Spatial Trends and Drivers

in Insurance Loss Modeling

Jonathan W. Lowe

Insurance companies are increasingly relying on geospatial technology and analysis for mitigating risk, offering policies, and deciding what to charge.

In an insurer's wildest dream, everyone buys insurance, but nobody ever collects a payment. In their worst nightmares, a sweeping catastrophe generates claims from every policyholder, potentially bankrupting the firm. So the game is about knowing in advance who to insure, for how much, and against what potential circumstances. Consequently, serious firms research the probability of risks carefully before insuring against them and compare their changing portfolio of customers to a landscape of potential loss. Increasingly, their due diligence includes spatial modeling and analysis using an ever-finer grain of underlying data.

Geography's Bottom Line

Underwriting is the insurers' practice of choosing what risks to insure against, where to offer the policy, and what to charge. According to Ed Felchner, an executive at the 75-year-old insurance company, Acuity (www.acuity.com), most lines of insurance generate steady income, but "Homeowner's insurance is notoriously unprofitable, partly due to underpricing, but also due to limited knowledge of how geography affects the level of risk to a home." Lack of adequate geographic background information is problematic not only for profitability, but for Acuity's (and most other insurers') business philosophy. In Felchner's words, "Everybody should pay only what they owe, without having to subsidize the risk of others." In practice, this means Acuity assesses the geographic weather patterns and builds that information into the rating of its insurance policies; policies in areas with more storm activity cost more than calmer areas.

In addition to recognizing geography in their underwriting, insurers hope to have widely geographically distributed customers. That way, even an extensive, mobile disaster, such as a hurricane, touches only a subset of their total investment — maybe five out of thirty covered states. By routinely geocoding policyholders' addresses and aggregating at the ZIP-code or county level, decision-makers can confirm the balanced distribution of their customers. This "policy map" also comes in handy just after bad weather, such as a tornado. Felchner explained that generating estimates of potential loss immediately after a catastrophic event gives insurers more time to prepare for the resulting claims. If policyholders are geocoded, rough aggregation of potential loss by custom polygons (such as a tornado's swath) generated on the fly becomes straightforward.

Regions where catastrophes are common events sometimes have geographic analysis written into state law. For instance, coastal U.S. states that absorb the full force of incoming hurricanes have been battered often enough that some insurers are no longer willing to write homeowner's policies for customers living within a certain distance of the coastline. In these cases, geocoding can determine whether a potential customer is within that buffer zone and may be eligible for a special state insurance plan. The simple concept of overlaying policyholders with a coastline buffer holds the essence of the more complex discipline of risk modeling and loss estimation.

What If?

To see the state of the art firsthand, I visited Brian Quinn, a GIS specialist for the City of Berkeley, California. Quinn previously worked for Charles Schwab's Business Resumption Services group on projects intended to estimate potential losses from large San Francisco

Net Results columnist Jonathan W. Lowe covers the role of emerging technologies in the exchange of spatial information. Lowe is the owner of Local Knowledge Consulting (Berkeley, California), where he designs and implements spatial Web sites. He can be contacted at info@giswebsite.com.

Glossary

FEMA: Federal Emergency Management Agency

HAZUS: Hazard United States

ISO: International Standards Organization

NIBS: National Institute of Building Sciences

USGS: U.S. Geological Survey

earthquake scenarios. His background in geology helps with a loss-modeling tool called HAZUS (Hazards United States, www.fema.gov/hazus/) developed for the National Institute of Building Sciences (NIBS) by Risk Management Services (www.rms.com) that turns geologic and demographic map data into highly detailed damage estimates. Quinn has generated several models of potential damage due to earthquake or slope failure in Berkeley, where the U.S. Geological Survey (USGS) has recently advised of a 27 percent chance (62 percent for the whole Bay Area!) of a magnitude 6.7 or greater earthquake before 2032 (http://quake.usgs.gov/research/seismology/wg02). To start HAZUS, he entered the parameters for a seismic event 9 kilometers below Berkeley along the Hayward fault. Ten minutes later, we were reading a seventeen page document describing the monetary damage to the city, four degrees of casualties, even an estimate of the number of tons of debris (0.55 million tons, or 22,000 truckloads at 25 tons/truck in this case) that would need to be hauled out of the city following the quake.

Obviously, HAZUS uses the geographic data to estimate how the shock of a quake will spread from its origin, either an epicenter point (the East coast method) or along a plane (the West coast method). The overlay for the seismic force is the census tract-level inventory of the built environment and residential population and demographics data, such as average income and population density. Structure vulnerability to earthquakes is also modulated by construction age and quality. HAZUS estimates structure damage both by the shaking and by the fires that so often follow a large tremor. HAZUS also estimates casualties caused by damaged or collapsed buildings.

Today's primary use for HAZUS is to determine whether a disaster such as a large earthquake caused enough damage to qualify for Federal Emergency Management Agency (FEMA) funding. For instance, a few hours after a recent large tremor with an epicenter in Yountville, a Northern California city, Quinn generated a HAZUS estimate simulating that quake. His HAZUS-estimated loss for the event ranged from $50 to $100 million depending on the geologic layers and earthquake depth input — amounts likely to merit federal aid. As predicted, the California Governor's Office of Emergency Services got a similar (though official!) HAZUS loss estimate that supported the state's request for federal assistance. This standardization of protocol based on an accepted modeling tool allows those directly responsible for mitigating a disaster, usually the local government, to know almost immediately whether they can rely on federal funding — they simply run HAZUS. So, after natural disasters, city governments are similar to insurers in realizing that, as Quinn says, "There's planning value to having information fast."

Fine-Grained Berkeley. Supposedly, one indication of a tool's success is when people use it in ways its creators didn't foresee. That's what's happening in Berkeley. Quinn has been able to apply HAZUS-estimated ground motion at the census-block and assessor's parcel level when supported by USGS-developed 10-meter gridded estimates of geologic parameters such as liquefaction susceptibility, soils amplification, groundwater depth, and seismic landslide hazard throughout Berkeley. A team of USGS scientists based in Menlo Park, California, developed these layers to support seismic hazard mitigation in FEMA's Project Impact communities of Oakland and Berkeley. By default, HAZUS ground motion estimate grids are no finer than 500 meters, with losses aggregated at the census-tract level. The gridded USGS data motivated Quinn to estimate a much finer-grained 10-meter HAZUS ground motion for Berkeley scenarios, as well as to summarize HAZUS parameters and USGS-developed slope failure hazard for individual assessor's parcels (see Figure 1).

It's important to recognize the difference between estimation and prediction. Each HAZUS simulation represents only one possible disaster, chosen by the person running the simulation. Earthquake magnitudes vary, and may cause different building types to resonate (and shake) differently. The time of day a disaster occurs has dramatic consequences on the death toll, depending on whether people

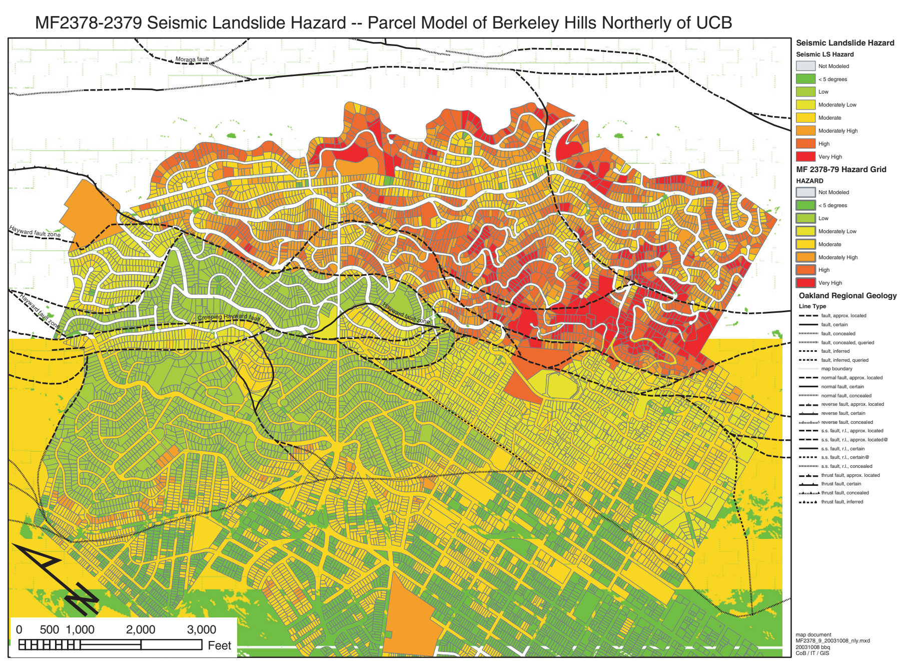


FIGURE 1 Seismic landslide hazard modeling of the hills north of the University of California, Berkeley applies the HAZUS model to data fine-grained enough to differentiate risk between assessor's parcels. Red indicates high hazard, gradating to low-hazard green.

are at home, work, or mid-commute. So, there's no single answer to the questions, "How exposed is my neighborhood?" (estimation) or "When's the next big quake coming?" (prediction). Fine-grained data and standard modeling tools do offer a reliable range of possibilities, however, and the value of the USGS's 10-meter grid for fine-grained loss-estimation hasn't gone unnoticed. The Nuclear Regulatory Commission has redirected USGS to collect similar data for the nation's nuclear facilities before returning to municipal mapping projects.

Quinn's HAZUS demonstration raises two lingering questions. First, what effect will accessibility to finer-grained data have on future insurance policies or even their availability in neighborhoods with high probability of extreme loss? Will local variations of the 1-mile coastline rule begin to appear as buffers around high-risk neighborhoods, or as coverage variations between parcels rather between states? Only time will tell.

Collective Consciousness. The second question does have an answer, however, and arose when Quinn explained that his greatest challenge in using HAZUS is not mastering the tool itself, but collecting, converting, and properly aligning the fine-grained data required to run the model at the parcel level. He is not alone in recognizing the value of carefully collected data. A handful of spatial consultancies, such as RMSI (www.rmsi.com), are not only conducting modeling studies, but are creating reusable libraries of the underlying data supporting their models.

RMSI serves large customers, such as The World Bank, Japan's OYO Corporation, and California-based Risk Management Solutions, in mapping potential floods, landslides, earthquakes, wind storms, and other natural disasters, using combinations of commercial mapping tools, collections of otherwise disparate data, and its own team of programmers to modify or create modeling algorithms. The end users in the modeling market are often insurers or reinsurers (that is, companies that provide insurance to insurers, thereby smoothing out the overall risk) proactively calculating the exposure of their portfolios.

For instance, The World Bank provides loans to regions of Asia suffering from cyclones, earthquakes, and floods, but wanted to re-evaluate their existing funding mechanisms. Part of this exploration for alternatives involved a catastrophic risk assessment study, conducted by RMSI, in the Indian states of Andhra Pradesh, Gujarat, Maharashtra, and Orissa. For these states, RMSI compiled historic records of past disasters, hazard assessment, vulnerability evaluation, exposure development, and loss analysis. It modeled natural catastrophes (cyclones, earthquakes, and floods) and mapped exposed assets (housing and public infrastructure). The company then delivered The World Bank a report akin to HAZUS's output, but in the language of finance, including "aggregate and occurrence loss exceeding curves/tables, average annual losses, loss costs and probably maximum losses," as well as graphic hazard and risk maps (see Figures 2a, 2b, and 2c).

RMSI's scientists used several modeling tools and probabilistic methods for their study, including the stratified sampling technique, the time-stepping wind field model, Global Seismic Hazard Assessment Program earthquake sources, and the Hydrologic Engineering Center's Hydrologic Assessment System river flood model. Because modeling is an estimate of events that have not yet happened, evaluating the quality of a model is difficult. However, RMSI reports that, "All attempts were made to calibrate and validate the models with the observed values. At many places the match between observed and modeled values was as close as ±10 percent."

Notable in RMSI's list of assets is the value of its data library and local knowledge, mirroring Quinn's experience when modeling Berkeley's earthquake exposure. For instance, RMSI acknowledges that the study regions exhibit a "lack of data availability, accessibility, and reliability, and [contain] limited domestic research." It was able to satisfy The World Bank's needs in a timely fashion thanks in part to "in-house data generated from past studies and projects." This only makes sense; as data become increasingly fine-grained, they will also become more plentiful, giving those who have taken the time to sort it out a market edge over those trying to find, validate, and organize it for the first time. RMSI seems well on the way to compiling such an in-house library, not only in its native India, but in the United States, Japan, and the United Kingdom, among others.

Structure by Structure. Another consulting firm, Partner Re (www.partnerre.com), shows similar attention to detail in a study of International Standards Organization (ISO) building-class performance (ISO1, ISO2, and ISO3) against wind storms, cross-referenced to three standard U.S. homeowner's insurance policies. Its study confirmed the obvious — that better quality homes covered by more expensive policies performed better than standard homes under cheaper policies. But it also revealed the unexpected — that the contents of a home, which can be insured separately from the home itself, have lower vulnerability than the home itself at lower wind speeds, followed by a sudden jump in exposure (and claims filed) at a higher speed. The explanation is simple — low winds damage minor extensions of the home, such as roof tiles or satellite dishes, but leave the contents untouched; higher winds can break windows, and then rain comes into the house, ruining its contents, the rugs, furniture, and belongings. Knowing which regions are subject to winds above that breaking point guides insurance underwriters in their pricing efforts region by region. What Partner Re doesn't reveal is the degree of effort required to put together their data about structures — the cleaning, digitization, geocoding, and cross-referencing with insurance policies, and then, of course, the modeling effort. Partner Re had to build a private library as well.

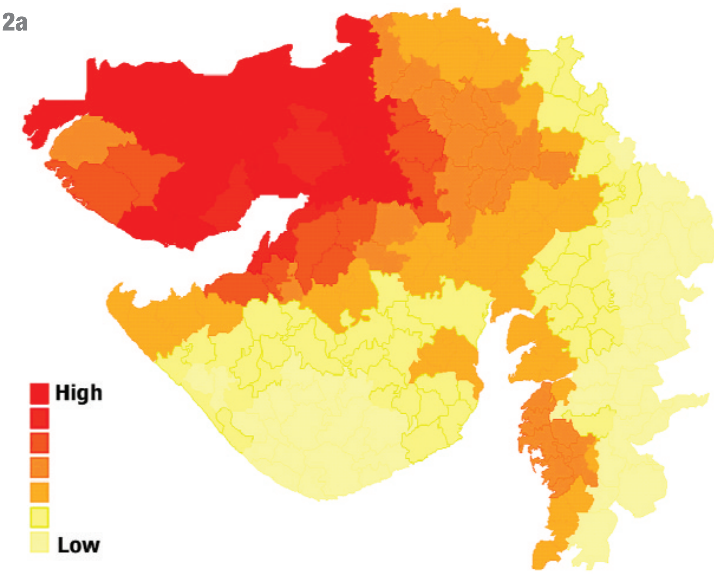
While You Were Sleeping

What do insurance companies want from geographic technology that they don't already have? When asked about his perfect technical world, Felchner referred to a service offered by Explore Information Services (www.exploredata.com) that Acuity already uses. In a completely automated process, Acuity's database sends Explore Information Services' database a list of insured drivers and receives (again, automatically) a list of any who have recently received tickets. This service, says Felchner, is exactly what Acuity hopes for in a geographic context. Explore Information Services' recent offering of property distances from fire stations may meet this kind of fully automated specification. For any address, the response is a rating, higher for homes more likely to get quick firefighter attention during a blaze.

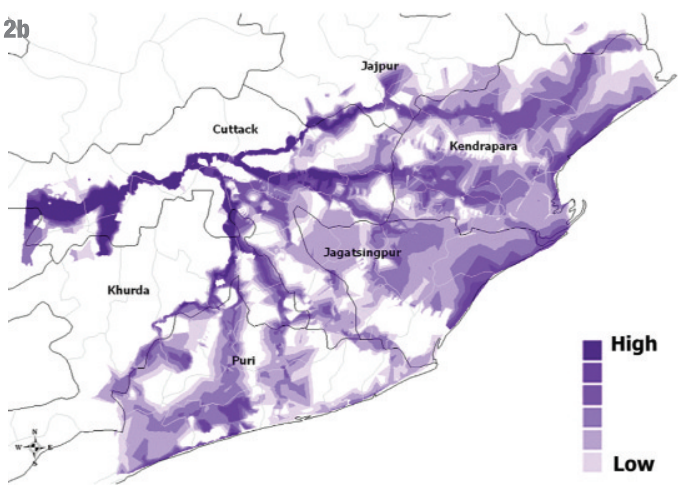
On the other hand, when Acuity researched the wider GIS market for a batch address scrubbing, standardization, and geocoding solution, they discovered that prices were too high and full batch automation options were missing. For more advanced spatial analysis support for underwriting, Felchner looks forward to the advent of an automated service similar to what he already enjoys with Explore Information Services for Acuity's auto policies.

Neighborhood-level modeling is in its infancy compared with today's options for, say, Web-services geocoding, which still apparently does not meet everyone's needs. However, in small pockets and the capable hands of local experts, increasingly fine-grained models are emerging to cross-reference human habitation, movement, and investment against multiple natural hazards. Insurance companies taking advantage of these tools today at the state or large regional scale will have increasing detail on which to base their policies. How will this invisible layer of insurers' willingness to make a financial investment influence our future lifestyles, or the way we develop our cities? Would you still buy your dream house if it cost twice as much to insure as a less attractive option down the block? Whatever your answer, you've got to admit — this geospatial profession of ours continues to provide a very interesting vantage point. ⊕

2a



2b



2c

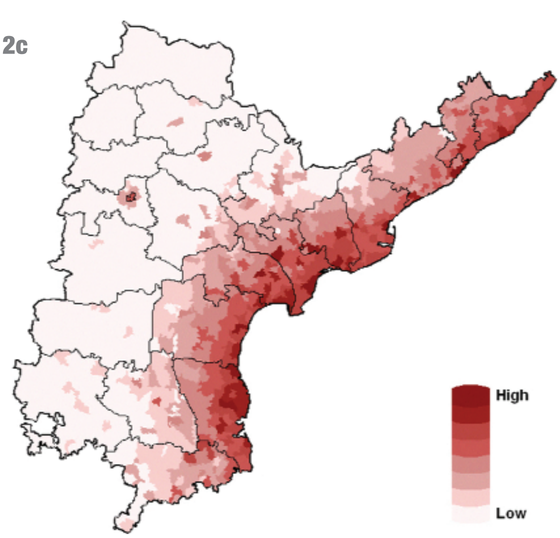


FIGURE 2 RMSI's map of a 200-year earthquake hazard in Gujarat, India (2a); 100-year Mahanadi flood hazard in Orissa, India (2b); and average annual loss to housing due to cyclones in Andhra Pradesh, India (2c).