Lessons and Challenges in Catastrophe Management in APAC

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Lessons in Cat from APAC

Nature is usually much more complex than our models

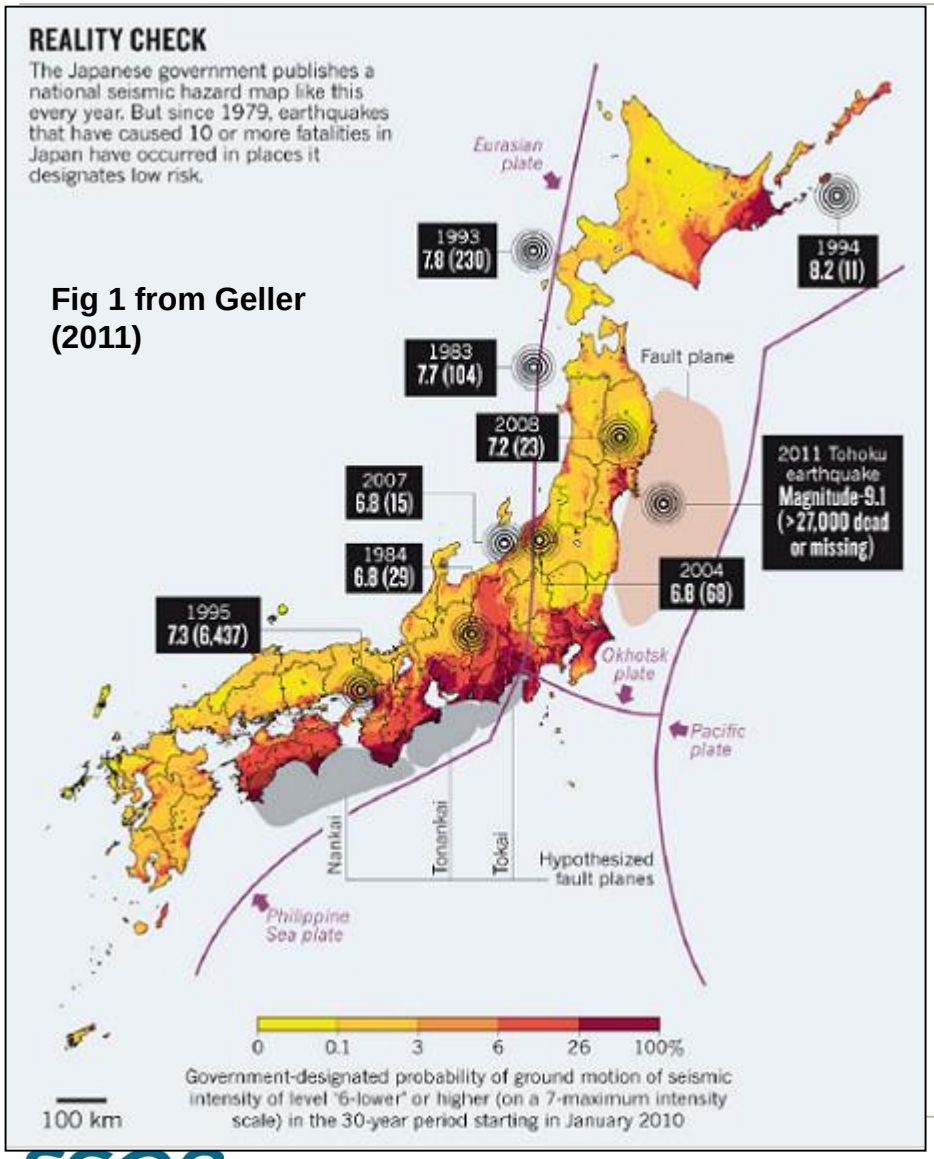


Fig 1 from Geller (2011)

- **2010 map reflects the widespread view among Japanese seismologists that M9.0 earthquakes would not occur on the Japan Trench off Tohoku**
- **Yellow shows <=0.1% chance of JMA VI intensity shaking in the 30 years starting Jan 2010, or once in 30,000 years**
- **However within only 2 years of the map being published such shaking occurred**

Source: Stein, Geller & Liu (2012) Tectonophysics, 562-563, p1-25.

0	Not felt by humans
I	Slight - extremely weak, mostly not felt
II	Weak - slight shaking of doors
III	Rather strong - slight shaking; no instinctive evacuation
IV	Strong - strong shaking of houses; feel afraid
V	very strong - cracks in walls, difficult to stand
VI	**Disastrous - collapse of <30% of houses; crawl to move**
VII	Very disastrous - collapse of >30% of houses

Some things should not come as a surprise

- M_w8.6 Jõgan tsunami in AD 869 is oldest historical event on the Sendai plain (Abe et al 1990; Minoura & Nakaya, 1991)

- ***More than 1100 years have passed since the Jõgan tsunami and … the possibility of a large tsunami striking the Sendai plain is high. (Minoura et al. 2001)***

- *Dec 2011 – policy change now forces consideration of maximum possible EQ and tsunami when designing tsunami countermeasures for nuclear power plants*

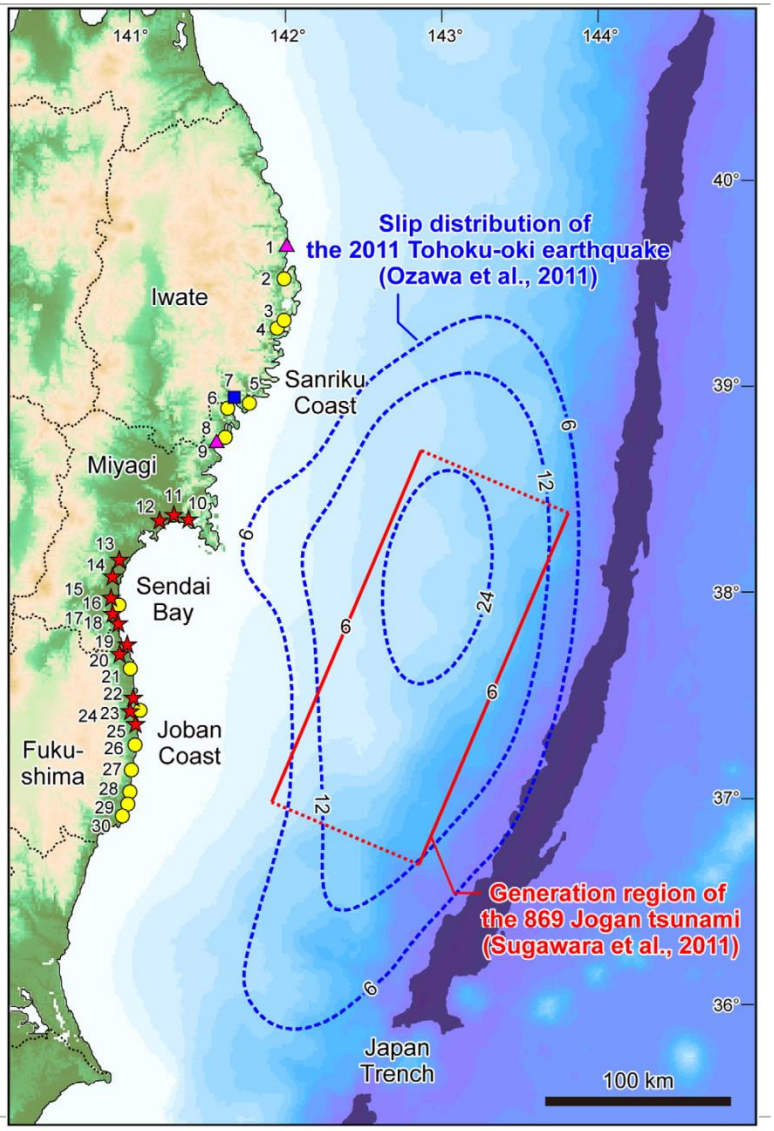


Fig 1 from Sugawara et al. (2012) Sedimentary Geology, 282, 14-26.

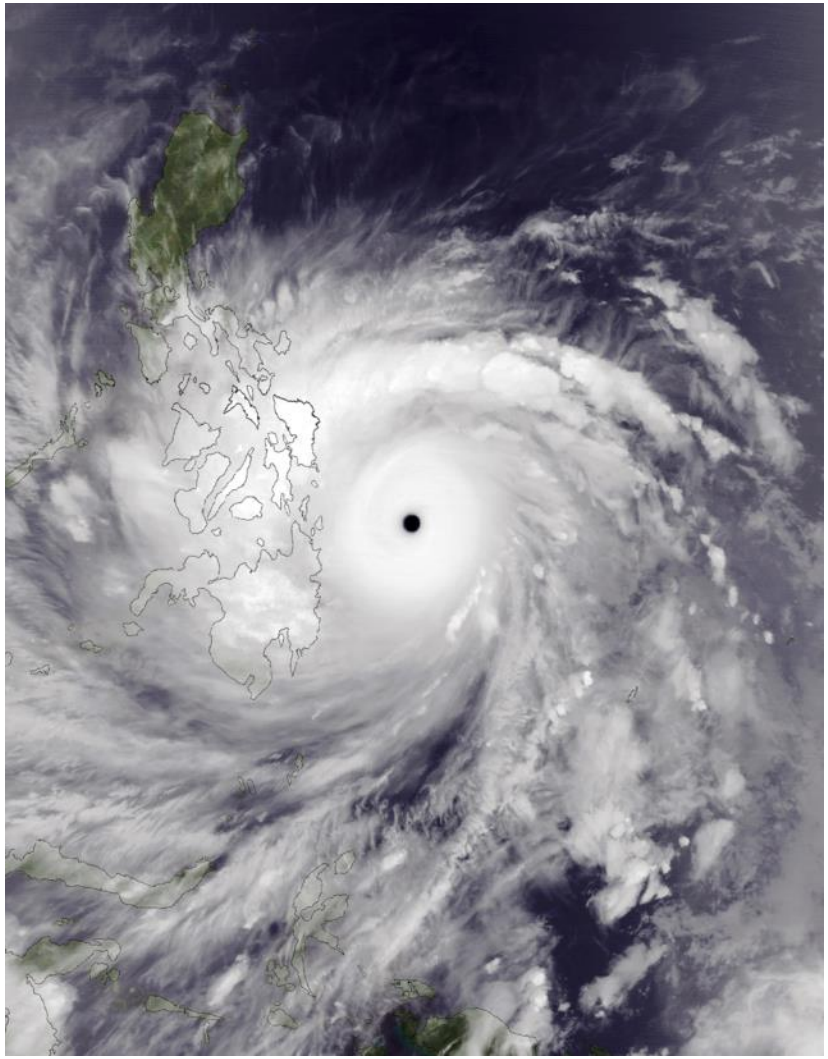
Some things should not come as a surprise

- Typhoon Haiyan 2013 was presented by media as "***unprecedented*** *and …* ***unforeseeable*****,** *a product of* ***global warming*** *that presages more extreme super storms to come*"[1]

- Tacloban was destroyed 3 x in past 120 years by storm surge - in 1898, 1912 and 2013

- How wise was it to rebuild Tacloban in the same location, yet again?

Super-Typhoon Haiyan at peak intensity, approaching the Philippines on November 7, 2013.

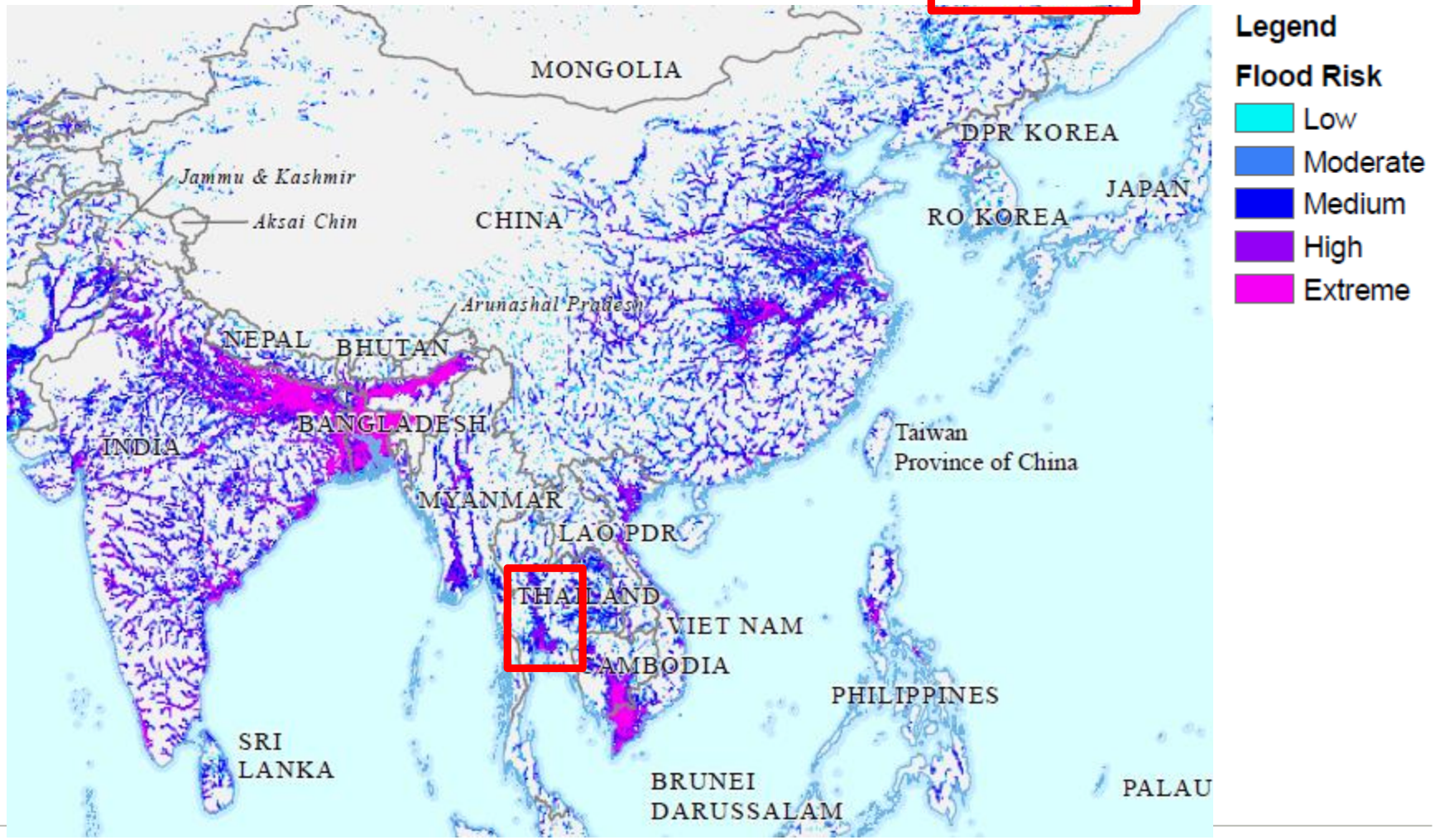


By NASA, LAADS Web, HDF File processed by Supportstorm [Public domain], via Wikimedia Commons

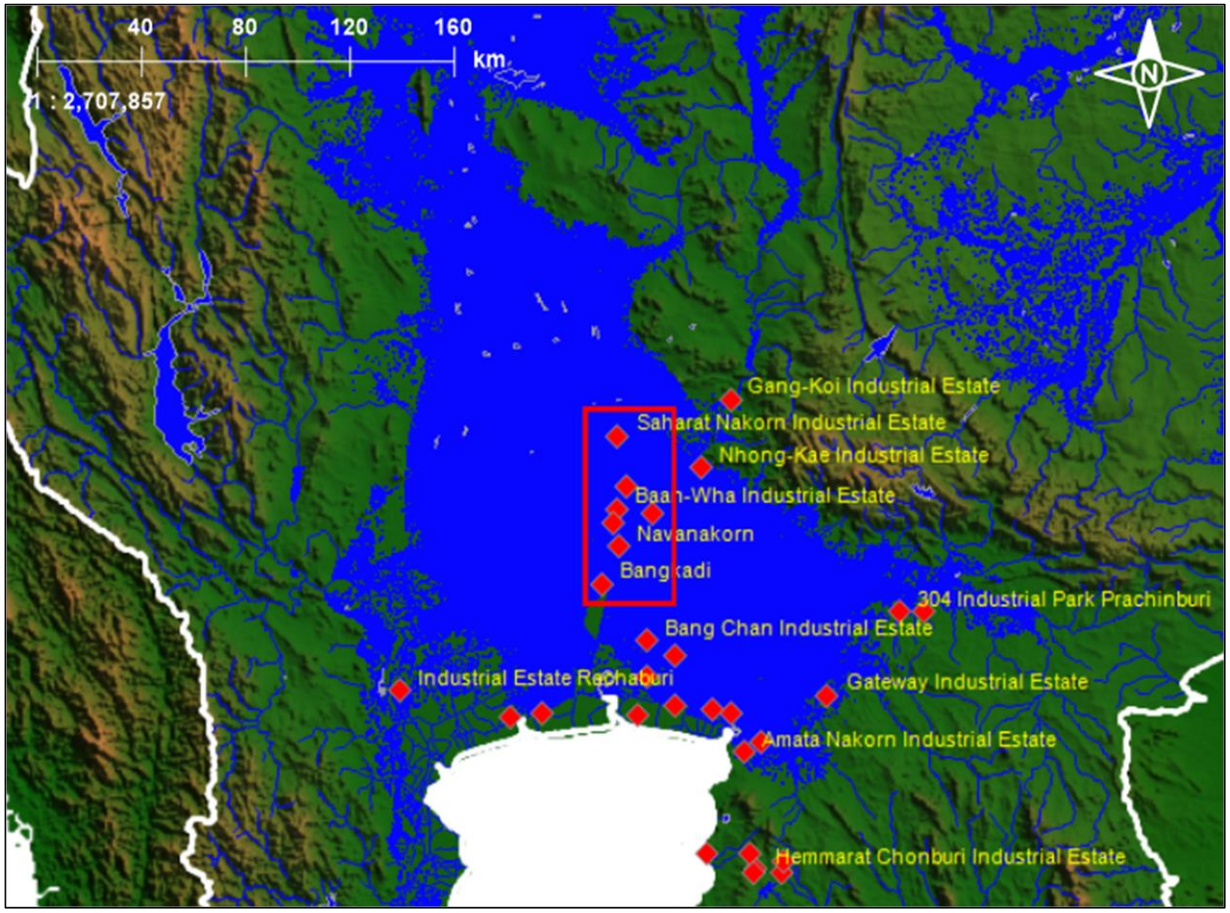
(1) Asia Insurance Review (2014) Bring on tomorrow: *Does Typhoon Haiyan presage a new era of Asian super-storms?* http://www.asiainsurancereview.com/Magazine/ReadMagazineArticle?aid=34520 This paper outlines the issues around Typhoon Haiyan and does not make these claims!

Some things should not come as a surprise

From flood risk in Asia-Pacific. UN-OCHA, May 2011.



Some things should not come as a surprise



- IEAT estimates return period of 2011 flood to be c. 70 years

- No formal recognition that flood is a PML driver by the industry in 2010
- No flood event limits on *pro rata* treaties – not seen as a risk
- **2011 loss was >4 x 2010 Thai non-life market premium and ~30 x Fire + IAR market premium**
- **Bangkok suffered major flooding 13 times from 1785 to 2011 – on average once every 18 years**
- **US$15-18 bn loss is still the world's largest commercially insured flood loss**
- **Lion's share of the loss came from ~1,000 industrial policies in industrial estates often shunned by local industries**

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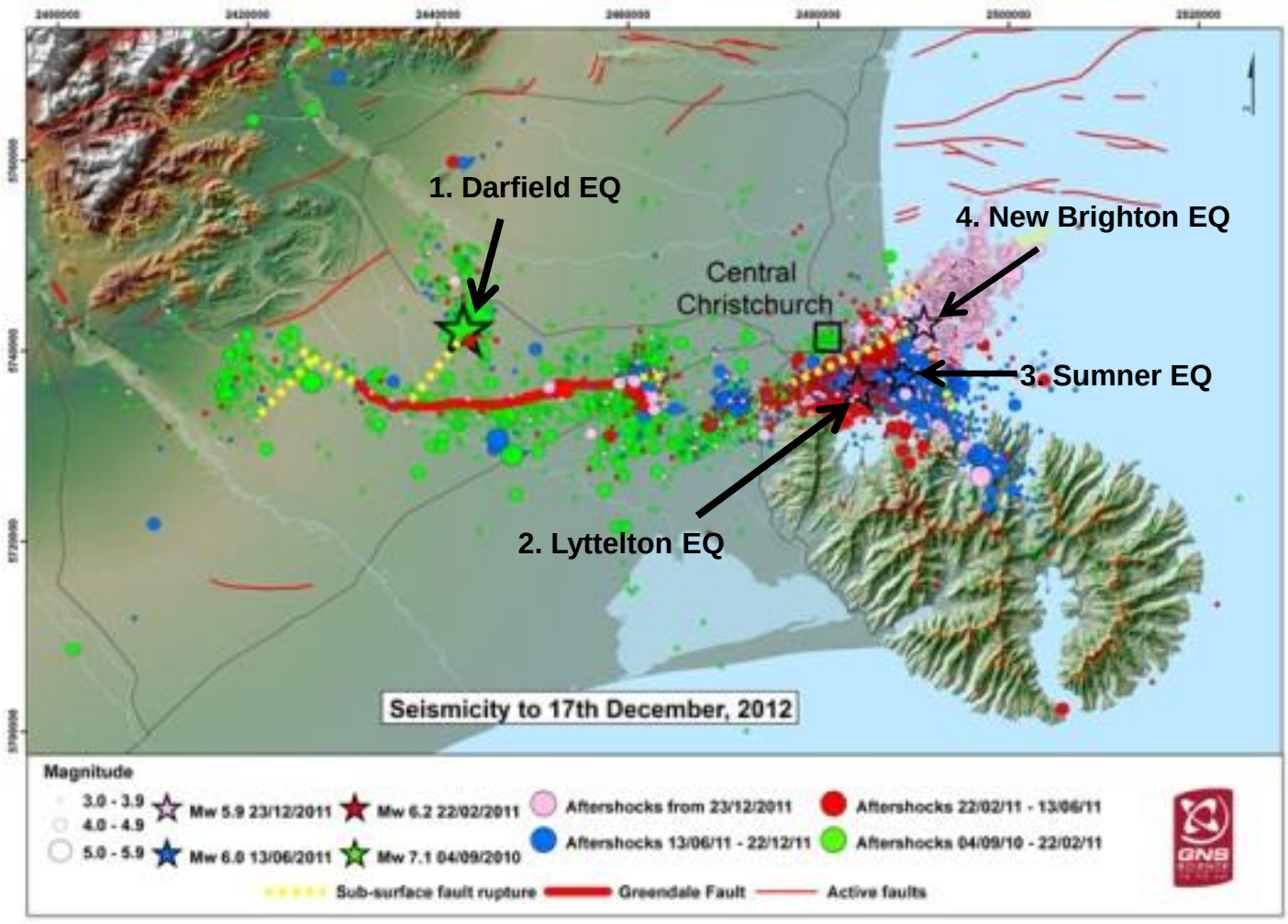
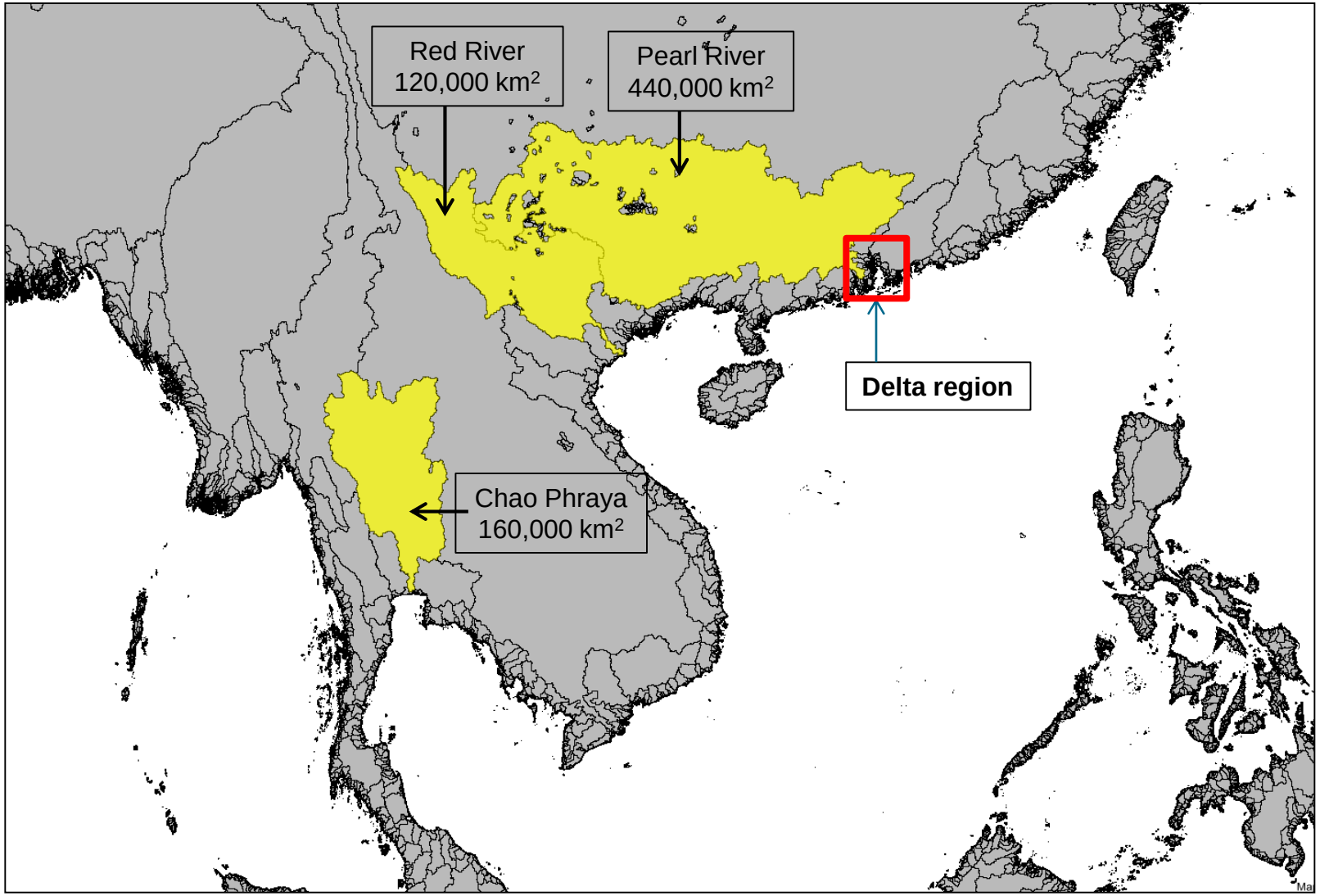
This surprised as industry was focussed on Wellington

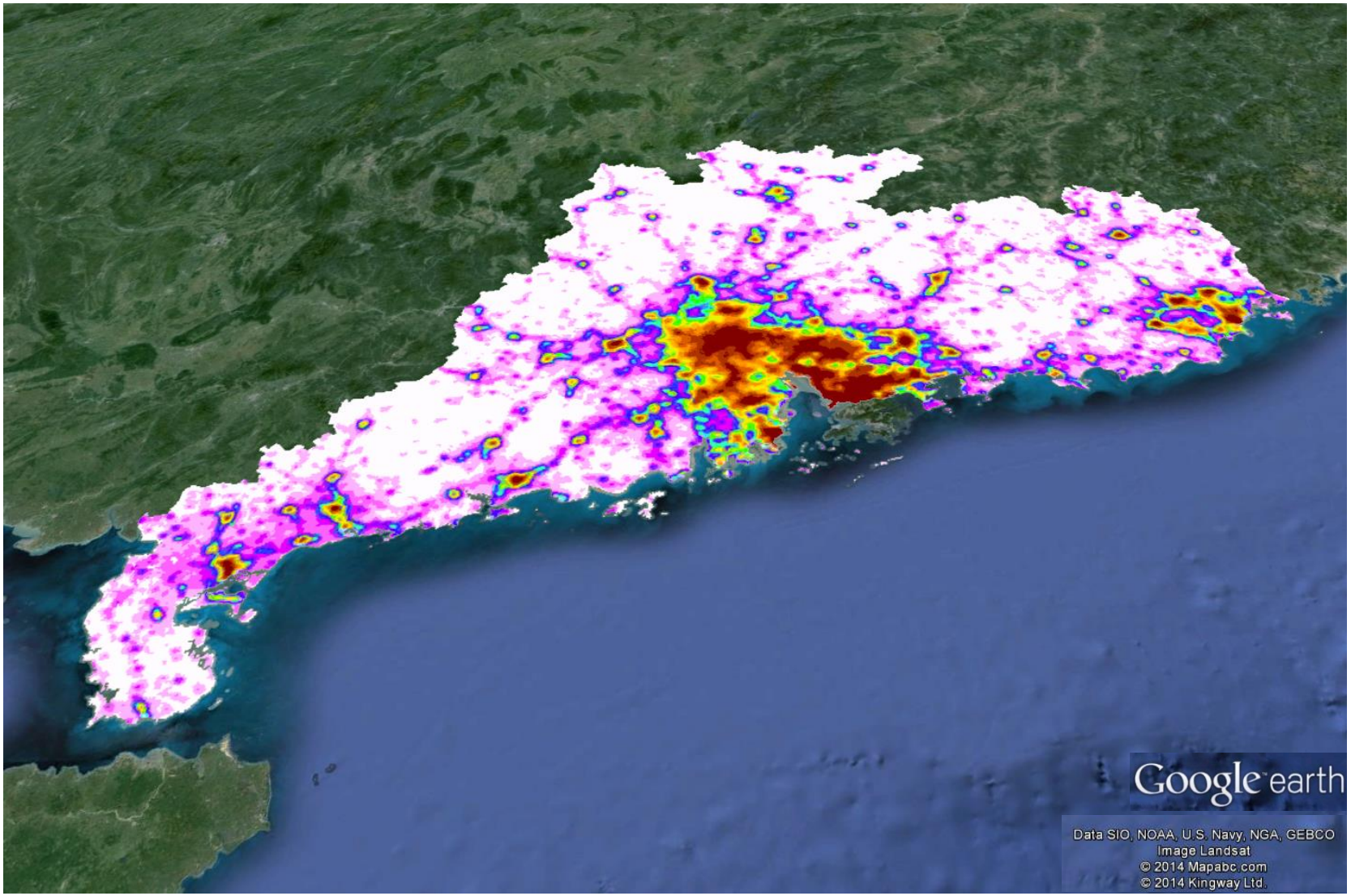


- Total 2010/11 claims were about **50 times larger** than any preceding event
- Darfield and Lyttelton are <u>each</u> one of the top 5 damaging EQ worldwide by insured loss
- 2 main events on previously unknown faults
- **Aftershocks not covered by Cat Models**
- Many un-modelled sources of loss

We should be able to predict major CAT-prone areas in advance



Obvious example - Pearl River Delta, Guangdong, China



Source: http://ngdc.noaa.gov/eog/

Pearl River Delta – last major storm surges 1874, 1862, 1245, 957 AD
Much of the western delta lies below sea-level (purple areas)

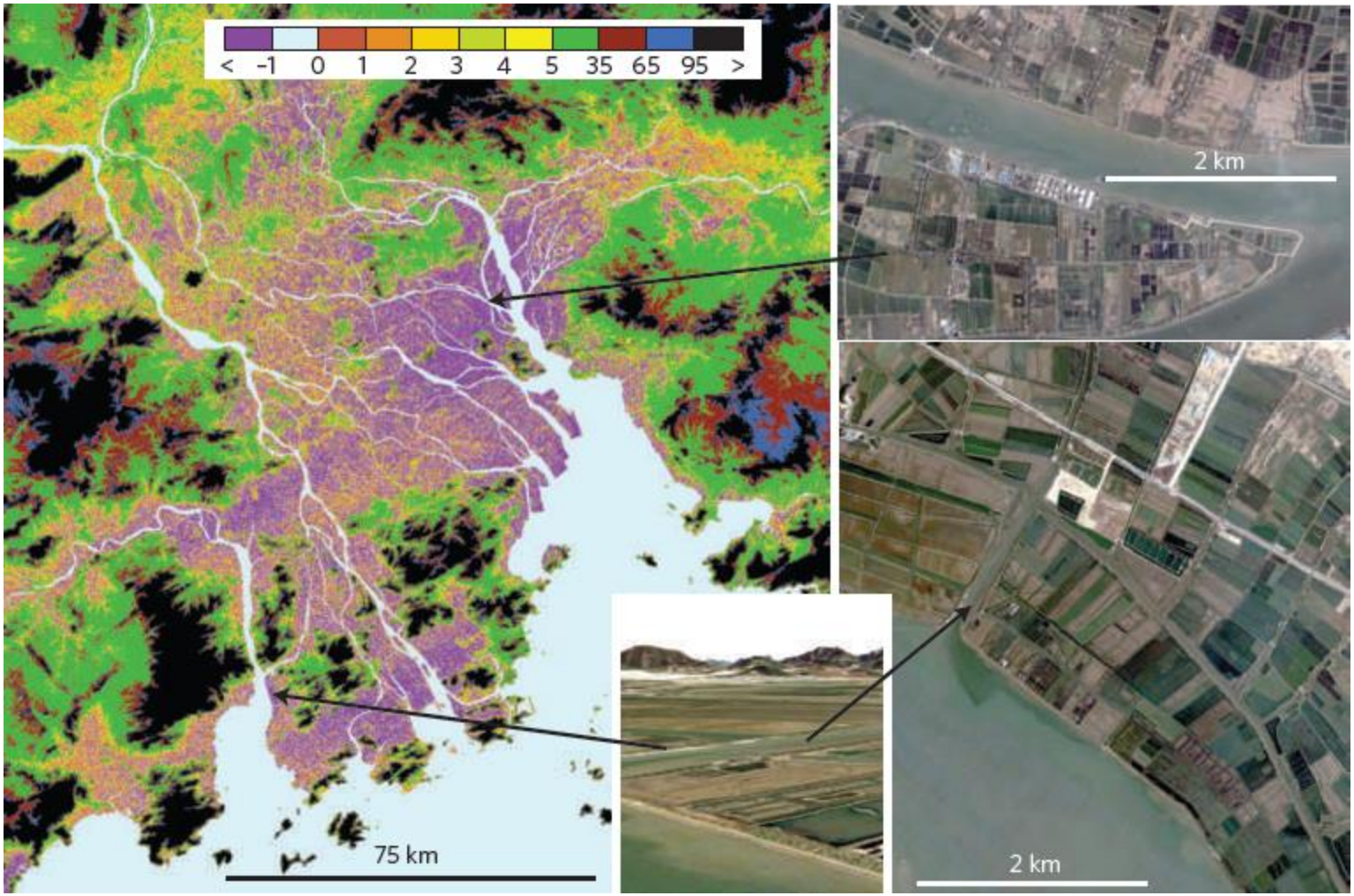


Fig 2 from Syvitski et al (2009) Nature Geoscience v2, p681-686.

Pearl River Delta - impressive statistics

- **4th largest economy in Asia**, after Japan, Korea and India, ahead of Taiwan
- **World's most densely populated delta**, >7,500 people/km^2 (Syvitski & Saito, 2007)
- **<1% of China's land area** but **contributes up to 20% of its GDP** (up from 9% in 2000)
- Called the "**world's factory**" by some economic commentators (Yeung, 2010)
- **Growing - (Ex-SAR) Population 48 MN in 2009, projected to reach 65 MN by 2020**
- 80% of annual rainfall during Summer Monsoon (May-Sept) often largely by Typhoons

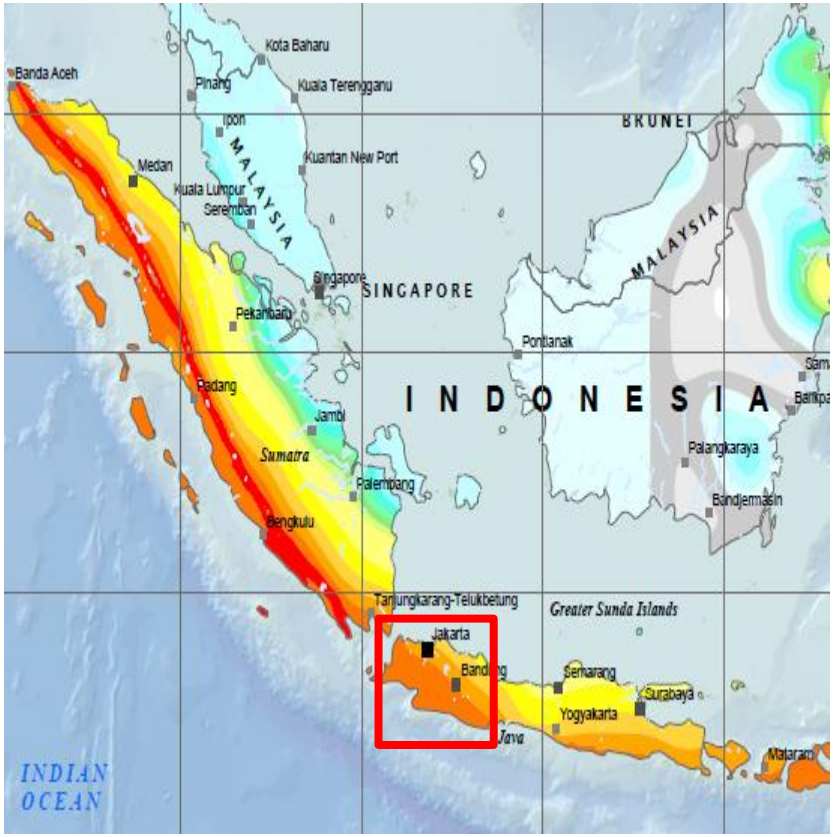
Other obvious examples of exposure at risk
Industrial risk concentrations – KIA/ JIA/ CIA/ TIA/ SIA

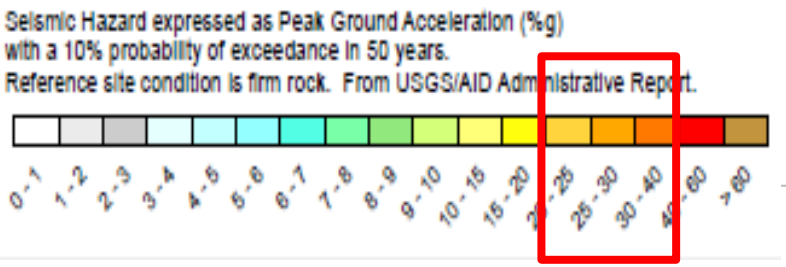
Country	Hotspot	Main Sector	Main CAT Perils
Thailand	Chon Buri, Rayong	Industrial	-
Vietnam	Red River delta	Industrial	Flood, TY storm surge
	HCMC, Binh Duong	Industrial	Flood, TY storm surge
Indonesia	West Java (ex. Jakarta)	Industrial	EQ, flood, volcanic ash
	Cilegon	Industrial	EQ, volcanic ash, tsunami
Malaysia	Selangor	Industrial	Flood
Philippines	Metro Manila, South Luzon	Industrial	EQ, flood, tsunami, volcanic ash
Myanmar	Yangon	Industrial	Flood, TY storm surge

Flooding of Rojana industrial estate in Thailand in 2011. U.S. Marine Corps photo by Cpl. Robert J. Maurer (Public domain), via Wikimedia Commons.

- Example above shows highly correlated loss (likely total) to multiple factories from flood
- Table to left shows major areas in SE Asia with growing industry – watch out for these in future

Obvious EQ scenario, but no historic precedent
Java Trench EQ - Regional Humanitarian PML driver





- Risk to western Java is driven by Java trench subduction earthquakes
- 28 million people live in western Java – see the red box shown to left
- Majority live in properties with non-engineered construction
- Ground shaking in NW Java likely to reach at least MMI VI intensity for several minutes – higher on soft soils (Jakarta)
- Expected fatalities >100k; injuries >500k; displaced 5 million+ ??? - TBC
- Indonesia's main economic and industrial areas also likely to be heavily damaged

Less obvious EQ scenario, but a historic precedent exists
South Korea EQ

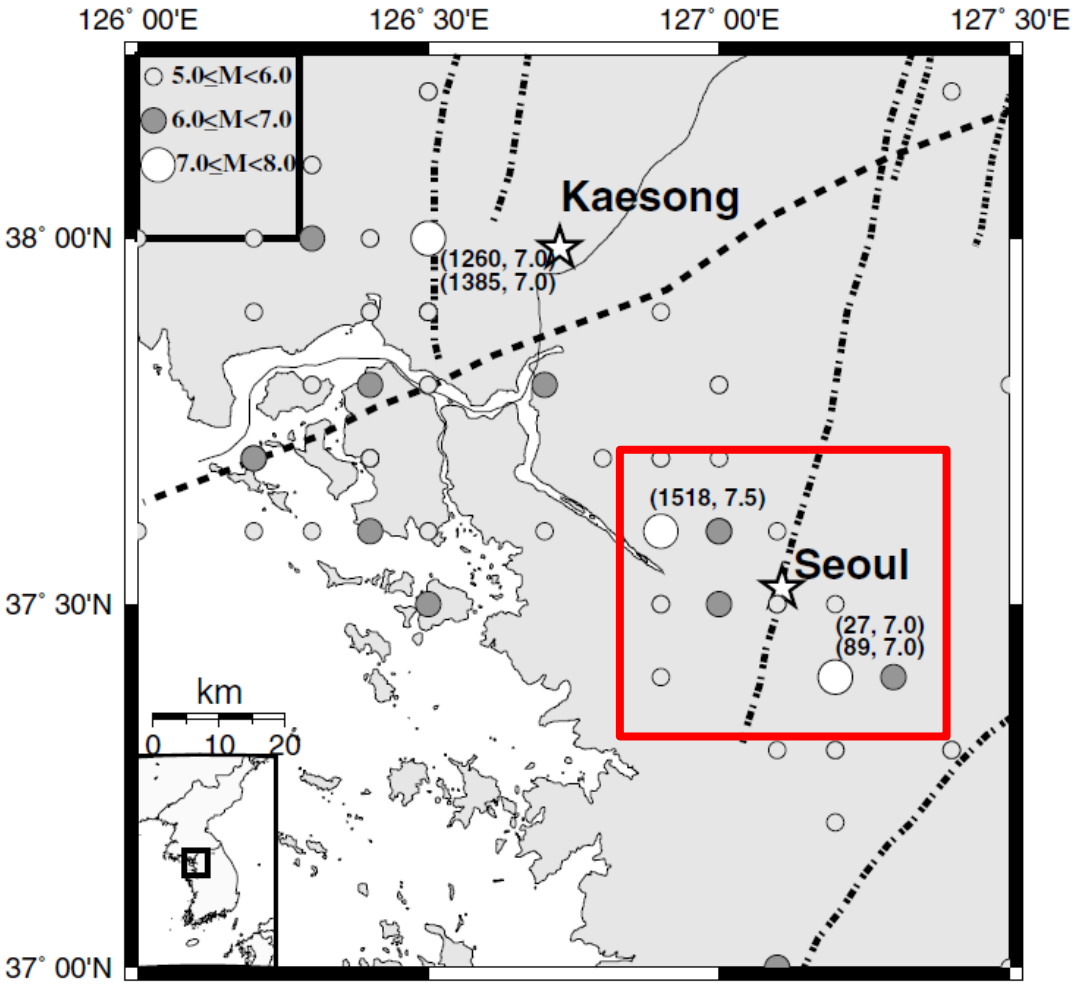
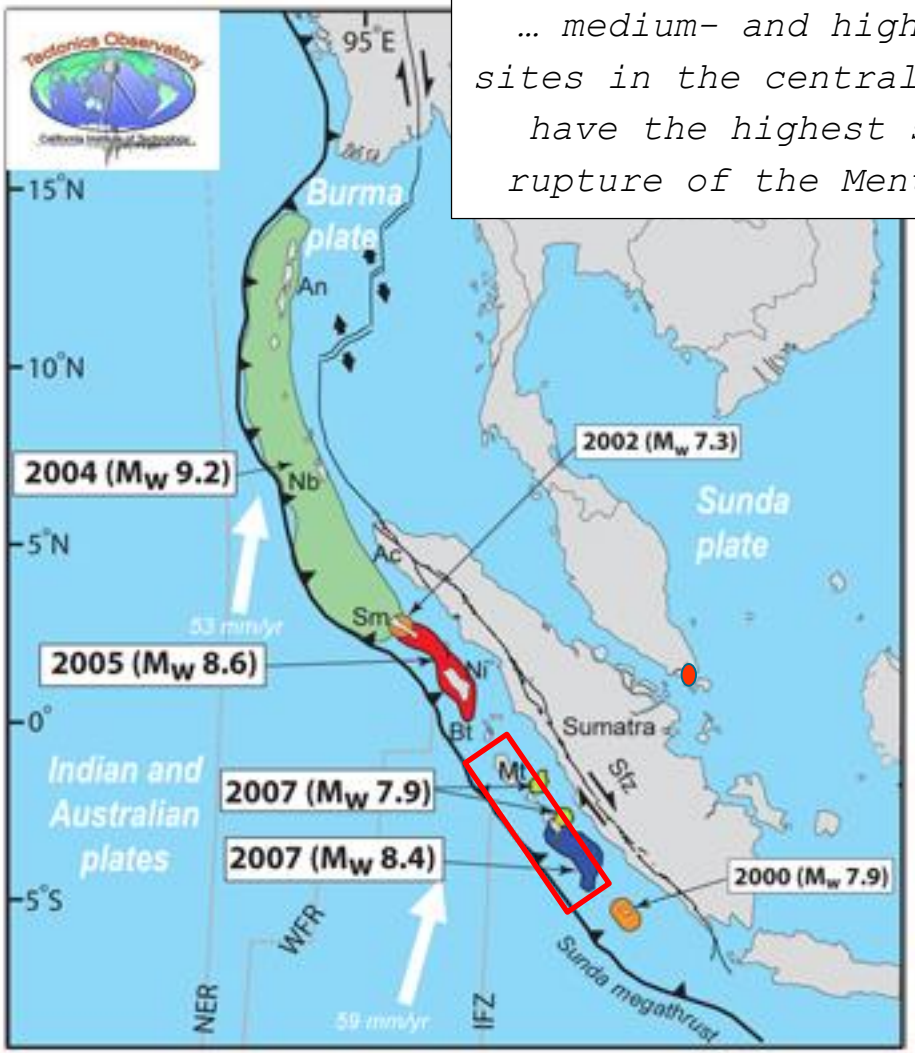


Fig. 11 from Chiu & Kim (2004) Bull. Seis. Soc. Am., 94(1), 269-284.

- Insurers consider Korea at low risk - **History speaks otherwise**
- **N**ational **E**mergency **M**anagement **A**uthority (NEMA) has plans for dealing with Korean EQ
- Five M>=7.0 between AD 2 – 1995. Last major event M7.5, only 20 km from Seoul – last in 1518
- No major EQ (M>5.0) in Korea since 1721
- Properties built prior to 1988 not subject to EQ design code
- Only ~10% of building stock conforms to seismic design code

Less obvious EQ scenario, but a historic precedent exists "Singapore" EQ

… medium- and high-rise structures founded on soft soil sites in the central and southeastern districts of the city have the highest seismic risk with regard to potential rupture of the Mentawai segment. (Megawati & Pan, 2009).



- Locked area of subduction zone has not failed since 1833
- This is the only large part of the Sunda trench not to have ruptured since 2000
- Estimates of rupture magnitude range from M_w8.6 (Sieh *et al.* 2008) to M_w9.2 (Megawati & Pan, 2009)
- Average recurrence interval between great earthquakes is 130-300 years. The current dormant period is 182 years (Borrero *et al.* 2006).
- Risk in Singapore is to mid to high rise buildings on soft soils and reclaimed land
- SGP building design code upgraded in 2013 to enforce seismic provision

http://www.tectonics.caltech.edu/outreach/highlights/sumatra/what.html

Less obvious typhoon scenario, but a historic precedent exists
Red River delta storm surge

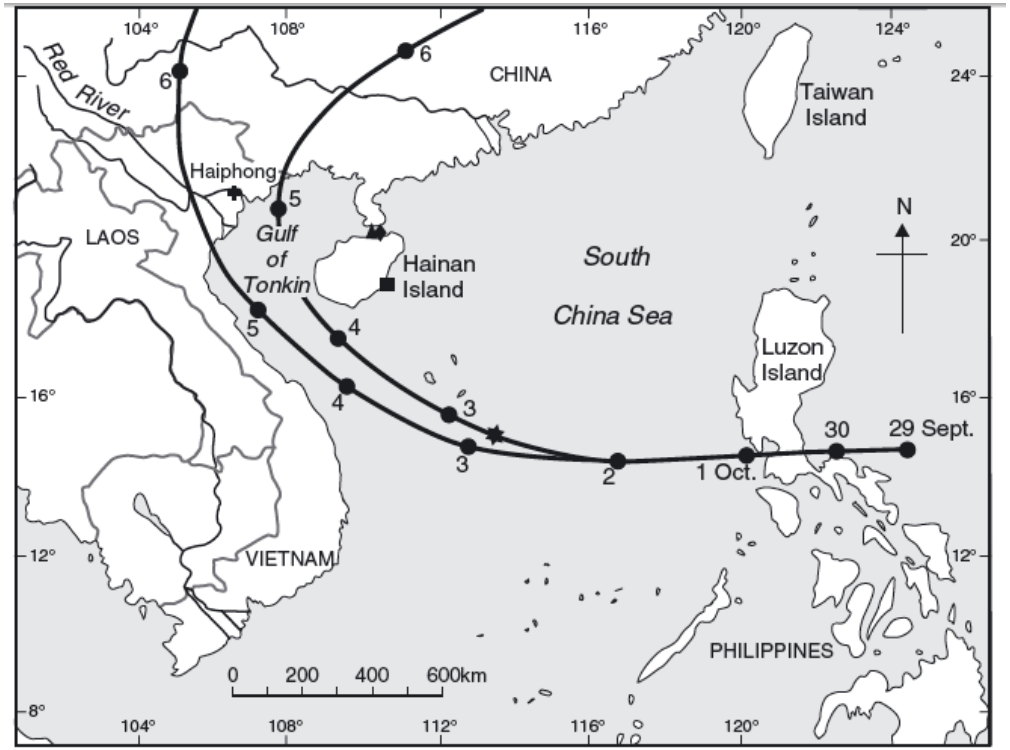


Figure 1. Suggested paths of the 'terrific Tongking typhoon' of early October 1881 as interpreted by Dechevrens (1882) from the weather logs of several steamships that encountered the storm and were able to record barometric pressure and wind direction (✸ SS Fleurs Castle, ■ Quinta, ▲ Tong-ting, ♦ HMS Magpie, ✚ Kang-chi). Dechevrens made an unusual interpretation, believing that traversing Luzon island had split the typhoon into two separate 'whirlwinds'. Black circles approximate the centre of these whirlwinds at midnight on the dates given. The actual (single) track probably travelled between the pair originally suggested. See text for details. Modern

The 'terrific Tongking typhoon' of October 1881 – implications for the Red River Delta (northern Vietnam) in modern times. Terry, Winspear and Cuong (2012), *Weather* **67**(3), p72-75.

- Very unusual typhoon in 1881 destroyed Haiphong – 3000 killed by storm surge
- Early period of French rule – no Vietnamese records we know of
- No such event since – although some weaker storms have taken similar tracks – e.g. Haiyan 2013

Typhoon Haiyan 2013

"Haiyan 2013 track" by Meow - Created by Meow using Wikipedia:WikiProject Tropical cyclones/Tracks. The background image is from NASA. Tracking data is from JTWC.. Licensed under Public Domain via Wikimedia Commons - https://commons.wikimedia.org/wiki/File:Haiyan_2013_track.png#/media/File:Haiyan_2013_track.png

Challenges in Modeling CAT in APAC

Catastrophe Modeling Landscape

A key tool for P&C (re)insurers…

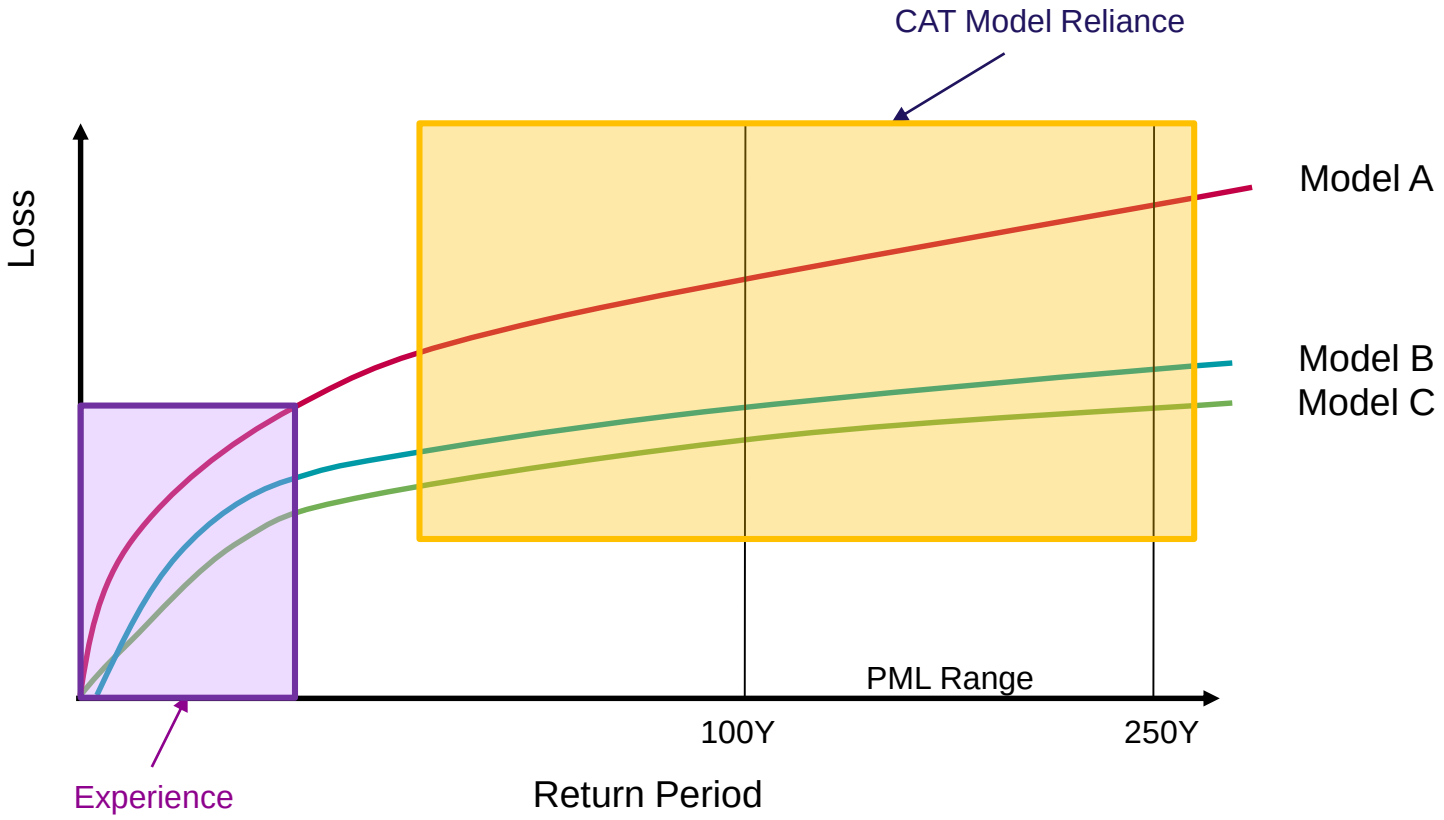
- Started in early 1990's by Karen Clark at EW Blanch
- Addresses key issue of lack of historical data to apply standard actuarial techniques to risk quantification
- Characterised by oligopoly of commercial suppliers
  - Big 3: RMS, AIR Worldwide, CoreLogic (EQECAT)
  - …plus a number of regional model vendors (ARA, Risk Frontiers, JBA, ERN…)
  - …plus broker models
- Used widely across the industry
  - Used for pricing, risk management, capital modelling, risk transfer incl. ILS
  - ~ USD 500m est. global annual licensing fees

A brief history …

- Widespread adoption of CAT models occurred primarily because of major US CAT losses
  - 1989 - Hurricane Hugo USD 4.2 billion
  - 1989 - Loma Prieta EQ USD 960 million
  - **1992 Hurricane Andrew – USD 15.5 billion**
    - **11 US insurers filed for insolvency**
  - **1994 Northridge EQ – USD 15.3 billion**
  - Source: Insurance Information Institute.

Vendor CAT models often differ greatly

- Many catastrophe models and many results
  - Is a model that appears wrong better than no model at all?
  - Are 3 answers better than 1?
  - Or would a blend of models reduce uncertainties?



The challenge of a realistic Asia scenario

- The following scenario highlights a common problem when modeling Cat-exposed property portfolios in Asian markets (which are dominated by Industrial & Commercial exposures)
- Domestic insurer has Cat XL and 2-line Surplus. Event limits are calibrated to **OEP 500** (Cat XL, **48 mil occurrence limit**) and **OEP 1000** (Surplus, **60 mil event limit**)
- Writes 3 peak risks (45 mil each), max retention 20 mil on each; cedes 25 mil each to Surplus
- An EQ or severe HU event occurs, causing total loss to all 3 peak risks
- **Recoveries are capped by the Cat XL and Surplus event limits at 80% of gross loss for these 3 peak risks + lots of smaller losses from the rest of the portfolio**

This example shows limited treaty recovery due to calibration of treaty limits against Cat model OEP 500 / OEP 1000 results										
	Cat XL treaty					**Surplus treaty**				
OEP PML	Limit / Max risk retention	Limit / PML	Gross Net Loss	Max Recovery	Recovery %	Event limit / Max risk cession	Limit / PML	Gross Ceded Loss	Max Recovery	Recovery %
500	2.4	1.0	**60.0**	**48.0**	**80%**					
1000						1.5	1.0	**75.0**	**60.0**	**80%**

- Event limits in both treaties are calibrated against Cat modeled OEP results
- Cedant thought it was being prudent relative to peers in its OEP benchmarking of limits
- Cedant should have realized that Cat XL limit is equivalent to only **2.4** max. retentions; the Surplus event limit is equivalent to only **1.5** max. cessions
- Calibration of Cat XL limit to **OEP 10,000** only covers total loss to **6.7** max. retentions
- **Is the chance of total loss to several risks so remote that these figures are acceptable?**
- **If not, why then do the Cat models say it is?**

Q: Is the chance of total loss to several risks really so remote that these figures are acceptable?

- **Turkey's experience in 1999 shows that modern industrial facilities within 20 km of the rupture were heavily damaged (cf. Sezen & Whittaker, 2004)**

> The 1999 Kocaeli earthquake occurred in northwestern Turkey, causing extensive damage to industrial facilities; see Figure 1. Many of these industrial facilities were located a short distance from that segment of the North Anatolian fault that ruptured during the earthquake. Twenty-four facilities representing different industries in the epicentral region were surveyed by an NSF-supported reconnaissance team shortly after the earthquake. Since many of the inspected facilities were designed in accordance with U.S. and European standards, their seismic performance is an indicator of the likely performance of industrial facilities in other seismically active regions of the world.

- Older facilities meeting weaker design requirements are clearly even more likely to suffer severe damage
- **It is clearly possible for heavy damage / total loss to multiple industrial facilities from EQ – applies to most seismically active territories in Asia**
- Much less of a risk from typhoon/cyclone in developed nations with stringent wind loading design regulations – Taiwan, Japan, Korea, Australia – but still possible in parts of the Philippines, Vietnam, China, India

Sezen, H. & Whitakker, A.S. (2004) performance of industrial facilities during the 1999, Kocaeli, Turkey earthquake. http://www.iitk.ac.in/nicee/wcee/article/13_282.pdf

Q: If not, why then do the Cat models say it is?

1. **Exposure geo-location** - whilst results can change significantly at (for example) postcode v. Cresta level, the overall conclusion is similar in that still only a handful of maximum retentions are covered by Cat XLs … hence this is not a primary cause

2. Use of **assumed severity distributions** (for damage uncertainty)

3. How severity distributions are **aggregated** – from coverage/ location/ policy/ … event

4. **Correlation assumptions** when aggregating severity distributions

5. Using a **single 'best' view of risk** does not do justice to modeling uncertainty

These are all areas for future priority investigation – and most are poorly understood by the Cat model user community at present

Likely relativity of these factors in explaining the challenge

Factor	Likely importance	Comment
Assumed severity distributions	High	Unimodal unlikely to adequately represent industrial and large commercial risk types
Aggregation of severity distributions	High	Question whether extremes are adequately represented in the final event-level severity distributions
Correlation when aggregating severity distributions	High	Will impact every aggregation level, hence compounding effect. Risk concentrations need to ensure fatter tails than appear to exist
Use of a single view of risk that does not adequately capture modeling uncertainty	High	Clear that there can be many different credible views on hazard, vulnerability, etc. – hence if background view on risk is optimistic then will systematically understate the risk

- Combined impact of these factors may explain why Cat models appear unable to adequately simulate loss to heterogeneous Asian industrial/commercial portfolios

Where to from here?

- **To test these (and other) factors we need a transparent, configurable Cat modeling framework to use as a testbed environment, running tests to explore all of the above**

- Only one independent, industry-supported, transparent, configurable, free-of-charge Cat Loss Modeling Framework currently exists (Oasis http://www.oasislmf.org)

- The World Bank have endorsed the Oasis platform for use in their projects

- The Insurance Development Forum (IDF); Risk, Modelling and Mapping Group have suggested Oasis for use in their own analysis

The Art & Science of Risk

Thanks for listening
Any questions?

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