First European Conference on Earthquake Engineering and Seismology
(a joint event of the 13th ECEE & 30th General Assembly of the ESC)
Geneva, Switzerland, 3-8 September 2006
Paper Number:

USGS "DID YOU FEEL IT?" COMMUNITY INTERNET INTENSITY MAPS: MACROSEISMIC DATA COLLECTION VIA THE INTERNET

David J. WALD[1], Vincent QUITORIANO[1] and James W. DEWEY[1]

SUMMARY

The U.S. Geological Survey Community Internet Intensity Map (CIIM) is an automatic Web-based system for rapidly generating seismic intensity maps based on shaking and damage reports collected from Internet users immediately following earthquakes. The use of the Internet for macroseismic data collection has significant advantages over prior approaches, but also has limitations, as we discuss herein. We also describe a number of post-processing tools, applications, and studies that use the extensive intensity data sets now gathered, including automatic location and magnitude determination from intensity observations, estimating ground motions from the intensity observations, automatic geocoding to allow for more refined intensity localization, and social science analyses of risk perception. Until late 2004, the automatic mapping capability was restricted to the United States and U.S. territories. Within the U.S., intensity observations are grouped, averaged, and plotted according to postal codes. In 2004 we implemented the CIIM system for international data collection, with observations grouped, averaged, and plotted by city. The international CIIM is triggered by earthquakes of M>5.5 or those for which many on-line observations are volunteered. Although the international CIIM has been available only the past two years, we have received thousands of responses for European, African, Asian, Middle Eastern, Central and South American, and Caribbean earthquakes. The international CIIM data rapidly confirm earthquake occurrence for us at the U.S. Geological Survey/National Earthquake Information Center, giving a quick indication of the extent and nature of shaking effects. The global intensity data are also now automatically used as constraints in our global predictive ShakeMap system, which is the hazard input for our prototype Prompt Assessment of Global Earthquakes for Response (PAGER) system. CIIM can be found online at the website http://earthquake.usgs.gov/dyfi/.

1. INTRODUCTION

The USGS Community Internet Intensity Map (CIIM), also popularly referred to as "Did You Feel It?®" is a Web-based system for rapidly generating seismic intensity maps based on shaking and damage reports collected from Internet users immediately following earthquakes. The automatically produced intensity maps provide a rapid assessment of the extent of shaking and damage. For regions with sparse strong-motion seismographic coverage, CIIM provide a substitute for instrumentally generated ShakeMaps.

The CIIM Web site provides a two-way information conduit, since citizens coming to the USGS for information become data providers themselves by contributing valuable observations that benefit the USGS as well as the observers and their local communities. The CIIM data also provide an important human perspective on earthquakes, providing documentation of the way people behave and respond, and how they perceive risk (e.g., Celsi *et al.*, 2006).

In this report, we first provide some background on the CIIM system, and then discuss how Internet data collection has changed the approach, coverage, and usefulness of intensity observations in the U.S. We discuss

[1] U. S. Geological Survey, National Earthquake Information Center, Golden, Colorado, wald@usgs.gov

both the advantages and limitations of online intensity data collection. CIIM is fundamentally a *citizen science* endeavor, and this affords opportunities to both educate and analyze societal response and earthquake awareness. We then discuss how interaction with the public as well as our own scientific considerations have led to a number of important, iterative improvements to the CIIM system. Finally, we describe some of our recently developed tools and analyses of the CIIM data that promise other possible uses and benefits from online intensity data collection.

2. INTENSITY DATA GATHERING IN THE INTERNET AGE

The Community Internet Intensity Map (CIIM) system went online informally in 1997, and was first fully described by Wald *et al.* (1999a). In the subsequent years, significant advancement of the system and its use has occurred, and here we highlight many of these developments. The CIIM system is an adaptation of the telephone-based intensity questionnaires developed by Dengler and Moley (1994) and Dengler and Dewey (1998). These researchers appreciated the need to assign intensities in a quantitative manner, eliminating the need for exhaustive and subjective assignments of individual intensity reports. They did this by assigning numerical values to answers of individual questions based on the Modified Mercalli intensity (MMI) questionnaire, and then relating the cumulative sum of the numerical values (weighted differently within varying shaking indicator categories) to independently assigned Modified Mercalli Intensity values. Once this was solved, intensities could be assigned objectively and numerically. This led to computerizing the data collection and processing system to take advantage of the growing popularity of the Internet, thus fully automating the collection of intensity data.

Designed to work in conjunction with rapid epicenter and magnitude determinations that are provided by regional and national seismic networks, the CIIM system is now triggered automatically and individuals can respond and view maps for a particular earthquake within minutes, and watch as maps are updated continuously (every 5 minutes) as new data are entered and additional postal ZIP code polygons are color-coded according to their computed intensity values. For earthquakes experienced outside of the US, we enable users to select their country and city from pull-down menus. Thus, the resolution for automatic intensity assignment outside of the U.S. is at the level of individual cities, which we color-code to the CII value and map as a circle. Currently we have approximately 140,000 cities in our database.

3. ADVANTANGES OF ONLINE MACROSEISIMC DATA COLLECTION

The Internet makes it possible to gather larger, more comprehensive, data sets than ever, with much quicker turn around and at minimal cost. Prior to this system, intensity maps were rarely made for U.S. earthquakes of magnitude less than about 5.5; now intensities are routinely reported for the smallest felt earthquakes nationwide, routinely as low as magnitude 2.0. In addition, thousands of reports are available for moderate to large events, often tens of thousands for those in densely populated areas. The greatly expanded data sets allow for post-processing and analysis in ways that were not before possible.

3.1 Speed and Accuracy

Data for widely felt earthquakes come in at a rate that allows confirmation of the fact of the earthquake's occurrence within minutes, preparation of maps that are useful to emergency responders within tens of minutes, and preparation of detailed maps within hours. For a 2005 magnitude 5.2 near Anza, California, a heavily populated area, nearly 21,000 responses were tallied in the first hour, for a sustained rate of nearly six per sec. Corresponding Web page visits (as opposed to filled-out questionnaires) have reached thousands of hits per sec.

The rate of responses prompted us to routinely plot entries contributed as a function of time. These plots are provided online for each event, and show logical patterns of immediate post-earthquake surges followed by rapid decays, and late-night lulls followed by morning surges. Continuous plots of the entry rates allow operators to track system performance and gauge future bandwidth requirements. Table 1 summarizes some of the notable statistics associated with CIIM data collection to date.

The data quality and quantity depend primarily on population density and Internet access, and not necessarily on earthquake awareness or the overall hazard of the region: Events in the eastern and western US have comparable responses, despite significantly different historical rates of earthquake occurrence in the two regions.

Table 1: Sample USGS Community Internet Intensity Map ("Did You Feel It?") Statistics (March, 2006)

Within The United States	
Maximum Number of Responses for an earthquake	**29,295** entries for M5.2 near Anza, CA, June, 2005
Number of US Postal ZIP Codes with entries	**16,771** (out of a total of ~ 40,000)
Total Number of Individual Entries in US	>**625,000**
Maximum Rate of Responses	**21,000** per hour (sustained 6 per sec for one hour)

Outside The United States	
Number of Cities with entries	**1918**
Total Number of Individual Entries	**11,400**
Number of Countries with Entries	**147**
Maximum Number entries for a city, country	**550**, Tokyo; **2084**, Japan
Maximum Number entries for an earthquake	**882** entries for M8.6 Nias, Sumatra, March, 2005

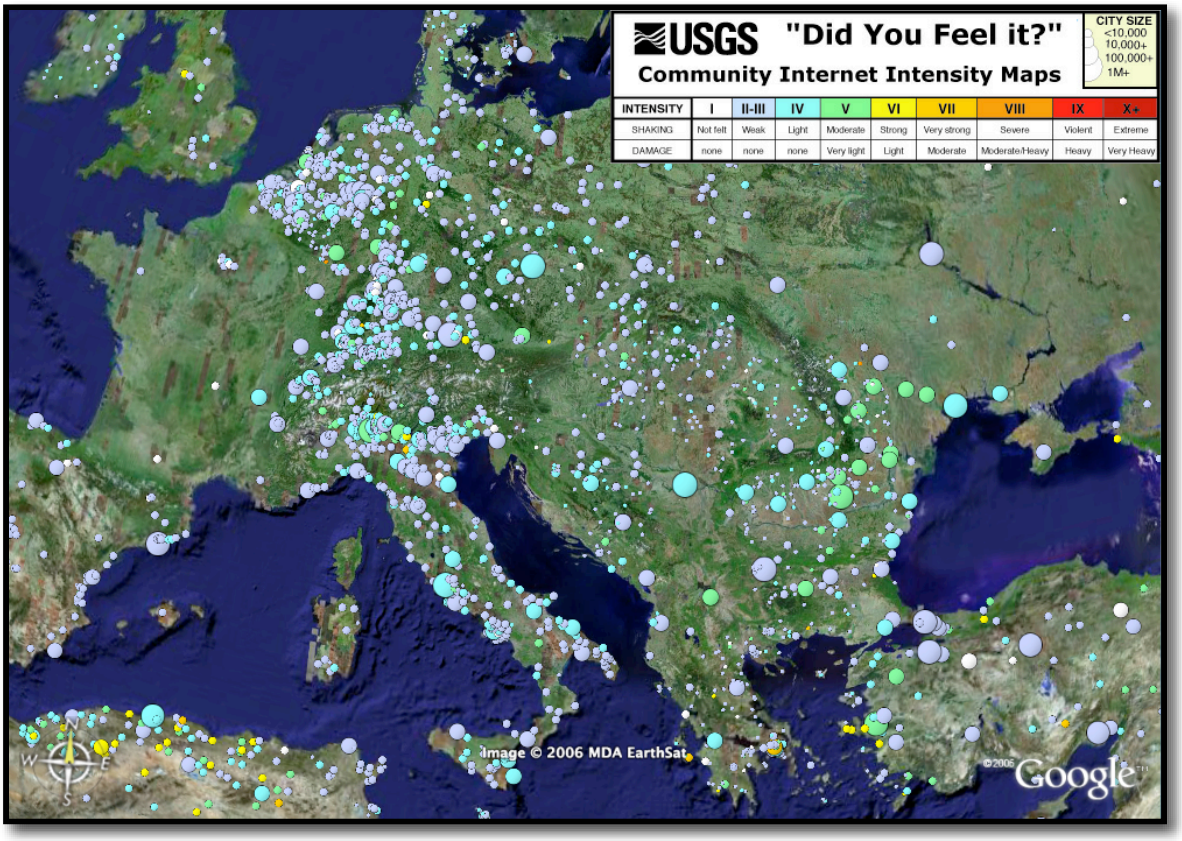


Figure 1: Cities in Europe reporting intensities to CIIM during from mid-2004 to February, 2006. Colors correspond to the maximum intensity reported for any earthquake in each city, and circle size is scaled in proportion to population.

Despite a short period of operations (since mid 2004), and very little publicity, we have received thousands of responses for European, African, Asian, Middle Eastern, Central and South American, and Caribbean earthquakes. The maximum intensity reported to CIIM from European cities is shown for a one and one-half year time period (mid 2004 to March 2006) in Figure 1. For similarly populated regions, the response per significant non-U.S. earthquake is typically in the hundreds, not in the thousands or tens of thousands as in the US. The response for non-U.S. earthquakes varies from region to region, reflecting variations in numbers of people with Internet access, percentages of people who speak English, and percentages of people who are likely to seek earthquake information from the USGS web-site.

Given that CIIM intensities are assigned by responses of the general public to questionnaires, one might expect them to be unreliable. However, the large number of responses from most communities make the intensities surprisingly robust. Typically, intensity values for a given community do not change by more than one intensity unit after five or more responses are acquired. CII macroseismic intensity maps generally agree well with instrumental intensity maps (ShakeMaps) that are based solely on seismographically measured ground motion in areas where both can be made.

Traditionally, intensities are assigned by a classification process and are assigned integer values (or even a range of integer values such as "6-8" or ">6" for less certain assignments; see, Grünthal, 1998, Section 4.5). The CIIM process of assigning numerical values to macroseismic observations and then calculating intensities thus represents a philosophical departure from traditional intensity-assigning procedures, in addition to a procedural departure. Analyses of the CIIM data also suggest that reporting intensities to higher precision is warranted. We now carry an extra decimal place, and the discrete (I to X) intensity scale is replaced with a continuous, real-valued, one. When the CIIM and similar decimal-intensities for widely-observed earthquakes are plotted as a function of distance, the retention of information to tenths of an intensity unit results in lower scatter than is the case when the calculated intensities are truncated to integers (e.g., Dengler and Dewey, 1998; Dewey *et al.*, 2002). For map representation of decimal intensities, a continuous palette of colors is chosen using algorithms that automatically interpolate between discrete color values, using a similar technique to the one used by ShakeMap (Wald *et al.*, 1999c). This allows us to present more subtle variations of intensity than previously.

For the most part, CIIM maps show smooth variations of intensity in areas from which there are many observations (e.g., Figure 2). Since each intensity level corresponds to roughly a factor of 2 increase in peak ground motion (Wald et. al, 1999b), the fact that maps show intensities that vary smoothly between integer values means that people, at least on average, are capable of distinguishing small differences in ground motion. From the seismological perspective, this observation is quite remarkable: a consensus opinion of the general public on the ground shaking, as determined from average responses to a series of simple questions, can result in the assignment of the *absolute level* of shaking to considerably better than a factor of 2.

3.2 Reduction of Missed Events

CIIM has proven to be of particular value for the U.S. Geological Survey/National Earthquake Information Center (USGS/NEIC) when earthquakes occur in areas of the US that have a few seismographic stations. Some earthquakes that are identified with macroseismic data are not automatically detected by seismographic networks: their locations can subsequently be confirmed by analysts and their magnitudes determined with seismographic data from several stations.

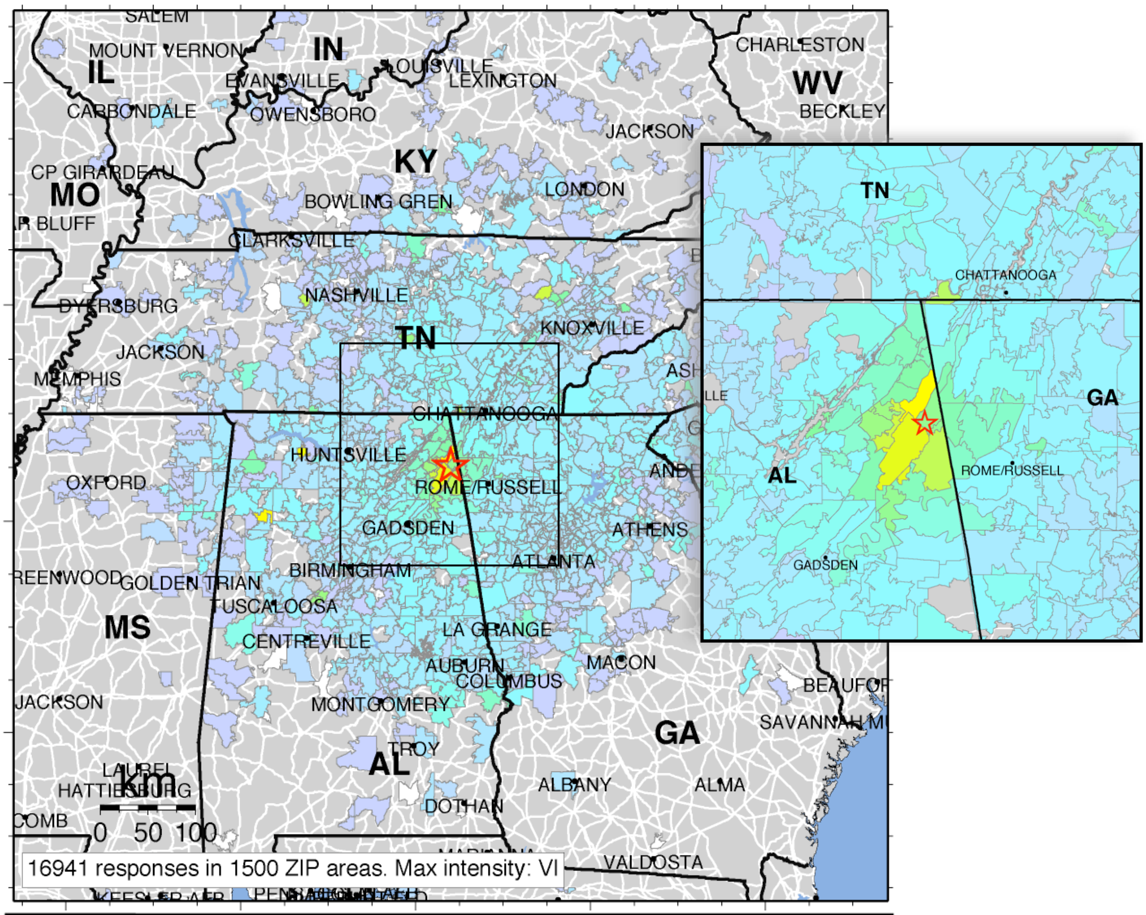
Remarkably, first arriving intensity observations from earthquakes often precede the seismic-network automatic determination of earthquake location and magnitude. We refer to these earliest, as yet unassociated, responses as "unknown event" responses, since at the time we receive them we do not have other information on the events that produced the reports. We monitor the unknown event reports by email and pager when the number of reports from a region exceeds 10 in a 5-minute period. Such a rate of unknown event reports is almost inevitably associated with an earthquake from which we have not yet received seismograph-based source information. Once the event is located, the earlier unassociated reports are associated with it based on appropriate space-time windows.

CIIM reports are also commonly submitted (by the hundreds) for sonic booms. The number of CIIM responses generated by a descending Space Shuttle passing over Los Angeles warranted a separate event web page dedicated to the reports, and the reports were sufficient to map out the re-entry trajectory. Sonic booms from aircraft, particularly in earthquake country, rattle residents and rile nerves, and yet prior to CIIM, most could not be confirmed since seismic networks do not routinely locate and report sonic booms. CIIM reports of sonic booms, however, have several characteristics that are diagnostic of the phenomena: spatially and temporally correlated low-intensity reports from a rather broad geographic area, the *lack* of an associated instrumentally recorded earthquake that is large enough to be felt over the area from which reports are received, and the nature of user entries. Rattled windows are noted nearly ubiquitously in the response or comments provided.

3.3 Uniformity and Flexibility

One long-term objective of the USGS in gathering Internet-based macroscismic data was to do so uniformly thoughout the US. This was particularly important as regional networks and universities began collecting email notifications of earthquake effects by employing a wide variety of questions that only approximated those required for systematic intensity assignments. Now, almost all Internet-based macroseismic data collection in the US is done via the USGS CIIM portal, providing uniformity of intensity assignments and, critically, a single collection point and long-term archive of these data. Regional network operators linking their felt reports to CIIM benefit directly by not having to support local macroseismic data collection and processing efforts and are forwarded CIIM data as it is received by USGS; we also customize event triggering, provide email and cell-phone notifications of regional CIIM triggers and provide links from the regional CIIM web pages back to their seismic network Web pages. CIIM questionnaires can also accommodate supplementary questions not explicitly used in the CII calculation. In this way, regionally-specific questions that have been traditionally found important in assigning intensities can be collected and passed on to the regional operators.

Outside the US, electronic macroseismic intensity assignment is made systematically by the USGS, and other systems have come, or are coming, online. We look forward to collaboration with other agencies interested in refining CIIM and other approaches as well as in adding multilingual and calibrated European Macroseismic Scale (EMS) assignments. We are currently collaborating with the Euro-Mediterranean Seismic Center (EMSC), the Geological Survey of Canada, and the Puerto Rico Seismic Network on such endeavors.



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 2: An example eastern US earthquake CIIM for a magnitude 4.6 in Alabama. Inset (box on main figure) shows smooth variations in intensity and regional extent of the data. There were 16,941 individual responses for this earthquake.

3.4 Interactivity

Millions of annual web visitors and hundreds of thousands of individual questionnaire entries are a testimonial to the outreach benefit and potential of CIIM. CIIM also provides a unique opportunity for "citizen science". While scientific data collection has long depended on the citizenry (e.g., backyard temperature measurements for the US National Weather Service), a number of other systems have sprung up in the past several years with similar "citizen science" applications, allowing scientists to obtain vast data collections in ways not otherwise or previously possible. A notable example is Cornell University's successful bird-surveying program, Project FeederWatch (http://birds.cornell.edu/pfw/), in which citizens contribute via the Internet a wealth of observations that help constrain migratory bird habits, quantify variations in population density, and establish species ranges. Such observations would not be possible without this informal organization of thousands of volunteer citizen scientists.

Participatory science not only expands the observational base for data collection, an obvious advantage for intensity observations, but it also empowers the community to take ownership and allow better understanding of important scientific issues of the day (e.g., Trumbull *et al.*, 2000). The CIIM system takes full advantage of online data collection by being fully interactive, providing users' intensity assignments instantaneously, and by showing the effects of their entries on the updated intensity maps.

Our system educates the public on often-misunderstood seismological concepts like the spatial variations of shaking intensity, and it provides a basis for clearing up confusion of macroseismic intensity with instrumental magnitude. As described in a later section, we have built educational tools that further this goal. Greater awareness of these concepts allows for more rational decision-making for both mitigation and the immediate post-earthquake aftermath (e.g., Goltz, 2003). CIIM also provides an important human perspective on earthquakes, providing sociological documentation of the way people behave and respond, and how they perceive risk (e.g., Celsi *et al.*, 2006). Finally and perhaps most rewarding to the authors, CIIM seems to provide emotional help to citizens who have just had a frightening or even traumatic experience. By allowing citizens to share their experiences and by enabling them to contribute their observations towards a general public understanding of the phenomenon they have experienced, the CIIM provides many with a form of therapy in a time of need.

4. CHALLENGES AND LIMITATIONS OF ONLINE MACROSEISIMC DATA COLLECTION

The voluntary nature of macroseismic questionnaires collected online, and the character of the Internet itself, pose problems in data collection that force us to continually modify some aspects our CIIM processing system. Likewise, we must also retain realistic expectations of the performance of the CIIM system in the immediate aftermath of a severely destructive earthquake.

4.1 Outliers

Automated data collection from the public via the Internet inevitably results in data outliers, which are both intentional and unintentional. We have developed automated filters that remove the bulk of such outliers, including the definition of limits of the maximum plausible intensities for a given earthquake magnitude that are based on observers' epicentral distances. Some outliers are identifiable by self-inconsistent answers (all possible damage options being checked is the most common). We also remove duplicate entries, keeping the last time-stamped entry. Experience shows that when users attempt to correct an error by sending in additional reports their last entry is normally the one with which they are satisfied. In the process of filtering, no data are discarded but rather they are flagged as suspect with tags that allow them to be bypassed in automated processing of results. Most users show genuine concern over the potential impact of their errors, often sending email to the operators when they realize that they have inadvertently caused an error (e.g., entering their home ZIP code rather than their work ZIP code) The most common source of unintentional outliers is apparently mild dyslexia at the keyboard where the user's ZIP code is mistyped. An erroneous transposition of digits in a postal code can place a user thousands of km away, an error that is easily flagged and recognized due to implausibility of the intensity value as well as by comparison of the reported ZIP code with the user's reported city.

Conveniently, intentional mischief is (mostly) obvious and can thus be filtered or sorted out; on the other hand, more subtle attempts have little impact on our results due to the overwhelming majority of quality reports. It is notable that mischievous responses tend to occur in times without earthquakes; in the post earthquake time period the vast majority of users are responsible or they seem to overwhelm any potential pranksters. The result is high quality data when most needed. Finally, the CIIM operators maintain ultimate data quality control over the data and results of the system. Analysts can flag suspected entries based these and other indicators.

4.2 Operational Robustness

A natural concern is the challenge of accommodating the post-earthquake deluge of input data and Web traffic. As our system grew in popularity, we continuously improved server capacity by making both hardware and software improvements. Due to the nature of the spike-like response of Internet traffic following a widely felt earthquake, we make nearly all CIIM Web pages static, requiring significant server CPU resources only for computing the individual's intensity value and for forwarding the questionnaire form response to a separate, secure database. Our hardware has evolved to redundant reverse-proxy servers, which cache commonly requested Web pages, freeing up the server processors for dealing with questionnaire forms almost exclusively. We carefully separate Web pages, form processing, and map and Web page generation to different, redundant servers. Finally, we contract commercially to a Web delivery service provider, which redistributes our cached Web pages to approximately 12,000 servers worldwide.

In spite of these precautions, we have no grand expectations for the performance of the CIIM system for the areas hard hit by damaging ground motions. It is likely that power outages, damage to computers, and limited online access will lead to significant data gaps. The likelihood of low CIIM reliability for receiving data from the most heavily damaged regions in the immediate aftermaths of destructive earthquakes necessitates a separate, robust post-earthquake response tool like ShakeMap (Wald *et al.*, 1999c). Unlike CIIM, ShakeMap does not depend on Internet-based human input to place ground motion and intensity maps online immediately. On the other hand, the CIIM approach does not require expensive high-quality real-time seismic stations – it can be implemented anywhere in the world where there are people with Internet connections, and CIIM data provide direct intensity observations as opposed to intensity values inferred from peak ground motions as in the ShakeMap system (Wald *et al*., 1999c). Moreover, we hope the CIIM system will perform well for much of the affected region even for damaging events, and that data will later be entered from areas that were not able to respond in the immediate earthquake aftermath. CIIM also provides a constantly improving database for calibrating relations from recorded ground motions to intensities. For these and other noted reasons, the two very different CIIM and ShakeMap approaches to rapidly mapping ground shaking and intensities naturally complement each other.

4.3 Supplemental Macroseismic Observations

For destructive earthquakes, it is necessary to have the capability to accommodate reliable alternative macroseismic observations in addition to CIIM as well as to minimize the influence of errors in web-questionnaire responses. Dewey *et al.* (2002) introduced the notion of Reviewed Community Internet Intensity (RCII) for just this purpose. RCII entails three elements that go beyond completely automated online data collection. Initially, by default, RCII is the CIIM computed at a 2-week cut off time, so that the CII value is not allowed to continue changing with more additional later responses. Second, RCII data are more thoroughly reviewed for errors or inconsistencies. Third, RCII may be adjusted from CII, or assigned to communities lacking CIIs on the basis of other types of macroseismic observations such as engineering reports, press reports, and field reconnaissance (see Dewey *et al.*, 2002, for more details). Hence, professional review by seismologists and field-based macroseismic observations will continue to be important for augmenting higher intensity CIIM observations in the future to enable seismologists to calibrate and fully document what the CIIM data represent.

5. NEW AND ONGOING DEVELOPMENTS WITH INTERNET INTENSITIES

After several years of CIIM data collection and processing, and from beneficial advice from our citizen and other scientists, we have developed numerous post processing tools and products for use with the CIIM data.

5.1 Distance Attenuation

In addition to mapping the ZIP-code averaged community intensities, it is convenient to portray these intensity data as a function of distance, thereby showing at a glance the attenuation of intensity from the epicenter. We now systematically generate and update intensity versus distance plots as CIIM data are processed. We plot the individual ZIP code intensities, and, following Bakun and Wentworth (1997), we graph the average intensity calculated for bins in increments of distance. The curves recovered from the CIIM data generally fit independent, previously derived, regional intensity attenuation functions well. In fact, obvious offsets of data from previous curves have provided an independent incentive to reexamine the seismic network magnitudes and/or location assignments for individual events. In Figure 3, we show a CIIM attenuation plot for the magnitude 4.9 May, 2002 Gilroy, CA earthquake. Blue squares show intensity values averaged over distance bins (uniform in Log space). Note the systematic attenuation of average intensity in most distance ranges as well as the slight increase of intensity with distance at around 100 km, which we think may be indicative of post-critical reflection of S-waves from the Moho.

5.2 Estimating ground motions from CII

Given the CII data for an event, we have developed tools to estimate ground motions in the absence of data from seismic instruments. We have compared mean ground motion estimates based on the ShakeMap instrumental intensity relations (Wald *et al.*, 1999b) with values computed from a Bayesian approach that is based on combining probabilities of ground motion amplitudes for a given intensity being observed for the magnitude and distance with the prior probability of their observation based on regionally-appropriate attenuation relationships (for details, see Ebel and Wald, 2003). The global CIIM data are also now automatically used as constraints in our global predictive ShakeMap system, which is the hazard input for the USGS prototype Prompt Assessment of Global Earthquakes for Response (PAGER) system (Earle and Wald, 2006). Ongoing efforts entail calibrating the relations among intensity and peak ground motion parameters used in ShakeMap and loss estimation (e.g., peak ground acceleration, velocity and spectral acceleration) with consideration of regional attenuation and intensity assignment variations around the globe.

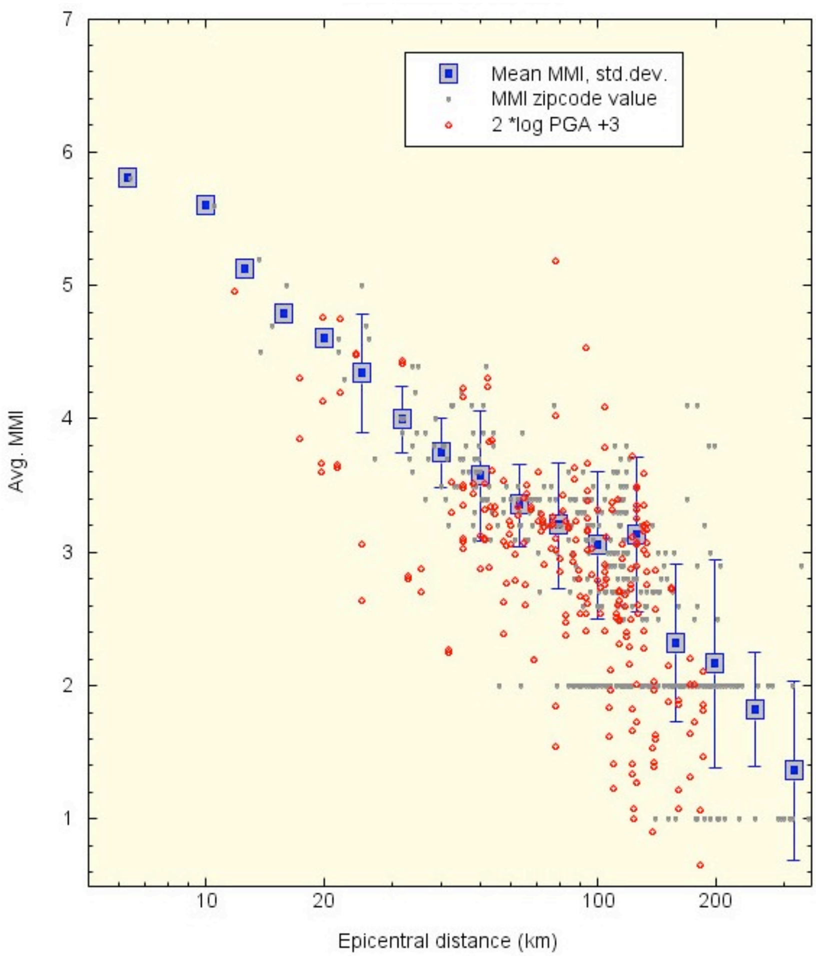


Figure 3: Attenuation of CIIM data with distance for the magnitude 4.9 May, 2002 Gilroy, CA earthquake (15,900 responses). Grey dots are CII ZIP-code values; Blue squares are intensity values averaged over distance bins. Red circles are peak acceleration recordings converted to intensity (2*log PGA + 3) for comparison purposes. Courtesy of G. Atkinson.

5.3 Geolocation

Within the U.S., we can manually trigger a CIIM-specific geocoding algorithm, which uses available online databases to turn street addresses into latitude and longitude coordinates with precision enough to distinguish adjacent street blocks. Typically about 90% of respondents to the USGS CIIM website questionnaire volunteer their address as well as their ZIP code, so it is possible to make new maps by grouping responses into latitude and longitude boxes of any convenient size. With experience, we have found that the additional geocoding processing to be unnecessary in populated areas where ZIP codes sizes are small, but the spatial refinement provided by geocoding is important where ZIP code extents are larger. For this reason, geocoding is manually operator-triggered as deemed necessary. Examples of the geocoded maps and data can be found online for many of the larger magnitude U.S. events for which thousands of responses are received.

5.4 Data Availability and Formats

In order to facilitate the further exploitation of the CIIM data for research, analysis, and visualization we provide online summary files of the data collected in a variety of formats. One simple form of the data available is a tab-delimited summary of the ZIP (geocode) intensity, ZIP code centroid latitude and longitude, epicentral distance, and the number of responses contributed to that ZIP code. Due to privacy considerations, we cannot redistribute personal information provided online. However, we do provide a sanitized version for research purposes, stripped of identifying data, yet allowing more detailed analyses of the nature of individual responses. Recently we have also begun to produce KML files of city and ZIP code intensities for visualization in Google Earth (see Figure 1). All completed entries and summary data (ZIP code averaged intensities) are permanently archived in an SQL database.

5.5 Earthquake Magnitude and Location based on Intensity

We have developed a method for deriving earthquake magnitude and location automatically from the CIIM data alone based on the algorithm of Bakun and Wentworth (1997). We perform a grid search centered on the area with the highest intensity responses, treat each grid node as a 'trial epicenter', and determine the magnitude and intensity centroid that best fits the CII observation points according to a region-dependent intensity-distance attenuation relation. Solutions are continuously updated as more data are received. The intensity centroid and ground motions determined from the CIIM data correlate well with instrumentally derived parameters. With further efforts at calibrating regional variations of intensity attenuation, this approach could be used to fully automatically determine location and magnitude globally, independently from seismic network operations, with the added capability of doing so for events below many regional seismic network's reporting threshold.

5.6 Graphical User Interface for Seismic Analysts.

In a recent advancement over manual interaction with scripts and databases, we now allow CIIM to be operated by the NEIC staff of seismic analysts**.** We have developed a Web-based Graphical User Interface (GUI) that allows our seismic analysts to trigger, delete, resize or re-center maps, as well as view, supplement, or flag intensity observations, and contact system support experts. Easy interactive searching and manipulation of the CIIM database allows for additional manual quality control including flagging obvious outliers or suspected entries and then regenerating maps and Web pages for that event.

5.7 Education.

CIIM has been recognized by a number of educators as a natural format and opportunity for earthquake hazard education. For example, the USGS produced an educational exercise using the Northridge earthquake CIIM map as a children's coloring map to help explain the difference between magnitude and intensity. This exercise was later adopted by the National Geographic Society for their educational Web pages and is used routinely to help explain a related question recently added to the State of California Education Standards which requires an understanding of the difference between magnitude and intensity (W. Shindle, USGS, personal communication, 2005). Independently, Park and Haase (2004) held a series of grade-school teacher workshops following a widely felt Indiana earthquake, training teachers to use CIIM for explaining magnitude and intensity, as well as getting students to submit online submissions (thus further improving the map for that event). The authors are aware of several elementary schools that routinely use CIIM for a 'teachable moment" right after students experience an earthquake first hand.

6. CONCLUSIONS

The U.S. Geological Survey Community Internet Intensity Map (CIIM) has significant advantages over earlier macroseismic intensity data collection approaches as well as some limitations arising from the data collection methodology. Awareness of the limitations reduces potential detrimental impact, and we are continuing to improve the system as new tools and approaches become apparent. CIIM has always been an evolving system. Among the developments, we have described a number of post-processing tools, applications, and studies that make use of the extensive intensity data sets now gathered, including automatic location and magnitude determination, estimating ground motions from the intensity observations, automatic geocoding to allow for more refined intensity localization, recovering higher precision decimal intensities rather than limiting intensities to integer values, and social science analyses of earthquake response and risk perception. We have also expanded CIIM data collection, which until recently was limited to US ZIP codes, to the rest of the globe, and early indications show the usefulness of the global data. We nonetheless see potential for improving the current international CIIM. The CIIM procedure also has limitations, as discussed. It is strongly conditioned by U.S. traditions of macroseismic data interpretation; we envision collaboration with non-U.S. macroseismologists to make the product more useful in non-U.S. contexts. Questionnaires in the native language of the source region would clearly facilitate collection of data globally. Ultimately, we expect the global intensity database will prove useful for regional attenuation as well as other seismological studies.

REFERENCES

Atkinson G. M. and D. J. Wald (2006) “Did You Feel It?” and ShakeMap: A new interface between seismological and engineering data, *Seis. Res. Lett.*, 77, 273.

Bakun, W. H., and C. M. Wentworth (1997). Estimating earthquake location and magnitude from seismic intensity data, *Bull. Seism. Soc. Am.*, 87, 1502-1521.

Celsi, R., M. Wolfinbarger, and D. J. Wald (2005). The Effects of Magnitude Anchoring, Earthquake Attenuation Estimation, Measure Complexity, Hubris, and Experience Inflation on Individuals’ Perceptions of Felt Earthquake Experience and Perceptions of Earthquake Risk, *Earthquake Spectra,* 21,987-1008.

Dengler, L.A. and K. Moley, 1994, Toward a quantitative, rapid response estimation of intensities, *Seis. Res. Lett.* , 65, p. 48.

Dengler, L.A. and J. W. Dewey (1998). An intensity survey of households affected by the Northridge, California, earthquake of 17 January 1994, *Bull. Seism. Soc. Am.* 88, 441-462.

Dewey, J.W., B.G. Reagor, L. Dengler, K. Moley (1995). Intensity distribution and isoseismal maps for the Northridge, CA, earthquake of January 17, 1994, U. *S. Geological Survey Open-File Report* 95-92, 35 pp.

Dewey, J.W., M.G. Hopper, D.J. Wald, V. Quitoriano, E.R. Adams (2002) Intensity distribution and isoseismal maps for the Nisqually, WA, earthquake of 28 February 2001, *USGS Open-File Report* 02-0346, 57 pp.

Earle, P. S., and D. J. Wald (2005). Helping Solve a Worldwide Problem— Rapidly Estimating the impact of an earthquake, U.S. Geological Survey Fact Sheet, in press; http://earthquake.usgs.gov/pager/.

Ebel, J.E. and D. J. Wald (2003). Bayesian estimation of peak ground motion acceleration and 5% damped spectral acceleration from Modified Mercalli Intensity data, *Earthquake Spectra*, 19, 511-529.

Goltz, J. (2003). Science can save us: Outreach as necessity and strategy, *Seis. Res. Lett.*, 74, 491-493.

Grünthal, G. (ed.) (1998). European Macroseismic Scale 1998, EMS-98, European Seismological Commission, Luxembourg, 99p.

Park, C. H., and J. Haase (2004). Mapping amplification of earthquake ground motion in Indiana. Purdue University, Report submitted to the EERI “Learning from Earthquakes” Program.

Trumbull, D., R. Bonney, D. Bascom, and A. Cabral (2000). Thinking scientifically during participation in a citizen-science project, *Science Education.* 84, 265-275.

Wald, D. J., V. Quitoriano, L. Dengler, and J. W. Dewey (1999a). Utilization of the Internet for Rapid Community Intensity Maps, *Seism. Res. Letters*, 70, 680-697.

Wald, D.J., V. Quitoriano, T.H. Heaton and H. Kanamori (1999b). Relationships between peak ground acceleration, peak ground velocity, and modified Mercalli intensity in California, *Earthquake Spectra*, 15, 557-564.

Wald, D.J., V. Quitoriano, T.H. Heaton, H. Kanamori, C.W. Scrivner and C.B. Worden (1999c). TriNet "ShakeMaps": Rapid generation of peak ground motion and intensity maps for earthquakes in southern California, *Earthquake Spectra*, 15, 537-555.