

INTRODUCTION

ENVIRONMENTAL MONITORING ON SHAKY GROUND

A terrible earthquake shook central Mexico on September 19, 2017. I was not in Mexico then, but I could not stop reading about what had happened. From my office in San Diego, I paged through news reports about the earth moving and the damage it caused. The videos I watched showed sickly swaying buildings, rising dust clouds, and crowds of people seeking safety. My research on earthquakes and earthquake risk mitigation meant none of it was exactly unexpected, but that did not make it easy to take in. I had lived in Mexico City on and off for several years. My feeling for the city and for people living there made the earthquake hard. It made me even more determined to write this book.

Desire to reduce the harm that earthquakes cause is nothing new, but novel technologies are increasingly involved in these projects. Data generated by seismometers and accelerometers have allowed twentieth- and twenty-first-century researchers to collect masses of information about earth motion and put it to uses unimaginable in previous environmental monitoring regimes. Technoscientists can now render the earth as a place constantly moving and crisscrossed by faults and tectonic plate interfaces. They can study the deep composition of the planet and detect secret bomb tests. The proliferation of seismic monitors makes new strategies for risk mitigation imaginable. One such strategy, developed in famously seismic Mexico, involves the Sistema de Alerta Sísmica Mexicano (SASMEX).

SASMEX relies on a network of accelerometers to automatically register quakes as they start and send out warnings. Mexico City can sometimes get more than a minute of notice before shaking that starts on the Pacific coast of Mexico reaches them, and SASMEX can offer at least ten or twenty seconds of warning to places elsewhere in Mexico, too. It may not be very much time, but it is better than nothing. When SASMEX went online in 1991 to provide public earthquake early warnings, it was the first system of its kind in the world. At that point SASMEX used just twelve stations strung across Mexico's western coast. Since then, maintained and championed by a small community of Mexican engineers, this state-funded system has expanded to include ninety-eight seismic field stations and provide alerts to six cities. Proponents suggest that this system, and others like it that have emerged around the world, can help ordinary people and automated systems alike prepare for oncoming earthquakes in ways that will save lives and limit economic losses. They think these technologies can change life with earthquakes.

Earthquakes are still, to the best technoscientific knowledge, unpredictable.¹ Advocates of SASMEX hope that having a warning a few seconds before an earthquake can make a big difference for protective action to save lives or prevent damage. While vocal critics remain, the promise of a chance to take shelter, protect crucial infrastructure, and shut down automatic processes when strong earthquakes are on their way has rallied a great deal of attention. The growth of the Mexican system and the proliferation of similar technologies around the world demonstrate the promise that governments, industries, and ordinary people see in earthquake early warning. This strategy for risk mitigation is important not only because of its growing popularity. It is also part of a broader trend in which technoscientific environmental monitoring tools are made increasingly crucial to our relation to the planet we live on.² Because of this, considering SASMEX's development and use in Mexico can help us understand other attempts to engineer new relationships between threatening environments and societies at risk, too.

In this book, I tell the story of a Mexican earthquake risk mitigation technology to demystify such projects. Engineers at the nonprofit Center for Seismic Instrumentation and Registry (Centro de Instrumentación y Registro Sísmico in Spanish, more commonly referred to as CIRES) have designed, developed, maintained, and advocated for SASMEX in the context

of changing environmental and social circumstances. Antonio Duran, one of the engineers at CIRES, told me that in any problem with earthquakes, you have to deal with nature, humans, and technology. “You have to put them on the map together,” he said.³ At CIRES, I saw Duran and his colleagues building that “map” as they went. While each element at stake here—“nature, humans, and technology,” as Duran put it—may seem easy to define and conceptualize separately, SASMEX demonstrates just how inextricably linked and, indeed, co-constitutive they are. Here, I make the case that the work Duran was describing at CIRES was about rearranging “nature, humans, and technology” on that metaphorical map, or, as I put it throughout this book, transforming relationships between environment, society, and technology.

As globally relevant as they are, both this technology and the particular notions about what it might do—what historian Matthew Wisnioski might call its “ideology of technological change”—came to be in the context of specific conditions which I seek to address in this book.⁴ Public earthquake early warning was first developed in Mexico. I point this out here because that context has shaped its conditions of possibility. It is especially worth emphasizing when technologies in Latin America, no matter how innovative or consequential they may be, are still under-considered in English-language science and technology studies (STS) literature. There is substantial reason to understand that what we often call European or Western technoscience is built with ideas and materials from colonized places generally considered peripheral to the formation of such knowledge. Knowledge production and innovation in such places was nonetheless substantial, and has never stopped.⁵ Despite these facts, popular narratives still treat technoscience in Latin America as “imported magic.”⁶ Unfortunately, we who read in English are still more likely to encounter analyses about technoscience in the United States or Europe than in Latin America. This is a tremendous loss for those of us who seek to better understand technologies and how they are developed, redeveloped, adapted, and used.

Throughout this book, you will find descriptions of Mexican technology grounded in Mexican material environments and sociopolitical realities. This book is, after all, the product of research on earthquake early warning in one very specific place where technoscientific innovation, limited and inequitably distributed wealth, and traumatic seismic histories are all undeniably present. However, I take every opportunity to suggest how Mexican experiences, and the insights of Mexican engineers, can illuminate puzzles

and help us better understand the challenges of environmental monitoring and risk mitigation elsewhere, too. In the chapters that follow, I develop three major arguments to help demonstrate what matters in efforts to change how people live with threatening environments.

First, I argue that the development and use of any risk mitigation technology that seeks to remake human–environment relations is a sociotechnical endeavor—and more. The specific environmental forces and conditions involved play important roles in such projects, and robust analysis should consider them too. Events including the settlement of land that would one day be Mexico City; its conquest and colonial exploitation; Mexican independence and subsequent nationalist and development projects; and subsequent economic booms and busts have all both responded to and informed the environmental, social, and technical conditions that spurred SASMEX creators and funders into action. I demonstrate that considering material environmental circumstances and culturally patterned understandings of earthquake risk and earthquake risk mitigation in Mexico can offer important insights for scholars and professionals in fields related to disaster response and recovery alike.

Second, I argue that there is an important contradiction in the ways that SASMEX and other technologies with similar potential benefits are often approached. While techno-optimistic accounts in both academic and popular discourse focus on how sensors or algorithmic processors will help achieve public safety, they neglect the very nontechnical elements that such outcomes require. These additional elements include, for example, considerations of how people already live with earthquakes and development of public education campaigns to help people make use of novel technologies in practical ways. Indeed, although SASMEX and systems like it are meant to change the way people live with earthquakes, the actual conditions of social life so crucial to their design and use do not get the same attention as system equipment does. Without these elements, public early warning will fail no matter how well technologies perform. I build this case as I describe how Mexican technoscience and policy have directed earthquake risk mitigation efforts, showing how the limits of their attention to and investment in SASMEX have foreclosed serious engagement with what it can really do. Through this argument, I explore the premises, opportunities, and limitations of efforts to change relationships between environment, society, and technology like SASMEX.

Finally, I argue that engineering as a field offers experts distinctive conceptual tools for environmental monitoring for risk mitigation.⁷ Disciplinary logics are resources for thinking through relationships between environment, society, and technology. I show how disciplinary logics in engineering are shaped by historical and contemporary configurations of power and expertise, and how they emerge as particularly meaningful in cases of technoscientific controversy. I also demonstrate how engineering matters in the course of ordinary work of maintaining SASMEX stations in terms of technical work and the practical challenges of negotiating rural Mexico. This argument allows me to tease out some of what is distinctive about the CIRES team, and the ideas and practices they use to approach relationships between environment, society, and technology.

In the rest of this introduction, I describe how this book came to be and my goals for it. I have given a short summary of my arguments already; in what follows, I describe my research methods and the forms of data and analysis that I have used to build these insights. Next, I address the scholarly conversations that have informed this project, situating my contribution within the interests, problems, and collaborative thought of others. I articulate the strengths and limitations of this project to the best of my ability so that readers might begin with expectations of what the book can and cannot do. I close with a detailed overview of the book, suggesting how it might be read by audiences concerned with different issues.

ENVIRONMENT, SOCIETY, AND TECHNOLOGY

Earthquake early warning systems only became viable in the latter part of the twentieth century, after innovations related to automatic data processing allowed technoscientists to rapidly distinguish an earthquake from other ground motion (created by the vibrations of things like passing pedestrians or vehicles), calculate its size, and relay that information to central servers.⁸ Studying such systems provides an excellent opportunity to consider how environmental monitoring technology is mobilized in risk mitigation projects.

Throughout this book, I direct readers' attention to broad categories I refer to as "environment," "society," and "technology." As an anthropologist and STS scholar, I approach these categories and the relationships among them as highly context-dependent and related to things people do,

experience, and reflect on.⁹ This means that the ways we navigate and make sense of environment, society, and technology are changeable; indeed, they are changing all the time. Considering these categories in the context of the Mexican earthquake early warning system's development and use allows me to both elucidate crucial issues related specifically to Mexican earthquake early warning and highlight critical concepts relevant to contemporary environmental monitoring and risk mitigation more generally.

Sociologist Sandra González-Santos writes that to provide real insights, research on technoscience and technoscientific practice must “avoid establishing a priori borders and distinctions between realms, between what can have agency . . . and what cannot, between the social and the technical, the macro and the micro, the national and the international.”¹⁰ In this book, I have refused received distinctions when possible and simply follow SASMEX, studying how the system emerged in different contexts. Data collection for this study required more than twenty months of fieldwork, primarily using participant observation, archival research, unstructured interviews, and survey research. I discuss these activities, and the work that came before and after them, in the methodological appendix at the end of this text. I also outline them briefly here.

I did fieldwork in Mexico between 2011 and 2019, which included a period between 2013 and 2014 in which I was entirely based in Mexico City and focused on this work. In various neighborhoods in Mexico City (especially Narvarte, Centro Historico, Condesa, and Xochimilco), as well as sites in the cities of Chilpancingo, Guerrero, and Oaxaca City, Oaxaca, I met with administrators, scientists, engineers, technicians, teachers, entrepreneurs, social scientists, and policymakers. I surveyed, interviewed, and learned from people interacting with SASMEX. I shared lunches, coffees, and long walks with many thoughtful people, joined them for meetings and conferences, and performed formal interviews and surveys. Access to the archives at the National Center for Prevention of Disasters (CENAPRED) and the libraries of the Center for Research and Higher Studies in Social Anthropology (CIESAS) and Iberoamerican University have been incredibly helpful. I allocated the most time to CIRES, spending eight months embedded in the offices of the nongovernmental organization responsible for SASMEX. Many of the people employed by CIRES were generous with their time and their reflections. I was particularly interested in how they worked in confusing and changeable conditions.

After I returned from fieldwork, I felt a strong sense of recognition when I read STS scholar Manuel Tironi's description of experiments that happen during disasters when "the world is uncanny and indeterminacies are excessive and radically vital."¹¹ Tironi demonstrates how disasters provide opportunities for novel organizing that he calls "experimental" both because they are emergent and in formation and because they involve efforts to understand the world in new ways. I found evidence of similar experimentalism in my explorations of SASMEX, in efforts to respond to past disasters, and tried to prevent new ones. Considering the essential novelty of this effort to change how people live with earthquakes helped me better understand how earthquake early warning's promises might mobilize advocates and trouble detractors.

I put these people—advocates and detractors alike, as well as those caught up in their efforts—at the center of my account of SASMEX. All of them, regardless of their relation to earthquake early warning, are involved in what disaster scholar Sandrine Revet describes as an effort to forge something shared but not homogenous—a "world of natural disasters," in which modes of legitimation, common language, and narratives are shared and debated.¹² Despite Mexico's internationally recognized leadership in disaster-related research¹³ and its growing digital economy,¹⁴ the nation lacks a reputation as a core site of innovation related to disaster risk mitigation technology or, indeed, technoscience in general. This perception has limited how widely insights developed in Mexico circulate.¹⁵ When I put Mexico's "world of natural disasters" in center stage, I showcase insights about environmental monitoring and risk mitigation that might otherwise be overlooked by readers.

These insights are grounded in ongoing experience as well as the research methods I outlined above. In the course of my work on this topic, I have been sent out to a Mexico City street at night by an earthquake warning with my shoes still untied. I have also given talks and debated at conferences and reviewed papers. I became, in the process, a member of the expert community concerned with producing sensible, effective earthquake early warnings. While I now spend less time in Mexico than I once did, my research on this topic has never properly ended. I continue to consider earthquake risk mitigation in other contexts, and this ongoing work informs the choices I make as I write today. I collect newspaper articles, policy documents, and reports. I attend lectures and engage in formal and

informal conversations with policymakers, students, entrepreneurs, scientists, and activists who have been brought together by their interest in earthquakes and earthquake safety. I also speak with and observe ordinary people who interact with earthquakes outside these expert conversations. These inform how I write this book.

SCHOLARLY CONVERSATIONS

This book is about an attempt to transform relationships between environmental, social, and technical conditions. By considering SASMEX like this, I join a growing community of anthropologists and STS scholars who explore environments, society, and technology at once. Broadly, this book is involved in the kind of project that historian Sara Pritchard has characterized as considering complex but reciprocal relationships with nature.¹⁶ Researchers have built nuanced insights related to this topic by studying the many forms these relationships take, noting that the apparently natural conditions might be created by humans, have important effects on technologies that humans build, or both.¹⁷

Scholarship on how changing technologies produce knowledge about the natural world—or, as I generally refer to it in this book, the “environment”—can help us consider how we understand and live in the world. It is a basic tenet of this work that anything we might call “nature” is always already related to human ideas, practices, and experiences. This, in turn, has helped scholars consider what “nature” and “environment” mean to us;¹⁸ specific practices of producing, applying, and circulating environmental knowledge;¹⁹ and the politics and novel forms of advocacy and accountability that these practices may afford.²⁰ I draw on this perspective to consider engineering and seismicity in Mexico—specifically, in Mexico City. As historian Matthew Vitz has noted, many stories about Mexico City paint it as a city in environmental decline and a site of destruction.²¹ Like Vitz, I reject that simple narrative. Certainly, the story I tell here includes destruction, but it also shows how environmental factors and forces have shaped, and continue to shape, ordinary experience in a lively city—and, to some extent, the nation and the wider world.

I use the terms “technology” and “technoscience” to describe a variety of technical practices and objects. Technoscience is an inclusive word that encompasses everything from what happens in a research laboratory to the

kind of computer-based work that occurs in an ordinary office, as well as the technical labor that makes both possible. I highlight engineering as a particular kind of expertise and practice within technoscience, contributing as I do so to a lively conversation in STS about engineering identities and agencies²² and how this form of expertise has taken its shape from, and informed, broader political and social conditions.²³ Conditions and relations involved in engineering expertise are worth interrogating, not just to better understand the development and maintenance of a single Mexican technology but to more fully grasp contemporary technoscientific work related to environmental risk mitigation.

Risk mitigation is, after all, far from straightforward. In literature explicitly related to disaster risk mitigation, risk is often a matter of mathematical probabilities regarding the likelihood and severity of potential dangers. This way of engaging with risk is useful for facilitating comparison between one potential outcome and another, or even one case and another.²⁴ It simplifies communication and helps decisionmakers navigating high-stakes work make challenging choices. This model of risk is, of course, historically contingent—it is just one way of talking about the likelihood of undesirable outcomes.²⁵ When we use the word “risk,” we are calling out what we consider unusual and troublesome, contrasting it to what we consider more ordinary.²⁶ In this book, I am interested in risk as a way that people indicate how they see this uncertain world that we share, what they value and prioritize, and how they seek to protect it.²⁷ Risk is an essential part of the vocabulary that disaster risk mitigation professionals use to assess and advocate for transformations in the relationships between environment, society, and technology. While these people are, like me, members of expert technoscientific communities concerned about public well-being, I do not adopt their risk languages wholesale. Instead, I seek to contribute to a body of literature that considers their approaches to risk and disaster in practice.²⁸ Mexican engagement with risk is framed by environmental hazards as well as politics and the distribution of power and resources in ways that determine not only exposure but also strategies for risk mitigation.²⁹ With its focus on one effort to mitigate risks, the account I offer here complements other social scientific work on the always-political distribution and impact of disasters.³⁰

In her book *Geontologies: A Requiem to Late Liberalism*, Elizabeth Povinelli argues that considering the everyday ways we relate to the materials that

comprise the earth itself helps us understand modern configurations of power and knowledge that inform how we understand disasters and their effects.³¹ My book owes a great deal to this insight as well as to other related work that encourages careful attention to how people live with the materials and forces underfoot, from metaphors³² to industries,³³ from surface soils³⁴ to deep aquifers.³⁵ Large-scale studies of earthquakes and seismic knowledge production in particular have already drawn attention to how seismicity is a social and political force.³⁶ In Mexico, where earthquakes are common and violent earthquakes have had terrible effects in recent memory, seismicity is a presence in electoral politics, institutional forms, and personal practice.³⁷

This book is written to participate in substantial scholarly conversations. However, I know that readers may also be interested in things far outside the scope of my work. For example, I anticipate that those involved in the practical and complicated task of risk communication may be concerned with issues related to helping share information so that people prepare for and take effective emergency actions. I can certainly recommend further reading on this topic,³⁸ but it is not one I address at great length in the book. While my focus is not on this issue (or, I'm sure, many others that may be important to readers), the book does advance understanding of what risk mitigation is and what it does, practically and conceptually, in the world.

READING THIS BOOK

While much of this introduction is written for anthropologists and STS scholars, I make a point to nod to people who don't fit into those categories. The truth is that I hope anthropologists and STS scholars will not be the only readers interested in this book. There are many people who are developing, advocating for, transforming, and rethinking earthquake risk mitigation technologies right now, and I have attempted to write for them, too. People invested in Mexican risk mitigation from a practical perspective may be interested in this account, if only as a record of challenging and innovative work that they and their colleagues have taken on through the years. The earthquake early warning practitioners who are building new systems across the world may pick up this book too.

The case that I make throughout this book—that environmental monitoring and risk mitigation technologies like SASMEX are efforts to transform relationships between environments, society, and technology—is specifically

designed to contribute to scholarly conversations in anthropology and STS. Those readers working to develop and use earthquake early warning systems may not be deeply interested in this intellectual project. They will nonetheless find, in the following pages, a robust empirical account that includes some crucial topics rarely addressed in reports and peer-reviewed articles on earthquake early warning systems and risk mitigation work.

The book is organized topically to showcase its three major arguments. In part I, “Environment, Society, and Technology,” I make the case that the development and use of this risk mitigation technology is not just a sociotechnical endeavor. In chapter 1, “Life with Earthquakes,” I explore the history of earthquakes and human responses to them in Mexico from the sixteenth century to the present. Earthquake science textbooks often refer to abstract narratives about the effects of earthquakes on their environments. However, the specifics matter. Engaging seriously with ideas and practices that inform technoscientific earthquake risk mitigation requires refusing vague, imprecise narratives about what earthquakes do. Instead, I trace the specific ways that new risk mitigation tools and political action become possible in the context of hazardous environmental conditions. Chapter 2, “Earthquakes and Warnings,” offers a window into what it is like to live with earthquakes as well as early warning systems. In this chapter, I consider all sorts of warning and earthquake events as part of the experience of using this kind of technology. Here I interrogate how this technology contributes meaningfully to life with earthquakes, for all that it may not utterly transform the experience of earthquakes in the way some proponents wish it would.

In “Risk Mitigation Technology,” part II of the book, I explore risk mitigation and disaster risk reduction. I put SASMEX in the context of global trends and ongoing conversations to draw attention to the discrepancies between how the promises of such technologies are often discussed and the practical realities of deploying them. Chapter 3, “A Technology to Mitigate Risk,” introduces earthquake early warning as both an international preoccupation and a Mexican phenomenon. I show how earthquake early warning fits into contemporary ideas about risk mitigation, exploring opportunities and challenges related to system implementation. In chapter 4, “Integrating Infrastructures,” I address earthquake early warning, not in isolated terms but as part of a set of semi-integrated systems in Mexico. Doing so allows me to illustrate the dynamics of risk mitigation technology

operation in practice. With a close examination of one memorable event, I explore what being responsible for earthquake early warning means.

In part III, "Engineering with Earthquakes," I focus on the experts who run SASMEX. I argue that the CIRES team draws on engineering to help them navigate their work on relationships between environment, society, and technology. In chapter 5, "Measuring Earthquakes like Engineers," I consider how the CIRES team uses engineering expertise to seek to understand and transform the ways people live with earthquakes. I describe how the team's engineering priorities play out in their technical choices regarding SASMEX. In chapter 6, "Fieldwork and New Encounters," I attend to CIRES engineers and technicians' work to maintain SASMEX. Here, I show engineering approaches to engaging with the network that early warnings rely on and the topography of the territory this network is in. I close by noting what SASMEX might do, not just for users but for those who build and maintain it. In the conclusion, I make the case for a more consistent and holistic approach to earthquake early warning. I consider the work of both scholarly and applied efforts to better understand emerging technoscientific approaches to environmental monitoring and risk mitigation. Finally, for those who are interested in better understanding how to undertake research like this, I provide an extended methodological appendix.

Contemporary discussions about these systems in public, policy-oriented, and even expert circles often focus on their technical processes and general principles for using them to prevent disasters. This book uses STS and anthropological insights to make sense of a variety of efforts to change how we live with earthquakes. Where do these efforts come from, what do they do, and what might they mean? Understanding them holistically and in context reveals the challenges that prevent such efforts from delivering on their promises.

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