PGA_{min}(cm/s^2)		0.32	1.91	6.31	17.78	52.48	85.11	141.25	269.15	575.44
PGA_{max}(cm/s^2)	$<$ 0.32	1.91	6.31	17.78	52.48	85.11	141.25	269.15	575.44	1148.15
PGV_{min}(cm/s)		0.01	0.10	0.28	0.74	2.57	5.75	9.77	21.38	39.81
PGV_{max}(cm/s)	$<$ 0.01	0.10	0.28	0.74	2.57	5.75	9.77	21.38	39.81	70.789