Institute and Faculty of Actuaries

GIRO40

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Institute and Faculty of Actuaries

Is Your Cat Model a Dog ?

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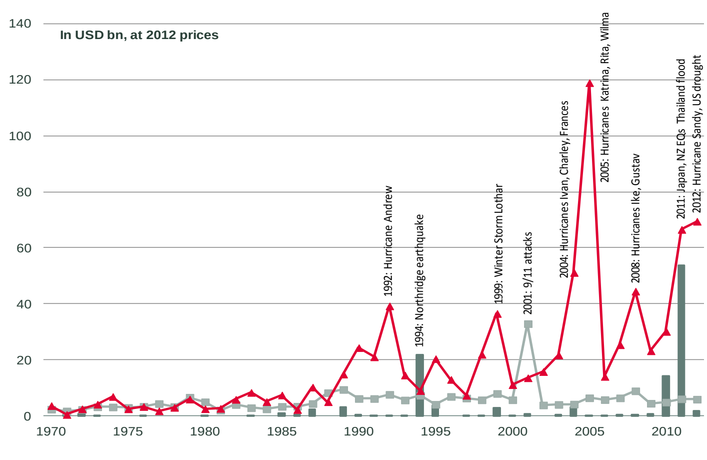
Introduction

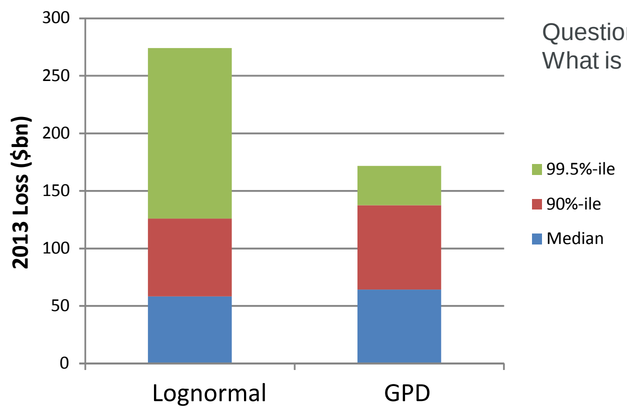
- Fitting to Historical Loss Data
- Invention of Catastrophe Models
- What Actually Goes into Cat Models ?
- Model Error in a Simple Cat Model
- Impact of Model Error on Reinsurance & Capital
- Conclusion

Swiss Re Catastrophe History



Source: Sigma reports

Fitted 2013 Distributions (GLM + MOM)



Question:
What is **Prob**{loss > $500bn}?

$500bn = 1-in-5000

$500bn = impossible

Invention of Cat Models

- Invented late 1980's, adopted early/mid 1990's
- Solve the problems of just using historic loss data
  - Limited credible historic loss information
  - Revaluing of losses for changes in portfolio through time
  - Loss experience doesn't reflect full potential of what could happen
- Catastrophe Models
  - Use actual exposures as inputs
  - Built from longer time series of hazard data
  - Allow use of latest scientific knowledge & theories

Exposure Data is Fact ?

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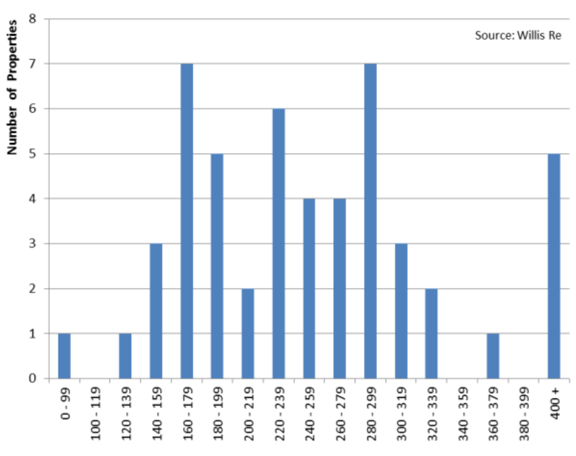
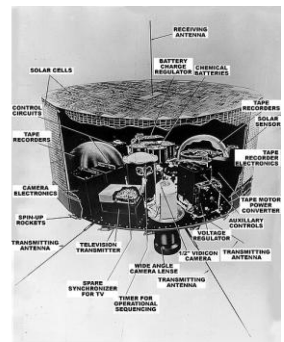


Why ?

- Source of Data
- Calculation Assumptions
- Timing of Data
- Consistency

Modifiers more consistent …

Long History Of Hazard Data ?
- Atlantic Hurricanes



- HURDAT   1851 – present
- Based on Observations
  - But, older storm 'data' is the output of models run to match very limited data
- Completeness ?
  - c.1900 onwards - landfalling storms
  - c.1950 onwards - all storms
- Reanalysis
  - Hurricane Andrew Upgraded to Cat 5 in 2002
  - June 2013 (1941-1945) TS+4, C2+1,C3-2,C4+1

Long History Of Hazard Data ?
- European (Extra-Tropical) Storm

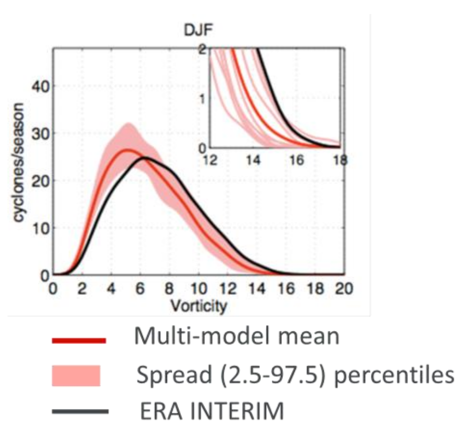
- Storm Events
  - ERA 40   mid 1957 - 2001   (44½ years)
  - ERA Interim   1979 - present   (34½ years)
- Site Based Wind Speeds
  - Gaps in records
  - Anemometers are moved
  - Station metadata important to understanding
  - Models used to adjust historical data to common basis

Long History Of Hazard Data ?
- Earthquake

- Seismic Observation
  - 1875 seismometer invented
  - 1892 seismometers installed at 40 locations around world
  - 1935 Richter Scale invented
  - 1961 World-Wide Standardized Seismic Network (paper records)
  - Mid-1970 digital records
  - paleoseismology
- Cat Models may all be based on same underlying information
  - Japan (JMA / Usami) Tohoku – expected magnitude
  - NZ Christchurch - unknown fault

Extending Observation History
- Use of GCMs

- GCMs increasingly being used to extend observation history
- GCM are just models and most have biases
  - Modelled North Atlantic ETC's are generally weaker and further south than observed

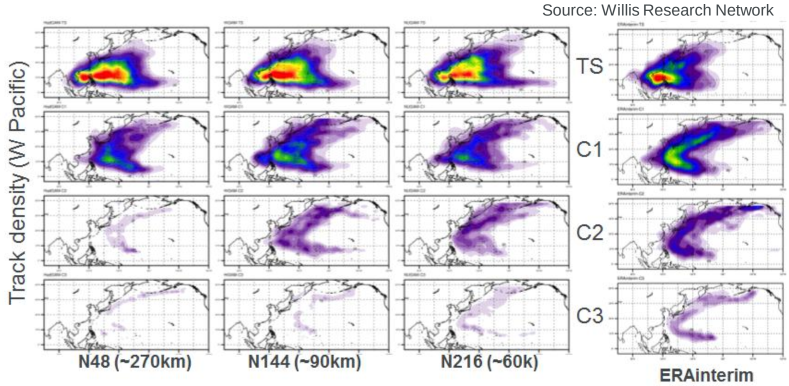


Source: Willis Research Network

Extending Observation History - Use of GCMs

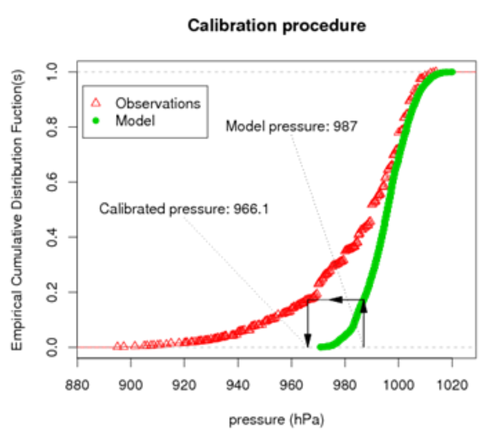
- Modelled Tropical Cyclones / Hurricanes are –
  - Weaker than observed

Source: Willis Research Network



Extending Observation History - Use of GCMs

- Therefore the output of GCMs is calibrated back to observations
- Partly defeats the purpose of using GCMs in the first place



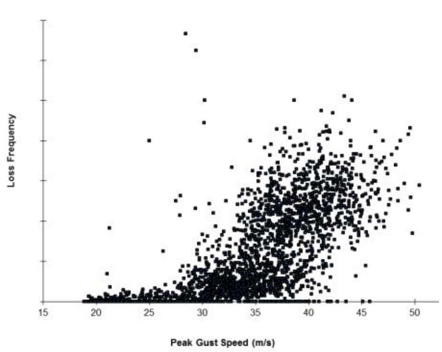
Source: Willis Research Network

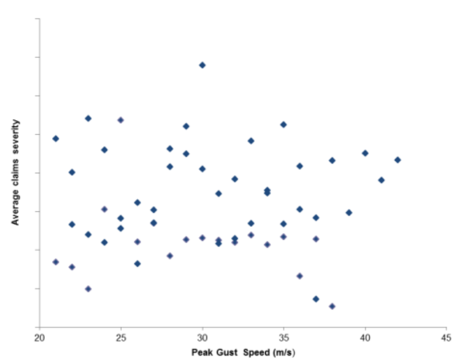
Vulnerability

- Vulnerability Curves relate the hazard at a location to damage
- To produce these you need, for historical events
  - individual claim data with corresponding sum insured & actual hazard value for that risk's location.
  - The hazard value for all risks that didn't give rise to claim.
- Detailed claims data is available though not generally very far back (mergers, systems changes etc)
- Hazard data can be harder, especially at right resolution for flood
- Historic Sum Insured data less reliable than present (but consistency needed…)

Vulnerability

- Individual claims data often shows much variability.
- Well behaved ETC example below





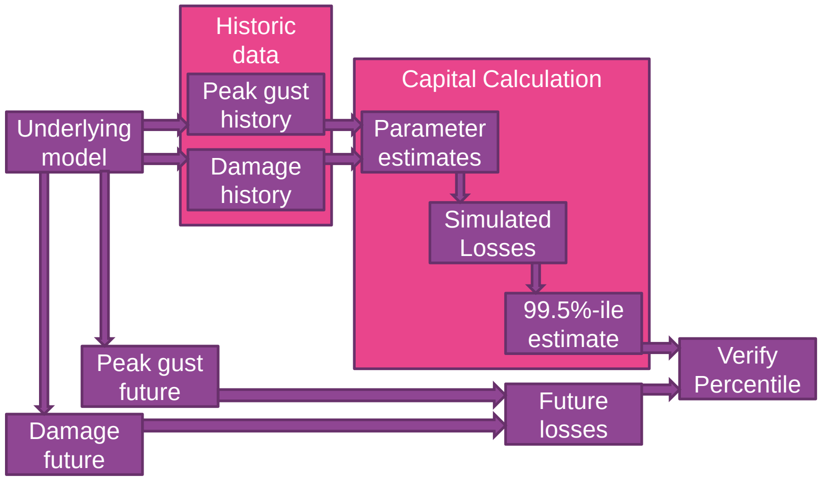
Calibration

- If you try to build a catastrophe model from lots of separate components the first results will generally be unexpected
- Most models will have a 'calibration' step
- e.g.
  - UK Windstorm – vulnerability calibration based on 90A (Daria)
    - but need to revalue historic data up to present day
    - we are almost back where we started without cat models

What can we learn from Statistics?

- There is an established statistical literature on parameter and model error (also called "robust statistics")
- We calculated an example based on EU windstorm
- 40 years' peak gust data, recording 52 storms with peak gust exceeding 25 m/s at a particular weather station (which implies a Poisson frequency $\varphi = 1.3$)
- Gust excess over 25 m/s have roughly a Pareto distribution with shape parameter $\alpha = 10$
- 10 years' damage ratio data. This suggests damage ratios are proportional to (max gust – 25m/s)^3. Given a 50m/s gust, the damage is generally (95% of the time) in the range from 5% to 10% of aggregate sum assured.

Allowing for Model and Parameter Error



Model and Parameter Error Results

- If we know the underlying model, and we generate 1999 scenarios, there is a 0.5% chance that the next observation lies above scenario #1990 (when ranked in increasing order)
- This is because the aggregate 2000 scenarios are a random sample so there is a 1-in-2000 chance that any particular observation is in the top 10
- This no longer works if
  - The next observation comes from the underlying distribution
  - But the 1999 scenarios come from a fitted distribution
- For our parameters, there is approximately a
  - 2% chance the next observation lies above scenario #1990
  - 0.5% chance the next observation lies above scenario #1998

Impact of Model Error - Reinsurance

- Example
  - Typical reinsurance programme structured and pricing using 'base' model output
- Gearing Effect of RI evident
  - Largest for 'binary' layers (e.g. ILW)

Example Company

Real World cf Model	Top Layer Expected Loss Ratio	% diff	1 in 200 layer attachment probability	% diff
+ 30%	47.7%	+ 45%	0.798%	+ 60%
+ 20%	42.9%	+ 31%	0.699%	+ 40%
+ 10%	37.9%	+ 15%	0.600%	+ 20%
base	32.8%	0%	0.500%	0%
-- 10%	27.7%	-- 16%	0.401%	-- 20%
-- 20%	22.4%	-- 32%	0.300%	-- 40%
-- 30%	17.2%	-- 48%	0.225%	-- 55%

Impact of Model Error - Capital Requirements

- Impact on 1-in-200 Net AEP
  - i.e. P(annual net loss >= X) = 0.005
- Excess of Loss Results in
  - Gearing
  - Skewness
- Net Results are Biased w.r.t. Model Error

Example Company

Real World cf Model	Gross 1-in-200 AEP Loss		Net 1-in-200 AEP Loss	
	£m	% diff	£m	% diff
+ 30%	312.7	+ 30%	107.2	+ 77%
+ 20%	290.8	+ 21%	88.8	+ 47%
+ 10%	263.9	+ 9%	66.7	+ 10%
base	**241.1**	**0%**	**60.6**	**0%**
-- 10%	219.3	-- 9%	54.9	-- 9%
-- 20%	195.3	-- 19%	52.8	-- 13%
-- 30%	173.2	-- 28%	50.4	-- 17%

Conclusions

- There's lots of model issues we haven't touched on. Many attempts at quantification of errors in cat model focus on a single component.
- Some applications (such as certifying 1-in-200 ruin risk) require CAT models to be accurate in absolute terms
- Other applications (such as monitoring exposure change over time or ranking yields on ILS) require only require relative accuracy, which is more plausible
- Established high layer reinsurers are implicitly aware of model risk which is why rate on line >> modelled burning cost. Is new capacity equally well informed?

Expressions of individual views by members of the Institute and Faculty of Actuaries and its staff are encouraged.

The views expressed in this presentation are those of the presenters and are not necessarily those of their employers.

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