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SUPERCAT The Future for Asia

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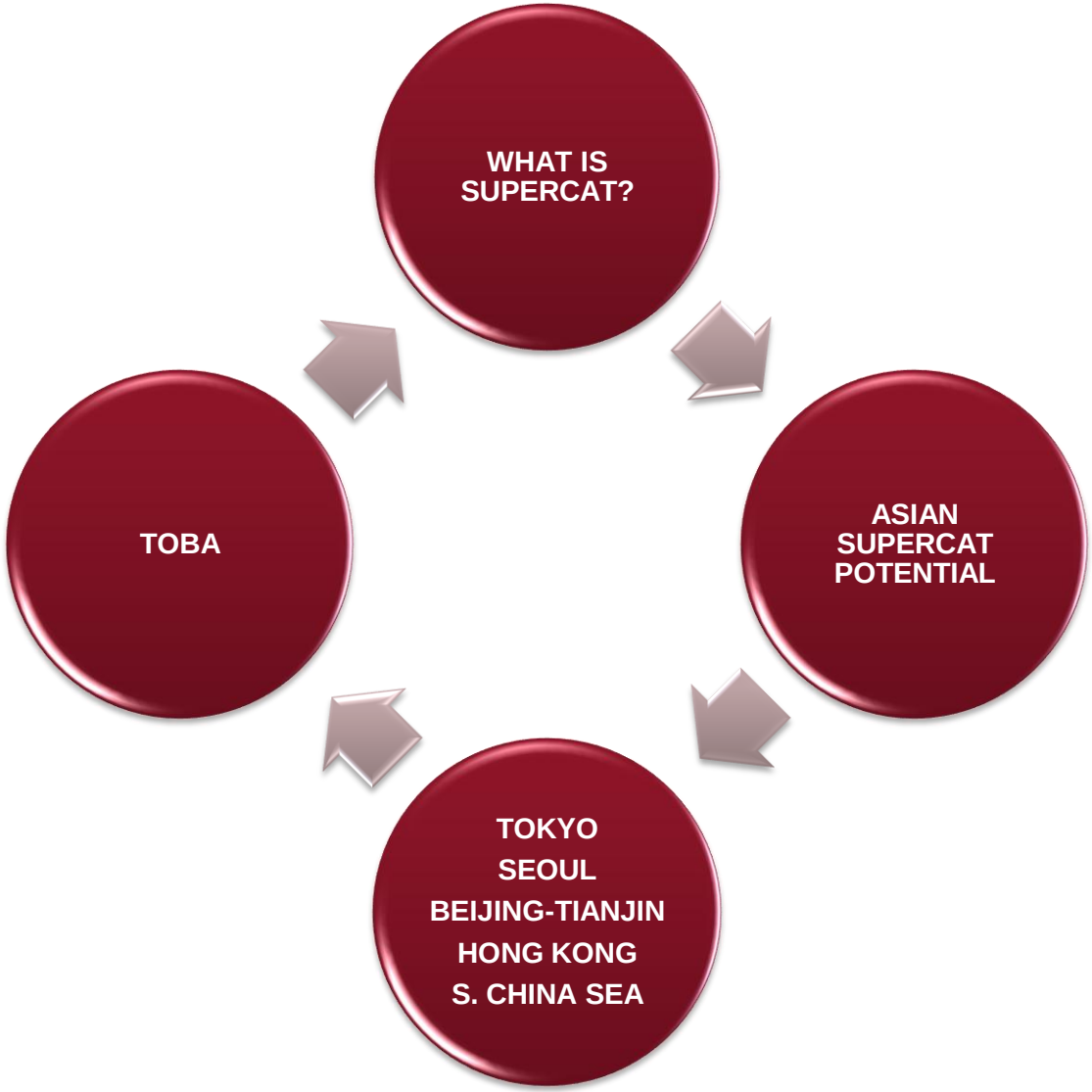
Agenda



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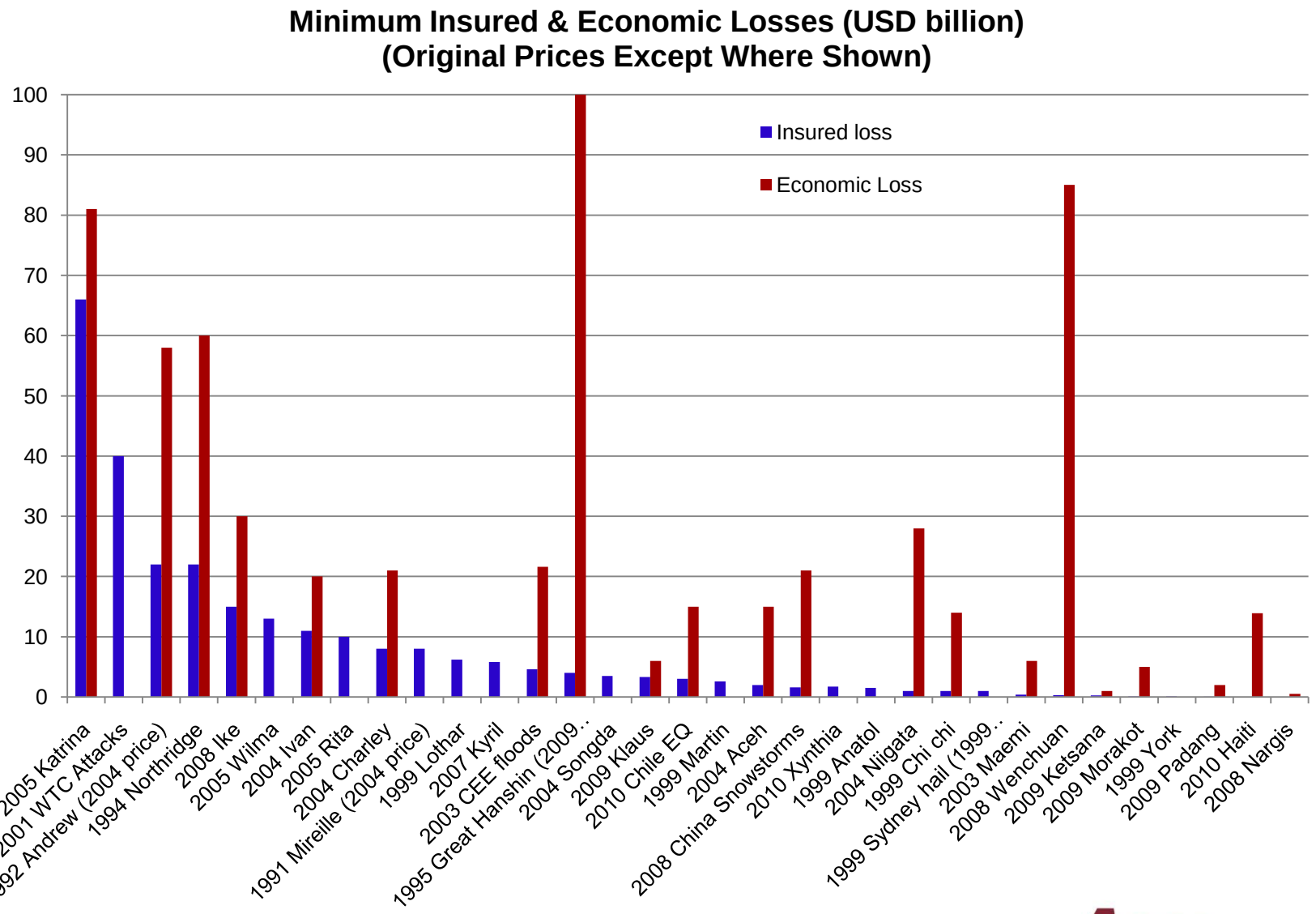
What is a Supercat?



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What does it look like? Hurricane Andrew 1992

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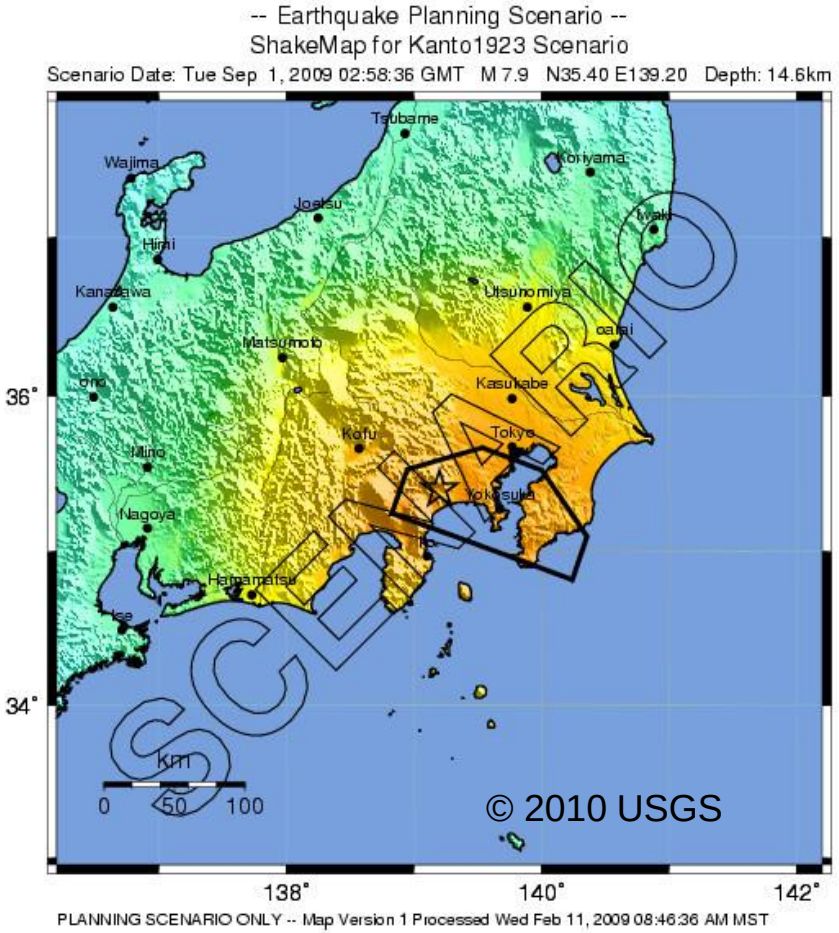
What does it look like? Haiti Earthquake 2010

http://upload.wikimedia.org/wikipedia/commons/d/d2/Haiti_earthquake_damage.jpg
© 2010 UN Photo/Logan Abassi United Nations Development Programme

Asian Supercat Potential – Tokyo EQ



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
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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
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INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

- Highly destructive earthquakes hit Tokyo area in **1703, 1855 and 1923**
- Appear overdue for a similar event
  - M_w7.1+ = 20% chance in next 30 years
  - M_w7.9+ = 8-11% chance in next 30 years
- M_w7.3 shock beneath Tokyo
  - **Economic loss** ~USD 1 trillion
- Repeat of 1855 M_w7.1-7.3 event
  - **Insured loss** ~USD 50 billion
- Repeat of 1923 M_w7.8-7.9 event
  - **Insured loss** ~USD 100 billion
- Repeat of 1703 M_w8.1 event
  - **Insured loss** > USD 100 billion

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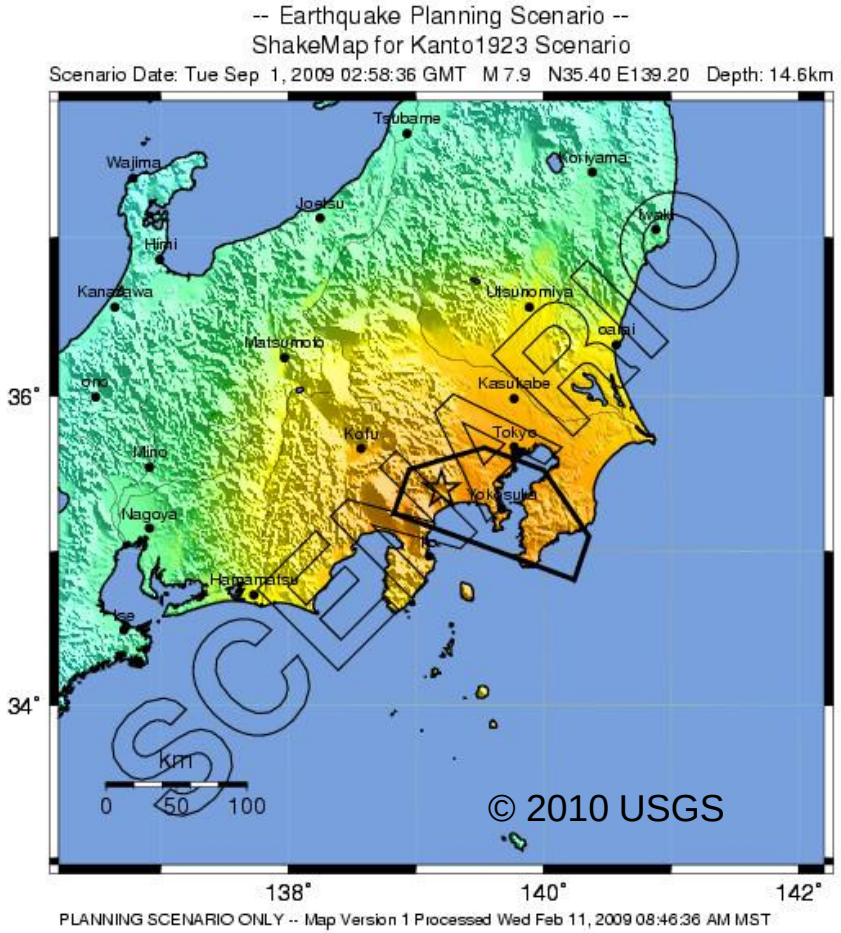
Asian Supercat Potential – Tokyo Great Kanto EQ



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- Repeat of **1923 Great Kanto** earthquake
- Magnitude M_w7.8 to 7.9
- The most destructive earthquake in Japanese history
- Fires that followed the earthquake caused most of the damage
- Insured losses today could exceed USD 100 billion

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Asian Supercat Potential – Tokyo Great Kanto EQ

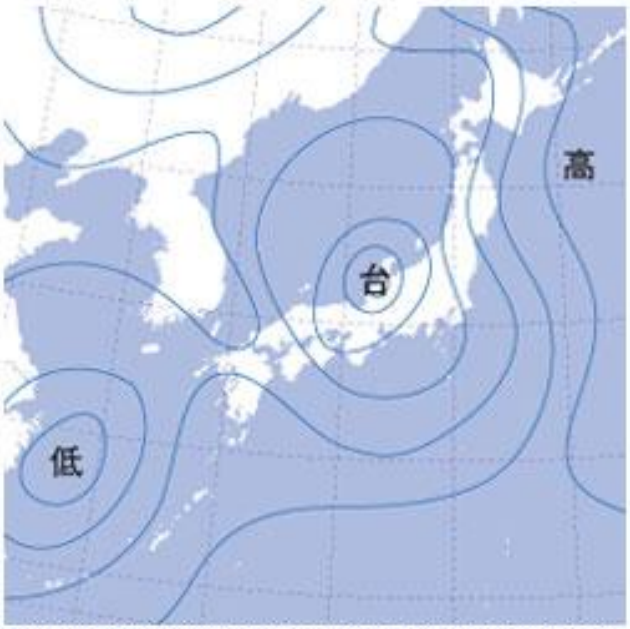


図１　関東地震発生当日 1923 年 9 月 1 日午前 6 時の天気図の写し

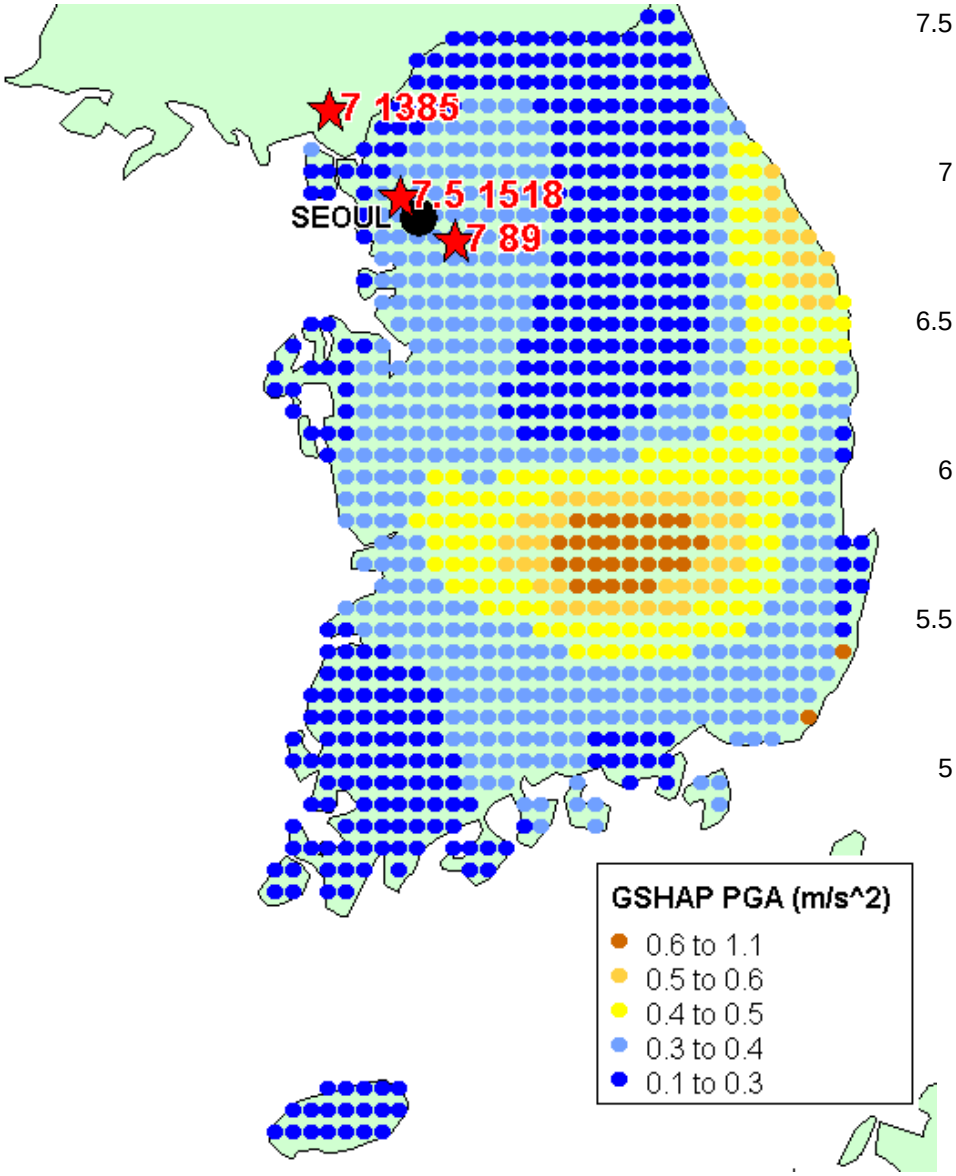
Weather map at 6am on 01/09/1923 showing depression over Honshu. Source: http://www.kajima.co.jp/news/digest/ sep_2003/ tokushu/toku01.htm

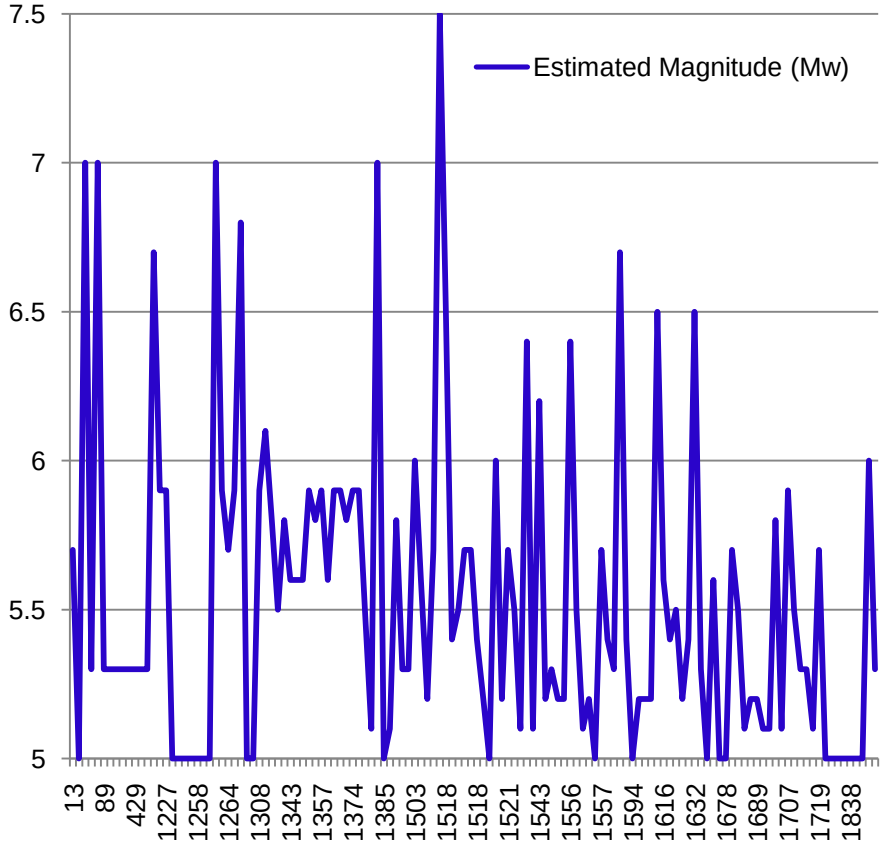
- M_w7.8-7.9 EQ at 11.58 am on 1 September 1923
- Timing meant cooking fires were lit
- Mostly wooden buildings
- Fires apparently spread rapidly under strong winds from passing typhoon

- 100-fold increase in rate of spread of fire under gale force winds compared with calm conditions in a wooden environment (Cousins et al. 2002) – as was Tokyo in 1923
- Uncertainty about spread of fire in a modern reinforced concrete environment

- Joint probability of these events is very low if independent events
- But Japanese seismologists consider that the typhoon may have been a factor in triggering the EQ via an abrupt pressure drop! (*cf.* Morozova, 2005)

Asian Supercat Potential - Seoul EQ





Event catalogue data from Chiu & Kim (2004).

PGA data from GSHAP (http://www.seismo.ethz.ch/gshap).

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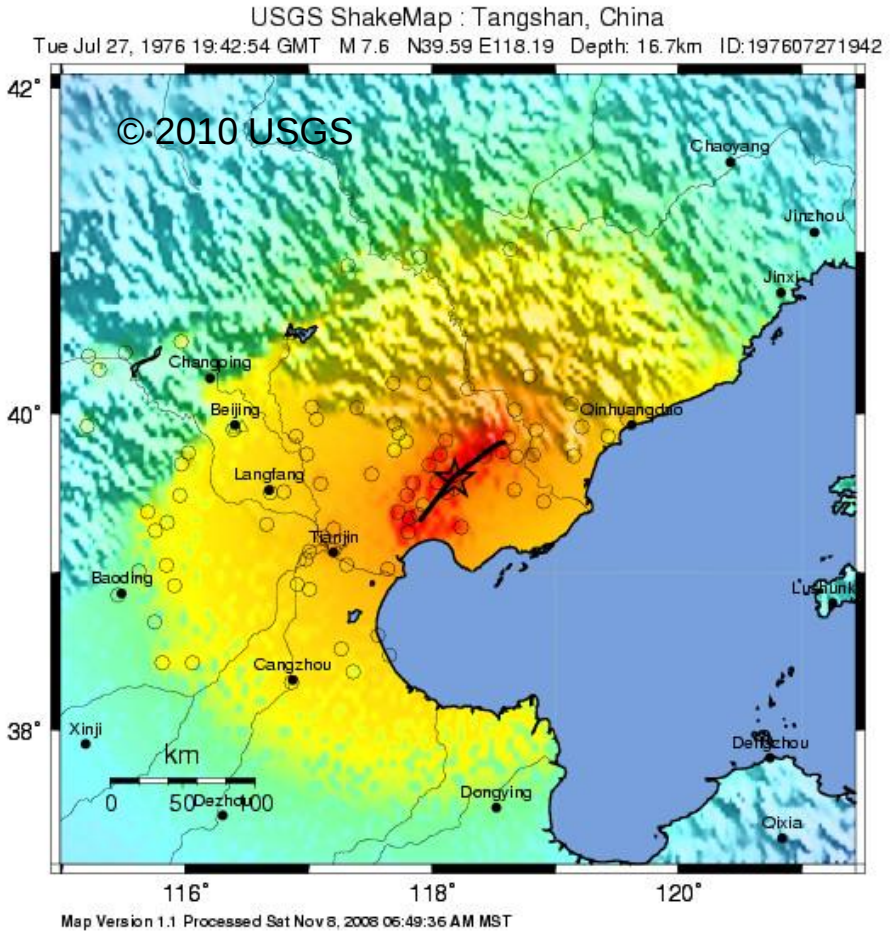
Asian Supercat Potential - Beijing-Tianjin EQ



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- Repeat of 1976 M_w 7.6 Tangshan event in 2006/7
  - Economic loss ~USD 32 to 100 bn
  - Insured loss ~USD 0.2 to 3.2 bn
- With economic growth and increased insurance penetration from 2010-2020
  - 10% economic growth pa
  - 10% growth in insurance penetration pa
  - USD 10 bn insured loss by 2016

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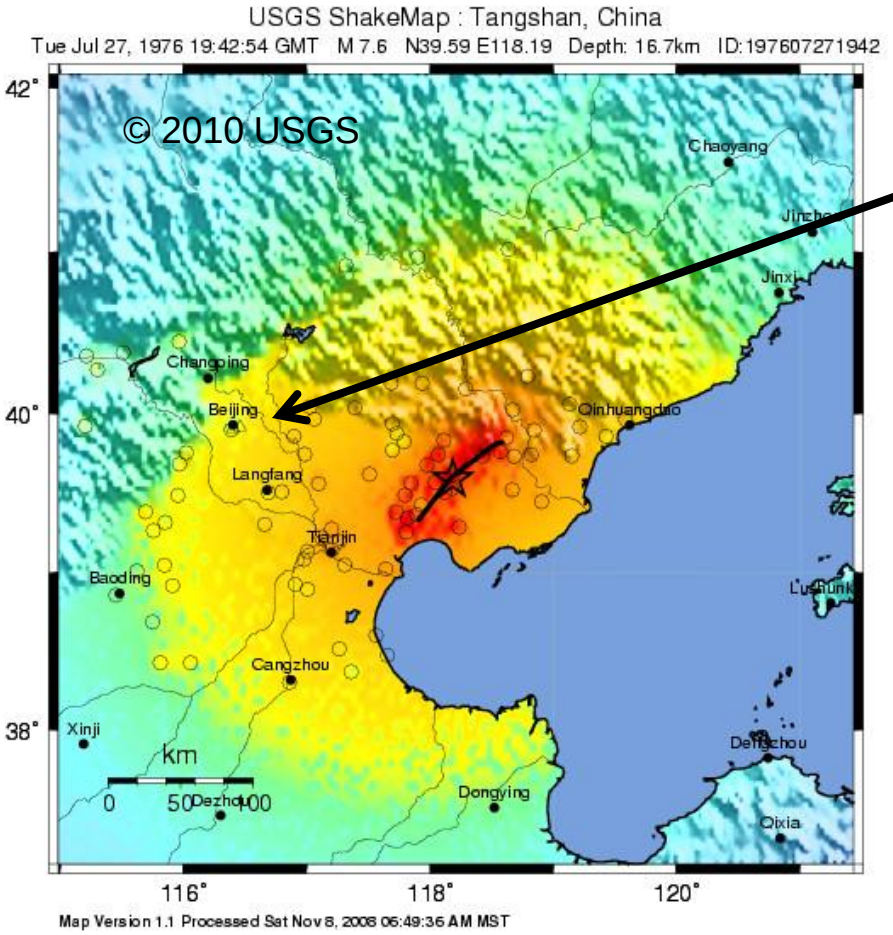
Asian Supercat Potential - Beijing-Tianjin EQ

		China Nationwide Insurance Penetration			
		Constant		Increasing @ 10% pa	
Year	Economic Damage (USD bn) - 10% Economic Growth rate	Penetration	Insured Loss (USD bn)	Penetration	Insured Loss (USD bn)
2010	100	3.0%	3.0	3.0%	3.0
2011	110	3.0%	3.3	3.3%	3.6
2012	121	3.0%	3.6	3.6%	4.4
2013	133	3.0%	4.0	4.0%	5.3
2014	146	3.0%	4.4	4.4%	6.4
2015	161	3.0%	4.8	4.8%	7.8
2016	177	3.0%	5.3	5.3%	9.4
2017	195	3.0%	5.8	5.8%	11.4
2018	214	3.0%	6.4	6.4%	13.8
2019	236	3.0%	7.1	7.1%	16.7
2020	259	3.0%	7.8	7.8%	20.2

Asian Supercat Potential - Beijing-Tianjin EQ



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- Repeat of 1679 Sanhe-Pinggu M_w8 event
  - MMI >X at epicentre
  - MMI VIII in Beijing (50km west)
  - Loss potential >> Repeat of Tangshan 1976

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Asian Supercat Potential – Eastern China

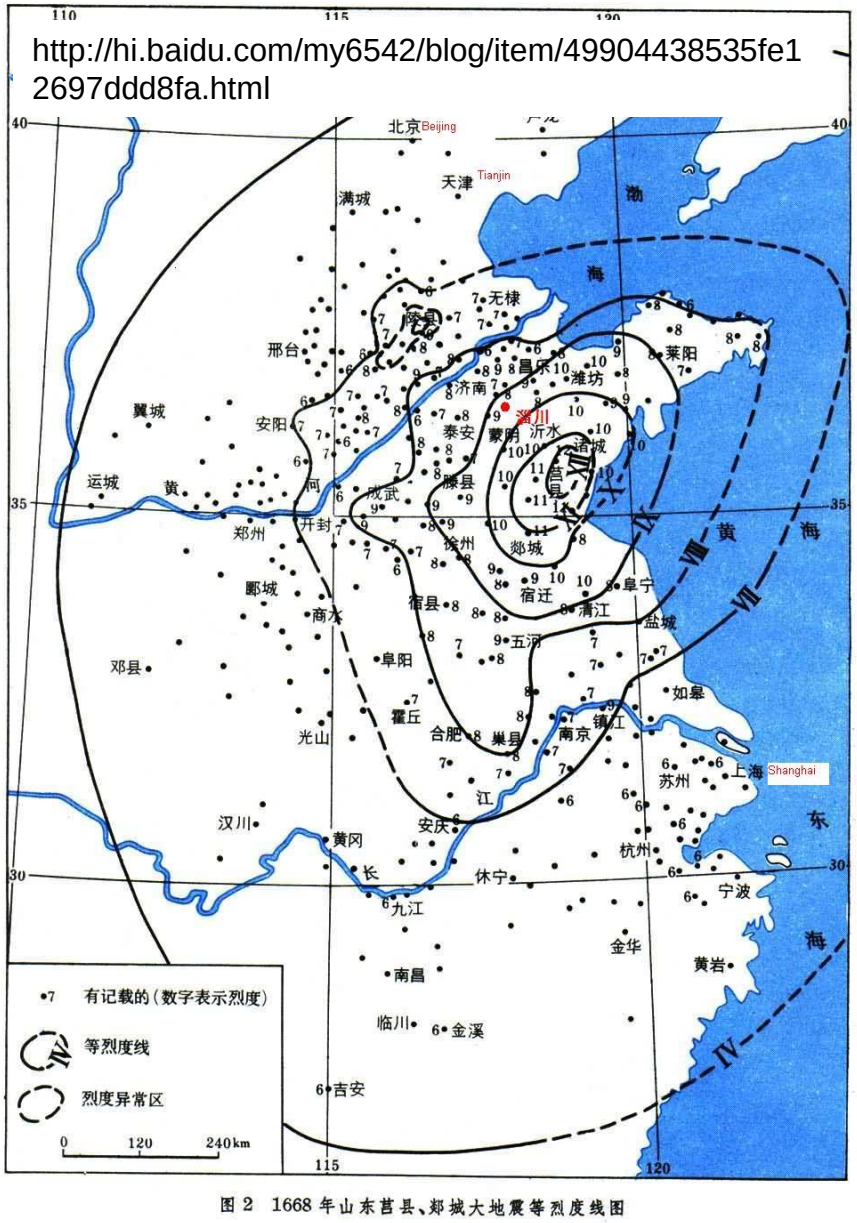

图 2 1668 年山东莒县、郯城大地震等烈度线图

- Repeat of 1668 Tancheng EQ in Shandong
- Magnitude ~Mw8.5, depth ~36km
- MMI intensity XII – Extreme!

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
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INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

- Total “as if” building loss in 2004 prices is estimated at > CNY 1.3 trillion (USD 157 bn) (ADB, 2009); total economic loss even greater
- Assume 3% insurance penetration = USD 5bn insured loss
- Could reach USD 10bn insured loss by 2020

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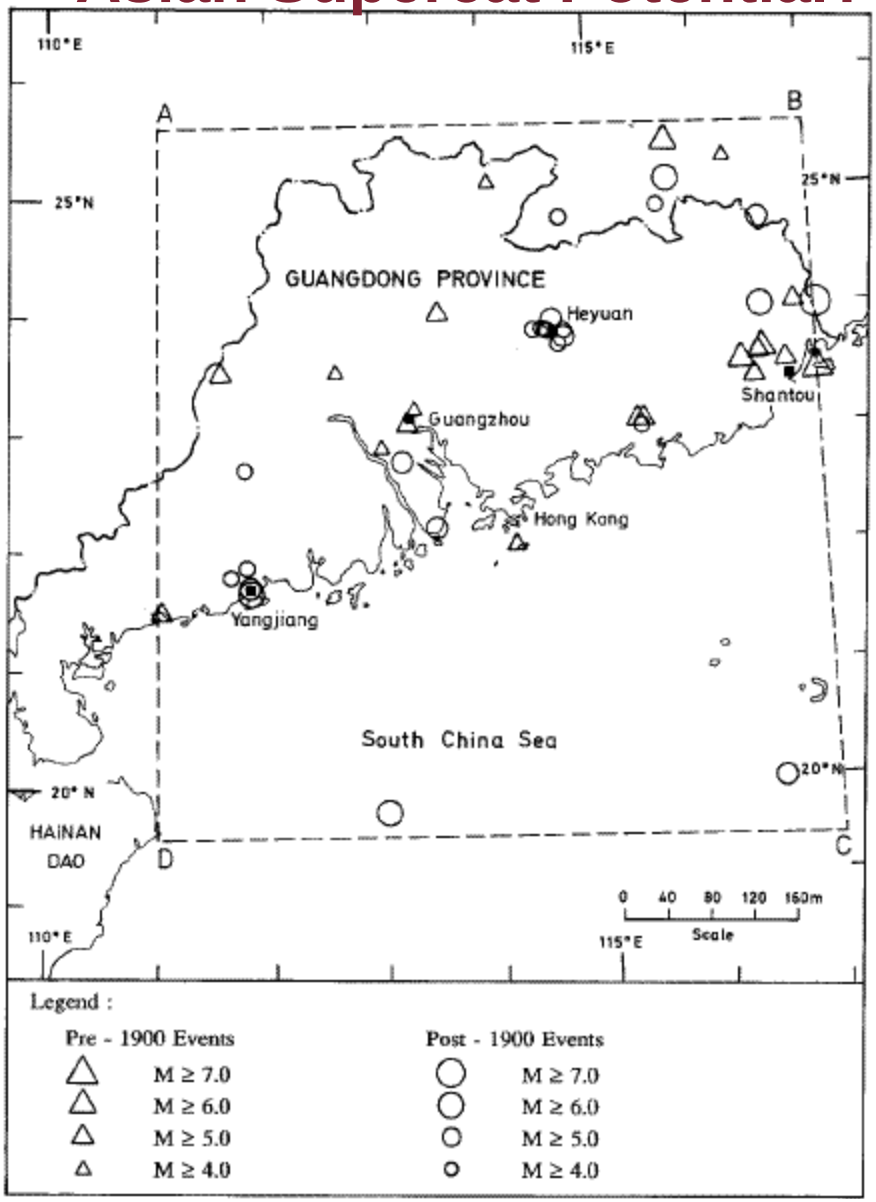
Asian Supercat Potential? - Hong Kong EQ



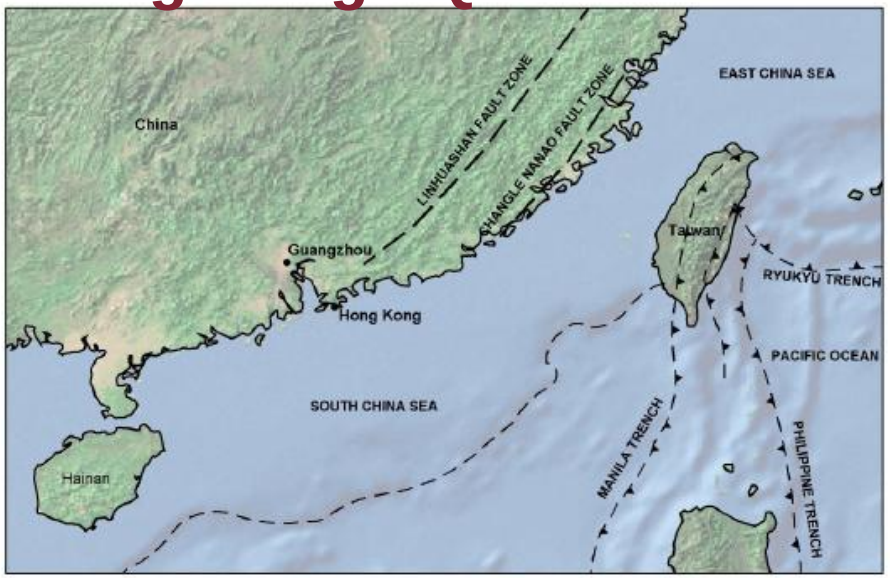


Figure 1. Tectonic setting of Hong Kong (Pappin *et al.*, 2008)

- Two events M_w>7 within 350km of Hong Kong in last 900 years
  - **1918** ~M_w7.4 near Shantou (MMI VI-VII felt in Hong Kong)
  - **1994** M_w7.3 in Taiwan Strait (MMI V-VI felt in Hong Kong)
- Chance of M_w>7 within 100km of Hong Kong in next 50 years is ~1.5% (Pappin *et al.*, 2008)
- Major EQ affecting Hong Kong is expected

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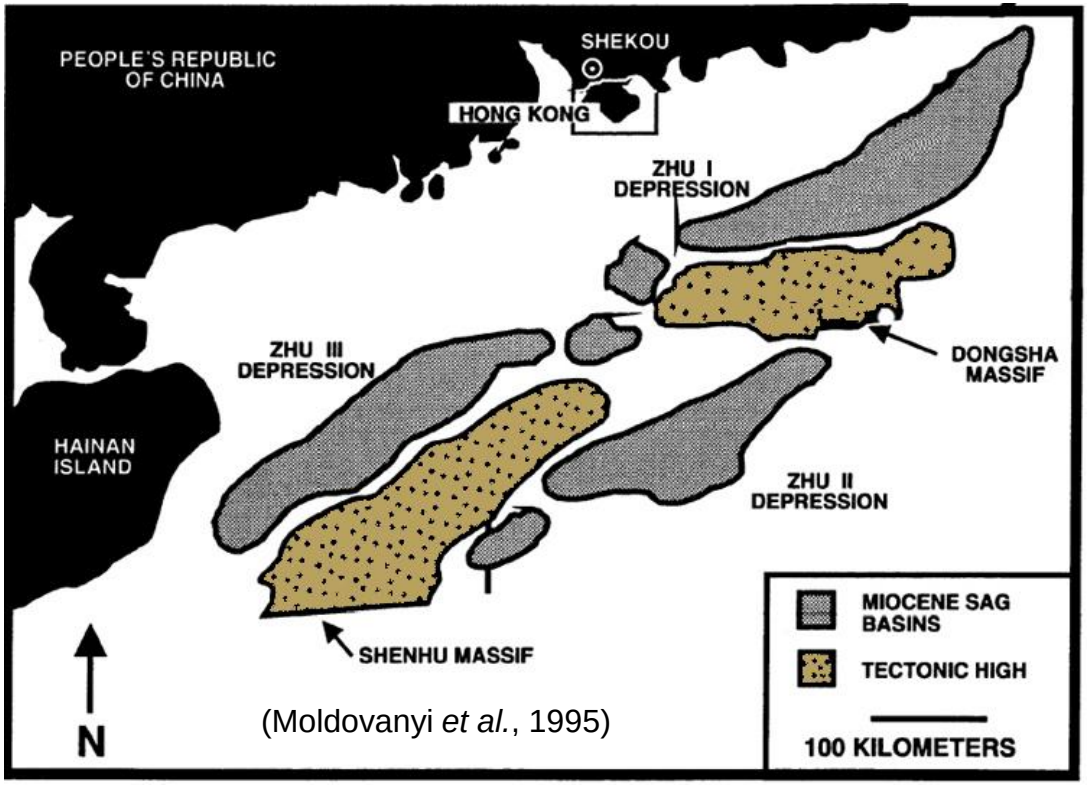
Asian Supercat Potential? - Hong Kong EQ

- Earthquake sources within 100km
  - Onshore - Pearl River delta region
  - Offshore - NE part of the Pearl River Mouth Basin
  - Not known if either area is capable of producing a large shallow event
  - Extensional faulting - not strike slip
- Main risk to Hong Kong is from surface (L) waves to very tall buildings on soft soils
- No precedent exists for response of such a concentration of very tall buildings to L-wave shaking



(Moldovanyi *et al.*, 1995)

Pearl River Mouth Basin

- Needs further research

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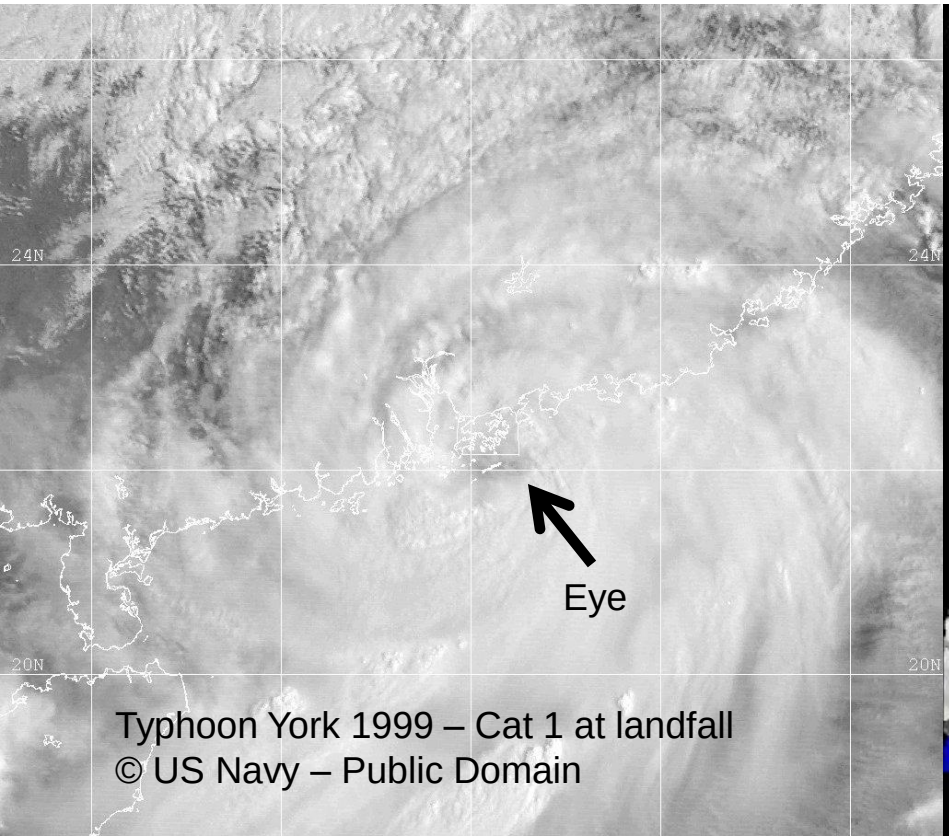
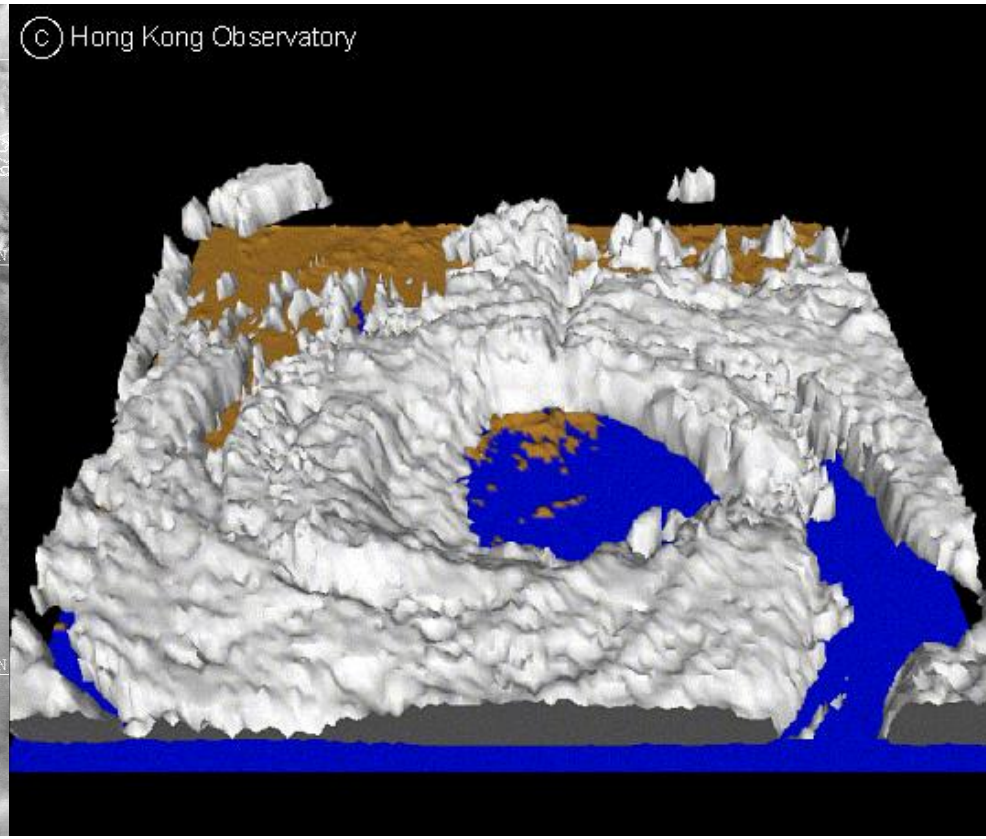
Asian Supercat Potential? – Pearl River Typhoon Surge

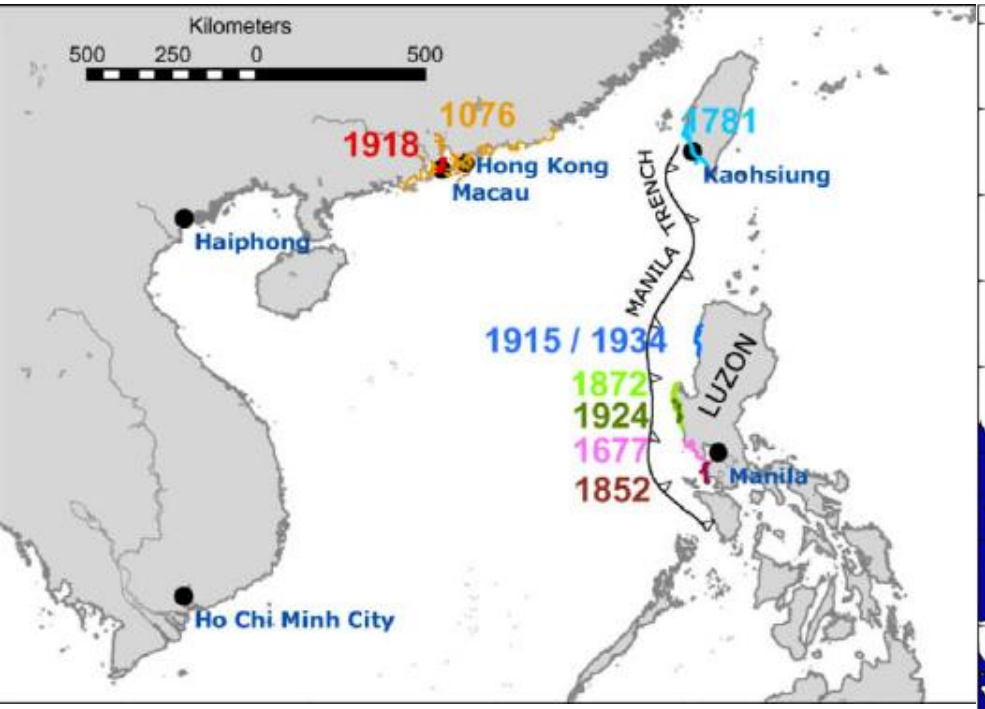


Typhoon York 1999 – Cat 1 at landfall
© US Navy – Public Domain

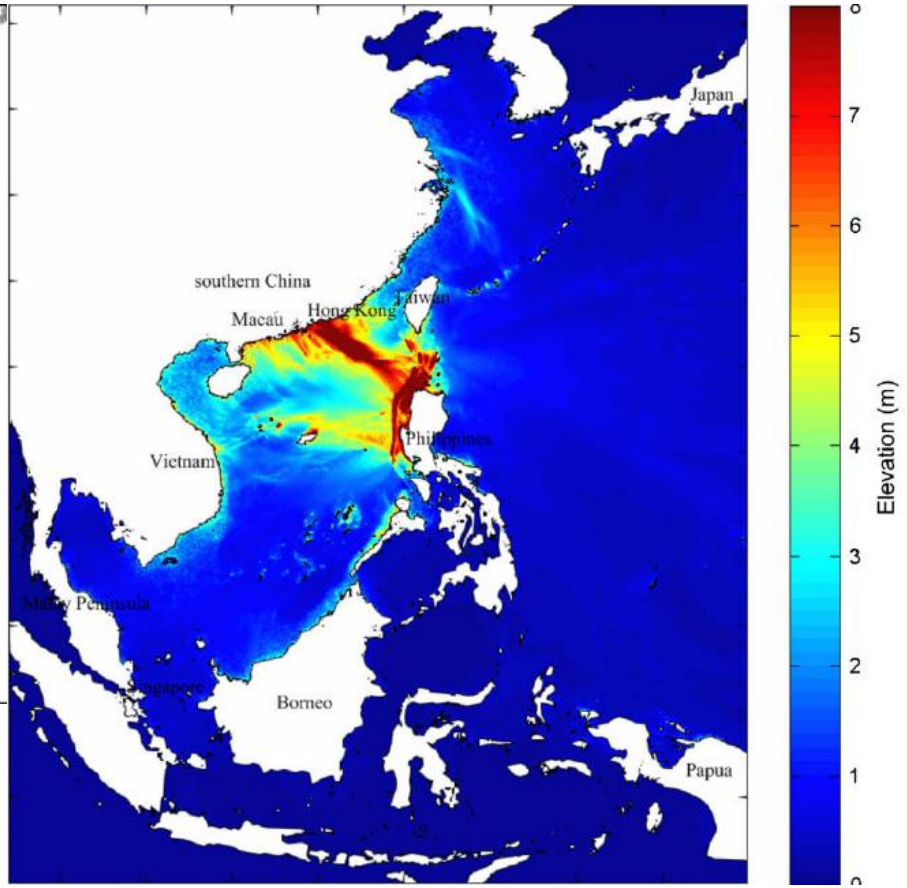


- Cat 4-5 typhoon with storm surge locally up to ~8m hitting Hong Kong and the Pearl River delta
- **Right Front Quadrant** of typhoon would pass directly upriver for maximum storm surge
- Heavy insured losses but unlikely to be Supercat loss at present - Might reach Supercat loss potential in next 10 years given economic growth and continued insurance penetration in this region

Asian Supercat Potential? – South China Sea Tsunami



Figures 1 & 7 from Megawati et al. (2009) Journal of Asian Earth Sciences v36, p13-20, reprinted with permission



- Assume 100% locking of the subduction interface – so that strain is accumulating
- No EQ > ~M_w7.8 since 1560s
- Megawati et al. (2009) assume a M_w9.0 event

- Wave energy focused on Luzon and China
  - >8m height in Manila + **4m subsidence**
  - 6-8m height in southern China
- Wave heights calculated to 10m offshore – could be locally much higher – **Pearl River**

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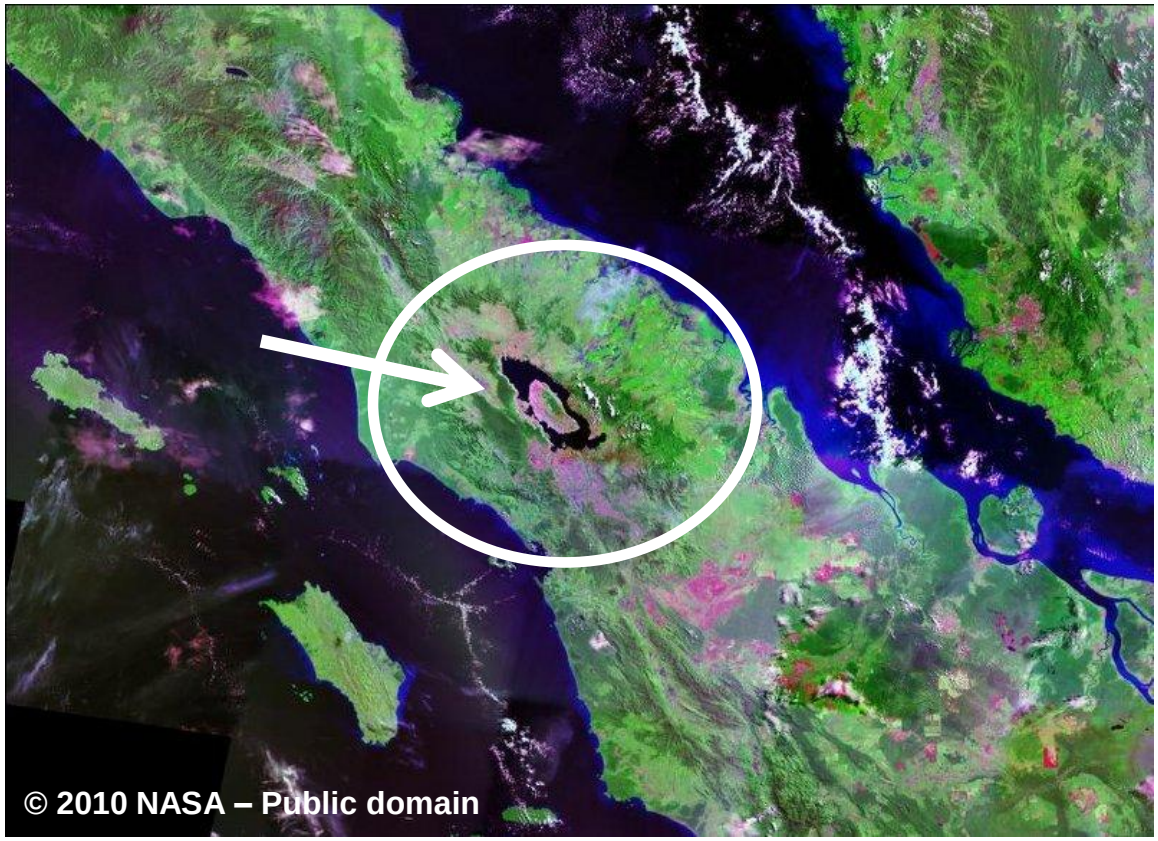
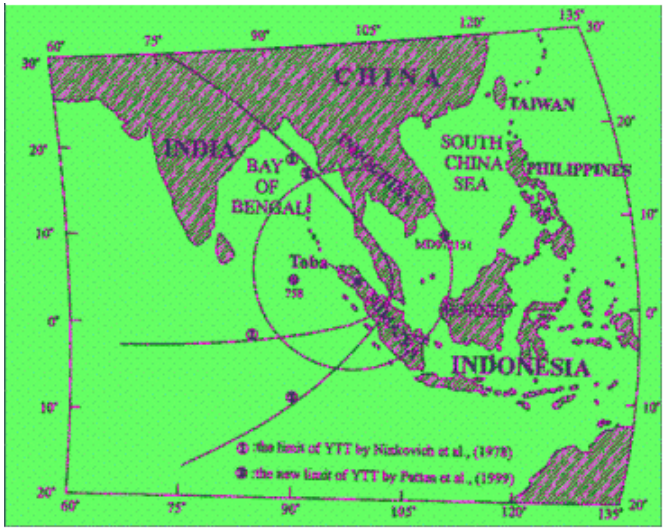
Toba Super-eruption





Extent of Toba ashfall.
From Patten *et al.* (2001)

- Probably the largest eruption in the past 25 million years
- Last eruption ~73,000 years ago
- ~2,800 to 3,500 km^3 of ejecta (~670 to 840 mi^3)
- Special geological conditions required for Rhyolitic magma generation

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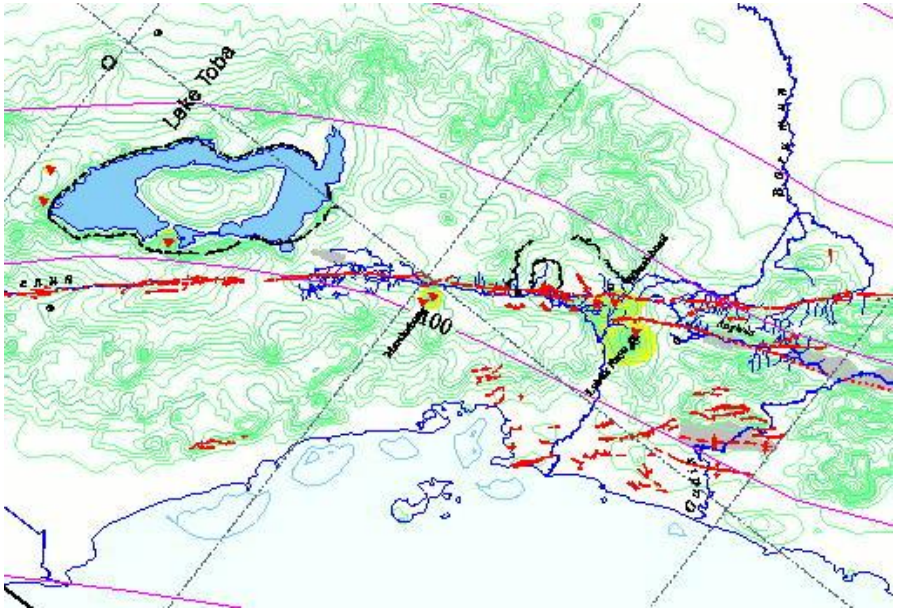
Toba Super-eruption

VEI	Classification	Description	Plume	Ejecta volume	Frequency	Example	Occurrences *
0	Hawaiian	non-explosive	< 100 m	< 10,000 m³	daily	Mauna Loa	many
1	Hawaiian/Strombolian	gentle	100-1000 m	> 10,000 m³	daily	Stromboli	many
2	Strombolian/Vulcanian	explosive	1-5 km	> 1,000,000 m³	weekly	Galeras (1993)	3477*
3	Vulcanian/Pelean	severe	3-15 km	> 10,000,000 m³	yearly	Koryaksky	868
4	Pelean/Plinian	cataclysmic	10-25 km	> 0.1 km³	≥ 10 yrs	Soufrière Hills (1995)	278
5	Plinian	paroxysmal	> 25 km	> 1 km³	≥ 50 yrs	St. Helens (1980)	84
6	Plinian/Ultra-Plinian	colossal	> 25 km	> 10 km³	≥ 100 yrs	Mount Pinatubo (1991)	39
7	Plinian/Ultra-Plinian	super-colossal	> 25 km	> 100 km³	≥ 1000 yrs	Tambora (1815)	5 (+2 suspected)
8	**Ultra-Plinian**	**mega-colossal**	**> 25 km**	**> 1,000 km³**	**≥ 10,000 yrs**	**Toba (73,000 BP)**	**0**

Count of eruptions in the last 10,000 years based on 1994 figures maintained by the Global Volcanism Program of the Smithsonian Institution

- Large silicic magma chambers remain <10km from the surface
- Toba will erupt again – but when?
  - No specific reason to expect eruption in 21st Century
  - Role of Sumatran Strike Slip Zone (SSZ) in eruption not known
  - Large water body (240km³) will cause a phreato-magmatic eruption
- "***Super-volcanoes represent the greatest potential hazard on earth***" – Professor Cas, Monash University, Australia



http://www.gps.caltech.edu/gislab/projects/sumatra.html
Natawidjaja & Sieh (1999)

Closing Thoughts

- Supercat loss magnitude is measured here by global rather than local standards (>=USD 10bn **insured loss**)
- Supercat loss events are relatively frequent in the USA
  - Mostly hurricanes – reflects relative frequency of these events
- No Asian loss events meet Supercat insured loss to date
- Lots of potential for Asian Supercat losses in future
  - Mostly earthquakes – Japan, China, Korea
- Because of frequency of Supercat hurricane losses, the USA will probably still rank #1 in terms of overall insured cat loss for the foreseeable future
- Toba could change all of this

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Thank You for Listening!

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