Utilization of the Internet for Rapid Community Intensity Maps

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(to appear in *Seis. Research Letters*, September, 1999)

1 Abstract

Automatic, rapid generation of seismic intensity maps is accomplished by collecting shaking and damage reports from Internet users immediately following felt earthquakes in southern California. Intensity survey questionnaires, contributed from members of the community using forms made available through the Internet, are converted to Community Internet Intensities (CII) using a modified version of the algorithm of Dengler and Dewey (1998). Here, "communities" are defined by the geographic boundaries of 5-digit ZIP codes. As information is received and processed through our World Wide Web site, the associated ZIP code region is color coded and an interactive, web-based, regional map of the seismic intensity distribution is updated. This application allows for much more rapid generation of intensity maps than the standard, labor-intensive practice of mailing intensity surveys and manual processing and interpretation.

Evaluation of this automated process has shown it provides robust results for questionnaire responses from recollected experiences of the 1994 Northridge earthquake as well as for several recent smaller earthquakes felt in southern California. This approach can be implemented on a regional or national scale, and we are in the process of coordinating such an effort. In the meantime, a magnitude 5.0 earthquake on August 17, 1999 occurred near Bolinas, California (just north of San Francisco) and we successfully logged and mapped over 1,100 responses. The URL for the Community Internet Intensity Map is http://www-socal.wr.usgs.gov/ciim.html. An online version of this manuscript with full-color figures can be found at that site.

2 Introduction

The most common information available immediately following a damaging earthquake is its magnitude and the epicentral location. However, it is also desirable to know the extent of the felt area, and more important, the range of shaking experienced and the areal extent of strongest shaking. For most of the United States, there is insufficient seismic strong-motion station coverage to quickly and accurately portray the extent of strong shaking.

Seismic intensity has been traditionally used worldwide as a method for quantifying the shaking pattern and the extent of damage for earthquakes. Though developed prior to the advent of today's modern seismometric instrumentation, seismic intensity scales nonetheless provide a useful framework to describe, in a simplified fashion, the complexity of ground motions and the extent and nature of the damage. A limitation of traditional intensity mapping has been the long time that is required to generate a detailed seismic intensity map, typically weeks to months. For this reason, intensity maps have had limited use immediately after the earthquake for response and recovery efforts.

We describe here a system that is intended to quickly tap the abundant information available about earthquakes directly from those people who actually experience them. By taking advantage of the vast numbers of Internet users, we can now generate initial intensity maps almost instantly and continuously update the maps as additional information is received.

The resulting intensity maps serve several purposes. They provide a very rapid means of displaying the pattern of shaking independently of strong-motion seismographs. With sufficiently distributed responses it has been shown (Hales and Dengler, 1998) that even small-scale variations in intensity can be recovered. In addition, once fully calibrated, voluntary Internet contributions may significantly reduce the manpower required to collect intensity observations and interpret questionnaires as done traditionally. Finally, the interactive nature of the web-based questionnaire and mapping provides an unprecedented avenue for community involvement. The interactive Web site provides an avenue for feedback among the communities affected by earthquakes, the scientists studying their effects, and agencies responding to the disasters. With continued outreach and development, these maps will improve public understanding of the effects of earthquakes.

The Internet has been recently utilized for collecting intensity information forms for earthquakes by several regional seismic networks and institutions (e.g., Qamar *et al.*, 1995; Cajka and Halchuk, 1998). In this paper we discuss the development of the first fully automated system. It is activated by a local earthquake trigger, in our case the Southern California Seismic Network (SCSN) event associator (Given *et al.*, 1994), updating our Web page for event-specific intensity data collection. The users' responses to the forms in turn trigger automatic processing which converts the information supplied into numerical intensity values and then makes maps specific to the earthquake location and the data received. The maps are automatically updated as new data are received.

Several factors make southern California a prime location for initiating, validating, and testing such a system. The relatively frequent occurrence of felt earthquakes and a high density of Internet users makes this area a natural laboratory. The existence of the SCSN and TriNet allow us to directly compare the Community Internet Intensity (CII) results with the seismically-determined location and magnitude of events and with the ground motions and instrumental intensities ("ShakeMaps" Wald *et al.*, 1999) for the same earthquakes. While the southern California CII system has been very useful for small shocks that produce low and intermediate intensities, it has not yet been tested by an earthquake that has produced damaging intensities. However, the deeply embedded memories of the 1994 Northridge earthquake have allowed us to directly compare CII results for that earthquake with the actual USGS Modified Mercalli Intensity (MMI) determinations (Dewey *et al.*, 1995).

3 Calculating Community Internet Intensities

In order to rapidly produce useful post-earthquake information, we need to convert the numerous individual observations of the effects of the earthquake into a map of the distribution of the seismic intensities. We use the Internet to post questionnaires and then assign an intensity value to each community from which a response has been recorded. For multiple observations in a community, the intensity value reflects the average effects of shaking reported by that community.

The form of the questionnaire and the method for assignment of intensities is based on the algorithm developed by Dengler and Dewey (1998) and applied by Dengler and Dewey to telephone survey data collected by the Humboldt Earthquake Education Center (HEEC) following the 1994 Northridge earthquake. This approach is particularly well suited for electronic gathering of responses using the Internet because it allows direct, instantaneous conversion of user input into numerical values of shaking intensity, rather than the time-consuming individual assignments of intensity by a qualified analyst.

To calculate a community decimal intensity (CII), we assign numerical values to individual answers to each question on the posted form; Appendix A provides the values used in our processing (as shown in brackets). Then, for each "community", the numerical values assigned to each question are averaged. A weighted sum of the community average values for each question, a "Community Weighted Sum" (CWS), is then computed based on the following equation:

$$\begin{aligned} CWS \; = \; & 5 \text{ x "felt" index [a value from 0 to 1]} \\ & + \text{"motion" index [a value from 0 to 5]} \\ & + \text{"reaction" index [0 to 5]} \\ & +2 \text{ x "stand" index [0 to 1]} \\ & +5 \text{ x "shelf" index [0 to 3]} \\ & +2 \text{ x "picture" index [0 to 1]} \\ & +3 \text{ x "furniture" index [0 to 1]} \\ & +5 \text{ x "damage" index [0 to 3]} \end{aligned} \quad (1)$$

The CWS indices in quotes above are annotated on the sample survey given in Appendix A to identify the corresponding subset of relevant question(s). Note that several questions on the survey are not directly used in the CII calculation, but responses to these questions are collected both for future research and for consistency with the standard USGS MMI postal questionnaire. These include questions on whether the observer was inside or out, on the type of structure in which the observer was located, and the perceived duration of shaking (See Appendix A). For much more detailed information concerning the makeup of the questions see Dengler and Dewey (1998).

Finally, in order to assign numerical intensities to the CWS values, we need to relate these CWS values to the MMI values. Dengler and Dewey (1998) calibrated their community decimal intensity (CDI) scale by developing a relationship between the USGS MMI values for the Northridge earthquake (Dewey *et al.*, 1995) and the CWS for the same communities. Using a linear regression, they determined that

$$CDI = 3.3 + 0.13CWS \quad (2)$$

Since they were primarily interested in the intermediate to high intensity values, this relationship was quite suitable (See Figure 11 of Dengler and Dewey, 1998), although the highest and lowest intensity values were not well fit. We would also like to apply this approach to all felt earthquakes, as well as damaging events, so we are interested in providing a better estimate of lower intensities as well.

Here, for higher intensities, we correlate the CWS values determined using our Internet responses for the 1994 Northridge (over 800 responses), the 1991 Sierra Madre (30 responses) and the 1987 Whittier Narrows (100 responses) earthquakes with the USGS Modified Mercalli Intensities for the same or nearby communities. At lower intensities, the Internet CWS values for recent earthquakes are compared with data from ShakeMap instrumental intensities (see Wald *et al.*, 1999). We then revised the regression to better fit the extremes of the intensity values using the logarithmic relationship:

$$CII = 3.40 log_e(CWS) - 4.38, \text{for } CWS \geq 6.53 \quad (3)$$

For any "felt" response and $CWS < 6.53$, $CII = 2$; for "not felt" responses, $CII = 1$. Figure 1 shows the data and regression using the relationship given in Equation 3. Henceforth, we will distinguish the Community Internet Intensity (CII) from the Community Decimal Intensities (CDI) of Dengler and Dewey (1998) to indicate that we use Internet exclusively for data collection and that the conversion of survey responses to intensity is slightly different as discussed above.

While the CII values are computed to two decimal places, they are then rounded off to integer values for comparison with the Roman numerals assigned to MMI values. The rounding adheres to the convention that, for example, values between 5.50 and 6.49 round to intensity 6. Dengler and Dewey (1998) showed that the macroseismic evidence is capable of resolving gradations between the integer intensity units, but we have not yet acquired data with sufficient density of observations to warrant such precision. Further, our empirical relation (Equation 3) will be re-evaluated as more data become available for future earthquakes.

In addition to using a different equation to calculate the CII, we have also slightly modified the questions and assignment of CII values from that of Dengler and Dewey (1998). To the question "Did you feel the earthquake?" (see Appendix A), we have added "Did others nearby feel the earthquake?". This followup question allows us to distinguish among the lowest intensities from a single response by obtaining information about the fraction of those in the area who felt the earthquake, rather than requiring multiple responses to "Did *you* feel it?" to obtain this percentage.

For convenience, we define "communities" to be ZIP code regions. Maps of ZIP codes are widely available and are often used in surveys. They correlate well with population; areas with small populations have large individual ZIP codes, making it more likely each ZIP code has at least one respondent. They are general enough that people are willing to give them out, as opposed to phone numbers or addresses, and they are universally known compared to, say, census tracts (see Hales and Dengler, 1998), 5+4 ZIP codes, or latitude and longitude. Further, they are somewhat recognizable on a map.

A problem with using ZIP codes is that some cover large expanses of lightly populated mountains or desert in addition to the population centers from which our results will come. It may be desirable to recover users' point locations more accurately from input street addresses (or 5+4 ZIP code). A ZIP code is a required element of the questionnaire, but respondents are encouraged to give additional location information such as address and nearest cross street. Many do, and this additional information could be used for a more detailed intensity map when major events occur. Latitude and longitude can be acquired from a street address using

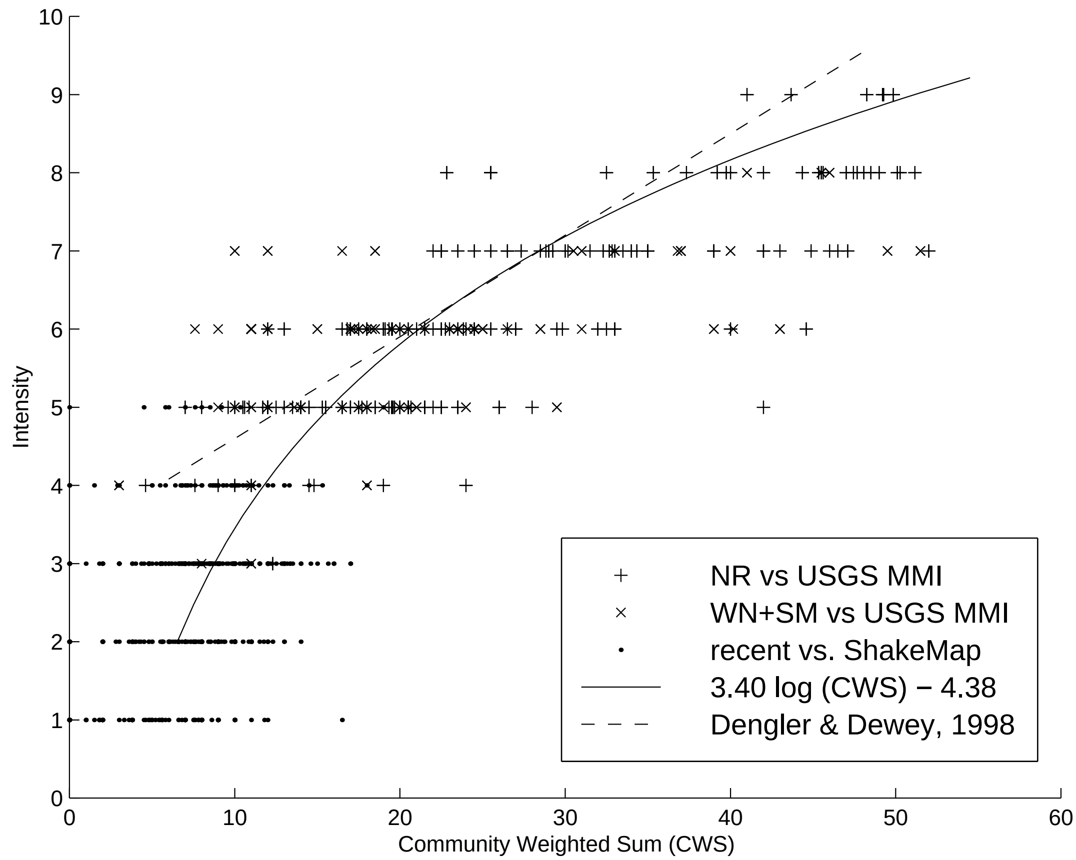

Figure 1: Regression of the Community Weighted Sums (CWS) verses observed and instrumental intensities given in Equation 3 (solid line). Data for higher intensities are USGS Modified Mercalli Intensities for the same communities from the 1994 Northridge (NR), 1991 Sierra Madre (SM), and 1987 Whittier Narrows (WN) earthquakes as labeled; lower intensities data (dots) are from ShakeMap instrumental intensities for recent earthquakes (see Wald *et al.*, 1999). The dashed line shows the linear fit to the CWS data collected by Dengler and Dewey (1998) verses USGS Modified Mercalli intensities for the Northridge earthquake.

GIS-based geolocation routines. However, this is likely to introduce errors and ambiguities as well, and more oversight may be required.

4 Community Intensity Web Pages

A Community Internet Intensity Map is made automatically a few minutes following any significant earthquake; it is also updated automatically as additional data are received. By default, regions are shown in gray and remain so until data for that ZIP code are received. As responses are received for a community, that ZIP code area is color-coded according to the computed CII. Currently our system can start receiving responses within about 3 minutes of the event origin time, and we update the map every 5 minutes if more data are received. Examples of the rate of response for recent, small southern California earthquakes are shown in Figure 2. We expect this rate to increase as the site becomes more widely known, particularly after larger earthquakes. When first entering the CII web page, the user is shown, by default, a map of the most recent earthquake and given a chance to submit a questionnaire for that quake. However, the user has the option of accessing maps and questionnaires of any of the recent earthquakes. For some widely-felt events, we received responses continuously for several weeks. We generally stop automatically revising each map one week after the occurrence, though further contributions enter the cumulative database.

At first only a few ZIP codes will have intensities assigned, but over time others will be assigned as more responses are sent in. Individual communities can change intensity (color) as data from more respondents are processed and a new consensus is reached. Ideally, a large number of responses would be available for each ZIP code "community". We expect that five or so responses are usually sufficient for a stable intensity assignment. Realistically, initial responses are dispersed regionally, so initially few ZIPS have multiple contributions.

Once an intensity map is generated, it becomes immediately available online in two forms. First we provide a GIF imagemap; with a Javascript-capable browser one can hold a mouse pointer over each colored ZIP code to see the ZIP code number, the intensity assigned, and number of responses provided. We also provide the maps in Portable Document Format (PDF) image. This format, although not usable as an imagemap, can be viewed by any PDF viewer and allows scalable zooming so that ZIP codes with small areas can be seen and printed with high resolution, unlike the bit-mapped imagemap version. An example snapshot of the CII Web page is shown in Figure 3.

Visitors to the our web site are also encouraged to respond to questionnaires on several events of recent years (the 1994 M6.7 Northridge, 1992 M7.3 Landers, 1991 M5.6 Sierra Madre, and the 1987 M5.9 Whittier Narrows earthquakes), that we feel are still memorable for many people in southern California. Because the majority of 'live' earthquakes exhibit low to moderate shaking, the responses to earlier strong shocks provide the most useful dataset of higher-intensity shaking which we have used to calibrate our procedure. Maps and questionnaires for recent events with a significant number of responses are also available for viewing online.

We must be careful to associate individual responses with data for the correct earthquake. While we designed the web page to clearly indicate which event is currently selected for a contribution, we also time-stamp the time of each response provided. This allows us the opportunity to check the time of a response against the earthquake origin time and to track the rate of post-earthquake contributions for Internet bandwidth considerations (e.g., Fig. 2).

The Community Internet Intensity Map Web site provides a link to our database of recent and historic earthquake maps, as well as a page of important disclaimers (see Appendix B) describing the inherent limitations of our mapping procedure and of using seismic intensities in general. We also provide information which introduces the concept of seismic intensity, summarizes the overall process of assigning intensities, and provides links to other references for further details.

5 Community Internet Intensity, USGS Modified Mercalli Intensity, and Instrumental Intensity

The procedure used to calculate the Community Internet Intensity values was calibrated so that the Community Internet Intensity values should, on average, be similar to the Modified Mercalli Intensity values for the same communities. In the United States, intensities have for many years been assigned on the basis of the Modified Mercalli Intensity scale (Wood and Neumann, 1931; Richter, 1958). Dewey *et al.* (1995) document the current procedures for assignment of USGS MM intensities, which have been slightly modified over the years to account for difficulties encountered using the earlier conventions.

At low-to-moderate shaking levels, the Modified Mercalli Intensities are based largely on postal questionnaires, in which respondents summarize the effects of shaking in their communities. In stronger shaking areas, Modified Mercalli Intensities are based on field study in areas of significant damage, on damage maps produced by emergency response agencies, on reports produced by the earthquake engineering community, and on press reports. For a destructive earthquake, the process of collecting and interpreting damage data and preparing a map of Modified Mercalli Intensities can take months. We hope that the CII map will serve as a useful first approximation to the Modified Mercalli Intensity map in the early hours and days following damaging earthquakes during which time the final Modified Mercalli Intensity maps are being prepared. We envision that the responses collected from the CII questionnaires will be considered in final assignment of USGS Modified Mercalli Intensities, but we do not currently envision that USGS MMI will be based on numerical values of CII that results from equation (3). Because there are major differences in the data and procedures used to assign the two types of intensities, the Community Internet Intensities cannot be considered to be identical to the USGS Modified Mercalli Intensities.

We received over 800 questionnaire responses for the Northridge 1994 event between May, 1998, shortly after our system when online, and July, 1999. We find that there is a good correlation between USGS MMI (numbered circles) assignments of Dewey *et al.* (1995) and the CII values derived from the recollections of the respondents (ZIP codes) as shown in Fig. 4. While there are occasional discrepancies of more than $\pm$ 1 intensity unit, these typically occur in ZIP codes where we received fewer than 5 responses.

The Community Internet Intensity (CII) maps were intended to be compatible with TriNet "ShakeMap" Rapid Instrumental Intensity Maps (Wald *et al.*, 1999). Like "ShakeMap", the CII maps are centered on the epicenter (star) of the earthquake and have similar overall dimensions as the "ShakeMaps". However, the "ShakeMaps" are based on point location measurements of the ground motion as recorded by seismometers; the Instrumental Intensity is inferred by empirically relating the recorded peak ground motions to MMI values and then interpolating the ground motions between the recording sites to complete the maps. In contrast, the CII maps provide intensity values only in areas (communities) where data have been provided; no interpolation is done, and hence the intensity in unrepresented areas is left undefined. Nonetheless, there is generally good overall agreement between the CII maps and the ShakeMap instrumental intensities (Figs. 4-9).

An example of a recent community Internet Intensity map is shown in Figure 6 for the M3.7 earthquake on June 3 1998, near Mt. Palomar, California. The corresponding

"ShakeMap" Instrumental Intensity map is given in Figure 7. Figures 8 and 9 show a second example of a CII map and a "ShakeMap", respectively, for the August 20, 1998, M4.4 earthquake which occurred near Wrightwood, California. Note the area of locally higher intensities near Riverside (approximately 117.3° W., 33.9° N.) on the CII map (Fig. 8) is confirmed by the instrumental measurements shown in Figure 9.

Even with the current sparse dataset, the CII dataset has proven to be a useful tool for calibrating the ShakeMap intensity algorithm for low amplitude shaking (Wald *et al.*, 1999). Since there is very little recorded (and digitized) ground motion data for areas that experienced Modified Mercalli intensities of IV or less, there is little empirical basis for assigning low intensities based on current ground motion recordings. Using the CII responses that we have collected for various historical and recent earthquakes, we can begin to put constraints on the intensities for low amplitude shaking. Figure 10 shows a comparison of CII and "ShakeMap" instrumental intensity values for historical and recent earthquakes. Since the instrumental intensities are derived directly from peak ground motion values, this figure shows how recorded peak motions relate to CIIs. We have determined that the approximate boundary between "felt" and "not felt" shaking occurs at about 0.2 %g, at least for small to moderate-sized events. These relationships will revised as we obtain more CII data near TriNet seismic stations recording the same events.

6 Advantages and Problems with Intensity Data Collected Online

The use of computer technology for survey data has several advantages over human processing (for example, see Bloom, 1998), but it also has potential pitfalls. The use of online forms allows an unprecedented number of responses to be collected (limited only by Internet access and the number of online users) at virtually no cost per response. With computerized processing, these responses can be converted into a maps of general shaking within a minute. As time goes on, new responses automatically update the map, resulting in a more accurate portrayal of ground shaking and damage.

Large (magnitude 6.0 or higher) earthquakes may generate hundreds of times the number of responses we have thus far received for moderate events. The CIIM processing system requires no scaling for handling this amount of data, unlike the direct scaling of the amount of manpower required to collect and process individual responses by hand. This should free up resources for a more concentrated effort of scientific personnel on areas characterized by higher intensity, which require more professional oversight for assignment than do lower intensities. Likewise, since our database is originally in digital form, it is simple to test modifications to the algorithms that assign intensities to questionnaires. This is not possible with the traditional postal questionnaires.

The primary problem of automatic processing is with quality control of the data. Obvious anomalies or extreme outliers are quite evident from a quick glance at a map, and any such data can be readily removed by hand and flagged for further examination. Less obvious anomalies must be found with alternative means. Self-consistency can be routinely checked such that a questionnaire with internally inconsistent answers, for instance a shaking response of "not felt" having a associated reaction index of "very frightened" in the same entry, can be flagged for removal. We have also imposed empirically-based maximum intensity limitations as a function of magnitude such that, for example, an intensity IX response for a magnitude 4.5 earthquake will not be mapped. However, no data will be deleted; saving greatly discrepant responses will give us a perspective on the level of problem responses. As in any survey, no automatic checking can consistently and correctly account for the variations in human response.

The anonymity of the Internet tends to bring out unusual characteristics in humans that might otherwise be left pleasantly untapped. Yet, thus far, very few problems have been encountered. In ZIP codes from which multiple responses are received, deliberately misleading and grotesquely uncomprehending responses are conspicuous in the midst of more reasonable responses, and they can be filtered out. However, a significantly erroneous response could dominate the CII computed for a ZIP code with one or only a few responses. For this reason, we make it clear on the web site description that a minimum of 5 responses per ZIP code is desirable for a stable intensity distribution. Rapidly produced maps should be considered preliminary and transient; later updates will hopefully be more accurate and more robust. There is a significant improvement in the fit of the CII to the MMI values assigned by Dewey *et al.* (1995) as the number of responses per ZIP code exceed 5.

Our Web site provides a comment form in addition to the questionnaire. We have occasionally received notifications of erroneous input which were easily manually corrected. The comment form is also useful for allowing suggestions and for reporting web-site problems, as well as compliments and, less frequently, complaints.

7 Community Involvement

The interactive nature of the web-based questionnaire and mapping provides an excellent avenue for community involvement. By sharing their experience of the earthquake, individuals make a unique contribution to the scientific body of information about the earthquake. This assistance from the public is vital to the success of the Community Intensity Map; the more questionnaires that are received for each ZIP code, the more reliable will be the average intensity assigned to that ZIP code. In turn, visitors to the Web site learn more about how their communities and others fared, and the maps can provide them with a general understanding of shaking variations and effects of earthquakes.

Our approach to reporting seismic intensities addresses a strong desire on the part of much of the public to participate and be heard following frightening experiences such as earthquakes. The questionnaire, as posted, provides room for extended written input or prose, an opportunity to "let go". The simple fact that we accept and appreciate feedback from the community may provide a critical outlet for many following a potentially traumatic experience. In fact, a number of comments have been received indicating how pleased people are to have a place to report what they felt, even for the more common small-to-moderate earthquakes that, while non-damaging, are nonetheless threatening psychologically. The responses archive, automatically, the human side of the earthquake experience. All of the responses are kept for future examination, perhaps for applications in the area of human response to earthquakes that we have not specifically considered here.

The CIIM Web site has been operating for only one year. After further calibration we hope to take this tool directly to the community, particularly through involvement with local high school science classes. Systematic contributions from high school classes in each ZIP code would insure more uniform coverage for all earthquakes, and targeted locations near seismic instruments would be particularly useful in further relating recorded ground motions to perceived shaking and damage. Many of the responses we now receive are from returning respondents—people who have found the web site and return when they feel or hear about an earthquake. This is encouraging since the users' experience will likely lead to more knowledgeable responses. Returning respondents may, with time, help minimize problems associated with underreporting from locations where an earthquake is not felt, since they will have been exposed to our Web page plea for "did not feel" reports (Appendix A).

8 Discussion

Our experience with the Community Internet Intensity concept as developed in this paper has to date been confined to a small subspace of the domain to which it may potentially be applied. We have so far operated the system only in Southern California. We have computed the CII for 5-digit Zip Codes. For small and moderate earthquakes, the CII system has been tested in real time, but for large, damaging earthquakes the system has been tested only on data provided years after the events. The CII concept will likely evolve significantly as we enlarge our application of it.

Although the CII procedure is currently triggered by seismographic data from a dense network of seismographs, the CII concept does not rely fundamentally on seismic network information. In fact, the concept may be particularly useful in regions that are not well monitored by seismographs capable of recording strong ground motions but which experience infrequent damaging earthquakes. For these regions, large numbers of intensity observations, such as those that might be provided by CII from a moderate or larger earthquake, might significantly enhance understanding of propagation and amplification of strong ground shaking.

We have emphasized that the CII, while calibrated to agree with the USGS MMI in some average sense, should not be considered equivalent to the USGS MMI. In the long run, we expect that data collected electronically will take the role of data collected by postal questionnaire in the assignment of USGS MMI's. It is not clear, however, that these data will be collected by a questionnaire that is identical to the CII questionnaire or that the assigning of USGS MMI will be based on equation 3. As the USGS MMI evolves, we expect continued emphasis on maintaining consistency of future USGS MMI with past USGS MMI, with less emphasis on the rapid processing and display of intensities that are primary goals of the CII procedure.

9 Acknowledgments

All maps were generated with Generic Mapping Tools (GMT, Wessel and Smith, 1991). Discussions with Jim Goltz improved this system, as did a various insightful comments from Internet users.

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10 Appendix A, Questionnaire

This Appendix displays the form of the questionnaire available online. The online version takes advantage of WWW form and radio buttons to simplify the process of responding and allows for default (no answer) for those questions left untouched. The form below indicates the numerical value assigned to each answer [numbers in braces] as well as the particular index words in brackets used to compute the Community Weighted Sum (see equation 1). The items enclosed by braces and brackets are *not shown* on the online version of the questionnaire.

COMMUNITY INTERNET INTENSITY MAPS

DID YOU FEEL IT? REPORT IT HERE!

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You can help provide information about the extent of shaking and damage
for earthquakes in southern California, and you may provide specific details
about how your area may respond to future earthquakes.

You can help by filling out the questionnaire below. Even if you did not
feel the earthquake, but were in the general region of the epicenter, please
respond! (We would like to know the areas over which the earthquake was felt
and not felt). In the future, for other earthquakes that occur in your area,
please do the same. Your input will be used to make maps of shaking
intensity distribution.

USGS scientists may use the information you enter in this form to provide
qualitative, quantitative, or graphical descriptions of damage in USGS
publications. If you would object to this possible usage of your data,
please do not fill out this form.

  -----------------------------------------------------------------------
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                    QUESTIONNAIRE FOR THIS EVENT:
                            Northridge
                    Mag. 6.7 Jan 17 1994 04:30 PDT

    Please make sure you are filling out this form for the right event.

For other events or historic events, or to view other regions, go to the
CIIM database. To report an event not yet in our database, go to the New or
Unknown event questionnaire.
  ------------------------------------------------------------------------

Name:________________  E-mail:________________  Phone: __________________

Your location when the earthquake occurred:
 Street Address:        ______________________________________________
 Nearest Cross Street: ______________________________________
 City:_________________ County:____________  State:____
 Zip Code: ____________ (REQUIRED!)

Date and time of the earthquake (approximate):
Month:    Day:    Year:     Time (HH:MM):

  ------------------------------------------------------------------------
While answering all these questions is optional, we encourage you to fill
out as many as you can as you can so we can provide a more accurate
intensity estimate.
  ------------------------------------------------------------------------
What was your situation during the earthquake?
  ___Inside  ___Outside  ___In Stopped Vehicle ___In Moving Vehicle  ___Other

If you were inside please select the type of building or structure:

  __Single family home or duplex  __Apartment building
  __Office building/School        __Mobile home w/ permanent foundation
  __Trailer/RV with no foundation
  __Other, please describe:___________________________________

Were you asleep during the earthquake? __No __Slept through it _Woke me up

Did you feel the earthquake? (If you were asleep, did the
earthquake wake you up?)
   ___No [0] ___Yes [1]                                         ^
                                                                |
Did others nearby feel the earthquake?                          |
  __No answer/Don't know/Nobody else nearby [0.72]        {FELT INDEX}
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```
  __No others felt it                      [0.36]              |
  __Some felt it, but most did not         [0.72]              |
  __Most others felt it, but some did not  [1.00]              |
  __(Almost) everyone felt it              [1.00]              v

  ------------------------------------------------------------------------
YOUR EXPERIENCE OF THE EARTHQUAKE:

How would you best describe the ground shaking? (Check one.)
 _Not felt[0] _Weak[1] _Mild[2] _Moderate[3]
 _Strong[4] _Violent[5]                                      {MOTION INDEX}

About how many seconds did the shaking last? _____

How would you best describe your reaction? (Check one.)
 __No reaction/Not Felt  [0]
 __Very little reaction  [1]
 __Excitement            [2]
 __Somewhat frightened   [3]                               {REACTION INDEX}
 __Very frightened       [4]
 __Extremely frightened  [5]

How did you respond?
   __Took no action __Moved to doorway __Ducked and covered
   __Ran outside __Other:__________________________________

Was it difficult to stand or walk?  __No[0] __Yes[1]         {STAND INDEX}

  ------------------------------------------------------------------------
EARTHQUAKE EFFECTS:

Did you notice the swinging/swaying of doors or hanging objects?
  __No  __Yes, slight swinging  __Yes, violent swinging

Did you notice creaking or other noises?
  __No  __Yes, slight noise __Yes, loud noise

Did objects topple over or fall off shelves?                  {SHELF INDEX}
  __No[0] __Rattled Slightly __Rattled loudly __A few toppled or
  fell off[1] __Many fell off[2] __Nearly Everything Fell Off[3]

Did pictures on walls move or get knocked askew?
 _No[0] _Yes, but did not fall[1] __Yes, and some fell[1]   {PICTURE INDEX}

Did any furniture or appliances slide, tip over,
```

```
    or become displaced? _No[0] _Yes[1]                   {FURNITURE INDEX}

Was a heavy appliance (refrigerator or range) affected?
  _No _Yes, some contents fell out _Yes, shifted by inches
  _Yes, shifted by a foot or more _Overturned

Were free-standing walls or fences damaged?
 __No  __Yes, some were cracked  __Yes, some partially fell
 __Yes, some fell completely




If you were inside, was there any damage to the building? Check all
that apply.

   __No damage                                    [0]          ^
   __Hairline cracks in walls                   [0.5]          |
   __One or several cracked windows             [0.5]          |
   __A few large cracks in walls               [0.75]          |
   __Many large cracks in walls                  [1]           |
   __Ceiling tiles or lighting fixtures fell     [1]           |
   __Cracks in Chimney                           [1]           |
   __Many windows cracked or broken out          [2]      {DAMAGE INDEX}
   __Masonry fell from block or brick walls      [2]           |
   __Old chimney, major damage or fell down      [2]           |
   __Modern chimney, major damage or fell down   [3]           |
   __Outside wall(s) tilted over or collapsed    [3]           |
   __Separation of porch, balcony, or            [3]           |
       other addition from building                            |
   __Building moved over foundation              [3]           v

[The numerical value that is used for the ``damage'' index in Equation 1
 is the largest value among those of the checked damages]

If you know the type of building (wood, brick, etc.) and/or your location
(basement, penthouse, etc.) please indicate here:  _____________________
--------------------------------------------------------------------------

You may clarify answers or to make observations that are not accommodated
by other questions. You may also use the following space to give first-
person descriptions of how the earthquake affected you. USGS scientists
may use some of the information that you enter in qualitative descriptions
of shaking or damage in USGS publications. You would be identified as ``an
```

observer'' and your location would be given in general terms. Parts of some first-person accounts may be reproduced as quotations in USGS publications.

11 Appendix B, Disclaimers

General Disclaimer

Some USGS information accessed through this page may be preliminary in nature and presented prior to final review and approval by the Director of the USGS. This information is provided with the understanding that it is not guaranteed to be correct or complete, and conclusions drawn from such information are the sole responsibility of the user.

Community Internet Intensity Map Disclaimer

These are automatic computer generated maps and have not necessarily been checked by human oversight, so they may contain errors. Further, the input data for these maps are taken directly from the community of Internet users. While we make efforts to sort out unusual individual observations, the “net” product may still contain errors.

Since there is potential for biased contributions to provide misleading results, these maps may not provide a sound basis for insurance claims nor for evidence of damage at or near any specific location.

These maps are preliminary in nature and they will be updated frequently as data is supplemented by additional observations. It is important to reload your browser to see the update.

Different locations within the same intensity area will not necessarily experience the same level of damage since damage depends heavily on the type of structure, the nature of the construction, and the details of the ground motion at that site, whereas a community Internet intensity value is intended to represent an average value for an entire ZIP code region. For this reason more or less damage than described in the intensity legend may occur.

At present, the procedure for preparing the CIIM is new and experimental. Some aspects of the procedure may change in the future.

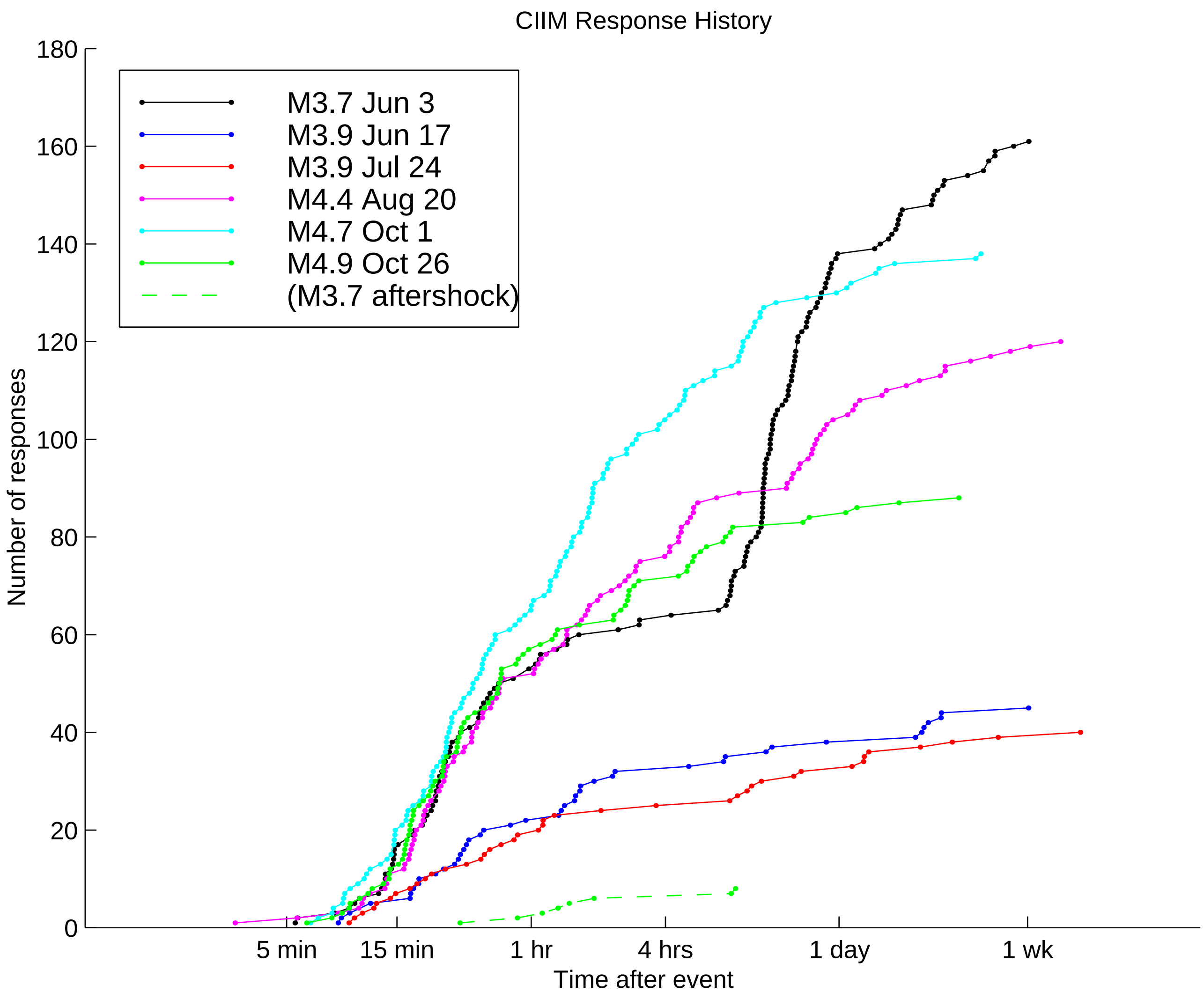


Figure 2: Time history of Community Internet Intensity responses for recent (1998) events. Responses are collected starting at about two minutes after trigger (usually <5 minutes after the event). Automated revision of the maps stops after two weeks, though collection of responses continues.

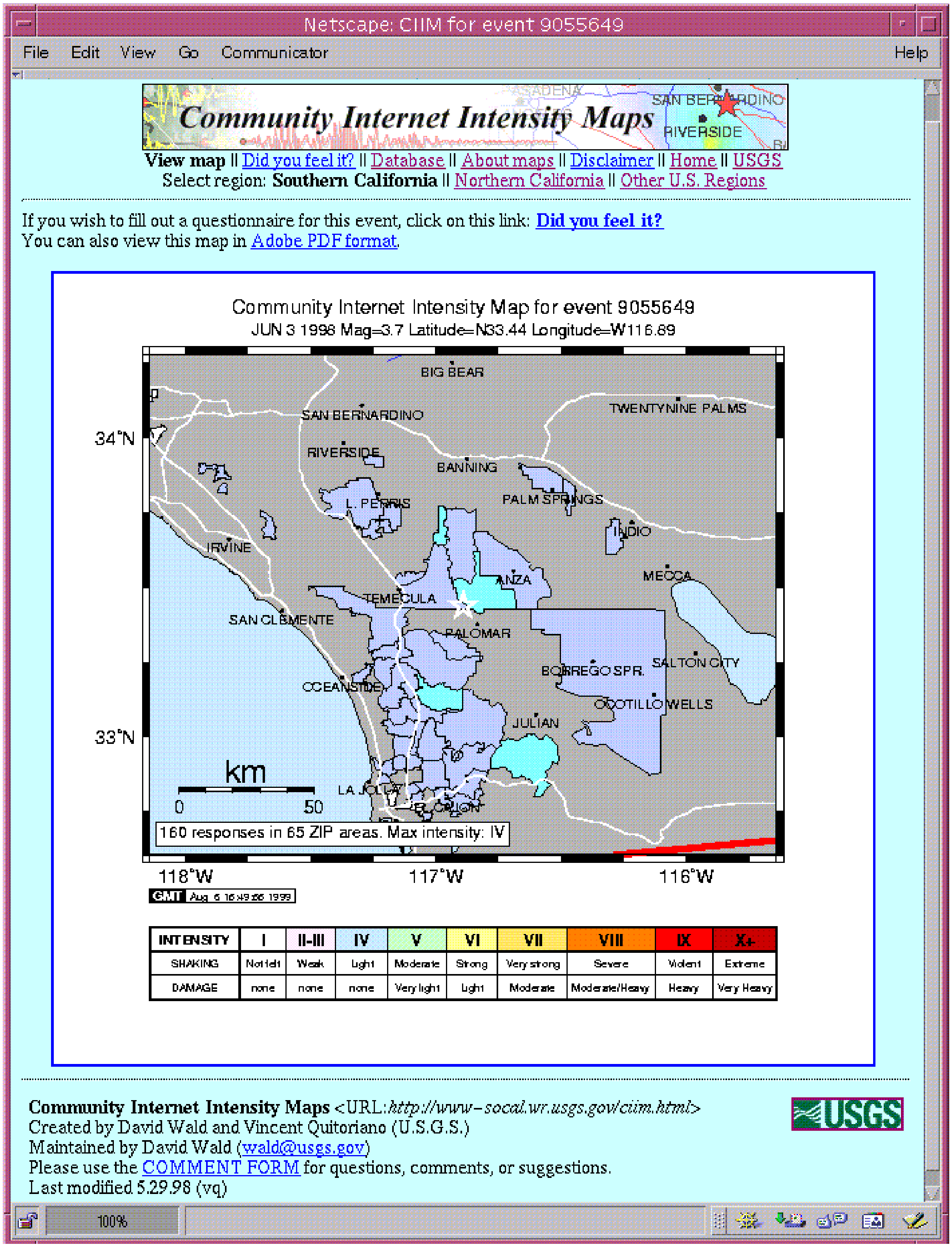
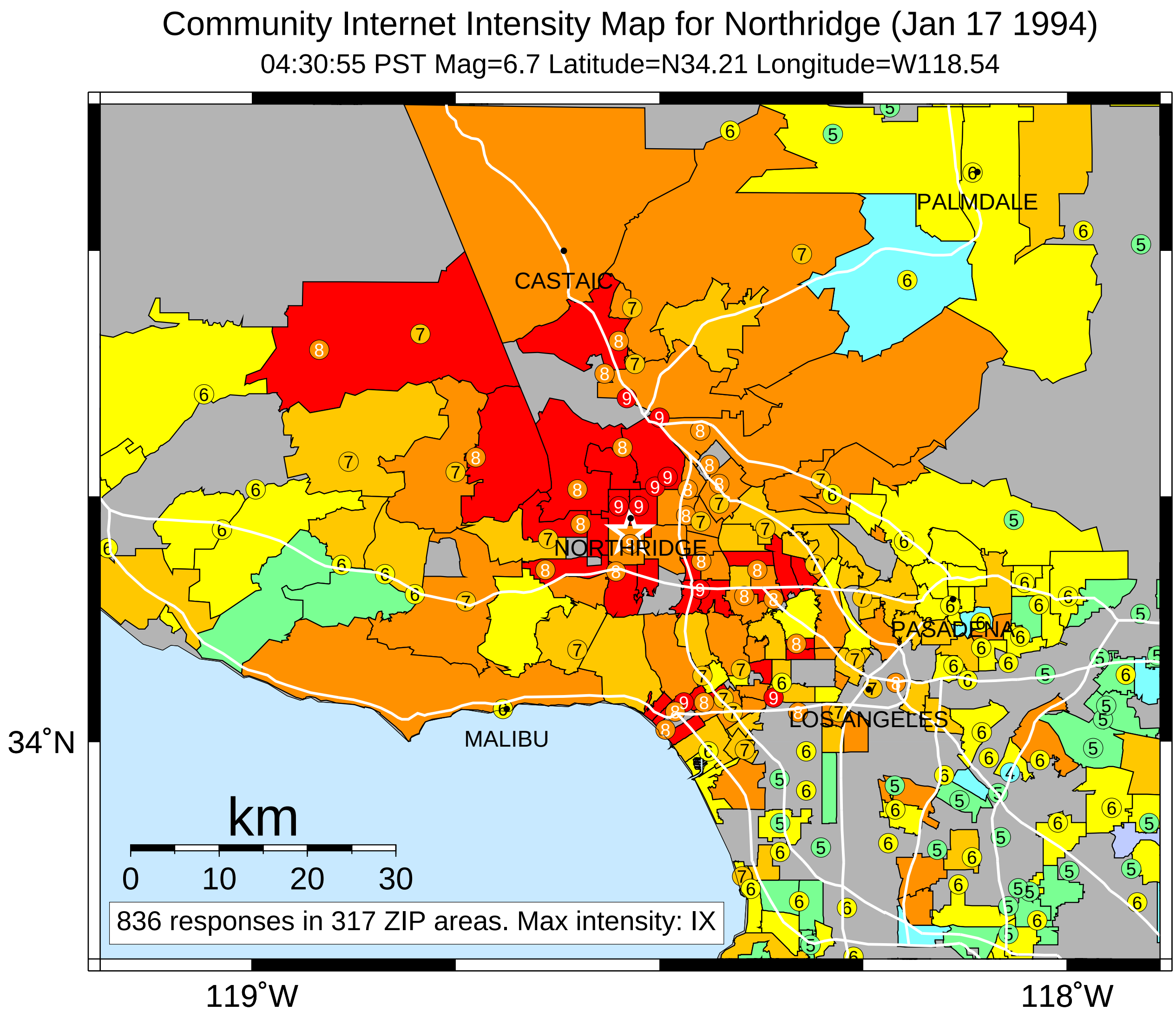
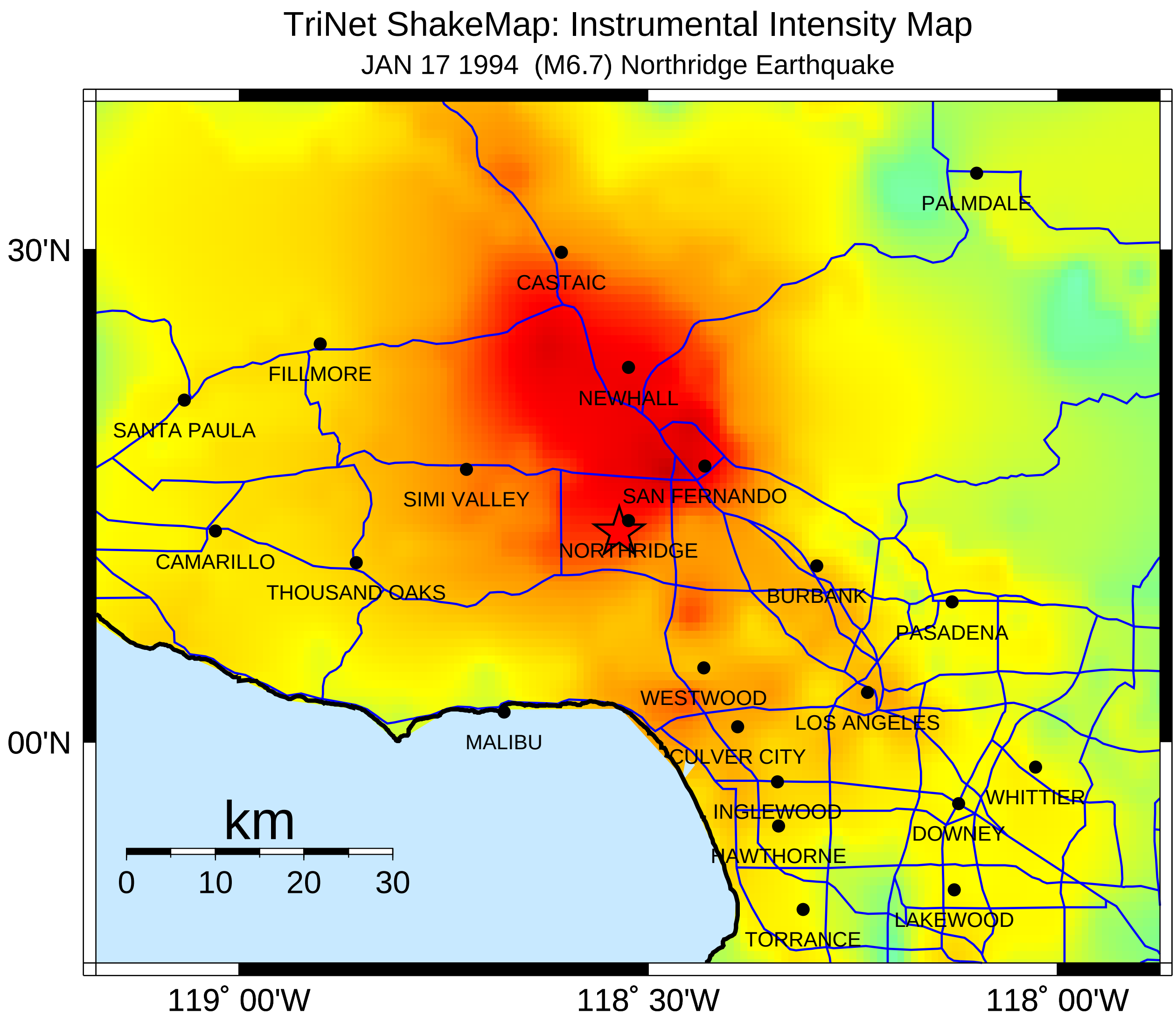


Figure 3: Example of Community Internet Intensity Map web page. The M3.7 earthquake occurred on June 3, 1998. Links allow access to the questionnaire forms ("Did You Feel it?"), the database, map information, other regions, and disclaimers. This map itself is an imagemap; selection of a ZIP code area returns the ZIP code number, the intensity, and the number of responses for that ZIP code. The legend provides a scale bar and one- or two-word descriptor of the levels of shaking and damage.



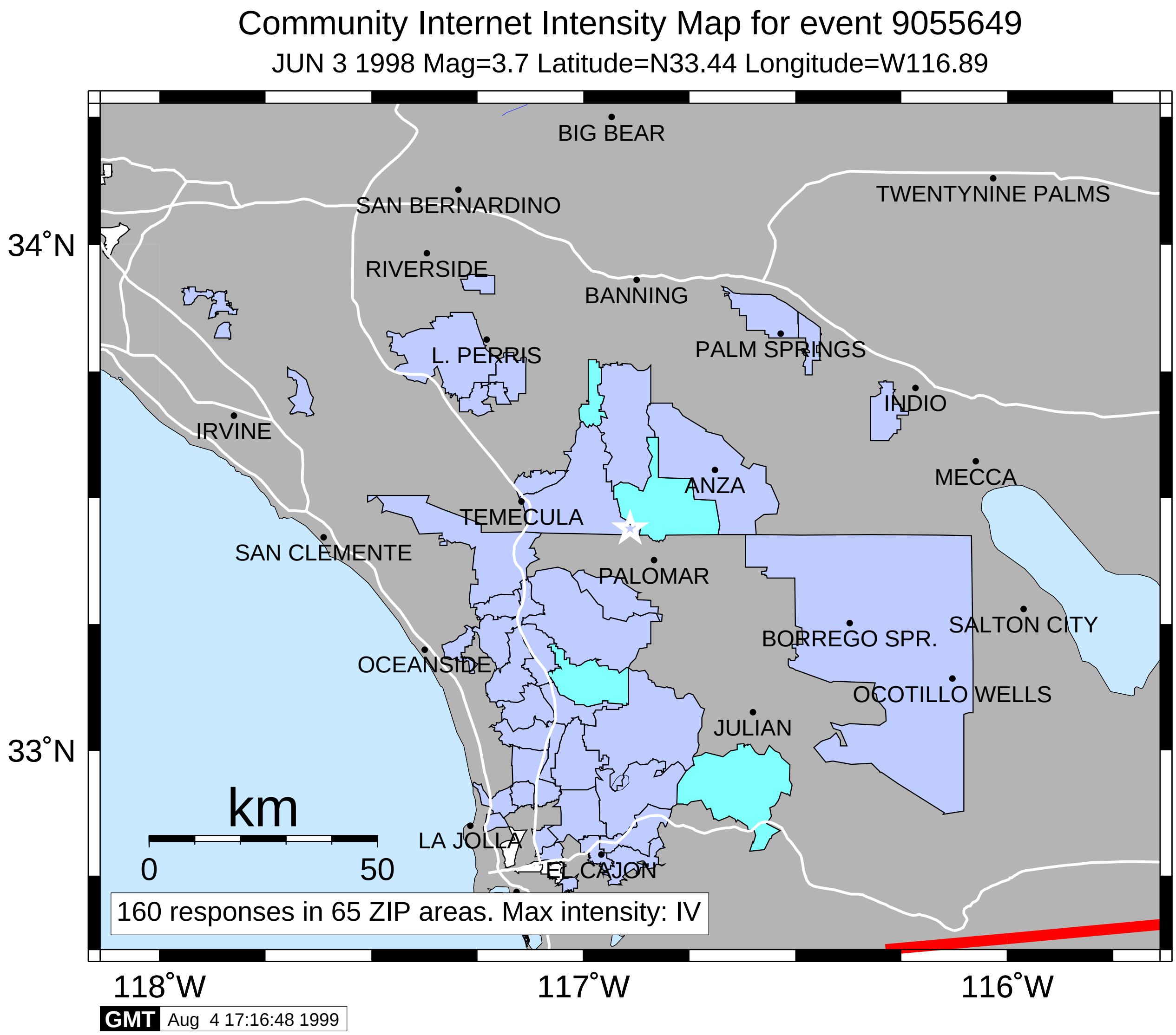
INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+
SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy

Figure 4: Community Internet Intensity maps for the Northridge 1994 event using data collected between May, 1998 and July, 1999. Superimposed on the ZIP code areas are the USGS Modified Mercalli intensity values (Dewey *et al.*, 1995) shown with number-filled circles.



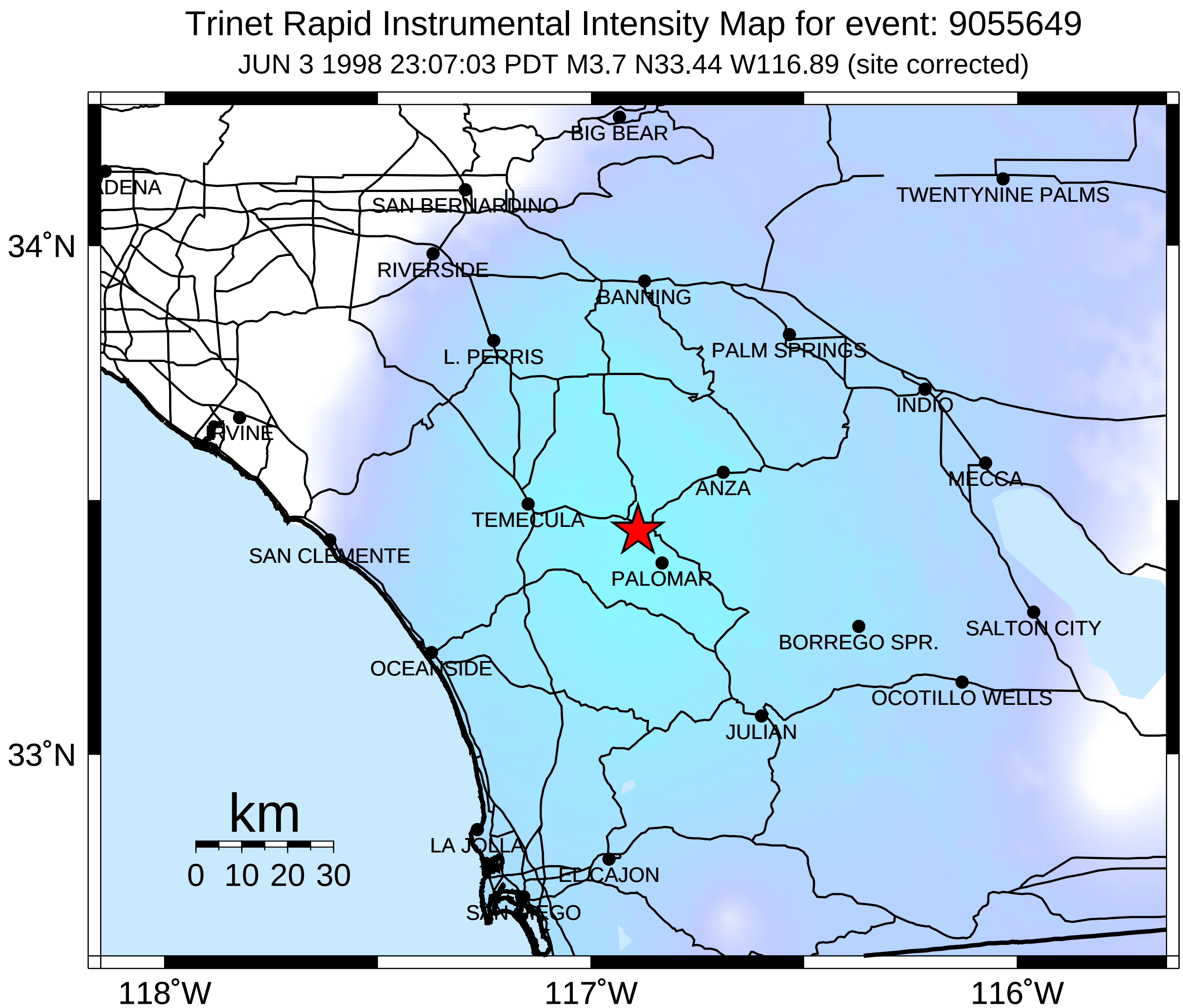
PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	***<.17***	***.17-1.4***	***1.4-3.9***	***3.9-9.2***	***9.2-18***	18-34	34-65	65-124	>124
PEAK VEL. (cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	***16-31***	***31-60***	***60-116***	***>116***
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Figure 5: Instrumental intensity "ShakeMap" from strong motion data recorded during the 1994 Northridge earthquake (Wald *et al.*, 1999). Fill corresponds to the intensity scale in the legend at the bottom of the figure. The epicenter is shown with a filled star; lines depict highways. Small circles show selected city locations as labeled. Also given in the scale bar are corresponding peak ground motion values, one- or two-word damage and perceived shaking descriptors.



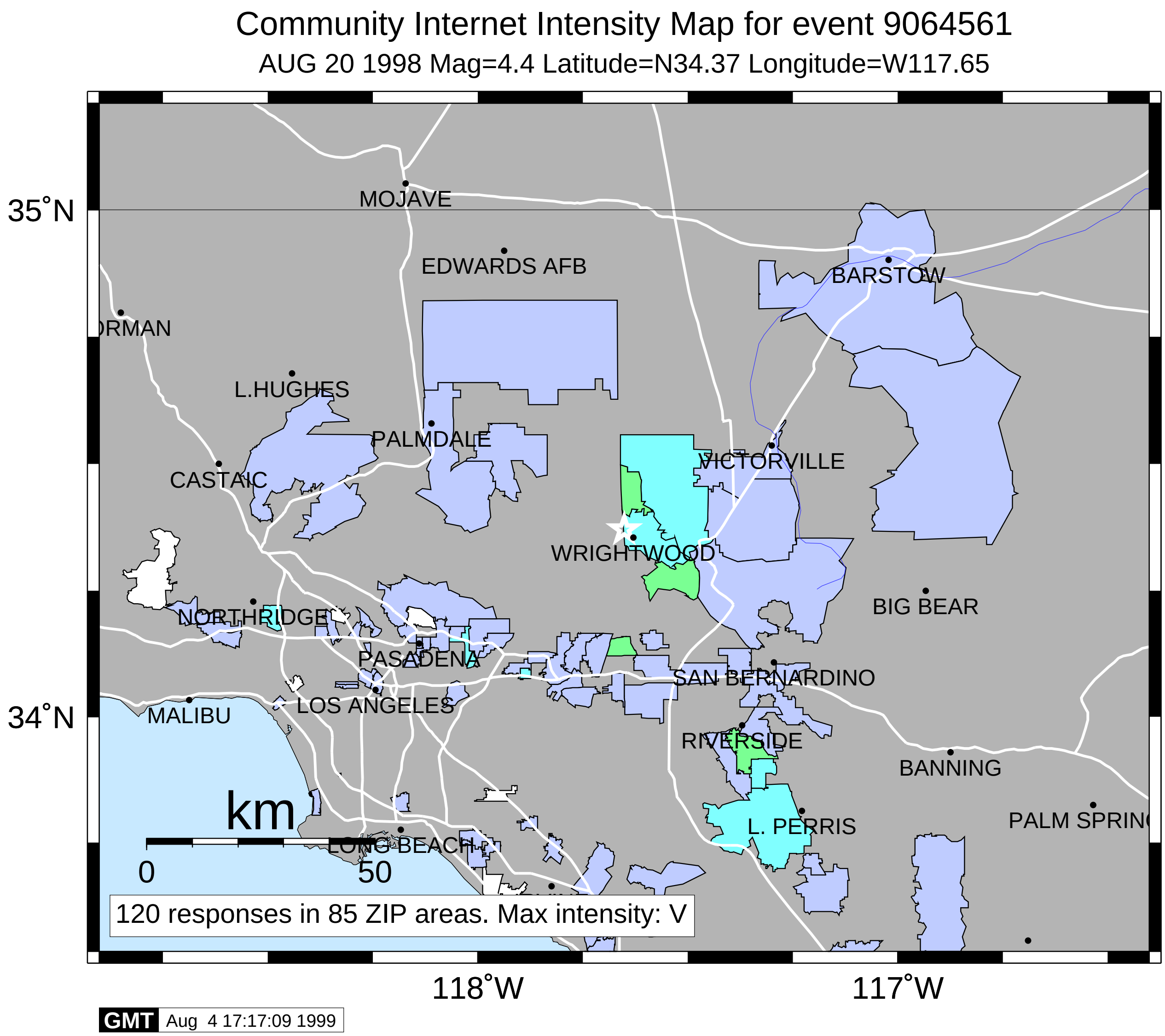
INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+
SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy

Figure 6: Community Internet Intensity Maps for the June 3, 1998 M3.7 earthquake near Mt. Palomar, California. The Web page version of the map is shown in Figure 3. A total of 161 responses were received, even though this small event occurred late at night in a fairly rural area.



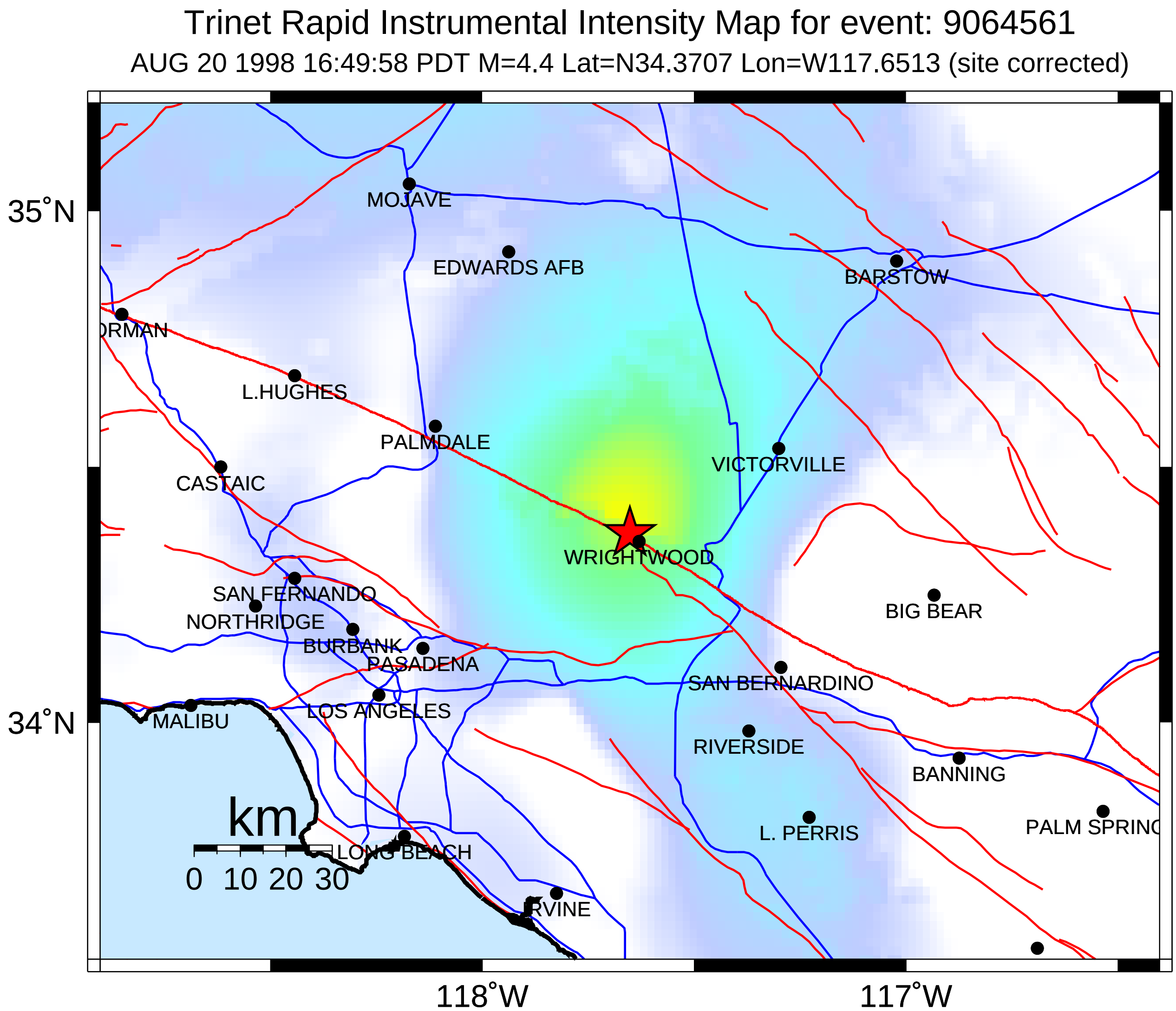
PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	***<.17***	***.17-1.4***	***1.4-3.9***	***3.9-9.2***	***9.2-18***	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	***16-31***	***31-60***	***60-116***	***>116***
INSTRUMENTAL INTENSITY	**I**	**II-III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X+**

Figure 7: Instrumental intensity “ShakeMap” for the June 3 1998, M3.7 earthquake for comparison with the CII shown in Figure 6. Fill corresponds to the intensity scale in the legend at the bottom of the figure. The epicenter is shown with a filled star; lines depict highways. Small circles show selected city locations as labeled. Also given in the scale bar are corresponding peak ground motion values, one- or two-word damage and perceived shaking descriptors.



INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+
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

Figure 8: Community Internet Intensity Maps for the August 20, 1998 M4.7 event near Wrightwood, California. A total of 120 responses were received.



INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+
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
PEAK ACC.(%g)	***<0.17***	***0.17-1.4***	***1.4-3.9***	***3.9-9.2***	***9.2-18***	18-34	34-65	65-124	>124
PEAK VEL. (cm/s)	<0.6	0.6-2.1	2.1-4.1	4.1-8.1	8.1-16	***16-31***	***31-60***	***60-116***	***>116***

Figure 9: Instrumental intensity "ShakeMap" for the August 20, 1998, M4.4 earthquake for comparison with the CIIM shown in Figure 8. (Wald *et al.*, 1999). Shading corresponds to the intensity scale in the legend at the bottom of the figure. The epicenter is shown with a filled star; lines depict highways. Small circles show selected city locations as labeled. Also given in the scale bar are corresponding peak ground motion values, one- or two-word damage and perceived shaking descriptors.

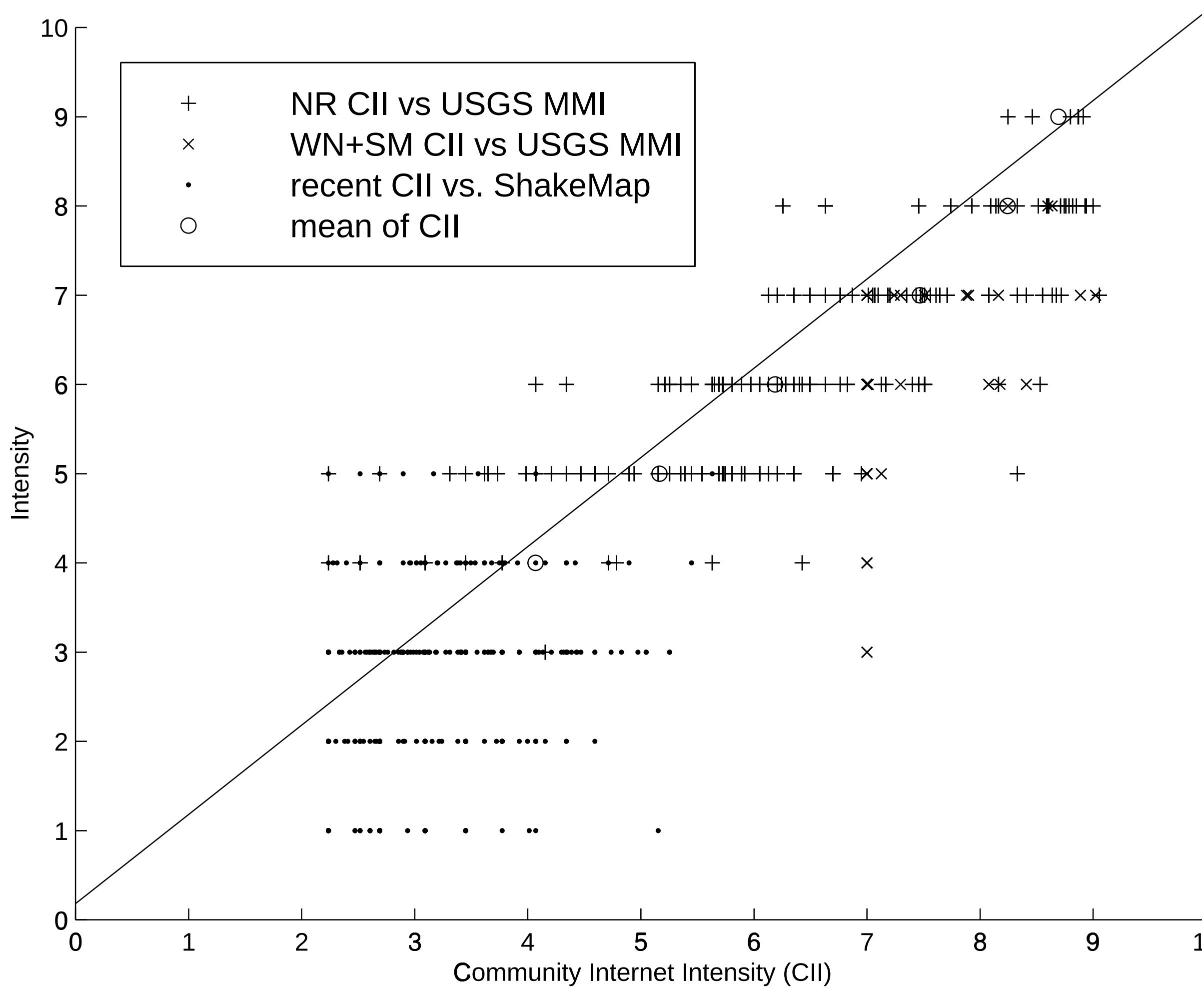


Figure 10: Comparison of Community Internet Intensities vs. TriNet ShakeMap Instrumental Intensities computed for recent (1998 and 1999) earthquakes (see Quitoriano *et al.*, 1998). For the TriNet ShakeMap Instrumental Intensities, ground motions recorded at seismic stations are interpolated at the center of each ZIP code. The solid line indicates one-to-one correspondence of Instrumental Intensity and CII. Shown also are comparisons of CII with USGS MMI for the Northridge (NR), Whittier Narrows (WN), and Sierra Madre (SM) earthquakes.