ESS 202

Today's lecture

- Scaling
  - Magnitude, rupture area, duration
  - Also energy
- Numbers of quakes
- Earthquake sequences
- Quake Prediction

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4 levels of predictability

- Time-independent hazard
- Time-dependent hazard
- Earthquake forecasting
- Deterministic prediction

Time-independent hazard

- Earthquakes are a random process in time
- Estimate future long-term seismic hazard from
  - use past locations of earthquakes
  - geological recurrence times
  - active fault locations, and deformation rates
- Then calculate the likely occurrence of ground-shaking
  - From source-magnitude probability
  - path and site effects,
  - include a calculation of the associated errors
- Such calculations can be used in
  - building design and planning of land use
  - for the estimation of earthquake insurance.

Time-dependent hazard.

- Here we accept a degree of predictability in the process, in that the seismic hazard varies with time.
- We might guess that the hazard increases with passing time after the last previous event.
  - 'characteristic earthquake' with a relatively similar magnitude, location and approximate repeat time predicted from the geological dating of previous events.
- Surprisingly, the tendency of earthquakes to cluster in space and time includes the possibility of a seismic hazard that actually decreases with time.

Earthquake forecasting

- Here we predict some of the features of an impending earthquake, usually on the basis of the observation of a precursory signal.
- The prediction is still probabilistic.
  - The magnitude, time and location are not given precisely or reliably.
  - Forecasting also should include a precise statement of the probabilities and errors involved.
- The practical utility is to enable the relevant authorities to prepare for an impending event weeks to months ahead of time.
- Practical difficulties include
  - identifying reliable, unambiguous precursors
  - the acceptance of an inherent proportion of missed events or false alarms, involving evacuation for up to several months at a time, resulting in a loss of public confidence.

Deterministic prediction

- Earthquakes are inherently predictable.
- We reliably know in advance, so that a planned evacuation can take place
  - their location (latitude, longitude and depth),
  - magnitude, and
  - time of occurrence.

Probability

- How often you expect something to happen
  - Example - flipping a coin lands on heads 50% of the time
- Reported as percent (50%), decimal (0.5) or fraction (1/2)
- Must be between 0% and 100%

What is Probability?

- Relative frequency of a given outcome when repeating the game (coin tossing,…)
- We say something like 80% probability of an M>7 in the next 30 years
- And we can't repeat the game, or even check how well it's working

Probability of quake

- Find the faults
- Estimate how faults are segmented
- How does each segment behaves
  - Size of its quakes
  - Time between quakes - recurrence interval
- Sum up risk from all segments of all faults
  - (This exercise tells how much shaking)
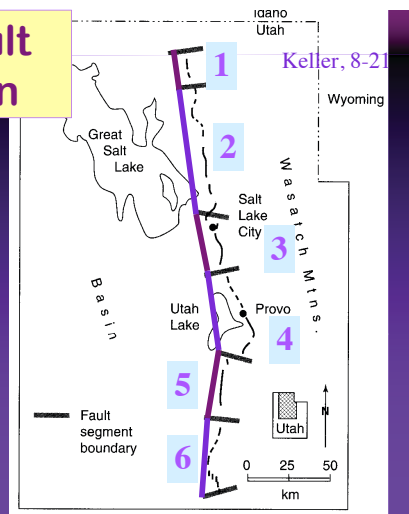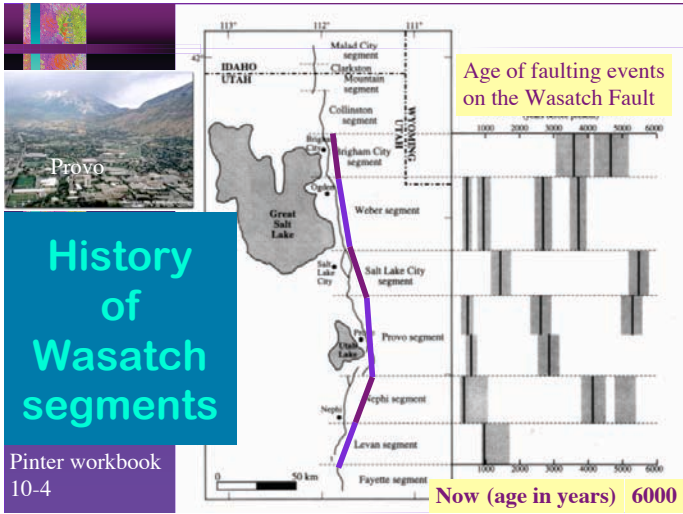- Then figure out expected damage
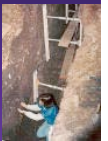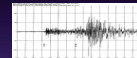
Fault zone segmentation

- Characteristic earthquake model
  - Only one segment breaks at a time
- Segments defined by
  - Ends of fault traces
  - Fault intersections?
  - Changes in rock type along fault?
- Best guesses - segment defined from prior quakes.
- Not clear whether the concept of fault segmentation is accurate or useful.

Wasatch Fault segmentation

Keller, 8-21

Trench in Japan

History of Wasatch segments

Age of faulting events on the Wasatch Fault

Provo

Pinter workbook 10-4
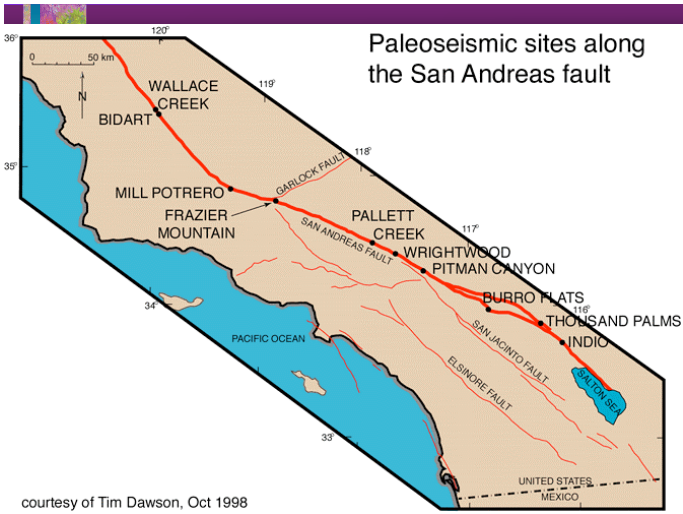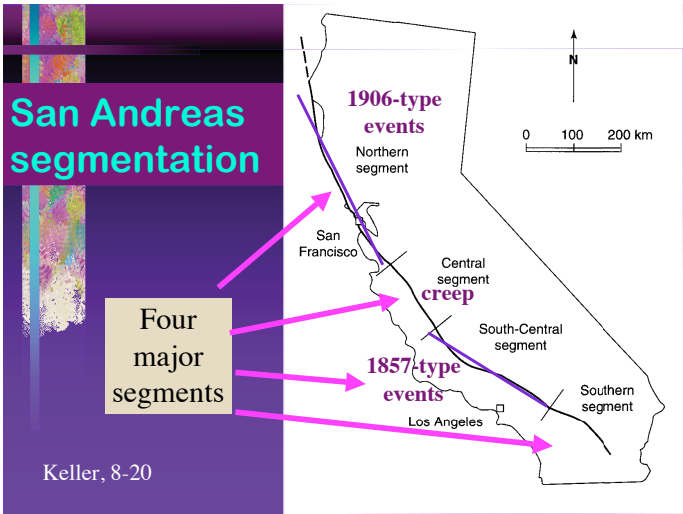
Now (age in years) 6000

Characteristic behavior of segments

Segment	Length (km)	Approximate displacement per event (m)	Approximate slip rate (mm/yr)	Approximate recurrence interval (yr)	Comment
1	30	–	–	>10,000	No known surface displacement past 13,500 yr
2	70	1.6	1.3 (+0.5, –0.2)	1000 to 1500	4 Holocene events. Most recent about 500 yr ago, oldest 4000 yr
3	35	2.0	0.76 (+0.6, –0.2)	1500 to 3500	2 Holocene events. Most recent about 1500 yr ago, oldest 5000 yr
4	55	1.6 to 2.3	0.85 to 1.0	1500 to 3000	3 Holocene events. Most recent about 500 yr ago, oldest 5000 yr ago
5	35	2.3	1.27 to 1.36	1500 to 2000	3 Holocene events. Most recent about 400 yr ago
6	40	2.5	less than 0.35	7000	1 Holocene event about 1000 yr ago

Keller, Table 8-2

Cookie cutter

How does this apply to an entire seismic region?

- **Outline**
  - **Segmentation of the San Andreas Fault**
  - **Behavior of a segment on the San Andreas**
  - **Probabilities for San Andreas segments**
  - **Locations of all SoCal faults**
  - **Total probability across SoCal**
    - **For level of shaking**
    - **For level of damage**

San Andreas segmentation

1906-type events

Northern segment

San Francisco

Central segment

creep

South-Central segment

1857-type events

Southern segment

Los Angeles

Four major segments

Keller, 8-20

Paleoseismic sites along the San Andreas fault

courtesy of Tim Dawson, Oct 1998
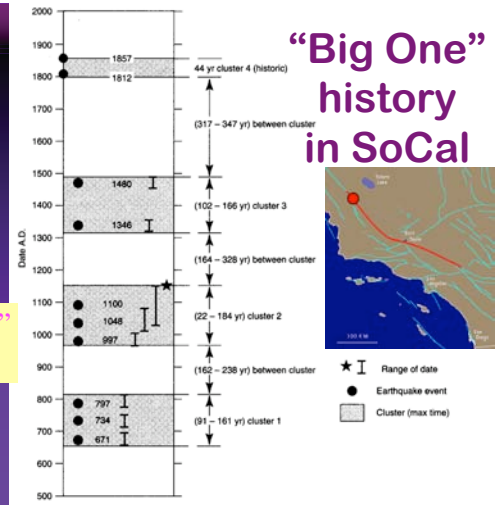
Pallett Creek: A former marsh

- Very fast deposition
- Offset beds overlain by continuous beds
- Earthquake occurred between depositing of bottom and top beds
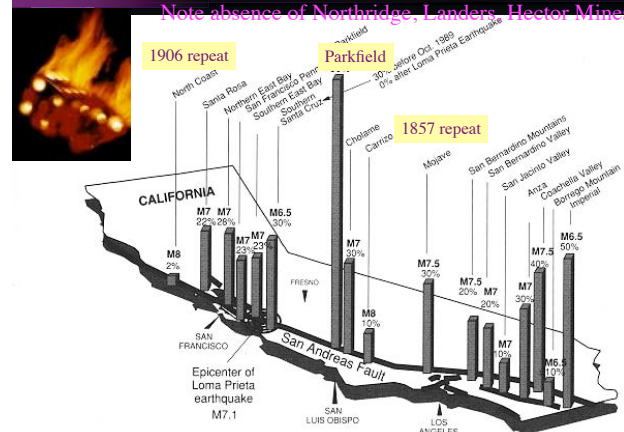- Dated by finding formerly living matter (plant leaves, etc.) and using Carbon-14

http://piru.alexandria.ucsb.edu/collections/atwater/saf/slide25.jpg

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"Big One" history in SoCal

"1857-type" segment

Keller, 8-23

Legend:
- ★ I Range of date
- ● Earthquake event
- ▨ Cluster (max time)

From this history

- 10 events in 1300 years
  - An event every 130 years, on average
  - Last event 145 years ago
    - They're overdue!
- But events are not regularly timed
- So another guess would be
  - about 25% chance in next 30 years
  - (that's 30 years / 130 year repeat time)

30-yr probability of quakes in California

Note absence of Northridge, Landers, Hector Mines, ...

1906 repeat

Parkfield

1857 repeat

1857-type is given 30% chance in 30 years

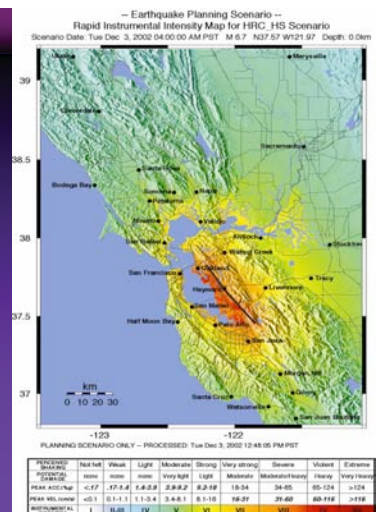
Example of a Forecast: 2002 Working Group Bay area report

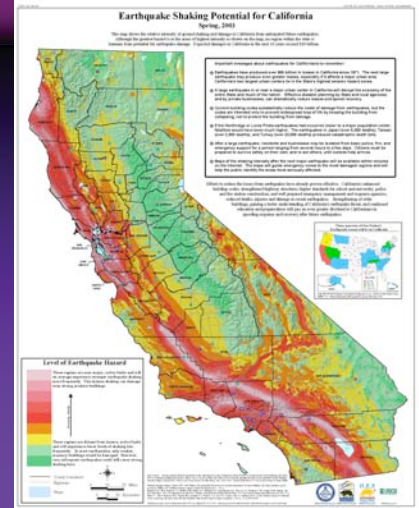- Calculated 62% probability of a major (≥6.7) earthquake n the Bay Area in the next 30 years

Image courtesy USGS

Predicted shaking from Hayward fault event

Combine earthquakes

From all known faults.

…and some model of unknown faults

Shaking potential

Earthquake Shaking Potential for California
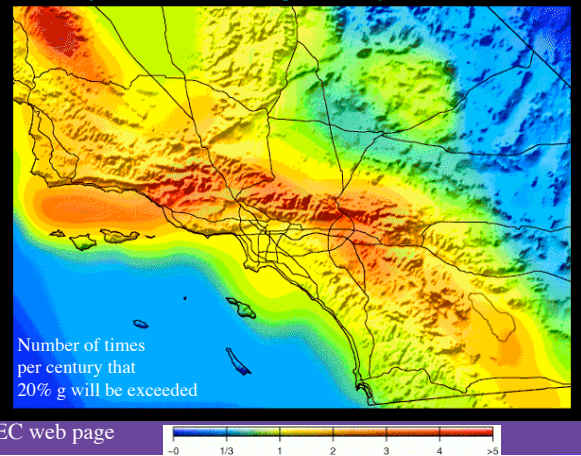Spring, 2003
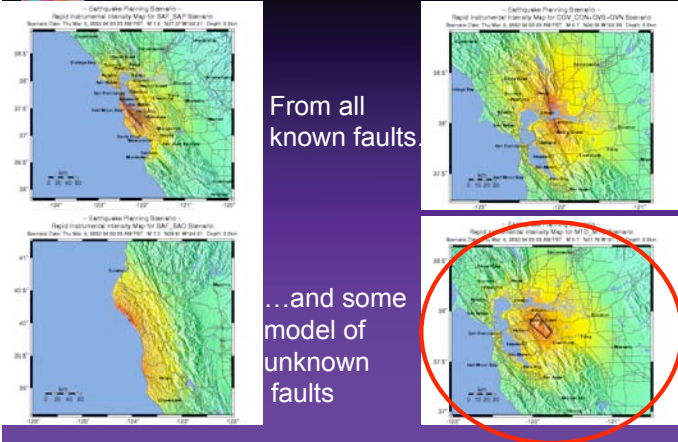
All known big faults in SoCal
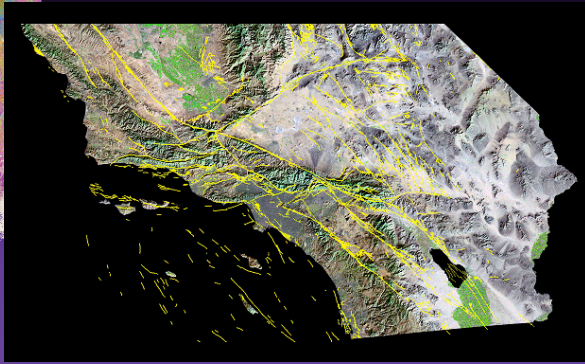
Most faults have longer repeat times than San Andreas

SCEC web page

A probability map for SoCal

Number of times per century that 20% g will be exceeded

SCEC web page

Earthquake Probability

Epicenters
States
Seismic Coefficient
- 0
- 0.01 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.4

0   500   1000 Miles
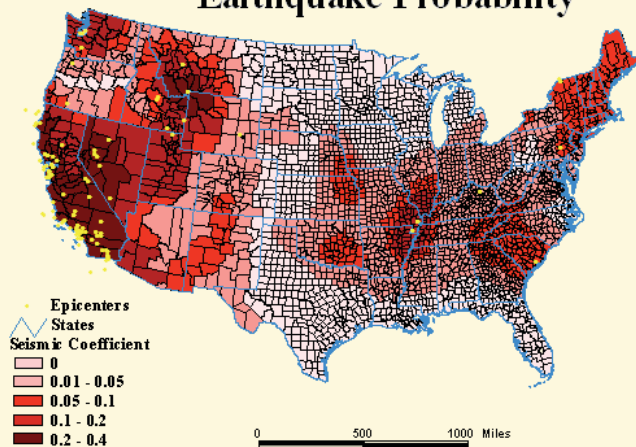
Sources: Applied Technology Council, National Geophysical Data Center, 1990 - 94

Tornados
Between 1950 - 1996

States
Tornado Count
- No Data
- 1 - 8
- 9 - 17
- 18 - 30
- 31 - 55
- 56 - 118

0   500   1000 Miles
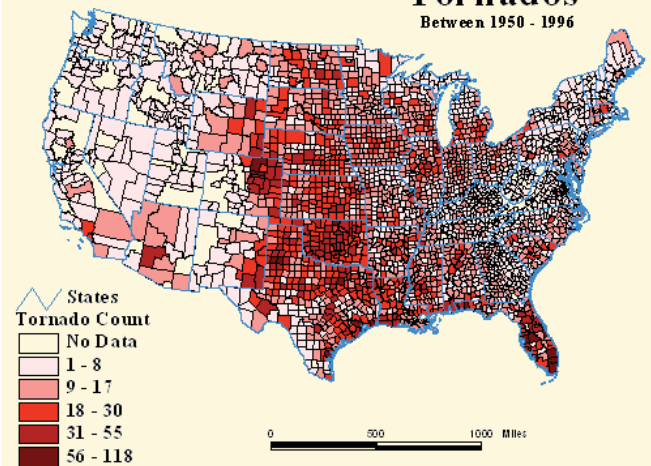
Hurricane Winds
1886 - 1996

States
County Boundaries
Hurricane Zones
0 - 59 mph
60 - 74 mph
75 - 89 mph
>= 90 mph
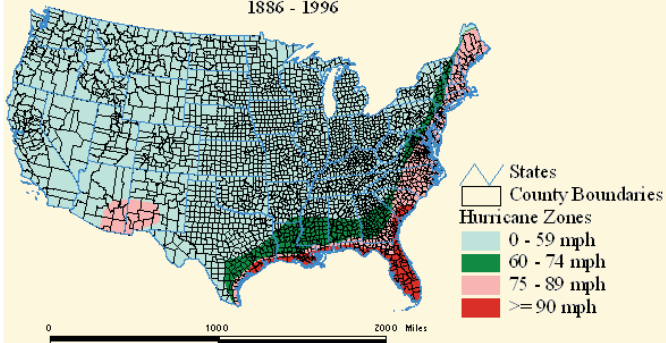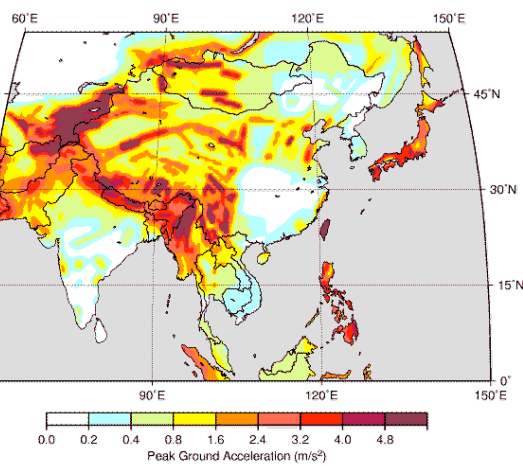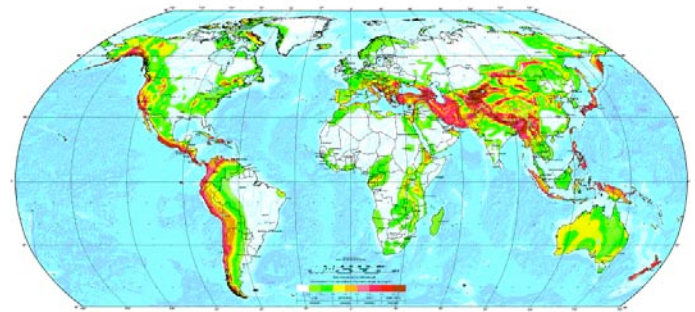
Copyright 1997 EDgeTech America, Inc.

World Hazard
GLOBAL SEISMIC HAZARD MAP

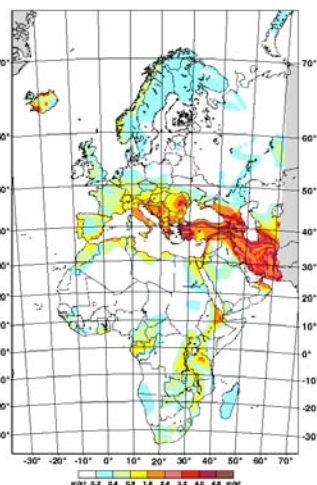Peak Ground Acceleration (m/s²)

Philippines, 1990
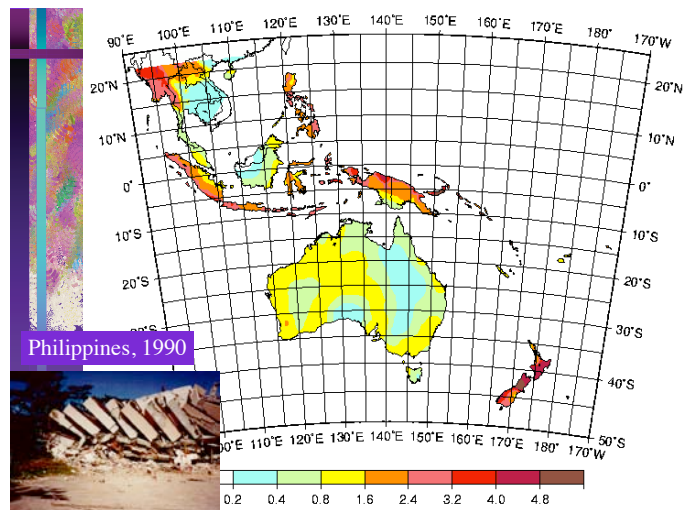
Europe, Middle East, and Africa
Turkey, 1999

Americas
Mexico City, 1985

Peak Ground Acceleration (m/s²)
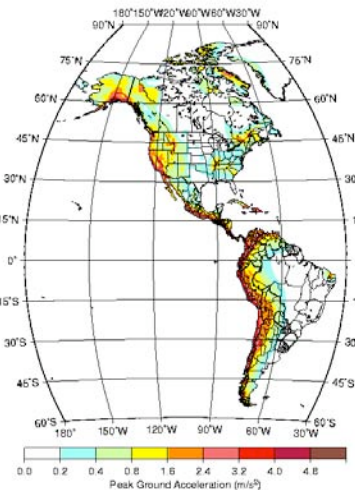
Some problems and complications

- Are magnitude 8-9 quakes possible on all faults, or just big faults?
- Do segments always break one at a time, or sometimes together? (same question, also a restatement of characteristic quake idea)
- Is seismicity uniform over time?
- How many faults don't we see?
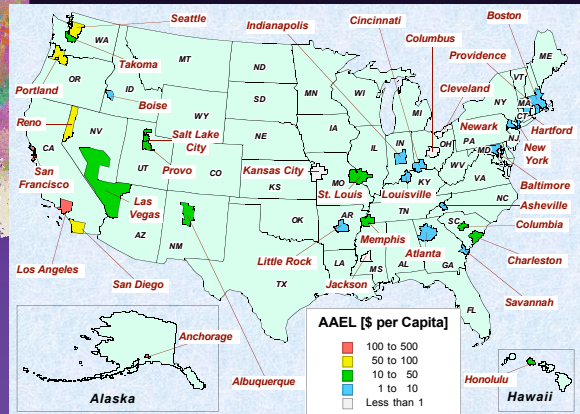- Effect of strong shaking on soil

Hazard and Risk

- **Hazard** – probability that a given area will be affected by a given destructive process
- **Risk** – Probability that a loss will occur
- Hazard is what seismologists predict
  - Includes earthquake probability
- Risk is what insurance companies, the government, etc. need to know.
- How do we close the gap?
- Risk = hazard * vulnerability * value

FEMA Hazus results

- Average Annual Earthquake Loss by state

AAEL [$ M]
- Over 500
- 100 to 500
- 50 to 100
- 10 to 50
- Less than 10

Nishenko, 2002

Average Annual Earthquake Loss per Capita for 35 Metropolitan Areas

AAEL [$ per Capita]
- 100 to 500
- 50 to 100
- 10 to 50
- 1 to 10
- Less than 1

Cost-Benefit Analysis

- **Benefit-cost ratio**:
  - Calculate annual benefits
  - Multiply by lifetime
  - Calculate projected cost of special earthquake construction
  - Take ratio to get benefit/cost ratio
- Would it be better to spend this money on new schools, hospitals, etc.

Takes big quakes to test predictions

$10,000 bill, Discontinued in 1969, Salmon Chase is pictured

- Several natural biases
  - Insurance companies like high rates
  - Cities like perception of low risk
  - Scientists like to make changes to status quo
- Real process is that everybody makes a guess, which is either verified or contradicted by real quakes
  - Often decades later

Global quakes per year

Magnitude-Frequency Relation (Global)
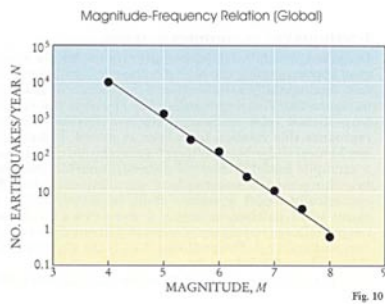
Gutenberg-Richter Relationship

1 magnitude 8 or bigger (or a little less)
10 magnitude 7 or bigger
100 magnitude 6 or bigger
1000 magnitude 5 or bigger
etc…

Average data from 1904-1980
Kanamori and Brodsky, 2001

Definitions

- **Sequence**
  - Set of quakes that are related
- **Foreshock**
  - Quake followed by a bigger quake in same sequence
- **Mainshock**
  - Biggest quake in a sequence
- **Aftershock**
  - Quake after the biggest quake in a sequence
- Corollaries
  - One never knows that an event is a foreshock until the mainshock comes along
  - Aftershocks can turn into foreshocks

Differences between mainshocks, foreshocks and aftershocks

•NONE!

Mainshock

- Largest earthquake in a sequence
- Larger mainshocks strain larger volume of rock, have more aftershocks
- Foreshocks and aftershocks usually at least 1 magnitude unit smaller than mainshock

Foreshocks

- **Smaller earthquakes that precede the mainshock**
  - often by just hours
- **Few in number**
  - only half of mainshocks have even one foreshock
- **Near mainshock hypocenter**
  - part of the nucleation process

FORESHOCKS OF ANTICHRIST

Haicheng 1975

Magnitude of earthquakes over time

main shock

Foreshocks

time
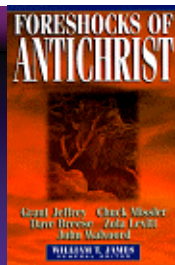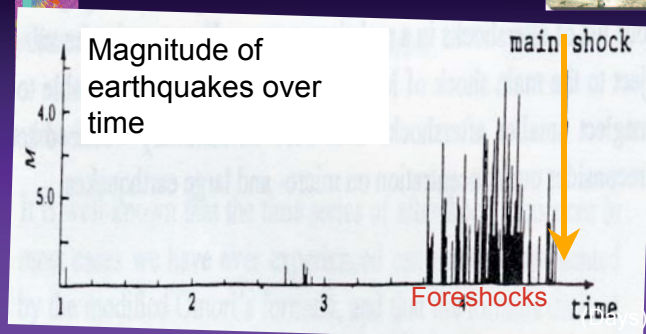
Aftershocks

- smaller earthquakes following the largest earthquake of a sequence (the mainshock) near mainshock rupture zone
  - follow almost all shallow earthquakes
  - cover ruptured area
  - can number in thousands
  - can last for years or decades
    - aftershocks of Northridge M 6.7 are still occurring
  - The most predictable (and therefore well-studied) earthquakes

Cause of aftershocks

- Every time there is an earthquake, the volume of rock around the rupture is strained, that is, twisted or squeezed.
- Sometimes, the strained rock breaks.
- Often, it takes a while for it to break, so the aftershocks may appear seconds to years after the causative quake.
- But we don't know for sure why there is a delay.
  - Static fatigue
  - Visco-elastic relaxation
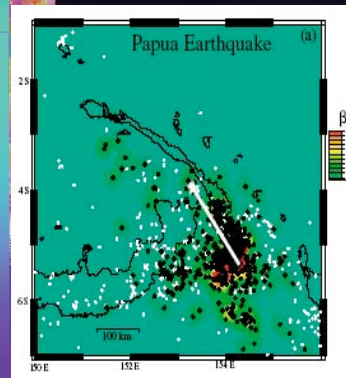 - Diffusion processes (fluids?)

Static stress triggering

Earth is stretched or compressed by fault movement (as in elastic rebound models)

Some earthquakes near fault
Some where stress level was raised
Fewer where stress level dropped
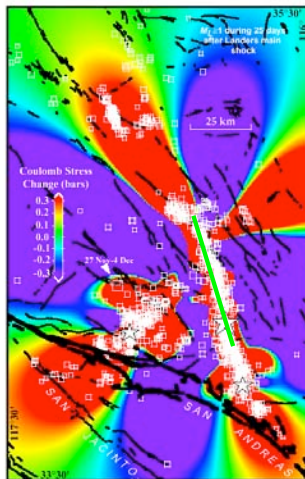
Dynamic Triggering

- Shaking, rather than just long-term loading, triggers aftershocks
- Evidence from earthquakes with strong directivity

Gomberg et al., 2003

Aftershocks tell us about mainshock

- Seismologists estimate the area of rupture by mapping aftershock locations
  - Aftershocks cover the rupture area and may expand slightly outside of it
    - Obtain length and width of faulted area => magnitude of mainshock
    - Obtain orientation of faulted area

Loma Prieta example

- 40-50 km long aftershock zone
- Extends to 12 km depth
- Slightly dipping to southwest
- Again, focus near middle of bottom of rupture zone
- Loma Prieta had two M 5 foreshocks 6 months earlier very near focus

Loma Prieta aftershocks
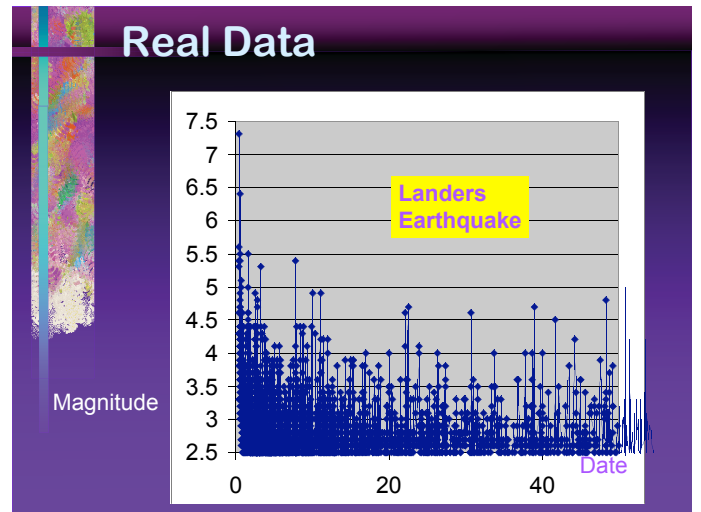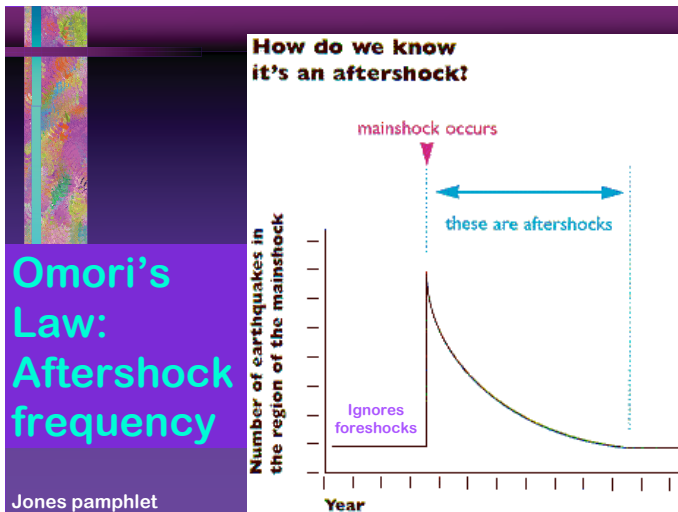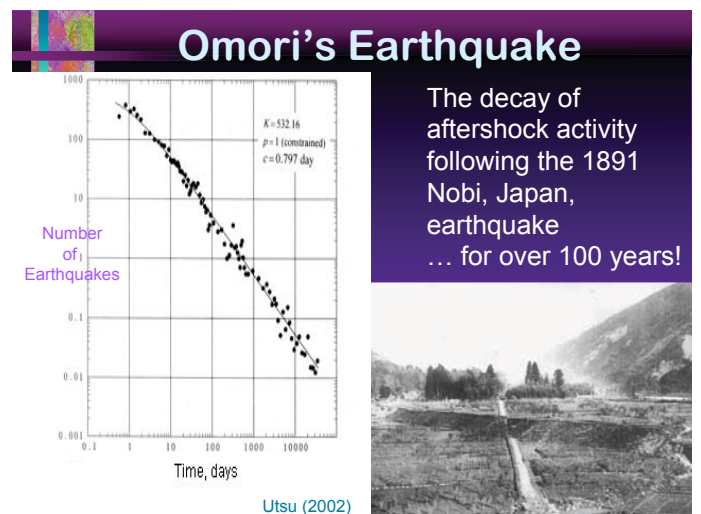
Along fault view

Cross-section

Map view

N

MAGNITUDES
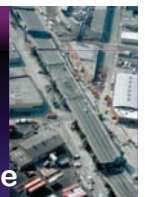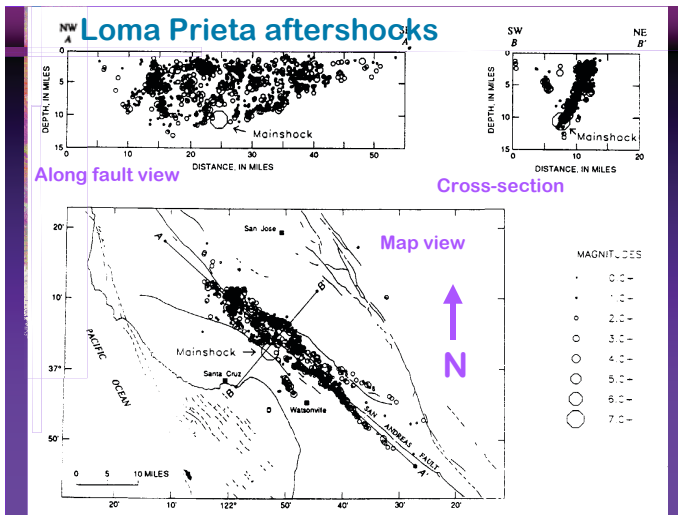
Distribution of sizes

- Like for mainshocks, there are many more small aftershocks in a sequence than big aftershocks
- If mainshock has M 6
  - 1 or 2 aftershocks with M 5 to 6
  - 10's of M 4 to 5
- If mainshock has M 8, an M 7 aftershock is likely

How do we know it's an aftershock?

mainshock occurs

these are aftershocks

Ignores foreshocks

Number of earthquakes in the region of the mainshock

Year

Omori's Law: Aftershock frequency

Jones pamphlet

Real Data

Landers Earthquake

Magnitude

Date

Omori's Law

- Number N of aftershocks decreases with time t
- Mathematically, rate of aftershocks follows

  N ~ C/t

  where: N is the number of earthquakes
  t is time
  C is a constant
- Likelihood of getting a big earthquake decreases with time
  - Combine Gutenberg-Richter and Omori's Law

- Most happen within first few weeks, many within first day or two

Omori's Earthquake

The decay of aftershock activity following the 1891 Nobi, Japan, earthquake
… for over 100 years!

$K = 532.16$
$p = 1$ (constrained)
$c = 0.797$ day

Number of Earthquakes

Time, days

Utsu (2002)

Prediction topics

- **As we just saw**
  - Foreshocks can be useful
- **Nutty amateur web pages**
- **Scientific efforts not much more successful**

HOW TO CONDUCT A SEANCE
By ANNA RIVA

To make an earthquake prediction need to state:

- **Time interval** in which quake will occur
- **Region** in which quake will occur
- **Magnitude range** of predicted quake
  - Small quakes occur more commonly
  - Easy to predict there will be magnitude 3 somewhere in Southern Ca. next month, but not useful

To be able to predict there must be precursors

- Sometimes there are,
- Sometimes not there or perhaps too small to observe
- Need many decades (several centuries?) to study the patterns because there is a lot of randomness

Japan downplays prediction
Nature, 1999

- Earthquake research in Japan should focus on understanding the mechanism of earthquakes, rather than predicting them, according to an advisory body to the Japanese prime minister. This shift is needed to develop new disaster prevention technologies.
- Although the prediction program has shifted its focus to making long-term forecasts, there is still no guarantee that this is actually possible.

Possible precursors

- Change (increase or decrease) in number of earthquakes
  - For example, foreshocks
  - Difficult to distinguish such changes from random variations
- Ground uplift or tilt
- Radon emission
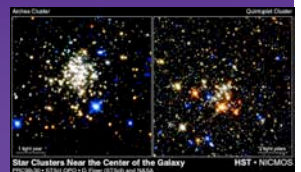- Electrical resistivity
- Seismic wave velocity

French machine

Clustering of seismicity

- Whenever there's a quake, it becomes more likely that more quakes will come soon
- 10% chance that any quake will be followed by a bigger quake
- With passing time (and no quake), odds return to normal
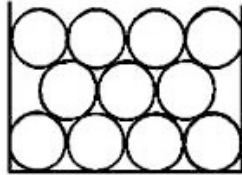
Star clusters

Dilatancy

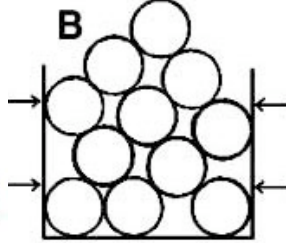- Swelling of rock as it approaches failure

Rock crusher

Normal

A

Just before failure

B

Footsteps in sand

- It is well known that when you walk on wet sand on the shore, your footsteps get dry.
- This is similar to what occurs in rock dilatancy.
- As a deformation is imposed on the sand, space between grains increase, allowing for upper water to invade the sand.

How rock properties could produce precursors

I

II
Dilatant
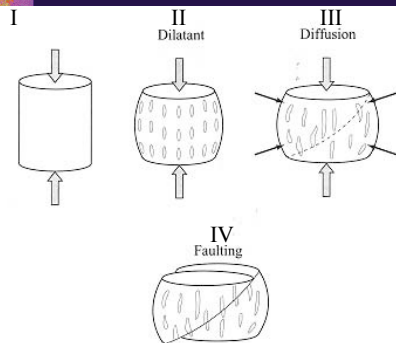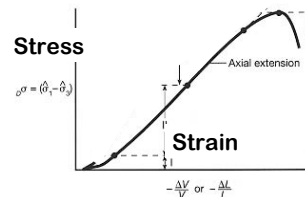
III
Diffusion

IV
Faulting

Figure 10.7 The dilatant-diffusion theory. A sequence of changes in rock under compression could lead to rock failure and earthquakes: the figure shows the dilatant or cracking phase; and the diffusion phase in which water enters the cracks.

Pg 193 Brumbaugh

Mechanical model of cracking

Stress

$_0\sigma = (\hat{\sigma}_1 - \hat{\sigma}_3)$

Axial extension

Strain

$-\frac{\Delta V}{V}$ or $-\frac{\Delta L}{L}$

A.

B.

Dilatancy

P-wave velocity

Ground uplift

Radon emission

Electric resistance

Number of quakes

Bolt

Palmdale Bulge -

A	B	C	D
E	F	G	H
I	J	K	L
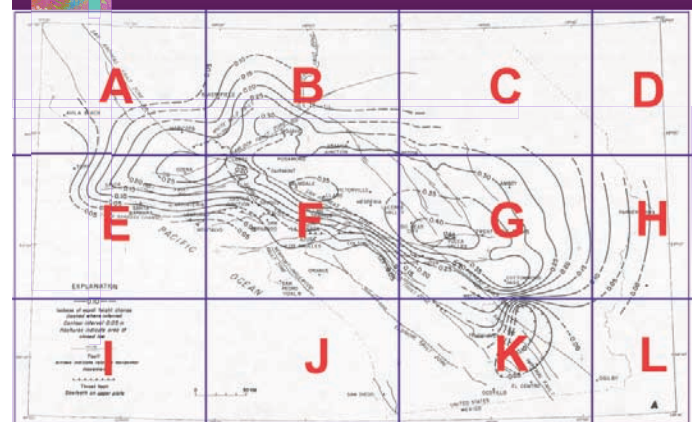
Example of the Problem

- Date: August 29, 2002 at 02:19:10   From: *deleted*,
- Subject: 24 to 72 hrs, Los Angeles, 8+ maybe 9, 100%
- There will occur a magnitude 8+ quake taking place in Los Angeles, actually Parkfield to San Bernardino and then around the turn down to Bombay Beach, Salton Sea.
- It will be the worse earthquake in American History
- This is NOT a prediction. Repeat, This is NOT a prediction.
- Instrument records have revealed major magmatic movement for 400 miles on the east side of CA, and the tilt and movement will trigger the San Andreas and possibly the San Jacinto, Elsinore and other faults.
- If I am wrong, may God forgive me.

Follow-up post

- Thanks to my hysteria, I've incorrectly posted the date that this will occur. It could be days to a few weeks as the MBP has NOT yet occurred. The SPI take place first then the MPB takes place just before the quake 24 to 72 hours.
- However the magnitude and area is correct. It will be well over 8+

Biological Earthquake Prediction

- Charlotte King
  - http://www.viser.net/~charking/
- "Unusual" ability to hear ULF, VLF, and ELF sounds
- For example, she claims sounds change pitch or rhythm, then a quake over 5.0 happens in 72 hours.

Are you sensitive? Charlotte King

- If you walk into a room and bump into furniture or you go to pour some juice and miss the glass, or go to put sugar in your tea and end up with sugar on the table, you may be clumsy, or you may be a potential biological sensitive..
- "Do you all the sudden crave popcorn.. you don't know why.. you just want it..
  - this is a definite precursor to earthquakes or volcanic eruptions…
- the event will hit within 12-24 hours."

Charlotte's details

- [She] discovered that if a quake was building in volcanic areas, the headache was a full-blown migraine. [She] had vertigo problems and her heart was hurting with small, sharp electrical-like shocks.
- Her accuracy rate is "85-90+% for quakes over magnitude 6; 100% for Mt. St. Helens; and near 100% on other volcanoes, for time, magnitude and location."

http://www.sollog.com/Quakes00.shtml
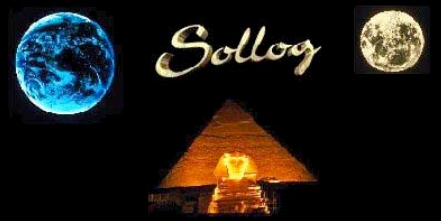
Sollog

PROPHECIES	BOOKS	MUSIC	NOSTRADAMUS
QUAKES	DISCOVERIES	ART	PLANE CRASHES
TERRORISM	DEATHS	POETRY	HURRICANES

Sollog's 2000 Easter Quake Prophecy
Hannakah Quake strikes where Sollog GUARANTEED!
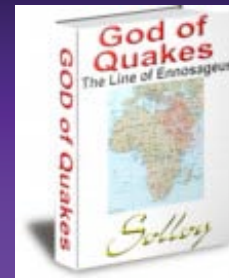XMAS QUAKE strikes where Sollog GUARANTEED!
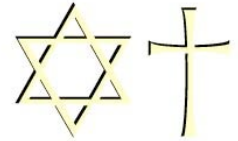
Line of Sollog
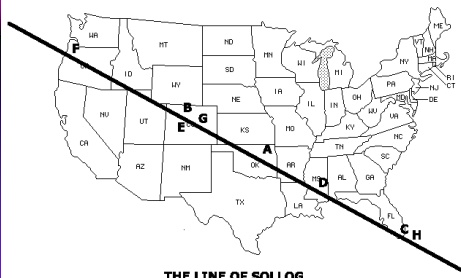
THE LINE OF SOLLOG

A. Oklahoma City Bombing
B. Jon Benet Ramsey Sacrifice
C. Versace Sacrifice
D. Pearl High School Shooting
E. Michael Kennedy "Accident"
F. Springfield High School Shooting
G. Columbine High School "Massacre"
H. Valujet 592

Sollog's books

God of Quakes
The Line of Ennosageus
GOD of Quakes
Sollog

The C.R.E.A.T.O.R. Formula
The Mathematical Proof of God
Written By Sollog

More Sollog

Ennis' mug shot from the Broward County Sheriff's Office, 2005.

- The recent earth quake predictions made by Sollog that occurred on the exact dates he gave, "have been estimated by seismology professors at odds up to 3.65 Billion to 1".
- Sollog says the reason he is so accurate, is to warn that
- **Nuke Terrorism is near!**
- Subscribers to the Usenet newgroup alt.usenet.kooks named him "Kook of the Month for June 1998

Another Prophet Gordon-Michael Scallion

- Some predictions from 1995
  – We can check for accuracy:
  – three new plagues,
  – super-mega earthquakes will hit the Ring of Fire,
  – Palm Springs will get a 9.0 earthquake (+/- 0.5),
  – eruption of twelve volcanoes worldwide,
    • reduced sunlight, physical and emotional problems, and
  – beginning stages of Armageddon.

http://www.nhne.com/specialreports/srscallion95.html

Gordon-Michael Scallion's
FUTURE MAP OF THE WORLD

Symmetrical Astrology
Janus 2 Software
Steve Lee

MC ^ Uranus
approx 4.5 d orb

MC / Apollon = Asc, Hades
"At this time and place is widespread misery, destruction."

Asc Hades Conjunction
by approx 5 min orb

Pluto 180 Asc, Hades
by just over 3 deg orb

Saturn / Node = Asc, Hades
Admetos / Vulcanus = Asc, Hades
Ad + Vu "Compression; forming of blocks and boulders"

Local MC
239d 51m
= Moon / Asc, Hades

Inscrutable

junojuno2.tripod.com/earthquakes.html

SEATTLE EARTHQUAKE 28 Feb 01 10:54 AM PST +8

Slide 1

Eclipse Path Data | India | 11 Aug 1999 Central Total | OK

Begin/End at Sun rise/set   Begin/End at .5 hr intervals   Print Stop Help Close

Kabul
Afghanistan
China
Lhasa
Pakistan
New Delhi Nepal Katmandu Bhutan
Red lines = path of totality Brahmaputra
1999 Solar Eclipse.
Karachi Ahmadabad Bangladesh Dhaka
India Calcutta
Arabian Sea Burma
Bombay Laos
Bhuj, India Hyderabad Bay of Bengal Rangoon
Thailand
Madras Bangkok
MAP BY JANUS 2 SOFTWARE.
Sri Lanka
Columbo
Indian Ocean

Relationship between Jan 2001 India Earthquake and 1999 Solar Eclipse path of totality.

S. Lee, Symmetrical Astrology

Slide 2

http://www.damien.edu//lee/lee_english.html

- … cycles of earthquakes in relationship to solar and lunar eclipses have been charted down to the minute.
- There are consistent patterns that show up .

Slide 3

Eli

Slide 4
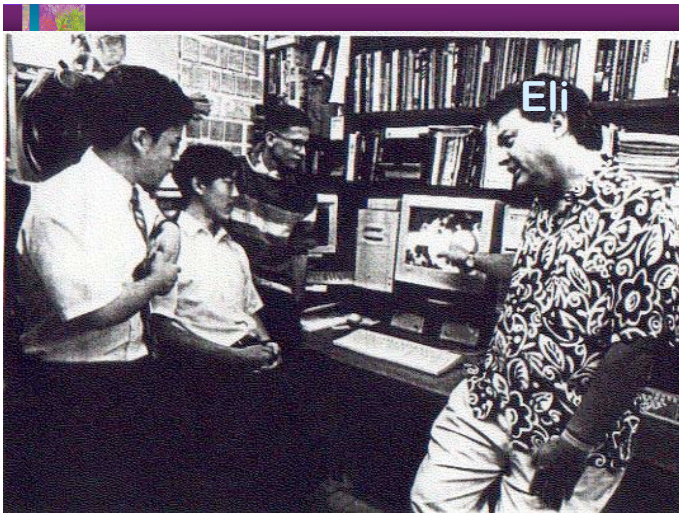
Eli's results

- On July 20 1963, Anchorage Alaska was visited on that day by a solar eclipse.
  - Eight months latter a 9.2 earthquake strikes Anchorage leaving a path of devastation.
- In New Madrid, a solar eclipse took place 3 months before the quake over the great lake Michigan and Lake Erie.
  - These two lakes have a fault connection on the New Madrid Fault and they hold the key to understanding the New Madrid fault especially Lake Erie.
- In Feb. 26, 1979 a solar eclipse took place over Mt. St. Helens volcano in the Pacific North West.
  - 15 months later it erupts.

Slide 5

9801010732.jpg
ftp://weather.cs.ucl.ac.uk/Weather/gms/jpg/ir1/4km/
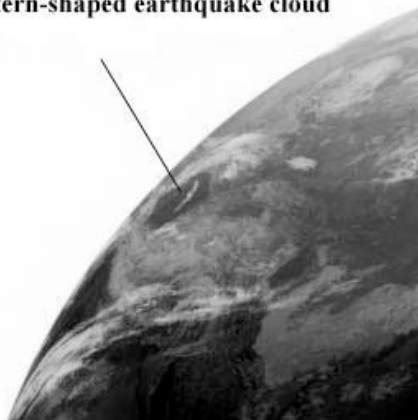http://quake.exit.com/
A lantern-shaped earthquake cloud

Quake cloud!

Slide 6

Northridge cloud

Around 7:15 a.m., January 8, 1994 the cloud suddenly appeared, shaped like sword, rising like a launching rocket in the northwest sky from Pasadena

Nine days later, an M 6.7 quake struck, supposedly without warning!

Another

- 1/12/99: "The world has been void of M6 quakes for too long. Expect an M6 or larger in China or New Zealand."
- 1/27/99: "Well, the M6 hit in Columbia, not in China, and unfortunately in a populated area. Damage is severe."

A bigger nuisance

- James O. Berkland
  - SYZYGY…An Earthquake Prediction Newsletter
  - http://www.syzygyjob.org
  - I am a country boy who grew up in the Valley of the Moon, in Sonoma County, north of San Francisco.
  - I was the first County Geologist for Santa Clara County from 1973 until my retirement in 1994.
  - I have been recognized in about eight Who's Who Publications.

Berkland example

- For the May 3-10, 2000 window I make the following predictions, with 80% confidence:
  - Within 2-degrees (140 miles of San Jose, CA) there will be a 3.5-6.0M earthquake;
  - Within 140 miles of Los Angeles, CA there will be a 3.5-6.5M earthquake.
  - In Oregon and/or Washington there will be a 3.0-5.0M earthquake.
  - Somewhere on Earth (probably within the Pacific Ring of Fire) there will be a major event of at least 7.0M.
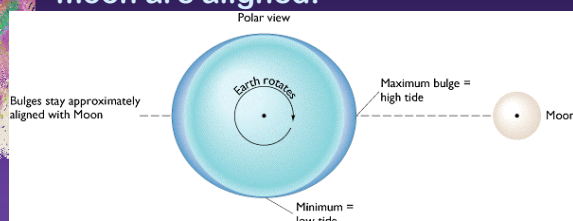
More from web page

- The 'Earthquake Lady', Clarisa Bernhardt, phoned me last week with a psychic seismic concern about California for April 15-May 15, 2000.

Basis of Berkland's predictions: Just as water is pulled and deformed by the moon, the solid earth is too. Solid earth tides are highest when sun and moon are aligned.

Polar view. Earth rotates. Bulges stay approximately aligned with Moon. Maximum bulge = high tide. Moon. Minimum = low tide.

Many studies have been done on this subject, and only a very, very small effect has been found.

Warning (from Drudge page): Planetary Alignment

- Idea is that gravity from all these bodies will "pull" stronger tides than usual.
- Planetary alignment fears are ancient
  - First recorded prediction in 300 BC
  - In February 1954, a similar alignment led the Chinese to restart their calendar at year 0
  - In 1962, panicked people surrounded Griffin Observatory
  - In 1982, "Jupiter Effect" was published
   - Predicted California earthquake

Prediction of ultimate disaster

- Not that infrequently, Jupiter, Mars, Mercury, Saturn and Venus will appear tightly clustered in the sky
- No astronomical significance to the pileup. It is just a "pretty coincidence."
- In the months before the May 2000 lineup, some thought it foretold widespread catastrophe.

Picture of 2000 alignment

DisasterRelief.org

The claim in 2000

DisasterRelief.org
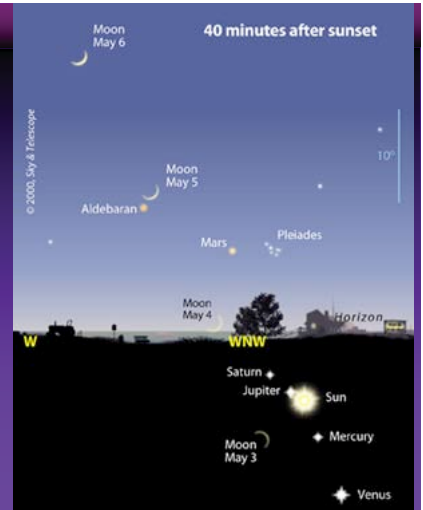
- Geological Armageddon
  - You'd have volcanism going on globally.
  - Earthquakes beyond the scale of anything Richter ever dreamed of.
  - Tsunamis hundreds of feet high.
  - The civilizations that built the pyramids disappeared because of planetary alignment.
- Richard Noone
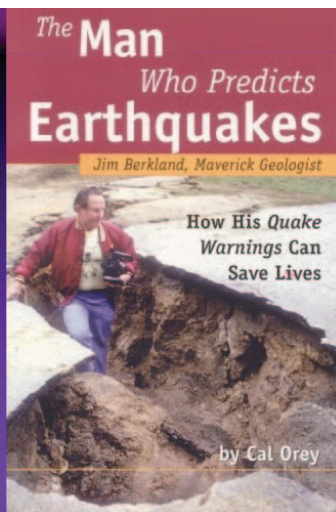 - 5/5/2000, Ice: The ultimate disaster

Best guess by scientists

Duncan Agnew

- Some work by me, a guy at UCSD, a woman in Japan, and mostly my ex-student Prof. Elizabeth Cochran
- Looked at lunar tides, the biggest tide
- At most favorable times for quakes, the risk of a quake is about 1% higher than average most places
- Risk is not noticeably different than normal
- A few places around the Pacific, when tide goes down 3+ meters, earthquakes can be twice as likely as average

New Berkland Biography

The **Man** Who Predicts **Earthquakes**

Jim Berkland, Maverick Geologist

How His *Quake* *Warnings* Can Save Lives

by Cal Orey

- By Cal Orey
- Amazon.com Sales Rank: peaked at #79,834 in Books
- I added a review.

China discouraging predictions

- From journal *Nature*, January 28th, 1999
- Unofficial earthquake warnings
  - 30 in the last 3 years
  - Brought factories and business to a halt
  - None has been accurate
- New law
  - Requires high standard of scientific reasoning
  - Or else predictors will be penalized
 - Being enforced with latest earthquake

A view to kill - James Bond

- An earthquake sensitive region in Northern California, the Hayward Fault, is key to Zorin's attempt to destroy Silicon Valley.
- Zorin intends to destroy Silicon Valley and all its technology by causing earthquakes to swallow the Valley.
- His evil plan is to gain control of the world's supply of microchips.

Not likely

We don't know where to trigger quakes, and can't exert enough force to matter
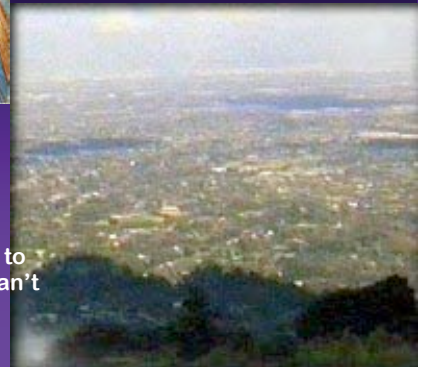
Superman the movie

- Lex Luthor sends two nuclear missiles to strike a stress point on the San Andreas Fault resulting in the western coast of California sinking into the ocean.
- That would turn the desert land he had just purchased into coastal property, making Luthor a very wealthy man.
- Missiles set off earthquake, but Superman flies backward to turn back time, so he can thwart the effort.

Real predictions

- Parkfield seemed to 22 year repeat time
  - Was supposed to happen in 1989 or so
  - Lots of equipment put out
- Broke in 1857, 1881, 1901, 1922, 1934, 1966, ?
- Or were those really similar events?
- We finally got the quake Sept 2004
- Not hard to find spurious patterns
  - Like presidential assassination

Parkfield scorecard

- Right area broke
  - Hole in the seismicity pattern
  - Mostly same as in some previous events
  - Maybe
- Well-recorded
- Broke the wrong way
- 20 years late
- No precursory signals
- Messed up drilling experiment
  - Most definitive instruments not yet in place, unlikely to capture mainshock now

Last two Parkfield events
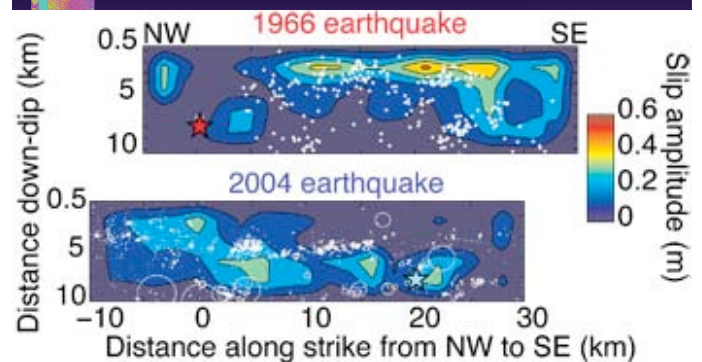
American Presidents

- **1861-1865: A. Lincoln**
  – 1865 April 14, Wounded by assassin John Wilkes Booth; 1865 April 15, died early in the morning from wound in Washington, D.C.
- **1881-1884: J. Garfield**
  – 1881 July 2, Wounded by assassin in Washington, D.C., 1881 September 19, died from wounds at Elberon, New Jersey
- **1897-1901: W. McKinley**
  – 1901 September 6, Shot by an assassin in Buffalo, New York, September 14, died from wounds in Buffalo
- **1921-1924 W.G. Harding**
  – 1923 August 2, died in San Francisco
- **1941-1945 F.D. Roosevelt**
  – 1945 April 12, died at Warm Springs, Georgia
- **1961-1964: J.F. Kennedy**
  – 1963 November 22, Assassinated in Dallas, Texas
- **1981-1984: R. Reagan**
  – 1981 March 30, wounded in an attempted assassination
- **2001-2004 GW Bush? nope**

A more successful prediction

- **1975 Haichung quake**
  – **Predicted**
  – **But there were many M=6 foreshocks**
    • So it was an easier than usual quake to predict
- **1976 Tangshan quake**
  – **No warning**
  – **Probably killed 750,000 people**
    • But official toll was 250,000 deaths
- **Now we do long-term probabilities**
 – **Lecture next week**

Basis of M8

- **different measures of intensity in earthquake flow, its deviation from the long-term trend, and clustering of earthquakes**
- **5-year windows of TIP: "Time of increased probability" assessed every 6 months**

  Prof. Keilis-Borok Works at UCLA and in Moscow

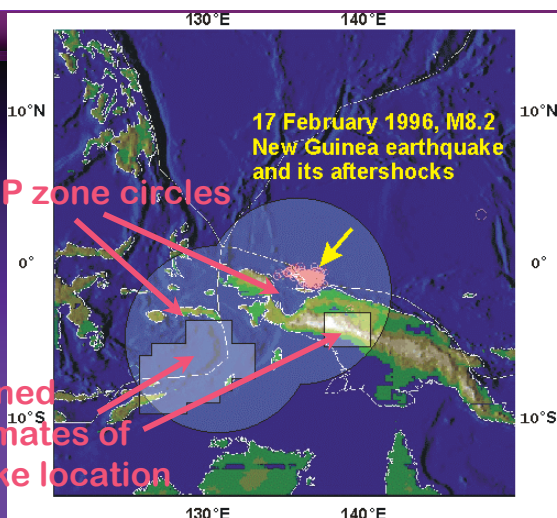- **Inside the TIP zones, 2nd method tries to further limit area of alarm**

M8 - a real forecast

Regions of Increased Probability of Magnitude 8.0+ Earthquakes as on January 1, 1996 (subject to update on July 1, 1996)

17 February 1996, M8.2 New Guinea earthquake and its aftershocks
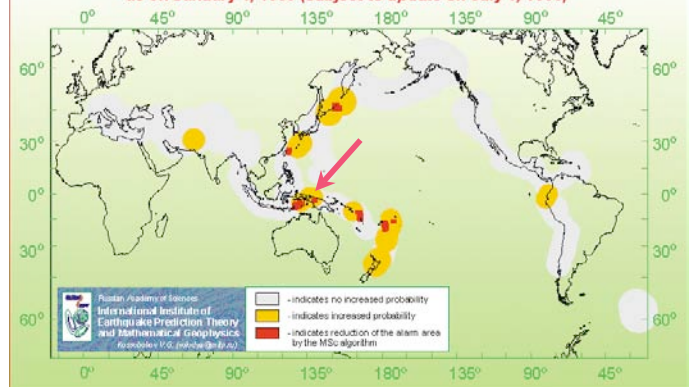
TIP zone circles

Refined estimates of quake location

In fact

- **2004, there was a prediction for Mojave-San Diego area**
  – **M6.4 to 7.4**
  – **Chance was estimated at 50% in next 9 months**
  – **3 different groups, not official**
- **Prediction for the Bay Area**
  – **M6.5+, hit in 2003, another "hit" for Japan**
- **The effectiveness of these methods is still not proven**

Done for the day