Crowdsourcing Felt Reports Using the MyShake Smartphone App

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Abstract

MyShake is a free citizen science smartphone app that provides a range of features related to earthquakes. Features available globally include rapid postearthquake notifications, live maps of earthquake damage as reported by MyShake users, safety tips, and various educational features. The app also uses the accelerometer in the mobile device to detect earthquake shaking, and to record and submit waveforms to a central archive. In addition, MyShake delivers earthquake early warning alerts in California, Oregon, and Washington. In this study, we compare the felt shaking reports provided by MyShake users in California with the U.S. Geological Survey's (USGSs) "Did You Feel It?" intensity reports. The MyShake app simply asks, "What strength of shaking did you feel?" and users report on a five-level scale. When the MyShake reports are averaged in spatial or time bins, we find strong correlation with the Modified Mercalli Intensity scale values reported by the USGS based on the DYFI surveys. The MyShake felt reports can therefore contribute to the creation of shaking intensity maps.

Introduction

"How strong was the shaking?" is a question we usually ask after each earthquake. From the very earliest written records in our human history to modern seismological instrumentation, we have tried to provide more quantitative answer to this question. More recently, with the wide adoption of the internet, computers, and smartphones, new crowdsourcing methods to answer this question have been developed. These methods include surveys to provide felt reports (Wald *et al.*, 2001; Wald and Dewey, 2005; Atkinson and Wald, 2007; Bossu *et al.*, 2012, 2015, 2018; Rochford *et al.*, 2018; Liang *et al.*, 2019; Quitoriano and Wald, 2020) using messages from Twitter (Earle, 2010; Earle *et al.*, 2010; Sakaki *et al.*, 2010; Ruan *et al.*, 2020, 2022) and smartphones or standalone low-cost sensors (Cochran *et al.*, 2009; Clayton *et al.*, 2012, 2015; Hsieh *et al.*, 2014; Minson *et al.*, 2015; Wu, 2015; Kong *et al.*, 2016; Jan *et al.*, 2018; Nof *et al.*, 2019; Steed *et al.*, 2019). Although the high-quality research grade regional seismic and geodetic networks provide precise but sparse observations, these crowdsourcing approaches provide a dense but noisier view of earthquake shaking. They also provide information about people's perception of shaking and observations of damage after an earthquake.

Within these newly developed crowdsourcing approaches, MyShake is an application developed for smartphones at the Berkeley Seismology Lab. It utilizes both the sensors inside smartphones and user-uploaded felt reports after an earthquake to learn more about the distribution of shaking and

its impacts (Allen *et al.*, 2019; Strauss *et al.*, 2020). To learn more about how MyShake uses the sensors inside the phones to detect earthquakes for earthquake early warning, please refer to Kong *et al.* (2020). In this article, we will focus on the MyShake users' felt reports provided through a short series of questions that the users can complete to evaluate the shaking after an earthquake. In particular, we compare these MyShake felt reports to the U.S. Geological Survey's Did You Feel It (DYFI) observations, representing the "gold standard" for such observations. We show examples of intensity maps derived from the MyShake reports and the distribution of responses. Furthermore, we show the strong correlation between the MyShake felt reports and those from the DYFI system. Even though the MyShake questions are very simple compared to the DYFI survey, with sufficient reports from a large group of the users in the earthquake region, these measurements can be useful and strongly correlate to the known intensity scale with careful calibration.
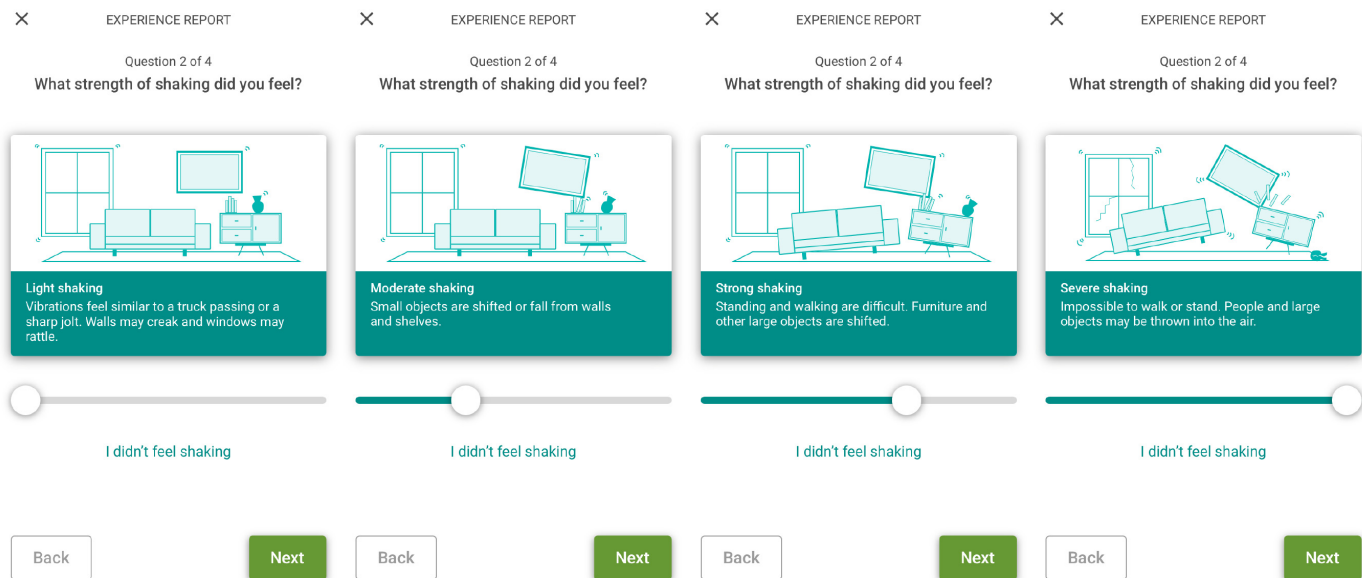
Overview of the MyShake Felt Report

The MyShake felt report is a set of four questions for the users to answer to provide information about their experiences

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EXPERIENCE REPORT   EXPERIENCE REPORT   EXPERIENCE REPORT   EXPERIENCE REPORT

Question 2 of 4   Question 2 of 4   Question 2 of 4   Question 2 of 4
What strength of shaking did you feel?   What strength of shaking did you feel?   What strength of shaking did you feel?   What strength of shaking did you feel?

Light shaking
Vibrations feel similar to a truck passing or a sharp jolt. Walls may creak and windows may rattle.

Moderate shaking
Small objects are shifted or fall from walls and shelves.

Strong shaking
Standing and walking are difficult. Furniture and other large objects are shifted.

Severe shaking
Impossible to walk or stand. People and large objects may be thrown into the air.

I didn't feel shaking   I didn't feel shaking   I didn't feel shaking   I didn't feel shaking

Back   Next   Back   Next   Back   Next   Back   Next

Figure 1. The five different shaking levels that users can select within question 2 of the MyShake felt report questionnaire (none, light, moderate, strong, and severe). "I didn't feel shaking" is the hyperlink that the user can click to directly report no shaking is felt. Users scroll through the images shown to identify the one that best matches his or her experience. For examples of question 3 and 4, please see Figures S17 and S18. The color version of this figure is available only in the electronic edition.

during the earthquake and observations of damage around them after an earthquake (Rochford *et al.*, 2018). With both simplicity and usefulness in mind, the felt report questionnaires are designed to minimize the effort for the user to complete a report after an earthquake. There are a total of four questions asked in the questionnaires as shown in Table 1, in which questions 2–4 are aided with pictorial representations to assist the user. An example of question 2 with selection options is shown in Figure 1. The user only needs to scroll through the images and descriptions to a level that matches his or her experience. The felt report completed by a user is then uploaded to the MyShake server. Each report immediately becomes part of an aggregated map of felt shaking intensity visible to all MyShake users in the app. The map provides an immediate visualization of the strength of shaking for the area, and a user can click on a location to see the number of reports and the different levels of shaking and damage. See figure 3 in Strauss *et al.* (2020) for an example of reported shaking maps with information for a recent earthquake in Puerto Rico.

In this study, we focus on earthquakes that have felt reports within California between 15 October 2019 and 11 May 2021 (based on the Advanced National Seismic System [ANSS] Comprehensive Earthquake Catalog from USGS). In each felt report, we get the timestamp when the report arrived at the server, the location of the user making the submission, and the shaking scale. See Table 2 for an example. The shaking scale is an integer number with −1, 0, 1, 2, and 3, representing none, light shaking, moderate shaking, strong shaking, and severe shaking, respectively. To compare and calibrate the shaking scales in the MyShake felt reports, we obtained the corresponding DYFI data from the USGS. Specifically, we downloaded intensity versus distance, responses versus time, and the intensity map from USGS earthquake websites.

Comparison with DYFI Intensity

Each USGS DYFI survey response is converted into an estimate of seismic intensity on the modified Mercalli intensity (MMI) scale (Wald *et al.*, 2011). Here, we will compare the MyShake reported shaking intensity scale with five levels to the 10 level DYFI MMI. Our goal is to determine the degree to which the

TABLE 1

Questions Used in MyShake Felt Report Questionnaires

| Question Number	Question	User Can Choose From
1	Where were you when you experienced this earthquake?	Click on map or type in address
2	What strength of shaking did you feel?	None, light, moderate, strong, and severe (see Fig. 1)
3	Describe any visible building damage that you see nearby.	No, minor, substantial, and destroyed (see Fig. S17)
4	Describe any visible road damage that you see nearby.	No, minor, substantial, and destroyed (see Fig. S18)
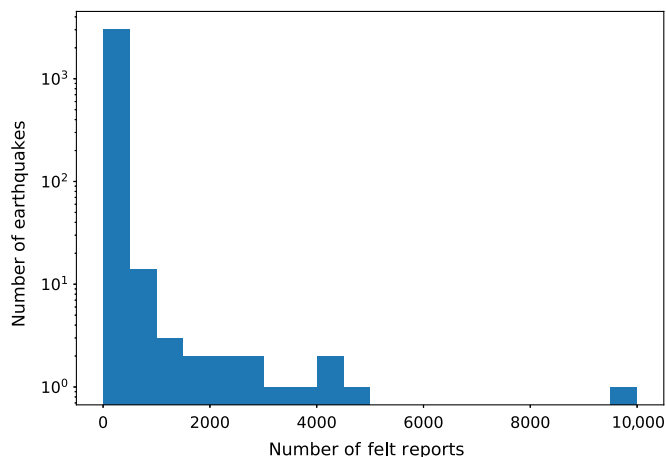
Figure 2. Histogram showing the number of earthquakes for which a specified number of felt reports were submitted between 15 October 2019 and 11 May 2021 in California. The color version of this figure is available only in the electronic edition.

Figure 3. Number of felt reports versus population (in millions) with 0.5° of the earthquake. The color shows the magnitude of the earthquake. Note, we add 1 to the reported population for each earthquake to plot on a logarithmic scale. The color version of this figure is available only in the electronic edition.

simplified MyShake survey provides intensity estimates similar to the DYFI survey. If they do correlate, then we want to develop a scaling relation that will allow us to convert the MyShake intensity shaking scale to MMI. The MyShake felt report system is still quite new and for most earthquakes provides far fewer felt reports than the USGS DYFI submissions. Still, a good number of events have more than a few thousands reports submitted, which enables us to take the first step to understand what these reports can tell us.

Figure 2 shows a histogram of the number of reports collected for each event from the period 15 October 2019 to 11 May 2021 in California. In total, there are 325 events that have at least one felt report, and the majority of the events have less than 500 reports, with 29 events having more than 500 reports and 20 events having more than 700 reports for each earthquake. Table 3 lists these 20 events with the number of felt reports that we later use for developing a conversion between MyShake intensity shaking scale to the DYFI MMI intensity. A relationship between the number of felt reports and the population within 0.5° of the event is shown in Figure 3 with colors representing the magnitude. The population data are extracted from the 2020 Gridded Population of the World V4 (see Data and Resources section). We can see the general trend: The number of reports increases when larger populations are nearby and for larger magnitude earthquakes.

We use 16 of the 20 events that have more than 700 felt reports to build a linear relationship between the MyShake felt report shaking scale (−1, 0, 1, 2, and 3) and the MMI intensity scale from DYFI data. We reserve the rest four events shown in bold in Table 3 as test set. We first bin the MyShake and DYFI intensity observations as a function of hypocentral distance by averaging the individual reports in these bins. To calibrate with the USGS DYFI intensities, we use the same distance bins as
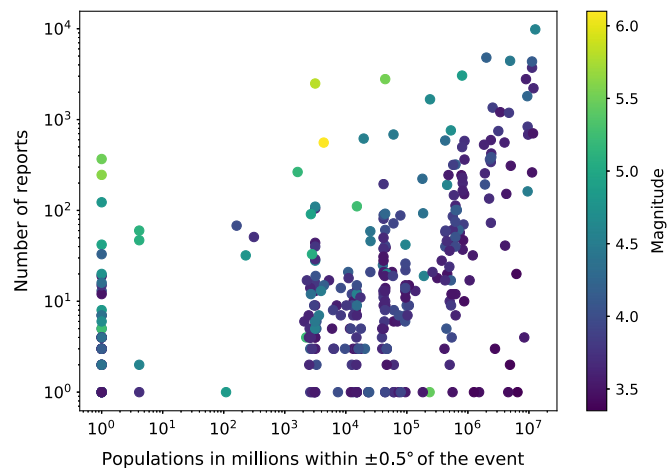
that used in the USGS intensity versus distance plots up to the maximum distance of 308 km. The binning process also ensures that we are sampling the data from all distance ranges, so that the relationship between MyShake and DYFI we will derive not affect by local or directional influences. The distance bins are 5.5, 7.3, 9.7, 13.0, 17.3, 23.1, 30.8, 41.1, 54.8, 73, 97.4, 129.9, 173.2, 231.0, and 308.0 km. For MyShake, to ensure a robust shaking estimate, we only compute the average shaking report value when there are 10 or more felt reports within a specific distance bin (see the reason of this choice in the Discussion section). This provides us 120 data points from the 16 events for building the relationship as well as 34 data points for testing. An example of the binned MyShake shaking scales as well as DYFI intensities is shown in Figure S1, available in the supplemental material to this article (i.e., data used to derive equation 1), in which a clear linear relationship can be observed. The averaged intensity scales within the distance bins from the MyShake felt reports and USGS DYFI MMIs are then used to determine a simple linear relationship:

$$MMI\_intensity = a + MyShake\_Shaking\_Scale \times b. \quad (1)$$

TABLE 2
An Example of the Felt Report Data Used in the Study

Name of the Data	Type	Example
Time of the submission	Integer, Unix timestamp	1621007178230
Location of the report	Float latitude and longitude pair	(37.23, −122.34)
Shaking level	Integer: −1, 0, 1, 2, 3	2

We use the least-square regression to fit the data, which is a standard approach in regression analysis to find the best-fitting relationship (in this case, linear relationship) between variables when multiple observation data are available (overdetermined systems) by minimizing the sum of the squares of the residuals. We found $a = 2.3$ and $b = 2.44$ yield the best results. This relation maps the −1 (none), 0 (light), 1 (moderate), 2 (strong), and 3 (severe) of the MyShake felt report shaking scale to 0.0 (converted to 0 for negative intensities), 2.3, 4.7, 7.2, and 9.6 on the MMI scale, respectively. Table 4 summarizes the results of the regression. The p-values associated with the two coefficients based on the t statistical tests are all less than 5%, which indicate they are all statistically significant. We then can use the derived relationship to convert all the MyShake raw shaking scales to the MMI intensities, which we call MyShake calibrated intensities. We also test the spatial binning for both MyShake and USGS DYFI data based on the Universal Transverse Mercator (UTM) boxes as an alternative approach to derive the linear relationship (see the Finding the relationship between MyShake and DYFI using the spatial bins section in the supplemental material and Table S1), and the results are very similar to the approach using the distance bins. We prefer the distance binning approach here due to the simplicity, and it is less sensitive to localized effect in the spatial UTM bins.

The fact that the MyShake felt reports have only five levels that might be interpreted to suggest that they provide less granular information than the 10-level DYFI MMI data. However, once the MyShake data are binned and averaged, it provides very similar information to the DYFI data. Figure 4 shows the four earthquakes in the test set and compares the converted MMI shaking scale from the MyShake data to the DYFI MMI shaking scale. Both the datasets are averaged within each hypocentral distance bin. Similar comparisons for a random selection of 10 training events are included in Figures S2–S11. From these figures, we can see that the majority of the events show good agreement between the two independent shaking estimates when there are enough MyShake felt reports to aggregate. Furthermore, Figure 5 shows the fit between the calibrated MyShake felt report intensity and DYFI for the 20 events that have 700 or more reports, that is, both for training and the testing sets. The mean absolute error (MAE) in Figure 5a is calculated by taking the absolute value of the errors in each distance bin and then taking the average for each event. These values show the overall fit for individual events. The vertical bars show the uncertainties of the MAE values in different distance bins within each event. Overall, more reports available will generally reduce the uncertainties.

Figure 5b shows the scatter plot between the USGS DYFI and MyShake calibrated intensities for each distance bins for all the events, which gives us a global view of the overall fit. About 136 sample bins out of 154 have the intensity difference within 0.5 unit, which is 88.3% of the data. The corresponding

TABLE 3
List of Events That Have More than 700 Felt Reports Submitted

Earthquake ID	Date (yyyy/mm/dd) and Time (hh:mm:ss)	Magnitude	Number of Reports
ci38695658	2020/09/19 06:38:46	4.5	9829
nc73512355	**2021/01/17 04:01:27**	**4.2**	**4810**
nc73291880	2019/10/15 05:33:42	4.5	4432
ci39838928	**2021/04/05 11:44:01**	**4.0**	**4357**
ci39400304	2020/04/22 07:03:47	3.7	3723
ci39126079	2020/04/04 01:53:18	4.9	3050
ci39462536	2020/06/04 01:32:11	5.5	2789
ci39277736	2020/01/22 07:41:10	3.6	2787
ci39493944	2020/06/24 17:40:49	5.8	2494
ci38905415	2019/10/18 07:19:51	3.5	2211
ci39322287	2020/07/30 11:29:29	4.2	1808
nc73559265	2021/05/07 04:35:14	4.7	1671
nc73322626	2020/01/02 07:16:31	3.9	1354
nc73505175	2020/12/31 13:41:59	3.3	1207
nc73510910	2021/01/14 19:18:10	3.6	1187
nn00725272	2020/05/15 11:03:27	6.5	931
ci39322767	**2020/07/30 13:48:19**	**3.7**	**836**
nc73292360	**2019/10/15 19:42:30**	**4.7**	**760**
nc73554215	2021/04/25 04:59:28	3.6	748
ci39762912	2021/01/20 16:31:58	3.5	705

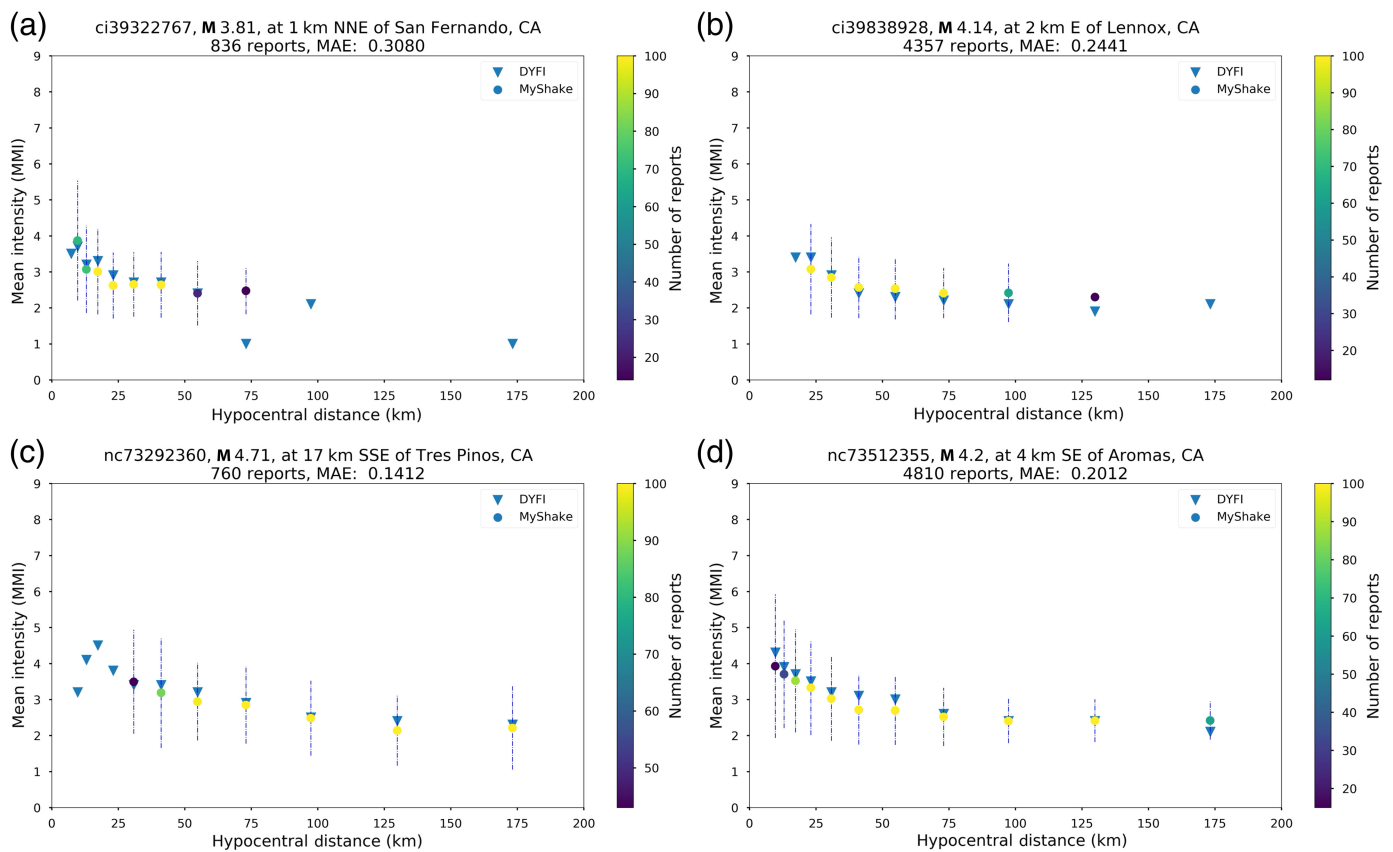Bolded events are reserved for testing purposes.

TABLE 4
Regression Results, t Shows the t Statistics, and $P > |t|$ is the Corresponding P-Value

Parameter	Coefficient	Standard Error	t	$P > |t|$	[0.025	0.975]
a	2.30	0.044	51.85	0.00	2.21	2.39
b	2.44	0.129	18.97	0.00	2.19	2.69

The [0.025 0.975] interval shows the 95% confidence interval.

histogram of the intensity differences from Figure 5b is shown in Figure 5c. Both the training and testing set are shown, and the differences are both centered around 0, with a standard deviation around 0.35. Figure 6 shows the spatial distribution of these 20 events and the variations in MAE for each event. The background population counts in 5 km grids are also shown.

Figure 4. (a–d) Shaking intensity (modified Mercalli intensity [MMI] scale) versus distance for four earthquakes in the test set. Each panel compares the estimated MMI shaking derived from the MyShake felt reports using equation (1) to the MMI estimates from Did You Feel It (DYFI). The MyShake data are shown as circles, and the DYFI data are shown as inverted triangles; the dotted vertical lines are the standard deviation of MyShake intensities in the distance bins. The color of the circles represents the number of reports in each distance bins. The distance bins are set to be the same as reported by DYFI: 13.0, 17.3, 23.1, 30.8, 41.1, 54.8, 73, 97.4, 129.9, 173.2, and 231.0 km. Each figure title gives the event id, magnitude, place of the earthquake, number of felt reports, and mean absolute error (MAE). The bins with fewer than 10 MyShake felt reports are not plotted. The color version of this figure is available only in the electronic edition.

Not only can we derive the intensity versus distance using MyShake felt reports (as shown in Fig. 4), we can also generate a map of intensity variations similar to a ShakeMap. Using felt reports from the 19 September 2020 **M** 4.5 Los Angeles earthquake (ci38695658) as an example, Figure 7a shows the spatial distribution of the MyShake calibrated intensities in 10 km UTM boxes (same as USGS DYFI UTM boxes). Figure 7b compares the derived intensities to the corresponding USGS DYFI intensities within each UTM box. The mean residuals is −0.08 unit (MyShake–DYFI), and the standard deviation is 0.75. Most of the residuals are small across the region. Figure 7c,d shows more detailed shaking distribution in 1 km UTM boxes; but the residuals are larger compared to the 10 km UTM version due to many boxes having only less than 10 reports. From both the 10 and 1 km UTM maps, we see similar shaking patterns comparing to DYFI maps: strong shaking about intensity IV–V around the epicenter, with stronger shaking over a wider region to the west of the earthquake. Figures S13–S15 show a similar spatial comparison for the 17 January 2021 **M** 4.2 earthquake (nc73512355).

We also plot the submission timeline of the MyShake and DYFI reports for the 19 September 2020 **M** 4.5 earthquake in Figure 8 (see another example in Fig. S16 for event nc73512355). Though the general patterns are similar on both the platforms, MyShake submissions are slightly slower in terms of the percentage of the total submission after the first 50%–60% submissions; this may be due to the different behaviors of smartphone and internet users, which needs more observations and analysis to confirm.

Discussion

MyShake's felt report system is new, and it will take some time for users to adapt and get used to it—both to report damage and also to use the live map in the app to see where the damage has occurred in an earthquake. It is important for the success of citizen science projects to provide interactive features that show the utility of a users' engagement. In the case of MyShake, showing the users a community-derived shaking
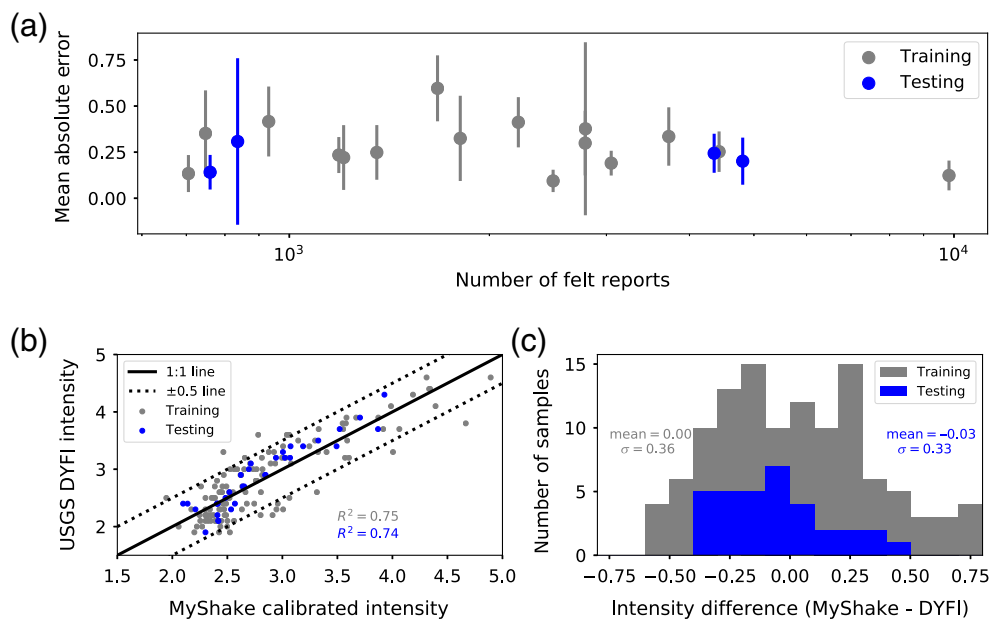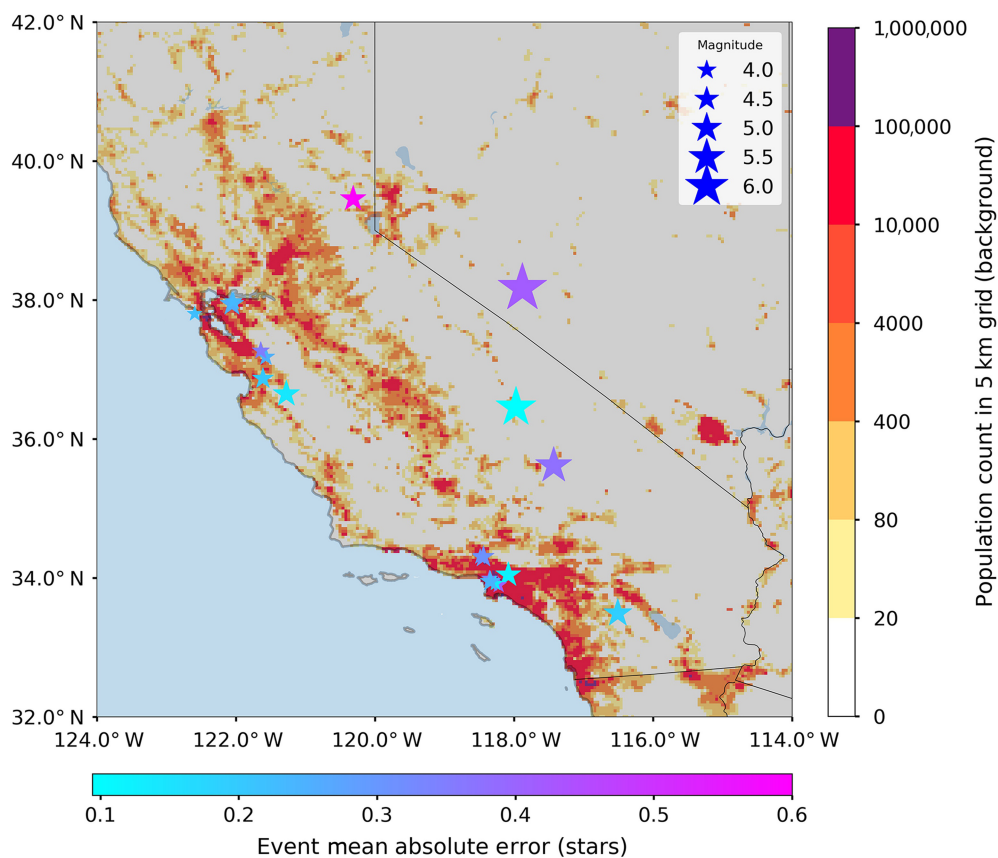
Figure 5. Fit metrics between MyShake calibrated intensity and the DYFI intensity in different distance bins for the 20 events with the most felt reports. (a) Mean absolute errors versus the number of felt reports for each event. The vertical bars are the standard deviation within each event. (b) Scatter plot between U.S. Geological Survey (USGS) DYFI and MyShake calibrated intensities. The solid line and the two dotted lines are 1-to-1 and the 0.5-unit error lines, respectively. The R-squared value is the coefficient of determination. (c) The histogram of the intensity difference between the MyShake calibrated and DYFI, the mean and standard deviation are listed in the figure. The color version of this figure is available only in the electronic edition.

Because the MyShake felt reports are relying on crowd-sourced estimates, we generally expect that having more reports within each binned location would yield more stable results. Figure 9a plots the difference between calibrated MyShake and USGS DYFI data aggregated in 1 km UTM boxes versus the number of MyShake felt reports. We can see that the standard deviations of the differences decrease with increased number of reports. There is a rapid decrease in the errors between 1 and 5 reports per bin, with more improvement as the number of reports increases to 10. For this reason, we required 10 reports per bin for the development of the regression relation to make stable estimates. From Figure 7, by comparing the 10 and 1 km UTM boxes, we can see this effect clearly. Because there are more reports to aggregate in the 10 km UTM boxes, the mean and standard deviation of the residuals are smaller compared to the map of the 1 km UTM boxes. Figure 9b shows the number of reports versus the standard deviation of the MyShake calibrated intensities in the 1 km UTM boxes (we also show the standard deviation of the raw MyShake shaking scales in Fig. S19), which provides us information about the uncertainties of the MyShake intensities within distance bins from different user reports. It shows a similar trend, with the uncertainties dropping rapidly from when there are a few reports to more than 10 reports. Overall, the MyShake calibrated intensities have a mean uncertainty of 1 unit within the 1 km UTM boxes, but the spread of this uncertainty decreases when more reports are available across different events.

To illustrate some of the apparent differences and discrepancies between the MyShake and DYFI felt report values, Figure 10 shows two events that have larger intensity discrepancies. The **M** 3.8 Morgan Hill event (Fig. 10a) shows discrepancies in just a few of the distance bins, all of which have smaller numbers of reports. Even with the requirement of 10 reports per bin, there may still be some large anomalies in bins at the lower end of the number of reports. In the future, we may consider ways to remove large anomaly values. Figure 10b shows the **M** 4.7 event near Truckee for which

map and the number of people who felt an earthquake near them provides a sense of participation and community. So far, with the current density of MyShake users for **M** 3.5–5.5 earthquakes, we have collected hundreds to a few thousands felt reports. To minimize the required effort by the users, the felt reports were kept very simple; but we did not know at the time of roll-out if this data could still be used to estimate shaking intensity in the same way that the more sophisticated DYFI reports do. The work reported earlier suggests that the five shaking-level scale in MyShake can indeed be converted to the MMI scale using a simple linear equation. Although the relationship developed here provides initial useful shaking information, it has several limitations, and needs to be verified and improved in the future as more events are recorded. In particular, there are three possible areas for improvement. First, the current dataset does not include examples of the strongest shaking intensities, that is, greater than MMI 5. This is key for an accurate shaking estimate for larger earthquakes, which usually draw more attention from the public. Second, the current linear relationship between MyShake and DYIF MMI should be reanalyzed when larger amount of data is available. Finally, the linear relationship that we developed based purely on distance bins may be enhanced by exploring some nonlinear conversion relationships.

Figure 6. Spatial distribution of the 20 events with more than 700 felt reports. The size of the star represents magnitude, and the color represents the MAE. The population counts in 5 km grid are plotted on the map background. The color version of this figure is available only in the electronic edition.

we can see that the MyShake converted intensities are systematically higher than that from DYFI by about 0.5–0.7 units. Most of the distance bins (two exceptions) have 50 or more felt reports. We do not have an explanation for this event with systematically different intensities. One possibility might be that people in different regions may have different interpretations of the five levels of shaking, as described in the MyShake tool. For example, people in regions with many earthquakes may have more opportunity to calibrate their sense of shaking. However, with a relatively small dataset, it is not obvious why the reports from MyShake users and DYFI users would be different in various locations.

The relationship that we derive in this article between MyShake and USGS DYFI MMIs provides a mechanism to collect macroseismic intensities from MyShake users. This is a complementary dataset for the earthquake hazards community. We acknowledge that this simplified version of MyShake felt report does not capture all the information that the more detailed USGS DYFI surveys do; it has lower precision and loss of individual macroseismic effects (safety behaviors, types of damage, and personal reports). Still, it provides the most

important shaking intensity information to the user, providing one of the motivations for their involvement in the MyShake citizen science project. When the MyShake felt reports were first designed, the 5-level shaking were not intended to be used by the scientific community; instead they were simply a way to engage users. However, we now find that with this relationship the MyShake data could be used to contribute to the broader scientific study of earthquake hazards and impacts.

This work is also a step toward the development of a citizen science platform that can utilize multiple data sources to study earthquakes and their impact. The MyShake felt reports are a relatively new feature in the MyShake app with the aim of collecting users' observations about the earthquake after it occurred. These data are complementary to the waveforms recorded with the accelerometer in the phone. The data collected from the felt reports are more subjective and depends on the sensitivity and interpretation of each person; but we show here that, by aggregating large numbers of these felt reports in a region, the averaged ground-shaking reports are consistent with the more detailed DYFI surveys and reports. In addition, even though the MyShake reports are based on a small number of categorical levels, that is, none, light, moderate, strong, and severe shaking, once averaged in spatial bins, the averaged values can provide a more granular estimate of shaking intensity than the in-app five report levels. This has the potential to provide a complimentary source of data to the USGS DYFI reports.

Looking forward, the collection of felt reports can be assisted by allowing the users to upload postearthquake images of damage to buildings, roads, or other infrastructures. These images could serve several purposes. First, by displaying the images in the MyShake felt reports map, they can be used to increase the feeling of user participation. Second, these damaged images can be potentially used in the civil engineering community for damage estimation or more detailed understanding of the shaking in the region. Initial work has been developed
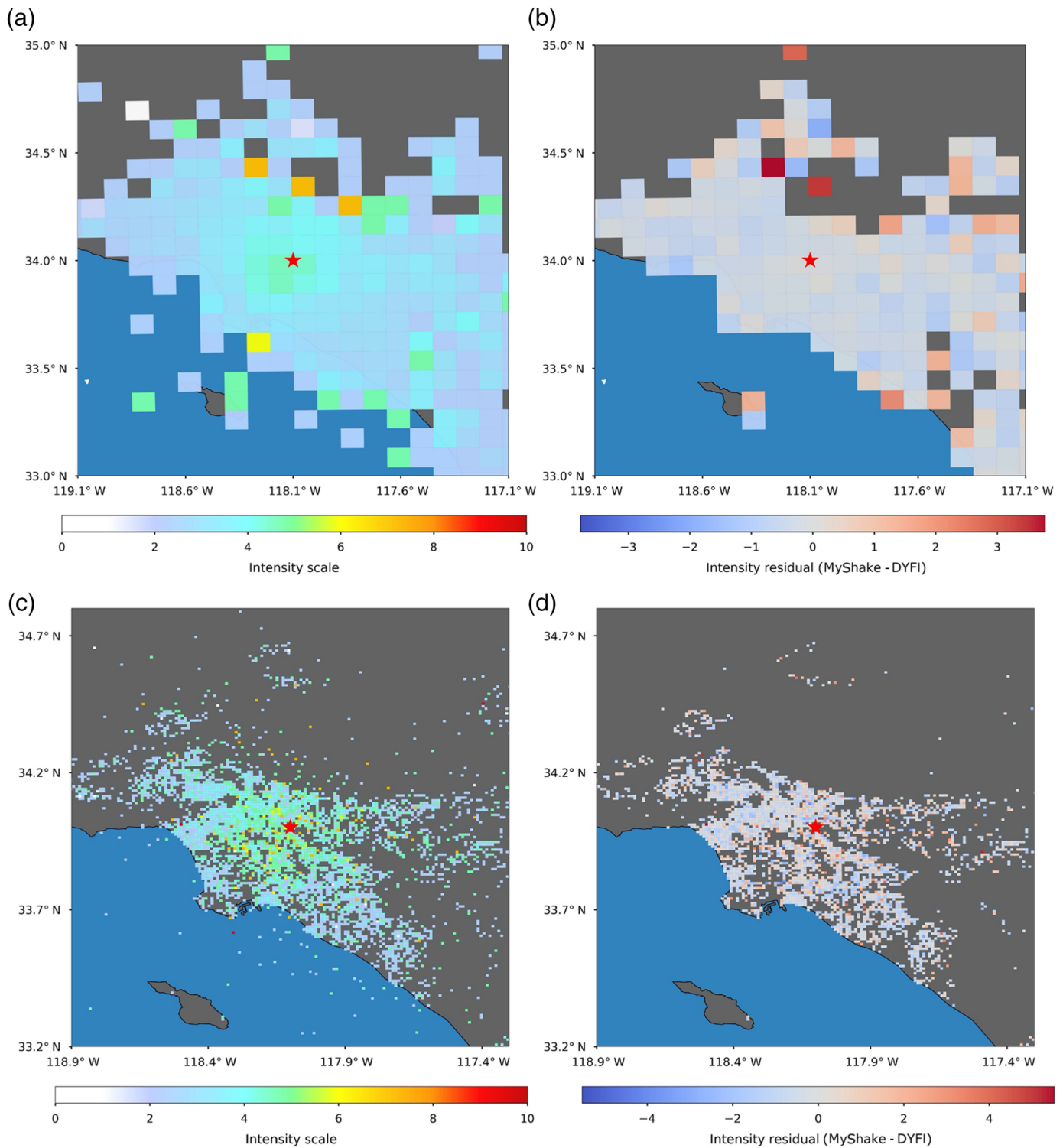
Figure 7. Spatial intensity distribution and the residual compared to DYFI in 10 and 1 km Universal Transverse Mercator (UTM) boxes. (a) Derived calibrated intensity map from MyShake felt reports in 10 km UTM boxes. The map uses the same intensity color scale as the one used in ShakeMap by the U.S. Geological Survey (USGS). (b) The intensity residual map compared to 10 km DYFI from USGS, the mean and standard deviation of the residuals are −0.08 and 0.75, respectively. (c,d) Same as panels (a) and (b), but for 1 km UTM boxes. The mean and standard deviation of the residuals for the 1 km UTM boxes are −0.22 and 1.12, respectively. Note, residual maps are made only for places in which data are available for both MyShake and DYFI. Because of the small number of MyShake felt reports in each UTM box, we do not use any quality control for this map, that is, no requirement of the minimum number of reports in each box to average. The red star is the location of the 19 September 2020 **M** 4.5 earthquake. The corresponding DYFI intensity map is shown in Figure S12. The color version of this figure is available only in the electronic edition.
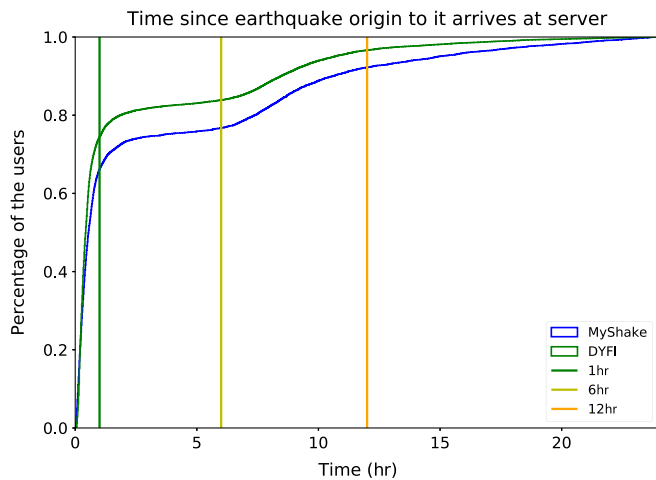
Figure 8. Reporting time history for the MyShake and DYFI felt reports. The percentage of the felt reports is shown versus time after the origin of the earthquake. The 1, 6, and 12 hr lines are also plotted in the figure. The color version of this figure is available only in the electronic edition.

(Chachra *et al.*, 2022) to use transfer learning to identify damage building images from crowdsourcing platforms in the hope to filter out unrelated pictures uploaded by the users.

Conclusion

This article shows our initial efforts to evaluate and link the simple MyShake felt reports to MMI shaking as reported by the USGS DYFI product. We find good correlation between the two using a simple linear relationship (equation 1 and Table 4) when they are both averaged in distance bins and compared as a function of hypocentral distance. The correlation improves with the increasing number of MyShake felt reports; we find that 10 reports in distance bins can be aggregated to a stable measurement. The spatially averaged felt reports can also be plotted as a map to provide a shaking intensity map. Through this established link between MyShake felt reports and MMI, the crowdsourced MyShake felt reports can be used by the scientific community to provide another independent shaking intensity dataset.

Data and Resources

MyShake data are currently archived at Berkeley Seismology Laboratory and use is constrained by the privacy policy of MyShake available at http://myshake.berkeley.edu/privacy-policy/index.html, but data for the research purposes can be requested from the authors. The data for the Gridded Population of the World can be available at https://sedac.ciesin.columbia.edu/data/collection/gpw-v4. U.S. Geological Survey (USGS) Did You Feel It (DYFI) data can be available at https://earthquake.usgs.gov/data/dyfi/. USGS Advanced National Seismic System (ANSS) Comprehensive Earthquake Catalog (ComCat) can be accessed at https://earthquake.usgs.gov/earthquakes/search/. The corresponding supplemental material contains extra examples for the raw MyShake felt reports, shaking scale comparison between MyShake converted modified Mercalli intensity (MMI) and DYFI MMI, as well as the spatial distributed MyShake converted MMI map. All websites were last accessed in June 2023.
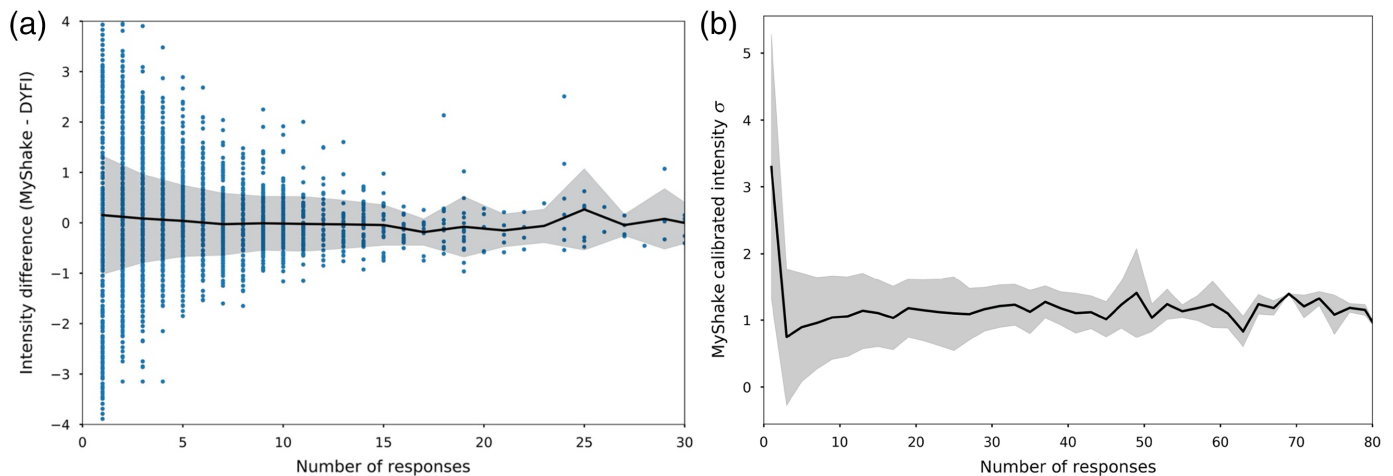
Figure 9. (a) Number of responses versus intensity difference between calibrated MyShake and USGS DYFI. The blue dots are the intensity differences within the 1 km UTM boxes, the black solid line and the gray shaded area are the mean and standard deviation of the intensity difference for different events, respectively. (b) Number of responses versus MyShake calibrated intensity standard deviation (σ) within 1 km UTM boxes. The black solid line and the gray shaded area are the mean and standard deviation of the MyShake shaking scale σ for different events. The number of responses versus the MyShake raw shaking scale intensity standard deviation plot is shown in Figure S19. The color version of this figure is available only in the electronic edition.

(a) nc73554215, **M** 3.82, at 15 km N of Morgan Hill, CA
748 reports, MAE: 0.3519

(b) nc73559265, **M** 4.65, at 19 km NW of Truckee, CA
1671 reports, MAE: 0.5962
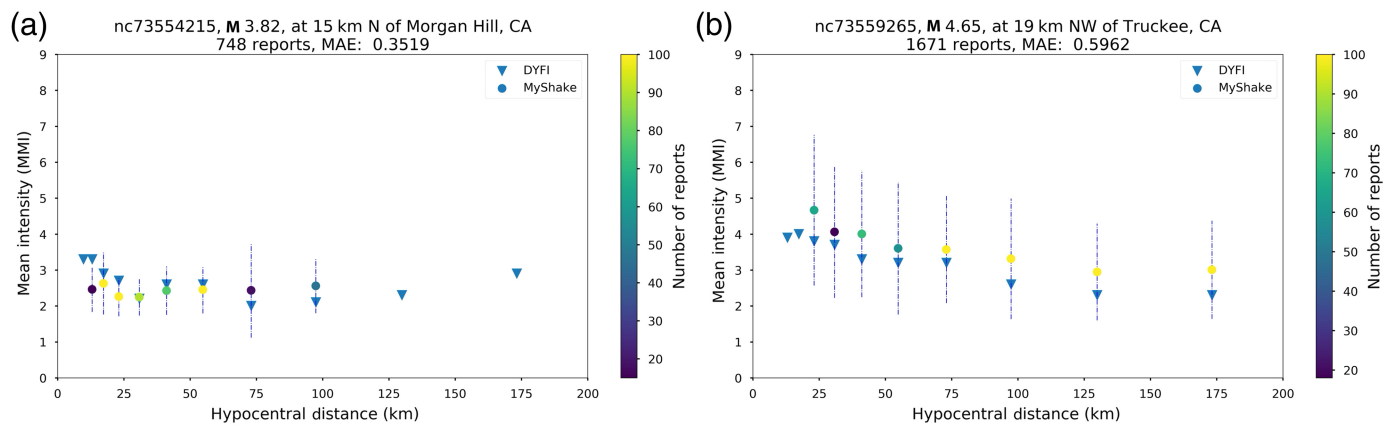
Figure 10. Two events with large intensity errors between the MyShake and DYFI felt reports. (a) **M** 3.86 Morgan Hill event. (b) **M** 4.65 Truckee event. MyShake shaking scales are color coded by the number of felt reports. The dotted vertical lines are the standard deviation of MyShake intensities in the distance bins. The color version of this figure is available only in the electronic edition.

Declaration of Competing Interests

The authors acknowledge that there are no conflicts of interest recorded.

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