Forecasting and Nowcasting Major Earthquakes

An Automated Cloud-Based Approach

John Rundle

Distinguished Professor, University of California

Chairman, Open Hazards Group

Topics:

Science

Applications

Tohoku, Japan

Earthquake and Tsunami
March 11, 2011

How do we estimate risk from these events?

What does this mean for the insurance industry?

Pricing Earthquake Risk: Current Practice

Science	Engineering	Economics	Products
Earthquake forecast model	Ground shaking model	Economic loss model	Pricing of insurance & financial securities

Science → Earthquake forecast model

Poisson
Log Normal
BPT
Fault models
Pattern Analysis
AMR
ETAS
NTW
Nowcast
Etc.

Engineering → Ground shaking model

Attenuation
PGA/PGV
Lquifaction
Surface geology
Basin structure
Etc.

Economics → Economic loss model

EP curves
Building damage
Socioeconomic data
Supply chain disruption
Lost income
Lifelines
Etc.

Products → Pricing of insurance & financial securities

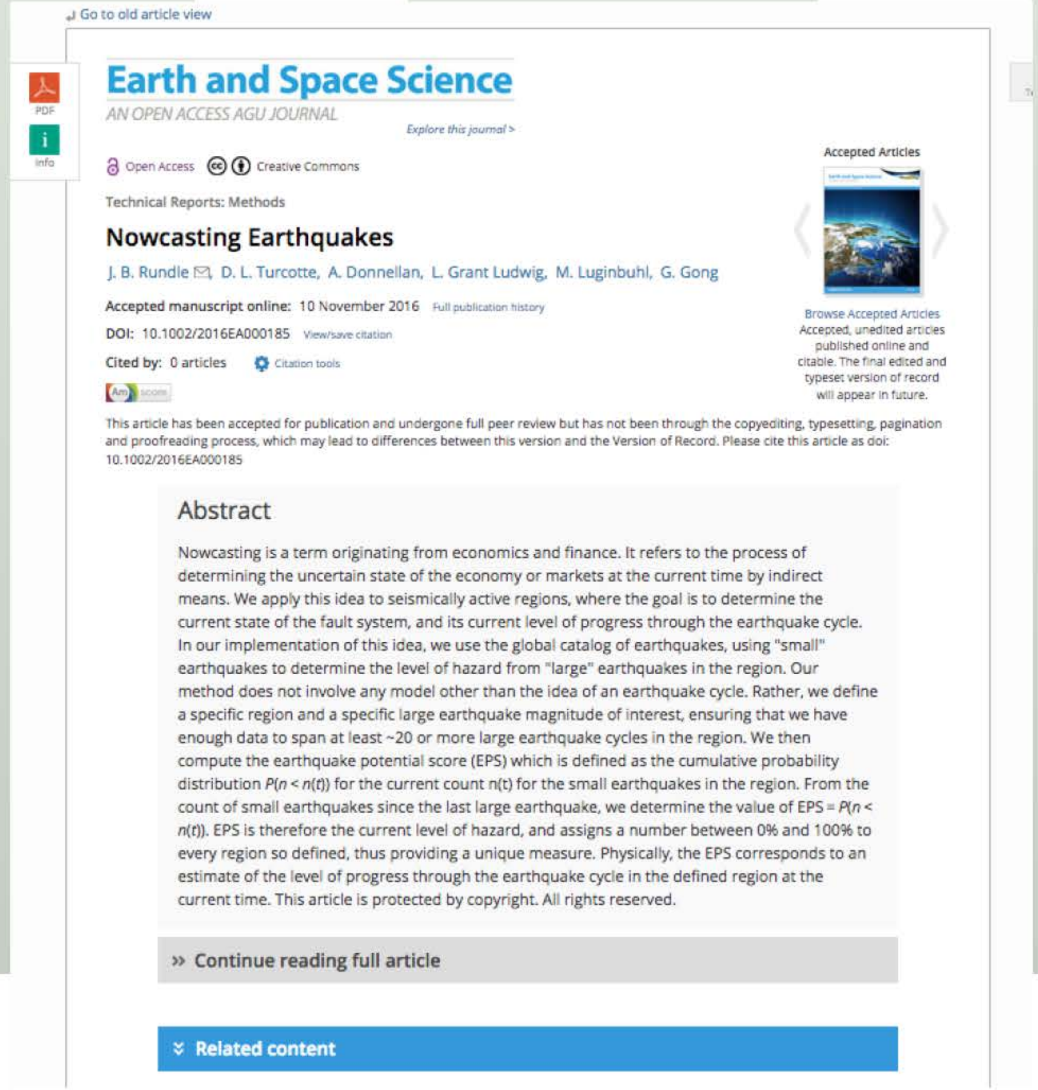
CAT Bonds
SPVs
Warrants
Traders
Hedge Funds
Options
Muni Bonds
Equities
Etc.

The Science

Nowcasting and Forecasting

Nowcasting Earthquakes

JBR et al. (2016)



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Nowcasting Earthquakes

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Abstract

Nowcasting is a term originating from economics and finance. It refers to the process of determining the uncertain state of the economy or markets at the current time by indirect means. We apply this idea to seismically active regions, where the goal is to determine the current state of the fault system, and its current level of progress through the earthquake cycle. In our implementation of this idea, we use the global catalog of earthquakes, using "small" earthquakes to determine the level of hazard from "large" earthquakes in the region. Our method does not involve any model other than the idea of an earthquake cycle. Rather, we define a specific region and a specific large earthquake magnitude of interest, ensuring that we have enough data to span at least ~20 or more large earthquake cycles in the region. We then compute the earthquake potential score (EPS) which is defined as the cumulative probability distribution $P(n < n(t))$ for the current count n(t) for the small earthquakes in the region. From the count of small earthquakes since the last large earthquake, we determine the value of EPS = $P(n < n(t))$. EPS is therefore the current level of hazard, and assigns a number between 0% and 100% to every region so defined, thus providing a unique measure. Physically, the EPS corresponds to an estimate of the level of progress through the earthquake cycle in the defined region at the current time.

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Related content

Nowcasting

Forecasting is a probability of future activity in the hazard (earthquake) cycle

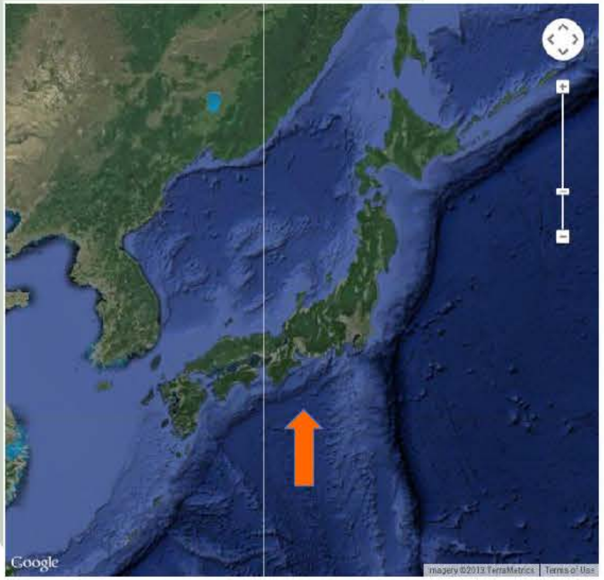
Nowcasting describes the current state of the hazard cycle

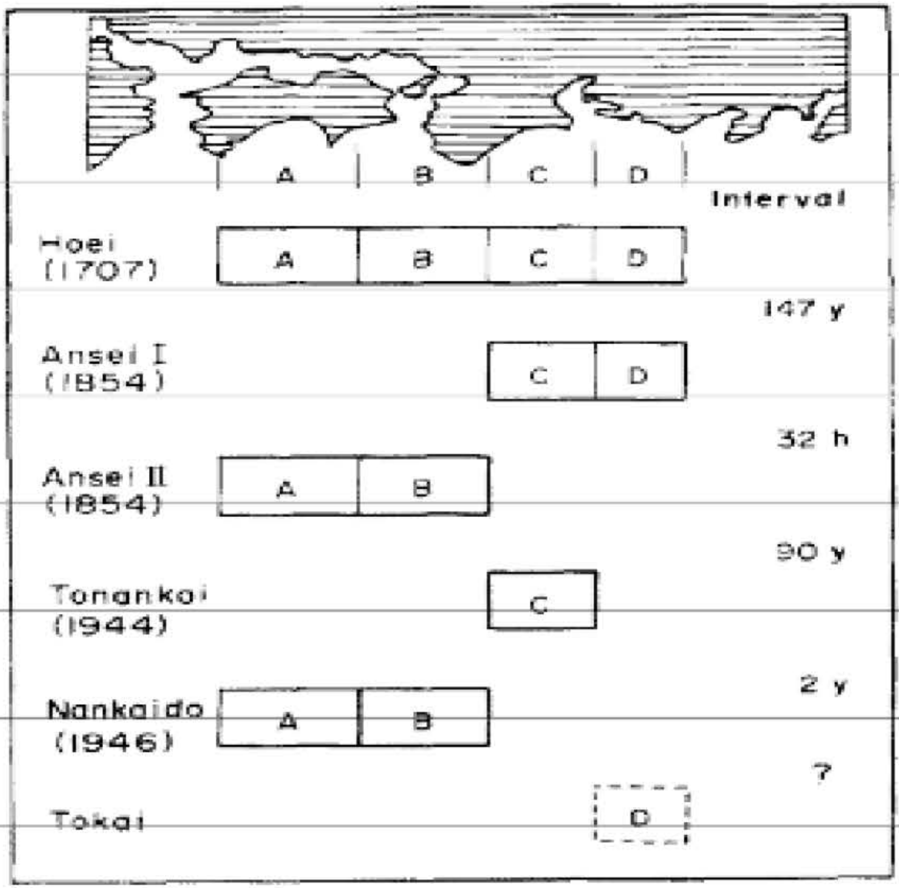
The term "Nowcasting" was first used to describe the current state of the economic/business cycle

Earthquake Cycle Example: Nankai Trench, Japan

M Ando, Tectonophysics, v27, p112 (1975)

- Data from historic writings in Japan
- The basic idea of the earthquake "cycle" started in Japan using historical data

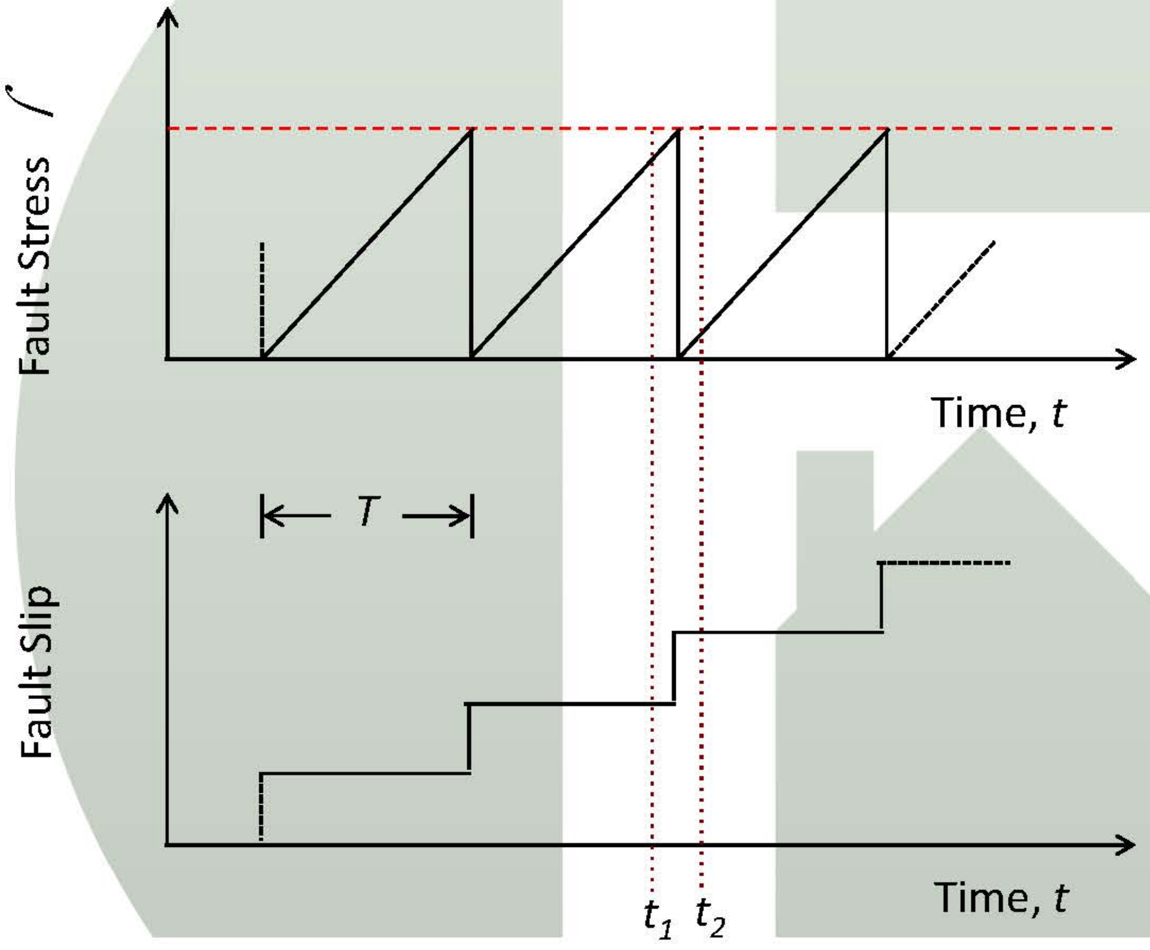




Elastic Rebound on a Fault

Report of the 1906 San Francisco Earthquake Investigation (1910)

Cycle of earthquakes was related to the cycle of stress release and recovery



Harry Fielding Reid (1859-1944)

Problem: How do we measure the state of stress in time??

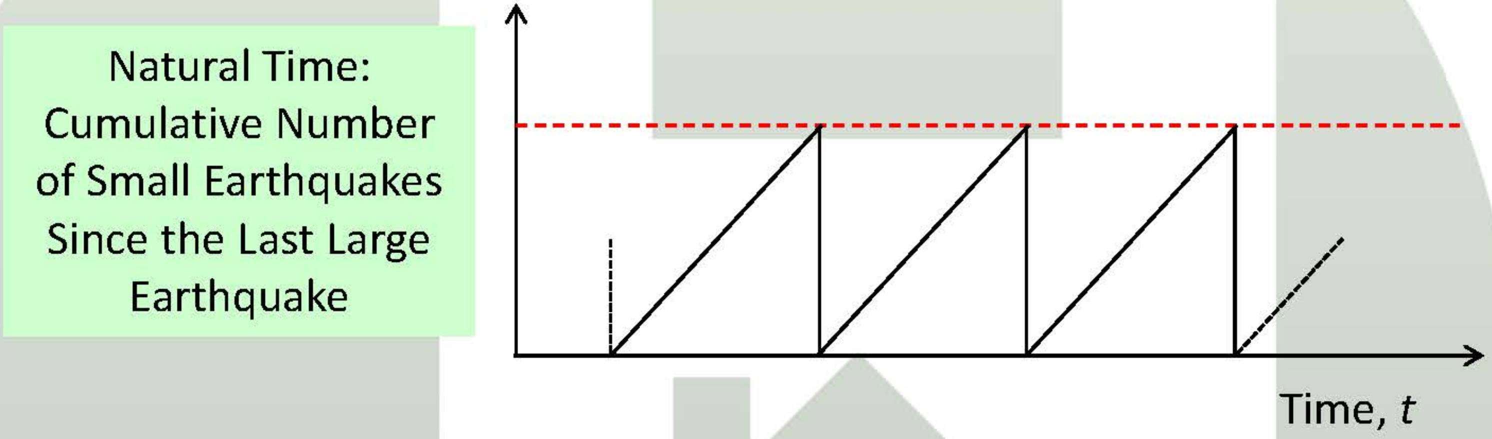
Elastic Rebound using Proxy Data

Accumulation of Small Earthquakes Between Large Earthquakes

Example:

"Large" EQ: $M_{Large} > 6$

"Small" EQ: $6 > M_{Small} > 3$

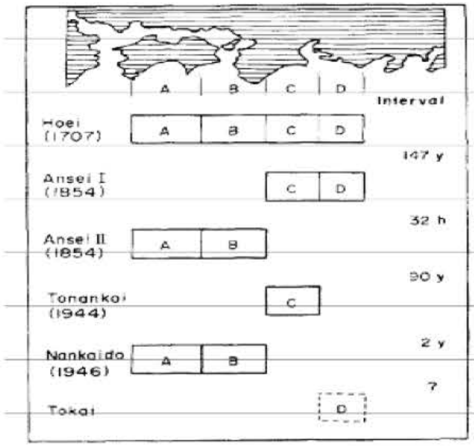


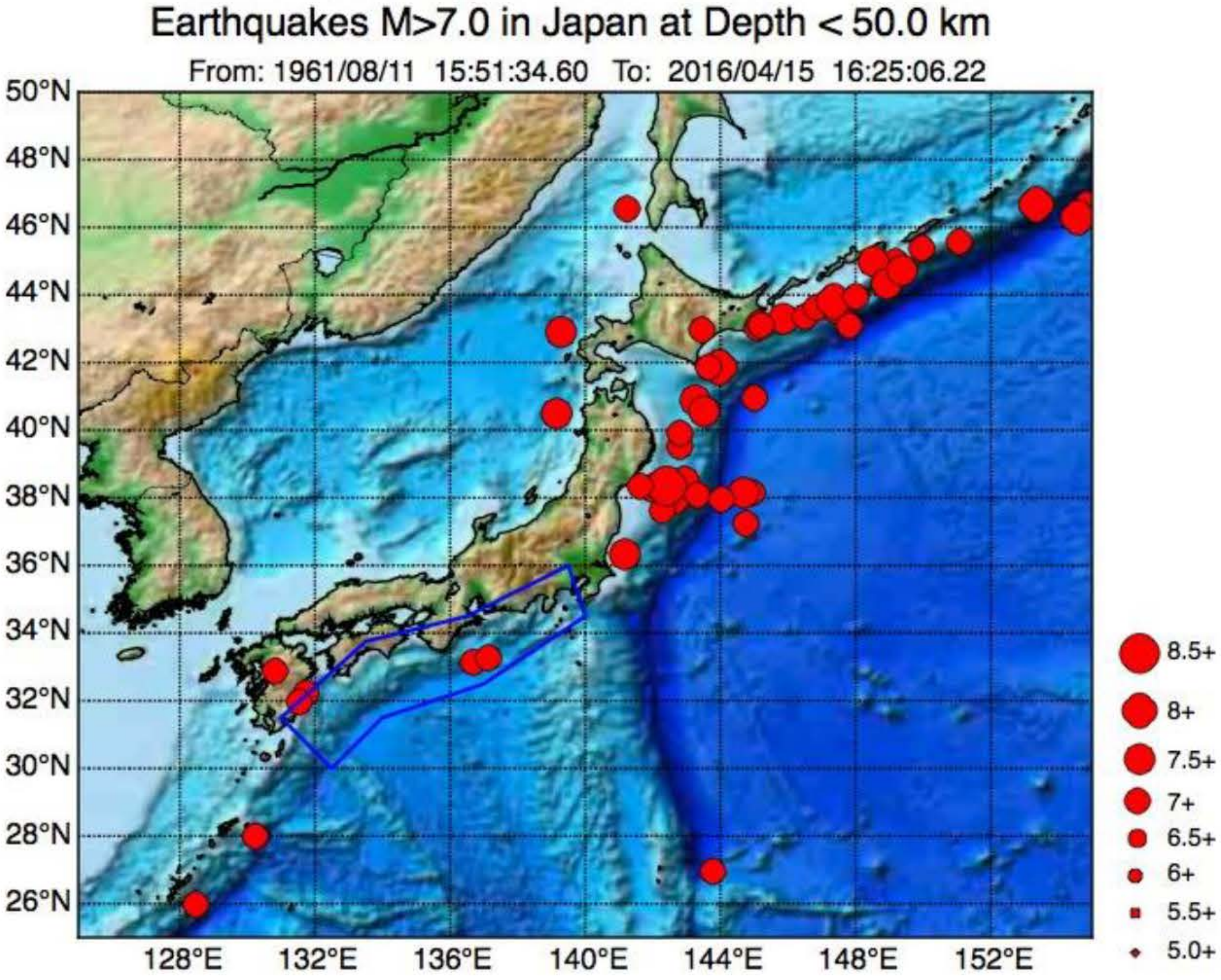
Accumulating small earthquakes are readily observable data unlike stress

The number of small earthquakes between large earthquakes has a stable average ratio (Gutenberg-RichterRelation)

The count of small earthquakes since the last large earthquake can be viewed as a marker for the hazard level

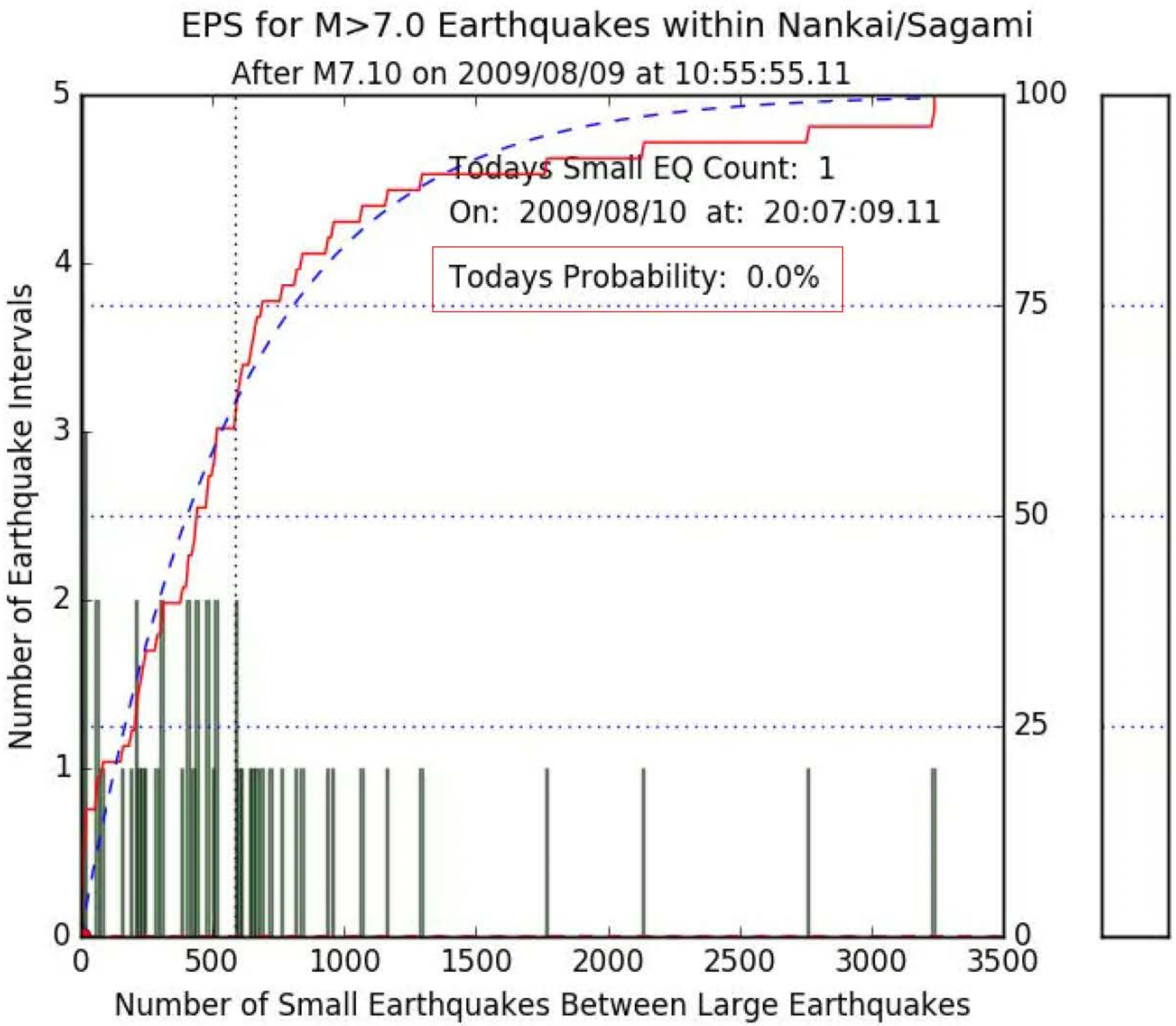
Example: Nowcasting the Nankai Trench



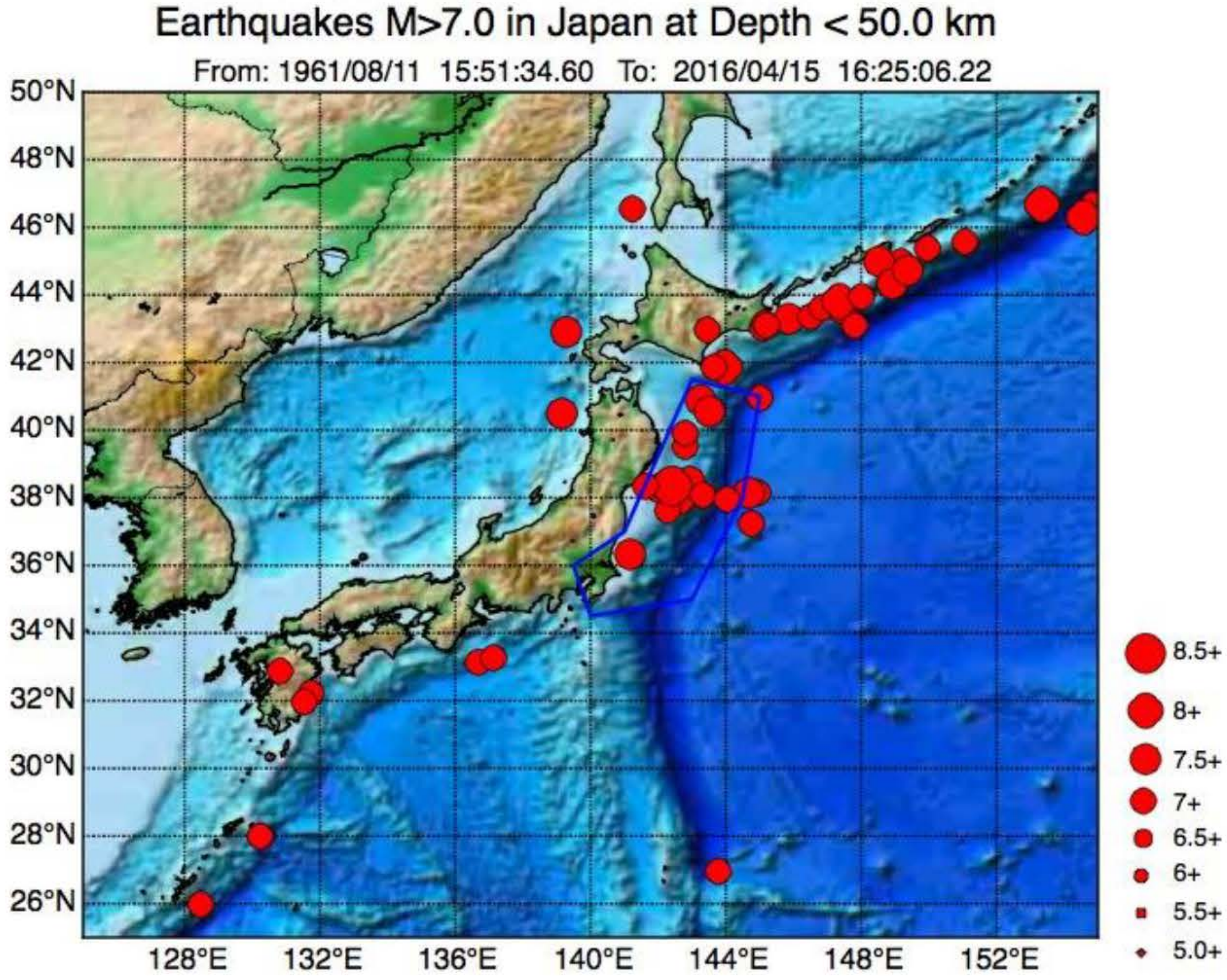


Earthquake Potential Score, Nankai Trench

Computed 3/31/2017. Depths < 50 km

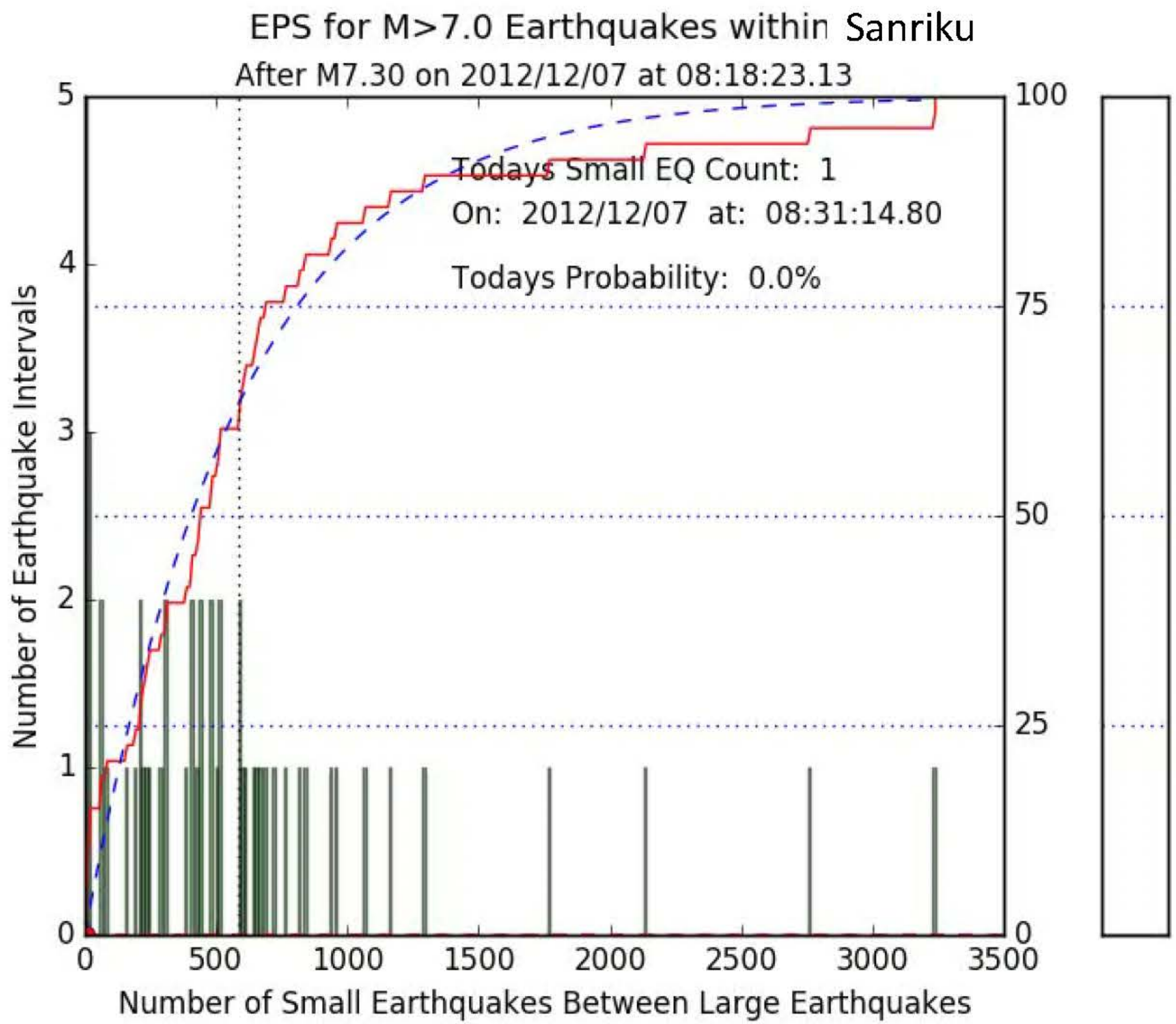


Example: Nowcasting the Sanriku Trench



Earthquake Potential Score, Sanriku Trench

Computed 3/31/2017. Depths < 50 km



Nowcasting Web App for Global Megacities (Under Development)

HTML-Javascript-CSS-Python

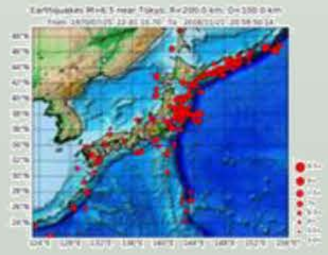
Nowcasting the Seismic Risk (EPS Score) for Global Megacities

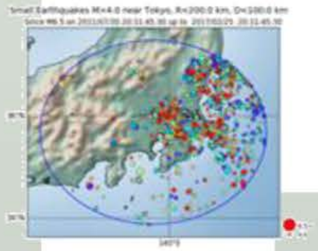
And Selected Other Large Cities (>1 million population)

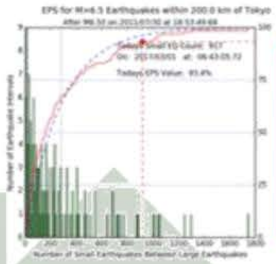
Thu Apr 27 2017 11:13:50 GMT-0600 (MDT)

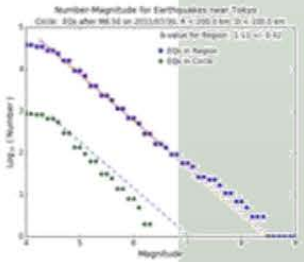
Click on Location Name in Table for Corresponding Map and Statistical Data

Click on Thumbnails for Full Size Images. Details at the Bottom of the Page.









Earthquake Potential Score (EPS) is the percentage of progress through the earthquake cycle. It is possible to get a score over 100% , which would mean the earthquake is overdue, based on historic statistics. The city location is at the center of the 200.0 km radius area.

Location (Center of Circle)	EPS(%) Score on 2017/04/26 at 14:06:10 PT	Date Last EQ	Mag Last EQ	Natural Time Count on 2017/04/26 at 14:06:10 PT	Mean Count	Std Dev	Number Large EQs in Region
Tokyo	93.4	2011/07/30	6.50	917	279	322	136
Santiago	77.8	2012/04/17	6.70	393	225	229	63
Sacramento	54.1	1989/10/18	6.90	214	200	196	37
Los Angeles	50.0	1999/10/16	7.10	180	210	191	32
Sendai	45.3	2016/11/21	6.90	127	268	323	139
San Diego	41.9	2010/04/04	7.20	171	223	183	31
Kathmandu	34.1	2015/05/12	7.30	158	288	246	41
Sapporo	23.5	2016/01/14	6.70	56	242	276	136

Earthquake Forecasting

Current Practice

- Expert elicitation is frequently used in forecasting, meaning that backtesting is not possible
- Most/many current forecasts use time-independent Poisson statistics in forecasting
- Poisson forecasts have the property that they have no memory of past events
- An example is the current UCERF3 forecast for California, which has not been backtested

From Nowcasts to Forecasts

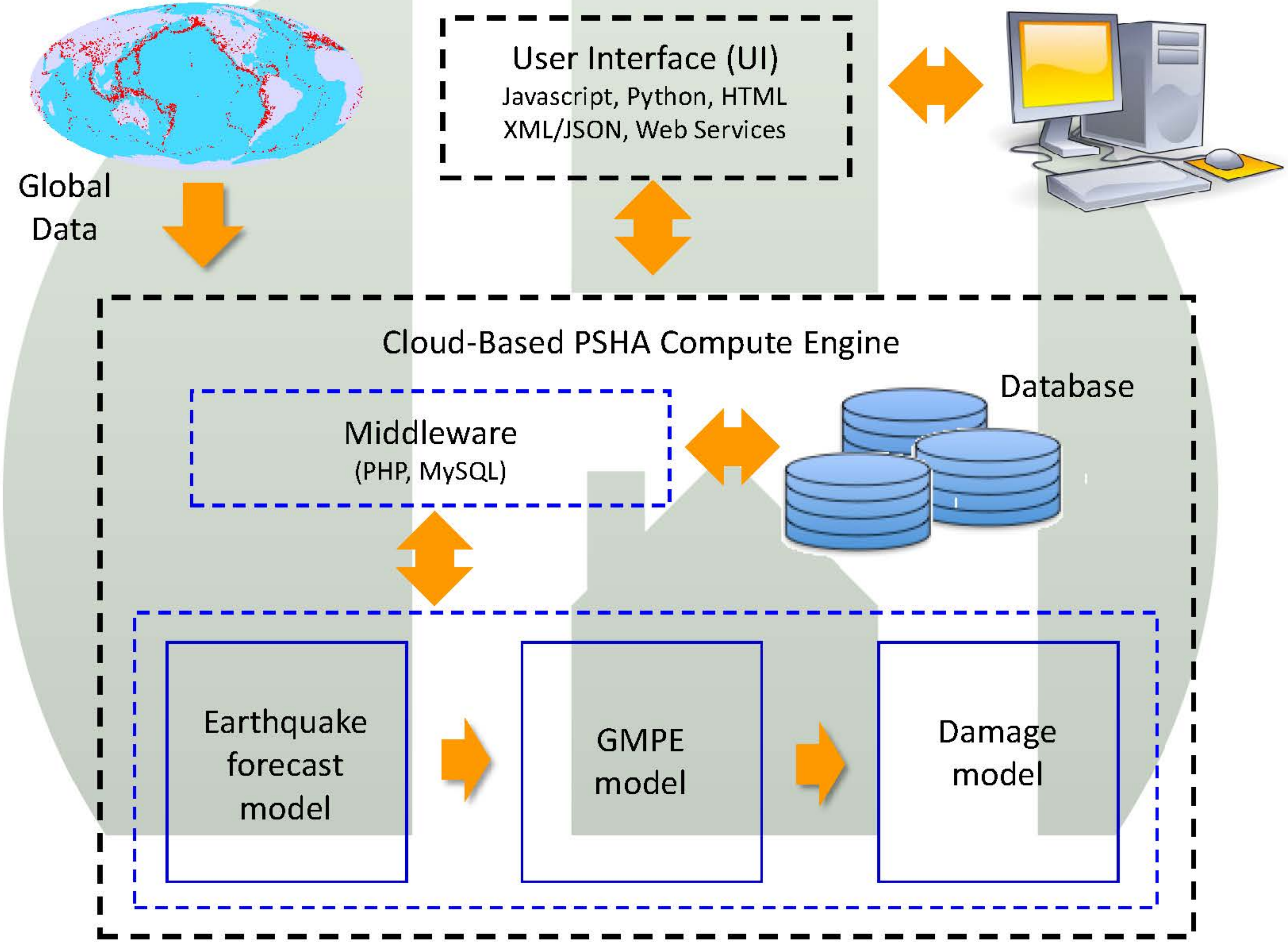
Forecasting with the Natural Time Weibull Method

JR Holliday et al. (2014)

- We begin by counting small earthquakes since the last large earthquake (Nowcasting)
- We build on the Nowcast by projecting the count forward in time using the current rate of small earthquake activity
- We combine these ideas with Weibull (1952) statistics, which are commonly used for engineering failure analysis
- The result is a fully automated computation of probability of future large earthquake occurrence
- Automation allows backtesting and optimization
- We have built this technology into a series of automated cloud-based web sites:

www.openhazards.com

Open Hazards PSHA Cloud Computational Framework



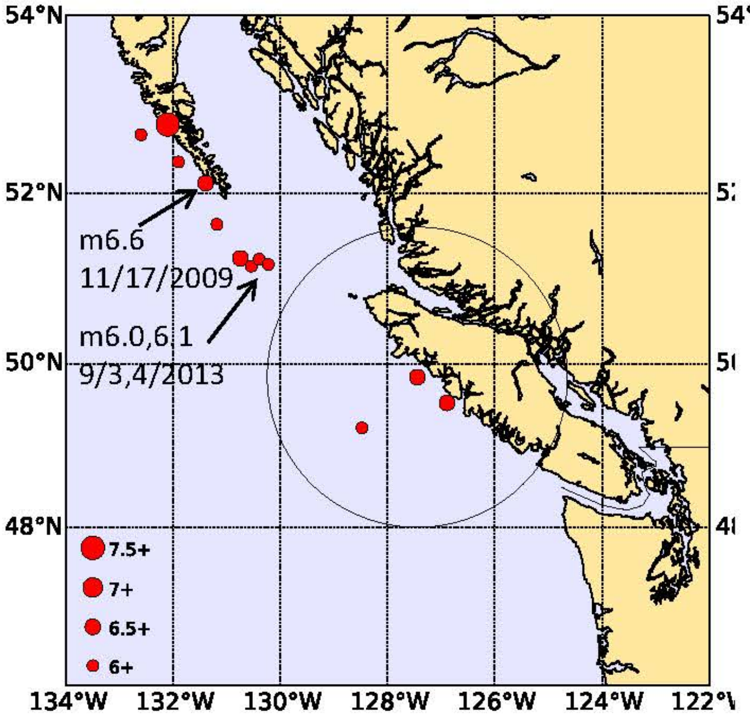
Automated forecasting and risk analysis allows rigorous backtesting.

Expert elicitation generally does not allow rigorous backtesting

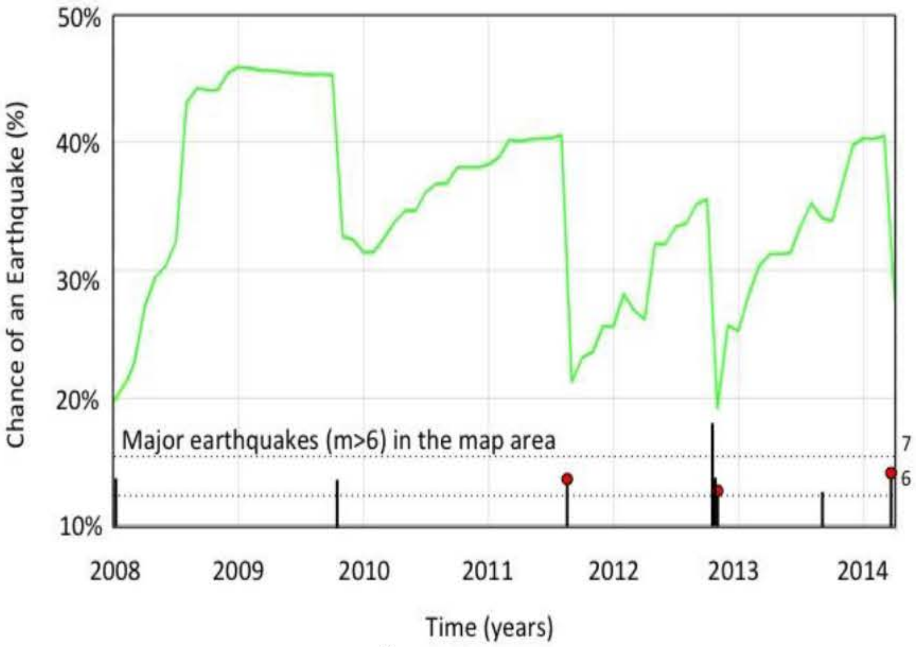
Example: Vancouver Island Earthquakes, NTW Forecast

Latest Significant Event was M6.6 on 4/24 /2014

JR Holliday et al. (2014)

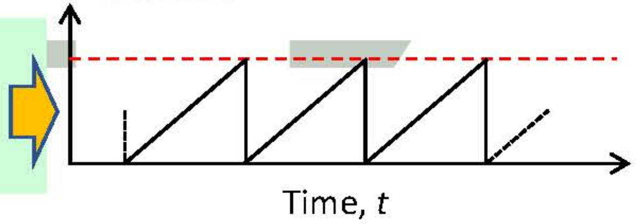


Chance of M>6 earthquake in circular region of radius 200 km for next 1 year.
Data accessed 4/26/2014



Observed Behavior

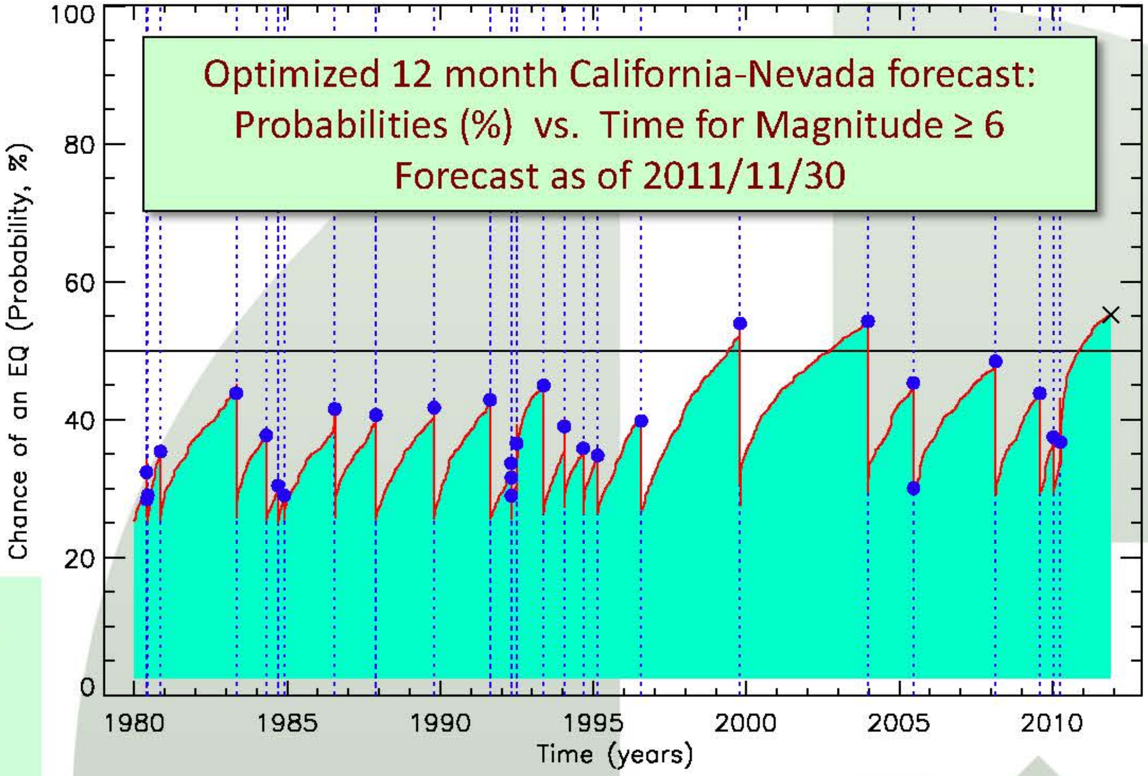
Idealized Expected Behavior

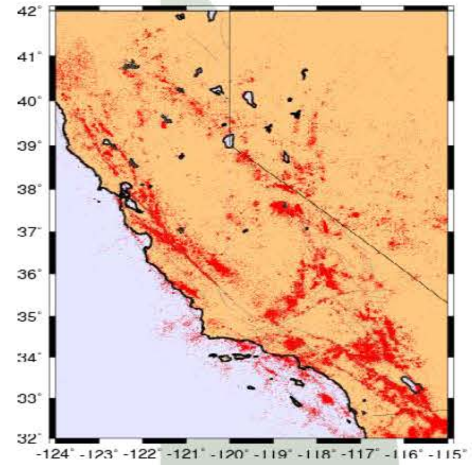


Optimal California-NV Forecast

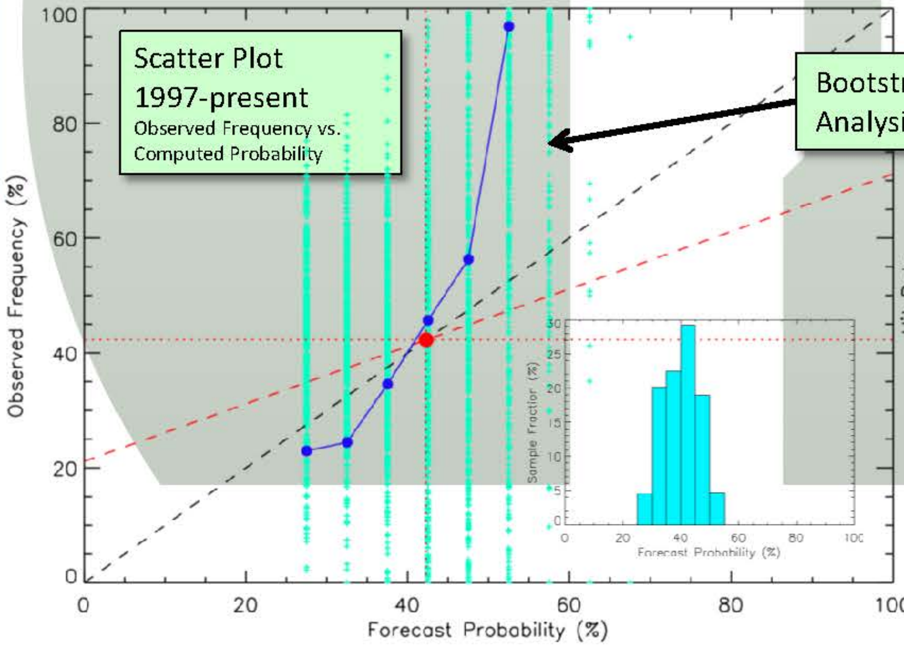
Optimal forecasts via backtesting, using common validation and verification testing procedures.

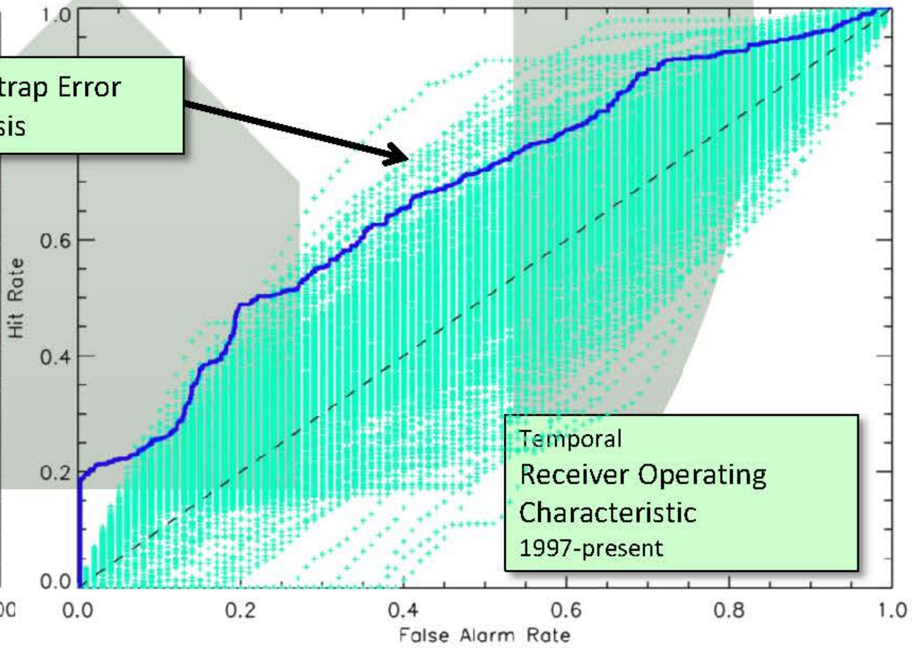
Automating Forecasts Allows Backtesting and Optimizing!





Bootstrap Error Analysis





Applications/Products

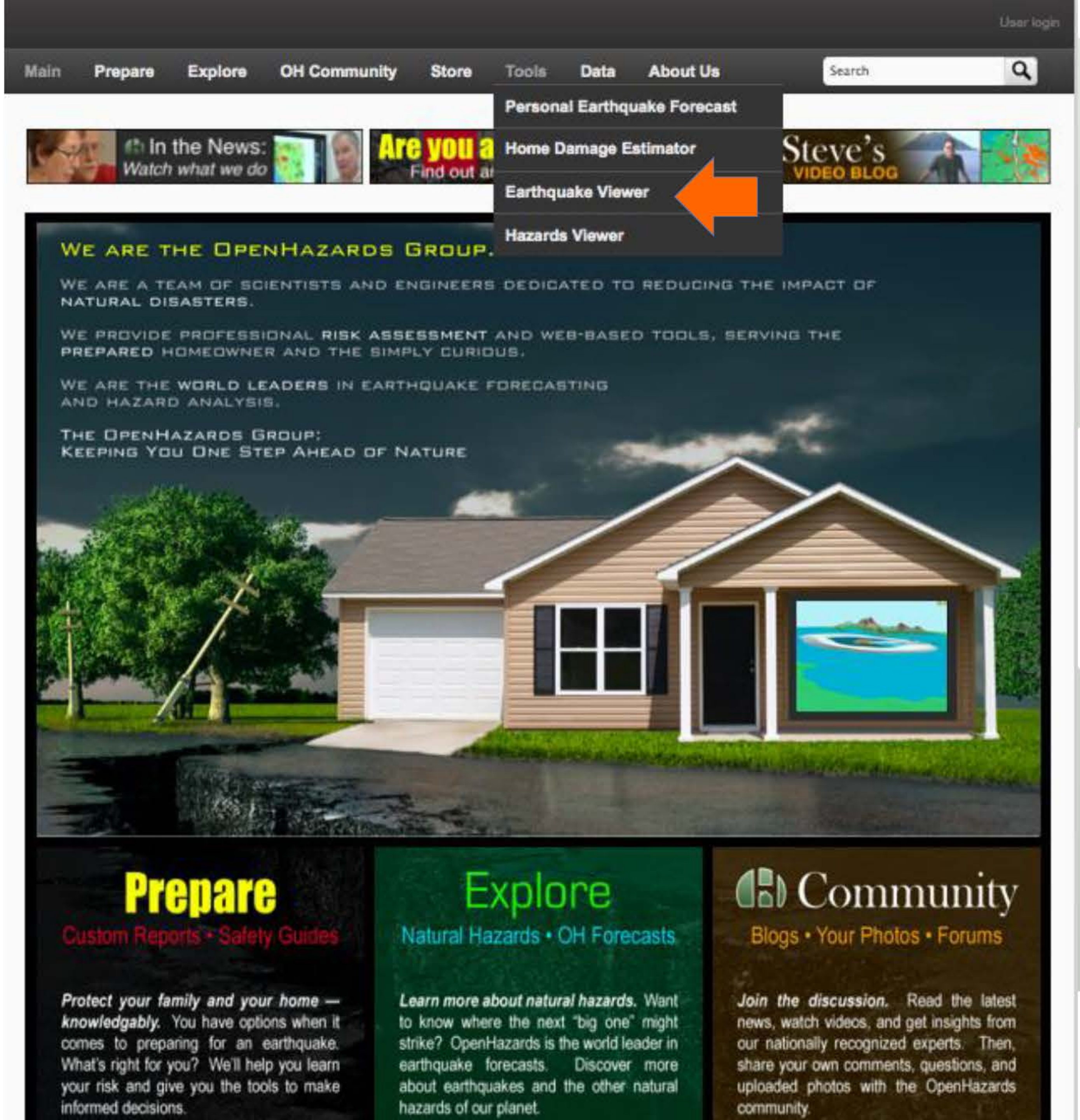
The Open Hazards Group

Risk Analysis and Management Reimagined

Risk: Applications and Products

The Open Hazards Group

- Public web site
  - NTW forecasts web app
  - Ground shaking web app
  - Structural damage factor web app
- Residential seismic safety reports
- Commercial seismic safety reports
- Cat bond analysis
- Natural hazard disclosures (required in California for transfer of property)
- Financial trading models for hedge funds



Automated Forecasting in the Cloud

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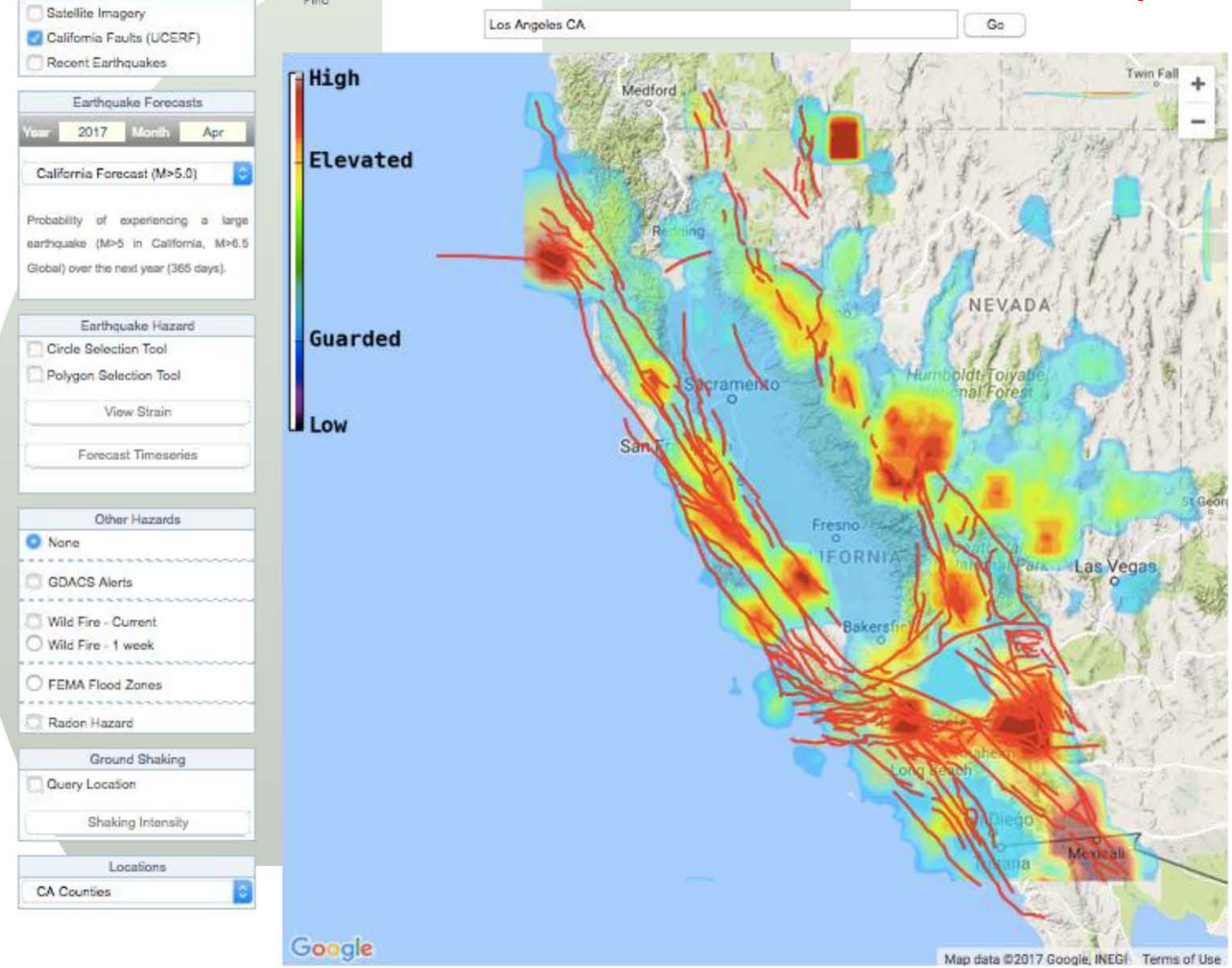
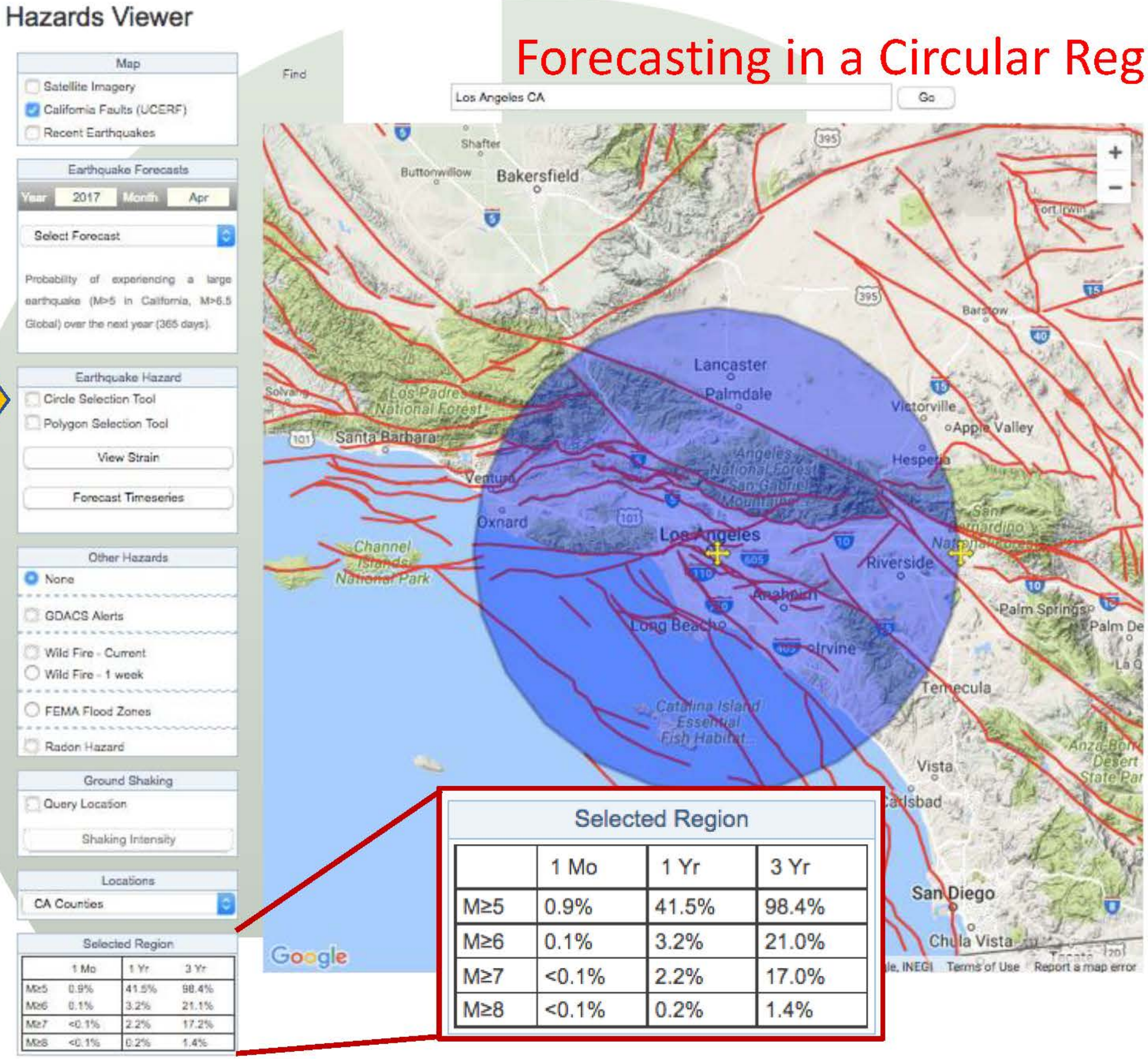
Automated California Forecast – Updated Nightly



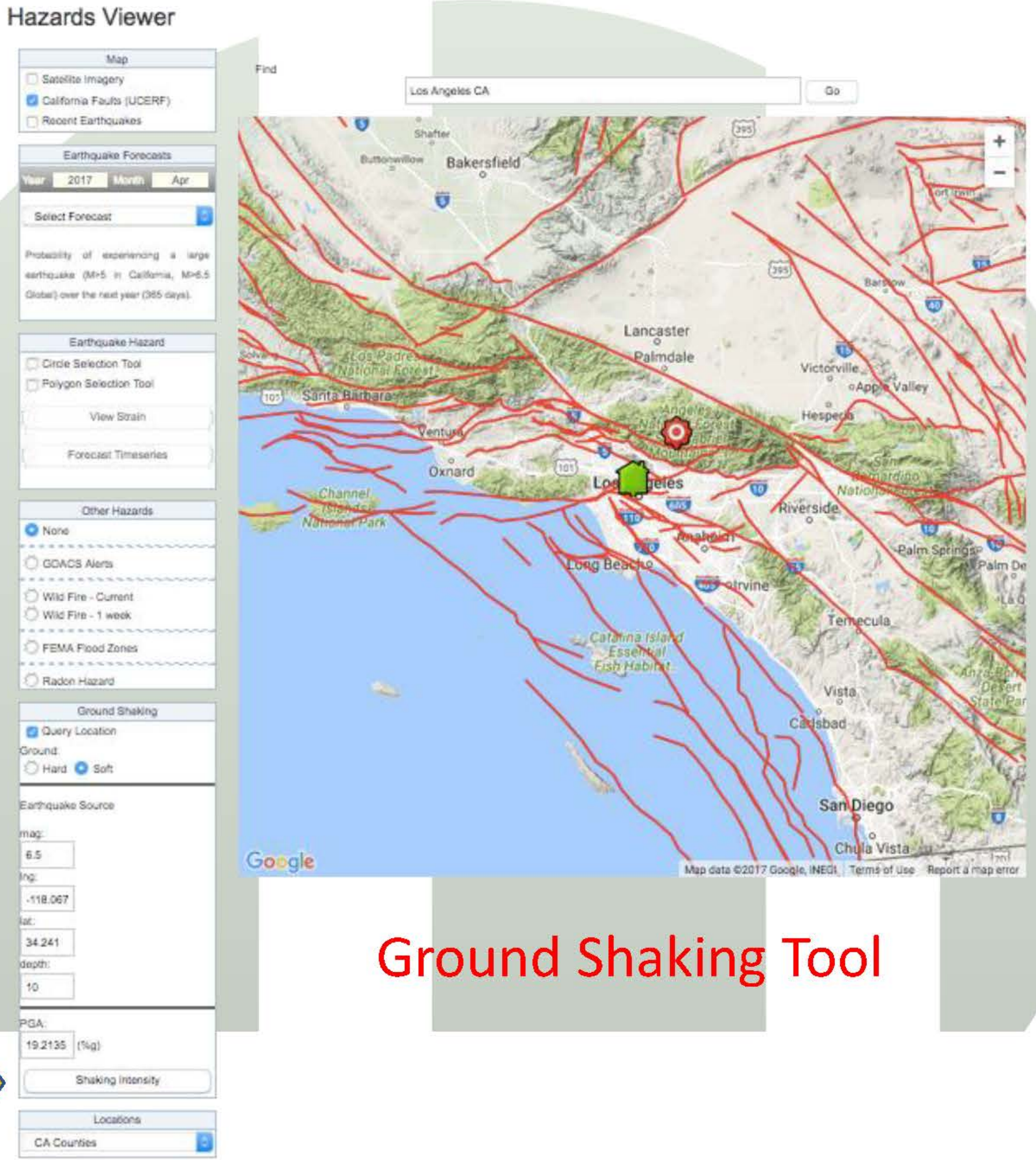
Forecasting in a Circular Region

Region Selection Tool



	1 Mo	1 Yr	3 Yr
M≥5	0.9%	41.5%	98.4%
M≥6	0.1%	3.2%	21.0%
M≥7	<0.1%	2.2%	17.0%
M≥8	<0.1%	0.2%	1.4%

Ground Shaking Tool



Shaking Intensity Tool

Risk Assessment For Likely Ground Shaking

Report Generated: Tue, 25 Apr 2017
Location: (34.052115021165484, -118.27862620353699)
Source: (34.24070193917228, -118.06713938713074)
PGA: 19.2135 (%g)
MMI: VII

Difficult to stand. Noticed by drivers of motor cars. Hanging objects quiver. Furniture broken. Damage to masonry D, including cracks. Weak chimneys broken at roof line. Fall of plaster, loose bricks, stones, tiles, cornices (also unbraced parapets and architectural ornaments). Some cracks in masonry C. Waves on ponds; water turbid with mud. Small slides and caving in along sand or gravel banks. Large bells ring. Concrete irrigation ditches damaged.

A descriptive table of Modified Mercalli Intensity is available from ABAG (Association of Bay Area Governments). A table of intensity descriptions with the corresponding peak ground acceleration (PGA) and peak ground velocity (PGV) used by the USGS is given below.

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

OpenHazards.com
Earthquake Forecasting and Hazard Analysis

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Residential Seismic Safety Report

For homeowners, property owners and renters

You need reliable information and advice. How safe are your loved ones, home, and belongings from earthquakes? What options do you have to reduce your risk?

For conscientious homeowners, property owners, and renters, OpenHazards provides a detailed earthquake forecast and home safety assessment. Decide on the most dependable and cost-effective steps to mitigate your risk. With an OpenHazards Seismic Safety Report, the information you need is at your fingertips.

Personalized safety score: Based on your location's earthquake risk and details you provide about your home — because you know your home best.

Earthquake forecasts: Based on the world's leading scientific methodology. Find out the chance a major earthquake will affect your home within 1, 5, 10 and 30 years.

Insurance facts: In plain English. Understand what earthquake insurance covers and the probability your damage will exceed a typical deductible. We provide you with the numbers to decide if investing in insurance makes sense for you.

Risks explained: Easy-to-understand explanations of earthquake hazards and tips for improving safety. We will point you to the most reliable sources of information on how to reduce your risk.

Dynamic updates: Based on current earthquake activity, your forecast may change. We will provide quarterly reports for one year to alert you to your newly increased or reduced risk.

And more — just view a sample report and see. [PDF] SAMPLE REPORT.PDF

Your home may be worth hundreds of thousands of dollars. Earthquake insurance could cost $1,500 a year. Peace of mind for your family is priceless. Make informed decisions about your risk with an OpenHazards Seismic Safety Report.

We are currently experiencing technical difficulties with our ordering system. If you'd like to order a report, please use the Contact Us page.

Residential Seismic Safety Report

1 Introduction

Whether you own, plan to buy, or rent property, you need the best advice possible about the financial and personal risks you might face. OpenHazards offers the only openly accessible tool to help you answer questions you may have about earthquake hazards in your area.

Welcome to the world of seismic safety.

What are the chances your home, condominium or apartment building could be badly damaged during or after an earthquake? After the first shaking stops, how vulnerable are you to associated hazards, more shaking (aftershocks), ground rupture (displacement), landslides, fires, soil liquefaction, tsunamis, or floods? How would the value of your property be affected? What can you do to protect your investment? Or if you haven't yet invested, what do you need to know to make a good decision?

Both owners and renters can benefit from an OpenHazards Seismic Report

OpenHazards seismic forecasting is a new concept in seismic safety. Both the OpenHazards website and personalized reports are designed to help you make critical decisions that affect your life and property.

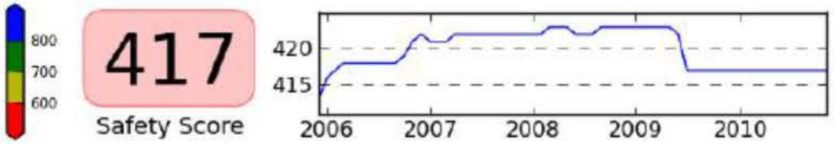
OpenHazards reports are particularly useful to prospective home-buyers. The reports can help you and your realtor accurately compare seismic risks for several properties. This allows you to choose the safest home possible.

We calculate two figures of merit for this purpose: the *Safety Score* (OHSS), and the *Hazard Discounted Value* (HDV). The Safety Score is an index reflecting a likelihood of damage to personal property or to your structure. The Hazard Discounted Value calculates the home value discounted by the effects of structural damage to the home in an average likely earthquake. By comparing the reports for two homes, you can assess the risk of loss quantitatively. The safety score may also be used to loosely compare risk of injury.

Property Synopsis

Property Address: 126 Huerta Place, Davis, CA 95616, USA
Declared Value: $1,500,000
Hazard Discounted Value: $1,305,983

Residence: Single Family
Year Built: 1967
 # Stories: 2
House Size: 2500 sq. ft.
Construction: Wood Frame
Soil Type: Hard Rock



This property has a Safety Score of 417 indicating it is at high risk of structural damage over the coming years. Earthquake insurance might be appropriate. Note that this calculation is based on home descriptions you supplied. OpenHazards does not verify the accuracy of the home details.

	Within 1 Year	Within 5 Years	Within 10 Years	Within 30 Years
At Least $9,000 Loss (1% Damage)	0.06% Chance	0.28% Chance	0.56% Chance	1.68% Chance
At Least $45,000 Loss (5% Damage)	0.02% Chance	0.09% Chance	0.18% Chance	0.53% Chance
At Least $90,000 Loss (10% Damage)	<0.01% Chance	0.03% Chance	0.05% Chance	0.15% Chance
At Least $135,000 Loss (15% Damage)	<0.01% Chance	<0.01% Chance	0.02% Chance	0.05% Chance
At Least $180,000 Loss (20% Damage)	<0.01% Chance	<0.01% Chance	<0.01% Chance	0.02% Chance

This table indicates the likelihood of damage and financial loss within a future time interval. The vertical columns designate the time interval from today, and the horizontal rows designate the ranges of loss. The *15% Damage* threshold indicates the typical deductible for residential earthquake insurance.

Risk Calculations: EP Curves

Residential Seismic Safety Report

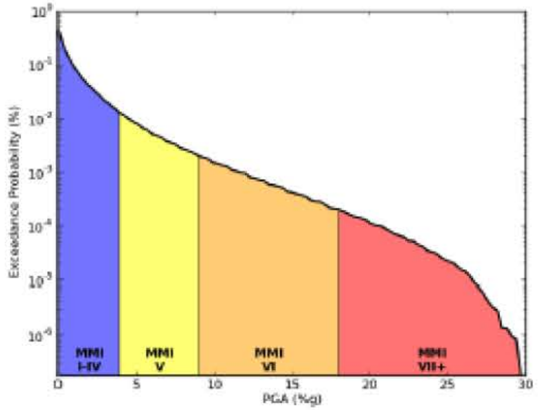


Figure 5: Peak ground acceleration—measured as a percent of gravity (%g)—exceedance probability curve calculated at your home's location. Shaking below MMI V (about 4%g) is generally not felt by individuals.

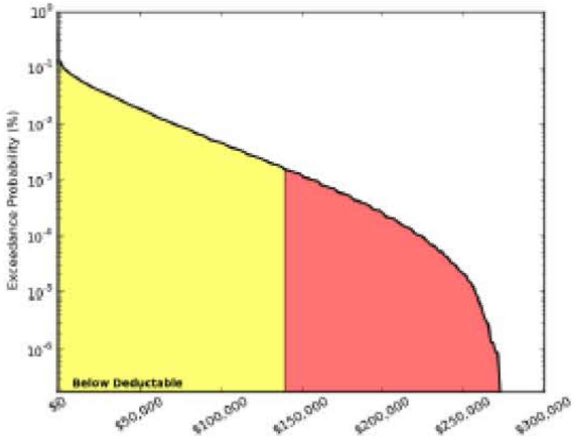
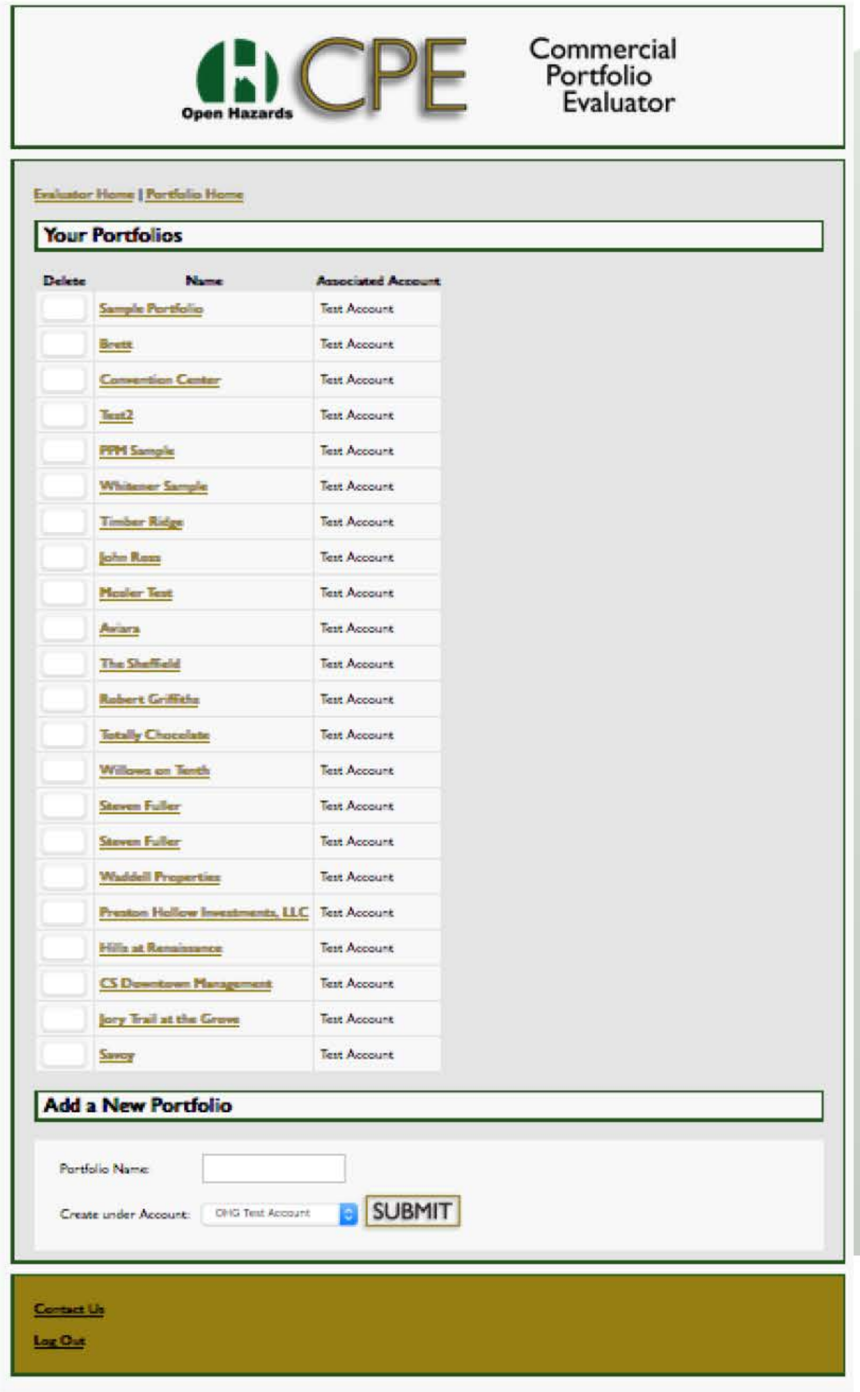


Figure 7: Dollar loss exceedance probability curve for your home. Damage values below the standard deductible (15% of the value of your home) are indicated in yellow. Damage values above the standard deductible are indicated in red.

Automated Commercial Portfolio Evaluator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	Brett	Test Account
	Convention Center	Test Account
	Test2	Test Account
	PPM Sample	Test Account
	Whitener Sample	Test Account
	Timber Ridge	Test Account
	John Ross	Test Account
	Mosler Test	Test Account
	Aviara	Test Account
	The Sheffield	Test Account
	Robert Griffiths	Test Account
	Totally Chocolate	Test Account
	Willows on Tenth	Test Account
	Steven Fuller	Test Account
	Steven Fuller	Test Account
	Waddell Properties	Test Account
	Preston Hollow Investments, LLC	Test Account
	Hills at Renaissance	Test Account
	CS Downtown Management	Test Account
	Jory Trail at the Grove	Test Account
	Savoy	Test Account

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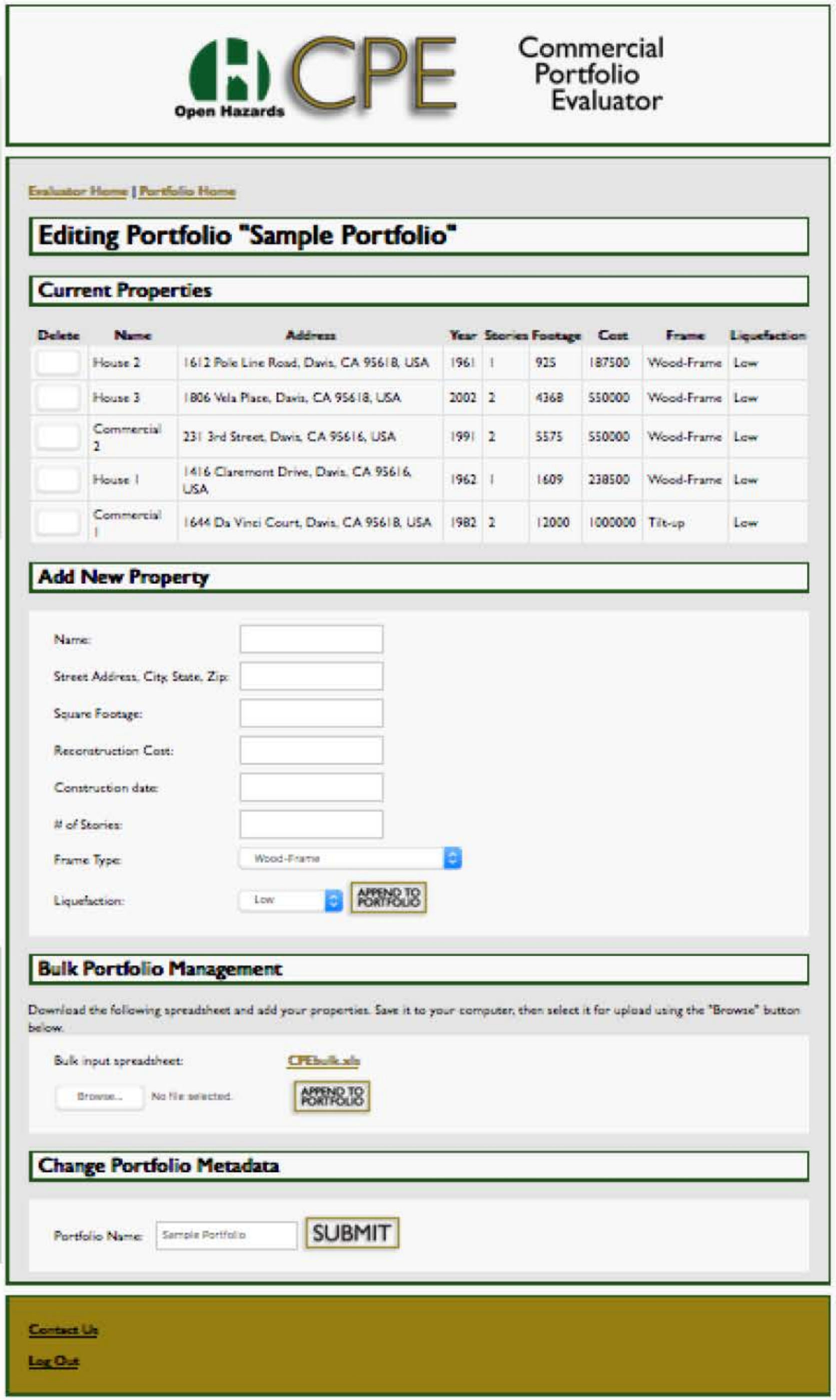
Open Hazards CPE Commercial Portfolio Evaluator

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Editing Portfolio "Sample Portfolio"

Current Properties

Delete	Name	Address	Year	Stories	Footage	Cost	Frame	Liquefaction
	House 2	1612 Pole Line Road, Davis, CA 95618, USA	1961	1	925	187500	Wood-Frame	Low
	House 3	1806 Vela Place, Davis, CA 95618, USA	2002	2	4368	550000	Wood-Frame	Low
	Commercial 2	231 3rd Street, Davis, CA 95616, USA	1991	2	5575	550000	Wood-Frame	Low
	House 1	1416 Claremont Drive, Davis, CA 95616, USA	1962	1	1609	238500	Wood-Frame	Low
	Commercial 1	1644 Da Vinci Court, Davis, CA 95618, USA	1982	2	12000	1000000	Tilt-up	Low

Add New Property

Name:

Street Address, City, State, Zip:

Square Footage:

Reconstruction Cost:

Construction date:

# of Stories:

Frame Type: Wood-Frame

Liquefaction: Low APPEND TO PORTFOLIO

Bulk Portfolio Management

Download the following spreadsheet and add your properties. Save it to your computer, then select it for upload using the "Browse" button below.

Bulk input spreadsheet: CPEbulk.xls

Browse... No file selected. APPEND TO PORTFOLIO

Change Portfolio Metadata

Portfolio Name: Sample Portfolio SUBMIT

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Evaluator Home | Portfolio Home

Editing Portfolio "Sample Portfolio"

Current Properties

Delete	Name	Address	Year	Stories	Footage	Cost	Frame	Liquefaction
	House 2	1612 Pole Line Road, Davis, CA 95618, USA	1961	1	925	187500	Wood-Frame	Low
	House 3	1806 Vela Place, Davis, CA 95618, USA	2002	2	4368	550000	Wood-Frame	Low
	Commercial 2	231 3rd Street, Davis, CA 95616, USA	1991	2	5575	550000	Wood-Frame	Low
	House 1	1416 Claremont Drive, Davis, CA 95616, USA	1962	1	1609	238500	Wood-Frame	Low
	Commercial 1	1644 Da Vinci Court, Davis, CA 95618, USA	1982	2	12000	1000000	Tilt-up	Low

Add New Property

Name:

Street Address, City, State, Zip:

Square Footage:

Reconstruction Cost:

Construction date:

\# of Stories:

Frame Type: Wood-Frame

Liquefaction: Low APPEND TO PORTFOLIO

Open Hazards CPE Commercial Portfolio Evaluator

Bulk Portfolio Management

Download the following spreadsheet and add your properties. Save it to your computer, then select it for upload using the "Browse" button below.

Bulk input spreadsheet: CPEbulk.xls

Browse... No file selected. APPEND TO PORTFOLIO

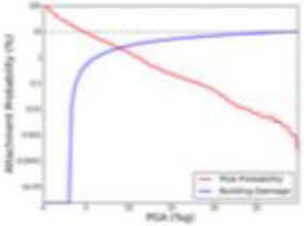
Change Portfolio Metadata

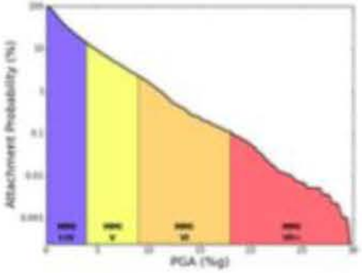
Address:	1416 Claremont Drive Davis, CA 95616, USA	
Year of Construction:	1962	
Number of Stories:	1	
Construction Type:	Concentric Braced Frame	
Soil Type:	Stiff Soil	

1 Year Probability Hotspot Map for M≥6.8 Earthquakes

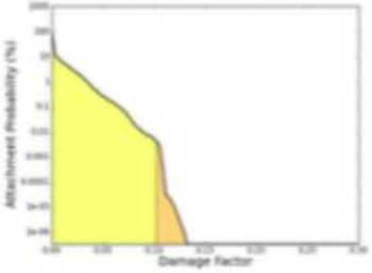
Locations of Previous Earthquakes Over the Past 5 Years

Attachment Prob	>15% Damage	>10% Damage	>5% Damage
1 Year	<0.01%	<0.01%	0.28%
3 Years	<0.01%	0.05%	2.46%
5 Years	<0.01%	0.14%	6.87%
10 Years	<0.01%	0.57%	26.21%





1 Year Attachment Probability as a Function of PGA



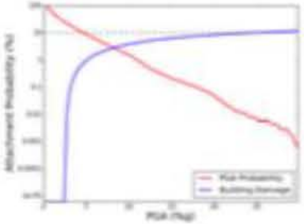
1 Year Attachment Probability as a Function of Damage Factor

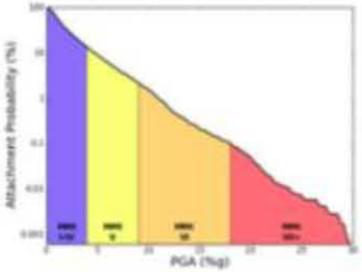
Address:	1612 Pole Line Road Davis, CA 95618, USA	
Year of Construction:	1961	
Number of Stories:	1	
Construction Type:	Concentric Braced Frame	
Soil Type:	Stiff Soil	

1 Year Probability Hotspot Map for M≥6.8 Earthquakes

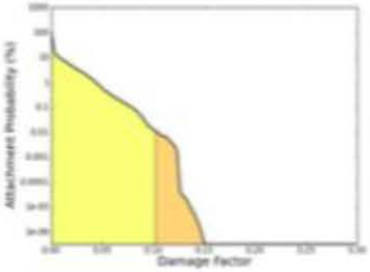
Locations of Previous Earthquakes Over the Past 5 Years

Attachment Prob	>15% Damage	>10% Damage	>5% Damage
1 Year	<0.01%	0.01%	0.66%
3 Years	<0.01%	0.12%	5.77%
5 Years	<0.01%	0.33%	15.58%
10 Years	<0.01%	1.41%	51.21%





1 Year Attachment Probability as a Function of PGA



1 Year Attachment Probability as a Function of Damage Factor

Pages from Sample Commercial Report

Natural Hazards Disclosures

for Transfer of Residential Real Estate in California

Open Hazards Disclosures

YOUR COMPLETE NHD REPORT DELIVERED IN 15 MINUTES OR LESS!

- Complete Report
- Free Report
- Order Report
- Sample Report
- FAQ
- About Us
- Contact Us
- Premium Login
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Complete Report

$50 Order Online

- ☑ **Natural Hazard Disclosure Statement**
- ☑ **Environmental Report**
- ☑ **Mello-Roos Tax Information**
- ☑ **Full Liability Coverage**
- ☑ **Quick Email Delivery**

Your complete Open Hazards Disclosures Report will include:

- Six Basic Statutory NHD Disclosures:
  - FEMA Special Flood Hazard Area
  - Dam Inundation Area
  - Very High Fire Hazards Area
  - Wildland Fire Area
  - Alquist-Priolo Earthquake Fault Zone
  - Seismic Hazard Area
- Toxic Mold Information
- Commercial/Industrial Zoning
- Military Ordnance
- Airport Influence and Airport Proximity
- Expanded Natural Hazard Information Identified By Local Jurisdictions
- Color Reference Maps For All Identified Hazard Areas
- Summary of Current Taxes
- Summary of Levies under 1915 Bond Act and Mello-Roos Community Facilities Act
- Disclosures That Meet the Requirements of Civil Code §1102.6(b)

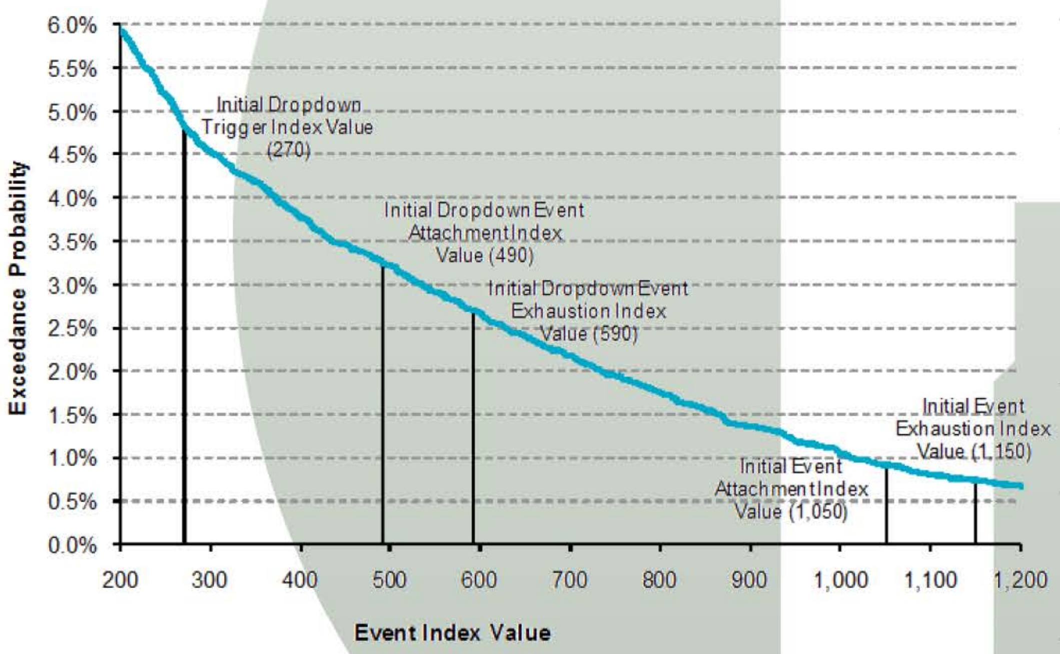
Order Complete Report

Kibou Notes 2012

Japan Railways – GC Securities

Modeled Annual Occurrence Exceedance Probability Curve

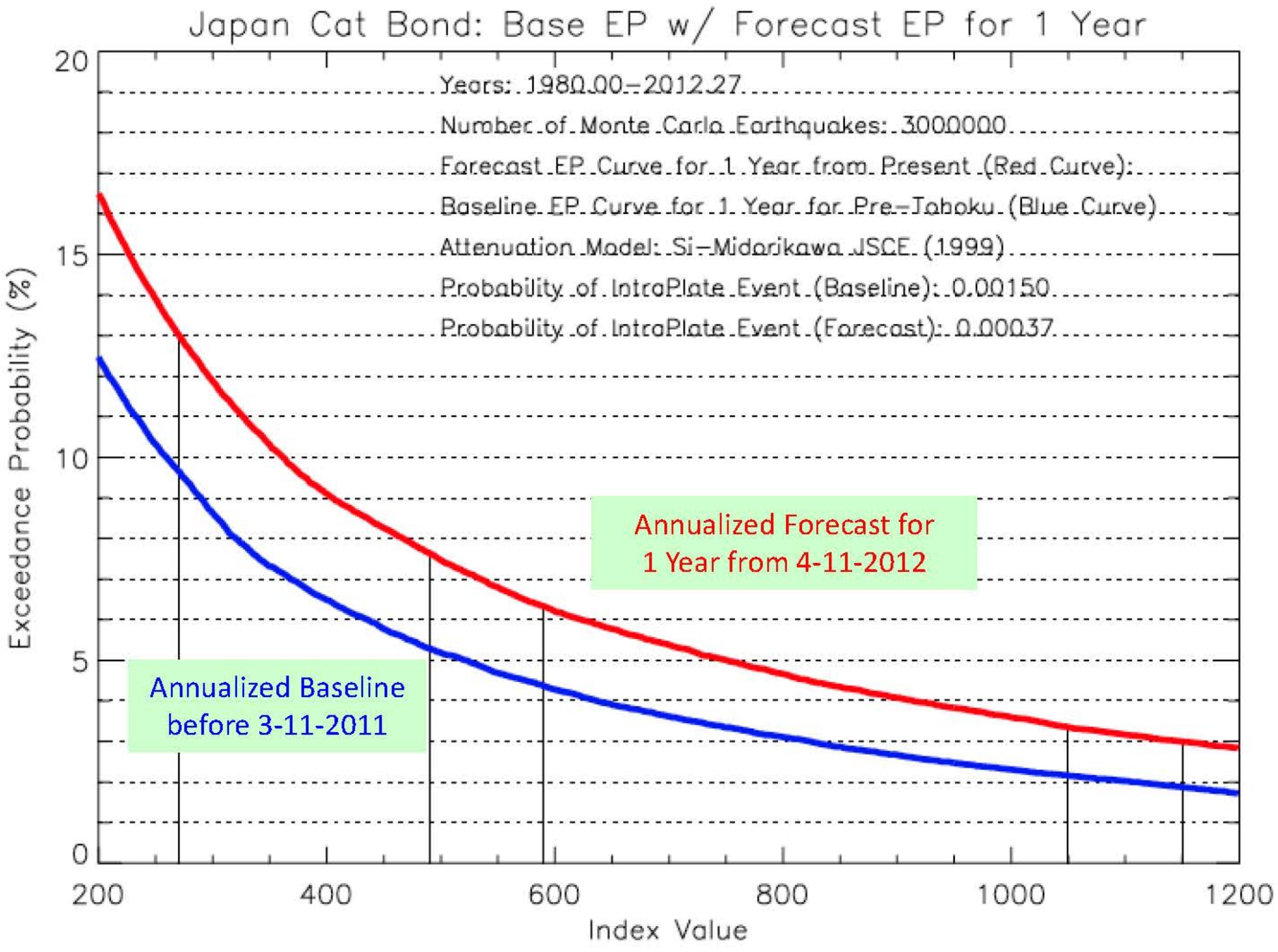
Modeled Annual Occurrence Exceedance Probability Curve



Modeled Event Index Value	Modeled Annual Occurrence Exceedance Probability[1]	Series 2012-1 Initial Attachment / Exhaustion Levels
1,158.7	0.73%	
1,154.1	0.74%	Event Exhaustion Index Value
1,132.4	0.75%	
1,067.9	0.89%	
1,055.6	0.91%	Event Attachment Index Value
1,037.5	0.93%	
1,011.0	1.00%	
863.7	1.50%	
733.7	2.00%	
627.1	2.50%	
594.1	2.70%	
590.6	2.71%	Dropdown Event Exhaustion Index Value
586.8	2.72%	
535.3	3.00%	
490.5	3.25%	Dropdown Event Attachment Index Value
434.0	3.50%	
373.3	4.00%	
305.3	4.50%	
270.6	4.83%	Dropdown Trigger Index Value
260.9	5.00%	

EP Curve from Investor Presentation

Kibou Notes 2012



EP Curve Computed by Open Hazards Group using NTW Forecast

WEEK IN REVIEW

A Richter Scale for Markets

By ERIC DASH JULY 31, 2010

Nicholas Felton

It's tempting to pull out the old earthquake metaphor when talking about the latest financial crises. How else to describe the economic devastation — the tremors in the subprime mortgage market, the seismic collapse of Lehman Brothers, and the aftershocks reverberating in Europe?

But some academics are now taking the metaphor seriously, pursuing a new approach to economics they call econophysics. The field represents a significant break from traditional economics, by studying financial earthquakes in much the same way geologists study those on terra firma. "New approaches are needed to address the fundamental and practical

Current Thinking | Strategies | About | How to Invest

Hedge Fund Strategies: Miller Value Partners

The Intellectual Investor

June 23, 2016

Using Earthquakes to Understand Markets: Why and How

John Rundle

John Rundle is a Distinguished Professor of Physics and Geology at the University of California, Davis. We had the pleasure of meeting Professor Rundle through the Santa Fe Institute and were intrigued by his work on the dynamics of complex systems, specifically in the geosciences. His work on earthquake and hazard forecasting, and the similarities of these hazards to the financial markets expanded how we think about market movements and crashes. This is the first in a series of posts by Professor Rundle to share his research.

On July 31, 2010 the New York Times ran the story *A Richter Scale for the Markets*. This article was one of the first in the popular media to draw attention to recent research in the new discipline of *Econophysics*, showing that earthquake dynamics may have important similarities to market fluctuations. But the basic idea is not new. Financial analysts have used the earthquake metaphor for markets frequently in the past.

Books such as Raghuram Rajan's *Fault Lines*, Robert Reich's *Aftershock*, and Nouriel Roubini's *Crisis Economics* all illustrate the idea that economic and financial influences on markets are analogous to the forces driving tectonic plates, ultimately leading to earthquakes. Economic cycles that proceed from recession to expansion and back, and intermittent market corrections and crashes, are modeled by earthquake-like events. Market crashes are followed by a series of lesser corrections, which are seen as aftershock-like events.

dev.lmminvestments.com/current-thinking/income-opportunity-strategy-commentary/ ...ly, can we learn about markets by studying the dynamics of other

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Income Opportunity

Rising Rates and Trumped Up Income

Bill Miller IV, CFA ~ January 25, 2017

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Opportunity Equity

Volatility Is the Price You Pay for Returns

Samantha McLemore, CFA ~ February 24, 2017

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Thank you for your attention

The Open Hazards Group

www.openhazards.com

About Me

Distinguished Professor of Physics and Geology, University of California, Davis

Co-Founder of Open Hazards Group and Chair of the Board, Davis, California

Executive Director Emeritus of the APEC Cooperation for Earthquake Simulations (ACES)

A Senior Advisor to the Association of Pacific Rim Universities (APRU)

Visiting Professor at Tohoku University at the APRU Multihazards Hub, Tohoku University, Sendai, Japan

John was Chair (1994-1996) of the scientific Advisory Council to the Southern California Earthquake Center. He has been a Distinguished Visiting Scientist at the Jet Propulsion Laboratory, Pasadena, CA (1995-present), is currently an External Professor at the Santa Fe Institute, and is a Fellow of both the American Physical Society (2005) and the American Geophysical Union (2008). Recently, he was a co-winner of the NASA Software of the Year Award (2012). John received his B.S.E from Princeton University (Magna Cum Laude, Phi Beta Kappa, Tau Beta Pi), and M.S. (1973) and Ph.D. (1976) from the University of California at Los Angeles. In addition to natural hazards and earthquakes, he also has professional interests in forecasting, validation of forecasts, and quantitative finance. He currently co-organizes (along with Michael Maouboussin, Will Tracy and Martin Lebowitz) a yearly meeting on risk for the Santa Fe Institute, often held at Morgan Stanley, Inc., in New York. He teaches courses in Risk and Natural Disasters; Complex Systems; and Econophysics and Quantitative Finance at the University of California, Davis.

The Open Hazards Group

Technical Team

- **John Rundle**. Board Chair, Earthquake Forecasting. He is a frequent commentator on earthquake science on the major national news networks CNN, FOX, and MSNBC.
- **Bill Graves**. President, CEO, Board Member. Bill Graves has worked as the Director of the Systems Science Lab and the Acting Director of Test and Measurements, Schlumberger. He was the first President and CEO of Cisco Systems (1987-1988). Bill Graves earned a BS in Physics from MIT in 1968, served in the US Army Reserve from 1969-1975, and then completed a PhD in Physics at UC Berkeley in 1977.
- **James R. Holliday**. Treasurer, Board Member, Forecast Validation and Software Development. James Holliday is a Research Scientist in Physics at UC Davis, and former President of Xerasys, Inc. He earned a BS in Physics at the University of Kansas in 1998 and a PhD in Physics at UC Davis in 2007.
- **Boris Jeremic**. Geotechnical Engineering. Boris Jeremic is a Professor of Civil Engineering at UC Davis and a Faculty Scientist at Lawrence Berkeley National Laboratory. He earned a Diploma Engineering degree in Civil Engineering from Belgrade University in 1989 and then worked as a consulting engineer in Yugoslavia, Iraq and Switzerland for three years. He completed post-graduate work at the University of Colorado where he earned an MS in 1994 and a PhD in 1997 in Civil Engineering.
- **Sashi Kunnath**. Earthquake and Structural Engineering. Sashi Kunnath is a Professor of Civil and Environmental Engineering at UC Davis and Editor for the ASCE Journal of Structural Engineering. He is a Fellow of the American Concrete Institute and a former Chair of the ASCE Committee on Seismic Effects. Sashi Kunnath earned a B. Eng. in Civil Engineering at Bangalore University in 1980, a M. Eng. in Structural Engineering at the University of Bangkok in 1982 and a PhD in Structural Engineering and Earthquake Engineering at SUNY Buffalo in 1989. In 2008 he was awarded the ASCE Raymond Reese Research Prize for his work in modal adaptive pushover analysis of building structures. He is also a registered Professional Engineer.
- **Kevin Mayeda**. Seismologist. Kevin Mayeda is a Senior Scientist at Weston Geophysical and a Research Faculty member at the UC Berkeley Seismology Laboratory. He was a Senior Seismologist at Lawrence Livermore National Laboratory from 1992 to 2006. Dr. Mayeda earned a BS in Geophysics at UC Berkeley in 1987 and a PhD in Geophysics at the University of Southern California in 1991.
- **Steven Ward**. Seismologist. Steven Ward is a Research Geophysicist at the Institute of Geophysics and Planetary Physics, UC Santa Cruz. He earned a BS in Physics at Bucknell University (1974) and a PhD in Geophysics at Princeton (1978). Steven specializes in the quantification and simulation of natural hazards.

The Open Hazards Group

Incorporated September, 2009

Summary

The Open Hazards Group builds scalable software for personal risk management focusing on tail risk from natural hazards.

Founders

Dr. William Graves, President and CEO. Ph.D., University of California, Berkeley. Previously, first CEO, Cisco Systems.

Dr. John Rundle, Chairman. Ph.D., University of California at Los Angeles. Distinguished Professor, Departments of Physics and Geology, University of California, Davis. External Faculty, the Santa Fe Institute.

Dr. James Holliday, Chief Technologist. Ph.D., University of California, Davis.

Business Models

Business models in the area of seismic and other natural hazards include:

- Seismic safety reports for residential and commercial structures
- Residential real estate natural hazard reports as required by law

www.openhazards.com