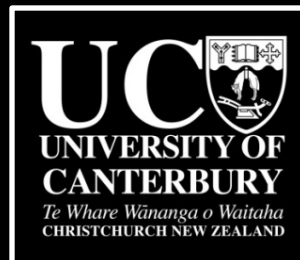


Risk communication: Lessons from the Christchurch and L'Aquila earthquakes



Dr. Mark Quigley

*Department of Geological Sciences
University of Canterbury*



Earthquake fatalities on an increasingly vulnerable planet

Scientific advances are not translating into fewer deaths

Expanding cities are expanding vulnerability and increasing life and financial risk



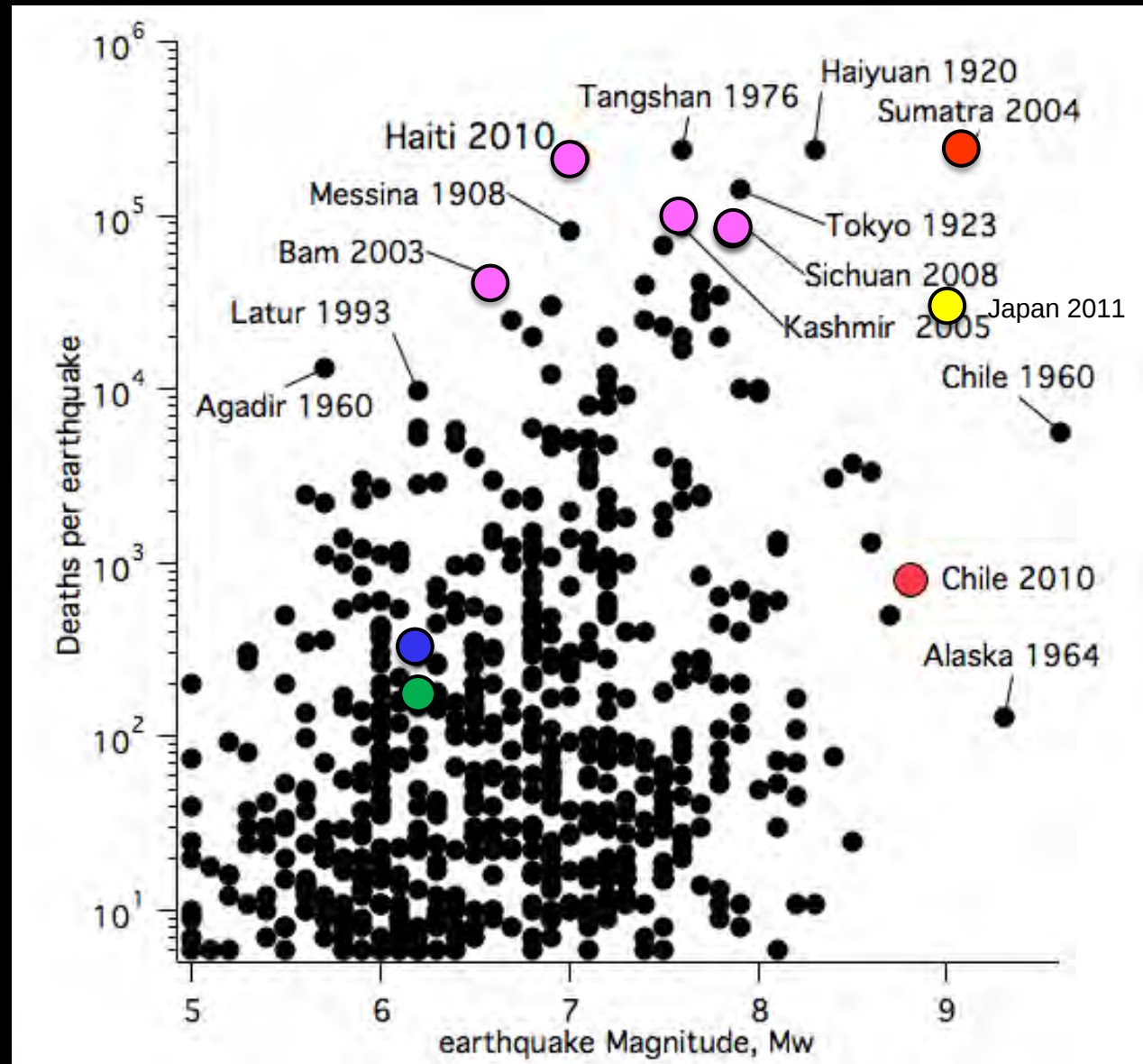
Notable quakes last decade (~630,000 deaths)



Previously unidentified fault

L'Aquila 2009

Christchurch 2011



Italy earthquake experts charged with manslaughter

Risks commission members to face trial over failure to give sufficient warning about L'Aquila earthquake in 2009

David Batty and agencies
The Guardian, Thursday 26 May 2011
[Article history](#)



Science Insider

Breaking news and analysis from the world of science policy

Japan's Earthquake Off the (Seismic Risk) Map

by Dennis Normile on 11 March 2011, 9:51 AM | [Permanent Link](#) | [20 Comments](#)

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TOKYO—The most surprising thing about the magnitude-8.9 earthquake that hit Japan today is that it was a surprise. Despite what may be the world's most intensive effort to map faults and assess risks by a notoriously earthquake-prone and earthquake-conscious nation, such a strong quake was not anticipated for the region, says University of Tokyo



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12 August 2010 Last updated at 08:11 GMT

Haiti quake was caused by previously unknown fault

By Victoria Gill

Science reporter, BBC News

The last decade has forced us to have a major rethink about how we communicate seismic hazard and risk

L'Aquila

- Situated within one of the most seismically active regions in Italy
- Largely destroyed by major earthquake in 1703
- An earthquake-aware society paradoxically co-existing with an abundance of quake-vulnerable buildings
- A 'cultural' approach to personal hazard mitigation

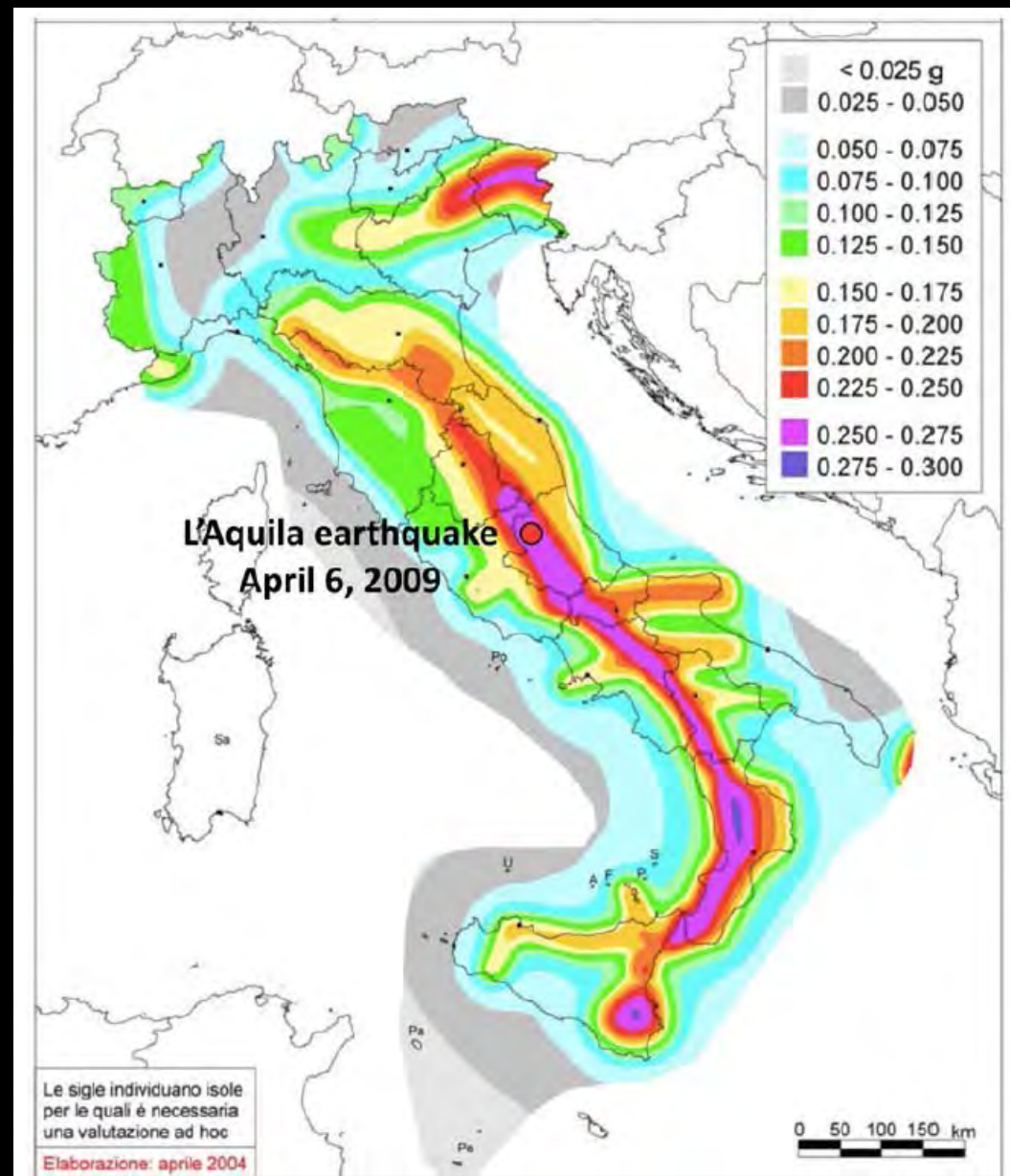
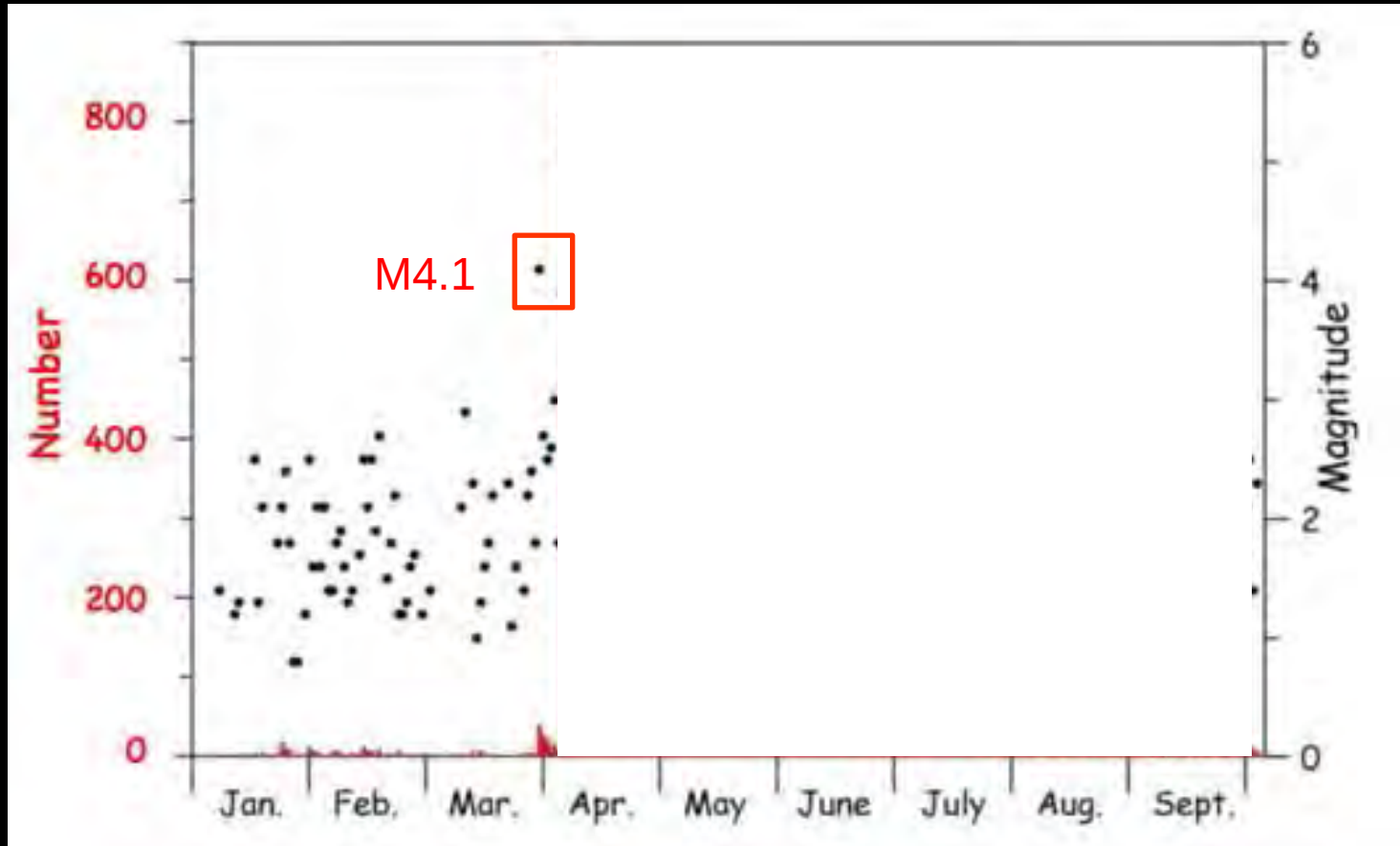


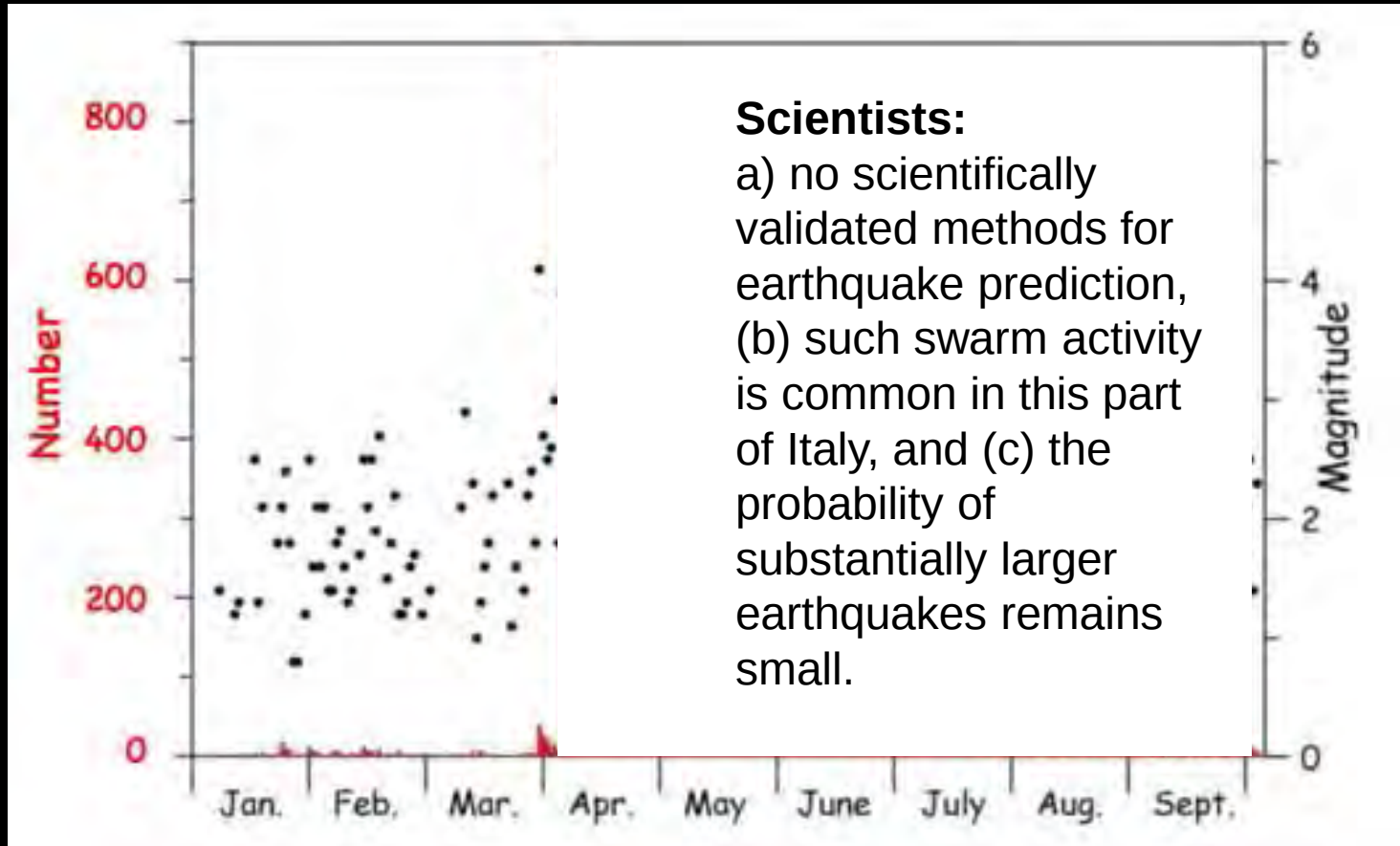
Figure 1.2. The probabilistic seismic hazard map for Italy [1], showing the location of the L'Aquila earthquake of 6 April 2009. The colors indicate the ground acceleration with a 10% probability of exceedance in 50 years, measured in units of surface gravitational acceleration, $g = 9.8 \text{ m/s}^2$.

Seismicity prior to L'Aquila eq



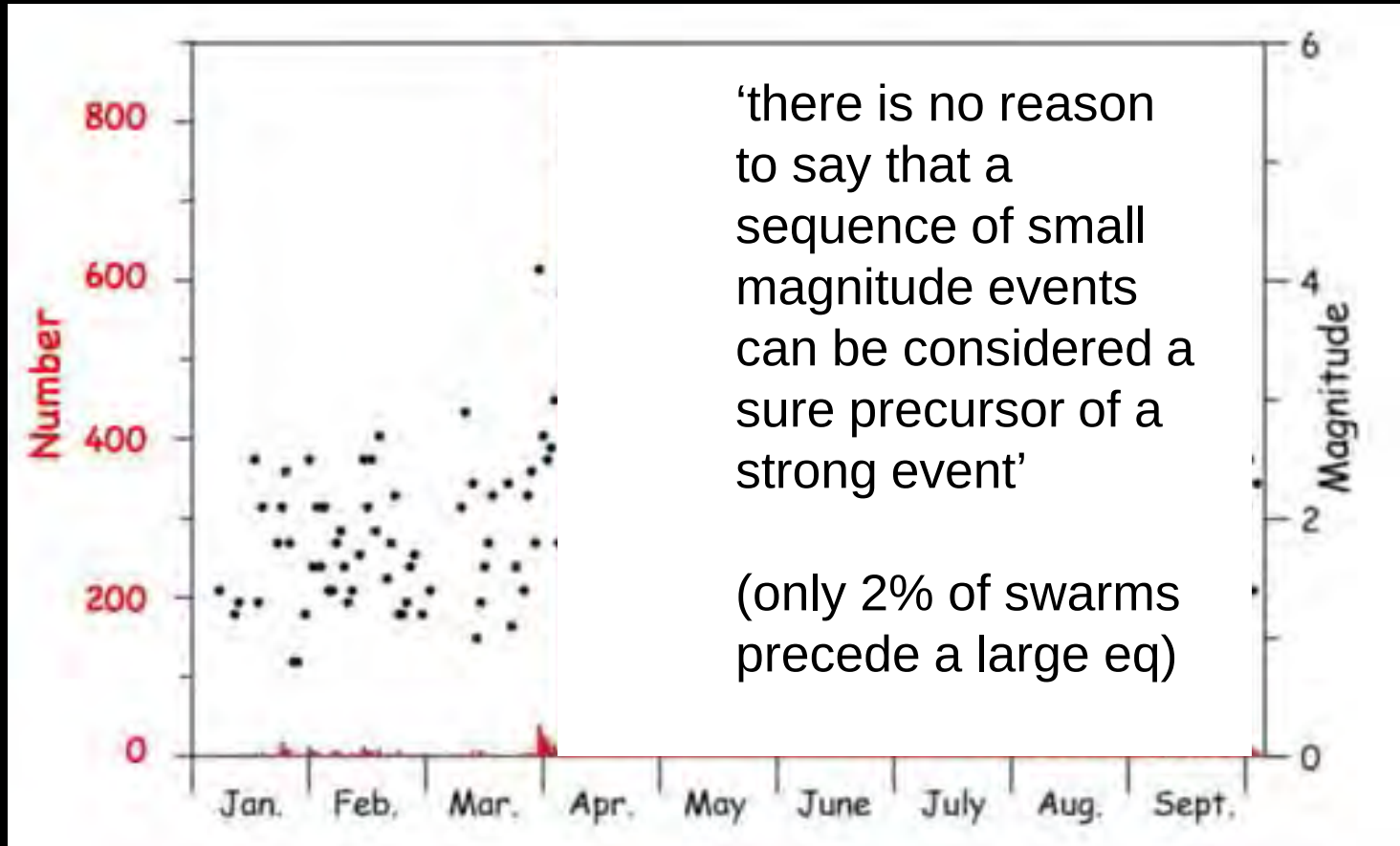
Feb-April 2009: Earthquake swarm - prompted school evacuations, increasing fear, eq 'predictions'

Seismicity prior to L'Aquila eq



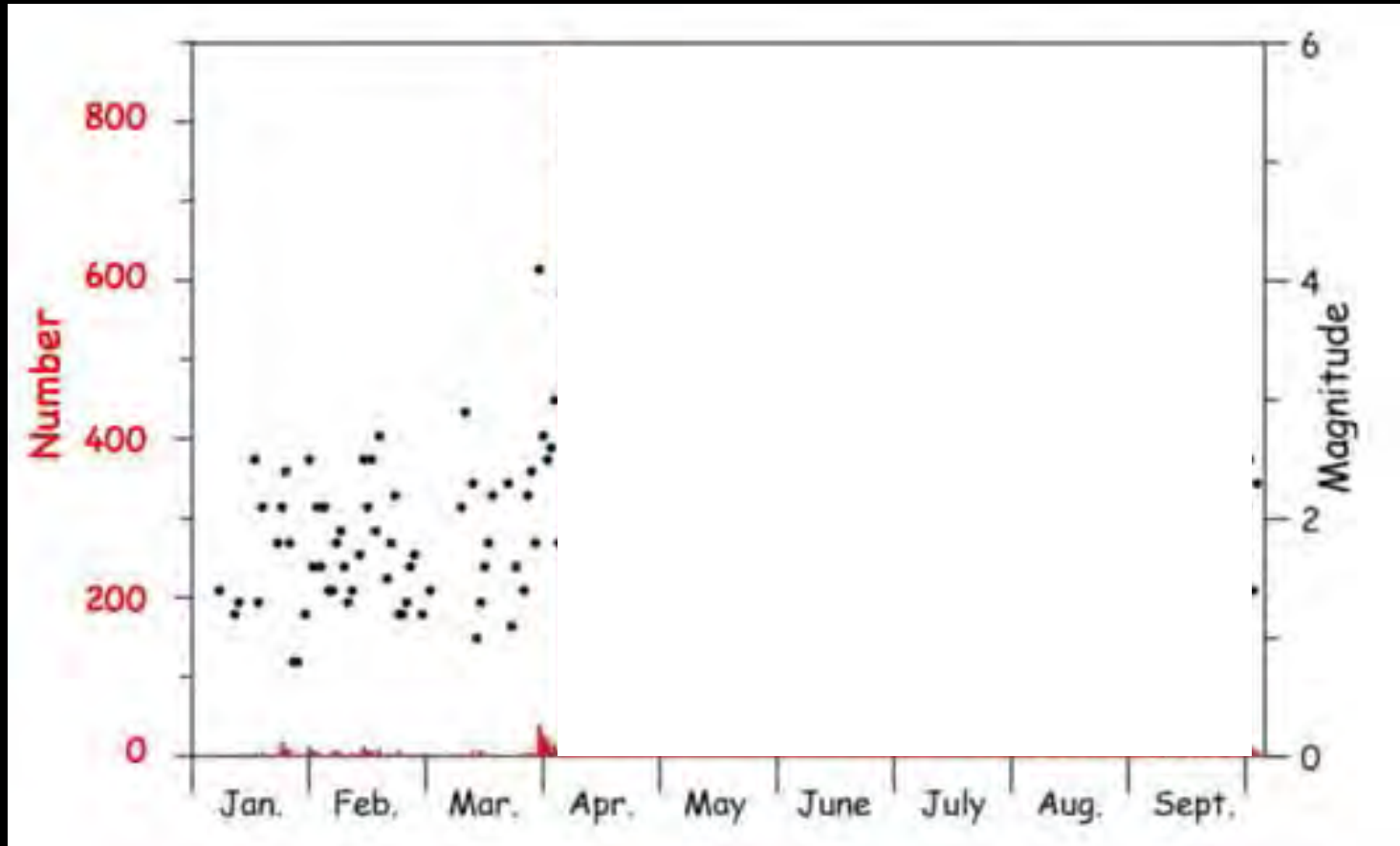
March 31: Meeting of *National Commission for Forecasting and Predicting Great Risks* that advises Italian Government releases statement

Seismicity prior to L'Aquila eq



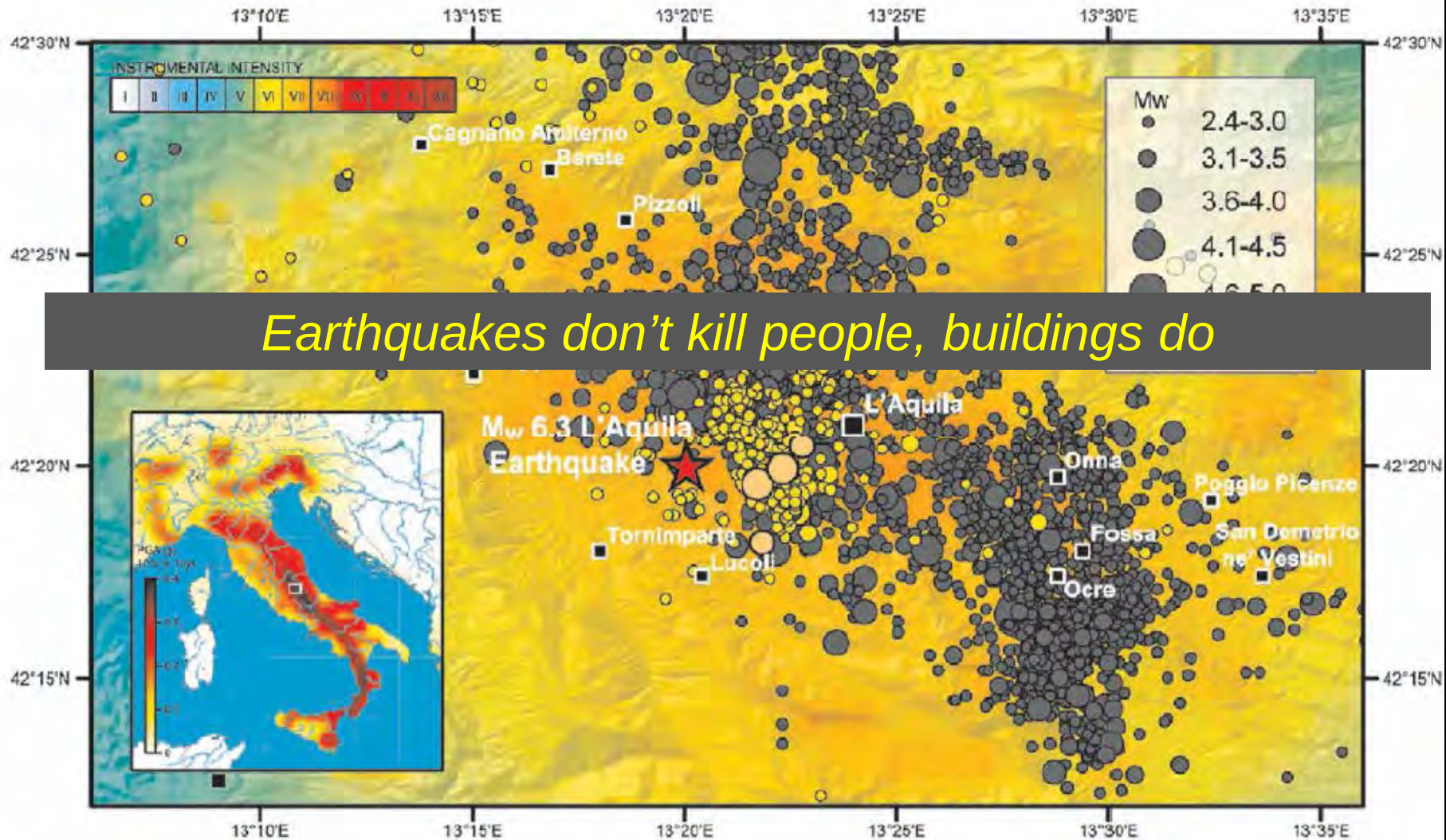
March 31: Meeting of *National Commission for Forecasting and Predicting Great Risks* that advises Italian Government releases statement

The L'Aquila statement

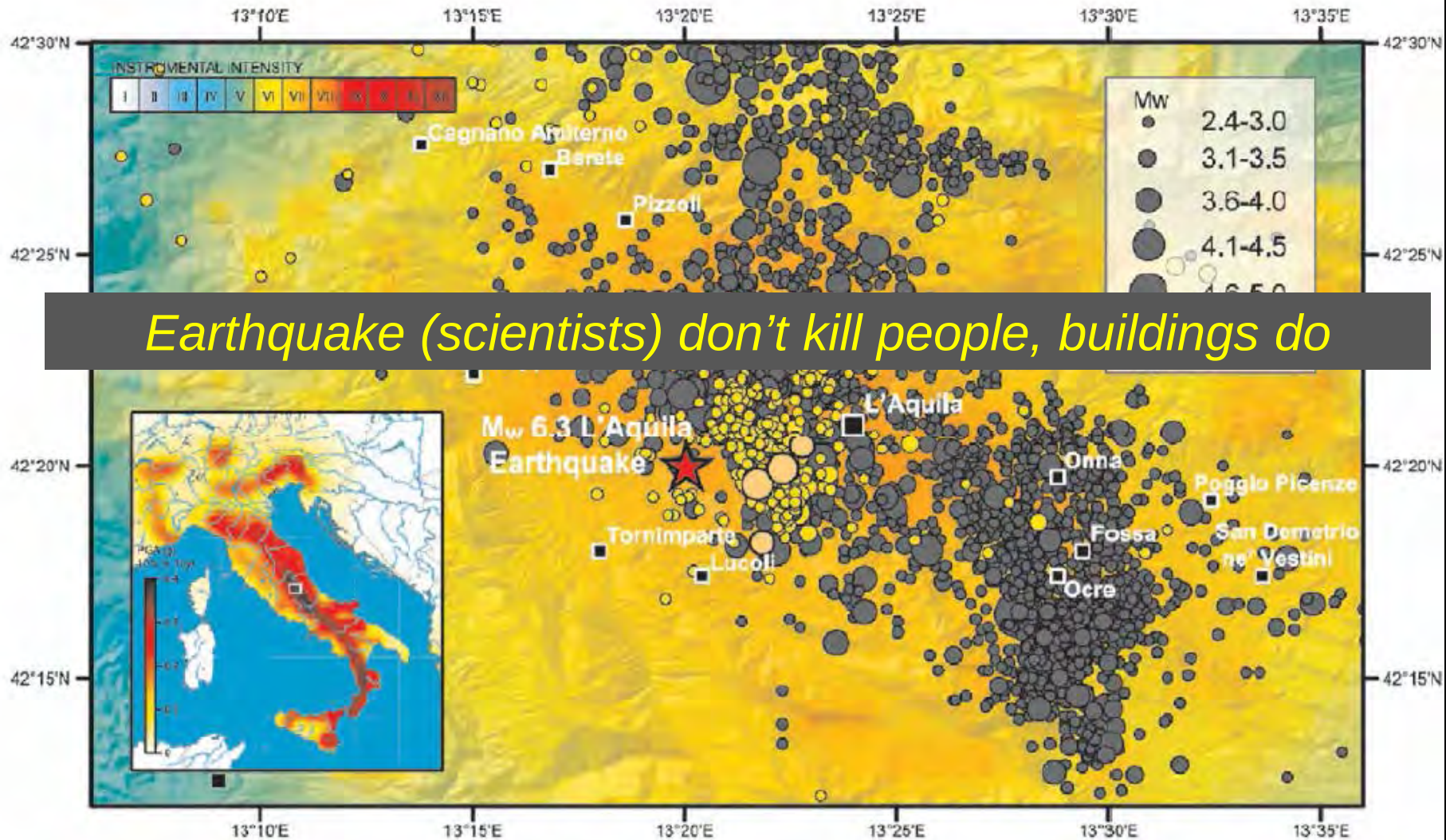


'The scientific community tells me there is an ongoing discharge of energy – the outlook seems positive'

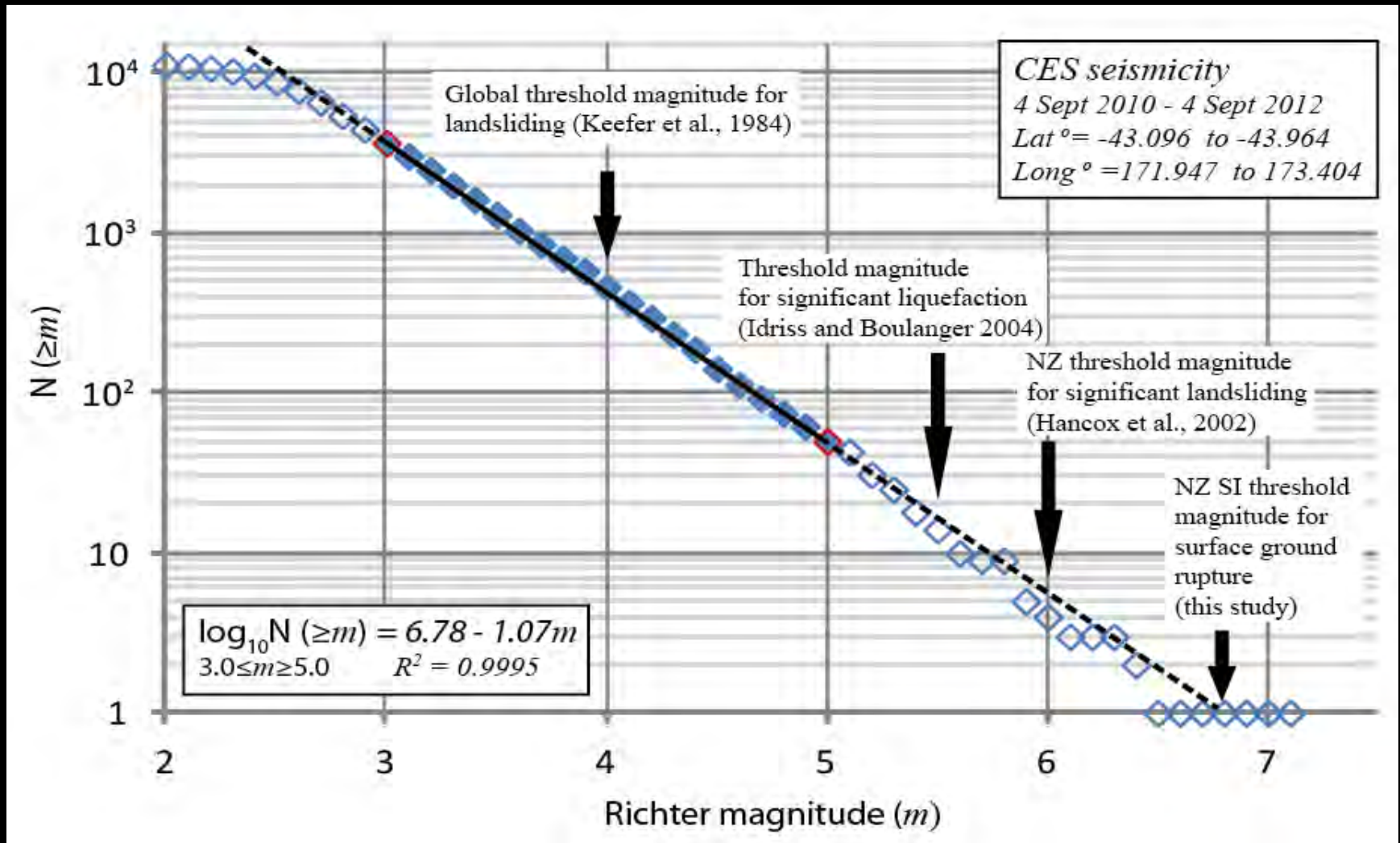
L'Aquila, April 6, 2009: Mw 6.3, 309 fatalities, 20,000+ buildings damaged



L'Aquila, April 6, 2009: Mw 6.3, 309 fatalities, 20,000+ buildings damaged

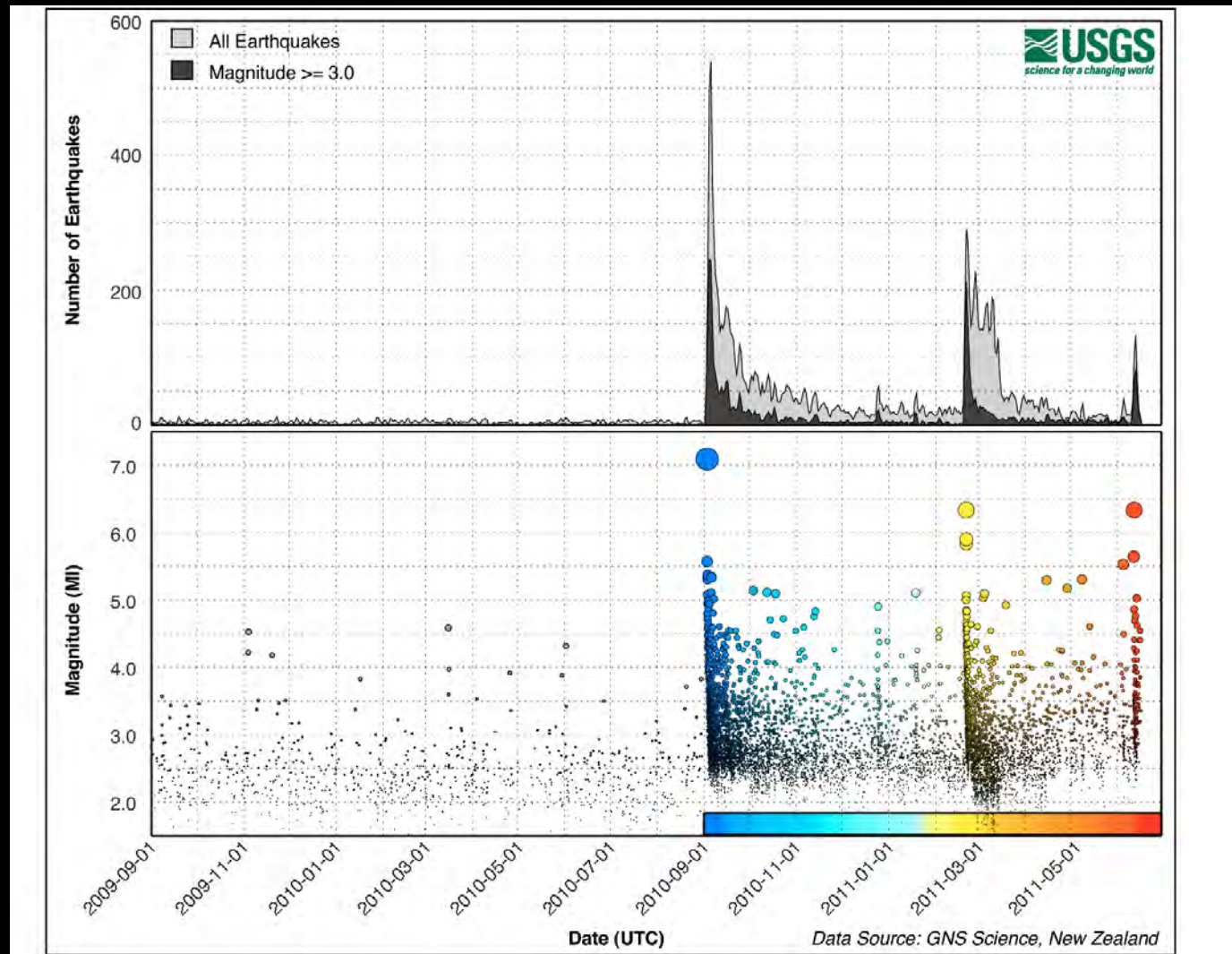


A brief aside: Truth and beauty of earthquakes



The G-R relationship and how it informs seismic risk

A brief aside: Truth and beauty of earthquakes



Omori's Law, Bath's Law and how they inform seismic risk

1. More frequent small earthquakes increase the probability of a larger earthquake (G-R rel and Omori's Law)

2. This is a small change in absolute probability, particularly on short-time scale (daily)

the daily probability was much below 1% on day of L'Aquila quake

BUT

3. This is often a large (several orders of magnitude) increase in 'relative' probability

the occurrence of a L'Aquila size earthquake was 5-100 times more likely (depending on area considered) on 6 April 2009 than forecast in this area from the long-term reference model

The Prosecution's Case against the Scientific Committee (6 scientists and 1 Govt official)

"[the messages from the commission meeting] may have in some way deprived us of the fear of earthquakes. The science, on this occasion, was dramatically superficial, and it betrayed the culture of prudence and good sense that our parents taught us on the basis of experience and of the wisdom of the previous generations."

Statement from man who lost his family in the L'Aquila earthquake, after deciding not to sleep outside in the courtyards as was tradition during earthquake swarms, based on scientific advice

The Verdict

Sentenced to 6 years in prison for multiple manslaughter based on the 'inexact, incomplete and contradictory' information given prior to the earthquake

Judge ruled that inadequate risk assessment and scientifically incorrect messages given in public statements by the group prior to the earthquake ultimately contributed to a higher death toll when the earthquake eventuated

7 Lessons from L'Aquila

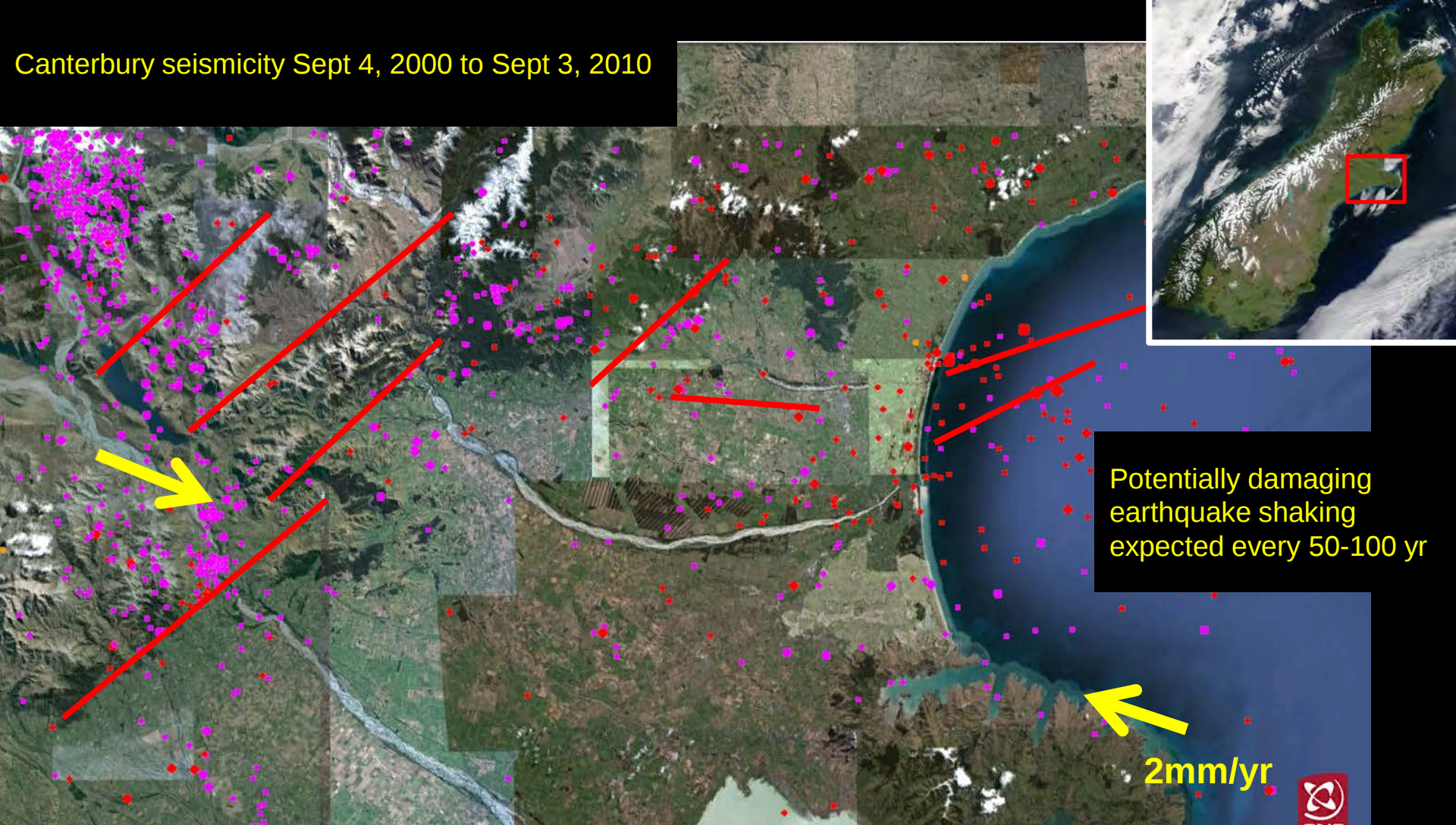
1. The trial is about science communication, not science - extremely important for scientists to have a balanced, clear, and cautious message and to be able to communicate this directly to the public
2. Answers to many of the 'earthquake questions' that affect a stressed public can be pre-prepared in 'peace time', including pre-emptive responses to earthquake-prediction claims that can be rapidly deployed to immediately diffuse the *'prediction effect'*
3. Results from operational earthquake forecasts must be publically available, with uncertainties clearly expressed, and 'worse case, low prob' scenarios stated

7 Lessons from L'Aquila

4. Reporting time-varying **probability changes (e.g pre-event vs post-event)** is as important as reporting the absolute probabilities, which can be very small over short time spans
5. Importance of working with government but NOT letting the message get misunderstood, muted or controlled by figureheads – yielding to pressure for ‘good news’ increases the risk of ‘being wrong’
6. Importance of scientists being able to communicate clearly, honestly and transparently directly with the media through multiple media channels
7. Importance of cultural sensitivity – deployment of ‘experts’ to the affected community is advised if they are not already residents

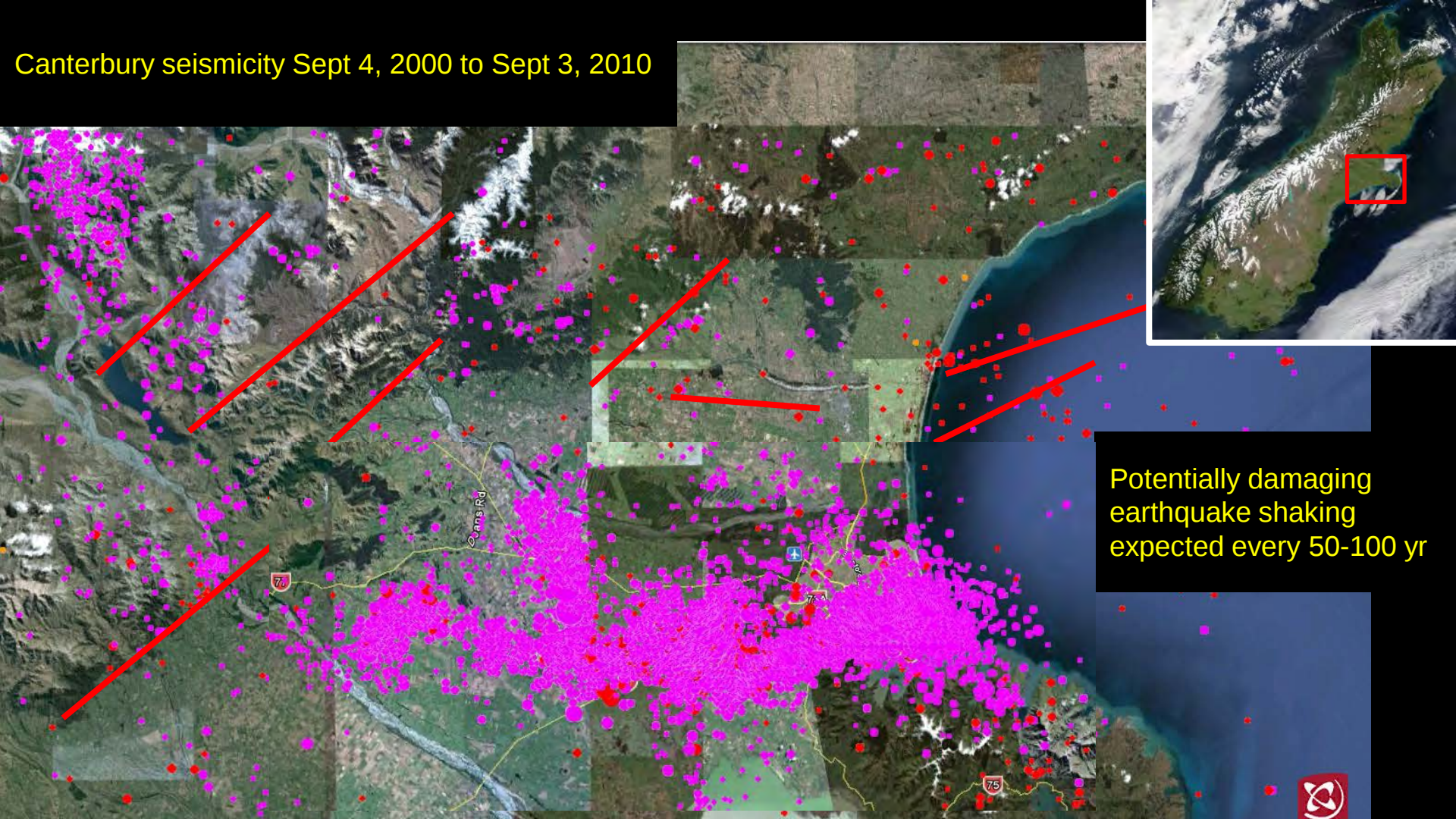
The Christchurch Experience

Canterbury seismicity Sept 4, 2000 to Sept 3, 2010



- Presence of 'unknown faults' beneath the Canterbury Plains acknowledged and some 'blind faults' imaged
- 'Floating' eq source of up to Mw 7.2 quake in NZSHM
- Liquefaction hazard well documented
- Historical record of damaging earthquakes (1869, 1888, 1901, 1922)

Canterbury seismicity Sept 4, 2000 to Sept 3, 2010



Some naive and ill-informed land use planning decisions that increased earthquake vulnerability

A NIMBY earthquake culture (Wellington and the West Coast, not Christchurch)

This changed on Sept 4 2010

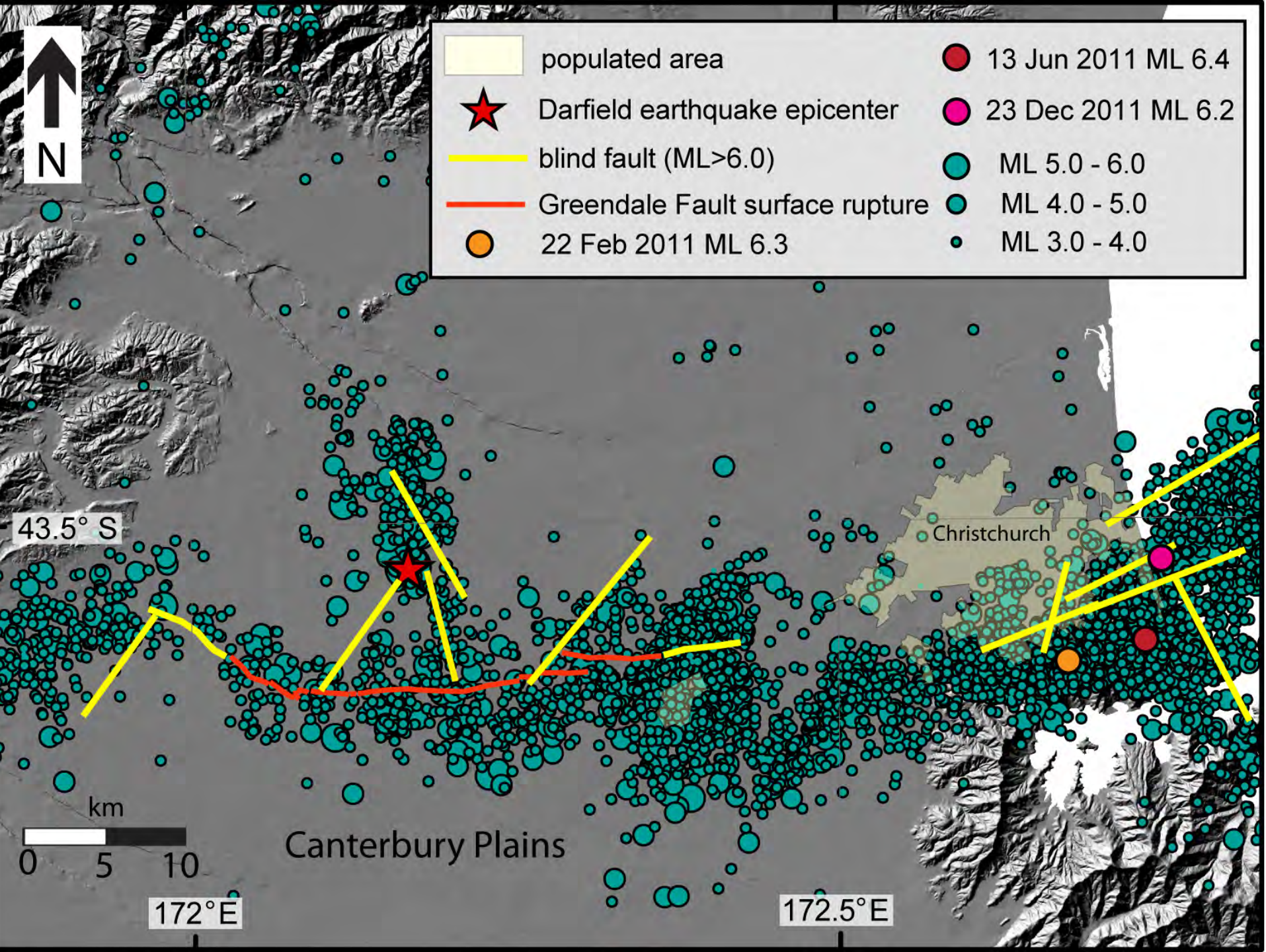


Table 1 Earthquake comparisons

	4 September 2010	22 February 2011	13 June 13 2011	23 December 2011
Mag (M_w)	7.1	6.2	6.0	5.9
Epicentre¹	30 km W	10 km SE	10 km SE	10 km E
Time²	4:36 am	12.51 pm	2.20 pm	3.18 pm
Max PGA³	0.6g (0.3g CBD)	2.2g (0.8g CBD)	2.2g (0.4g CBD)	0.96g ⁴ (0.25g CBD)
Casualties	0 fatalities	185 fatalities	0 fatalities	0 fatalities
Building Damage	To older brick & URM	All pre-1970s & several modern buildings with eccentric design	Further residential damage in Port Hills & already damaged CBD buildings	Minor, but several instances of progressive failure buildings
Liquefaction	Widespread in eastern suburbs	Extreme damage in many eastern Christchurch suburbs	Further damage in eastern Christchurch suburbs	Minor damage in eastern Christchurch suburbs
Cost⁵	4-5 billion	15-20 billion	c. 1.5 billion	c. 26 million

Loss of life and most damage occurred in an 'aftershock'
Most fatalities in two building collapses – building stock performed well from life safety perspective but poorly from a 'post-event functionality' perspective

Table 1 Earthquake comparisons

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Notes:

1. Epicentral distances are with respect to Christchurch CBD

Cost estimates now exceed \$40 Billion – this is almost 30% of New Zealand's real GDP

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Building Damage	To older brick & URM	All pre-1970s & several modern buildings with eccentric design	Further residential damage in Port Hills & already damaged CBD buildings	Minor, but several instances of progressive failure buildings
Prob	1/475 yr	1/12,000 yr	1/1,000 yr	1/300 yr
%	0.2	0.008	0.08	0.3
Cost ⁵	4-5 billion	15-20 billion	c. 1.5 billion	c. 26 million

Notes:

1. Epicentral distances are with respect to Christchurch CBD

Time-evolving hazard from earthquake temporal clustering:

What role can risk communication play here?

What was important immediately post-disaster?

- Willingness to directly engage and communicate the same message over and over across all forms of media
- Willingness and ability to be time-flexible and geographically adaptable (and patient, although not my strongest virtue)
- Broad knowledge base and the willingness to expand this via discussions with colleagues and '10-minute scholarly article reviews'
- Respecting your audience, responding (at some level) to public and media interests, helping channel interests where appropriate
- Being culturally sensitive and 'human'

Christchurch Lesson 1:

Low probability events happen!

Temporal clustering happens!

Aftershocks can be more damaging than
mainshocks!

Hazard estimates can vary dramatically in
time and space!

Christchurch Lesson 2:

The public and stakeholders CAN handle hypotheses, optimism, probabilities, and complex science if it is explained well and if scientists engage with local community

Public forums and lectures, Ask a Scientist, (personal) websites, media interviews (TV, radio, print), Facebook, Youtube

What we know and why we know it, what we don't know, and why we don't know it

'Controlling the message' – direct communication with the public

Dr Mark Quigley

STUDENTS PHOTOS TALKS HOME

HOME

BIO AND CV

ACTIVE RESEARCH

PUBLICATIONS

IN THE MEDIA

TEACHING

SEARCH



WHO'S ONLINE

We have 3 guests online

MAIN MENU

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WELCOME TO MARK QUIGLEY'S HOME

Mark is Senior Lecturer in Active Tectonics and Geomorphology at the University of Canterbury, Christchurch, New Zealand.

For those interested in peer-reviewed scientific articles or international journals, please visit my Publications page (c)

The material below is written in plain language to aid this sequence.

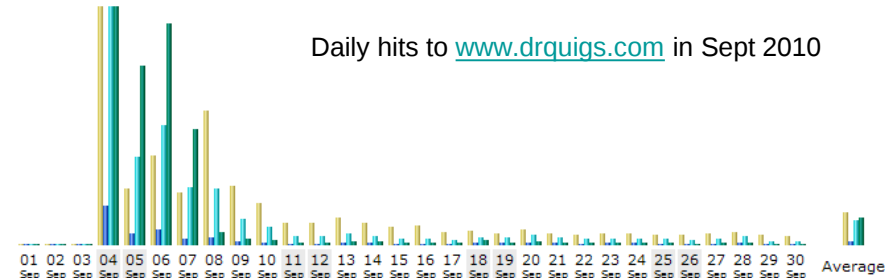
Together with colleagues from several institutions through hopefully answer some of the questions you may have about what can be read at

<http://www.royalsociety.org.nz/2011/03/16/earthquake->

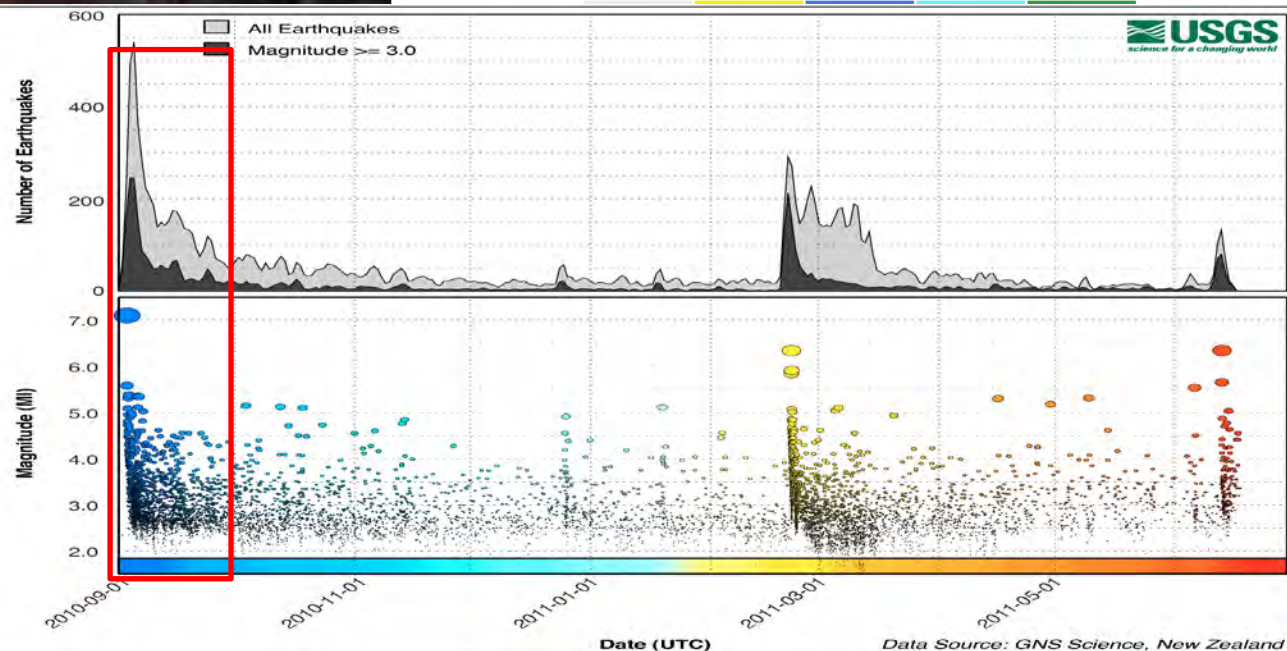
The Greendale Fault map produced by UC and GNS science

Month	Unique visitors	Number of visits			
Jan 2010	178	466			
Feb 2010	318	569			
Mar 2010	213	544			
Apr 2010	455	782			
May 2010	266	778			
Jun 2010	728	1,765	57,578	65,245	8.96 GB
Jul 2010	480	1,147	13,773	21,615	3.58 GB
Aug 2010	533	1,645	12,322	25,740	3.57 GB
Sep 2010	29,630	41,967	335,660	2,310,042	136.92 GB
Oct 2010	5,505	9,648	61,221	311,347	5.34 GB
Nov 2010	3,862	8,550	55,260	194,222	6.54 GB
Dec 2010	3,466	7,687	44,916	91,802	6.08 GB
Total	45,634	75,548	662,062	3,140,276	178.36 GB

Days of month



Daily hits to www.drquigs.com in Sept 2010



Science of science communication:
Positive covariance of website hits with earthquake frequency – magnitude variations



Combining a top-down and bottom-up approach to science communication



Christchurch Lesson 3:

More pro-active pre-event hazard and risk communication could have greatly reduced financial cost and might have saved a few lives



RIP Bexley

Born: ca. 1990s to 2005

Red Zoned: July 2011

Human Nature
*"If you build it, and if they will
insure it, we will buy it"*

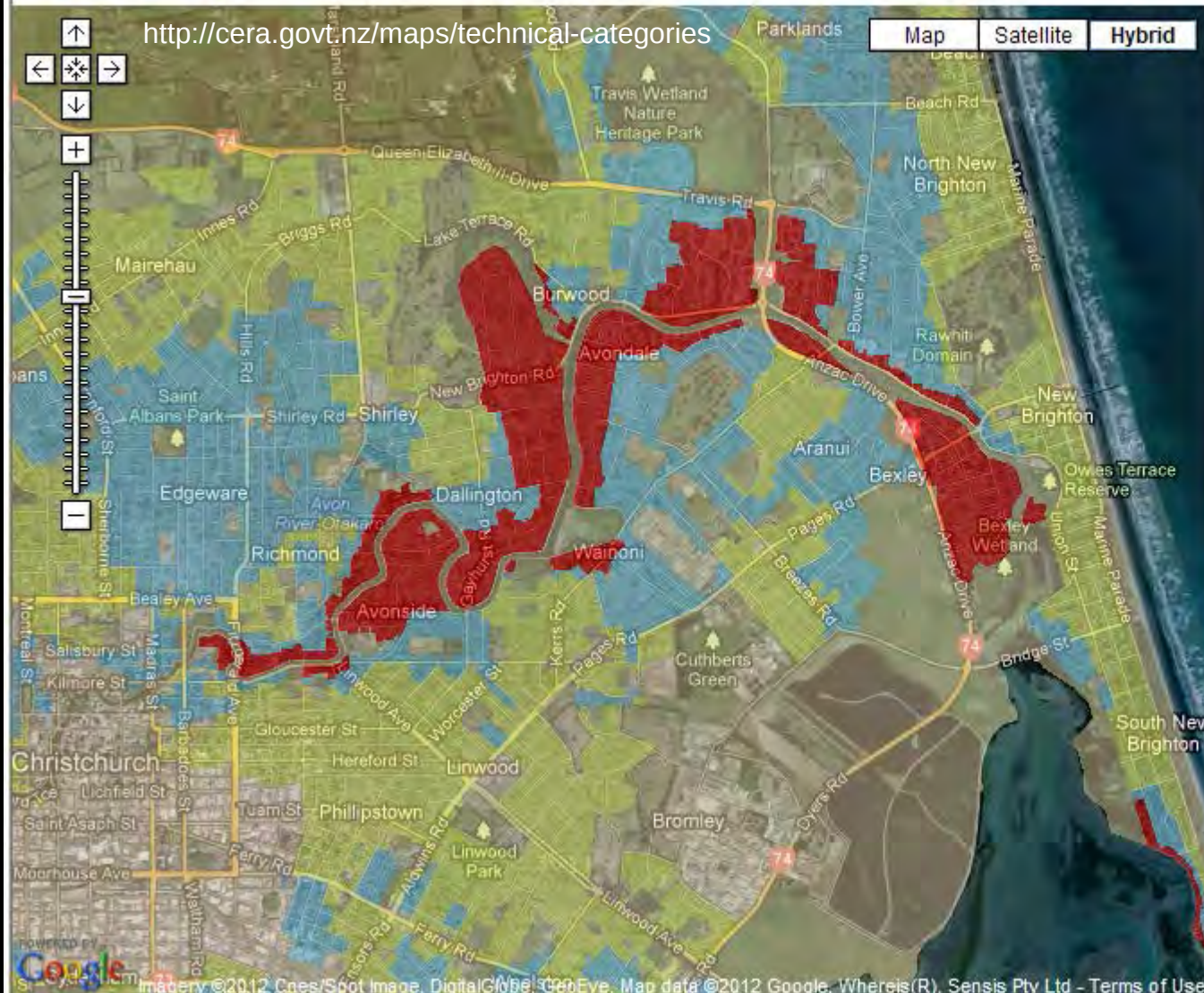
*Developers bought council land in 1980s,
successfully sought rezoning, and built houses
that people bought: who's to blame?*

A 'new' suburb built at
sea-level in a
designated high-risk
flood zone on ChCh's
most liquefaction-
susceptible soils (1/75
to 1/100 yr threshold)

Our recently reclassified landscape: residentially zoned by council, now a \$1.1 Billion dollar question for government

Central City

<http://cera.govt.nz/maps/technical-categories>

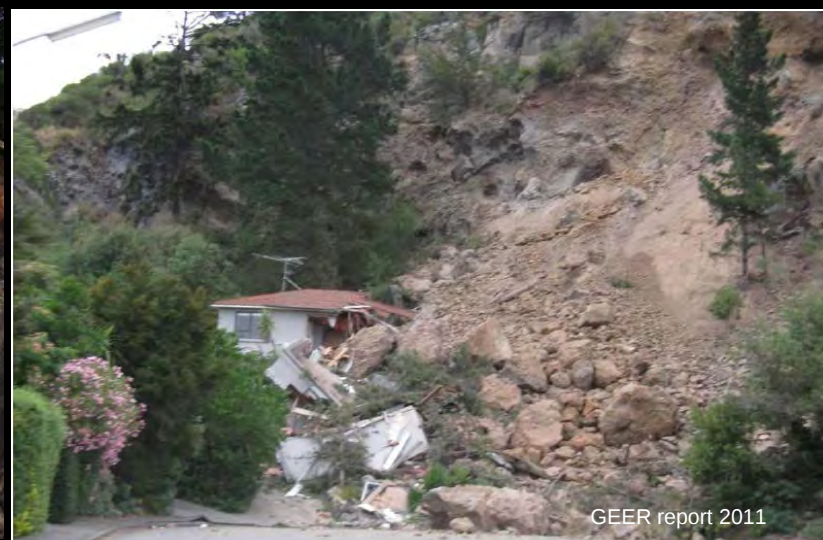


Key

- Technical Category 1
Future land damage from liquefaction is unlikely.
- Technical Category 2
Minor to moderate land damage from liquefaction is possible in future significant earthquakes.
- Technical Category 3
Moderate to significant land damage from liquefaction is possible in future significant earthquakes.
- N/A - Urban Nonresidential
- N/A - Rural & Unmapped
- Port Hills & Banks Peninsula
- Orange Zone
Further assessment required.
- Red Zone
Land repair would be prolonged and uneconomic.

Zoom to areas

- [Central City](#)
- [Eastern Suburbs](#)
- [Kaiapoi](#)



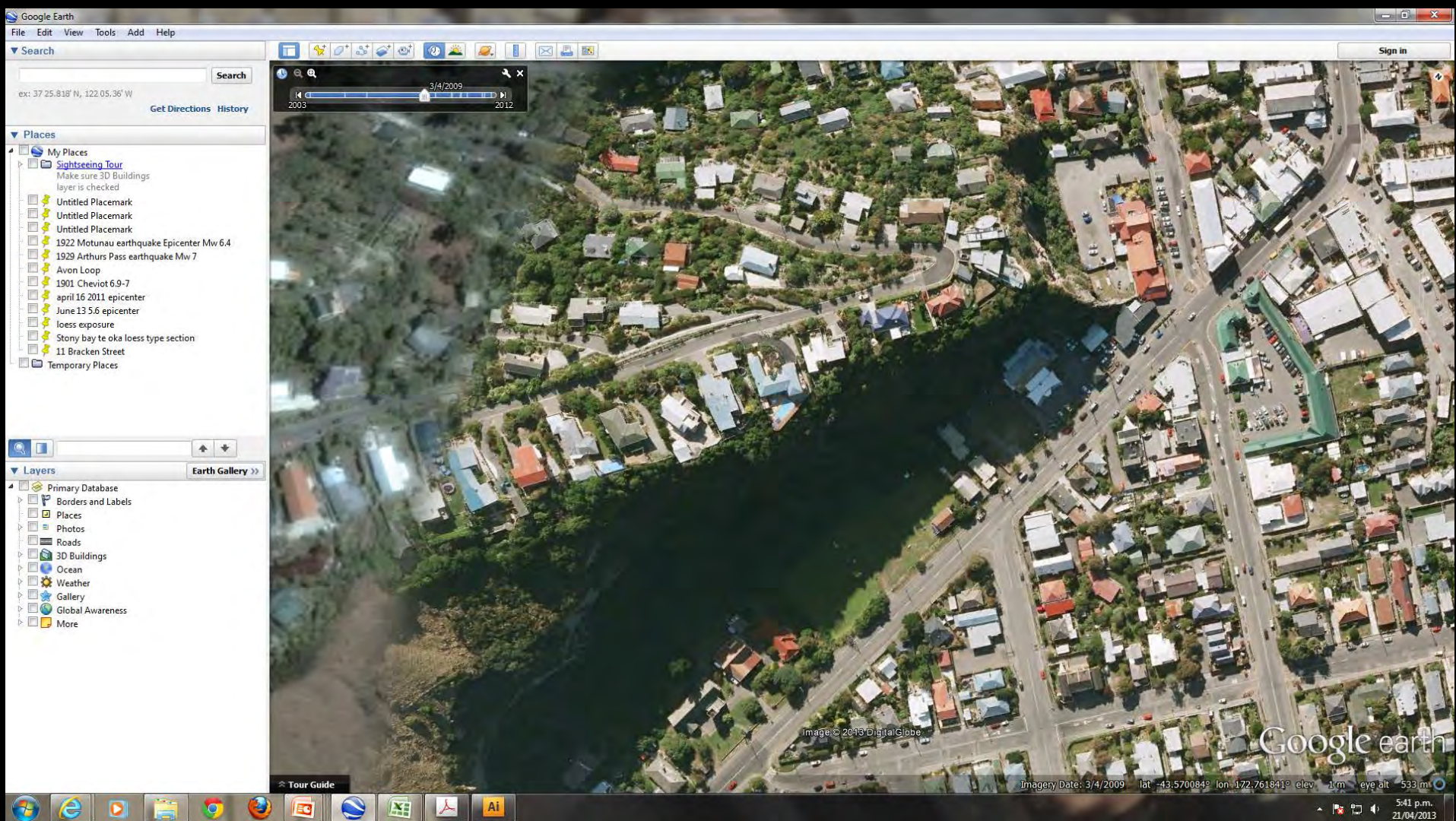
Central City



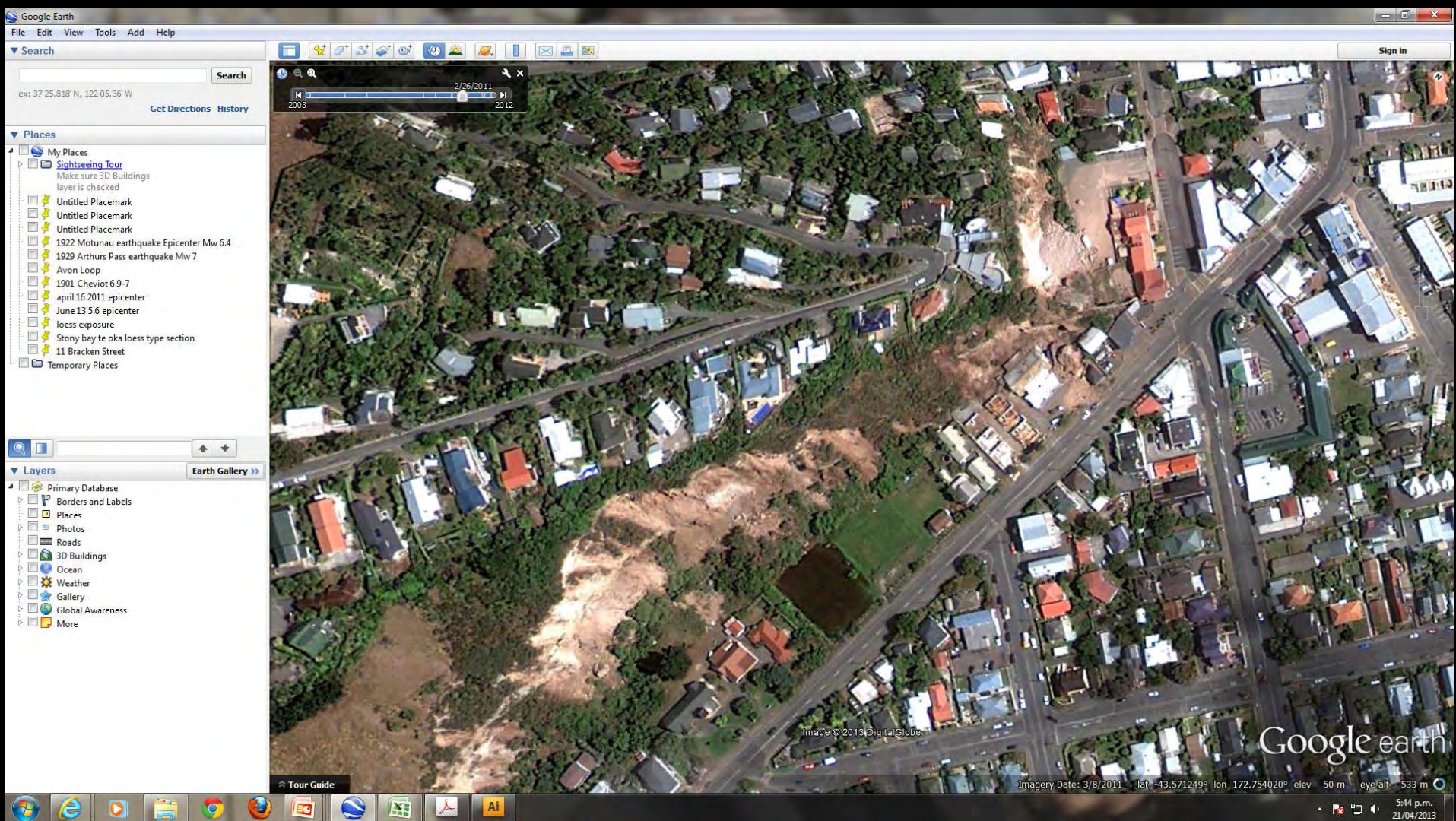
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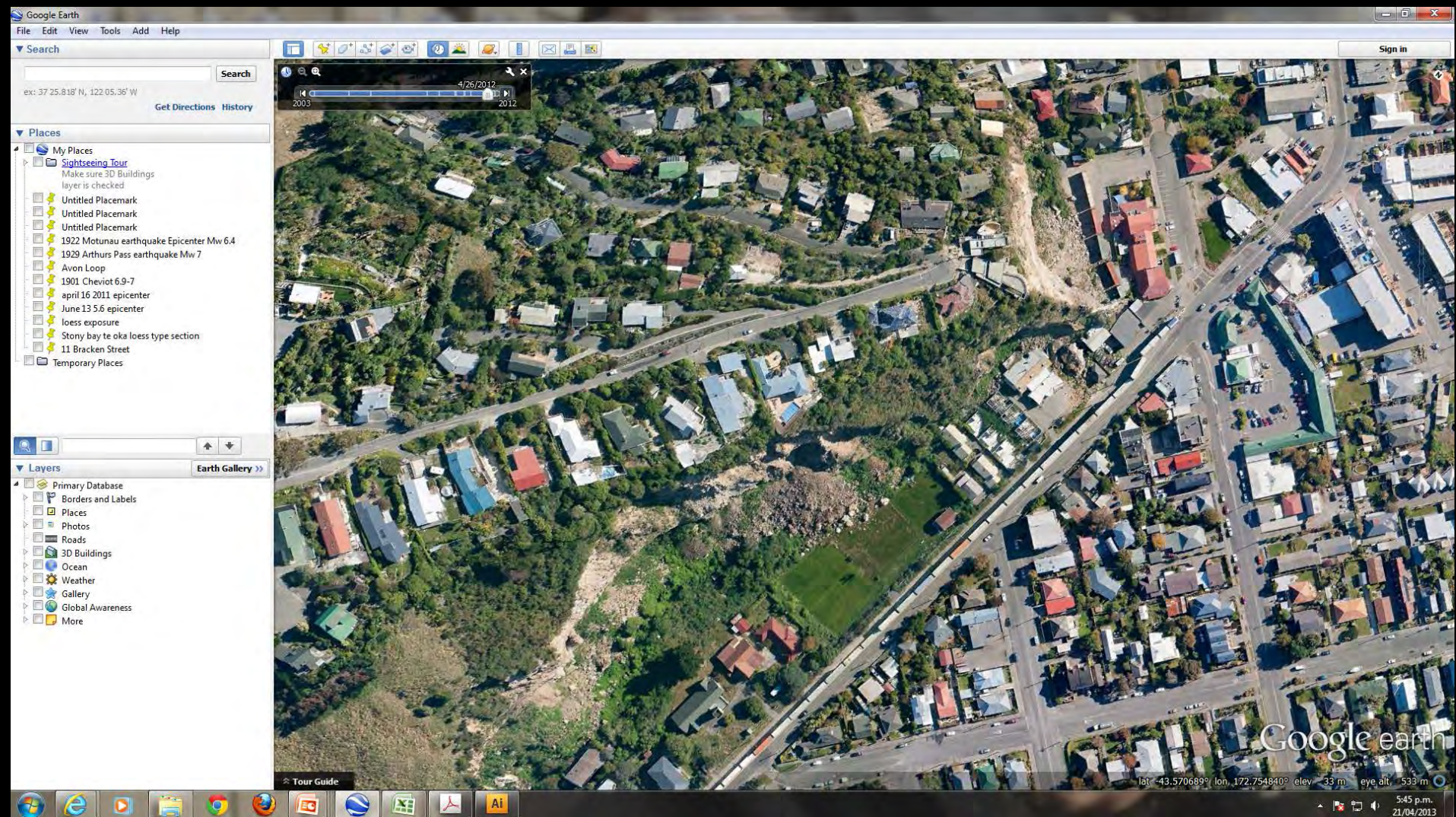
5 rockfall fatalities, lots of luck, and some lessons learned



Mapping rockfall – where, why, how much?



Mapping rockfall – where, why, how much?



Mapping rockfall – where, why, how much?

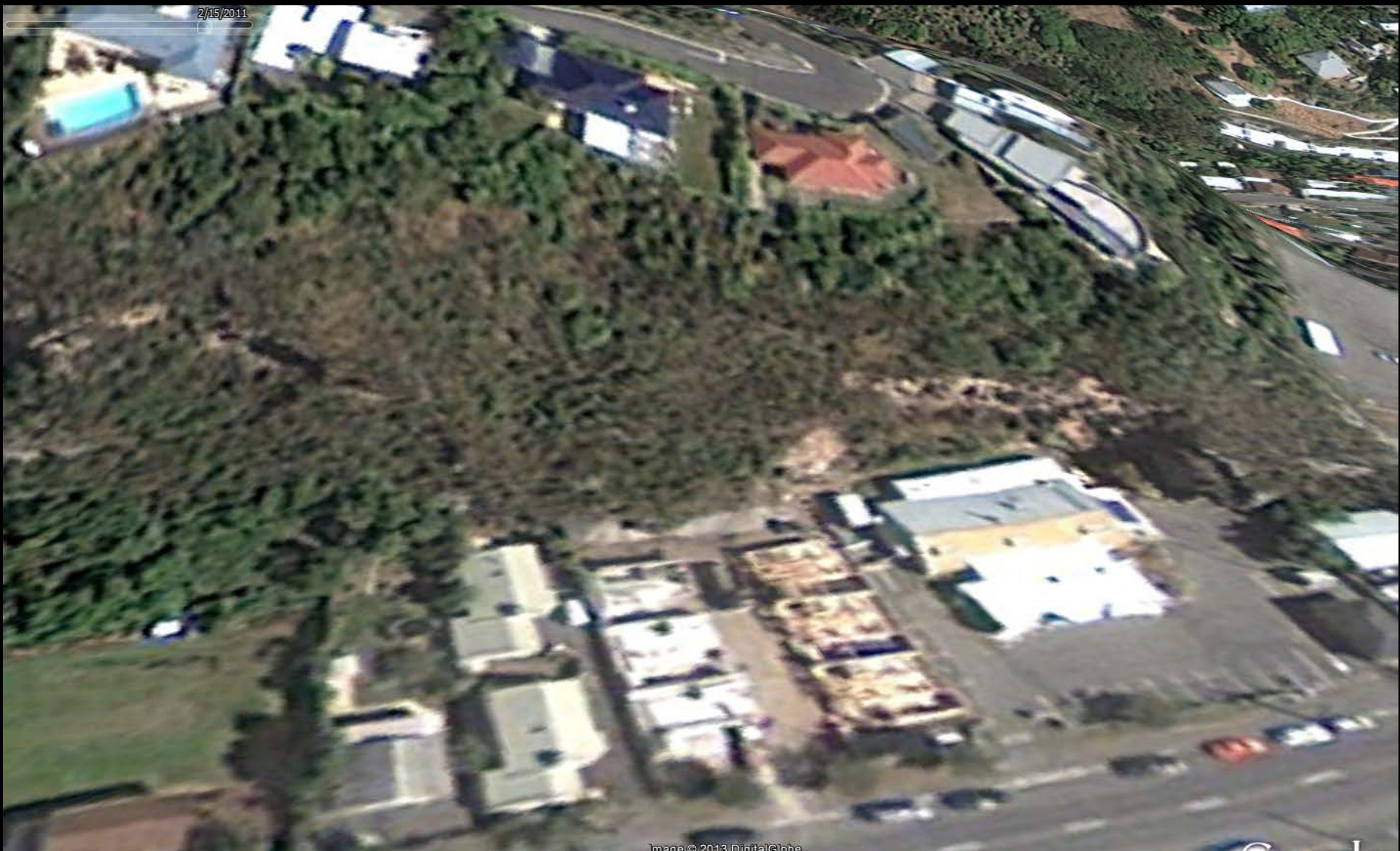
2003

2012



Risk communication, life safety and fiscal responsibility

Pre-Sept earthquake, Sumner



Risk communication, life safety and fiscal responsibility

Pre-Feb earthquake, post-Sept earthquake, Summer



Risk communication, life safety and fiscal responsibility

Post-Sept, June, Dec earthquakes, Sumner



Risk communication, life safety and fiscal responsibility

Post-Sept, June, Dec earthquakes, Sumner

Christchurch Lesson 4:

Good science and risk communication probably did save lives



Christchurch Lesson 5:

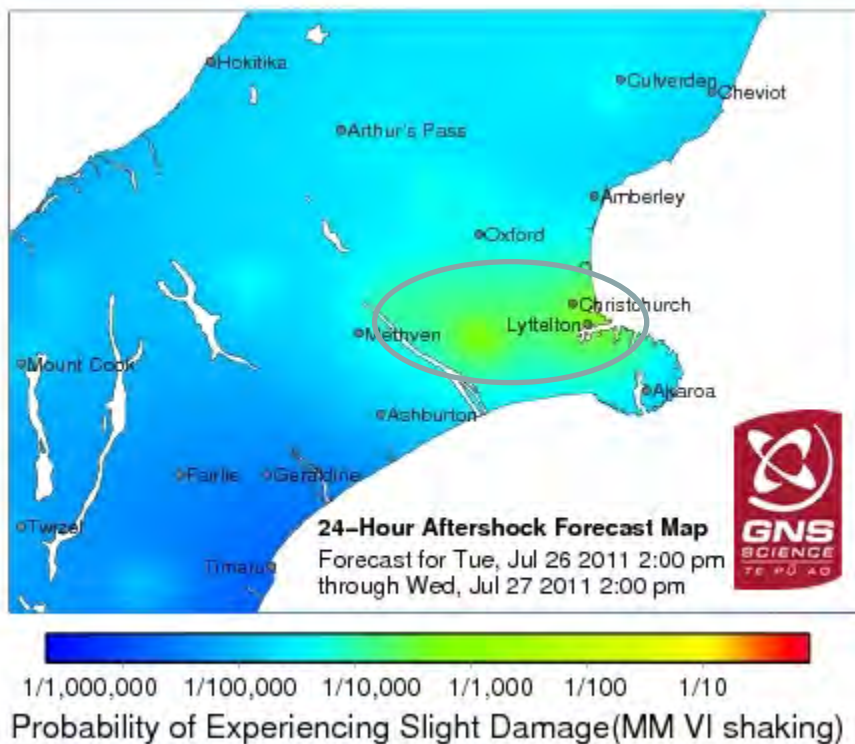
Modern methods in quantifying time-dependent hazard (e.g. operational earthquake forecasting) provide an important tool for science communicators, stakeholders and the general public

But temporal and spatial contextualization of the 'new normal' relative to 'the old normal' is important if the numbers are to be understood

The future is now:

Operational earthquake forecasting

- Publically available
- Continuously updated
- Multiple timescales

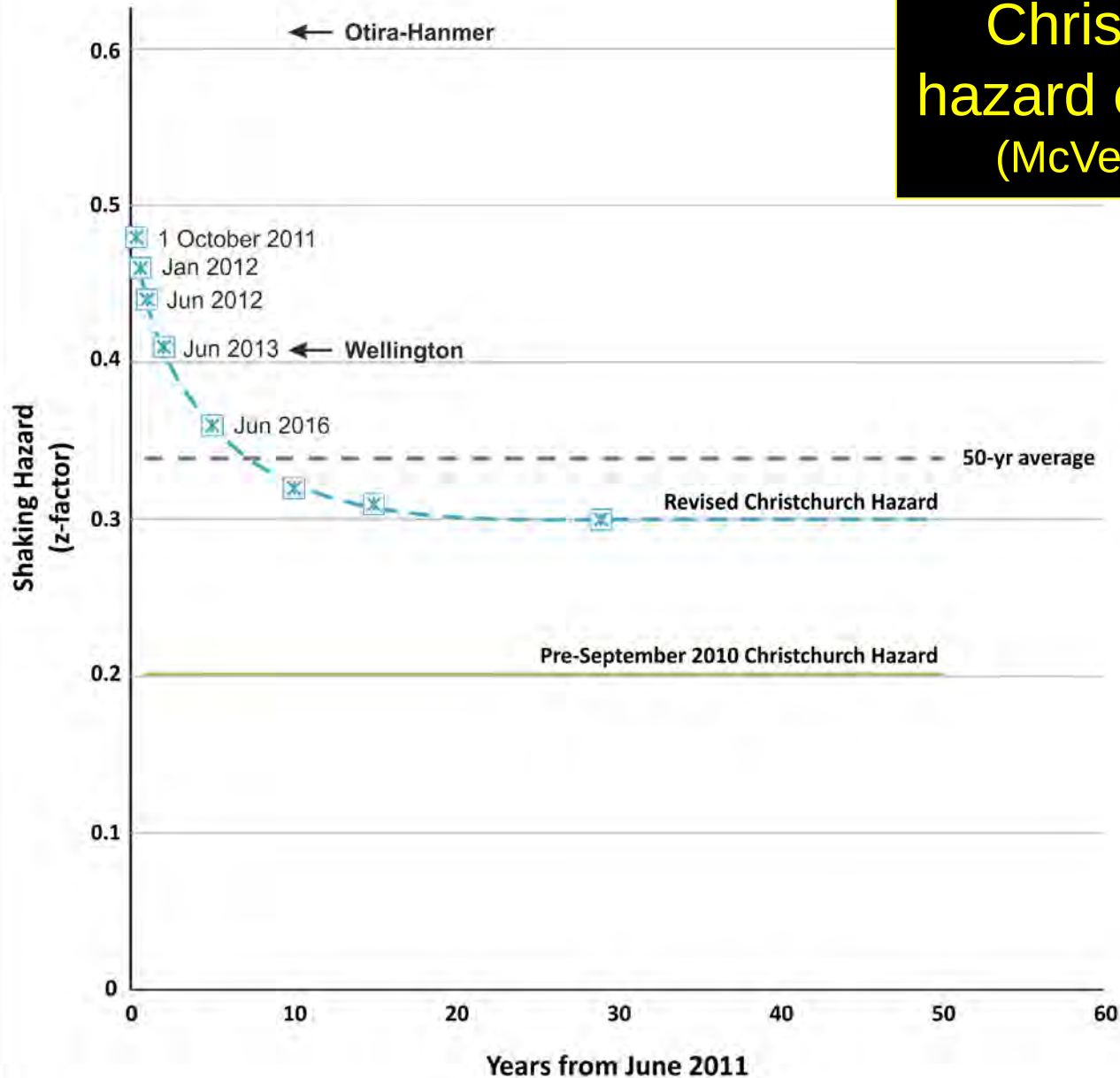


MM 6 = felt by all, objects fall from shelves, some furniture moved on smooth floors, very unstable furniture overturned, slight damage to unreinforced masonry and some damage to chimneys

Canterbury region long-term probabilities						
One month: July 15 2011 - August 14 2011				One year: July 15 2011 - July 14 2012		
Magnitude range	Expected range	Expected average	Probability	Expected range	Expected average	Probability
5.0 - 5.4	0 - 2	0.39	32%	0 - 5	1.9	85%
5.5 - 5.9	0 - 1	0.12	11%	0 - 3	0.9	45%
6.0 - 6.4	0 - 1	0.04	4%	0 - 1	0.2	15%
6.5 - 6.9	0 - 1	0.01	1%	0 - 1	0.07	7%
7.0 - 7.9	0 - 1	0.005	<1%	0 - 1	0.02	2%

This table was last updated on July 22 2011

Christchurch seismic hazard over next 50 years (McVerry et al., RC report)



Christchurch Lesson 6:

The public needs transparency in data and methods if they are to see (and accept) the value of science in decision making

[FULL STORY](#) [VIDEO](#)

Red zoners protest Govt compensation

TV3 Sept 2011

[Email](#) [Print](#) [Like](#) 62 [Tweet](#) 3 [+1](#) 0

Sun, 11 Sep 2011 6:23p.m.



The rally in the eastern suburb of Richmond drew homeowners from as far away as Kaiapoi

By Anna Burns-Francis

While it has been yet another shaky day in Christchurch, residents whose homes have been earmarked for demolition still came out to protest against the Government's compensation deal.

Related Articles

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- » Apology labelled 'gobbledygook'
- » No ill-feelings, despite closures
- » No 'sorry' from Hekia Parata

Video



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Tags

- » Government
- » Christchurch Quake
- » Red Zone

“...they feel forced into a decision without being given vital geotechnical data about the land their homes sit on.

Kaiapoi resident Brent Cairns says all he wants is transparency.

“I want to see is why my land deemed to be in the red zone, when we've lived there for over a year.”

Christchurch Lesson 7:

Risk 'personalization' – involving the public in the process of science at the hypothesis and observation stage can develop better awareness of natural hazards and risk

THE PRESS, Christchurch

Tuesday, Ma

■ GEOLOGICAL RECORDS

Dig reveals ancient liquefaction

Deposit found in backyard

Paul Gorman
paul.gorman@press.co.nz

The first evidence of historical liquefaction in Christchurch has been uncovered in the back garden of Canterbury University earthquake star Mark Quigley.

Quigley, whose lectures on the quakes were immensely popular and who became one of the media stars during the region's aftershocks, has turned over the silt and sand-covered grounds of his red-zoned Avonside home to science.

Geological sciences master's student Sarah Bastin and Quigley, her supervisor, have dug a muddy trench about 2 metres deep through the liquefied sediments where the paved barbecue area used to be.

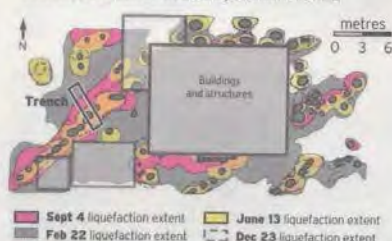
Sloshing around up to the tops of their gumboots in contaminated water and ooze, they have found an intrusion, or patch, of "palaeo-liquefaction" that is cut by near-vertical feeder dykes through which liquefied sand squirted to the surface in the September 2010 and February, June and December quakes last year.

The aim is to date chunks

Palaeo-liquefaction map

Lines of boils and volcanoes that erupted liquefied sand across Mark Quigley's red-zoned Avonside property in the big 2010-11 quakes can be seen in this graphic outlining the extent of liquefaction.

The trench dug to look for historical liquefaction is marked.



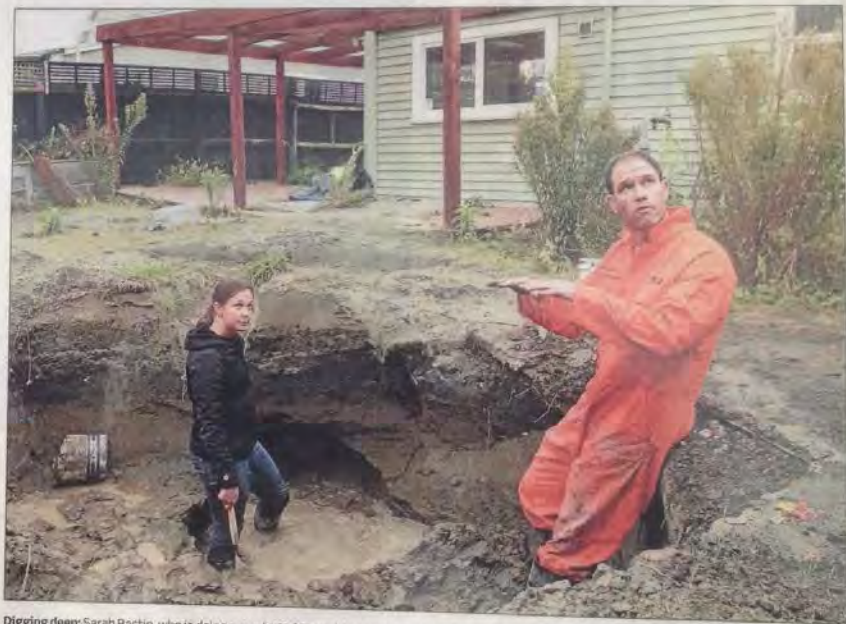
of charcoal found in the palaeo-liquefaction to find out roughly when a large enough quake occurred to cause the historical deposit, which has a mottled appearance, with streaky orange lines distinguishing it from recent liquefaction.

Quigley said it could be hundreds or thousands of years old. Fluctuations in groundwater over time had oxidised soil layers and caused the mottled look.

However, even when it was dated, it might still be difficult to fix it to a single event and draw a clear link with quake magnitude.

Liquefaction often required peak ground shaking of at least 15 per cent that of gravity, and that could be caused by a magnitude-7.3 quake 100 kilometres away, a magnitude 7.0 about 60km away or a magnitude 6.0 only 15km away, he said.

It might also have occurred



Digging deep: Sarah Bastin, who is doing a master's degree documenting palaeo-liquefaction sites around Christchurch, stands in a hole she and her tutor, Dr Mark Quigley, dug in the backyard of Quigley's Avonside property.

Photo: DEAN KOZANIC/FAIRFAX NZ

as a result of a magnitude-8.0 quake on the Alpine Fault.

"The really important and unresolved question this might help us determine is, would an Alpine Fault earthquake cause liquefaction in Christchurch?" Quigley said.

"Some of the literature suggests no, that peak ground accelerations would not be high enough. But duration of shaking is also important."

It was known that the magnitude-6.9 Cheviot quake in November 1901 caused lique-

faction in Kaiapoi, but "my feeling is this was caused by something bigger than that".

Bastin said this was the first evidence of historical liquefaction in Christchurch, although it had been found at Greenpark, near Lincoln.

More trenches would be dug around the city's eastern suburbs to find other historical liquefaction deposits.

She became interested in liquefaction after the September 2010 quake, Bastin said.

Closing comments

Becoming more risk aware in isolation will not save lives or reduce vulnerability **HOWEVER**

- more risk-educated people will be more receptive to taking precautionary measures (e.g., earthquake kits, fastening of TVs, etc)
- more risk-educated people will be more reluctant to live or work in earthquake-prone buildings, so owners will be under pressure to retrofit
- more risk-educated people will avoid purchasing highly vulnerable properties so developers will be less inclined to seek them out for development
- combining top down and bottom up approaches to risk communication will enable the best result