The New Cartographers: Crisis Map Mashups and the Emergence of Neogeographic Practice

Sophia B. Liu and Leysia Palen

ABSTRACT: Crisis situations are ripe for expansion of the neogeographer population and skill set. We qualitatively examine the design and creation of crisis map mashups to describe emergent neogeographic practices in this particular domain. We analyze the circumstances that led to their creation, data selection, and design choices vis-à-vis spatial and temporal information representation. We then discuss the implications of emergent neogeographic practice based on two case examples, which illustrate the merging of professional and participatory geotechnologies, and the opportunity a blending of the two provides for widespread cartographic literacy.

KEYWORDS: Crisis informatics, disasters, mashups, neogeography

Introduction

The mapping of crisis information online is on the rise among nonprofessional cartographers. Map-based "web mashups" result from the application of social media or Web 2.0 technology to existing or developing data sets. Map mashups combine or "mash up" multiple sources of data, which are displayed in some geographic form. Though "participatory" forms of geotechnology—such as Google My Maps—makes maps and geographic information relatively accessible, obligations of accuracy and careful interpretation do fall to the neogeographers who pursue this new form of technical enterprise. The rise of the neogeographer in the hazards and crisis context is of particular interest, as the desire to mitigate crises through some sort of participation and assistance by members of the public is strong. The management of crisis information, and its spatial and temporal modeling, presents particular challenges which are specific to the new map-based forms of social media.

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Sociology of Disaster: Models of Spatio-Temporal Behavior

Disaster researchers and practitioners often use spatial and temporal models (Dynes 1970; Powell 1954) to describe and anticipate macro social behavior. Typically, the codification and classification of time-and-space models are important methodological disaster research tools and heuristic devices, since the different disaster phases and zones represent different types of individual and group behavior (Stoddard 1968; Neal 1997). For example, Dynes (1970) describes the geography of disaster events based on a series of concentric zones. The center is an area with very severe impact, which is surrounded by a fringe area with significant damage and disruption. Aid from distant communities passes through the regional and adjacent filter zones to provide resources to the impacted areas.

The following four disaster phases are used in practice to describe macro-behavior: preparedness, response, recovery, and mitigation. Powell (1954) elaborates this depiction to include eight finer temporal stages. In our own earlier work, we relied on these macro social descriptions of spatial and temporal ordering to help frame a larger set of imminent changes arising from pervasive information and communications technology (ICT) diffusion (Palen and Liu 2007). Neal (1997), however reconsiders the disaster phases and suggests that the staged model limits how we might understand the many diverse behaviors arising in disaster and masks the variety of experiences relative to different populations and stakeholders.

The rise of what is known as Web 2.0 technology supports, inadvertently perhaps, an ability to tease apart actual behavior in disasters and pinpoint the multi-dimensionality of the experience and its effects on social life. In particular, map-based "mashups," through the use of frequently updated data from multiple sources, allow us to "see" micro-behavior spatio-temporally. As such, crisis map mashups are emerging as interesting artifacts in the practical work of reporting on, assisting in, and managing emergencies.

Neogeography

This observation is in line with ideas of *neogeography*. More than a decade ago in the GIS (Geographic Information System) community, Dangermond (1995), Monmonier (1998), and Krygier (1999) urged that next-generation GIS should be more interactive and accessible to citizens to foster public participation and collaboration in the development and management of geographic databases and any decisions made based on such data. Now in the geography discipline, the notion of "neogeography" has emerged to address a new set of geographic concerns with the rise of such enabling technologies as web mapping services and pervasive GPS-enabled devices. Turner (2006) describes neogeography as "a set of techniques and tools that fall outside the realm of traditional GIS" (p. 2). More specifically, it is about "people using and creating their own maps, on their own terms, by combining elements of an existing toolset" (Turner 2006, p. 3). Goodchild (2009) defines neogeography as "a blurring of the distinctions between producer, communicator and consumer of geographic information" who become involved in the "mapping process" (p. 82). Within neogeography, volunteered geographic information (VGI) describes the increasing "interest in using the Web to create, assemble, and disseminate geographic information provided voluntarily by individuals" (Goodchild 2007, p. 211).

The emergence of the Geospatial Web, particularly Web Mapping 2.0 (Hakley et al. 2008), has led to increases in geobrowsing activities (e.g., browsing through Google Maps or Google Earth). According to Kraak (2001a), web maps can "function as an interface or index to additional information" (p. 1) in a way that facilitates an up-to-date, dynamic, and interactive presentation and dissemination of geospatial data to many more users at a minimal cost. Web maps also allow users to explore and find answers to location-specific questions as opposed to mainstream media's broad reporting tailored to an "average" viewer (Blok 2001). Kraak (2001b) also points out that maps aid thinking and prompt decision-making. The key difference in the networked world is collaboration between people, with information flows that are changing from "a linear, publishing 'push' model…to an inter-networked, participatory model" (Hakley et al. 2008, p. 2033).

Social Media in the Crisis Context and the Rise of Map Mashups

Research on social media use in crisis situations is beginning to emerge in the *crisis informatics* field, a research area investigating the socio-technical concerns and the "changing information pathways" of computer-mediated communication (CMC) and information and communication technology (ICT) use in large-scale emergency response (Hagar and Haythornthwaite 2005; Palen and Liu 2007; Palen et al. 2009). For example, distributed problem solving and collective sense-making emerged through the use of social networking sites (including Facebook) after two school shootings (Vieweg et al. 2008; Palen and Vieweg 2008; Palen et al. 2009). The emergence of eyewitness photojournalism and other social practices around photographic content has emerged after several crises worldwide through online photo-sharing sites, including Flickr (Liu et al. 2008). Mark and Semaan (2008) show how ICT supports the repair of broken routines in war-torn areas. Shneiderman and Preece (2007) consider how "community response grids" can support rapid emergency response based on public participation. Qu et al. (2009) elaborated the ways in which a social networking site was used to support communication after the 2008 Sichaun earthquake. A recent study analyzed the information activities within Twitter, a micro-blogging service, after the 2009 Red River flooding in the U.S. and Canada (Starbird et al. 2010).

Data mashups are another form of social media. Increasingly, people are creating map mashups by aggregating two or more data feeds or functionalities from other web sites using application programming interfaces (APIs). While investigating the experiences of web mashup developers, Zang et al. (2008) found that map mashups are

a common form of data mashups because they are "the most visual and adaptable of the mashup options" (p. 3175). Hakley et al. (2008) further point out that "different categories of neogeography mashups have emerged, depending on the type of data collected (e.g., scientific, commercial, or user-generated data).

The Harvard Humanitarian Initiative's Program on Crisis Mapping and Early Warning[1] was launched in 2007 with the vision of developing a "geo-referenced crisis monitoring platform for conflict prevention and disaster management." Meier (2009a) and his colleagues are starting to develop this cross-disciplinary "field of crisis mapping" which focuses on three research agendas: crisis map sourcing, crisis mapping analysis, and crisis mapping response. Furthermore, Nourbakhsh et al. (2006) mention how "the emergence of a new breed of volunteers—online data managers—highlights the potential of a web-based community approach to disaster operations" (p. 787), which may be a step toward seeing "the public's role shift from passive viewer to active contributor" (p. 788). This brings us back to the following question that Hakley et al. (2008) raise: "What kind of participatory practices are emerging with the support of these technologies and how do they influence the relationship between people and places?" (p. 2035).

The purpose of this paper hopes to elaborate on the first part of this question: the emerging neogeographic practices around crisis map mashup development. To that end, we qualitatively examine the origins of a set of crisis map mashups which have experienced success vis-à-vis their longevity and presumed viewership and describe the issues that the neogeographers have faced in the design and long-term support of the mashups. We then focus on two cases which illustrate how interaction between participatory and professional geotechnology platforms and expertise arises, and the lessons this might have on future expansion of cartographic skill or literacy.

Method

We conducted a qualitative study which focused on nine crisis mashups to illustrate different, key approaches to mapping hazards and disasters. These mashups were originally selected as part of a complementary research project on interface design choices and the implications on use (Liu and Palen 2009). However, as a second stage of the research, the results of which are presented here, we collected and descriptively report on additional data which account for the conditions of their creation, objective, and design choices. These mashups, then, were selected because of the diversity of their information representations vis-à-vis hazards and crises and the diversity in those choices arising from the different circumstances from which they were created. These circumstances—the emergent neogeographic practices of mapping crises—are the subject of discussion here.

Table 1 describes each mashup that we studied in more detail. We conducted in-person, phone, and e-mail interviews with the mashup developers/creators when possible, and used secondary sources in complement. Specifically, we conducted phone interviews with the creator of the *Southern California Wildfires Google My Maps* mashups—a *Los Angeles Times* reporter—and one of the team members who created the *Repopulation Indicators for New Orleans* mashup. We conducted e-mail interviews with the creator of the *Live Earthquake* mashup, as well as the mashup developer who created the *Los Angeles Fire TWEETS*, *Swine Flu Tweets*, *Iran Protest Tweets*, and *Sea Level Rise* mashups. For the *Sea Level Rise* mashup, we refer to the Coastal Impact Study report titled "Nation Under Siege: Sea Level Rise at Our Doorstep" (Mazria and Kershner 2007). For the *Ushahidi* mashups, we conducted e-mail interviews with the program director and an advisory board member. In addition, we used data from informal, face-to-face interviews conducted with two members from the *Extreme Ice Survey* (EIS) team as well as secondary sources. The interviews were informal because they were conducted before this specific research direction was underway; in fact, those interviews helped establish this line of inquiry. We complement informal interviews with secondary sources, namely the EIS web site and its blog, James Balog's TED talk (Balog 2009) and the "*Extreme Ice Survey in Action*" Vimeo video (*Extreme Ice Survey* 2008).

Analysis

In this analysis section, we investigate the emergent neogeographic practices of mapping crises with respect to the selected crisis map mashups. First, we examine the diverse circumstances that led to map-based mashup creation. Then we examine how these mashups were created in

[1] http://hhi.harvard.edu/programs-and-research/crisis-mapping-and-early-warning.

Crisis Mashup	Description	Link to Mashup	Technology	Data Choice for Mashup	Research Data
Live Earthquake (Figure 1)	Displays earthquakes over the previous 7 days or 24 hrs on map and timeline	http://www.oe-files.de/gmaps/eqmashup.html	Google Maps API, Simile Timeline widget	U.S. Geological Survey, European-Mediterranean Seismological Centre, GFZ Potsdam	E-mail interview with creator
Los Angeles Fire Tweets (Figure 2)	Displays near real-time "fire" tweets in the LA area	http://www.mibazaar.com/lafires.php	Google Maps API, Twitter API	Tweets with "fire" geocoded within 100 mi radius of LA	E-mail interview with creator
Swine Flu Tweets (Figure 3)	Displays near real-time "swine flu" tweets based on different regions around the world	http://www.mibazaar.com/swineflue	Google Maps API, Twitter API	Tweets with "swine flu"	E-mail interview with creator
Iran Protest Tweets (Figure 4)	Displays near real-time "iran protest" tweets based on different regions worldwide	http://www.mibazaar.com/irantweets.html	Google Maps API, Twitter API	Tweets with "iran" and "protest"	E-mail interview with creator
2009 Los Angeles Fires by LA Times (Figure 5)	Displays warning and response information about the wildfire in near real time	http://www.latimes.com/news/local/la-me-la-fire-map-html,0,7464337.htmlstory	Google My Maps	*Los Angeles Times* reporters, InciWeb, USGS satellite images, viewers' comments	Phone interview with creator
Repopulation Indicators for New Orleans (Figure 6)	Visualizes repopulation patterns in New Orleans at a block-level view of new Orleans since 2005 Hurricane Katrina	http://www.gnocdc.org/repopulation	Google Maps API, ESRI's ArcMap, Arc2Earth	U.S. Postal Service Delivery Statistics, Valassis direct marketing, Housing and Urban Development Census, Road Home data	Phone interview with a team member from the non-profit who created mashup; secondary sources
Sea Level Rise on Coastal Cities in US (Figure 7)	Displays present-day and sea-level rise images for each of the 31 U.S. coastal cities	http://www.mibazaar.com/nationundersiege	Google Maps API, Google Earth	Images from the "Nation Under Siege" online report by Architecture 2030	E-mail interview with creator; online report
Extreme Ice Survey on Google Earth (Figure 8)	Displays time-lapse videos and photos of glacial changes across the Northern Hemisphere	http://www.extremeicesurvey.org	Time-lapse cameras, film software, Vimeo, Google Earth	Approximately 500,000 photographs of melting glaciers	In-person interview with two EIS team members and secondary sources
Ushahidi (Figure 9)	A platform for crowdsource mapping and monitoring of real-time crisis reports from the general public	http://www.ushahidi.com	*Ushahidi* Engine with the ability to integrate plug-ins and extensions	Reports from the public via mobile phone, e-mail, the web, Twitter, RSS feeds from official news sources	E-mail interviews with the Program Director and an Advisory Board member for *Ushahidi*; secondary sources

Table 1. Nine Crisis Map Mashups described. [See corresponding figure for a screenshot.]

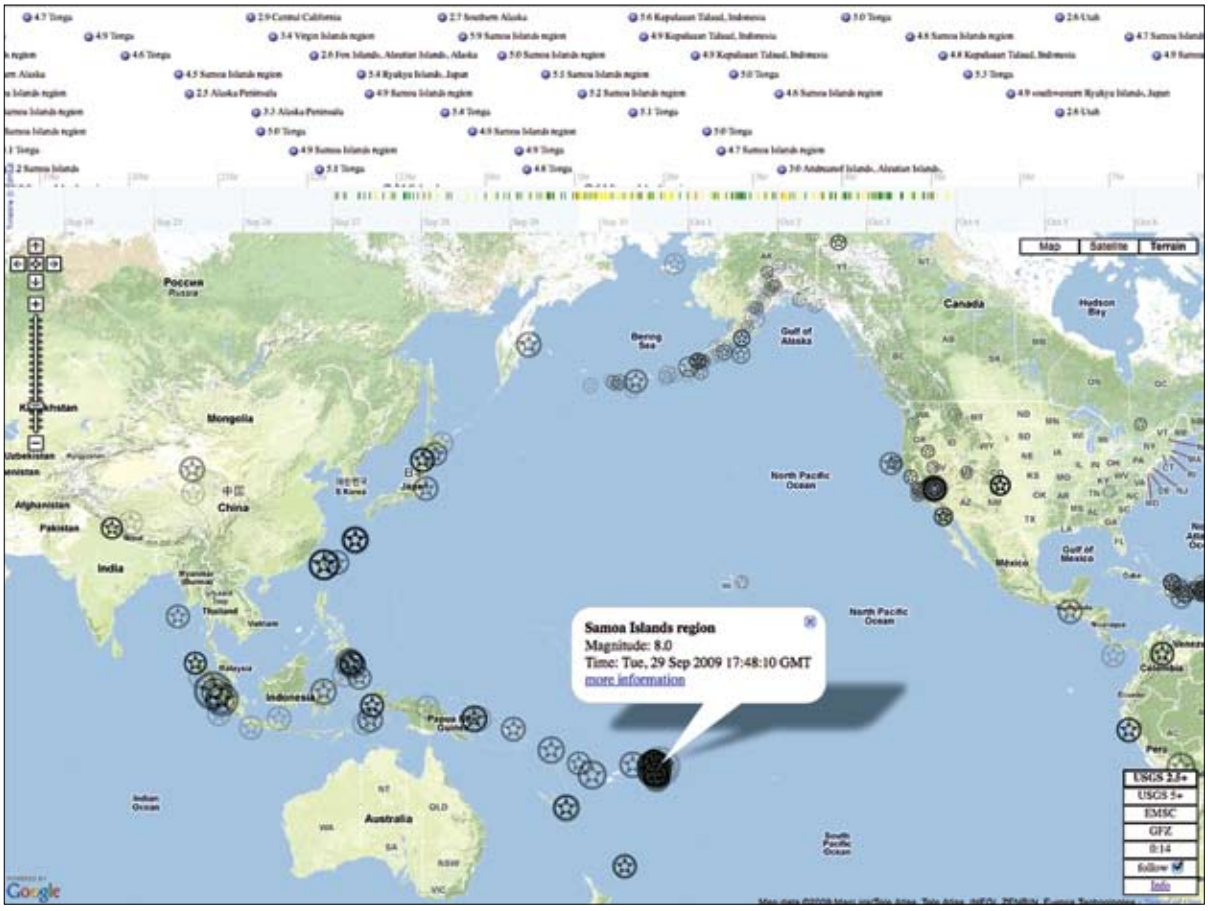

Figure 1. *Live Earthquake* mashup.

terms of their data set selection, as well as the kinds of design decisions the creators subsequently faced, especially with respect to spatial and temporal representations.

Crisis Mashup Creation: Becoming a Neocartographer

The development of neocartographic skill can be motivated by a number of reasons. We describe the genesis of the neocartographer and the forms that such a role might take with respect to the specific map mashup environments under study.

Personal Interest and Gain

A system administrator at a university in Germany first created the *Live Earthquake* mashup (Figure 1) in October 2006 just with Google Maps, purely out of personal interest around the mashup hype at the time. He had programmed some other "toy applications" using Google Maps before using GPS data. He found that creating this mashup was "fun and something he could do within a few evenings" which he could then promote on his web site. He does not self-identify as a mashup programmer, and is rather "just a computer geek…who picks up new technologies from time to time." Creating these mashups is a way to "publish them on my website and brag about them," which he considers a form of "hubris," one of the virtues often associated with programmers. In a similar vein, the creator of the *Twitter* mashups (Figure 2, 3, and 4) also creates and shares his work with his readers on his blog. He notes that he sees an increase in traffic to his mashups after they are mentioned on sites such as Mashable.com and GoogleMapsMania. Feedback via the web fuels ongoing interest in maintaining and developing new mashups.

Curiosity about Information Display Potential

Other crisis mashups are born out of curiosity about visualizing certain crisis event information with end-user tools. The developer (a social media and software developer by profession) created the three *Tweet* mashups within a few days after news reports about the crisis events were aired. He created the *Los Angeles Tweets* mashup (Figure 2) because he was "curious as

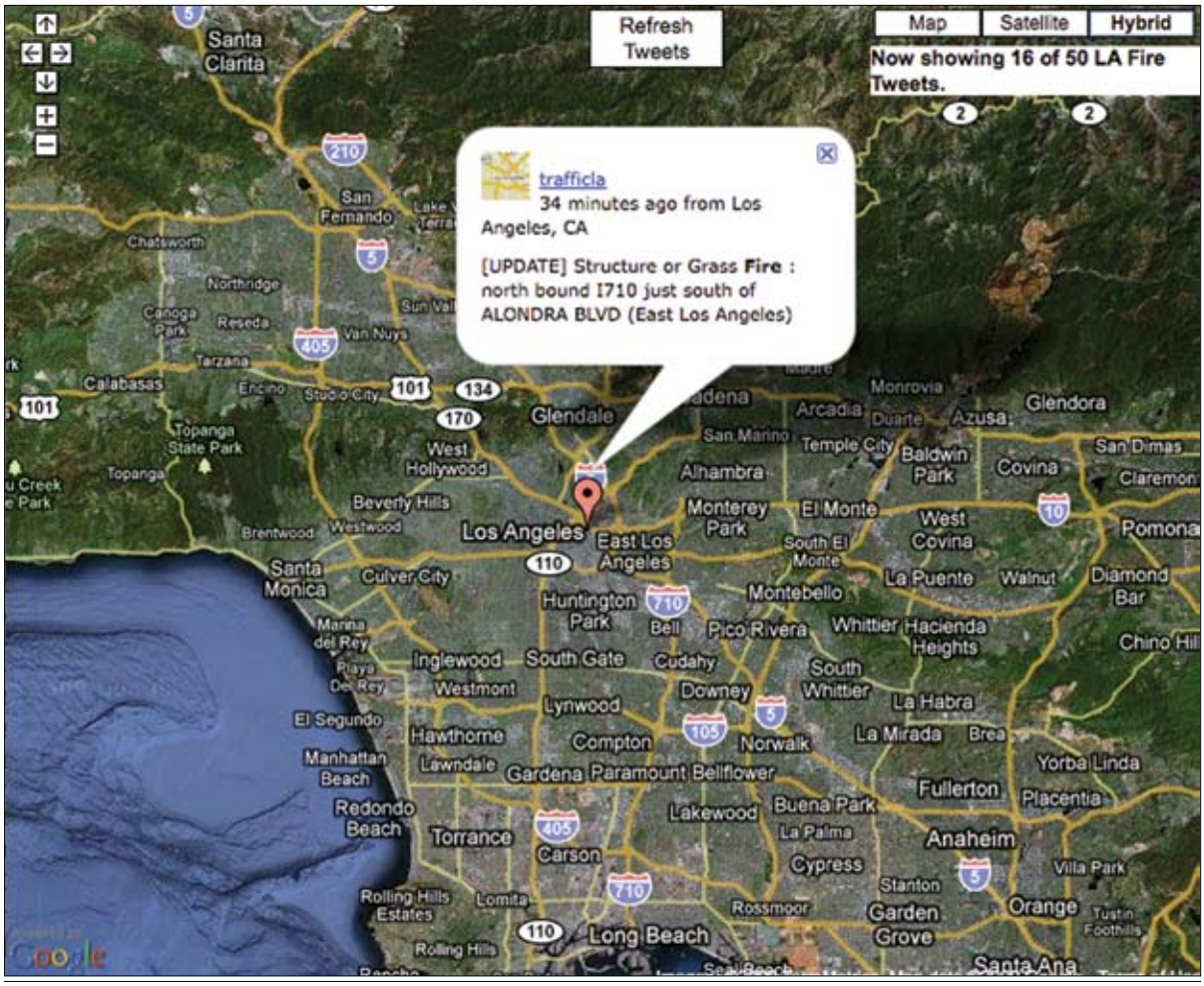

Figure 2. *Los Angeles Fire Tweets* mashup.

to what folks on the ground and eyewitnesses [were saying] and how they were reacting and reporting about California Fires." In the case of the *Swine Flu Tweets* mashup (Figure 3), he envisions it as being "a great tool to alert people in real time about potential swine flu cases within their vicinity" and hopes that it could be used to "identify where cases are occurring and where they are serious." These types of crisis mashups are a way of visualizing real-time, ephemeral news from social media sites around specific topics based on certain geographic regions.

Expediting Communication of Information

Crisis map mashups might also be created because they are perceived as a way of expediting communications. The *LA Times* reporter, the author of the *LA Times Fires* mashup (Figure 5), first created Google My Maps mashups in October 2007 when he was asked by his employer to keep track of the numerous fires happening throughout Southern California at that time. Since the My Maps feature in Google Maps had launched in April of that year, he decided to experiment with it first for his personal use, because it seemed to be an easy way to keep track of rapid change. He decided to share the mashup online for formal news dissemination only after he had discovered how quickly it expedited reporting and appealed to viewers.

Making Information More Accessible and Usable

After Hurricane Katrina hit in August 2005, many residents of New Orleans and the entire Gulf Coast region were dispersed across the country. After Hurricane Katrina's landfall, The Greater New Orleans Community Data Center (GNOCDC.org)—a product of the Nonprofit Knowledge Works—wanted to provide information about re-population patterns which would support the New Orleans community. This led to the development of the *Repopulation Indicators for New Orleans* mashup (Figure 6). Its creators wanted a mapping environment which would be easy to use and sustain. They were already using

Figure 3. *Swine Flu Tweets* mashup.

professional mapping technology (ArcIMS) for online mapping, but this technology required "too much overhead" for map development. The nonprofit also believed that the problem with using high-end geotechnology products is that they are proprietary and inflexible, and often require specialized training. They wanted to "replicate Google Maps as much as possible so that users would not have to relearn anything." More specifically, they wanted to select a technology which was easy to use but "looked similar in terms of tools and cartography," and which was fast and robust enough to visualize different data types at multiple geographic scales to make the information accessible to multiple stakeholders.

Persuasion and Mobilization of Audience

Another reason for map mashup creation is to try to make crisis information more compelling than text-based reporting. In the case of the *Sea Level Rise on Coastal Cities in U.S.* mashup (Figure 7), the images in the mashup originated from an online report published by a nonprofit group (Mazria and Kershner 2007) explaining how "difficult [it is] to visualize and grasp the implications of sea level rise" through two-dimensional imagery which provides "little, if any, visceral connection for the viewer" (Mazria and Kershner 2007). They instead present their data "in a familiar format, that of looking out an airplane window at a city or town when making the approach for landing." This mashup creator overlaid the images onto a Google Map to make each image more directly "associated with a place," and therefore more compelling and personal to its viewership.

As another instance of working from an objective of persuasion, the *Extreme Ice Survey*'s (EIS) crisis mashup (Figure 8) was created to make slow, extended hazards risk more perceptible to human cognition about time. EIS' mission is to gather historical evidence to more effectively communicate the critical nature of climate change

Figure 4. *Iran Protest Tweet* mashup.

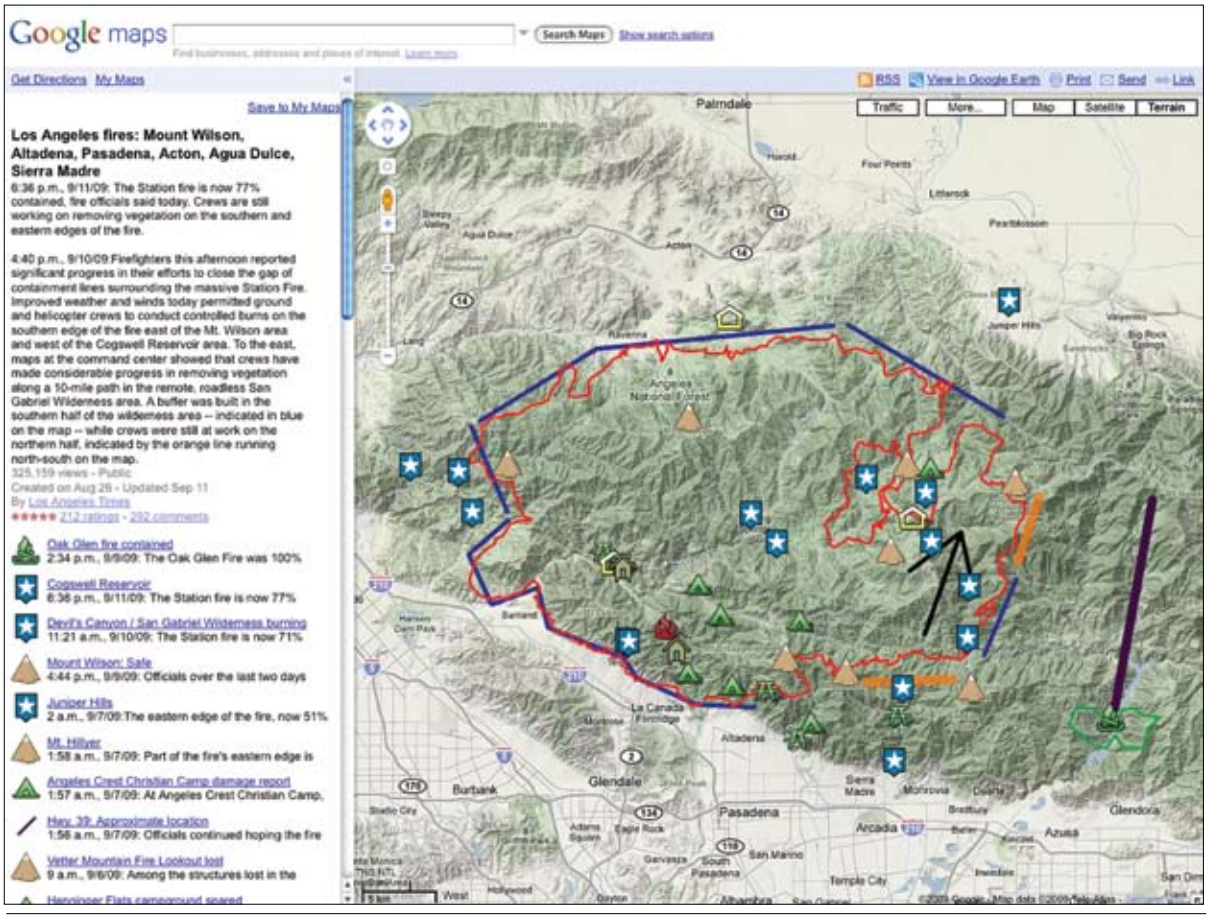

Figure 5. *Los Angeles Fires 2009 by LA Times Google My Maps* mashup.

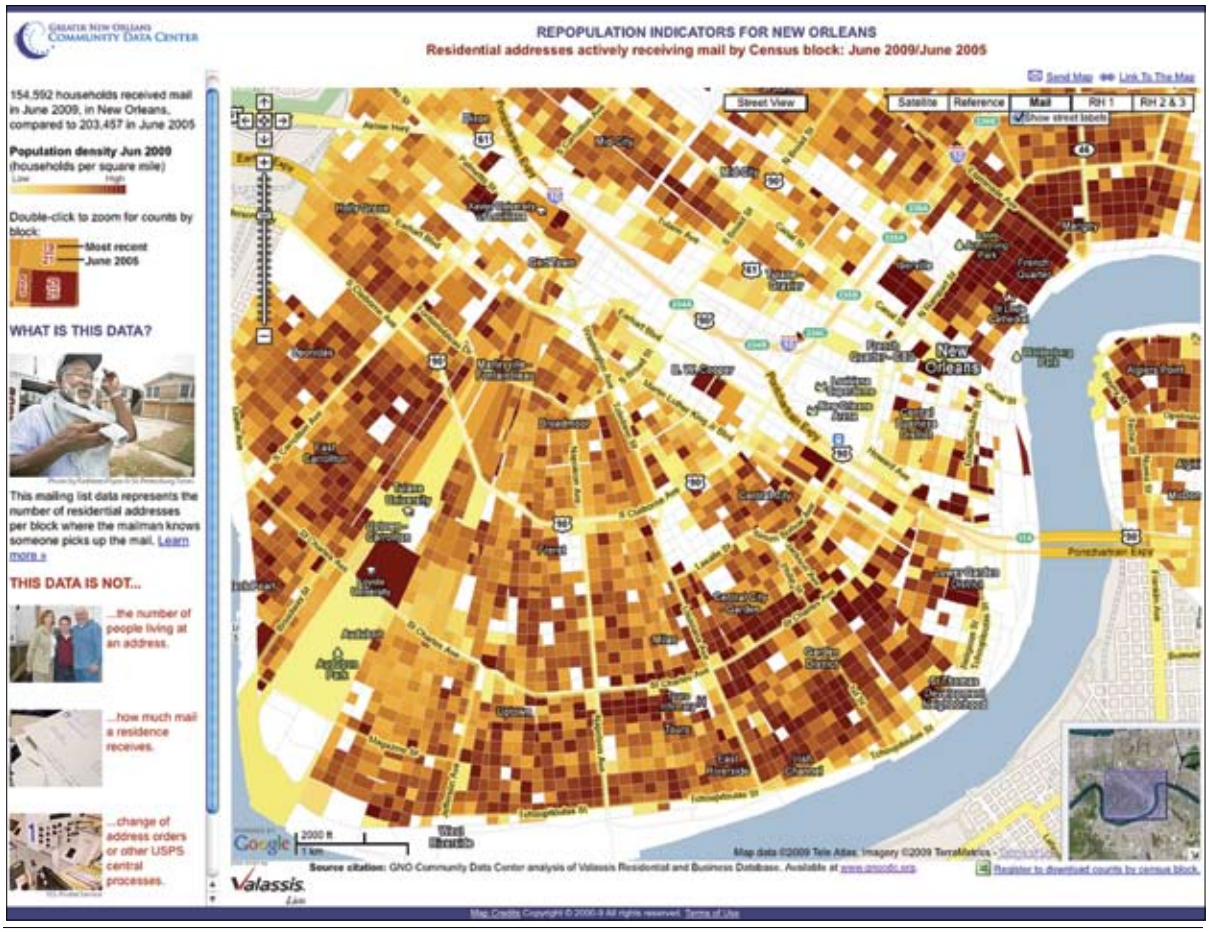

Figure 6. *Repopulation Indicators for New Orleans* mashup.

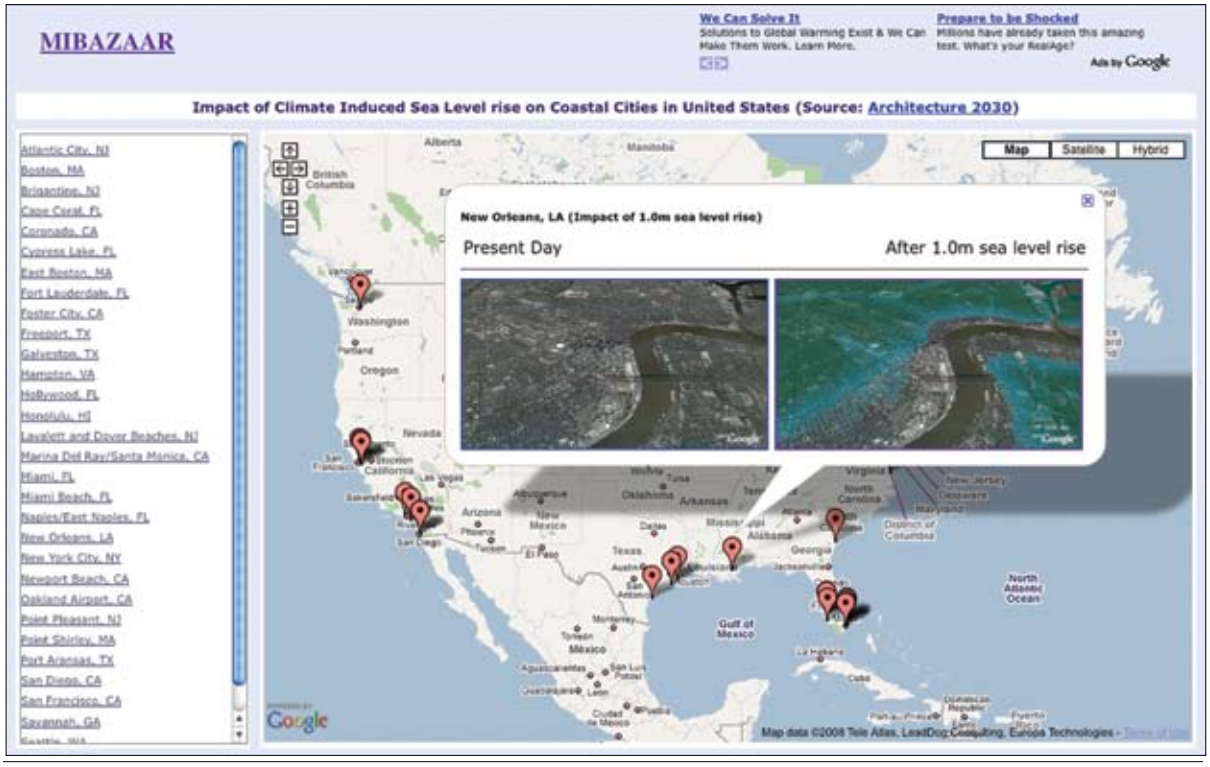

Figure 7. *Sea Level Rise on Coastal Cities in United States (US*) mashup.

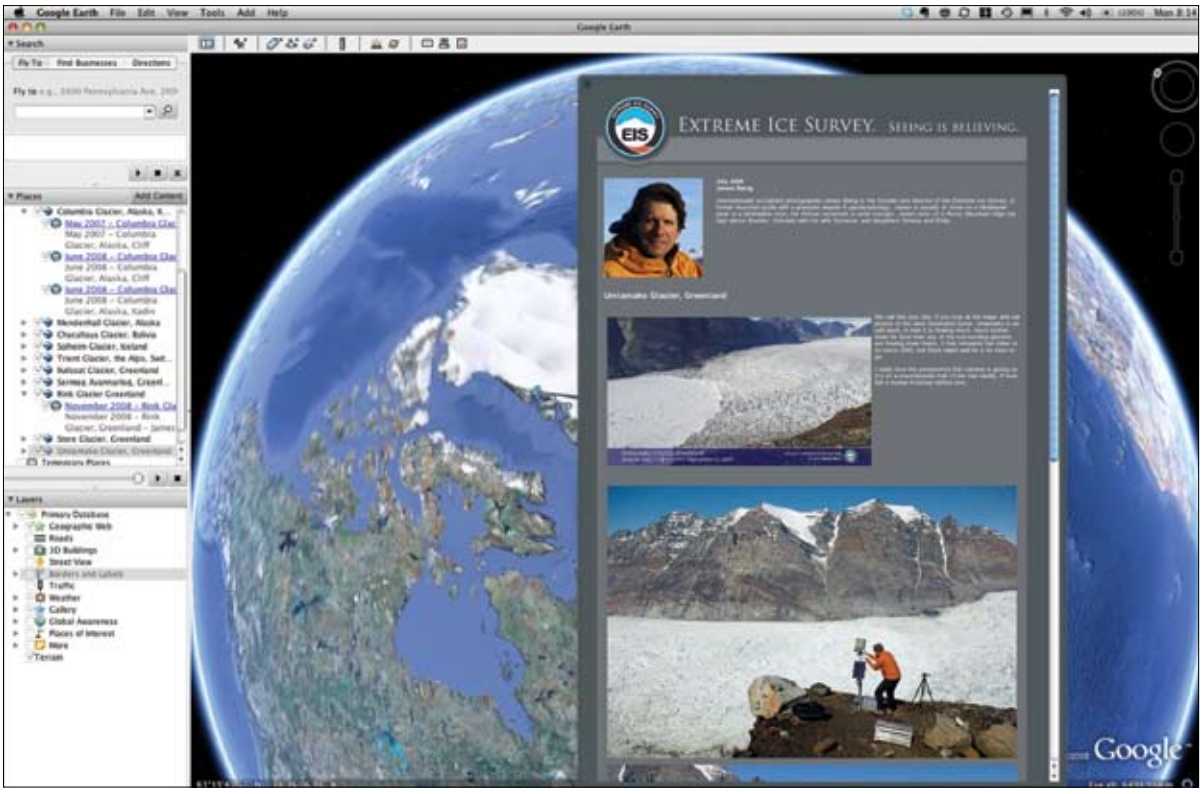

Figure 8. *Extreme Ice Survey on Google Earth* mashup.

as "the biggest environmental story of our time" (*Extreme Ice Survey* 2008). Their purpose is to document the melting glaciers and to "communicate the tremendous sense of urgency" in how these changes may ultimately lead to sea level rise. James Balog, a world-renowned nature photojournalist, founded EIS with the mission to capture "a unique record at a decisive moment of historic geologic time" by "merging art and science" (Balog 2009). Using time-lapse photography, they capture the "geologic process in action" and then overlay this onto Google Earth satellite maps "to educate as many people as possible" about the immediate impact [of] global warming" and to change "human perception."

The *Ushahidi* platform (Figures 9, 11, and 18) is intended for "crowdsourcing crisis information," according to their web site. *Ushahidi* (which means "testimony" in Swahili) was first voluntarily developed by Kenyan citizen journalists, developers, and designers in December 2007 as a web site for mapping reports of violence in Kenya after the elections. According to the Ushahidi program director, its goals are to "create a way for everyday Kenyans to report incidents of violence which they saw, using the tools they had [text messaging from mobile phones]; create an archive of news and reports around those same events; and show where the majority of the violence was happening." They eventually turned this mashup into the basis for creating the *Ushahidi Engine*, an open source platform which gathers real-time crisis information generated by the public from any place in the world in the hopes that crowdsourcing this information will mobilize assistance and government intervention.

Practice: How the Crisis Map Mashups were Created

Choosing the Data to Mashup

The data chosen for each of the mashups depended on the skills of the mashup creator and the projected needs of the potential users. Here we describe data set choices made to create the mashups we evaluate and some of the subsequent issues that arose from working with these data sources.

Using Publicly Available Scientific Data

Many crisis mashups use free and publicly available data online. For example, the *Live Earthquake* mashup displays official earth-

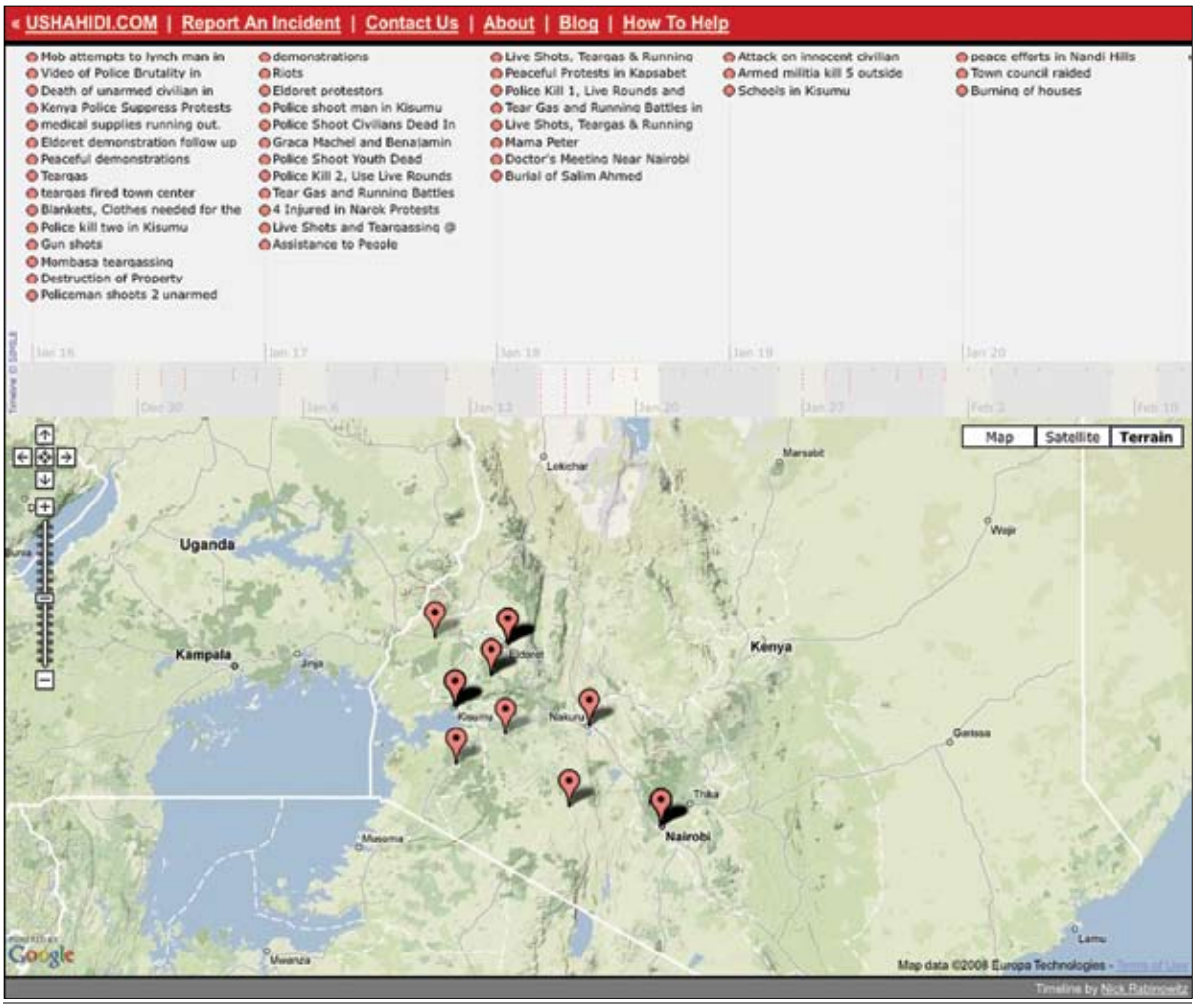

Figure 9. *Ushahidi* mashup.

quake reports using data feeds from the United States Geological Survey (USGS) to show earthquakes for the previous seven days, European-Mediterranean Seismological Centre to show earthquakes for the previous 24 hours, and GeoForschungsZentrum Potsdam also for the previous 24 hours. The creator of this mashup emphasizes that "usability and continuity of data" are important issues which need to be addressed because "a lot of data is enclosed in web pages that are hard to process automatically." He hopes that "people who have data to share (e.g., government agencies, news agencies, companies) will see the potential of publishing their data for free in standardized formats."

The creator of the *LA Times Google My Maps* mashup used wildfire data updates from InciWeb—an online, interagency, all-risk incident information management system provided by the United States Forest Service. However, he realized that sometimes the data were not up-to-date when compared to information from the *LA Times* reporters in the field, and so he used journalistic sources to supplement publicly available data. In addition, to give people "a sense of the footprint of the fire," he also uploaded satellite and aerial images from USGS.

For the *Sea Level Rise* mashup, the creator populated the map mashup with data from a nonpartisan, nonprofit climate change study group's report (Mazria and Kershner 2007). This generated flood maps which were superimposed over Google Earth satellite images for each U.S. coastal city and town "to illustrate in detail how localities will be flooded on a calm, rain-free day at high tide at various increments of sea level rise" (Mazria and Kershner 2007).

Using Commercial and Licensed Data

For the *Repopulation Indicators* mashup, The Greater New Orleans Community Data Center (GNOCDC) needed population data at parish-

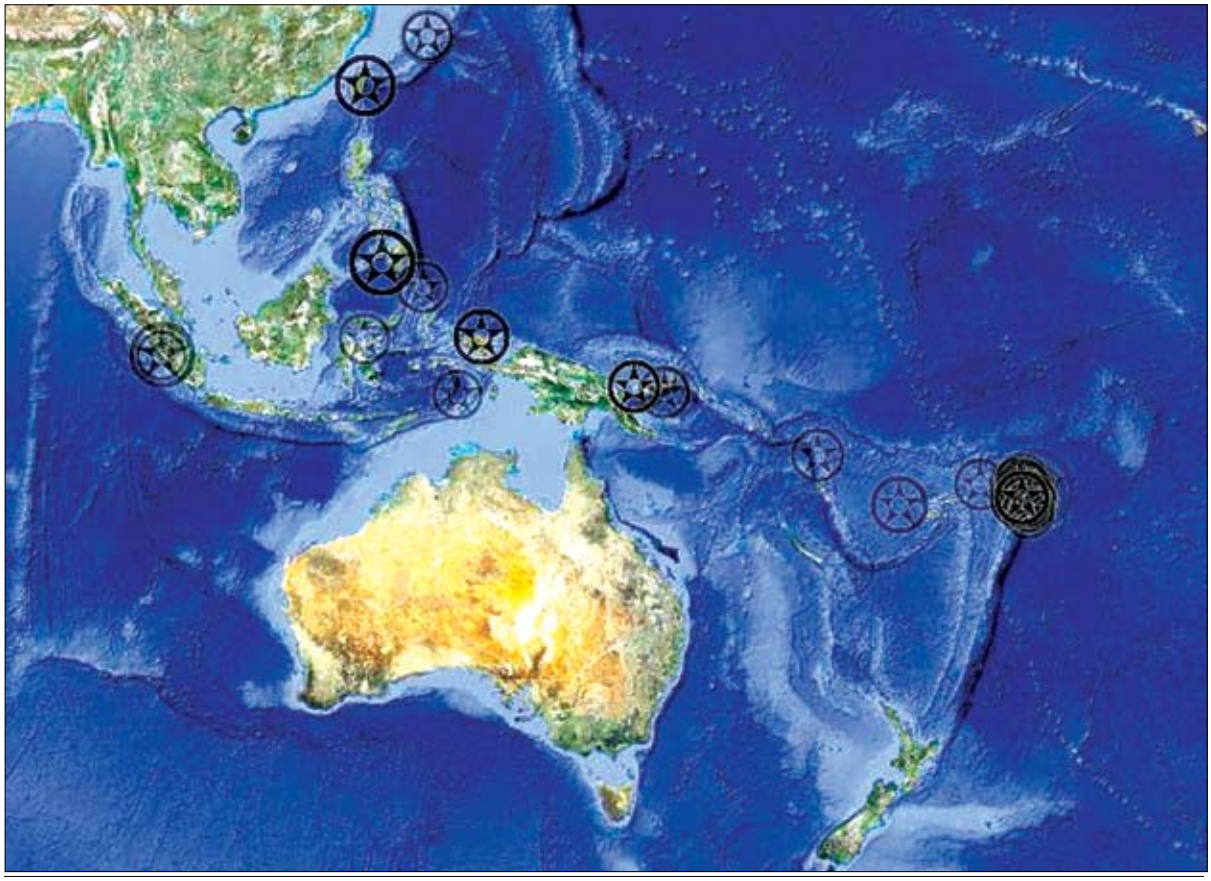

Figure 10. *Live Earthquake* mashup—satellite view.

Figure 11. *War on Gaza Ushahidi* mashup—timeline slider above line chart.

and address-level population scales. The Census Bureau data did not provide sufficient granularity of data, nor could they do so with sufficient frequency. However, U.S.PS postal data could be used for repopulation estimates because they were available, frequently updated, and quickly released. The mashup combines three types of postal data. They pay a nominal fee for the U.S.PS Delivery Statistics Product, which aggregates carrier route and ZIP Code data monthly. Additionally, they use free Housing and Urban Development (HUD) Census data, which is aggregated to census tracts and available quarterly. Lastly, they buy non-aggregated data from a direct mail marketing company at a cost of thousands of dollars because it reliably provides collated monthly address-level data. However, because the direct marketing company was itself a customer of other providers, there are limits on what they could do with the data, and they had to incorporate those use limits into their interface design decisions.

Using Journalistic Information

A majority of the data used to annotate the *LA Times Google My Maps* came from *LA Times* reporters themselves. The mashup creator always puts "*LA Times*" in the description pop-up box for each icon on the map so that people know where the data are coming from. For the 2009 August/September LA Fires mashup, the creator monitored and annotated the map for 18 hours a day using data from *LA Times* reporters' e-mail feeds, as well as phone conversations with reporters in the field and at press conferences. He uploaded changes immediately, supporting rapid news reporting. The mashup creator also stated that he also uses his skills as an editor when he annotates these maps. For example, he would routinely delete information to make it readable. He also decided not to include information about road closures, which cluttered the map, and instead focused on fire lines and evacuation locations, which he thought most readers would want to know.

The *Extreme Ice Survey* uses time-lapse videos created from EIS' own photos of glaciers to populate their Google Earth mashup. The EIS team has 33 cameras at 16 glaciers in Greenland, Iceland, Alaska, Switzerland, Bolivia, British Colombia, and Montana. Each camera takes an image at least once an hour, amounting to "approximately 4,000 images per year for a total projected archive of nearly 500,000 photographs by the completion of the survey," according to the EIS web site. Melting glaciers are "photographable and measurable" and have become "ground zero of global warming," according to Balog (2009). By using the cinematography technique of time-lapse photography, the team is able to document real-life topographical changes of glaciers. Stitching the photos into a time-lapse video innovatively illustrates longitudinal terrain changes at a fine scale. Also, embedding these time-lapse videos into Google Earth, yields additional context for understanding the relationship between glacial activity and global consequences.

Using Citizen Journalism and Crowdsourced Data

Data from citizen journalism activities and crowdsourcing are increasingly being used to support crisis reporting. For example, one difference between the 2009 *LA Fires Google My Map* mashup and the creator's previous *LA Times Fire* mashups was that he included a link for readers to provide feedback right back to the reporter. He viewed these two-way communication features as a way to "get tips for reporting," which ultimately compelled reporters in the field to search for information based on requests from members of the public. However, the mashup creator did feel "pressure to update everything over time from viewers... because of the demand… to keep the readers happy" even when the fires began to die down.

The creator of the *Tweets* and *Sea Level Rise* mashups also used data freely available online. In the case of the *Tweet* mashups, the creator explains that social media sites and services such as Twitter are "great tools to express what people see and observe…and get a feel of what the situation is on the ground." He further explains that he is interested in "the reactions from the average person from the crisis location," as well as what people around the world are saying.

The platform upon which the *Ushahidi* mashups are based is viewed by its developers as a "platform for 'crowdsourcing'" because it "transfers the task of reporting human rights abuses onto the largest number of people possible"[2] to facilitate public accountability. Meier (2009b) extends the description of *Ushahidi* as not only "crowdsourcing crisis information" [but] also "*crowdfeeding* crisis

[2] http://mobiles.tacticaltech.org/Documentinghumanrightsabuses

information" by returning information "directly to the crowd itself." Meier explains that "crowdfeeding" occurs through the subscription feature on the *Ushahidi* platform. Individuals can subscribe to particular types of events/alerts in specific locations and receive this information by automated e-mail and in the future by automated SMS. Ultimately, the data that is displayed in the *Ushahidi* mashups are reports from members of the public via mobile phone, e-mail, or the web, which are then aggregated for use in crisis response. Many of the *Ushahidi* projects are set up so that data managers can approve each submitted report before it is publicly displayed on the mashup.

User Feedback

With their strong commitment to user-centered design, the GNOCDC incorporated the 3,000+ requests received from the Ask Allison system—a feature on their web site which allows the public to ask any data-related questions to an in-house expert—to make the design of their *Repopulation Indicators* mashup fit the needs of the users. They also conducted usability testing in the Lower Ninth Ward, a neighborhood in New Orleans, Louisiana, to address any design issues with their mashup. This meant getting feedback about the mashup from the users in front of their own computers to better understand real working conditions. Based on these user studies, GNOCDC incorporated "just-in-time learning" features to make sure the "metadata was visible" when relevant and to ensure that the data would not be easily misinterpreted.

Design Decisions for Spatial and Temporal Features

The design decisions for each of the mashups depended on the spatial and temporal features of the crises themselves, as well as the nature of the data and technology chosen by the mashup creator. Some design choices represented spatiality and temporality simultaneously while others focus on either the spatial or temporal features of the crisis, depending on the mashup creator's desired emphasis.

Manual Time-stamping and Geocoding

The *LA Times Google My Maps* mashup creator needed to manually geo-code and time-stamp each icon that he annotated on the map. Although reporters provide him with geographic information, it is still in the form of estimation in reference to other locations. For example, he needed to extract and interpret geographic information after being told, "I am at the corner of this and this and I can see the fire this many ridges away from me, and its coming south." In the future, he hopes that reporters will be able to provide their latitude and longitude coordinates.

Rapid Updates for Regions

The creator of the *Los Angeles Tweets*, *Swine Flu Tweets*, and *Iran Protest Tweets* mashups had to make cogent design decisions about how to display information pertaining to regional areas but coming from worldwide sources. For each event type he customized and restricted the display criteria, and then in some cases allowed end-user visualization choices. For the *Los Angeles Fire Tweets* mashup, the creator chose to only show tweets from within a 100-mile radius of Los Angeles containing the word "fire" (see Figure 2). Currently, geo-coded data in Twitter are sometimes but not always available within the user's profile (not their actual location, as this feature was not available from Twitter at the time). Just a few days after the June 2009 Iranian election protests, he created the *Iran Protest Tweets* mashup, which displays Twitter messages or "tweets" with the words "iran" and "protests." Users can choose to only show tweets from four different regions: the Middle East, Europe, Eastern U.S., or Western U.S. (see Figure 4 upper left side). Similarly, for the *Swine Flu Tweets* mashup, he isolates tweets shown on the map based on eight regions: Mid-West U.S., North-East U.S., Southern U.S., Central U.S., South-West U.S., North-West U.S., Europe, and India (see Figure 3 middle left side). He also had to decide how he would deal with data aging: The tweets which appear in these mashups, cycle through the last 50 tweets, unless the user presses the "Refresh Tweets" button on the map (see Figures 2, 3, and 4 middle and upper right side).

Annotating Projections on a Map

In the case of the *Sea Level Rise* mashup, the creator decided to redisplay the "present day" images (as of September 2007) and the "sea-level rise" images from the "Coastal Impact Study" report onto a Google Map, since this has become a more familiar geographic interface for

Figure 12. *Sea Level Rise* mashup—satellite view.

Figure 13. *Extreme Ice Survey* mashup—overlay animation using school buses for scale.

online users (see Figure 7 for the New Orleans example). Furthermore, the Google Map interface allows users to choose a map, satellite, or hybrid view, thus providing the ability to compare the images with the most up-to-date geographic information in Google Maps (see Figure 12). In contrast to maps depicting historical and current data, the *Sea Level Rise* mashup depicts

Figure 14. *Extreme Ice Survey* mashup—overlay animation using lines for temporal scale.

future projections of what will happen in highly populated coastal cities if the sea level were to rise.

Illustrating Spatial and Temporal Scales via Computer Animation

Balog, the founder of EIS, explains that "we have a problem of human perception" and that it is "hard to grasp the scale of these places." Many of the time-lapse videos they create overlay other well known objects (e.g., Eiffel Tower, U.S. Capital Building, school buses (see Figure 13)) or line animations to delineate time (see Figure 14) and to give the viewer "a feeling for the scale" of the glacial retreat. Even with this additional animation visualization, one EIS team member wrote on the EIS blog that calving events remain "difficult to conceptualize within the context of our modern world." As an example he writes, "Imagine ice chunks the size of skyscrapers tumbling into the sea over the course of several hours. The volume of water that will be produced by this ice as it melts would be enough to overflow a sizeable lake."

Temporal Color Spectrum with GIS Tiling

The *Repopulation Indicators for New Orleans* mashup uses a color spectrum feature (see Figure 15) to indicate the population density ratio for each block pre- and post-Katrina (see Figure 16). Repopulation patterns can be discerned based on different color patterns using the different zoom levels of the map. The temporal aspect of this mashup uses a baseline map representation to indicate pre-Katrina (June 2005) conditions, whereas the post-Katrina data are dynamic and updated quarterly.

Innovating Spatial and Temporal Graphic Representations

For the *Live Earthquake* mashup, the creator hopes that his mashup is "helpful in giving a better understanding of the spatial and temporal development of earthquakes because these are dimensions one can hardly grasp." First, the creator added in March 2007 the Simile Timeline,[3] a widget for visualizing temporal data, because he appreciated how the design supported what he thought was a more "natural" user interaction. The top band of the timeline contains icons plotted according to the time (i.e., the hour) when the earthquake hit, together with textual information about the magnitude and location of the earthquake (see Figure 17). The bottom band—a zoomed-out overview of the top band—indicates the date (i.e., month and day) in which the earthquake took place, as well as visual indications of hot zones using colored vertical bars, where green indicates earthquakes

[3] http://www.simile-widgets.org/timeline/

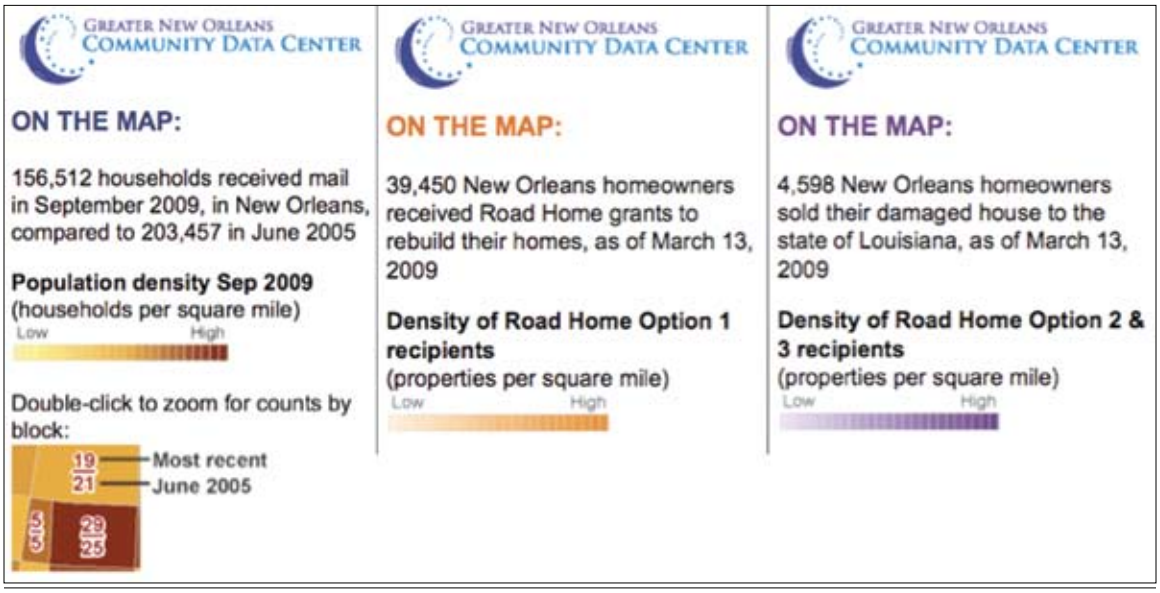

Figure 15. *Re-population Indicators for New Orleans* mashup—three types of color spectrums.

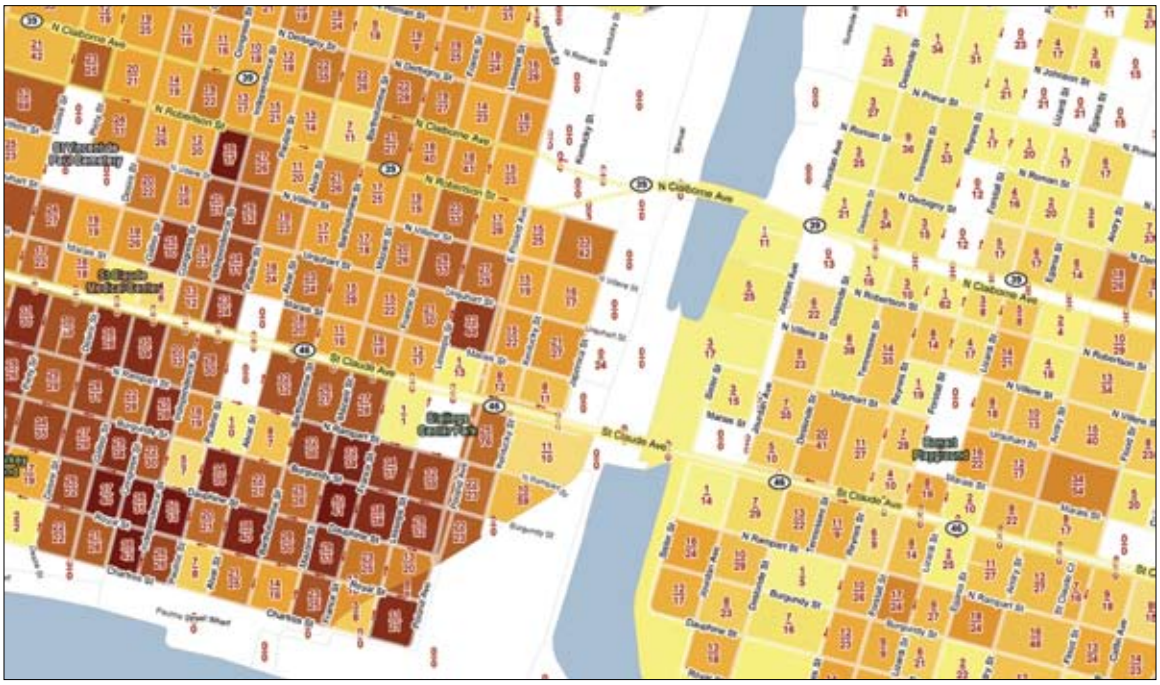

Figure 16. *Repopulation Indicators for New Orleans* mashup—block-by-block view of households receiving mail.

4.0 or less, yellow indicates 4.0 to <6.0, and red indicates 6.0 or more (see Figure 17).

The creator then decided to add the Google Terrain Map immediately after its release in December 2007 because of the uniformity of the coloring and the graphical treatment of the text this provided. He also switched to the Google Maps satellite view because of the clear depiction of fault lines and plate boundaries (see Figure 10). In addition, he had to consider how he would design the icons to best represent earthquake information. On the map, the size of the star icon corresponds to the earthquake's magnitude. He created "transparent icons" to visualize the age of the earthquake events, where darkly shaded icons indicate more recent earthquakes (see Figure 1). He points out how his mashup can sometimes be an "earthquake meta-detector," where "you can actually watch the development of an earthquake nearly in real time" and "literally see it coming." He said he knew about some major earthquakes before they appeared on Google News. This was in

Figure 17. *Live Earthquake* mashup—Simile Timeline widget.

part because he noticed a cluster of minor earthquakes before a major earthquake would hit. He analyzed where the increase in traffic took place from his log files, which allowed him to "guess" the location of a big earthquake before he heard about it in the news.

For the *Ushahidi* projects, three different types of timeline interfaces were used. The first timeline type integrated the Simile Timeline widget, creating a seamless visualization and synchronization of temporal information with the spatial context. This timeline feature was added to the *South Africa*[4] and *Kenya*[5] Ushahidi projects in late December 2007 (see Figure 9). A continuous timeline interface is superimposed on a digital map showing icons which only appear at the chosen time frame. The program director explained how in early 2008, they "realized aggregating the information on a map was not enough [because] users of the mashup needed to know the dates that information was reported and how the crisis was progressing over time." The second timeline type is a timeline slider with a graph which plots the number of incidents based on the specified period. The user can change the start and end points of the timeline to only show the number of reports in the chart and the location of these reports on the map within that specific time period. This timeline type first appeared in October 2008 in the *Democratic Republic of Congo*[6] Ushahidi project, the *War on Gaza*[7] Ushahidi project (see Figure 11), and then for the recent 2009 *Vote Report India*[8] Ushahidi project. The third timeline type is the same as the previous but with a "play" feature, which automatically shows the change in number of reports over time in the chart and the location of these reports on the map simultaneously. This type only appears in the *Swine Flu*[9] project (see Figure 18).

Discussion: Merging the Professional with the Participatory

After looking at the diverse practices of creating crisis map mashups, we discuss implications of emergent neogeographic practice. A merging of professional and participatory geotechnologies can be valuable under some circumstances, and can be of benefit to *both* the neocartographer who is progressively scaffolding skills as well as geotechnology proprietors who could benefit by widespread cartographic engagement. We echo Hakley et al.'s (2008) argument that a more synergistic approach is needed because "neogeographic techniques and collaborative ways of working have demonstrated reduced development time and improved usability…[but] these new techniques do not negate the importance of spatial analysis or cartography or surveying used in traditional geography and GIScience" (p. 2034).

In the following discussion, we provide brief case examples of how this merging of professional and participatory geotechnologies has been achieved from different directions in two of the crisis map mashups we examined.

From Informal to Formal: The Case of the *Ushahidi* Platform

To recall our earlier discussion, we explained that *Ushahidi* began as a one-off deployment with the goal of mapping reports of violence after the December 2007 Kenyan election. Here we discuss how this deployment has progressed into a comprehensive, organized software development effort with a mission of service for any kind of crisis situation.

[4] http://www.unitedforafrica.co.za/timeline.asp; [5] http://legacy.ushahidi.com/timeline.asp; [6] http://drc.ushahidi.com/; [7] http://labs.aljazeera.net/warongaza/; [8] http://votereport.in/; [9] http://swineflu.ushahidi.com/.

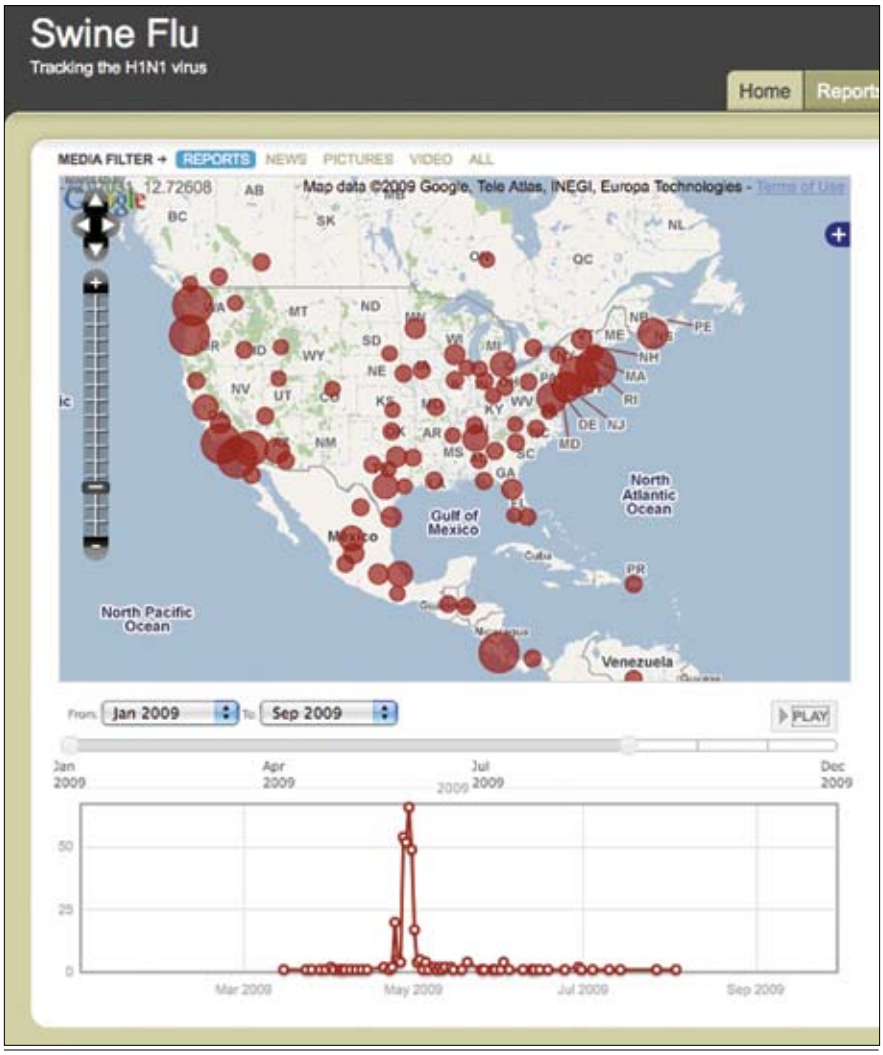

Figure 18. *Swine Flu Ushahidi* mashup—timeline slider with "play" button.

Okolloh (2009), the cofounder of *Ushahidi*, explains how "at the heart of *Ushahidi* is the idea of liberating information and avoiding the information silos and data-hugging disorder." A year after *Ushahidi* was launched, Hersman (2009c) reflects on *Ushahidi*'s role in democratizing information as "creating a new way to gather, visualize and disseminate distributed data," particularly "just-in-time data" (Hersman 2009a). It not only crowdsources crisis information from members of the public, but it also documents the reports by mapping them (*Ushahidi* 2009). Okolloh (2009) mentions the difficulty with gathering crowdsourced content, emphasizing the need for closing "the feedback loop" as well as getting "the word out beyond the internet… [by partnering] with radio, and [getting] on the local newspapers." As we mentioned earlier, Meier (2009b) refers to this as "crowdfeeding," where the information returns directly to the crowd itself. This type of information feedback can have significant impacts, especially since "a number of major humanitarian organizations have argued that information in crisis is as important as food and water," according to Meier, one of the *Ushahidi* advisory board members.

More importantly, the *Ushahidi Engine* is a free and open source platform, or rather free and open-source software (FOSS), which its developers believe can be easily adapted to local needs. According to Hersman (2009b), an open-source technology platform "provides a unique functionality" because it is customizable. A commercial product, on the other hand, is "a specialized tool" which cannot be as easily extended or modified (Herman 2009b). The developers of *Ushahidi Engine* began private alpha deployments in September 2008. In May 2009, they launched their open beta version allowing anyone to download, customize, and deploy the *Ushahidi Engine* for their own needs. On their web site, they exhibit 14 *Ushahidi* projects in the field, including the recent 2010 Haiti earthquake, using the the *Ushahidi Engine*.

This case highlights a progression from informal support to an organized larger-scale deployment with goals for ongoing technical viability across a potentially global user set.

From Formal to Inclusion of Informal: The Case of the New Orleans Re-population Maps

The mission of the Greater New Orleans Community Data Center (GNOCDC.org), the developers of the *Repopulation Indicators for New Orleans* map mashup, is to "build sustainable sources of data" and "to democratize this information, so that it can be used for planning, decision-making, and advocacy by a broad audience"

(GNOCDC 2009). As they began developing this mashup, they realized they wanted "an online solution, not just for this map but for all our paper maps," according to GNOCDC. They also realized that they needed to select some kind of geotechnology. They decided not to work with GIS vendors because they would "only offer technology as a solution" and may disregard subject matter expertise. They were also specifically worried about engaging with neogeographers—map mashup developers—who may not appreciate the scientific and interpretive meaning behind the data sets. Eventually, they collaborated with a GIS consultant, to whom they refer to as their "Mapping Sherpa." With his guidance, they chose Arc2Earth, ArcMap, and Google Maps.

They chose Google Maps as a platform with end-users in mind. Google Maps provides users with the ability to zoom in and out of maps as well as to choose the "street view," thus providing a much richer and more dynamic perspective. They used Arc2Earth to export the tile layers from ArcMap into Google Maps. This technique allowed them to make maps using the professional cartographic tools in ArcMap (with which they were already more familiar), while at the same time reaching a wide audience, thus fulfilling their mission of democratizing information.

The popularity of this site is indeed remarkable. Six months after the mashup was launched, it was accessed "more than 10,000 times by a diverse audience," according to a team member of the nonprofit. For example, the Lower Ninth Ward used it to deploy their volunteers on projects focused on rebuilding homes. A local geography researcher in New Orleans used this data to analyze repopulation patterns relative to elevation. Dutch planners used it to give advice based on Dutch flood protection expertise. A grocery store chain used it to plan the development of new stores. An interesting use of the service occurred when two different stakeholders used the repopulation data against each other to address long-term recovery issues. A university planning team used the data to evaluate the long-term impacts for constructing a hospital in particular locations. Similarly, the neighborhood association in the area used the data to demonstrate how many active households will be displaced because of this construction.

In this crisis map mashup, we see a progression from formal geotechnology support to the inclusion of, and design for, informal geotechnology support for a broad set of users.

The Impact of Hybrid Forms: Supporting Cartographic Literacy

Participatory geotechnology, such as web mapping 2.0 tools, are increasingly becoming more accessible and widely used. Amidst the hype around map mashups since their origination in 2005, differences in cartographic skills as well as an appreciation of the needs of end-users ultimately determine how map mashups evolve, and which ones will persist over time. As geospatial technologies (e.g., Google Maps, GPS-enabled cameras, location-aware phones) become increasingly a part of our everyday life, new cartographic skills are likely to emerge within the public. Additionally, as society increasingly amasses large data sets and the world becomes enabled by "cyberinfrastructure"—through data capture of digital traces resulting from engagements with organizations, institutions, and technology devices—the appeal and need for cartographic information visualization will increase. As such, there will arguably be a greater demand for merging the professional GIS culture with the participatory neogeographic culture to address the mapping challenges which are likely to arise in this increasingly networked world.

From a neogeographer's perspective, "we are all experts in our own local communities" (Goodchild 2009, p. 95), suggesting that the power of place and manipulation of data that the amateur is familiar with has great appeal. The power of computer-mediated collaboration and participation is growing, and amateur cartographic skills are being fostered by interested audiences, low-cost experimentation, free technology, and increasingly available data sources. Crisis situations create additional imperatives for visualizing information rapidly, and because natural hazards are geographic in their extent, mapping is a natural—and increasingly at-hand—information visualization solution for the interested person's use. This is not to say that problems will not arise in geographic representation of information by those without formal training; indeed, we note that this is a universal problem (Monmonier 1996).

Nevertheless, the descriptive accounts of neogeographic practice offered here describe features of a growing *cartographic literacy* which is desirable both for producers and consumers of proprietary as well as free geotechnology. The ability of professional geotechnology to interface with participatory

geotechnology could be a watershed for enabling cartographic literacy to meet the needs of a cyber-enabled society. The power of hybrid forms of technology use in map creation and consumption could make individuals and organizations more versatile in their offerings, capitalizing on professional-level services and representations and end-user accessibility, depending on the needs at hand. In critical situations, the ability to distribute the creation and manipulation of geographic representation is of considerable importance, as suppliers of information and other forms of assistance often come from highly improvised sources (Kendra and Wachtendorf 2003). The power of hybrid forms could expand the audience for all kinds of geotechnology and be the basis for mainstream cartographic literacy.

Summary

In this paper, we have presented an analysis of emergent neogeographic practice in the context of crises. We describe the genesis of crisis map mashup creation, features of their evolution with respect to the goals and issues developers faced, and design decisions with respect to features and spatio-temporal information representation. We give accounts of crisis map mashup operations, which employ hybrid forms of informal, participatory systems with professional (or professionalized) systems. We suggest that these examples work toward building a case for increased accessibility of, and interoperability between, professional and participatory forms of geotechnology, with widespread cartographic literacy in a cyberinfrastructure-enabled world as the grand goal for shaping such a progression.

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