GUY CARPENTER

Catastrophe Risk Management
AIRC Seminar, Taipei

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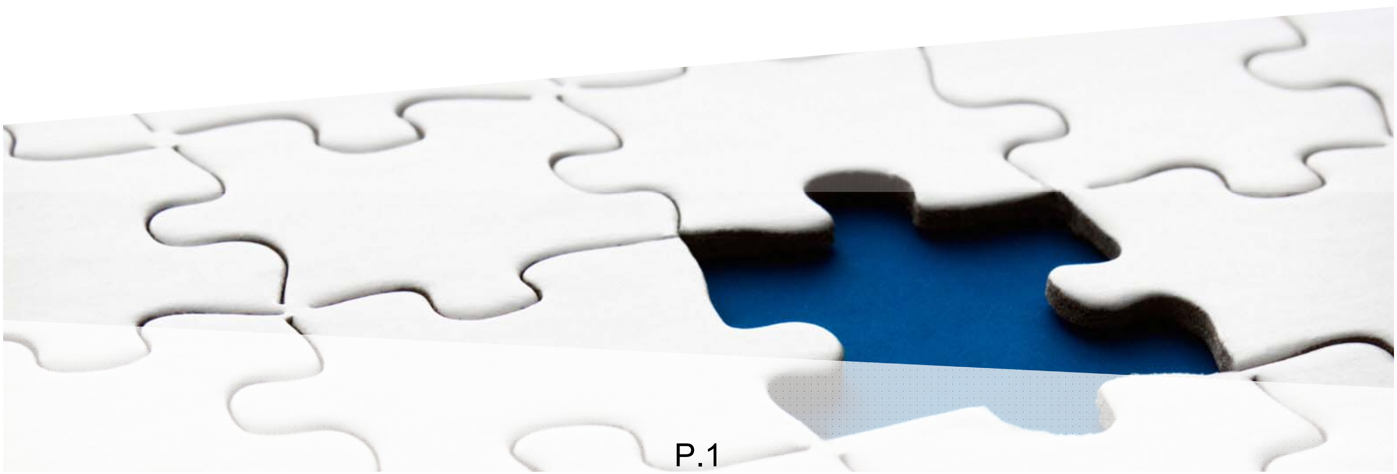
AIRC Seminar – Catastrophe Risk Management
Agenda

- Background to Catastrophe Modeling
- Catastrophe Model Framework and Development
- Data Quality and why it is Important

- Then Modeling output, pricing, reinsurance markets, etc, for Mike



Background to Catastrophe Modeling

What are Catastrophes ?

- Infrequent large events that have the potential to result in large economic/insured losses and/or loss of life
- The term is associated with natural disasters such as Earthquake, Typhoons and Flood



Characteristics of Natural Hazard

Generalised claims burden of Central European insurers between 1983 and 2002: The trend for fire losses is very consistent. Historical claims data offers reliable clues for the full spectrum of future annual losses. However, annual natural hazard losses fluctuate wildly and can have a dramatic impact on a re/insurer's annual financial results. This is clearly illustrated by losses in 1999, which were principally caused by the European winter storms *Lothar* and *Martin*. Even loss statistics that are tracked and indexed accurately over a fifteen-year period are not sufficient to assess natural hazard risks reliably.

Annual losses caused by:
- Fire
- Natural hazards

Source: Swiss Re

Characteristics of Natural Hazard

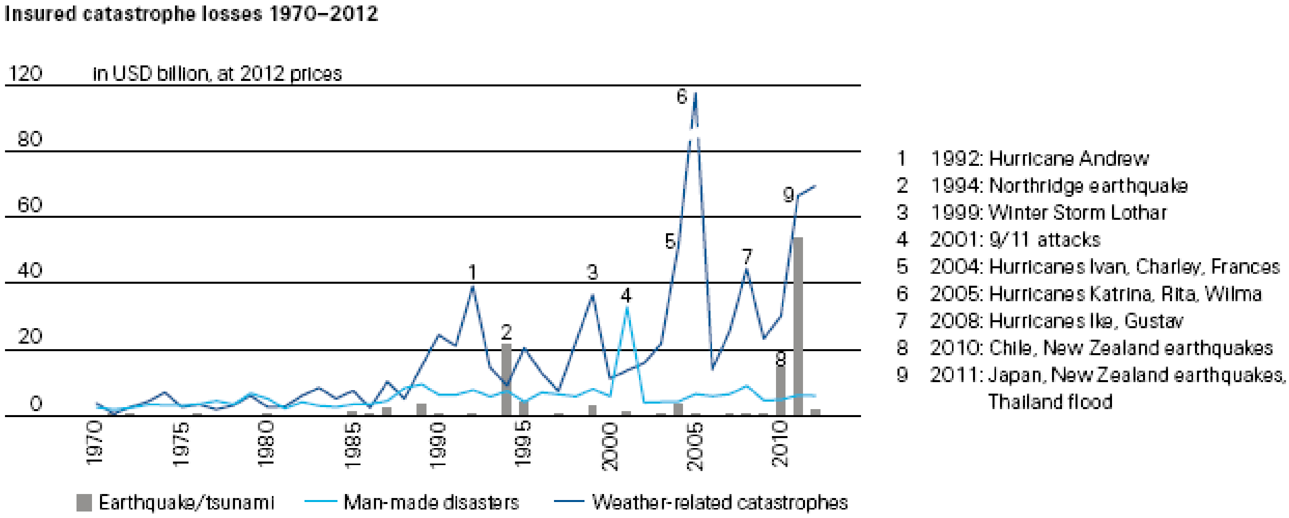
Fire

Natural hazards

	Fire	Natural hazards
Differences		
Occurrence frequency	High	Low
Event size	Individual risk affected (individual building or complex of buildings)	Entire portfolios of risks affected
Location	Low importance	High importance
Consequences		
Pricing	Minor fluctuations in the loss burden; therefore, burning cost analysis and exposure rating are sufficient	Major fluctuations in the loss burden; therefore, scientific models are required
Loss potential from single event	Low to medium	Very high
Geographical distribution	Minimal impact on losses, no accumulation control required	Major impact on losses, accumulation control important

Source: Swiss Re

Global Catastrophe Insured Losses – 1970 to 2012
Upward Average Loss Trend Continues



Source: Swiss Re Economic Research & Consulting

Insured Catastrophe Losses – 1980 to 2010
Geographic Distribution – USD 20.7bn Average

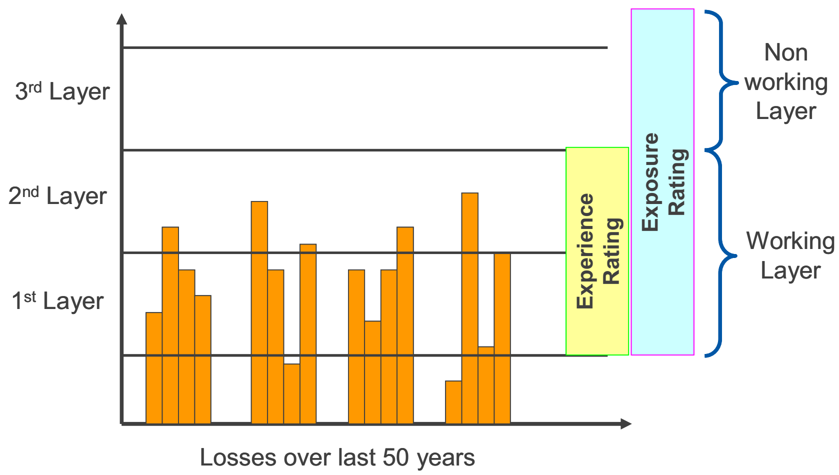
- Insured cat losses are traditionally determined by North American hurricane losses

Insured Catastrophe Losses – 2011
Geographic Distribution – USD 116bn

- Shift in perils and regions
- 2011: earthquake losses were the highest ever
- 2011: flood losses were the highest ever
- 2011: Other weather-related natural catastrophes were the 3rd highest ever (after 2005 and 2004)

Estimating Catastrophe Loss Potential
Experience Rating vs. Exposure Rating

- Experience Rating = Modeling Future Losses Based on Past Loss Experience



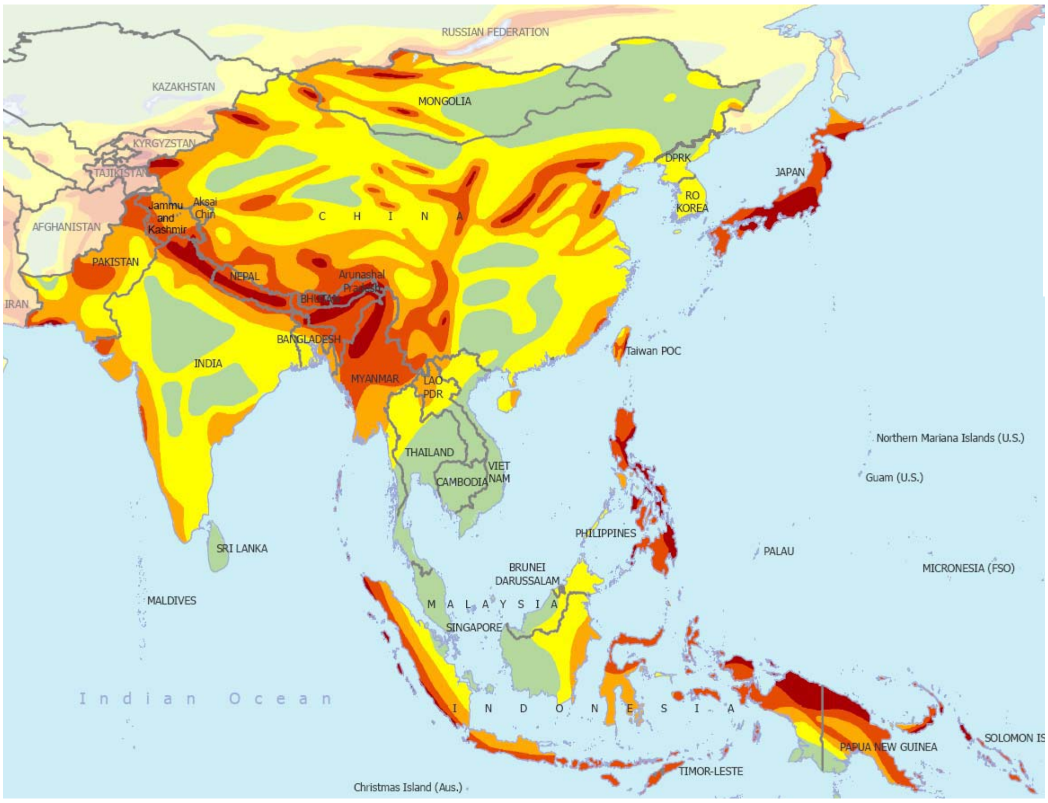
- Exposure Rating = Modeling Future Loss Potential Based on Value at Risk
  - Simple Probable Maximum Loss (PML) Estimate
  - Sophisticated Catastrophe Models

Perils in Asia Pacific

Tectonic Plates and Faults in Asia Pacific

Source : OCHA

Earthquake Intensity
Modified Mercalli Scale



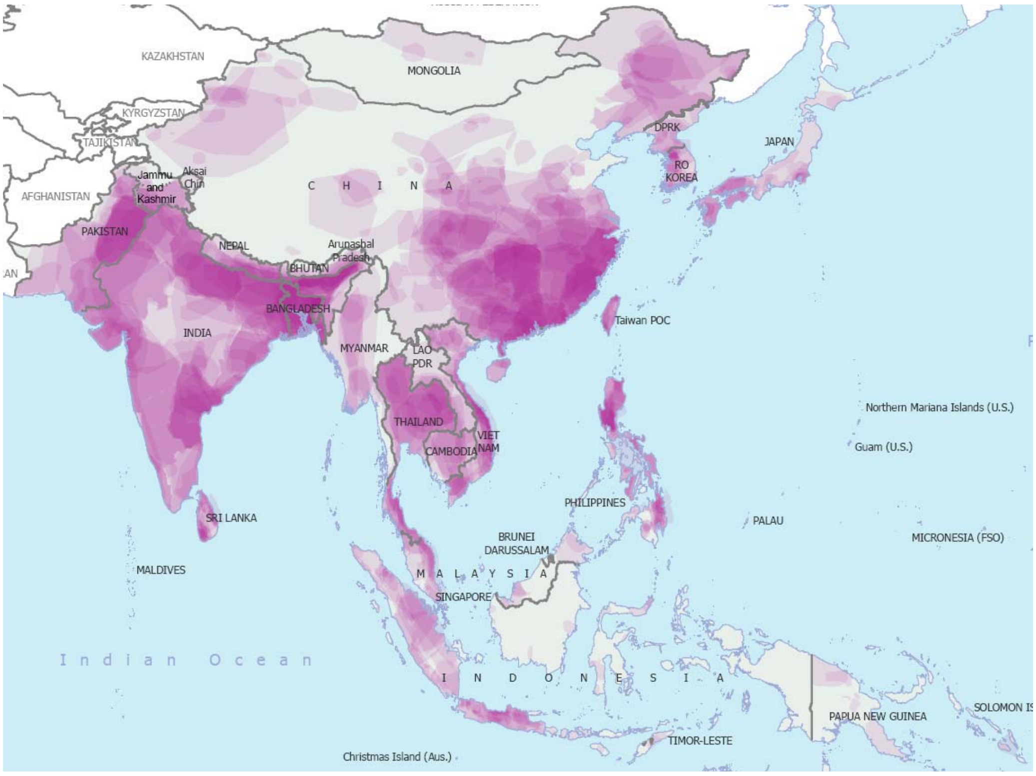
Earthquake Intensity
Modified Mercalli Scale

- Degree I-V
- Degree VI
- Degree VII
- Degree VIII
- Degree IX-XII

The Zones indicate where there is a probability of 20 percent that degrees of intensity shown on the map will be exceeded in 50 years

Source : OCHA

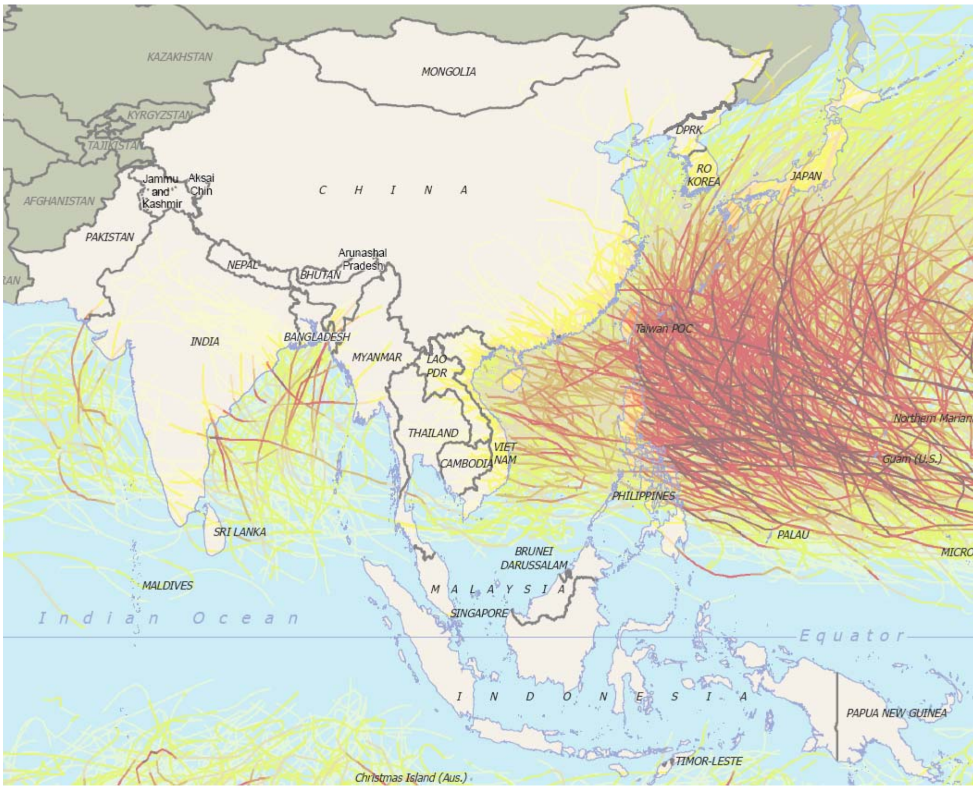
Flooding in Asia Pacific
1985 – 2005



Annual Flood Risk
Low High

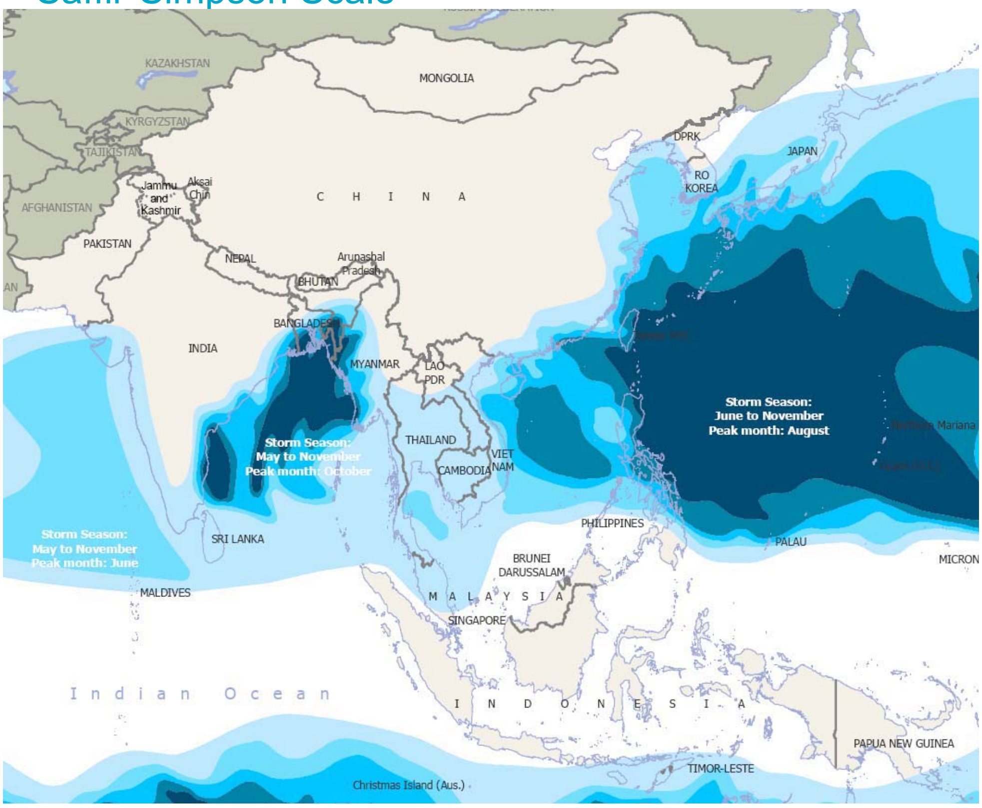
Source : OCHA

Tropical Storms in Asia Pacific
1956 – 2006



Source : OCHA

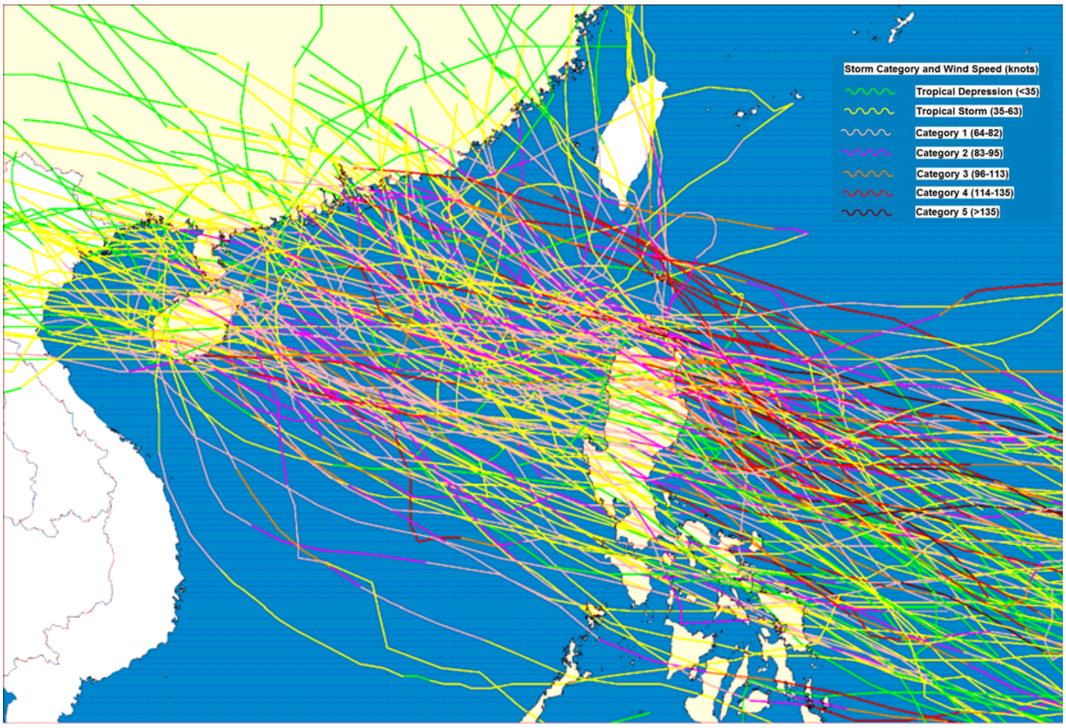
Tropical Storm Risk Zones
Saffir-Simpson Scale



The Zones indicate where there is a probability of 10 percent that degrees of intensity shown on the map will be exceeded in the next 10 years

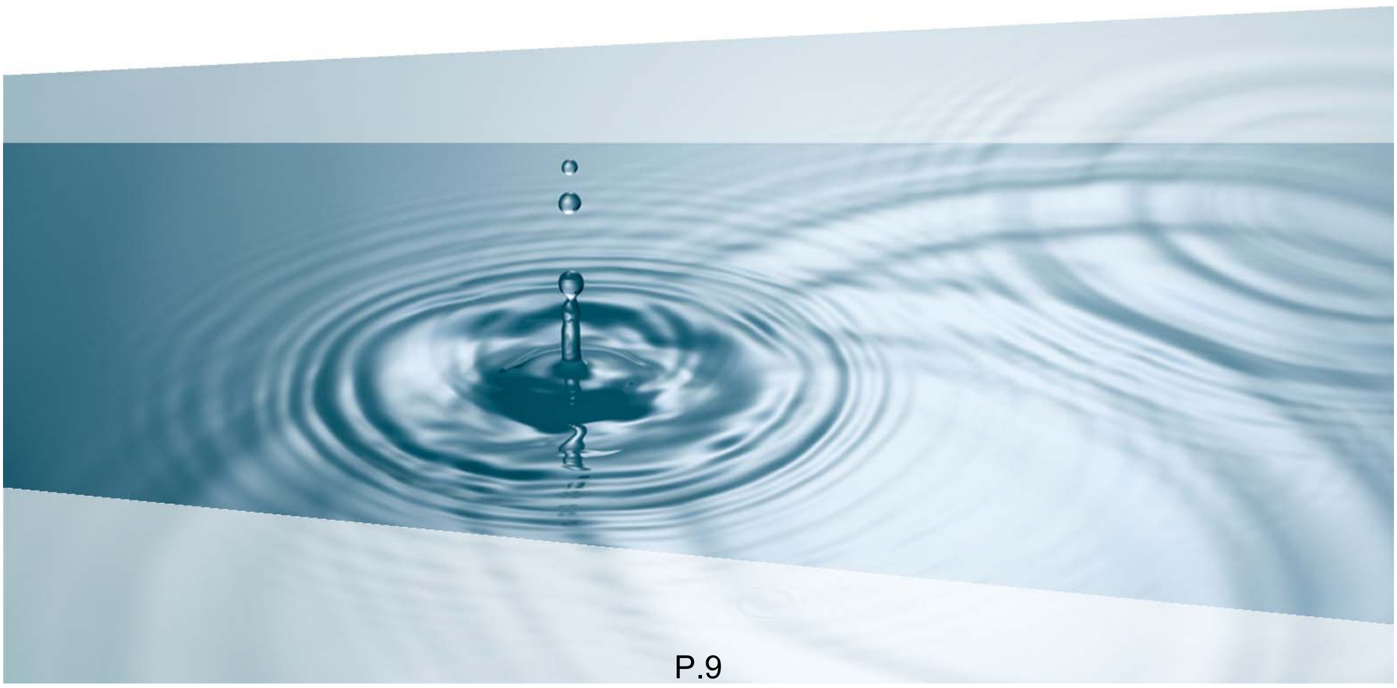
Source : OCHA

Wind Hazard Correlation
Philippines & China (Typhoons Only)



Source : JTWC BEST Track

Catastrophe Modeling Framework and Development



Catastrophe Modeling

Models produce estimates, not facts

Don’t trust the models too much and don’t trust them too little

Jim Stanard (ex CEO Renaissance Re)

R M S

EQECAT

AIR WORLDWIDE

Catastrophe Model Evolution

Model History

1980

Significant World Events

Limited use, predicted potential for losses excess of US$8bil – IGNORED

Considered worse case scenarios

1989 Hugo US$4.5b
1991 Mirellie US$5.2b

Europe experiences hurricane type winds

1990 Vivian US3b

The rise of the CAT Model – RMS, AIR, EQECAT

1992 Andrew US$18b

Increased worldwide coverage

Continual refinement, increased acceptance

1994 Northridge US$12b
1995 Kobe US3b

New Catastrophe – Casualty modeling emerges.

2001 WTC US20b

Frequency questioned

2004 Charley, Frances, Ivan Jeanne US28b
2005 Katrina US$50b

Models feel the strain – losses exceed modeled results

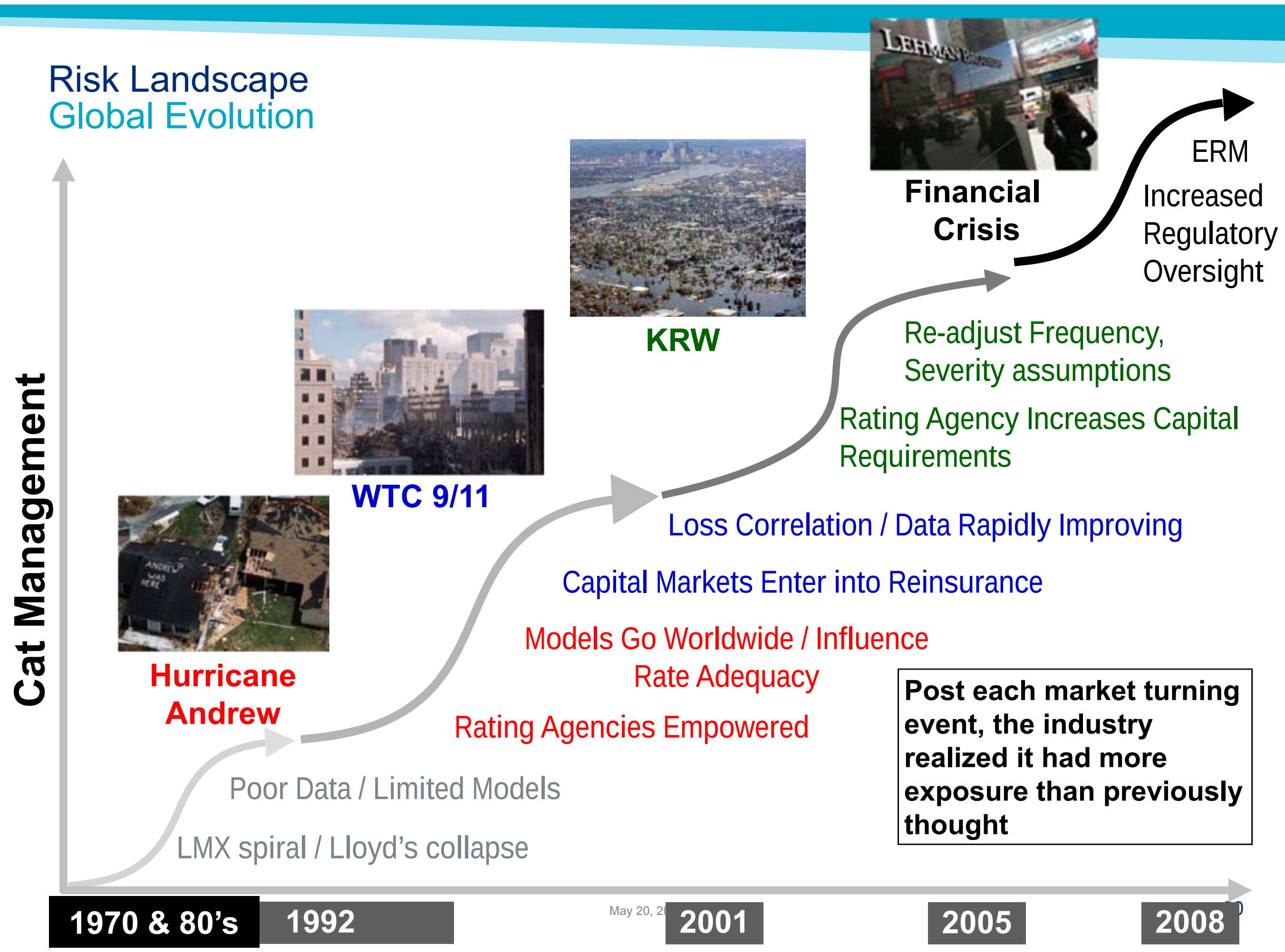
Severity questioned ‘Super CAT’

RMS v11 released

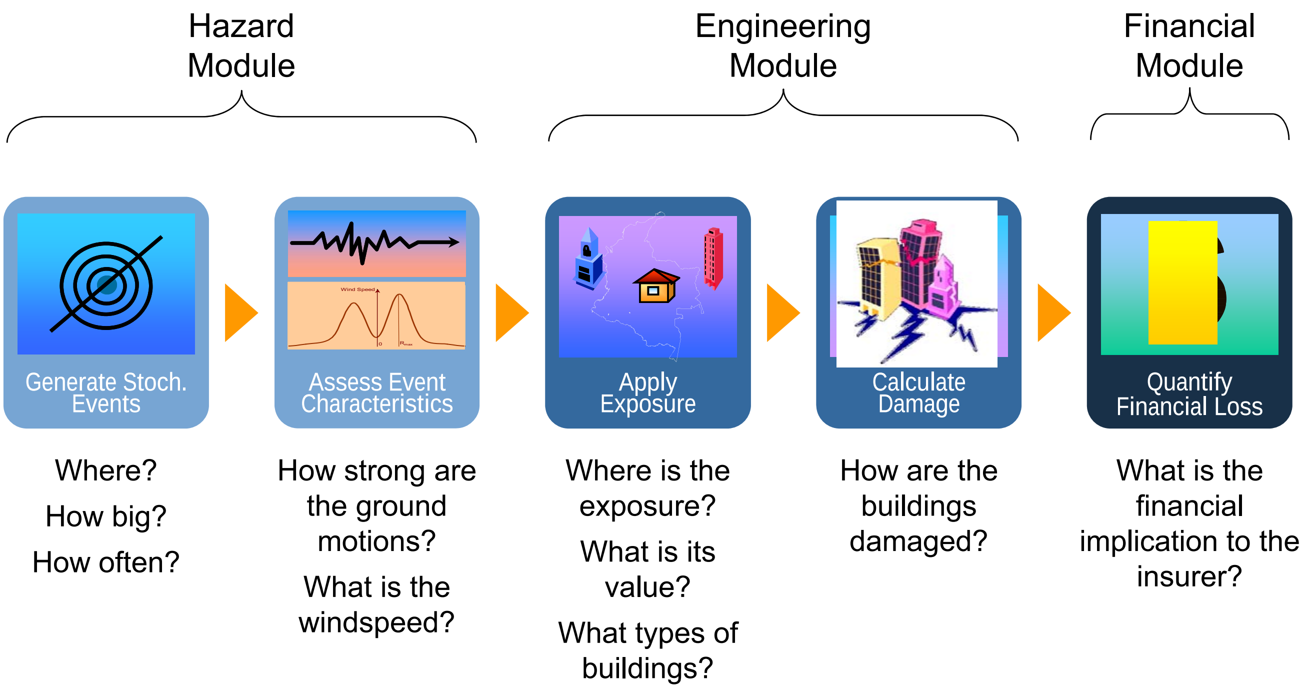
Industry questioning results

2011

Risk Landscape
Global Evolution



Catastrophe Modeling Framework



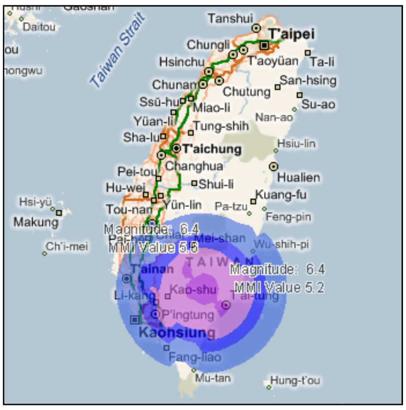
Catastrophe Model Data Requirements

- Hazard Module
  - Location: CRESTA, state, district, city, latitude/longitude
- Engineering Module
  - Construction & Occupancy classes
  - Age, number of stories, soft story, etc.
- Financial Module
  - Limits and values by coverage
  - Deductibles
  - Reinsurance details

All modeling is based around assumptions related to the hazard, vulnerability and the exposure. We have greatest control over the exposure assumptions and improving the information content will reduce the assumptions and uncertainty in the analysis.

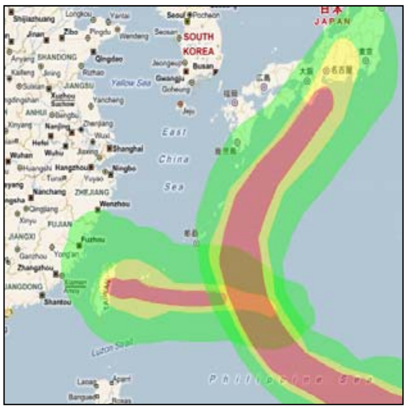
Hazard Module
Where & How Big?

Earthquake



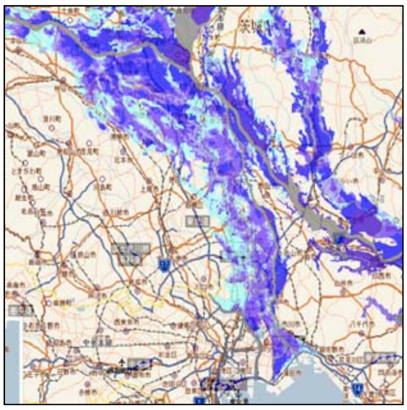
Footprint of a 6.4M earthquake in Taiwan 2008

Typhoon



Footprint of Typhoon Melor and Morakot 2009

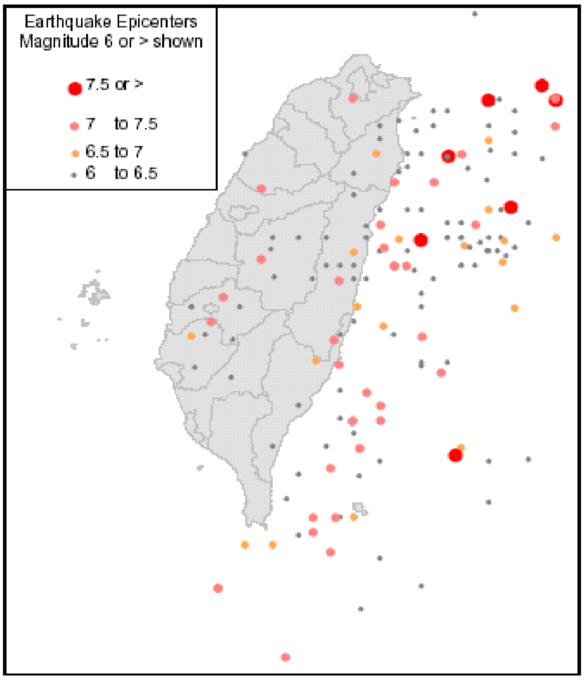
Flood

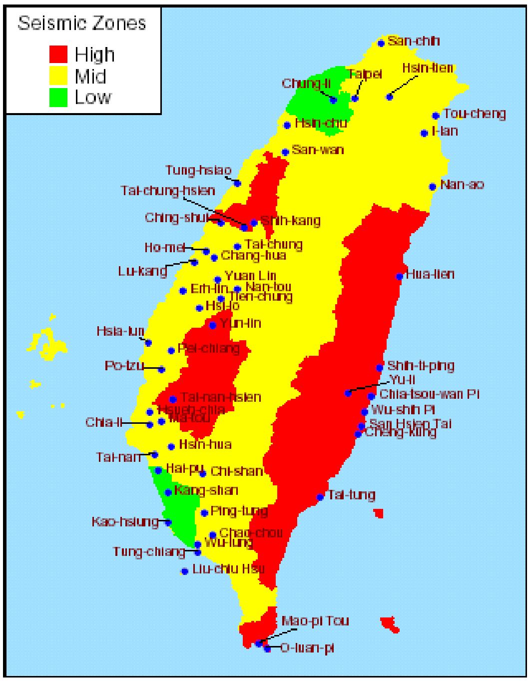


River Tone 200yr Flood, Japan

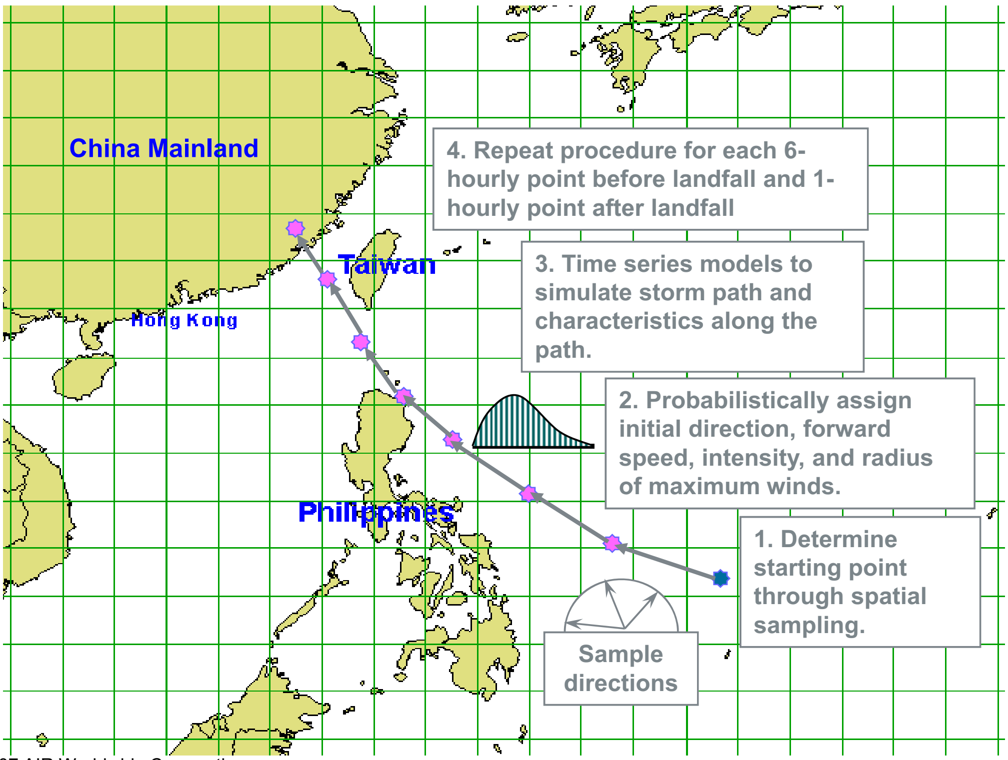
Illustrations of footprints resulting from earthquake, windstorm and flood, respectively. In the hazard module, such footprints are available for each probabilistic event and form the basis of the calculations in the subsequent modules

Hazard Module
Where & How Big?





Hazard Module
How Often? Stochastic Catalog Generation

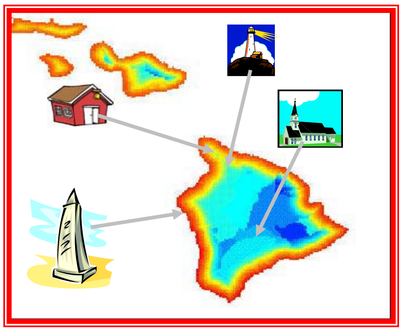


Hazard Module
How Often? Stochastic Event Set

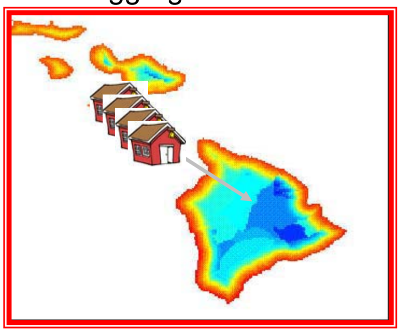
- Each modeler (RMS, AIR, EQE) has a set of synthetic events
- Lots of variation in the number of events catalogued by each model
- For example, earthquake event set by model for Japan
  - RMS: 38,000+
  - AIR: 130,000+
  - EQE: 80,000+
- But bigger event sets are not necessarily better

Engineering Module
Where is the Exposure?

Detailed Data

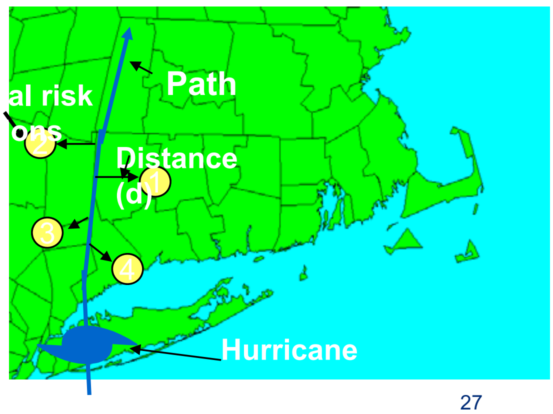


Aggregated Data



Where is the exposure and what is the construction and occupancy ?

Location resolution **will** impact the model results as we shall see later



Engineering Module
Vulnerability

- Estimates physical damage to structure and contents.
- Vulnerability function definition *"Mean damage given site intensity for every structural type"*
- Models vary on:
  - Classifications of structures
    - Wood frame versus steel frame, etc
  - Year built (now primary driver in RMS)
  - Square footage, number of floors
- Damageability can be based on
  - Engineering analysis, Historical Data, expert opinion

Engineering Module
Vulnerability

- Residential Wood Frame - How extensive will the damage be ?

Source : AIR Worldwide Corporation

Engineering Module
Vulnerability – Occupancy Type

Single Family	Apartment	Commercial
		
Non-Engineered Structure Major Damage	Marginally Engineered Structure Medium Damage	Engineered Structure Minor Damage

Engineering Module
Vulnerability – Construction Type

Masonry	Steel	Reinforced Concrete
		
Major Damage	Medium Damage	Minor Damage

Engineering Module
Vulnerability – Height Correlated to Damageability

Low-Rise: 1 - 3 stories

Major Damage

Mid-Rise: 4 - 7 stories

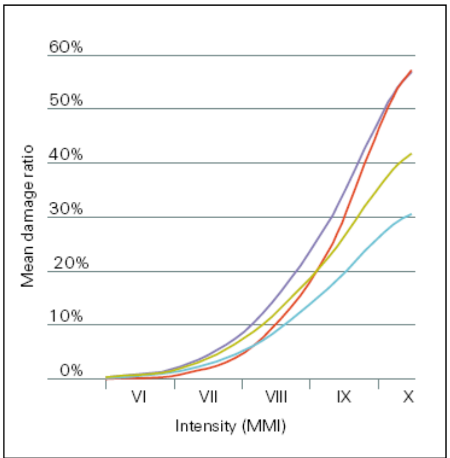
Medium Damage

High-Rise > 8 stories

Minor Damage

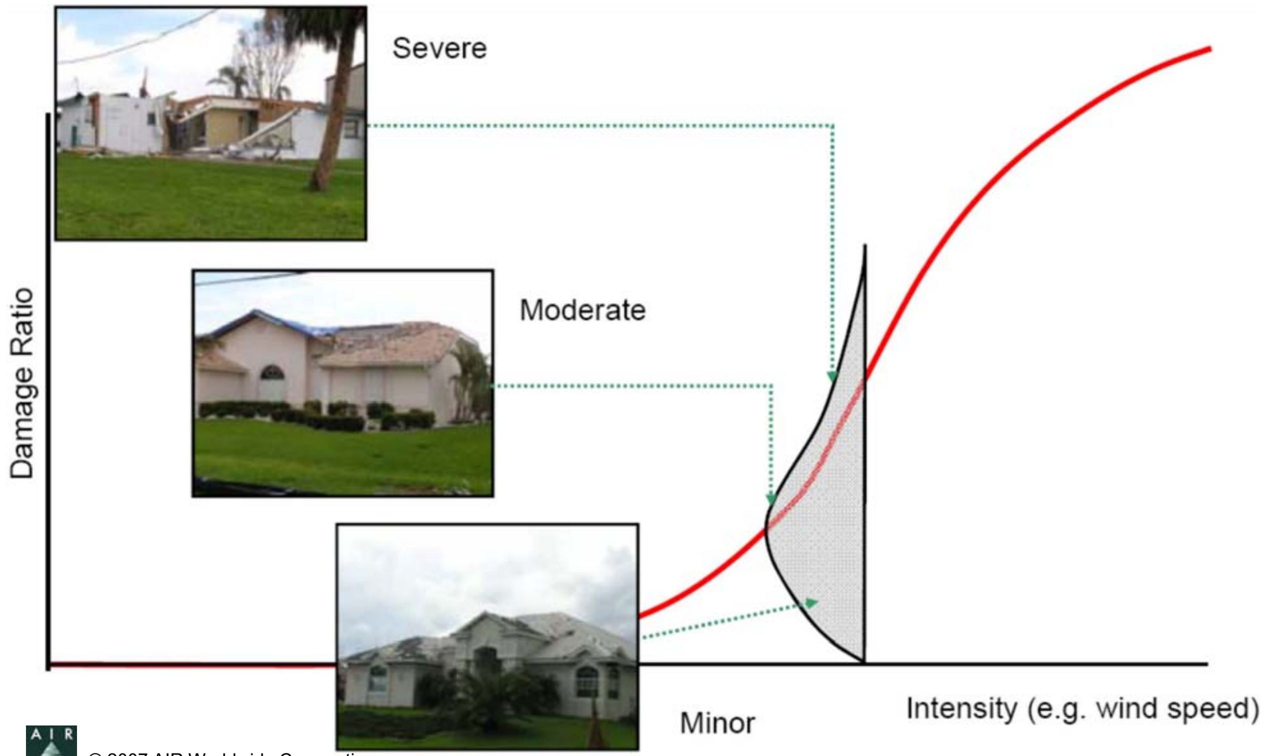
Engineering Module
Vulnerability – Factors

- Location
- Occupancy
  - Single family, apartment, commercial, industrial, etc
- Construction
  - Masonry, steel, and reinforced concrete, etc.
- Building, contents, and time element coverage's
- Height
- Year built (now primary driver in RMS)
- Number of risks
- Policy terms (in terms of the insured loss)

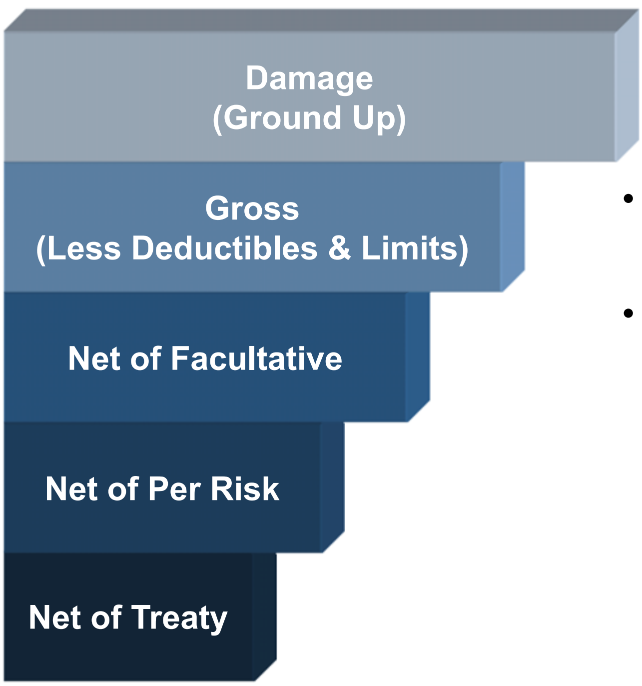


Typical earthquake vulnerability curves for:
- Residental buildings (single family)
- Residental contents (single family)
- Commercial buildings mix
- Industrial equipment and machinery

Engineering Module
Vulnerability – Uncertainty

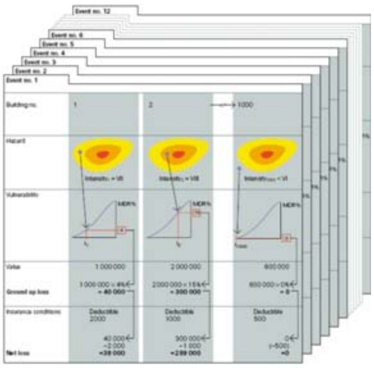


Financial Module

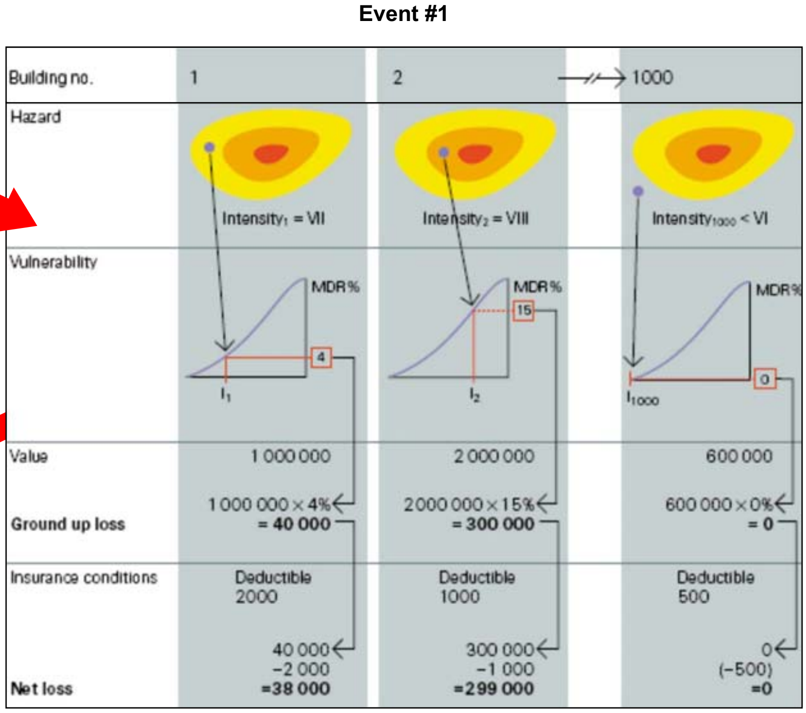


- Estimates loss after application of financial structures
- Ground up losses are translated to insured losses by applying the following
  – Policy deductibles and limits applied
  – Facultative reinsurance
  – Proportional reinsurance
  – Catastrophe reinsurance

The Loss Modeling Process



Event catalogue



Event loss

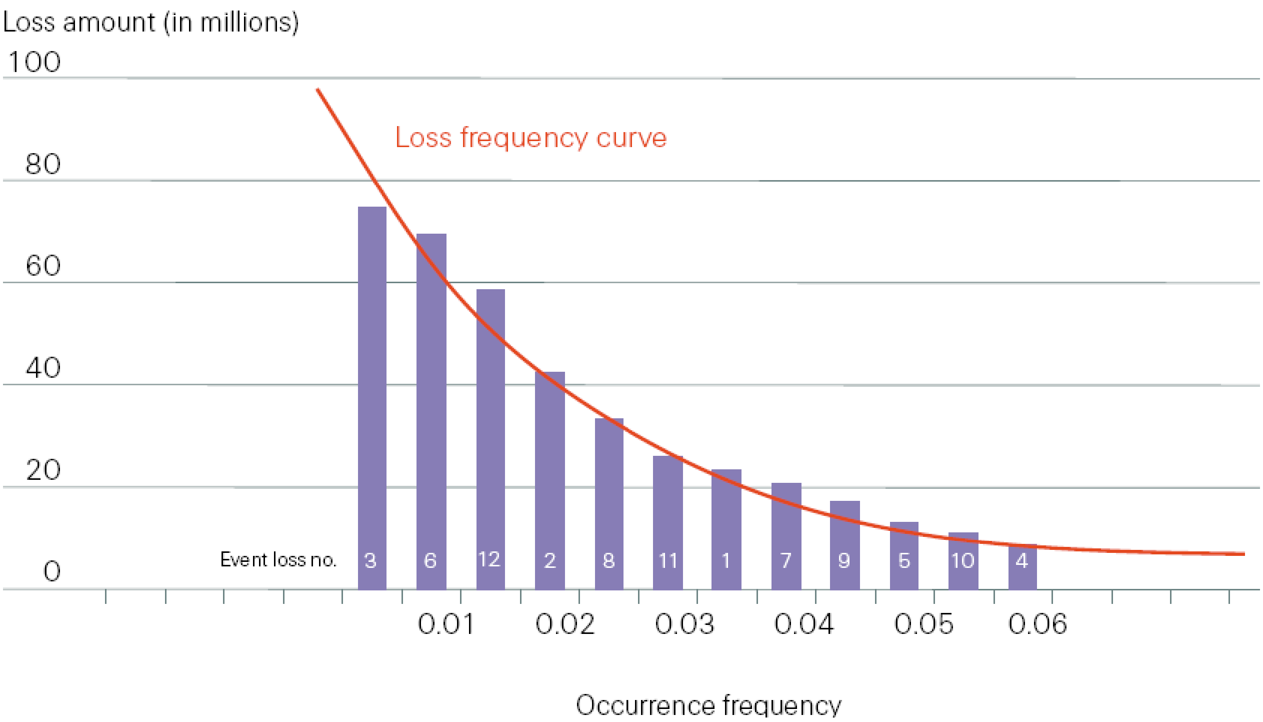
No. 1 = (38 000 + 299 000 + ... + ... + 0) = 23.5 m
No. 2 = (0 + 25 000 + ... + ... + 54 000) = 42.5 m
No. 3 = (75 000 + 36 000 + ... + 15 000 + 0) = 74.8 m
No. 4 = (0 + 0 + ... + ... + 63 000) = 8.9 m
No. 5 = (..... + ... + ... + ... + ...) = 13.1 m
No. 6 = (..... + ... + ... + ... + ...) = 69.6 m

No. 12 = (0 + 0 + ... + ... + 63 000) = 58.6 m

Impact of each event of each risk

Source: Swiss Re

The Loss Modeling Process
Loss Frequency Curve



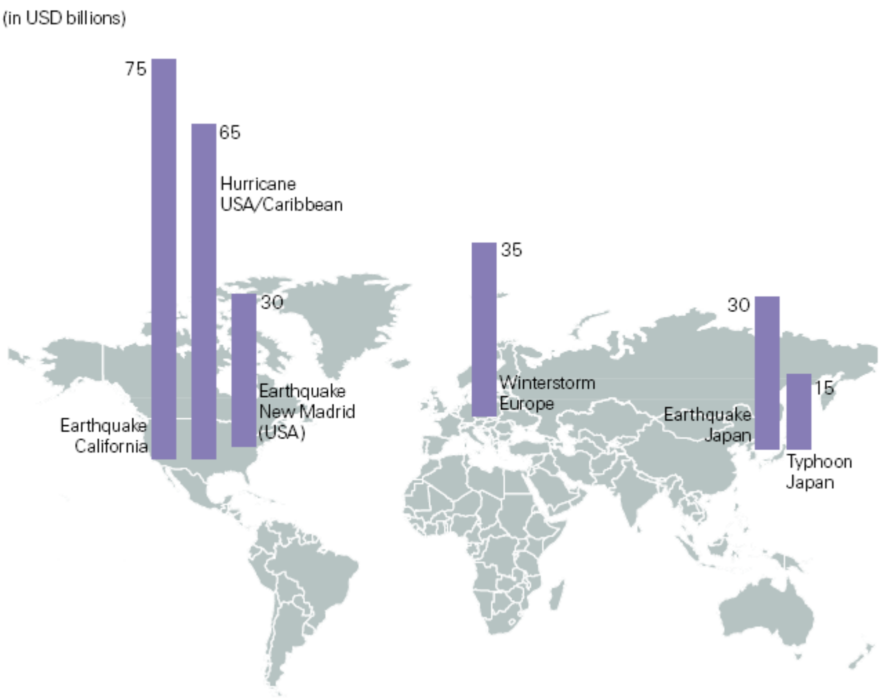
Source: Swiss Re

Scenario Testing
Tools to help examine the influence of specific events

- Important to examine cat model results with respect to historic and specific scenarios
- Detailed cat models allow each event to be analysed in terms of size and location.
- Tools such as GC Scenario Analysis Tool enable users investigate the 'tail' events.

Natural Hazard Loss Potential

The insurance industry's largest potential event losses with a return period of between 100 and 500 years. (Earthquake Japan does not include claims that would be paid by Japan Earthquake Reinsurance Co, JER).



Source: Swiss Re

Natural Hazard Loss Potential
Uncertainty

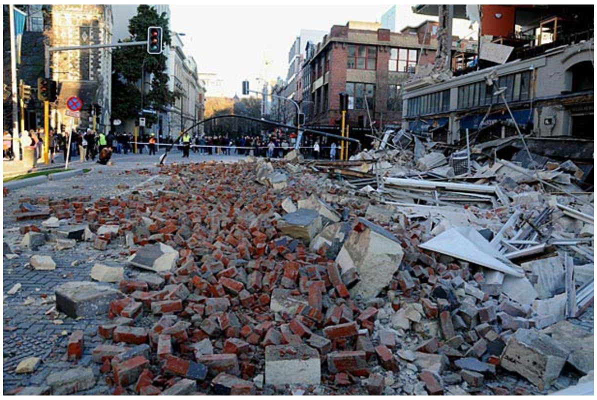
Varying Levels of Liquefaction Damage to Similar Structures in the 1964 Ni'igata Earthquake

Natural Hazard Loss Potential
Uncertainty

Natural Hazard Loss Potential
Uncertainty

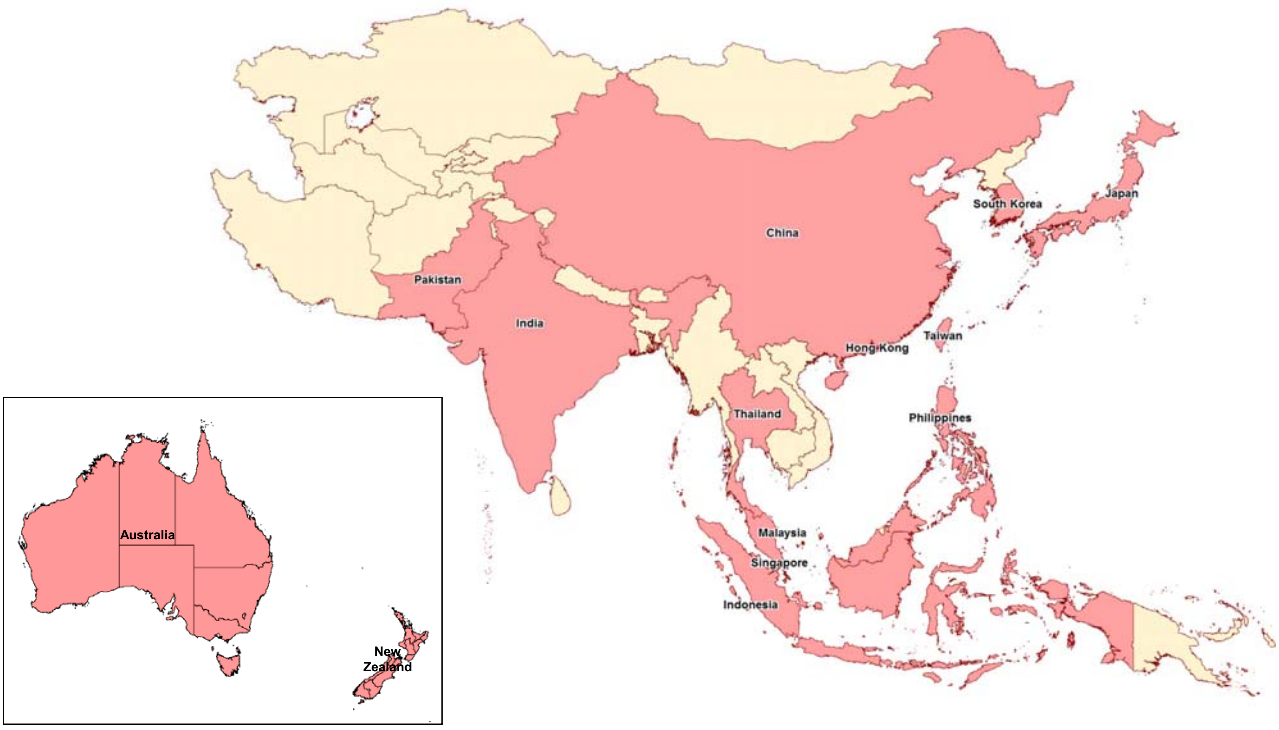



Natural Hazard Loss Potential
Uncertainty

Catastrophe Models in Asia Pacific

Available Models in Asia Pacific



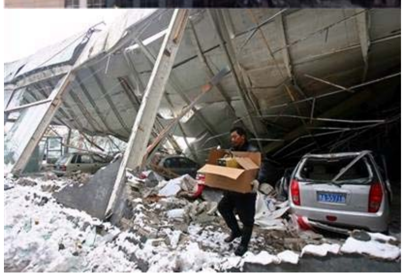
Available Models in Asia Pacific

Asia Pac Country	Earthquake Impact	Earthquake RMS	Earthquake AIR	Earthquake EQE	Wind Impact	Wind RMS	Wind AIR	Wind EQE	Flood Impact	Standard Data Resolution
Australia	Low		2012		Med		2012		Med	Address
China	High				High				High	CRESTA
Hong Kong	Low				Med				Low	Postcode
India	High				Med		2012		Med	CRESTA
Indonesia	High				Low				Med	CRESTA
Japan	High				High				High	Prefecture / Shiku
Korea	Med				High				High	CRESTA
Malaysia	Low				Low				Med	CRESTA
New Zealand	Med				Low				Med	Address
Pakistan	High				Low				Low	CRESTA
Philippines	Med				High				Med	CRESTA
Singapore	Low				Low				Low	Postcode Area
Taiwan	High				High				High	CRESTA
Thailand	Low				Low				High	CRESTA
Vietnam	Low				Low				Med	CRESTA

Key:
- Detailed model updated/released in 2010/2011
- Detailed model
- Aggregate model or detailed model not updated in last 4 years
- No model
- No Hazard

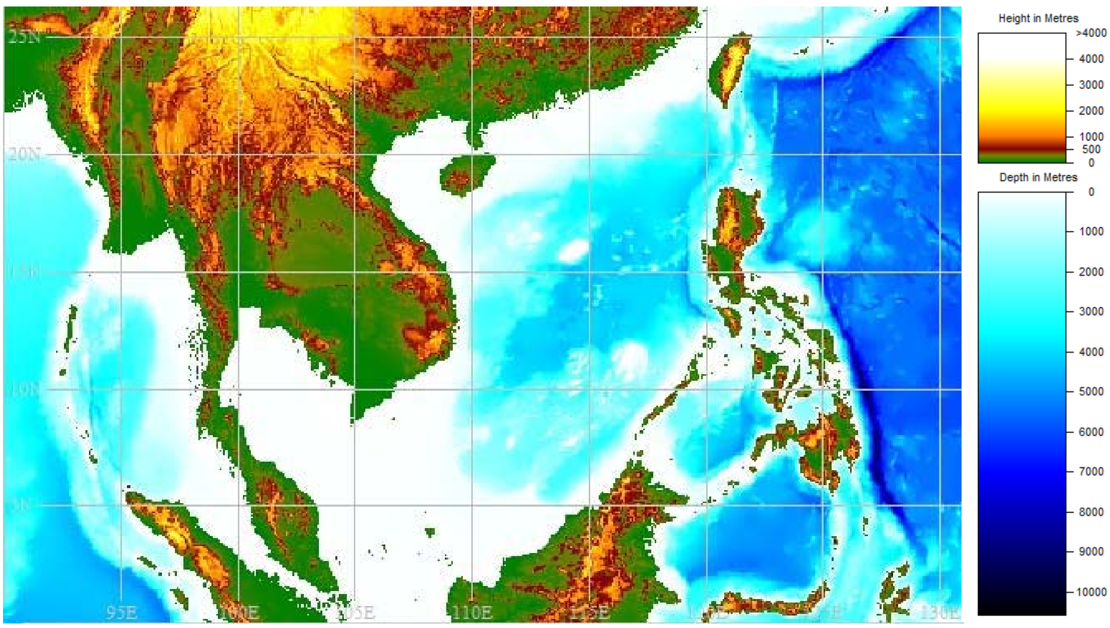
Non-Modeled Risks

Non-Modeled Risks



- Katrina
  - Significant portion of the loss related to un modeled flood & inadequately modeled storm surge
- Man Made Events
  - World Trade Centre 9/11 was the 2nd largest global catastrophe
  - Correlation between lines of business
- Asia Many Un-modeled Perils
  - Asian tsunami saw correlation amongst many territories
  - China snowstorms were not modeled
  - Flood risk in Asian mega cities is growing
  - Hail and bushfire not well modeled

Tsunami Risk
East Asia



Source : World Bathymetry Data

Tsunami Risk
East Asia

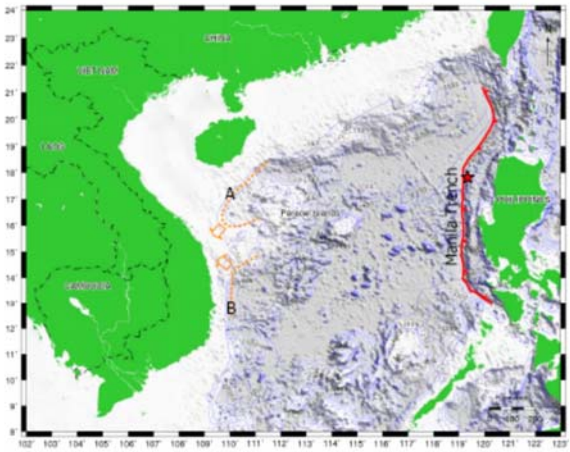


Figure 1. Fronts A and B pointing towards Vietnam coastal area caused by near shore bathymetry. To the East is location of Manila trench which is the distant source of tsunami. The red star shows the Feb. 14th 1934 earthquake with magnitude of 7.5 on northwest coast of Luzon island which generated tsunami. It will be simulated to estimate how high it might attack the coastline of Viet Nam.

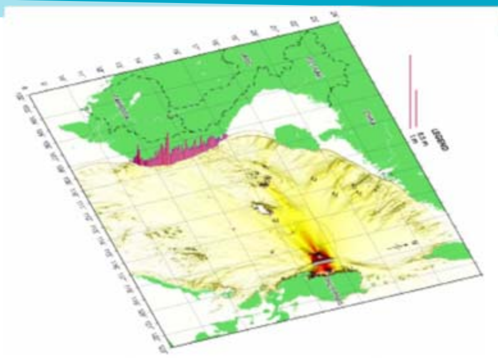


Figure 2. Distribution of tsunami height along coastline of Vietnam showed by columns and maximum tsunami height drawn by contour lines caused by the earthquake with magnitude of 7.5 which occurred in Manila Trench in 1934.

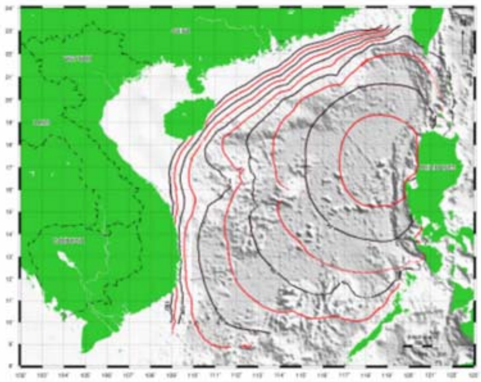
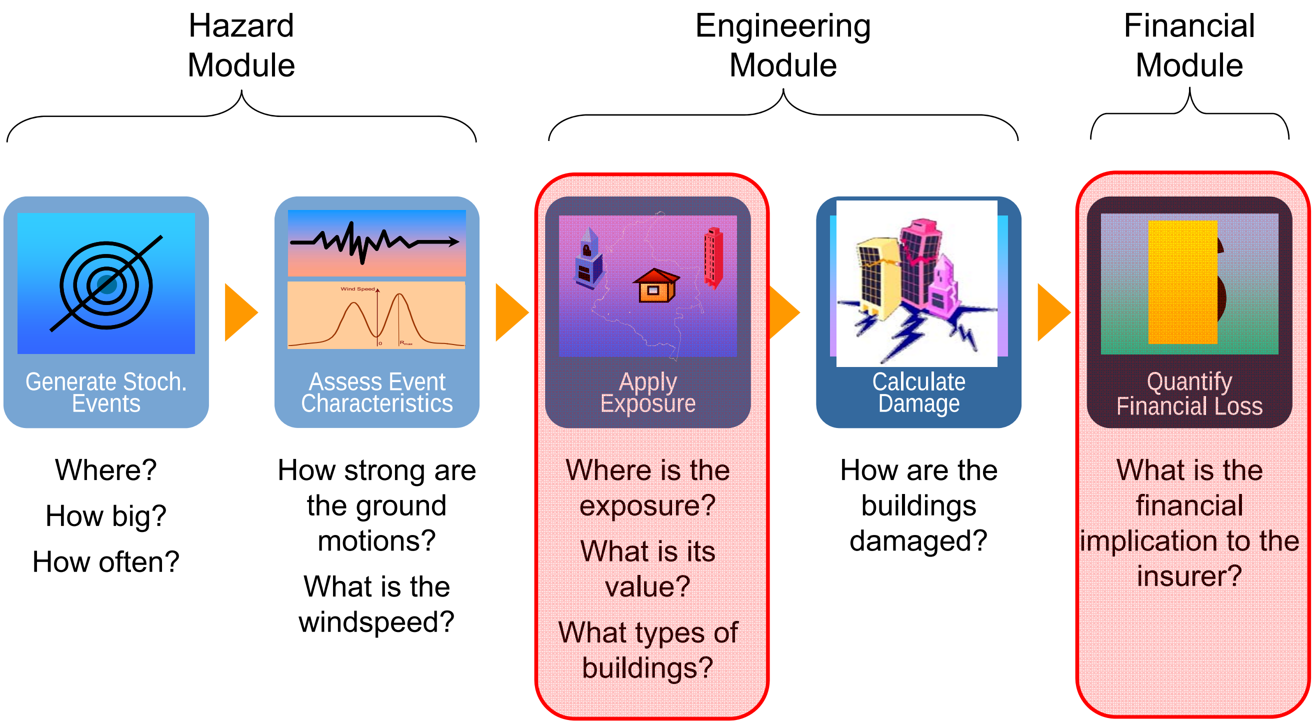


Figure 3. Tsunami travel time map counted from M7.5 Manila Trench source in 1934. Contour timelines indicate each 15 minute from the origin time

Source : N. A. Duong, F. Kimata, and I. Meilano

Data Quality and Why it is so Important

Where client data is used in the models?



Catastrophe Modeling
Review of Data Requirements

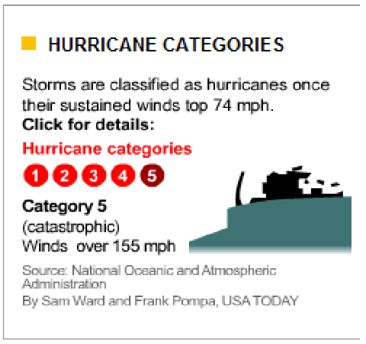
- Hazard Module
  - Geographical Location: CRESTA, state, district, city, latitude/longitude
- Engineering Module
  - Construction & Occupancy classes
  - Age, number of stories, soft story, etc
- Financial Module
  - Limits and values by coverage
  - Deductibles
  - Reinsurance details

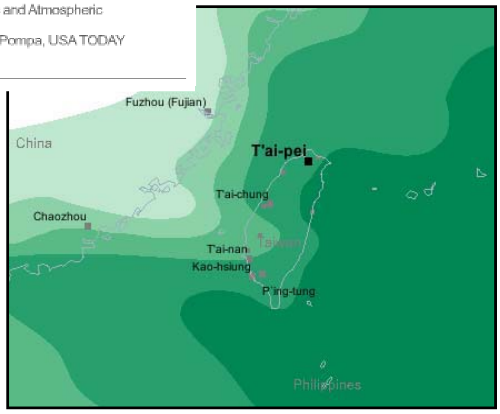
All Modeling is based around ***assumptions*** related to the hazard, vulnerability and exposure. We have greatest control over the ***exposure*** assumptions and ***improving the data*** will ***reduce*** the assumptions and **uncertainty** in the analysis

What is Important?

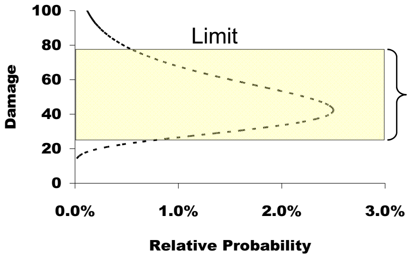
Location (determines the hazard)

Construction, Occupancy and Year Built





Deductibles and Limits



Data improvements take time...

- History of Japan
  - Models introduced around 1998
  - Windstorm aggregates by LOB and Prefecture provided for many years
  - Detailed data provided around 2003
  - Detailed data for Multi-location earthquake risks has always been available
    - Very low limits relative to structure value

- History of Taiwan
  - Models introduced around 2002
  - Aggregate data provide by Cresta Zone
  - Postal code data started to be provided around 2006
  - Still working to improve some of the multi-location facultative policy data

Sample Data for Multi-Location Risks – Example 1

1. Insured : Company 8
2. Period : April/30/2009 - April/30/2010
3. Total Fire Sum Insured (100%) : JPY 157,527,256,250
4. Cover conditions (100%) EQ Limit : JPY 5,000,000,000 AOA&AGG
   Deductible : JPY 1,000,000,000
5. Type of Industry : Electronics
6. Company's Share : 12.5% of 100%
7. Leading Insurer : ACE
8. Number of buildings: 67

(As at September 30, 2009)

Zones	Pref.No	Prefecture	Aggregate 100% Insured Values Split between: Buildings	Contents Equipments	Business Interruption	Number of Buildings	Site of Top-Location	Total Sum Insured for 100%: Buildings	Contents Equipments	Total
1	1	Hokkaido	0	1,097,943,750	1,089,693,750	1	Chuo-ku, Sapporo	0	1,097,943,750	1,097,943,750
Total	ZONE 1		0	1,097,943,750	1,089,693,750	1		0	1,097,943,750	1,097,943,750
2	2	Aomori	0	195,006,250	118,750,000	1	Tsugaru city	0	195,006,250	195,006,250
	10	Akita	0	0	0	0		0	0	0
	11	Yamagata	0	0	0	0		0	0	0
	30	Niigata	0	0	0	0		0	0	0
Total	ZONE 2		0	195,006,250	118,750,000	1		0	195,006,250	195,006,250
3	3	Iwate	0	0	0	0		0	0	0
	4	Miyagi	0	4,375,318,750	2,135,906,250	3	Aoba-ku, Sendai	0	2,598,131,250	2,598,131,250
	12	Fukushima	0	0	0	0		0	0	0
Total	ZONE 3		0	4,375,318,750	2,135,906,250	3		0	2,598,131,250	2,598,131,250
4	20	Ibaraki	0	0	0	0		0	0	0
	21	Tochigi	0	639,675,000	676,168,750	1	Utsunomiya city	0	639,675,000	639,675,000
	22	Gunma	0	2,206,362,500	1,565,012,500	2	Takasaki city	0	671,825,000	671,825,000
	23	Saitama	0	3,044,900,000	2,115,243,750	2	Chuo-ku, Saitama	0	828,693,750	828,693,750
Total	ZONE 4		0	5,890,937,500	4,356,425,000	5		0	2,140,193,750	2,140,193,750
5	24	Chiba	0	1,081,606,250	633,093,750	1	Kashiwa city	0	610,506,250	610,506,250
	25	Tokyo	0	53,701,950,000	38,638,393,750	39	Koto-ku	0	13,951,500,000	13,951,500,000
	26	Kanagawa	0	6,793,087,500	5,474,531,250	5		0	0	0
	(26-1)	(Kawasaki)	0	0	2,320,312,500	1	Kawasaki-ku, Kawasaki	0	1,013,687,500	1,013,687,500
	(26-2)	(Yokohama)	0	0	3,154,218,750	1	Nishi-ku, Yokohama	0	1,784,456,250	1,784,456,250
	(26-3)	(Rest of Kan.)	0	0	0	0		0	0	0
Total	ZONE 5		0	61,576,643,750	44,746,018,750	47		0	14,562,006,250	14,562,006,250
6	34	Yamanashi	0	0	0	0		0	0	0

Sample Data for Multi-Location Risks – Example 2

1st Loss Multi-location policies
(@ 30 September 2009)
(*) Figures for 1 unit

* Please refer to the sheet "code table".
**All monetary values provided in the data are after the application of our acceptance
***Insured Value provided is before the application of the Reduced Indemnity percentage

Pol_No	Site_No	Zone	*Pref Code	*Zip Code	*Policy Type	Our Share	R/I %	*LOB	*Structure Type	*Occupation	Coverage Type	Insured Value	Pol Limit	Site Limit	Pol Ded	Site Ded
1	1	05	24	12212	1	71.0%	100.0%	3	2	3-042	Bldg&Cont	65,919,496,125	70,974,285	0	0	0
1	2	06	42	22203	1	71.0%	100.0%	3	2	3-042	Bldg&Cont	7,076,845,925	70,974,285	0	0	0
1	3	06	44	24207	1	71.0%	100.0%	3	2	3-042	Bldg&Cont	21,349,064,832	70,974,285	0	0	0
1	4	05	25	13108	1	71.0%	100.0%	2	1	2-409	Bldg&Cont	28,236,409,417	70,974,285	0	0	0
2	1	04	20	08215	1	77.2%	100.0%	3	2	3-351	Bldg&Cont	3,525,396,099	231,396,161	115,698,080	0	77,132
2	2	02	02	02410	1	77.2%	100.0%	3	2	3-351	Bldg&Cont	2,961,084,883	231,396,161	115,698,080	0	77,132
2	3	11	84	43208	1	77.2%	100.0%	3	2	3-351	Bldg&Cont	125,031,059	231,396,161	77,132,054	0	77,132
2	4	11	81	40108	1	77.2%	100.0%	3	2	3-351	Bldg&Cont	10,006,850,813	231,396,161	154,264,107	0	77,132
3	1	05	26	14111	1	10.0%	100.0%	2	1	2-514	Bldg	48,978,254	19,992,756	0	4,998,189	0
3	2	05	26	14104	1	10.0%	100.0%	2	S	2-409	Bldg	14,291,822	19,992,756	0	4,998,189	0
3	3	05	26	14104	1	10.0%	100.0%	2	S	2-409	Bldg	38,142,180	19,992,756	0	4,998,189	0
4	1	06	42	22214	1	100.0%	30.0%	3	S	3-791	Bldg&Cont	5,659,749,366	8,416,180,659	0	0	0
4	2	06	34	19407	1	100.0%	30.0%	3	S	3-791	Bldg&Cont	5,317,473,379	8,416,180,659	0	0	0
4	3	09	70	34212	1	100.0%	30.0%	3	2	3-791	Bldg&Cont	3,526,722,202	8,416,180,659	0	0	0
4	4	06	42	22214	1	100.0%	30.0%	3	2	3-791	Bldg&Cont	2,575,166,968	8,416,180,659	0	0	0
4	5	06	41	21621	1	100.0%	30.0%	3	2	3-189	Cont	305,889,171	8,416,180,659	0	0	0
5	1	05	24	12219	1	32.5%	100.0%	3	2	3-853	Bldg&Cont	88,643,749,200	3,573,705,179	0	97,464,687	0
5	2	06	44	24202	1	32.5%	100.0%	3	2	3-853	Bldg&Cont	68,890,968,404	3,573,705,179	0	97,464,687	0
5	3	06	44	24202	1	32.5%	100.0%	3	2	3-853	Bldg&Cont	7,049,307,278	3,573,705,179	0	97,464,687	0
5	4	10	73	37203	1	32.5%	100.0%	3	2	3-853	Bldg&Cont	47,814,686,688	3,573,705,179	0	97,464,687	0
5	5	08	58	27201	1	32.5%	100.0%	3	2	3-853	Bldg&Cont	46,761,454,694	3,573,705,179	0	97,464,687	0
6	1	01	01	01105	1	42.5%	100.0%	2	S	2-409	Bldg&Cont	1,726,120,269	212,423,035	0	0	0
6	2	01	01	01104	1	42.5%	100.0%	2	S	2-409	Bldg&Cont	482,200,290	212,423,035	0	0	0
6	3	02	10	05201	1	42.5%	100.0%	2	S	2-409	Bldg&Cont	27,317,602	212,423,035	0	0	0
6	4	02	11	06201	1	42.5%	100.0%	2	S	2-409	Bldg&Cont	119,615,411	212,423,035	0	0	0
6	5	02	30	15201	1	42.5%	100.0%	2	S	2-409	Bldg&Cont	751,340,275	212,423,035	0	0	0
6	6	03	03	03201	1	42.5%	100.0%	2	S	2-409	Bldg&Cont	99,881,311	212,423,035	0	0	0
6	7	03	04	04101	1	42.5%	100.0%	2	S	2-409	Bldg&Cont	1,927,405,115	212,423,035	0	0	0
6	8	03	04	04102	1	42.5%	100.0%	2	S	2-409	Bldg&Cont	697,359,334	212,423,035	0	0	0
6	9	03	12	07201	1	42.5%	100.0%	2	S	2-409	Bldg&Cont	284,646,867	212,423,035	0	0	0
6	11	04	22	10201	1	42.5%	100.0%	2	S	2-409	Bldg&Cont	287,280,913	212,423,035	0	0	0
6	12	04	23	11204	1	42.5%	100.0%	2	S	2-409	Bldg&Cont	149,545,817	212,423,035	0	0	0
6	13	05	24	12101	1	42.5%	100.0%	2	S	2-409	Bldg&Cont	617,263,104	212,423,035	0	0	0
6	14	05	25	13206	1	42.5%	100.0%	2	S	2-409	Bldg&Cont	8,384,682,597	212,423,035	0	0	0
6	15	05	25	13103	1	42.5%	100.0%	2	S	2-409	Bldg&Cont	1,860,825,788	212,423,035	0	0	0
6	16	05	25	13205	1	42.5%	100.0%	2	S	2-409	Bldg&Cont	1,178,353,060	212,423,035	0	0	0

FLM_bordereau / Code_table

Sample Data for Multi-Location Risks – Example 3

	B	E	F	G	H	J	L	N
1	Policy ID	Policy #	LOB	INCEPTDATE	EXPIREDATE	SHARE	100% Limit	100% Ded
2	1	01080031013	Commercial	04/01/2009	04/01/2010	30.00%	1,308,000	0
3	2	01089528557	Commercial	04/01/2008	04/01/2010	100.00%	36,000,000	0
4	3	01089533704	Commercial	11/18/2008	11/18/2013	100.00%	84,000,000	400,000
5	4	01089533780	Commercial	03/31/2009	03/31/2014	100.00%	160,000,000	0
6	5	01089580885	Commercial	06/01/2009	06/01/2010	100.00%	368,000,000	400,000
7	6	01089581083	Commercial	08/01/2009	08/01/2010	100.00%	3,500,000,000	140,000,000
8	7	01089581377	Commercial	11/30/2008	11/30/2009	100.00%	240,000,000	0
9	8	01089581776	Commercial	03/31/2009	03/31/2010	100.00%	272,000,000	6,800,000
10	9	01089584635	Commercial	12/30/2008	12/31/2009	100.00%	600,000,000	20,000,000
11	10	01089584953	Commercial	03/10/2009	03/10/2010	100.00%	160,000,000	0
12	11	01089584961	Commercial	04/01/2009	04/01/2010	100.00%	143,752,000	2,053,600
13	12	01089585054	Commercial	04/03/2009	04/03/2010	100.00%	1,505,600	0
14	13	01089596307	Commercial	09/28/2008	09/28/2009	100.00%	418,754,400	0
15	14	01089596404	Commercial	10/01/2008	10/01/2009	100.00%	400,000,000	0
16	15	01089596714	Commercial	01/31/2009	01/31/2010	100.00%	18,000,000	6,000,000
17	16	01089596838	Commercial	03/01/2009	03/01/2010	100.00%	40,000,000	400,000
18	17	01089596901	Commercial	03/01/2009	03/01/2010	100.00%	2,216,800	0
19	18	01089596919	Commercial	02/28/2009	02/28/2010	100.00%	1,008,000,000	504,000,000
20	19	01089597672	Commercial	02/28/2009	02/28/2010	100.00%	234,000,000	67,600,000
21	20	01089597681	Commercial	03/31/2009	03/31/2010	100.00%	156,000,000	5,200,000
22	21	01089597711	Commercial	03/31/2009	03/31/2010	100.00%	20,000,000	20,000,000
23	22	01089612981	Commercial	12/03/2008	12/03/2009	100.00%	684,816,000	0
24	23	01089613091	Commercial	12/10/2008	12/10/2009	100.00%	20,000,000	0
25	24	01089613180	Commercial	02/21/2009	02/21/2010	100.00%	4,300,000	800
26	25	01089613201	Commercial	02/20/2009	02/20/2010	100.00%	16,617,600	0
27	26	01089613244	Commercial	03/01/2009	03/01/2010	100.00%	170,000,000	0
28	27	01089614020	Commercial	02/20/2009	02/21/2010	100.00%	10,000,000	100,000
29	28	01089768876	Commercial	01/01/2009	01/01/2010	100.00%	120,000,000	1,400,000
30	29	01089768914	Commercial	01/01/2009	01/01/2011	100.00%	1,608,000,000	0
31	30	01089768990	Commercial	01/01/2009	01/01/2010	100.00%	211,680,000	0
32	31	01089774108	Commercial	03/27/2009	03/27/2010	100.00%	64,000,000	0

Policies (Accounts) / Locations / Reinsurance

Sample Data for Multi-Location Risks – Example 3 (Continued)

	C	D	E	F	G	I	K	L	M	N	T	Z	AI
1				LOCATION	# OF	STR.	OCC.	YEAR	# OF				
2	POLICY #	LOC #	COUNTY	CODE	BLDGS	TYPE	TYPE	BUILT	FLOORS	BUILDING	CONTENT	BI	CITY
3	01080031013	1	CHIBA	2404000	1	SP	6	2001	10	1,308,000	0	0	FUNABASHI-SHI
4	01089528557	1	OSAKA	5829000	1	1	6			2,698,180,800	0	0	Chuo-Ku Osaka-Sh
5	01089533704	1	MIYAZAKI	9106000	1	2	7			2,363,049,200	0	0	HYUGA-SHI
6	01089533780	1	CHIBA	2463163	1	2	7			2,843,496,000	7,717,919,200	0	NAGARA-MACHI CH
7	01089533780	2	CHIBA	2411000	1	2	6			59,600,000	0	0	MOBARA-SHI
8	01089533780	3	CHIBA	2436000	1	2	6			22,000,000	0	0	TOMISATO-SHI
9	01089580885	1	IBARAKI	2035000	1	2	7			1,273,801,200	0	0	KAMISU-SHI
10	01089581083	1	KANAGAWA	2626000	40	2	7			706,150,340	2,752,584,240	0	ODAWARA-SHI
11	01089581083	2	KANAGAWA	2623000	50	1	7			6,565,514,200	9,128,691,600	0	HIRATSUKA-SHI
12	01089581083	3	SHIZUOKA	4209000	24	SP	7			2,722,622,980	2,763,293,120	0	SHIMADA-SHI
13	01089581083	4	OSAKA	5801000	20	1	7			519,746,080	1,236,724,020	0	KITA-KU OSAKA-SI
14	01089581083	5	AKITA	1001000	22	2	7			1,263,434,480	1,406,729,660	0	AKITA-SHI
15	01089581083	6	FUKUSHIMA	1216000	22	2	7			1,424,182,060	5,642,802,340	0	IWAKI-SHI
16	01089581083	7	OSAKA	5838000	19	2	7			1,678,852,560	2,670,246,320	0	TAKATSUKI-SHI
17	01089581083	8	TOKYO	2509000	33	SP	6			6,503,412,580	5,072,983,580	0	SHINAGAWA-KU
18	01089581083	9	TOKYO	2525000	16	SP	6			5,470,659,740	3,337,385,380	0	EDOGAWA-KU
19	01089581083	10	SHIZUOKA	4218000	45	2	6			1,108,637,040	739,605,860	0	FUKUROI-SHI
20	01089581377	1	IBARAKI	2029000	1	2	7			648,390,000	616,694,100	0	CHIKUSEI-SHI
21	01089581377	2	SAITAMA	2341000	1	2	6			731,778,000	187,179,200	0	MISATO-SHI
22	01089581377	3	SAITAMA	2313000	1	2	6			412,400	261,337,600	0	KASUKABE-SHI
23	01089581377	4	SAITAMA	2326000	1	2	6			110,534,000	0	0	TODA-SHI
24	01089581776	1	SAITAMA	2301000	1	2	7			1,703,400,000	0	0	KAWAGOE-SHI
25	01089581776	2	AICHI	4301000	1	2	7			226,827,600	312,086,000	0	CHIKUSA-KU NAGC
26	01089581776	3	SAITAMA	2301000	1	2	7			1,387,268,000	2,342,260,000	0	KAWAGOE-SHI
27	01089584635	1	TOKYO	2543000	1	2	7			3,149,086,400	11,372,219,600	1,997,232,000	HINO-SHI
28	01089584635	2	TOKYO	2531000	1	2	7			1,477,549,200	5,110,807,200	1,800,000,000	HACHIOJI-SHI
29	01089584635	3	KANAGAWA	2626000	1	2	7			0	382,577,200	242,454,800	ODAWARA-SHI
30	01089584635	4	OSAKA	5876000	1	2	7			646,158,400	2,612,152,400	1,461,826,400	OSAKASAYAMA-SH
31	01089584635	5	HYOGO	5912000	1	2	7			660,476,000	4,200,403,200	321,776,000	NISHI-KU KOBE-SH
32	01089584635	6	AICHI	4327000	1	2	7			522,522,600	1,617,426,000	0	TOYOKAWA-SHI

Policies (Accounts) / Locations / Reinsurance

Sample Data for Multi-Location Risks – Example 3 (Continued)

	C	E	F	G	H	I
1	POLICY #	PCNTREINS	100% LIMIT	100% DED	REINS ID	REINSTYPE
2	01080031013	37.5%	1,308,000	0	EQQS	T
3	01089528557	37.5%	36,000,000	0	EQQS	T
4	01089533704	37.5%	84,000,000	0	EQQS	T
5	01089533780	37.5%	160,000,000	0	EQQS	T
6	01089580885	37.5%	368,000,000	0	EQQS	T
7	01089581083	37.5%	3,500,000,000	0	EQQS	T
8	01089581377	37.5%	240,000,000	0	EQQS	T
9	01089581776	80.0%	272,000,000	0	FAC_CESSIONS	F
10	01089584635	37.5%	600,000,000	0	EQQS	T
11	01089584953	37.5%	160,000,000	0	EQQS	T
12	01089584961	37.5%	143,752,000	0	EQQS	T
13	01089585054	37.5%	1,505,600	0	EQQS	T
14	01089596307	50.0%	418,754,400	0	FAC_CESSIONS	F
15	01089596404	37.5%	400,000,000	0	EQQS	T
16	01089596714	37.5%	18,000,000	0	EQQS	T
17	01089596838	37.5%	40,000,000	0	EQQS	T
18	01089596901	37.5%	2,216,800	0	EQQS	T
19	01089612981	37.5%	684,816,000	0	EQQS	T
20	01089613091	37.5%	20,000,000	0	EQQS	T
21	01089613180	37.5%	4,300,000	0	EQQS	T
22	01089613201	37.5%	16,617,600	0	EQQS	T
23	01089613244	37.5%	170,000,000	0	EQQS	T
24	01089614020	37.5%	10,000,000	0	EQQS	T
25	01089768876	100.0%	120,000,000	0	FAC_CESSIONS	F
26	01089768914	42.0%	1,608,000,000	0	EQQS	T
27	01089768914	30.0%	1,608,000,000	0	FAC_CESSIONS	F
28	01089768990	100.0%	211,680,000	0	FAC_CESSIONS	F
29	01089774108	37.5%	64,000,000	0	EQQS	T
30	01089774361	37.5%	158,400,000	0	EQQS	T
31	01089774566	37.5%	626,974,800	0	EQQS	T
32	01089774671	37.5%	400,000,000	0	EQQS	T

Policies (Accounts) / Locations / **Reinsurance**

Sample Data for Multi-Location Risks – Example 4

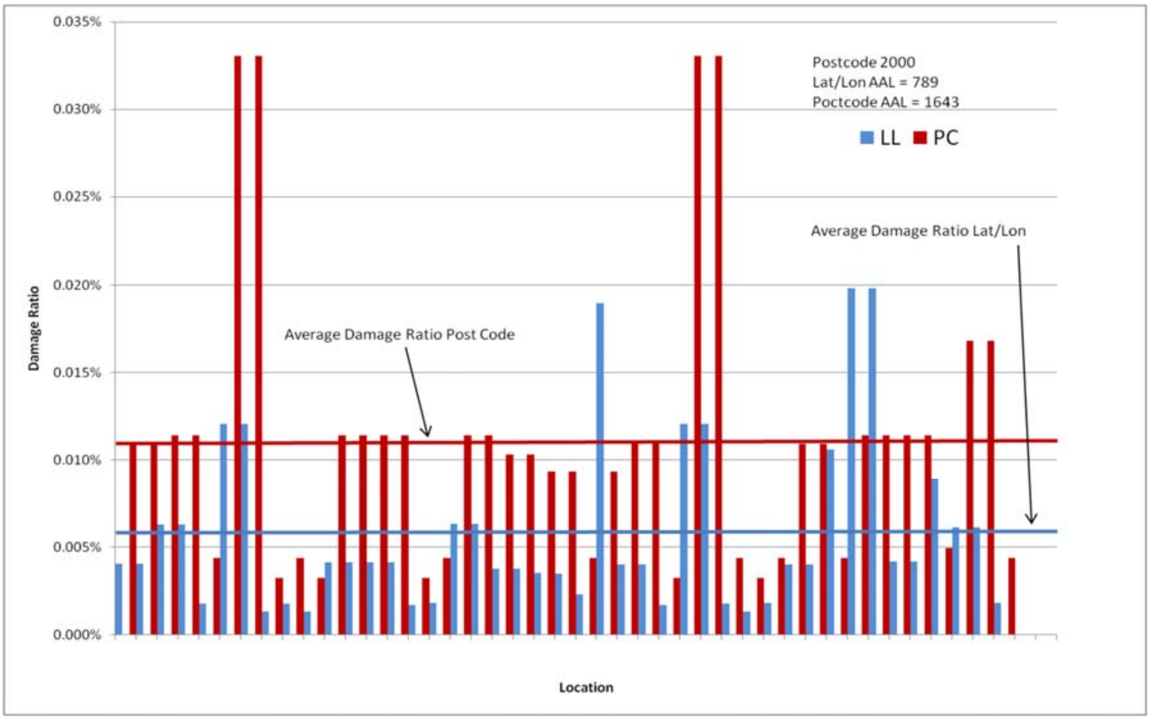
Fire and F.A.P. Net Retained Account

Earthquake Aggregates as at September 30, 2009

Currency: NT$

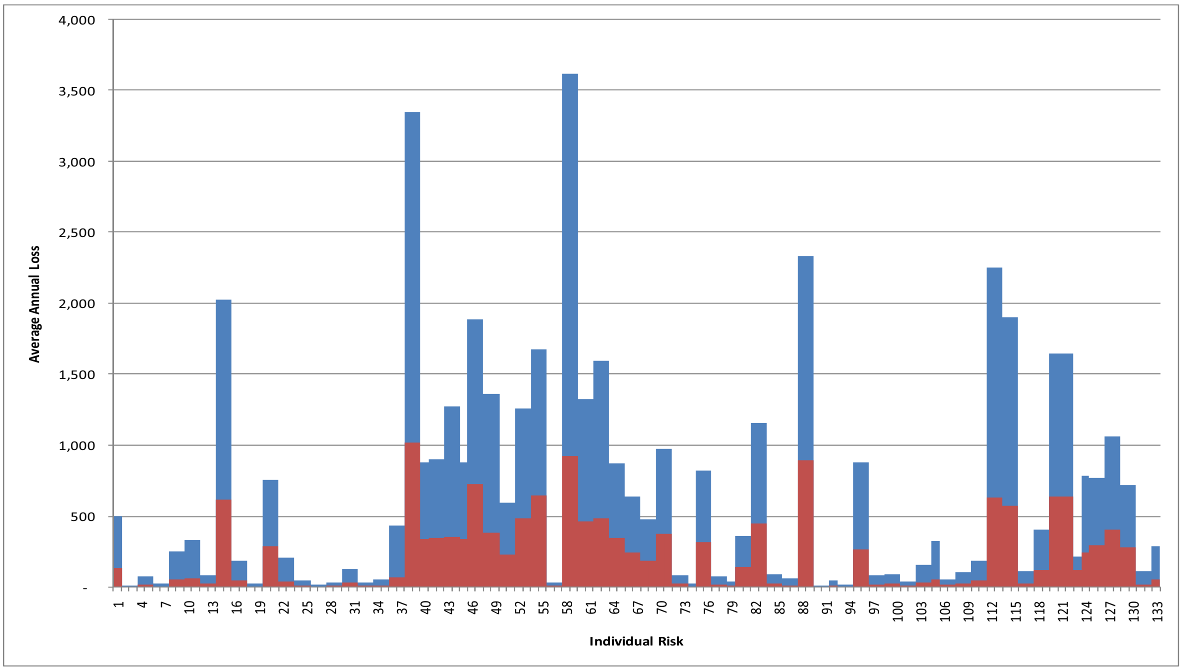
Zone No.	District	Building Total Sum Insured EQ Agg	Building Total Sum Insured EQ Sublimit	Contents Total Sum Insured EQ Agg	Contents Total Sum Insured EQ Sublimit	Business Interruption Total Sum Insured EQ Agg	Business Interruption Total Sum Insured EQ Sublimit	TOTAL No. of Risk	TOTAL Total Sum Insured EQ Agg	TOTAL Total Sum Insured EQ Sublimit
1	Taipei City	19,182,018,787	14,597,596,782	3,265,840,103	2,489,921,113	520,671,459	484,443,707	765	22,968,530,349	17,571,961,602
1-1	Taipei Hsien, Keelung	6,989,508,264	4,603,465,205	4,844,945,024	3,335,371,820	1,100,462,748	690,743,129	619	12,934,916,036	8,629,580,154
2	Taoyuan	4,939,930,786	3,471,521,500	9,541,175,594	6,748,735,306	1,626,939,160	967,468,487	312	16,108,045,540	11,187,725,293
3	Hsinchu	5,652,816,868	3,948,047,188	10,218,809,079	7,721,354,059	2,403,016,199	1,495,751,541	250	18,274,642,146	13,165,152,787
4	Miaoli	1,613,005,552	1,077,831,351	3,844,043,320	2,664,533,208	836,145,026	425,436,343	46	6,293,193,898	4,167,800,902
5	Taichung	1,815,713,324	1,248,316,919	1,890,563,529	1,498,591,435	557,713,649	311,327,672	230	4,263,990,502	3,058,236,026
6	Nantou	251,370,455	196,629,928	565,638,067	457,599,759	8,083,889	6,871,305	35	825,092,411	661,100,993
7	Changhua	366,383,054	260,713,283	1,344,643,036	874,140,331	16,703,298	8,802,638	53	1,727,729,388	1,143,656,252
8	Yunlin	174,061,614	134,840,188	1,179,373,136	668,963,892	24,319,587	19,455,669	28	1,377,754,337	823,259,750
9	Chiayi, Tainan	5,750,787,234	4,045,310,679	8,735,709,628	5,015,462,255	728,613,735	451,222,515	210	15,215,110,597	9,511,995,449
10	Kaohsiung, Pingtung	6,220,344,365	4,460,867,657	8,225,265,728	5,658,029,797	1,316,538,198	830,238,189	331	15,762,148,290	10,949,135,643
11	Hualien, Taitung	46,247,285	37,584,350	153,288,881	118,673,477	0	0	21	199,536,166	156,257,827
12	Ilan	181,956,862	165,842,048	163,981,096	144,302,055	29,661,693	25,759,788	18	375,599,651	335,903,891
13	Taiwan Areas	2,119,799	1,295,963	798,368,083	341,089,943	0	0	15	800,487,882	342,385,906
14	K.M.P.L. Islands	70,407	56,326	69,036	55,229	0	0	1	139,443	111,555
15	Others	621,292,882	97,914,723	3,110,348,182	1,127,839,022	2,094,052,875	412,102,955	73	5,825,693,939	1,637,856,700
	Total	**53,807,627,539**	**38,347,834,089**	**57,882,061,522**	**38,864,662,702**	**11,262,921,515**	**6,129,623,938**	**3,007**	**122,952,610,576**	**83,342,120,729**

Impact of Better Location Data



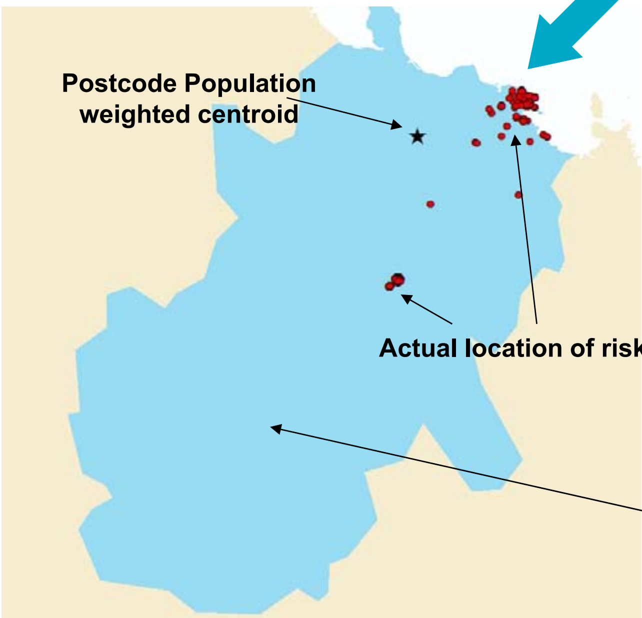
Earthquake **:** A single postcode will only get one soil type allocated while address level data will pick up the higher resolution soil data. In this example we see losses coming down with better data.

Impact of Better Location Data



Typhoon **:** A single postcode will only get one distance to coast (a key variable for typhoon) while address level data have numerous distances. In this example we see that the losses go up with better data.

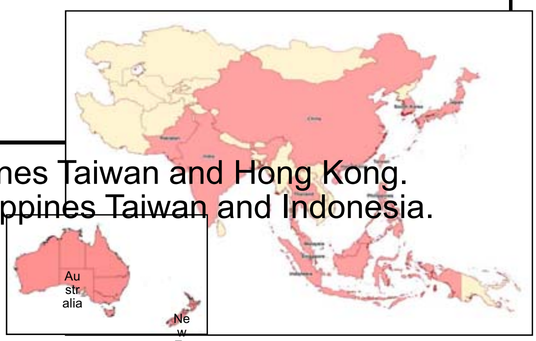
Impact of Better Location Data



Location details we typically receive

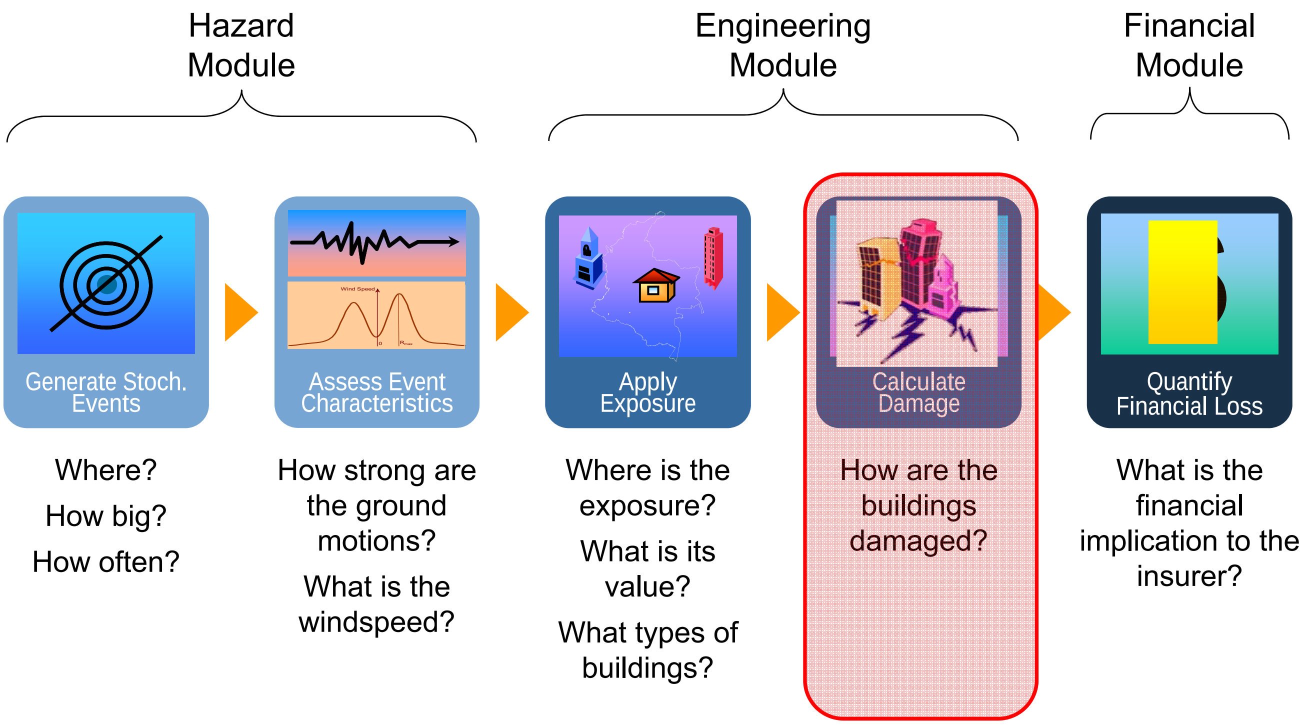
Asia Pac Country	Earthquake Impact	Earthquake RMS	Earthquake AIR	Earthquake EQE	Wind Impact	Wind RMS	Wind AIR	Wind EQE	Flood Impact	Standard Data Resolution
Australia	Low		2011		Med		2011		Med	Address
China	High				High	2011	OCT		High	CRESTA
Hong Kong	Low				Med	2011	OCT		Low	Postcode
India	High				Med		2011		Med	CRESTA
Indonesia	High		OCT		Low				Med	CRESTA
Japan	High		OCT		High		OCT		High	Prefecture / Shiku
Korea	Med				High		OCT		High	CRESTA
Malaysia	Low				Low				Med	CRESTA
New Zealand	Med				Low				Med	Address
Pakistan	High				Low				Low	CRESTA
Philippines	Med		OCT		High		OCT		Med	CRESTA
Singapore	Low				Low				Low	Postcode Area
Taiwan	High		OCT		High		OCT		High	CRESTA
Thailand	Low				Low				High	CRESTA
Vietnam	Low				Low				Med	CRESTA

Key:
- Detailed model updated/released in 2010
- Detailed model
- Aggregate model or detailed model not updated in last 4 years
- No model
- No Hazard



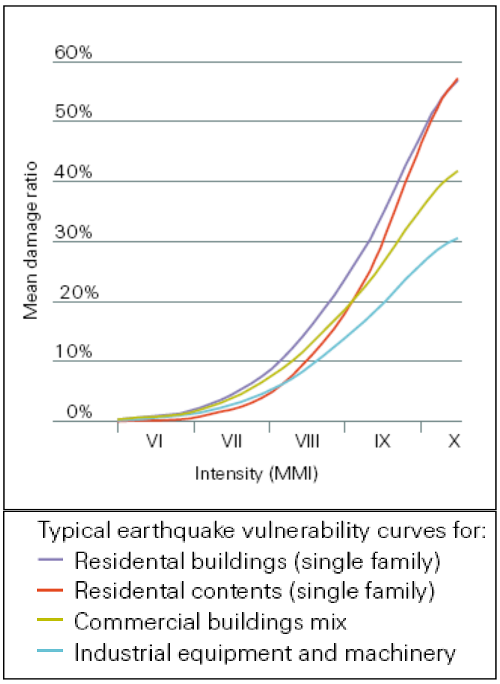
AIR has aggregate typhoon models for Philippines Taiwan and Hong Kong.
AIR has aggregate earthquake models for Philippines Taiwan and Indonesia.

Where client data is used in the models?



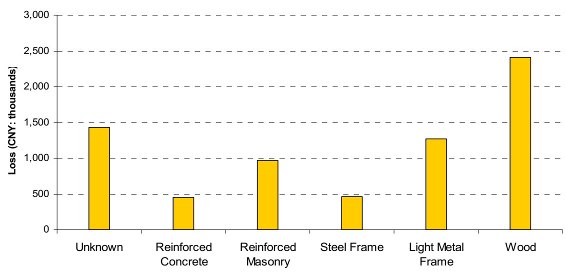
Vulnerability calculations are based on...

- Location
- Occupancy: single family, apartment, commercial, industrial, etc
- Construction: masonry, steel, and reinforced concrete, etc.
- Building, contents, and time element coverage's
- Height
- Year built
- Number of Risks
- Policy terms (in terms of the insured loss)

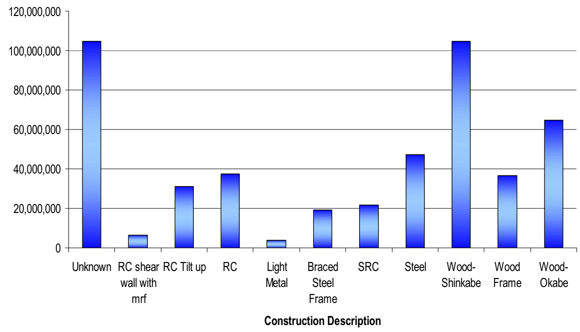


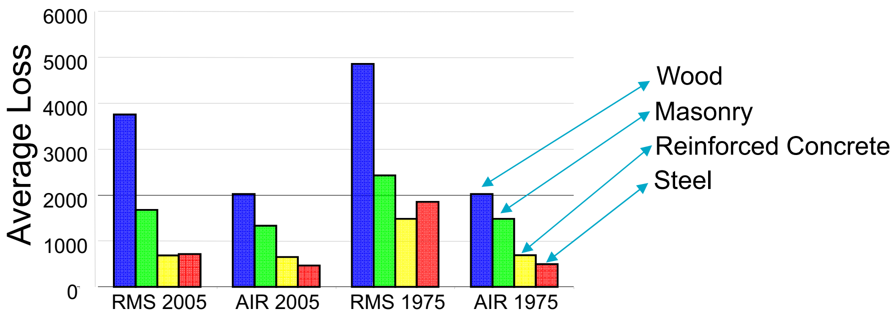
Sensitivity to Construction / Year Built

Average Annual Loss (Beijing Earthquake)



1 in 250 Year Loss (Tokyo Earthquake)

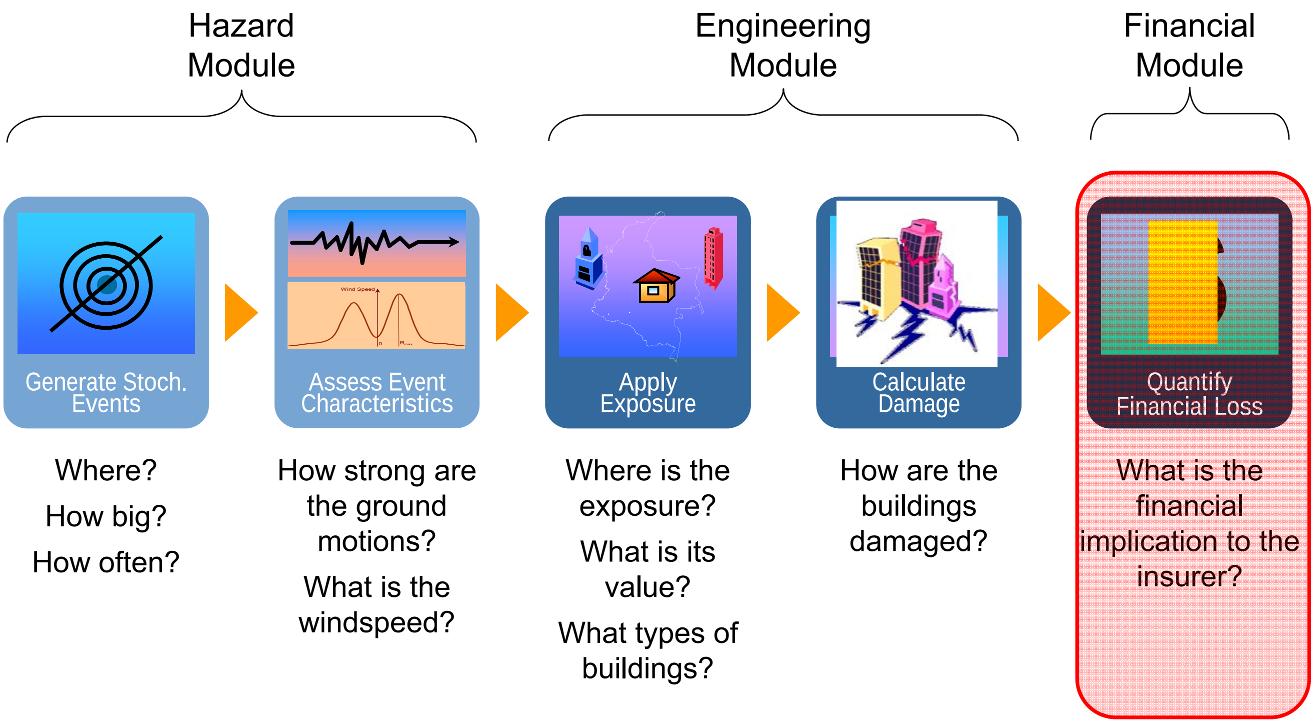




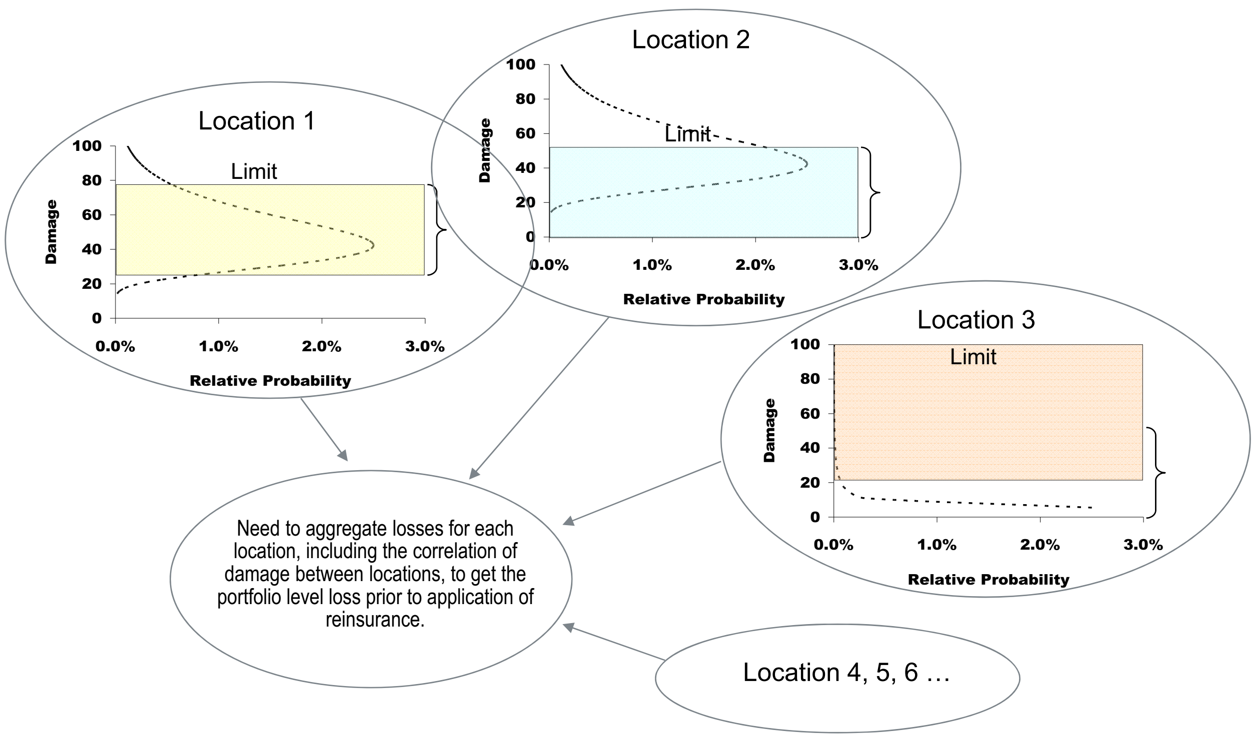
Sensitivity to Occupancy – Taiwan Earthquake

MODEL OCCUPANCY	A R	A C	A I	B R	B C	B I	C R	C C	C I
CRESTA ZONE	AVERAGE ANNUAL LOSS								
1	533	616	435	808	529	698	1194	1046	1001
1.1	495	569	402	477	229	392			
2	231	302	200	404	189	325	1118	979	937
3	329	456	319	469	224	354	1122	984	941
4	494	581	414	559	262	416	1203	1055	1009
5	842	796	589	695	335	545	1210	1061	1015
6	951	1043	743	936	434	679	1236	1084	1037
7	424	488	340	1346	788	1084	820	719	688
8	673	478	340	929	1111	1549	849	744	712
9	1061	1095	853	913	506	723	1340	1175	1124
10	260	233	171	771	462	615	1595	1397	1337
11	1919	2337	1782	3043	1513	2131	3506	3070	2937
12	981	1445	1000	1723	832	1288	2808	2456	2349

Where client data is used in the models?



Financial Module
Application of Deductible and Limits by Location



Financial Module
Impact of Deductibles on the Insured Loss

Deductible as % of Total TSI	Total
1.0%	18%
2.0%	27%
3.0%	34%
4.0%	39%
5.0%	44%
6.0%	48%
7.0%	51%
8.0%	54%
9.0%	57%
10.0%	[illegible]
12.5%	[illegible]
15.0%	[illegible]
17.5%	[illegible]
20.0%	[illegible]
25.0%	83%
30.0%	87%
35.0%	91%
40.0%	93%
45.0%	95%
50.0%	96%
60.0%	98%
70.0%	99%
80.0%	100%
90.0%	100%
100.0%	100%

For this portfolio, if each location had a deductible equal to 1% of the insured value, then 18% of the losses would be below the [illegible] and 82% insured.

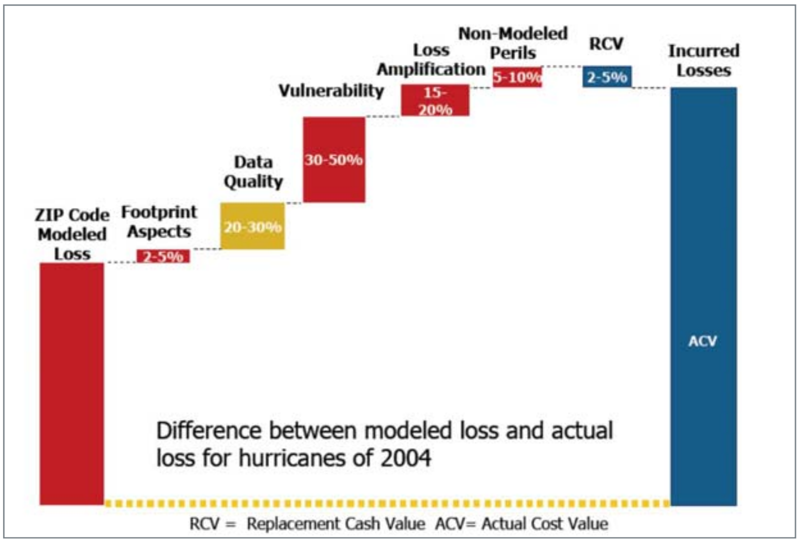
[illegible] below a 5% deductible,

[illegible] will depend on location, the magnitude of the events, the structure type, etc.

In many territories we don't get good deductible and limit information.

Data Management
Data Quality Impacts Results

- Data quality = completeness, resolution, accuracy
- The new versions of the catastrophe models are far more data intensive than ever before
- Increased regulatory and rating agency focus on catastrophe risk analysis and enterprise risk management
- Poor input data significantly distorts results
- Poor data increases reinsurance costs and may distort catastrophe risk loads



An RMS post event review suggests Data Quality issues understated losses from the 2004 hurricane season by 20% to 30%

Aggregate vs Detailed Catastrophe Models

At the ‘detailed, precise picture’ level an aggregate model can be confusing and lacking in information content compared to a detailed model

Good Quality Data will…

- Improve your data in areas that really matter
  - Improve geographic resolution in high hazard areas
  - Align construction characteristics with global cat models
  - Increase individual risk information, reduce aggregations

Reduce uncertainty in results and ***increase*** your ***ability to effectively*** implement and demonstrate a strong ***risk management*** approach

Data Management
Comments

- Data improvement takes time
- Reinsurers always ask for more detailed data and will argue for a higher price when it is not available...
- ... but many reinsurers, in particular in Asia, only license the aggregate models
- Detailed data is most important for large accounts that have unique deductibles and limits (inwards facultative XS business, for example)
- A small number of large policies might contribute to a majority of the company's losses
  – Concentrate on provide details on the policies
- Spend time getting details for the features that have the largest impact

Catastrophe Modeling
SUMMARY THOUGHTS

- Don't trust the models too much or too little
  – Do not rely on one number
  – Use scenario testing to better understand tail of distribution
  – Evaluate non-modeled risks
  – Do not rely on old fashioned "rules of thumb"
  – Understand model uncertainty
- Minimise Model Uncertainty
  – Maximise data quality
  – Ensure correct parameters are used

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Understanding and Working with Catastrophe Model Output

May 2013

Michael Owen
Managing Director

Taiwan Actuarial Conference

Agenda

- Model Output
- AIR Output
- RMS Output
- Model Uncertainty
- Pricing Catastrophe Risk

Model Output

Catastrophe Model Output

- Deterministic
  - Recreate historical events or hypothetical events
  - Large uncertainty
  - Loss and standard deviation for event

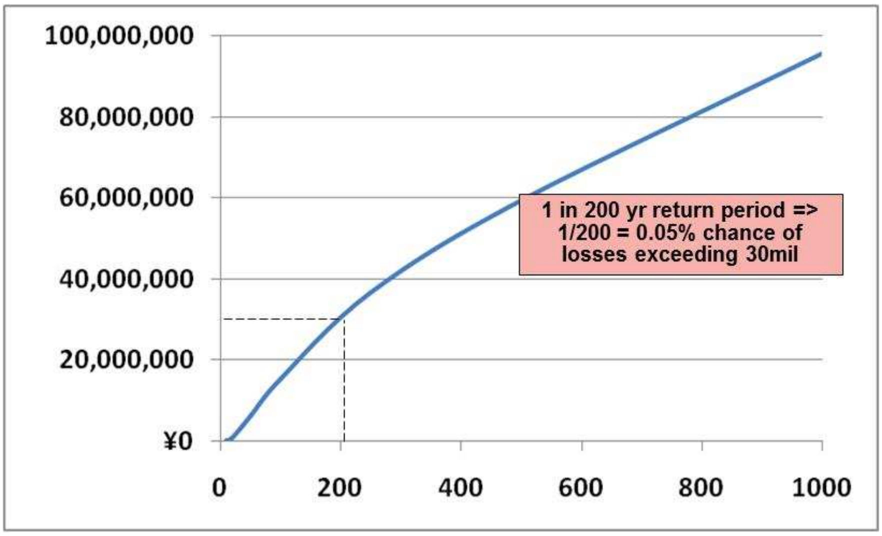
  → *Useful for benchmarking and scenario analysis*

- Probabilistic
  - Stochastic event set
  - EP Curves and Average Annual Losses

  → *Focus for reinsurance decisions, risk management, etc.*

Probabilistic Output

Exceeding Probability (EP): Probability of exceeding specified loss thresholds. There is Annual Exceedance Probability (AEP) and Occurrence Exceedance Probability (OEP)..



Exceeding Probability Curves

- OEP
  - Useful for **Per Occurrence** reinsurance (XOL coverage)
  - Not useful for Stop Loss or Quota Share reinsurance
  - 1 in 100 OEP loss is the largest event expected to happen in a 100 year period
- AEP
  - Useful for **Aggregate, Stop Loss, and Quota Share**
  - Not useful for per occurrence reinsurance
  - 1 in 100 AEP loss is the largest year of losses expected to happen in a 100 year period

AIR Output

AIR Output

- The AIR model produces 10,000 years of possible losses
  - There is one exception. In the US there is an option to run 50,000 years.
- Based on the 10,000 years, they calculate the aggregate loss distribution and the occurrence loss distribution.
  - Occurrence loss distribution is not the same as the severity loss distribution.
- The AEP distribution is calculated by adding up all the events in each year and sorting the results
- The OEP distribution is calculated by taking the largest event in each year and sorting the results

Exceeding Probability Curves
AIR Calculations

The 1 in 5 year largest aggregate loss is $7,050k

1 in 5 year largest occurrence is $4,000k

Year	Loss 1	Loss 2	Loss 3	Loss 4	Loss 5	Maximum	Total
Year 1	1,000,000	2,500,000				2,500,000	3,500,000
Year 2	250,000					250,000	250,000
Year 3	1,500,000	2,000,000				2,000,000	3,500,000
Year 4	3,700,000	1,600,000	180,000	270,000	1,300,000	3,700,000	7,050,000
Year 5	290,000	450,000	10,000	4,000,000		4,000,000	4,750,000
Year 6	1,150,000	160,000	420,000			1,150,000	1,730,000
Year 7	5,000,000					5,000,000	5,000,000
Year 8	1,850,000	1,800,000				1,850,000	3,650,000
Year 9	650,000	1,000,000				1,000,000	1,650,000
Year 10	1,050,000	1,650,000	3,900,000	2,400,000	1,530,000	3,900,000	10,530,000

1 in 10 year largest occurrence is $5,000k

The 1 in 10 year largest aggregate loss is $10,530k

Exceeding Probability Curves
AIR Calculations

Return Period	Occurrence Exceeding Probability	Annual Exceeding Probability
10.00	5,000,000	10,530,000
5.00	4,000,000	7,050,000
3.33	3,900,000	5,000,000
2.50	3,700,000	4,750,000
2.00	2,500,000	3,650,000
1.67	2,000,000	3,500,000
1.43	1,850,000	3,500,000
1.25	1,150,000	1,730,000
1.11	1,000,000	1,650,000
1.00	250,000	250,000

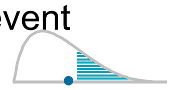
- Show some sample calculations in Excel

RMS Output

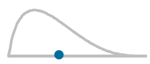
http://www.airc.org.tw/newsfiles/CAT%20Risk%20Management-1020521.pdf (retrieved 27 June 2016)

RMS Output

- RMS assigns frequencies to how often you would expect an event to happen in a given year.



- Frequencies are assumed to follow a Poisson distribution.



- For each event, they produce an average loss amount and a standard deviation.

1+CV^2	Event ID	Mean Loss	Frequency (Poisson Lambda)	Standard Deviation	Total Sum Insured	Alpha (α)	Beta (β)
1.04	148079	1,084,023,648	0.00001622	210,769,197	108,000,000,000	26.177	2,582
1.06	150437	774,512,326	0.00004564	183,398,375	108,000,000,000	17.700	2,450
1.07	145661	749,089,482	0.00000864	200,302,992	123,000,000,000	13.895	2,268
1.06	147727	711,603,802	0.00000739	181,203,608	96,000,000,000	15.300	2,049
1.05	145108	684,465,893	0.00006544	148,438,241	120,000,000,000	21.135	3,684
1.05	150392	672,474,847	0.00005859	144,033,611	75,000,000,000	21.594	2,387
1.04	151008	654,975,834	0.00000494	135,561,223	75,000,000,000	23.132	2,626
1.07	150353	651,507,830	0.00005859	174,570,854	96,000,000,000	13.827	2,024
1.08	147020	647,492,728	0.00003355	178,844,917	117,000,000,000	13.029	2,341

RMS Calculations

- Annual Frequency, $\lambda = \Sigma\, \lambda_i$
- Annual Average Loss = Σ $\text{Mean}_i \times \lambda_i$
- Annual Standard Deviation = $[\Sigma\, \lambda_i \times (1+cv_i^2) \times \text{Mean}_i^{\,2}]^{1/2}$

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1.08	147020	647,492,728	0.00003355	178,844,917	117,000,000,000	13.029	2,341

RMS Calculations
Assumes a Beta Distribution for the Size of Loss

- α and β are calculated based on the method of moments
- Mean = $\alpha / (\alpha + \beta)$
- Variance = $\alpha\beta/[(\alpha+\beta)^2(\alpha+\beta+1)]$

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RMS Calculations
α and β Parameters

- First calculate average damage, d = mean / TIV and standard deviation as s = standard deviation / TIV
- $\alpha = d^2 (1 - d) / s^2 - d$
- $\beta = \alpha (1 - d) / d$

1+CV^2	Event ID	Mean Loss	Frequency (Poisson Lambda)	Standard Deviation	Total Sum Insured	Alpha (α)	Beta (β)
1.04	**148079**	**1,084,023,648**	**0.00001622**	**210,769,197**	**108,000,000,000**	26.177	2,582
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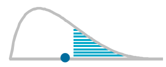
RMS Calculations
Occurrence Exceeding Probability (OEP) Calculation

- Loss at various return periods can be calculated by finding the conditional excess frequency which follows a Poisson distribution.
- Conditional excess frequency greater the $\lambda_F = \Sigma \Pr[x_i > L]\, \lambda_i$
- Since L follows a Poisson distribution, then the probability of having a loss greater than L is 1 – probability of no losses greater than L. The probability of no loss is $1 - e^{-\lambda F}$. This is the OEP distribution.

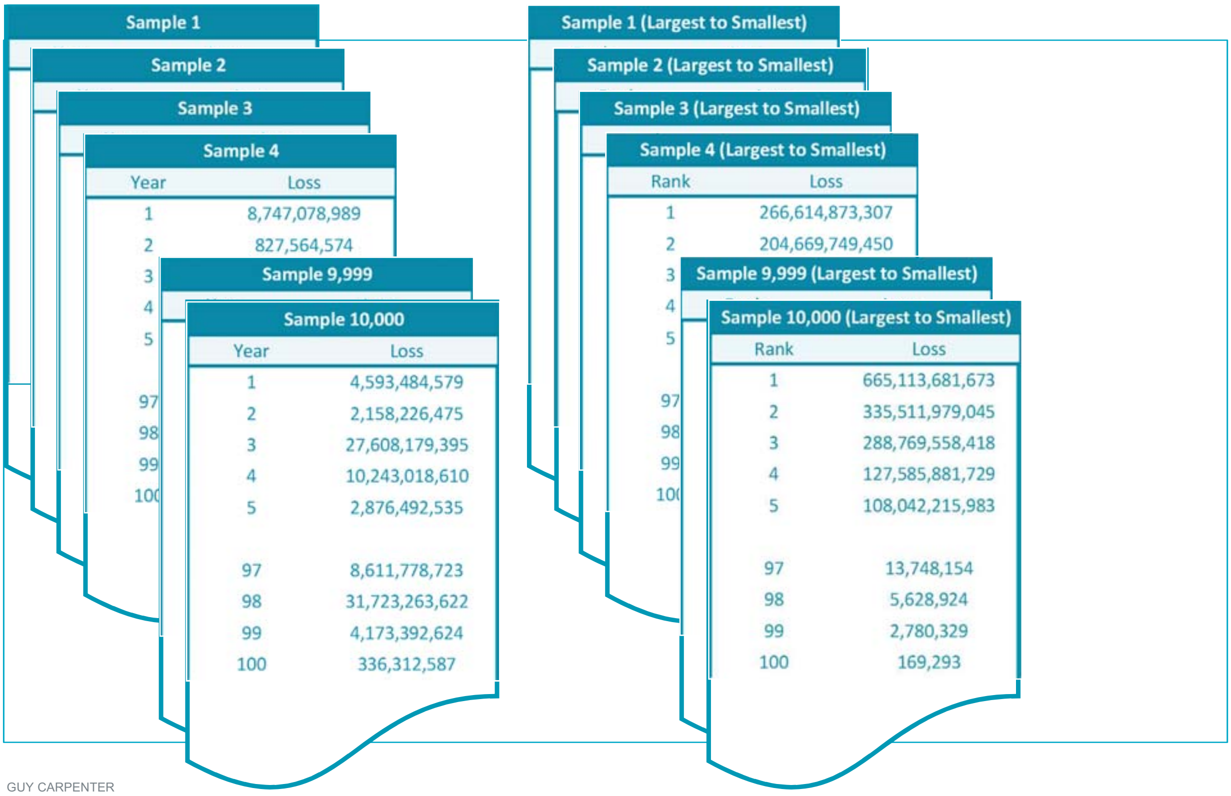
RMS Calculations
Aggregate Exceeding Probability (AEP) Calculation



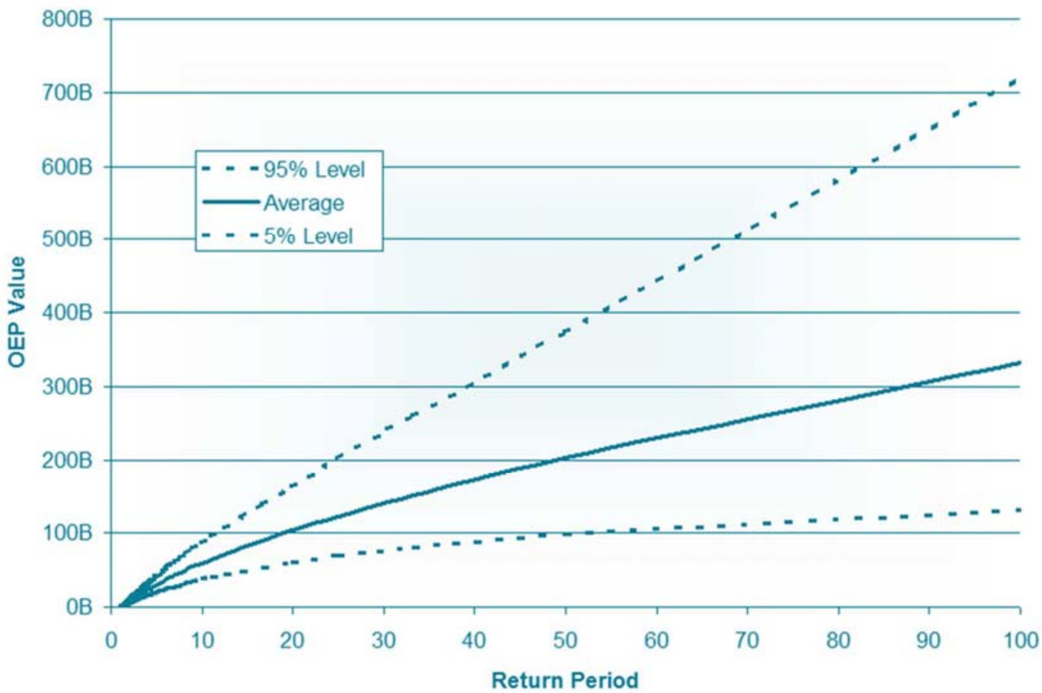
- Aggregate distribution is calculated using a Fast Fourier Transform.
- Step 1 - Assume the continuous distribution is a discrete distribution with equally spaced loss values and a total number of points of 2^n, for any value of n.
- Step 2 - Perform convolutions of the discrete distribution.
- Step 3 - There is an adjustment to correct for assuming the distribution is discrete.

Model Uncertainty

Model Uncertainty Due to Limited Historical Record



Model Uncertainty Due to Limited Historical Record



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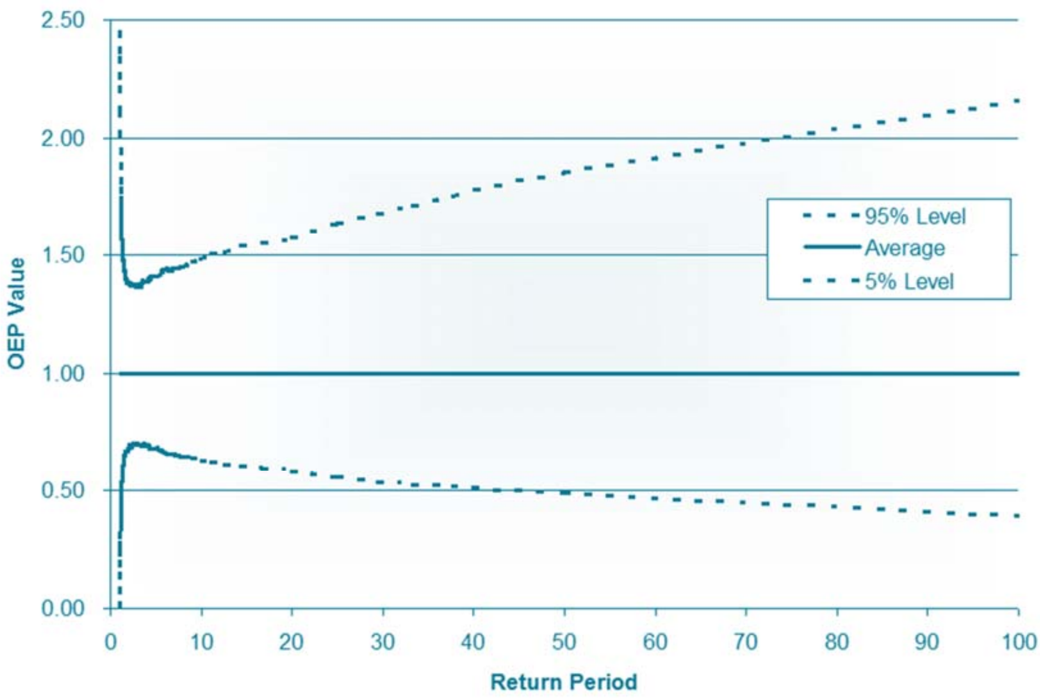

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Pricing Catastrophe Risk

Basic Pricing Formula

- The reinsurance price should be sufficient to cover the expected loss, expenses and a risk load.
- Risk loads can be calculated based on:
  - Standard Deviation of loss
    - The large the uncertainty, the larger the standard deviation, the larger the price (assuming the risk load factor is positive)
- Risk loads can be based on a return-on-equity / capital approach.
  - Leverage ratios
  - VaR or TVaR of loss to the reinsurer
  - Marginal Capital
    - Capital is the marginal amount of capital required to write an additional contract and maintain the same level of protection (e.g. $VaR_{99\%}$ Level)

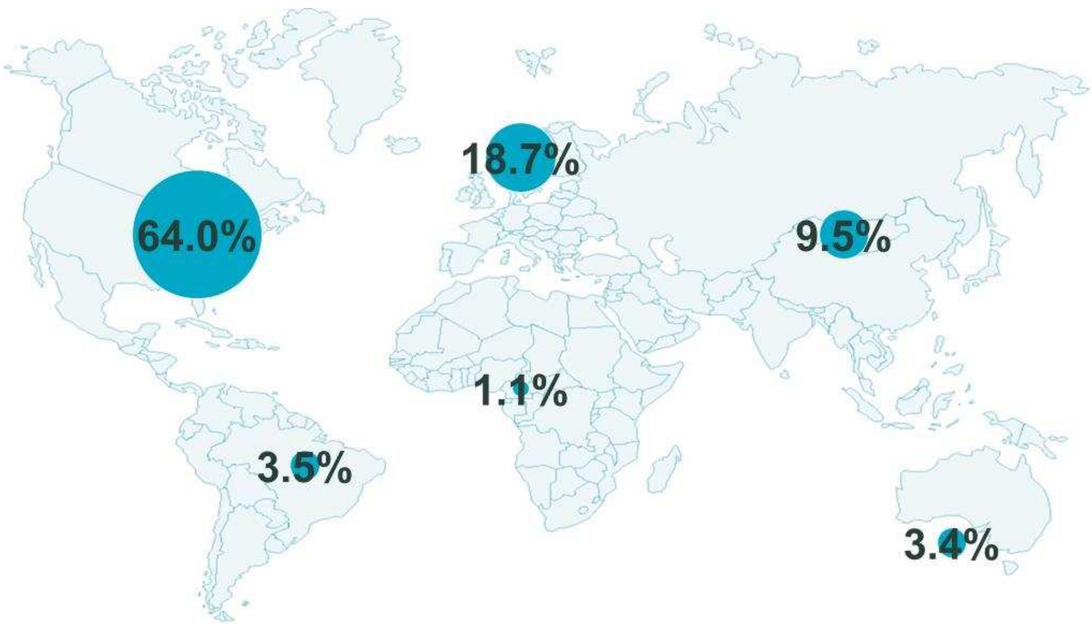
Risk Loads and Determining Required Capital

- Standard Deviation loading
  Capital is a factor of estimated standard deviation of loss (for each layer of a contract)
- Leverage Ratio Pricing
  Capital is factor of written premium. Higher factors are used for more volatile lines of business.
- Investment Equivalent Pricing
  Capital is chosen such that the reinsurer can pay all losses up to some high confidence level (Usually stated as VaR or TVaR)
- Marginal Surplus
  Capital is the marginal amount of capital required to write an additional contract and maintain the same level of protection (e.g. $VaR_{99\%}$ Level)

Investment Equivalent Reinsurance Pricing
The Basic Premium Formula

- P = [EL + Risk Load] ÷ [1 - Expenses]
- For using standard deviation pricing, the risk load is X% times the standard deviation of loss.
- Typical cat risk loadings are between 10% and 50% but can be as high as 100% and are sometime negative
  - Probably best to modify this approach if the risk loads are negative.
- Risk loads will depend on factors such as:
  1. Capacity requirements by territory / peril
  2. Client loss experience
  3. Market capital levels
  4. Recent industry losses (globally and locally)
  5. Interest rates

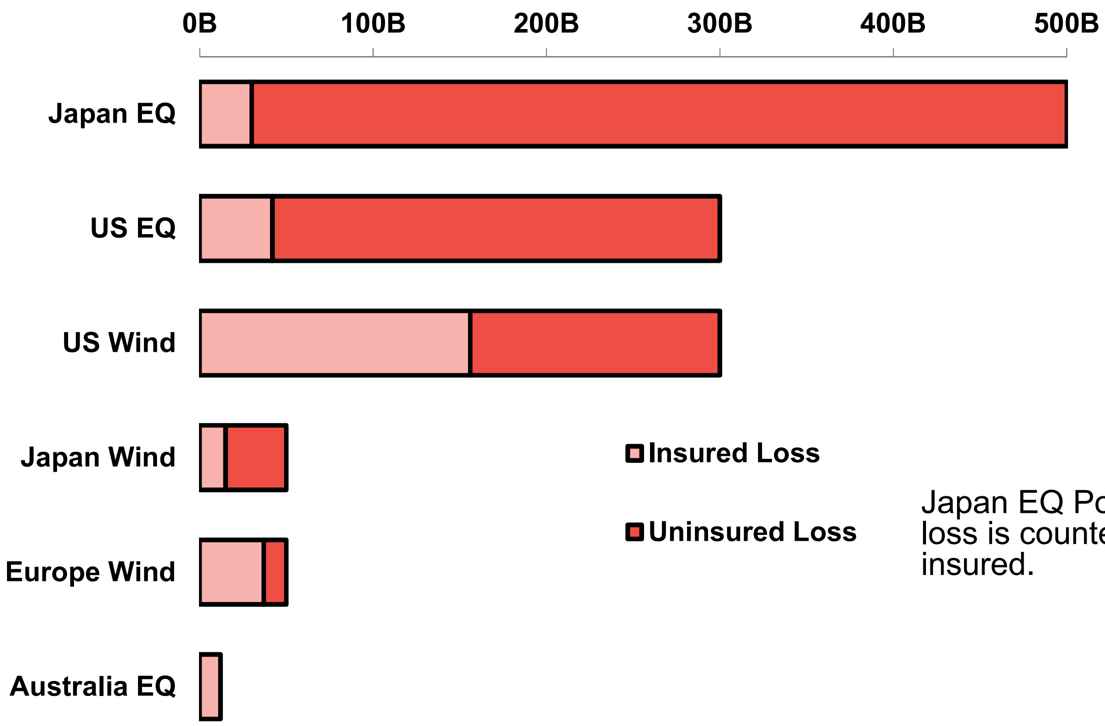
Capacity Requirements
Insured Cat Losses 1980 – 2010 (20.7B USD Average)



Insured cat losses are traditionally determined by North American hurricane losses

Source: Swiss Re

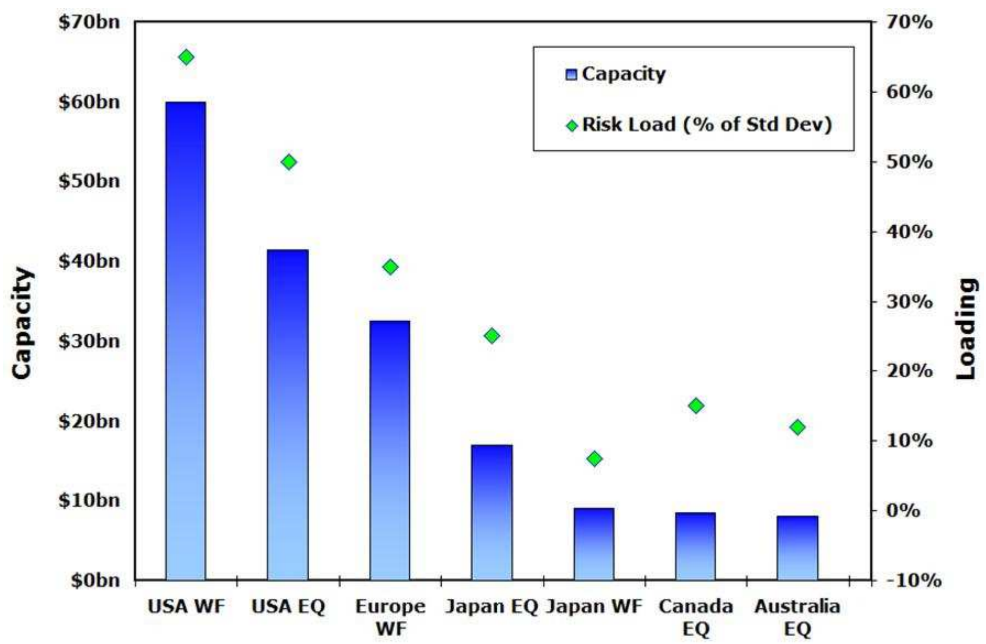
Capacity Requirements
How Big Can the Economic and Insured Losses Be?



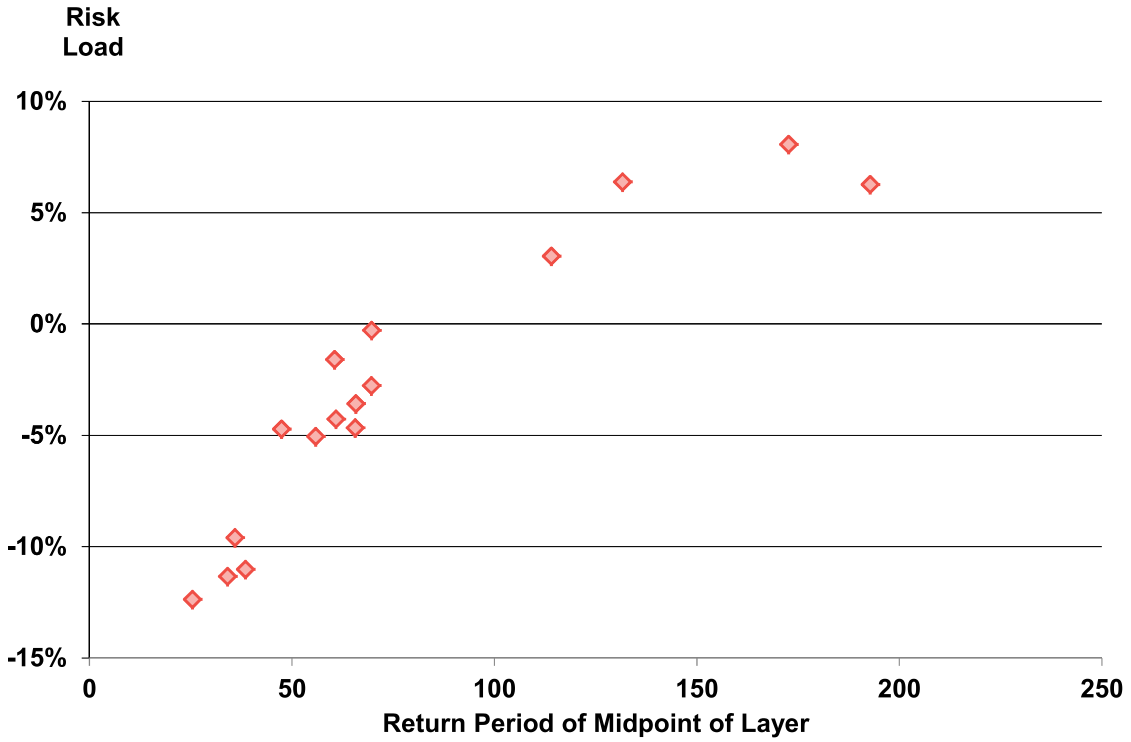
Japan EQ Pool (JER) loss is counted as not insured.

Capacity and Risk Loads by Region/Peril

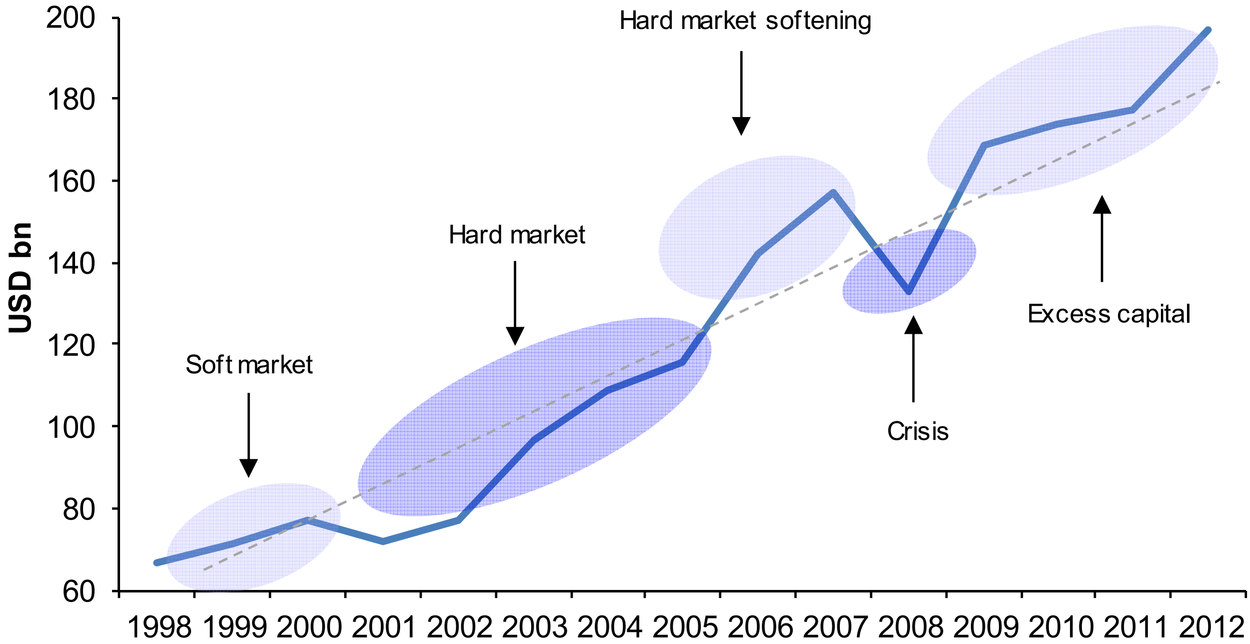
- P = [EL + (Standard Deviation of Loss x Risk Load)] ÷ [1 – Expenses]



Taiwan Risk Loadings as a % of Standard Deviation
EQ only Layers

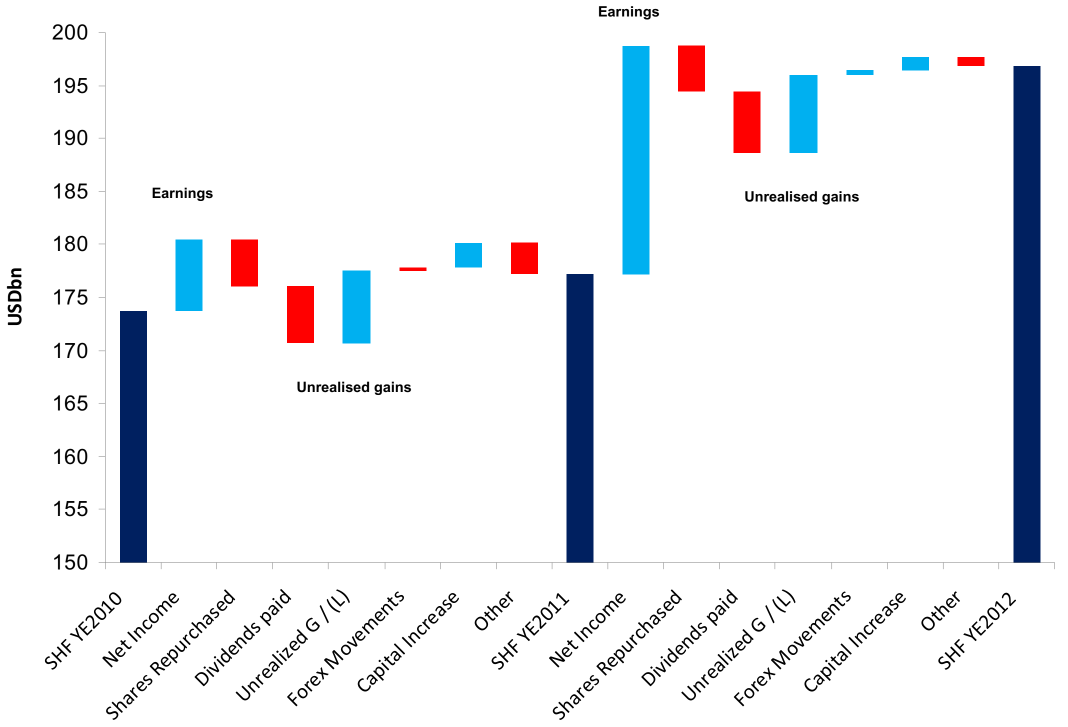


Market Capital Levels
Guy Carpenter Global Reinsurance Composite capital position



Source: Guy Carpenter

Recent Industry Performance - Globally
Guy Carpenter Global Reinsurance Composite capital position



Source: Guy Carpenter

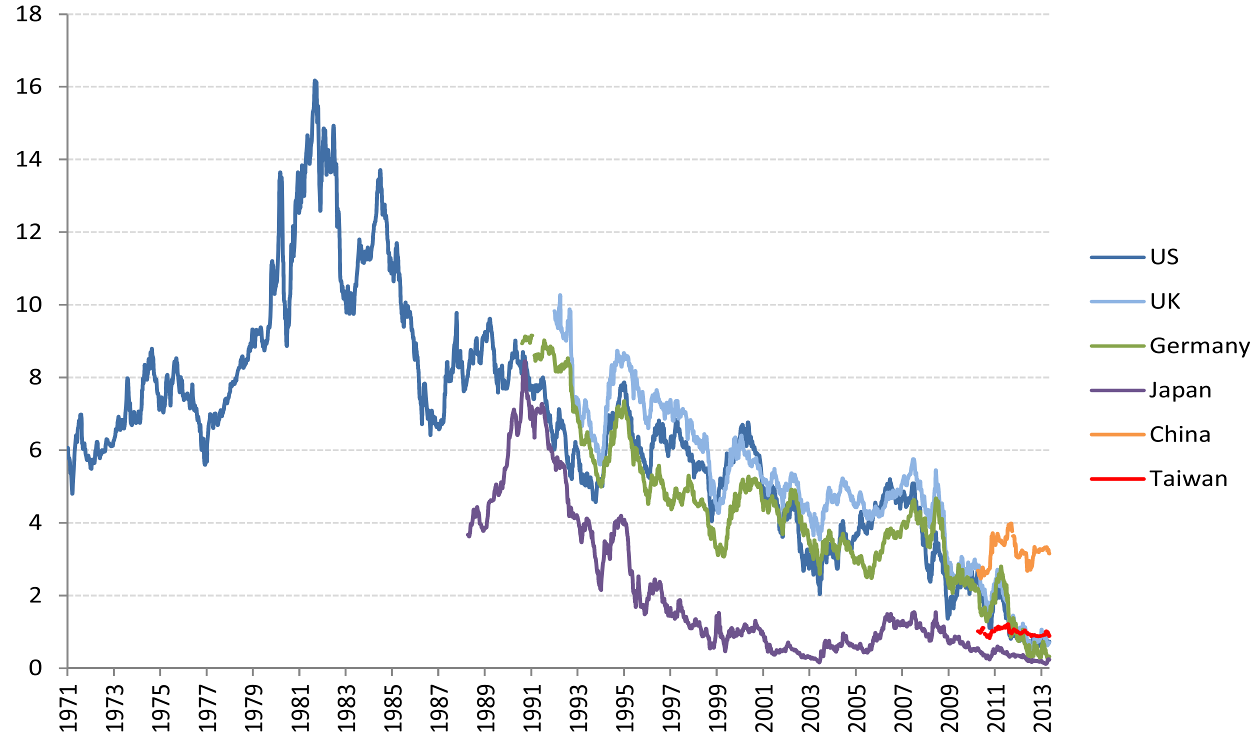
Recent Industry Experience – Globally
2012 Was a Good Year Globally in Terms of Combined Ratis

	Reinsurers	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Multi-Line	Everest Re	132%	152%	95%	99%	120%	90%	92%	96%	89%	103%	119%	94%
	Hannover Re	108%	95%	101%	97%	113%	102%	101%	96%	97%	98%	104%	96%
	Lloyd's	140%	99%	91%	97%	112%	81%	85%	98%	86%	93%	107%	91%
	Munich Re	135%	122%	97%	99%	112%	93%	96%	98%	94%	101%	111%	94%
	Partner Re	130%	98%	93%	95%	116%	85%	80%	94%	82%	95%	125%	88%
	SCOR	124%	118%	120%	106%	107%	97%	98%	100%	100%	99%	105%	92%
	Swiss Re	124%	104%	98%	97%	109%	92%	92%	99%	93%	95%	101%	82%
	XL	145%	104%	119%	95%	127%	89%	88%	95%	94%	95%	108%	96%
Cat	Ariel	/	/	/	/	/	44%	42%	108%	65%	82%	98%	XXX
	Montpelier	/	67%	50%	78%	201%	60%	61%	91%	62%	82%	131%	81%
	Renaissance Re	62%	62%	48%	104%	140%	55%	59%	79%	46%	48%	120%	59%
	Validus	/	/	/	/	/	57%	62%	92%	69%	86%	99%	87%

Recent Industry Experience – Regionally
Different picture in APAC in terms of Combined Ratios

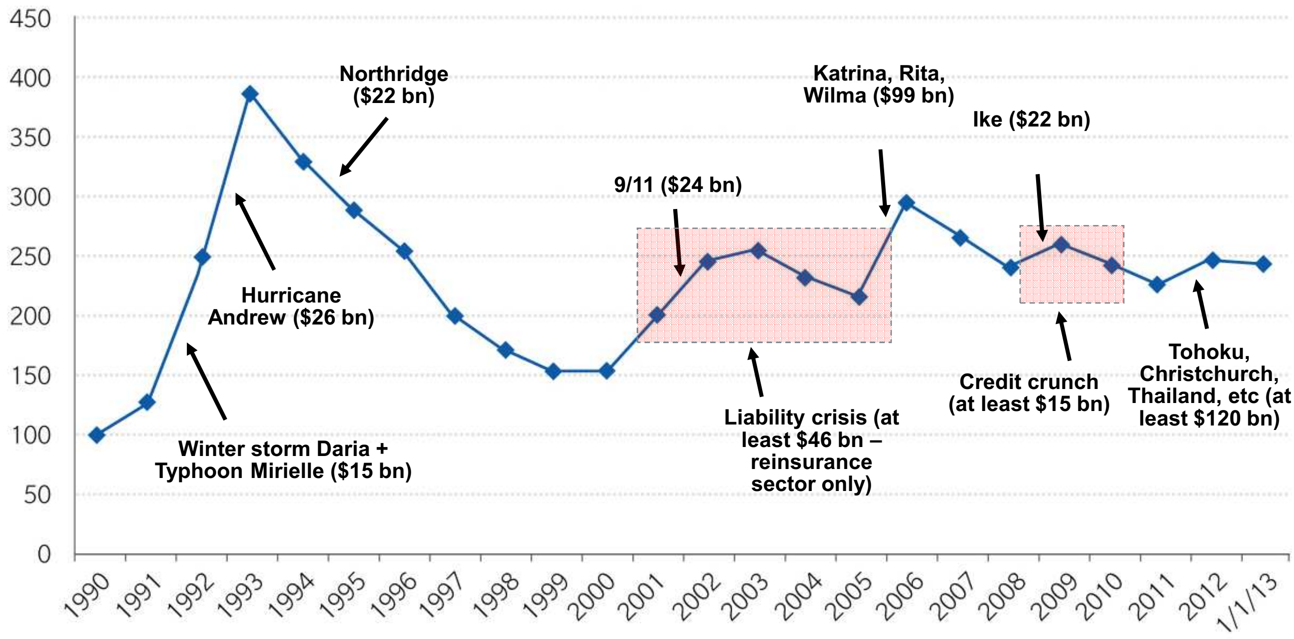
	Reinsurers	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
APAC	ACR	/	/	/	/	/	/	122%	105%	94%	103%	135%	/
	Asian Re	/	/	98%	97%	96%	96%	98%	111%	106%	99%	200%	235%
	BEST Re	87%	91%	90%	89%	90%	87%	94%	94%	96%	97%	101%	/
	Central Re	103%	100%	97%	97%	97%	98%	91%	88%	89%	95%	103%	103%
	China Re	/	/	/	96%	97%	99%	112%	110%	98%	99%	133%	102%
	GIC	124%	118%	101%	114%	127%	102%	113%	103%	110%	111%	144%	/
	Korean Re	95%	96%	96%	97%	97%	98%	101%	103%	96%	99%	112%	/
	Labuan Re	156%	112%	95%	97%	100%	96%	99%	99%	98%	99%	123%	/
	Malaysian Re	/	/	/	/	86%	91%	98%	99%	97%	93%	94%	/
	Milli Re	97%	99%	109%	104%	99%	104%	105%	104%	110%	107%	139%	108%
	Taiping Re	100%	84%	96%	98%	100%	96%	93%	82%	94%	94%	106%	107%
	Thai Re	/	/	98%	88%	89%	89%	87%	85%	78%	91%	147%	214%
	Toa Re	112%	105%	93%	105%	118%	122%	93%	94%	93%	109%	168%	/

Interest Rates
5-year sovereign debt yields



Source: Bloomberg, Guy Carpenter

Guy Carpenter Global Property Catastrophe Rate-on-Line Index

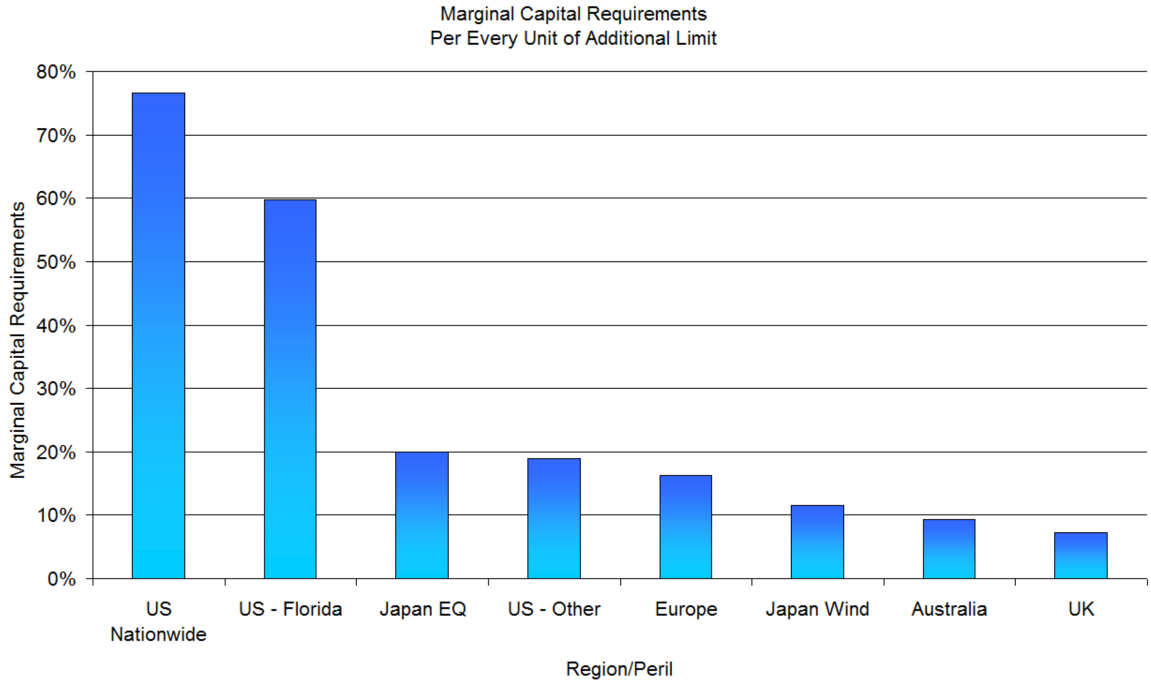


Source: Guy Carpenter & Company, LLC

Return on Capital Approach

- Risk Load = (Required Capital) x (Target Return on Capital)
- Capital can be calculated on a stand-alone basis (contract by contract).
  - e.g. target have enough capital to pay the 1 in 100 year loss to the contract
- Capital can be calculated on a company basis
  - e.g. target have enough capital to pay the 1 in 100 year loss to the company
  - Allocate the capital down to contracts
- Marginal capital required to write the contract
  - e.g. target have enough capital to pay the 1 in 100 year loss to the company. Marginal amount is the amount of company required capital if they write the contract less what it would be if they didn't write the contract.

Marginal Capital Requirements based on 1 in 100 Year TVaR Results
Hypothetical Reinsurance Company



Capital Requirement Example using 2 x 1 in 100 Year TVaR Loss (U/W)

	1 in 100 Year U/W Loss	Capital Requirement	Target Return on Capital	Estimated Risk Load
Company (A) Total Prior to new contract	10,000,000	20,000,000		
Company (A) Total After new Contract	10,300,000	20,600,000		
Margin Amounts	300,000	600,000	25.0%	150,000

Expected Loss	100,000
Risk Load	150,000
Price	250,000

Comments on Pricing

- The same risk potential in the US will demand a higher price than if it was located in Asia
- US requires the most reinsurance capacity so writing a risk in the US directly impacts a reinsurer's capital requirements
- Writing risks in Asia may only have a small impact on required capital
- In addition to capital requirements, recent loss experience will also impact current risk loads

Important Disclosure