# Informating Crisis: Expanding Critical Perspectives in Crisis Informatics

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Over the past 20 years, the practices of crisis preparedness, response, and recovery have become increasingly dependent on information and communication technology (ICT) to accomplish their work. More recently, crisis informatics has developed an analysis of these phenomena from social and computational perspectives. To further to assess the consequences and opportunities of technological developments in the field, we re-interpret the concept of *informating*, first developed by Zuboff to describe the impacts of technological changes on the workplace during the 1980s. We draw on four contemporary examples of how ICT is changing the way we conceive of and respond to natural hazards to offer a new reading of the concept of informating in the growing field of crisis informatics. We then argue that this concept suggests the adoption of a more critical agenda for crisis informatics research to better respond to contemporary challenges presented by climate change and natural hazards.

CCS Concepts: • **Groups & Organization Interfaces** → collaborative computing, computer-supported cooperative work; Social Issues

**KEYWORDS**

Crisis informatics: Critical Studies; Disasters; Hazards; ICT; Informating

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## 1 INTRODUCTION

*This inscription, what does it cost us? What do we lose? What do we win?*
- Barthes, 2009:3

In her 1988 study of technology in the workplace, *In the Age of the Smart Machine*, Shoshanna Zuboff introduced the term *informating* to describe "the process through which digitalization translates activities, events, social exchange, and objects into information" [139]. For Zuboff, informating produced both a new form of labor automation and a new site of contestation between labor and management as work processes were increasingly quantified, described, or otherwise captured through computational means. Despite the book's status as a classic in the fields of workplace studies, information science, and computer-supported cooperative work, the term itself has not been widely adopted [17]. Yet we see echoes of its intent in Fortun's separate use of the term in research on environmental risk and emerging web

technologies in the 1990's and early 2000's [42], the introduction of *social informatics* in the 1990s [64], and the rapid adoption of similar terms by research areas that have sprung up to examine the digitization of other domains being changed by the introduction of information and communication technology (ICT). Among these is *crisis informatics* [51, 87].

Crisis informatics has been described as a "multidisciplinary field combining computing and social science knowledge of disasters" [90]. Concerned with the ways in which information systems are entangled with socio-behavioral phenomena connected to disasters, crisis informatics offers a rich set of research methods and empirical opportunities for examining the consequences of the role of technology in mediating our relations with the world. Here we focus in particular on crises and disasters stemming from natural hazards, the authors' area of focus. Due to climate change, urbanization, and a range of other socio-political factors, these disaster events are occurring with increasing frequency and impact [57]. In this paper, we reflect on what crisis informatics research might look like with an expanded and more critical agenda that is demanded of it as ICTs are increasingly enrolled into practices of crisis response and management. In doing so, we also re-examine what *informating* might mean to us today, and how *crises,* as increasingly frequent and globalized affairs, inform studies of technology.

To motivate the discussion, we first relate an unexpected encounter with an exhibition at the San Jose Institute of Contemporary Art about the Lick Observatory in California. As a research site for astronomers, Lick was the first permanently occupied mountain-top observatory in the world. It has been in continuous operation since 1888, with its high-power infrared and visible light telescopes attracting premiere scientists from around the globe. A central feature of the exhibit was a fascinating series of hand-written notebooks of the eight original Lick astronomers, containing records of their observations of the characteristics and Jupiter and Saturn in the summer of 1897. In displaying the data recorded by each scientist together, the exhibit confronts viewers with the diversity of styles in which the astronomers went about inscribing their perceptions. The inscriptions within the notebook of James Schaberle, for example, indicate someone working quickly and passionately. His drawings are rough; his handwriting is large and looping with frequent underlines to emphasize points. Most strikingly, he does not use any numbers or coordinates. This is in contrast to the work of his colleagues whose notes were sparser, more exacting in their portrayals, or more quantitative in approach.

As the exhibit takes viewers forward in time through new technologies and information systems that enforced greater consistency in observations, we recognize how these new tools would enable a regularity to allow techno-scientific research to scale and advance along some trajectories. But, in the spirit of the Barthes quote at the beginning of this paper, we are also forced to wonder about what is lost during this process, and what shape that scientific understandings of the universe might have taken if different tools or alternative approaches to standardization had been adopted. What perspectives might have been erased along the way to the practice of contemporary research in astronomy? What have been the consequences of the particular socio-technical research practices adopted by the field? What, if anything, remains of the vigorous, idiosyncratic approach to documenting planetary phenomena employed by Schaberle? For us, this encounter seeded questions about the nature of inscriptions of scientific data—a kind of *informating*—and how those forms allow us to make sense of the phenomena we seek to understand and, as such, must be under question.

It is with such questions in mind that this paper addresses our own area of study: crisis informatics. We recognize that significant progress has been made over the past decade, but we also see an urgent need to include an expanded set of research methods, theoretical perspectives, and design practices to address the pressing issues confronting the world. A 2013 report by the International Committee for the Red Cross argues that "a more technology-oriented approach to humanitarian action is essential—and inescapable—to take advantage of the opportunities to improve, for example, information gathering, analysis, coordination, action or fund-raising" [125:9]. As the quote indicates, ICTs are increasingly central to the ways in

which we collectively make sense of, and coordinate our response to, crisis. Complex computer models calculate risk of natural hazards like floods or earthquakes in ways that are used to set insurance rates and land-use plans [112]. RFID tags, iris recognition software, and blockchain technology are used to manage humanitarian supply-chains and track their beneficiaries [59]. Drone and satellite imagery supports post-disaster damage assessment [70], and emergency managers are increasingly looking to social media to support situational awareness [71, 118].

The concept of *informating* directs our attention to the situated practices surrounding the socio-technical accomplishment of representing the world through data. It was first developed by Zuboff in the early 1980s to direct attention to the significant shifts in the ordering of the workplace underway as a result of the introduction of digital information systems [137,138]. We argue that it serves to foreground important issues that deserve greater attention from crisis informatics researchers. It also holds the potential to assist designers of information systems not dealing directly with crises to more carefully consider the roles their designs play in a digitally-connected world. Most importantly, we argue that the concept helps to surface critical perspectives in crisis informatics, orienting research not only toward answering empirical questions or solving particular problems in the area of practice, but also to a close examination of how such questions and problems are posed in the first place, with what consequence, and to whose benefit. In doing so, crisis informatics is positioned to draw from, and contribute to, a rich tradition of critical research and design in human computer interaction (HCI) and computer-supported cooperative work (CSCW).

The paper proceeds as follows. First, we explore relevant literature in CSCW, science and technology studies (STS), and the social sciences to set the ground for our arguments. Then we delve further into *informating* and related ideas to establish an analytical frame that can be deployed to make use of the concept within crisis informatics research. We then discuss four examples of contemporary practices in informating crises linked to natural hazards, relying on published literature as well as several cases with which the authors have direct knowledge or prior publications. Based upon this review of theoretical literature and empiric examples, we argue that informating is: 1) a socio-technical and cooperative practice; 2) both representational and generative; 3) a site of politics and contestation; 4) an influence on our own subjectivities; and 5) a potential target of design. We then outline a research agenda that could deepen and expand critical perspectives in crisis informatics and support wider engagement with work being conducted in HCI, CSCW, and the social sciences.

## 2 RELATED WORK

### 2.1 Crisis Informatics

Since its emergence in 2007, crisis informatics has made important contributions to scholarly and practitioner understanding of information systems in mass emergencies. The field draws on computing and social science perspectives to study the ways in which ICT enables, constrains, and mediates human practices related to crisis and disaster [90]. Crises can be sparked by many different kinds of societal stressors, including natural hazards, "man-made" hazards, political strife, criminal activity and more. Crisis informatics researchers in HCI and CSCW have studied events that arise from criminal or political hazards— including the violence in the 2007 Kenyan election [82], the 2007 Virginia Tech Shootings [88], the Iraqi War [106], the 2013 Boston Bombings [114], and "urban warfare" in Mexico [83]. Though there are additional definitions of crisis that matter to the field, for the purposes of this paper we focus specifically on our area of expertise, disasters arising from hazards such as flooding, earthquakes, and hurricanes, over "crisis" in general. The distinction between natural hazards and other forms of crisis is nevertheless worth making, because the technologies and practices that informate different types of crisis diverge as do the socio-behavioral responses [90].

Crisis informatics researchers who study these topics share common commitments to a sociological understanding of hazard and disaster; an understanding of information systems that draws from studies of computer-supported cooperative work; and an inclusive view of who counts as users and producers of information relevant to crisis. This perspective has proved generative, enabling crisis informatics to engage productively in research as diverse as social media, software development, big data analytics, infrastructure studies, and citizen science. Though a large number of studies have been conducted in this growing research area over the past decade, we remind readers that the field is still relatively young. To date, relatively few review papers that help research communities assess progress, articulate agendas, or delineate areas of debate, have been published [88,91,100]. In this paper, we contribute to the further development of critical perspectives in crisis informatics research. The resulting, expanded, agenda raises questions about how particular understandings of crisis are created and sustained through information systems—with what consequences—and supports the development of alternatives that are better attuned to the challenges of the present moment.

### 2.2 Social Science & Disasters

Disasters have long been objects of study in the social sciences. Contemporary approaches are often traced to the 1755 Lisbon Earthquake, which is cited as both the first major disaster in which the state took responsibility for recovery and that was systematically studied through the lens of science [24, 38]. In a letter to Voltaire, Rousseau penned the first arguments in the Western tradition that disasters were social constructions, and that vulnerability to naturally occurring hazards was unevenly distributed and the result of our economic and political systems [38]. These themes continue to be important questions in studies of disaster in geography, sociology, anthropology, and other disciplines. Disaster and climate risk in late modernity is associated with increased "anxiety" as risks become more globalized, harder to assess and therefore manage [10,79], and as risk science itself has become more ambitious in its attempt to discipline the future through the quantitative rationalization of threat [10,16,39]. At the same time, critiques of disaster response have assessed the way in which compassion for the suffering of affected peoples, mobilized through the logic of humanitarian rationality, has reproduced undesirable power relations between affected communities and those seeking to assist them [40,119,121]. Crisis informatics has yet to fully interrogate the question of the role that information and communication technology plays in sustaining such relations, and we hope to demonstrate that there is a rich opportunity to do so.

### 2.3 Critical Studies of Technology & Crisis

Critically-oriented research in human geography, media studies, and STS have brought important perspectives to the role of technology in shaping our understandings of, and responses to, crisis and disaster. They remind us that "there is no such thing as raw data," and that our technologies are always shaped by, and serve, some interests over others [47]. This body of work emphasizes the role that data standards, classification practices, and the design of information products in humanitarian assistance legitimate some understandings of disaster while foreclosing others [20], shape what kind of material assistance is made available as "aid" to affected communities [98], or expose underlying tensions within the humanitarian community over such questions [41]. While scholars in this area have argued that such perspectives could bring valuable insight to the area of crisis informatics across a number of issues, including to further challenge to the narrow temporal framing of the crisis perspective or to draw attention to the role of technologies in perpetuating structural inequities affecting who is affected by a disaster and who is able recover [25], this potential has yet to be fully realized within HCI and CSCW research. Through a reinterpretation of the concept of informating

within this context, we seek to provide a conceptual scaffolding to support a more active engagement with these questions.

## 3 INFORMATING

The word *informate* has two distinct, though complementary, usages in the CSCW and STS literatures. Zuboff first coined the term as part of her ethnographic study of the relationship between changing technologies and the political economy of the workplace in the 1980s. [137,138] She observed a two-fold threat in the practices surrounding the informating of labor. The first, as an extension of automation, was tied to the de-skilling of work that occurs as investments in workplace technologies, which was in turn tied to the goals of management that sought to increase intensity, regularity, and predictability of worker's output. In addition, she urged caution that the unique ability of information technology to produce new streams of data about work reflexively creates a new regime of knowledge with the potential to be used by managers to exert greater discipline and control over workers. Informating thus became a new site of struggle between labor and management, a concern to important debates within early CSCW and second wave HCI [12,117,130].

In a more recent formulation of the concept by Fortun [42], informating is again used to describe a societal shift in practices related to ICT. In this case, the focus is on "informating environmentalism," or the cultural shift that has been underway since the late 1990s as a result of public access to an increasing amount of data about environmental conditions, risks, and harms made available through online, interactive, web technologies. Fortun is concerned with the "particular bias and blindnesses" that result from reliance on the classificatory schemes designed into information systems to apprehend worldly phenomena, and the discursive impacts that such biases have on our understanding of the environment and the kinds of subjectivities that are inculcated through practices of informating. As with Zuboff, Fortun sees informating as a site of politics and contestation. She writes that "when fields of practice are informated, previous latent signification often comes to the surface; discursive gaps—spaces where established analytic and explanatory language fail, spaces where hegemony comes to crisis—can be displaced" [43:21].

Importantly, both scholars reject a naïve determinism that would essentialize the current practices of informating in their research sites as the inevitable outcomes of factors inherent to technology. In the work of each, we can see the possibility of more positive practices of informating. Zuboff writes that the particular features of technology "define the horizon of our material world as it shapes the limits of what is possible and what is barely imaginable; it erodes assumptions about the nature of our reality, the 'design' in which we dwell; and it creates new choices" [137:5]. She holds out hope for ICT to flatten workplace hierarchies and liberate human potential, act as a support for creative collaboration rather than an agent of de-skilling and drudgery. Fortun argues that the affordances of modern website technology could allow people to engage more deeply in science, rather than act as passive recipients of environmental information. The concept of informating thus provides an approach to consider how the design choices that shape information systems intersect with culture and politics.

Informating shares resemblance with a number of other ideas coming from social science research and critical theory. It is reminiscent of Latour and Woolgar's discussion of the role of *inscription* as a central element of scientific practice captures how material artifacts and social practice shape how observations of the world are converted into recorded measurements that are both mobile and durable [74]. Foucault's development of the concept of *apparatus* (*dispositif*) is also relevant here[1]. He writes that an apparatus is a "heterogenous ensemble consisting of

[1] Deleuze [30], Barad [6], and Agamben [1] have also worked productively with this concept.

discourses, institutions, architectural forms, regulatory decisions, laws, administrative measures, scientific statements, philosophical, moral and philanthropic propositions ... The apparatus itself is the system of relations that can be established between these elements" [44:194-195]. Apparatuses are crucial technologies of governance, shaping—and in turn being shaped by—culture, social relations, and individual conduct [127]. Informating, from this perspective, is central to the replication and self-maintenance of these apparatuses, co-productive of the information and communication technologies through which the world is increasingly ordered.

In putting the Zuboff and Fortun's work on informating in conversation, we highlight several key ideas for HCI and CSCW research into crisis informatics. Crucially, the concept turns our attention to the ways in which information does not emerge spontaneously, *ex nihilo*, but rather is enacted through collective human effort in concert with technology. Such efforts are increasingly a part of the ways in which high-tempo coordination work of humanitarian response as well as the governance of disaster risk and post-disaster recovery are accomplished. The distribution of risk, the provision of aid, and the planning of recovery all occur along uneven socio-technical landscapes shaped by various forms of expert knowledge, economic and social inequality, and politics in which ICTs are implicated. Zuboff's concerns about the delegation of authority to machines vs human agency [see also 2] are equally relevant to the practices of informating relevant to crisis informatics. These relationships can only be understood through careful attention to the ongoing interplay of human action and technology that sustain them. The perspective of informating thus aligns with many of the concerns raised in the evolving debates around the "practice turn" in HCI [69,97,105], though a full discussion of this relationship is beyond the scope of this paper. Informating nonetheless affords a conceptual tool for critically evaluating the practices surrounding ICTs and crisis management.

## 4 EXAMPLES OF INFORMATING

To develop the concept of informating within the field of crisis informatics, we discuss four examples, drawn from relevant literatures and our own experience in the field. In each, we seek to describe the practices through which the crisis event is being informated and assess their consequences. In doing so, we seek to both further elaborate our understanding of the concept and demonstrate its value as an analytic approach. These examples cover a range of natural hazards, geographies, and temporal dimensions but neither exhaust the forms of informating that are conducted in the domain of crisis response and management nor fully outline the range of issues that informating forces researchers to contend with. However they do begin to provide a sense of what is at stake, and how the concept of informating may help develop a more explicitly critical perspective to the study of information systems and crises.

### 4.1 OpenStreetMap Haiti and the Conditions of Participation

Following the 7.0 magnitude earthquake that struck Haiti on January 12, 2010, thousands of volunteers from around the world converged online in an effort to assist with the humanitarian response. The Haiti earthquake was the first large-scale online disaster where volunteers used social media and other digital platforms, in patterns that have since grown familiar, to seek and share information, connect survivors to responders, and otherwise assist the international relief effort [89,110]. This convergence was facilitated by developments of new technology, changing attitudes around crowdsourcing, social media, and open data, and, importantly, a network called "Crisis Mappers" that consisted of technologists and humanitarians who for several years prior to the earthquake had been advocating for the role that new information and communication technologies could play in humanitarian response. One of the more prominent platforms was OpenStreetMap (OSM). OSM is an online, openly accessible map of the world that is created by its user community. Participants trace features like roads or buildings from satellite imagery, collect GPS data, or draw directly into the map, producing an open source and open access

geospatial database that, in many parts of the world, rivals official sources in terms of accuracy and completeness [4,52]. One of the core motivations of OSM participants is to "democratize mapmaking," historically a domain controlled by governments and the military [133], through involving the public in creating the maps that represent their communities [19,53].

As news of the earthquake spread, hundreds of OSM mappers, organized in part by the then-nascent group of volunteers called the Humanitarian OSM Team (HOT), logged into the platform and, using aerial imagery made available by providers like Google and the World Bank, created the most detailed map of the quake-affected areas of Haiti in existence [110,136]. Within a month, members of the international OSM community had traveled to Haiti to involve residents in the use of the platform for creating maps in support of the response efforts. Funding from the International Organization for Migration (IOM), the World Bank, and other donors supported the training and employment of hundreds of Haitians to map, in OSM, damaged buildings, public health infrastructure, and camps for earthquake-displaced people that were constructed following the disaster [110]. Central to the logics underpinning these activities was the belief by both HOT and their international donors that involving Haitians in the mapping work that would lead to a more effective, inclusive, and equitable response. Drawing inspiration from the field of participatory development and mapping [18,22,92], HOT sought to create a process that would provide employment opportunities for individuals affected by the earthquake, support local skill development in the areas of mapping and computing, and, most importantly facilitate the incorporation of the knowledge and priorities of Haitians into the information products that would guide response and recovery activities [110].

One limitation of this example of informating was that most of the important decisions over what kinds of things that the local teams would map, and the data standards that were used to describe them, were made by HOT and their funders [110]. For example, when mappers were tasked with working on collecting information about the location and characteristics of public health infrastructure to plan a response to the cholera outbreak, they were given detailed instructions and survey forms enumerating what kinds of buildings—e.g. hospitals, clinics, and temporary sites—and what information about each—e.g. GPS location, patient capacity, and contact details—to collect [110]. In processes of informating, these decisions produce a kind of closure in the "knowledge politics" [20] surrounding the issue at hand, in this case the cholera response in Haiti. Such closures have a coordinating function: as durable abstractions they support communication and enable Latour's "action at a distance" [72]. At the same time, they foreshorten debate over contentious issues, mask uncertainty, and limit the inclusion of alternative perspectives [20,112]. We do not know what the Haitian mapping teams involved in the project would have understood the cholera response infrastructure to be because, despite HOT's aspirations to support a participatory process, no one truly asked them. Though the mapping process may have supported the work of the formal disaster response agencies, they limited Haitian input about what got counted as public health infrastructure, and ultimately affected which people received assistance and how.

Today, the Haiti earthquake response is remembered as anything but effective and inclusive. In fact many of the criticisms center around the ways in which international organizations, in their rush to respond to the disaster, crowded out Haitian communities and institutions from the planning and execution of the response and recovery work [60,104]. These arguments place the international humanitarian effort within a much longer arc of political conflict, foreign intervention, and economic interference that made Haiti so intensely vulnerable to the earthquake in the first place [104]. The informating practices adopted by OpenStreetMap Haiti, though only one small part of the multi-billion dollar response effort, are instructive for evaluating the participatory potential of new disaster information systems. Practices of categorization and classification [15] are central elements of informating; they play a major role in determining what is represented in ICTs and in what manner. The process by which Haitians could participate in the informating of the disaster was narrowly circumscribed by the

information standards that dictated how their perspective was included in the maps [5,132]. Thus the labor of the "participants" was aimed at producing a valuable commodity, map data, for humanitarian responders and their work had the character of employment, rather than active citizenship. Such relationships, central to Zuboff's conception of informating, are an important feature of contemporary, professional, humanitarian work, yet so far have largely gone unexamined in crisis informatics.

### 4.2 Social Media & Situational Awareness in Hurricane Sandy

When Hurricane Sandy slammed into the US mid-Atlantic region in October 2012, the massive storm caused billions of dollars in damage, becoming what was at the time the second most destructive storm in US history. Because of the population density of its US landfall, and at a moment when Twitter had achieved high public awareness, the amount of social media communications that were generated before, during, and after the storm was enormous. Twitter claimed there were 20M tweets that described Sandy's social media footprint [123], with approximately 6-7M of these geotagged with some sort of spatial reference [128]. The sheer volume was perceived as evidence of social media's value to disaster response, and tempted some practitioners and researchers into uncautious analysis of the raw data. Despite the apparent utility of such a large amount of information, the role of social media data in informating situational awareness during large disaster responses has yet to meet its promise.

To date, crisis informatics has been most recognized for the study of social media in disasters. This aspect of the research can be organized into three main areas [91]: These include, first, the *socio-technical innovations* afforded by social media including citizen reporting and journalism, digital volunteerism, community-oriented organizing, and distributed problem-solving [85,86]. Second, social media had been examined as a *tool for emergency responders* to communicate with the public, and how it affects their roles and practices, often negatively, as a result of the limited resources agencies have to address the changing information landscape [31,55,71]. It has been the third area of social media work, which considers *social media traces as data sources* [21] that can be "harvested" to support real-time detection of information that has been most challenging. Attempts to develop methods to use social media in ways that can be relied upon consistently to provide situational awareness [106] — how emergency responders assess the status of the impact of a crisis on people and infrastructure at any one time to make decisions about deploying aid—has garnered immense attention from popular accounts while simultaneously proving extremely difficult.

A recent analysis of the Twitter data from Hurricane Sandy argued that a multitude of factors including intermittent power outages, uneven adoption or access to social media, and the polysemous relationship between geotags and physical space challenged simplistic claims about the role of social media in situational awareness of the event [106]. The authors conclude that "seeing spatial concentrations of social media activity in disaster situations as being equivalent to areas in need of relief vastly oversimplifies the ways that social media is used in disaster situations, while also potentially reinforcing offline social inequalities by failing to provide relief to areas which may not be producing such content" [106:178]. Another study showed that people in Far Rockaway, a both especially disaster-prone and socioeconomically vulnerable area, felt that their requests for aid from formal response organizations through Twitter went unheard [2]. These findings support what crisis informatics researchers have long argued: only through careful treatment of social media traces could researchers obtain smaller datasets to interpret and properly contextualize. Despite a mostly thoughtful body of work by crisis informatics researchers dedicated to studying socio-behavioral phenomena and with the capacity to meet the computational demands of big data [91; and for example, 67,106], the pace of social media's growth has attracted both data scientists new to disaster research [135], and social scientists with limited background in computational sampling of social media data [80].

By the time Sandy hit, there had been 5 years of study on how to derive actionable information from social media. This research is challenged by frequently changing user interfaces, terms of service, and APIs of the technology platforms. In addition, retaining the temporal coherence of large amounts of social media data in real-time is difficult, though necessary if it is to be used for disaster response [85]. Further, the liability of trying to make decisions about what data is collected is high—any computational solution will invariably introduce new types of bias into an already difficult situation. Who gets heard? Whose perspectives on disaster or requests for assistance get amplified, and whose do not [2]? How should we interpret the silences of those who do not appear at all? How should we account for the ways that existing inequalities are replicated or reinforced through social media? The use of social media data for the informating of situational awareness holds promise, but significant challenges remain, and the impact on the practice of crisis response has been less than hoped. This provides a special challenge for a crisis informatics agenda that perhaps can be in part addressed through a turn to more critical analyses.

### 4.3 L'Aquila & The Dangers of Risk

In the middle of the night on April 6, 2009 an earthquake struck central Italy near L'Aquila, collapsing thousands of buildings and killing 309 people. Three and a half years later, seven seismologists and government officials were sent to prison, convicted of involuntary manslaughter, for failing to provide the public with the necessary information to protect themselves during the disaster. The incident and court case sparked a massive global controversy. At its height, over 500 scientists from around the world wrote a letter to the Italian government, stressing the impossibility of predicting earthquakes and urging that the charges be dropped [32]. According to many outraged reports in the popular press, the case was about an incompetent and scientifically illiterate government looking to assign blame in the aftermath of a major disaster whose high mortality rate had more to do with poor design and enforcement of building codes than scientific malfeasance [54]. While there is some truth to this account, the controversy raises more complex questions about science communication, coping with uncertainty, and the relationship between technical expertise and public policy. For the purposes of our argument, we focus on an emerging set of challenges driven by the enrollment of ICTs in the creation, circulation, and use of information about disaster risk.

In the months leading up to the earthquake, the region had been affected by hundreds of minor earthquakes. Seismic researchers have attempted to understand the connection between seismic "swarms" of this type and the probability of a larger earthquake [32]. However, there is no consensus on this relationship. Meanwhile, a local amateur had begun publishing predictions of an imminent earthquake based on a spike in readings coming from homemade radon gas detectors [32,54]. Though there is no scientific evidence to support this claim, some have speculated that radon gas, released by small fissures in the earth's crust, might foreshadow a major earthquake. The public was increasingly concerned and, following local tradition in a seismically active area, began sleeping and spending most time outside to protect themselves from falling buildings in the event of an earthquake. On March 30, the head of the Italian Department of Civil Protection convened a meeting of scientists and government officials intended to reassure the public. Some of Italy's leading seismologists were called upon to address the links between seismic swarms, radon gas, and earthquake forecasting.

At the meeting, and in press interviews that followed, the scientists reported, correctly, that science was unsettled on the link between these phenomena and there was no firm evidence to suggest that a quake was any more likely to occur in the coming days than at any other time. They also stressed the impossibility of accurately predicting earthquakes and the necessity of focusing on improving the building stock as a means of risk reduction [34]. To make their claims, they relied on their backgrounds in probabilistic seismic risk assessment. This multi-disciplinary scientific practice has expanded rapidly in the past 40 years, in part due to the new

affordances of powerful computers, sophisticated software, and new sensing technologies. Practitioners use these tools to bring into relation historic seismic observations, detailed fault, soil and geologic maps, and data on the location and structural features of built infrastructure. Unlike earlier deterministic approaches that sought to characterize the impact of a single, modeled event, probabilistic risk assessments attempt to encapsulate all possible earthquakes in a given area, along with associated damage levels of each, into a single analytic frame. Drawing on their prior research [14] and expertise in this area, the scientists reported that no firm link could be made between ongoing seismic swarms and the likelihood of an earthquake in the near future. Six days later, an earthquake destroyed L'Aquila.

Risk science has been developed largely in relation to the insurance industry [39] but, in recent years, has moved to prominence in a wide range of governmental decisions about health, safety, and environmental hazards [16]. In this example we see some of the challenges that arise when scientific understandings of disaster risk produced by increasingly complex and powerful technologies, software, and data standards developed within a particular domain, escape into other contexts, including public discourse, that lack the conceptual tools to properly assess its claims and limitations [73,112]. Public difficulty interpreting probability is well-documented [50] as are the challenges in public decision-making processes around low-probability, high impact events like major earthquakes [34]. The increasing role of complex computer models in the study of earthquake risk has served to deepen these challenges [34]. Such models, while valuable to governments and insurance industries looking to distribute risk across large territories or asset portfolios, are not designed to advise individual protective behavior. In earlier periods of Italian history, popular understandings of earthquake threat would move the public to spend their time outdoors during times of earthquake swarms, as indeed they did in this case. Public confusion about the meaning of emerging, informated formulations of seismic risk, along with government concerns about popular panic shaped the impact of this disaster. Though all the scientists were eventually acquitted, the place of informated understandings of risk in the governance of disaster is far from settled.

### 4.4 The Post Disaster Needs Assessment in Nepal: Figuring Loss, Prescribing Recovery

Within two weeks of the 7.8 magnitude April 2015 Nepal Earthquake, the government of Nepal, with guidance and technical support of the international community and development banks, began conducting what is called a *Post-Disaster Needs Assessment*, or PDNA. The PDNA, created in 2007 but drawing on earlier forms of damage assessment, is a technology of sense-making about disaster. It is one of the primary means by which governments of affected countries attempt to determine the impact of large disasters and coordinate recovery strategies with international donors. According to the official guidelines, published jointly by the World Bank, the United Nations, and the European Union, the goal of the PDNA process is to "assist governments to assess the full extent of a disaster's impact on the country and, on the basis of these findings, to produce an actionable and sustainable Recovery Strategy for mobilizing financial and technical resources" [48:12]. These guidelines, covering two volumes and hundreds of pages, provides detailed information on the rationale and conduct of the PDNA process, along with a toolkit that prescribed how damage was to be informated, including sample forms, terms of reference, and recovery planning templates.

Over 250 people, including international experts, statisticians, engineers, and Nepal government officials, participated in the PDNA or provided guidance to various actors involved. Many of the participants were chosen for their prior experience conducting PDNAs [11], and two of the individuals responsible for creating the PDNA methodology were present for part of the process. The work was divided into 23 thematic areas and sought to quantify, from an economic perspective, the damage and losses caused by the earthquake, and develop recovery strategies across four sectors: social, productive, infrastructure, and cross-cutting [48]. Given

the short time period, it was impossible to conduct a complete, field-based survey, so the teams had to develop the means by which they could develop rough estimates [70]. They collected pre-event, "baseline" datasets from various sources, held phone calls with local government officials across the 14 most-affected districts that were included in the assessment, poured over satellite imagery for evidence of impact, and conducted site visits to validate reports and calibrate models used to extrapolate damage totals for entire districts based on limited information. Once gathered, the data was entered into template spreadsheets, in both US dollars and Nepal rupees, provided by the PDNA toolkit and shared among all of the teams for further expert review and verification through Google Docs and Dropbox [personal communication].

The PDNA took three weeks to complete. At the end of the process, it estimated that total recovery needs were about $6.7 billion USD, about half of which was comprised by the housing sector [48]. The speed and orderly manner in which the assessment was conducted was widely commented upon in Nepal at the time. Some speculated that the unexpectedly large amount of funding ($4.4 billion USD) promised at the donor conference on June 25$^{th}$ of that year was in part reflective of the great deal of consensus surrounding its findings. Yet for the all the consensus, it was quite clear that the results of the assessment were not completely accurate. For example, in some cases, local government officials reported that the number of houses damaged to be exactly equal to 2011 census figures on number of households in the area [70]. An official for one international development agency close to the process told us that the point is not to achieve absolute accuracy; what matters is that national government and donor agencies come to agreement over the figures in the report and the next steps those numbers suggest. Thus the level of correspondence between these numbers and the damages they purport to represent was less important than the degree of consensus about them between the government and the donor agencies. The apparent efficiency of the process was crucial to supporting this consensus, highlighting the ultimately social and political character of processes involved in the informating of official disaster statistics [77].

The suite of tools, standards, and expertise that together formed the technology of the Nepal PDNA was deployed in a manner that was necessarily flexible. This is evidenced by the emphasis on consensus, driven by the recognition of inability to achieve perfect accuracy, the inclusion of expert judgment, and the collaborative review process. Flexibility was important because the consensus produced during the PDNA process in turn dictated how the funding pledged by donors for various aspects of the recovery would be allocated. However, it was not complete. Important aspects of post-disaster recovery that are harder to measure in economic value, such as mental health, addressing communal land tenure, or the planned resettlement of communities in landslide prone areas, received less attention in the PDNA [48,49], and less support in the subsequent recovery process. In addition, the process was largely closed to those who were not part of the group of assembled disaster experts, donor agency representatives, and government officials, limiting the kinds of judgment and perspective that could be brought to bear on recovery planning [11]. As tools and methods aimed at improving the speed and accuracy of PDNA processes develop [70], it will be important to assess whether they serve to expand this flexibility and increase the agency of affected communities, or further delegate the informating of damage, and the scripting of recovery practices [109], to these technologies.

## 5 DISCUSSION

### 5.1 Informating Crisis

In this section we draw upon prior usages of the term *informate* by Zuboff and Fortun and the examples provided above to highlight five aspects that informating offers in support of critical study of contemporary technological changes in the domains of crisis and disaster.

First, informating is **a socio-technical and cooperative practice**, a means by which our information systems are designed, enacted, and maintained. The informating of crises takes place in particular contexts, particular spaces, and at particular moments in history. Research and writing on informatics can present abstracted and decontextual understandings of information systems, whereas as we seek to use informating to return our attention to the situatedness of such practices [97,116]. Informating thus aligns with earlier understandings of information as a processual activity of informing a person or situation, rather than the contemporary approach of treating information as a discrete element that can be commoditized and measured [29]. Locating disaster information in the context in which it is created, maintained, and used also suggests attention to the material properties of software, data, and information, an area of growing concern to CSCW scholars [36]. Disasters, and disaster-vulnerable places, offer rich opportunities to investigate these issues.

Second, **informating is both representational and generative**. It is an attempt at developing abstractions to describe complex and ultimately irreducible phenomena in the world through ICTs. Dourish and Mazmanian argue that the "ways in which information can be interpreted, negotiated, manipulated and understood to represent then carry implications for organizational processes and social practice" [37:8]. In doing so, these abstractions can come to stand in for what they represent [37]. They shape our imaginations of the world, the objects within it, and how they may be acted upon [15,133]. Informating frequently has the character of converting contested political and social issues into technical problems [75] that are amenable to expert intervention and management. In Nepal, for example, the PDNA was both the means by which the impacts of the earthquake were determined by the government and the donor community, as well as the basis upon which the recovery was designed. The discursive consequences of various approaches to informating is an area that deserves more attention.

Following from this, **informating is a site of politics and contestation**. It shapes the form of knowledge that can be created and delimits the authority to create and access it. To informate is to make decisions about what phenomena count and in what ways. These decisions are inescapably political acts [62]. In Haiti, the data standards that determined what was to be mapped, and how, was made by the international agencies, placing strong constraints on the ability of Haitian participants to represent their own experience and perspective, which was quite different than that of the formal disaster response. The controversy surrounding the L'Aquila tragedy demonstrates that apparently "objective" scientific research can be far more contentious than its practitioners believe, or have the training to assess, when situated in the social and political context in which it is produced, circulated and used.

Fourth, **informating shapes us**. These tools and practices increasingly mediate our understandings about our lives and the world around us. They help craft what we believe it means to be human, what life should consist of, and how we should act. We see this attention to the influence of informating on subjectivity in Zuboff's arguments about the different kinds of capacities that are developed in workers given routinized versus open-ended tasks [138]. Fortun argues that interactive websites that give users the ability to explore environmental data, drill down to specific locations, or compare across different areas can more deeply engage the public in environmental issues, leading to increased curiosity, investment, and commitment [42]. CSCW research has described the "torque" that occurs when practices of classification and individual biographies intertwine, shaping people's beliefs about their own identities [15], and that technology design choices have profound interactions with how humans explore their desires and curiosities, and express agency [7,134]. What might such insights express in relation to the ICTs that designate populations that are either victims, or at-risk, of natural hazards?

Finally, **informating is a potential target of design**. Neither Zuboff nor Fortun see contemporary means of informating as fixed or inevitable. On the contrary, informating is a part of larger, shifting apparatuses, of knowledge, technologies, and politics that are developed, and open to reexamination, through any of the various approaches to design in HCI and CSCW

that aim to unsettle dominant practice or envision alternatives. The practices of informating crisis are continuously being remade, experimented with, and redeployed, and design plays an important role in this evolution [98,99].

### 5.2 Expanding Critical Perspectives in Crisis Informatics

Informating, as described above, offers a powerful analytic with which to study the social and political consequences of the information systems we use to understand crises. In doing so, we find that it offers the opportunity to expand the critical perspective within crisis informatics. Rose has written that critique has the potential "reshape and expand the terms of political debate, enabling different questions to be asked, enlarging spaces of legitimate contestation, modifying the relations of the different participants to the truths in the name of which they govern or are governed" [102, cited in 75:22]. Within HCI, numerous formulations of "critical" are at work, including debates over the place of non-instrumentality in design research and practice [8,28,33,67,94], reflexive interrogation of the positionality of the ethnographic researchers in the field [129], and considerations of the possibility of technology as an emancipatory agent [114]. Crisis informatics, by drawing upon sociological research into disaster, has raised important critical questions about who produces and consumes information related to crisis. Through the concept of informating, we see opportunities to deepen and expand critical perspectives in the field. Here we sketch an outline of a research agenda that could respond to this opportunity.

#### Beyond Social Media

Crisis informatics scholarship was initially developed just preceding the advent of social media. As a result, the field has tended to focus on the affordances of these new technologies as they relate to sense-making, communication, and collaboration during periods of disaster. Work in this space has been valuable, as it helped to temper the techno-centric frame that enthusiasm for social media demanded at the time (for example [87]). However, recent studies have begun to expand the range of technologies under investigation, including the role of participatory mapping in disaster risk modeling [110], the linkage between situation reports as information products and wider ideological tensions in humanitarianism [41], interplay between social media and traditional communication technologies [26], application development [56], and the information standards that guide flood mapping in the United States [112]. Continued efforts at widening the domain should prove generative and allow crisis informatics to in turn widen the range of theoretical and methodological contributions it is positioned to make.

#### Developing a Long View of Crisis

Similarly, we also need to look beyond the immediate moments of crisis to the various ways in which social life produce the very vulnerabilities that produce crisis and disaster and give shape to their impacts. Critical research into disaster has long demonstrated that there is no such thing as a "natural disaster"[96,131], instead pointing to the ways that hazards and stressors like earthquakes work to reveal, and often deepen, pre-existing, socially produced vulnerabilities. As demonstrated by the L'Aquila controversy, the technologies that describe risk and vulnerability are increasingly the means by which these phenomena are understood, and an important terrain on which competing political values and beliefs are contested. Disasters reverberate through the history of the places in which they occur. Long after the period of crisis is deemed to be over, they continue to have impact, foreclosing some possible futures, and opening others. Taking the long view of crises, and the practices of informating that surround them, is therefore a necessary step toward understanding their genesis, dynamics, and meaning. Research into the longevity, maintenance, and decline of ICTs [23,58,101] provides a solid foundation upon which these questions could be raised in crisis informatics.

### Foregrounding the Politics of Crisis Information

Recent literature in the area of critical data studies has sought to assess data, algorithms, and information systems as sites of power where claims over what gets measured and how data is combined and analyzed have material consequences and are important sites within wider political struggles [27,47,62]. Such concerns have been increasingly taken up in recent work within HCI and CSCW on big data and the politics of measurement [61,95,112,126] but also featured in some of the field's earliest debates [117,130]. Practices of informating determine whose perspectives about disaster are heard, who receives assistance during a crisis and how, who is considered vulnerable, and who will live with risk. Humanitarian agencies are situated differently in relation to situational awareness about disasters than affected populations. As discussed in the Haiti examples, responders have different relations to risk information than residents of vulnerable areas. These positionalities shape the approach to informating that various actors practice. The processes by which we informate disaster are thus political. Taking these politics, and their consequences, seriously should be a priority for crisis informatics.

### Historical Analysis of Crisis Information Systems

Both Zuboff and Fortun focus on placing informating within particular historical moments, focusing on periods of change, and asking questions about the implications of such change. Genealogical approaches to research, such as those deployed in critical theory and STS, can support better understanding about how technologies came to be how they are, provide evidence that they could have been otherwise, and resurface under-explored approaches. Within HCI, Bødker's call for historical analysis to "focus to the question of why (technology) use is organized the way it is, how different roles of artifacts come into play, and in particular why some contradictions occur" [12:10], is important, but not widely responded to. One possible reason is that genealogy, as an approach to research, is quite different from the phenomenological posture that much HCI and CSCW theory draws from [35]. As shown by the L'Aquilla example, tracing the lineage of disaster risk modeling to its roots in the insurance industry help to explain the outcomes of its application to other problem areas. More attention to historical analysis could assist in evaluation of current approaches to informating by supporting more thorough study of the contexts in which these practices occur, and suggest concepts for designers to explore.

### Design as an Means for Engaging with Informating

Crisis informatics, as a field of research, has strong connections to HCI and CSCW. We thus have access to well-established traditions of design research and practice that offer the potential to reimagine and reshape contemporary modes of informating crisis. Work in the area of participatory, critical, speculative, and values-sensitive design, to name some of the more prominent areas, provide a strong foundation to engage with ways in which crisis is currently being informated, and allow us study how the design of such systems might yield outcomes that are in greater alignment with our values and political commitments. In expanding the range of phenomena that crisis informatics studies, and highlighting the political character of crisis, we can also look at how different modes of informating can privilege some outcomes over others. In the case of the Nepal example, how might design research suggest new approaches to post-disaster damage assessment that can meaningfully account for thorny issues of trauma and land-ownership, or invite a wider range of perspectives? The significant body of design research developed in HCI and CSCW should be deployed in support of efforts to undermine problematic discourses of disaster, reshape the ways these events are understood, and support new forms of sense-making, information-sharing, and collaboration in response.

## 6 CONCLUSION: TOWARD NEW PRACTICES OF INFORMATING CRISIS

As we have argued, informating is anything but a neutral practice of representing the world through data. In the area of disasters and natural hazards, current approaches are often defined by techno-scientific expertise in engineering and physical sciences, aligned with bureaucratic needs of the state [75,102,113,121]. This alliance, comprised of institutions, communities of practices, funding agencies, and scholarly disciplines acts as an epistemic gate-keeper, determining what counts as expertise, how problems are framed, and whose voice is heard. It is further shaped and mobilized through ongoing processes of late capitalism, in particular neoliberal reorganization of the economy, that guide the creation and distribution of risk and access to resources for post-disaster recovery [63,127,131]. Critical disaster research has highlighted the limits of this orientation, but government policy and practice have been slow to adopt its recommendations [65,66]. Informating reminds us that the hegemony of contemporary apparatuses, though formidable, is never complete [46,76]. In efforts toward developing new practices of informating, including those described in this paper, we see attempts to reconfigure relationships between responders and affected communities, between planners and "at-risk" populations, between people and the natural environment. Crisis informatics has the potential to expand and better define this space for designers, researchers, activists, and practitioners.

In many ways, this paper is simply a call to bring the insights of critical social theory to bear more expansively on crisis informatics, and it is not the first paper to do so [25]. We have argued that HCI and CSCW literature provide a collection of critical perspectives and methods to support this engagement. This research has considered the environmental impacts of computing [107], the development of technologies for use in constrained resource environments [122], the ongoing legacy of colonialism [93], and designing with/for Anthropocene futures [78]. ICT will continue to play an ever-expanding role in shaping the nature/culture divide. As this divide grows increasingly troubled and prospects for sustainable futures decline, such research will become more important. Ethnographers use a variety of tactics in their research to "make the familiar strange" [124], or to establish a critical distance from everyday life to better understand the societies in which they live. Disasters, as sites of "information convergence" [45], demand a critical analysis that can challenge frames that are taken for granted or understandings that appear objectively observed and measured. In this paper, we offer a re-interpretation of the concept of informating as a tool for achieving these goals.

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