1st Capacity Building Seminar in Crop Insurance

Hotel Sea Princess, Mumbai
26th September 2019

Catastrophe Modelling for Property

Kanad Manjrekar

Senior Manager, Property Retrocession,
GIC Re

Institute of Actuaries of India

How it all started

Late 1960s	Geographical Information System (GIS) Application example: Google Maps
Late 1980s	Early development of catastrophe models in USA
Factors that helped	- Increasing computing power - Increasing understanding of natural hazards - USA was largest insurance market - Availability of data
1987	AIR was established
1988	RMS was established
1994	EQECAT was established

How it all started

1992	Hurricane Andrew made landfall in Florida USA
	Many companies went insolvent
	stakeholders pressured companies into adopting scientific analysis of the portfolio and effects on balance sheet
Late 2000s	First India CAT Models were developed

Perils modelled

Hurricanes / Cyclones / Typhoons

Earthquakes

Floods

Emerging Risks

Cyber Risk

Terrorism

Agriculture

Burning Cost is not enough

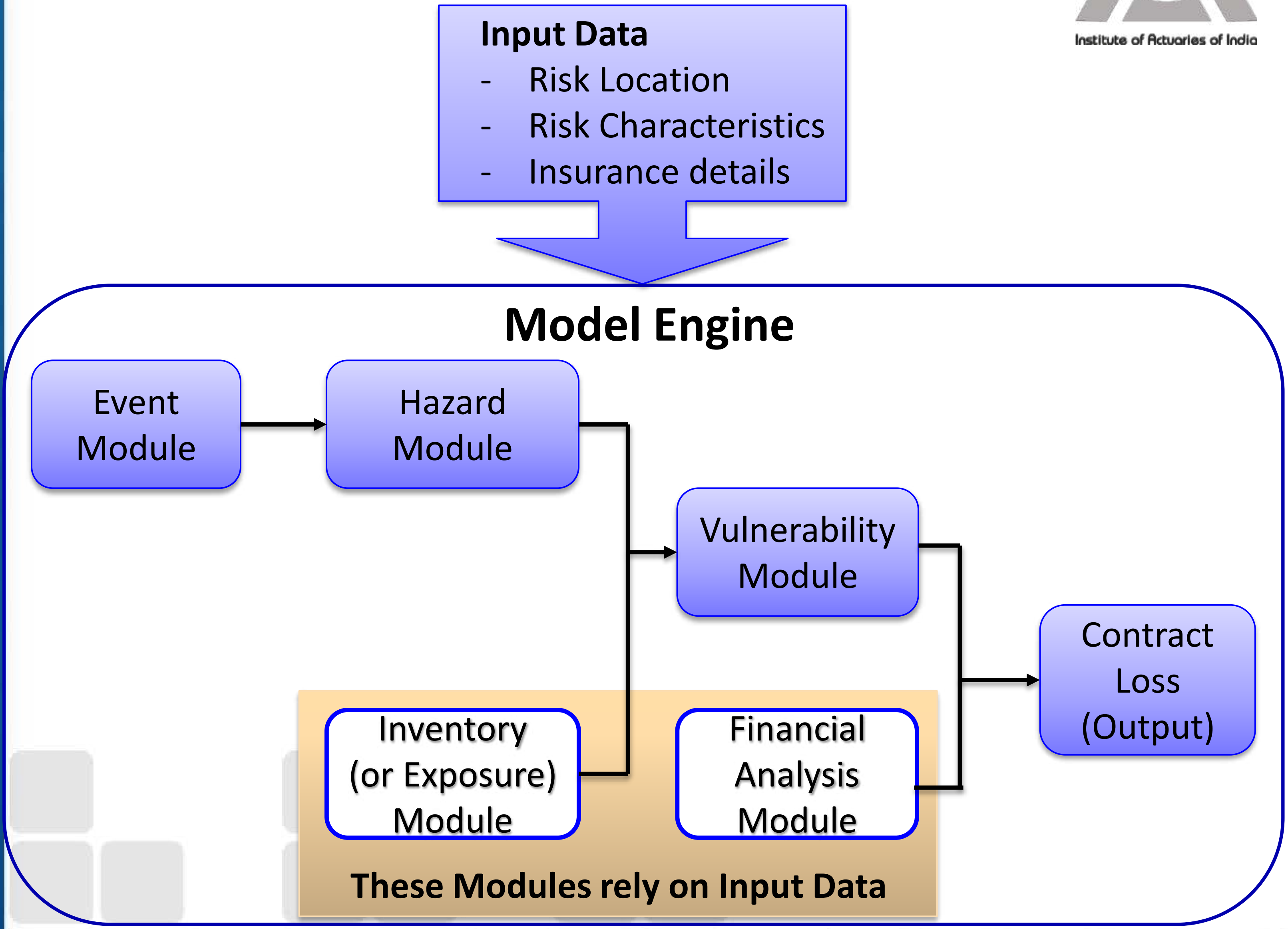
- The natural catastrophe events are sudden and can occur at places with no past history of such events
- High severity of events: Estimating losses accurately is very important
- Low frequency of events: Company experience data is inadequate due to very long return periods
- A 10 year burning cost model is unlikely to be a reliable method of pricing a NATCAT risk with 100 year return period
- The models provide better understanding of risk and likely exposure of the portfolio to catastrophe losses

Approach of Catastrophe Models

Institute of Actuaries of India

Start with Past Data	Use all available information of the event and losses faced
Understand the underlying reason for natural hazard	Use information such as soil maps, hydrological maps, terrain, weather data etc.
Generate a Stochastic Event Set	Use simulation techniques to generate events that have never been observed in the past. The event set will also contain past events.
Input the portfolio information	Enter details of properties covered and applicable insurance structures
Calculate effect of NATCAT event on the portfolio	Use all information above and arrive at the loss estimates and related probabilities
Update the model when necessary	Update the model with new developments in sciences or when new scenarios manifest which are not assumed within the model

Structure of Catastrophe Models



Input Data

Property Modelling

- Risk Location
- Risk Characteristics
  - Occupancy
  - Construction Type
  - Height
  - Year Built
  - Replacement Value
  - Etc.
- Insurance Details

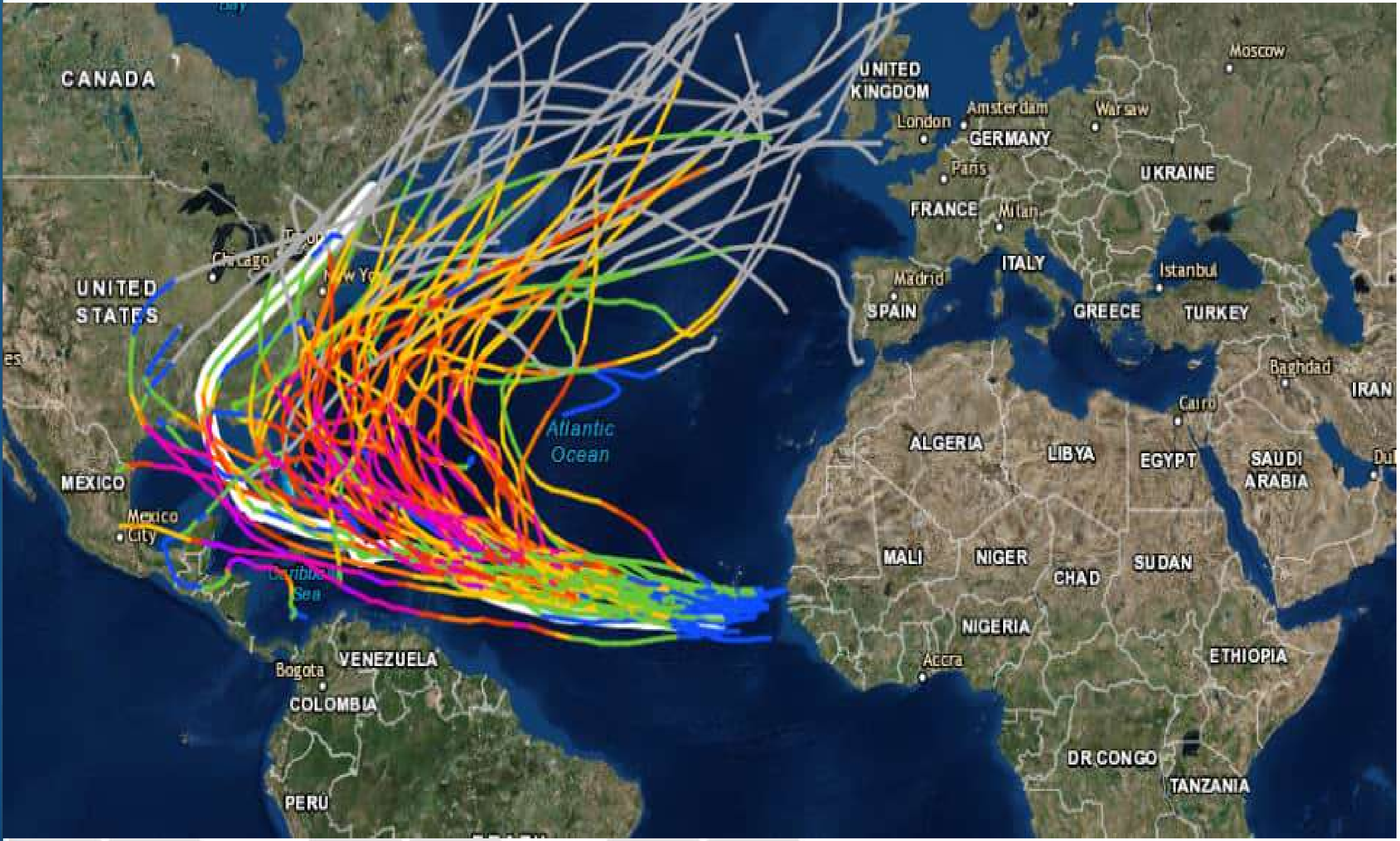
Crop Modelling

- Risk Location
  - Cluster details
- Risk Characteristics
  - Crop details
  - Planted Area
  - Irrigation information
  - Etc
- Insurance Details

Event Module

- This is a database of stochastic events (the event set)
- This event set is created using past events and stochastically simulated events that may not have occurred in the past
- For each event in the set, its physical parameters, location and annual probability are defined

Event Set



Source: National Oceanic and Atmospheric Administration (NOAA)

Hazard Module

- This module determines the hazard of each event at each location
- Hazard is the consequence of the event that causes damage
- E.g. in case of hurricane, wind speed is the hazard and for earthquake it is ground shaking
- At each location, this module will lookup various information such as soil type, elevation, liquefaction, landcover etc. from the background database
- It will determine the event's physical characteristics at every location based on all the above information

Inventory Module

- This is a detailed database of the insured structures
- This will include location, age, occupancy, construction type etc for each risk
- Similarly for crops, it will include cluster location, crop type, planted area etc.

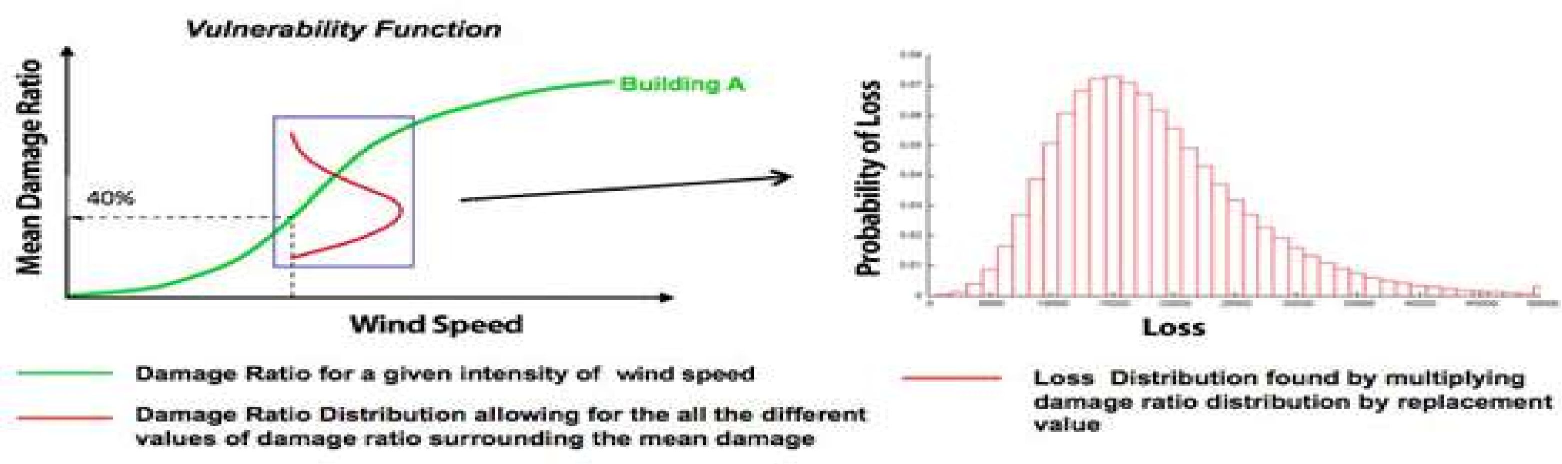
Vulnerability Module

- Vulnerability can be defined as the degree of loss to a particular structure due to exposure to given hazard (expressed as percentage of sum insured) or damage ratio
- This module specifies the likely damage an insured property will sustain compared to the replacement value due to a certain peril by calculating damage functions
- This is based on the engineering assessment
- And is sensitive to the risk information contained in the inventory module

Vulnerability at same location

Liquefaction during 1964 Niigata Earthquake, Japan
Source: Wikipedia

Vulnerability Function and Mean Damage Ratio (MDR)



- A given intensity of the event at a given location on a given building will not always cause the same amount of damage
- There is a distribution of damage ratios at each given level of intensity (Shown by red line in the left hand side graph)
- The green line depicts the mean damage ratio for given intensity of the event for the particular building
- The Vulnerability function will change on the basis of various building characteristics such as construction type, age of building, occupancy etc.

Image Source: https://understandinguncertainty.org/node/622

Financial Analysis Module

- This converts the damage ratios from vulnerability module into financial loss
- The damage ratio function for specific event is multiplied with building replacement value to arrive at ground up loss distribution
- Further, the database of policy conditions (such as limits, excess, sublimit, coverage terms etc.) are used to arrive at various levels of loss distribution such as insurer's gross loss
- This module computes combined loss distribution of all buildings through convolution process

What is Exceedance Probability (EP)

- Output CAT Model is in the form of exceedance probability (EP) curves
- EP is the probability that a stochastic process exceeds some critical value
- Exceedance Probability can be thought of similar to survival function
- Survival Function = 1 – Cumulative Distribution Function

OEP and AEP

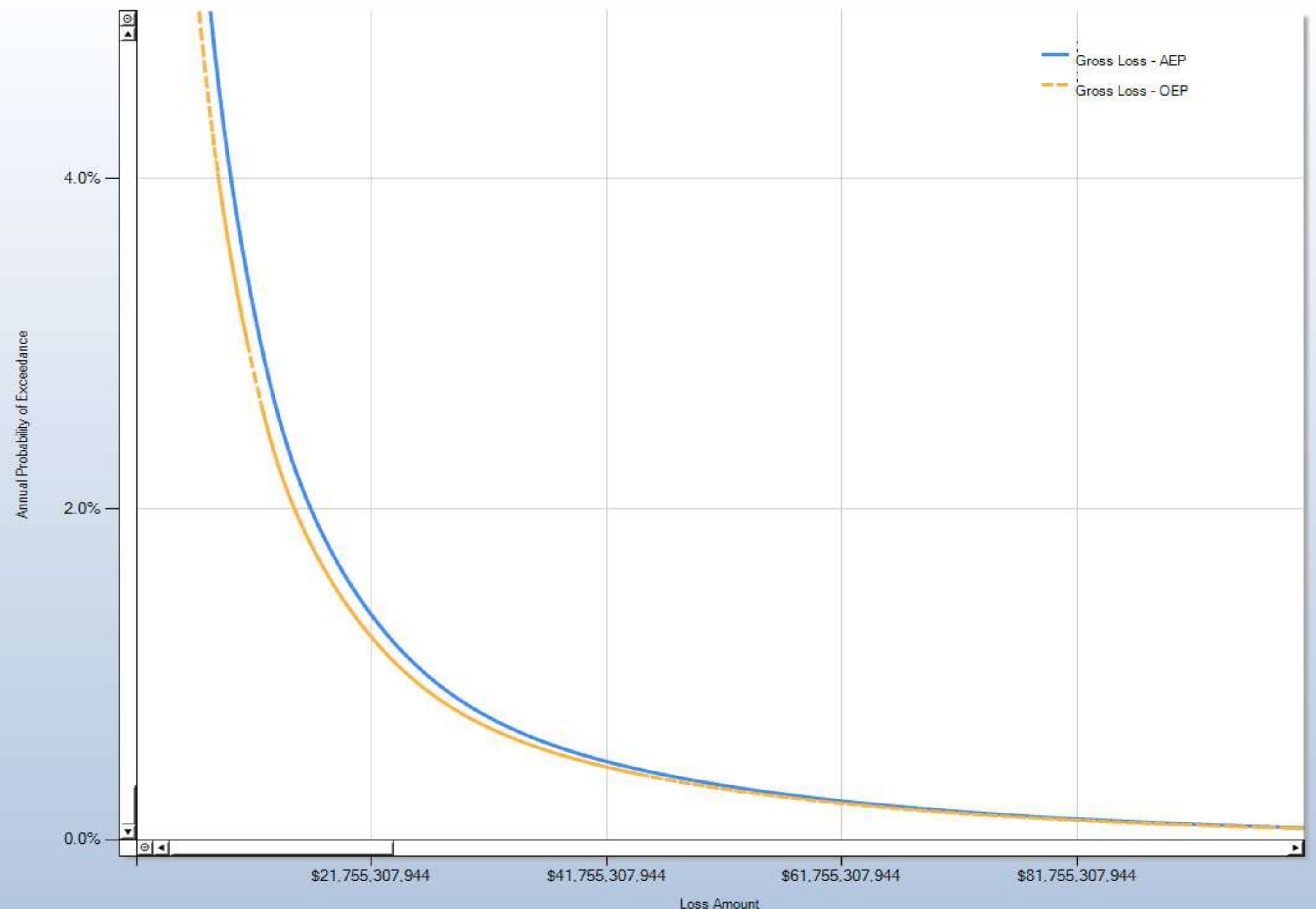
Occurrence Exceedance Probabilities (OEPs)

- The OEP is the probability that the largest individual event loss in a year exceeds a particular threshold
- The OEP is used mainly to analyze losses due to single events
- Can be used in Catastrophe XL reinsurance purchase decisions
- Ignores the possibility of multiple events within a year

Aggregate Exceedance Probabilities (AEPs)

- The AEP is the probability that the total cost of all loss events in a year exceeds a particular threshold
- This file is often used for capital and reserving projections

Exceedance Probability Curve



Summary of Output

Summary Losses:

Critical Prob.	Return Period	India ALM (INR) Gross Loss AEP	India ALM (INR) Gross Loss OEP
0.010000 %	10,000	19,414,832.29	18,658,654.71
0.020000 %	5,000	17,845,986.19	17,213,233.74
0.125645 %	796	12,909,469.94	12,462,404.78
0.200000 %	500	11,425,747.38	11,011,812.76
0.400000 %	250	9,049,761.58	8,679,193.02
0.500000 %	200	8,254,562.64	7,895,216.99
1.000000 %	100	5,824,448.40	5,504,838.93
2.000000 %	50	3,784,725.36	3,532,167.17
4.000000 %	25	2,244,930.45	2,067,073.57
10.000000 %	10	847,009.14	753,121.63
20.000000 %	5	291,081.99	248,673.65

Summary Statistics:

Statistics	India ALM (INR) Gross Loss
Pure Premium	365,233.14
Standard Deviation	1,164,406.54
Coefficient of Variation	3.1881

Output of a CAT Model

Institute of Actuaries of India

Average Annual Loss (AAL) / Pure Premium

- AAL is the expected amount of loss from all events in a year
- It is the annual pure premium required to cover the modelled loss over time

Standard Deviation and Coefficient of Variation

- Annual Standard Deviation represents the volatility surrounding the AAL
- Coefficient of variation (CV) is Std. Deviation normalized by AAL to provide comparative matric showing uncertainty relative to loss
- CV can be used to compare relative volatility of two portfolios

Event Loss Table

- All the statistics (OEP, AEP, AAL, Standard Deviation and CV) are calculated from the Event Loss Table
- The event loss table contains the set of events from the Event Module along with Average loss, standard deviation, annual rate of occurrence and other information for each event

Event Loss Table (ELT)

Institute of Actuaries of India

Mean Loss Ground Up Loss	Annual Rate	Event Id	Source ID	Peril	Region
45,53,722.60	0.0036%	2875068	31638	Windstorm	North America
45,50,719.08	0.0004%	2869789	26359	Windstorm	North America
45,37,163.45	0.0001%	2866228	22798	Windstorm	North America
44,64,845.49	0.0002%	2866420	22990	Windstorm	North America
44,50,964.32	0.0001%	2855173	11743	Windstorm	North America
44,33,914.67	0.0002%	2872019	28589	Windstorm	North America
44,12,180.23	0.0031%	2874928	31498	Windstorm	North America
43,63,158.72	0.0000%	2865464	22034	Windstorm	North America
43,35,223.78	0.0003%	2873609	30179	Windstorm	North America
42,83,110.35	0.0010%	2867264	23834	Windstorm	North America
42,61,811.03	0.0002%	2868308	24878	Windstorm	North America
42,45,757.15	0.0006%	2850409	6979	Windstorm	North America
42,22,942.60	0.0004%	2862318	18888	Windstorm	North America
41,88,163.56	0.0020%	2875776	32346	Windstorm	North America
41,76,178.21	0.0002%	2873336	29906	Windstorm	North America
41,47,920.87	0.0002%	2877041	33611	Windstorm	North America

- These are first few simulated events in the event loss table (ELT), generated using a US portfolio of risks for hurricane peril.
- There are thousands of simulated events in this particular ELT which are not shown here
- It will also contain past events that have actually occurred and provide average loss for the current portfolio (as-if analysis)

What is 1 in 200 year event

Institute of Actuaries of India

A 1 in 200 year return period loss **does not** mean that this loss can only occur (return) once every 200 years

It means that the loss value with 1 in 200 return period has **annual probability** of exceedance of 0.5%

OR

This particular loss is at 99.5th percentile in the event loss table

OR

The probability of not exceeding the particular threshold is 99.5%

Combining two of more events

Example to illustrate combining two event sets

EVENT SET 1

Event	Annual Rate	Loss	EP
CA EQ 101	0.10%	15,000	0.10%
CA EQ 202	0.30%	14,500	0.40%
CA EQ 103	0.10%	13,000	0.50%
CA EQ 304	0.20%	12,500	0.70%
CA EQ 105	0.15%	12,000	0.85%
CA EQ 206	0.21%	11,000	1.06%
CA EQ 407	0.10%	10,500	1.15%

100 Year Loss is about 11,000

EVENT SET 2

Event	Annual Rate	Loss	EP
US HU 101	0.12%	20,000	0.12%
US HU 202	0.11%	16,000	0.23%
US HU 103	0.15%	14,000	0.38%
US HU 304	0.22%	13,500	0.60%
US HU 105	0.25%	12,750	0.85%
US HU 206	0.12%	12,600	0.97%
US HU 407	0.10%	11,500	1.07%

100 year Loss is about 12,500

COMBINED EVENT SET

Event	Annual Rate	Loss	EP
US HU 101	0.12%	20,000	0.12%
US HU 202	0.10%	16,000	0.22%
CA EQ 101	0.10%	15,000	0.32%
CA EQ 202	0.30%	14,500	0.62%
US HU 103	0.15%	14,000	0.77%
US HU 304	0.22%	13,500	0.99%
CA EQ 103	0.10%	13,000	1.09%
US HU 105	0.25%	12,750	1.33%
US HU 206	0.11%	12,600	1.44%
CA EQ 304	0.20%	12,500	1.64%
CA EQ 105	0.15%	12,000	1.79%
US HU 407	0.10%	11,500	1.88%
CA EQ 206	0.21%	11,000	2.09%
CA EQ 407	0.10%	10,500	2.19%

100 Year Loss is about 13,500

Stakeholders

- **Board and Management**
  - Assess the size of potential losses on the underwritten portfolio
  - Planning/Forecasting
  - Shareholder Communications
  - Reinsurance purchase
- **Underwriters**
  - Individual risk selection and application of CAT loads
  - Pricing of Catastrophe XL reinsurance treaties and setting of event limits in proportional treaties
- **Actuaries**
  - Reserving of Individual catastrophe events
  - Capital allocation and assessment
  - Financial Condition Report
  - Stress Test Report
- **Regulators**
  - As per IRDAI Reinsurance Regulations, 2018, the insurer has to file catastrophe modelling report along with proposed reinsurance program
  - Economic Capital assessment
- **Rating Agencies**
  - Assigning rating to the company

Thank You

Kanad Manjrekar
Senior Manager, Property Retrocession
GIC Re
Email: kanadm@gicofindia.com
Linkedin: https://www.linkedin.com/in/kanad-manjrekar/