

# Cat Models: Useful Tools or Budget Sinkholes?

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## Agenda

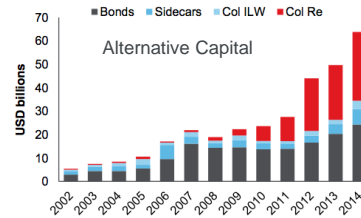
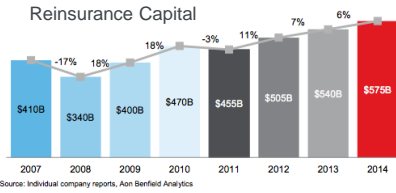
- Context
  - Industry, what are catastrophe (Cat) models, why do we need them, platforms and vendors
- Uncertainty overview
  - How much, sources, terminology
- Cat model structure and uncertainties
  - Hazard, vulnerability, financial modelling, platform
- Uncertainty in the spotlight
  - Examples of cat models uncertainty case studies
- What can be done to help deal with this uncertainty?

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## There is consolidation within the industry caused by an influx of capital, low rates...



“Outlook for the reinsurance sector is negative, as intense market competition and sluggish cedant demand has resulted in a softening market for reinsurers. In addition, the onslaught of alternative capital, which Fitch views as enduring, leads us to expect that prices will continue to fall, and for terms and conditions to weaken into 2015 across a wider range of business lines.”

Fitch, 2015 Outlook: Global Reinsurance

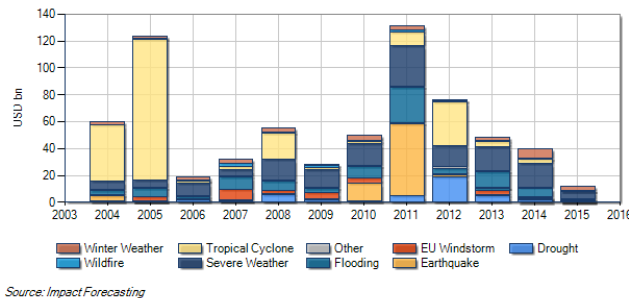


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## ... and no game changing losses.

Global Insured Loss by Peril (Bar Chart)



- Average insured loss circa 60bn USD - USHU normally needed to take a year “above average”, apart from...
- 2011: Thai Flood, New Zealand EQ, Japan EQ & Tsunami
- Charles Goldie, Partner Re: Model bust could potentially change the market

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## What are Cat models...

- Exposure based models simulating the affect of catastrophe perils
- Incorporate data and learnings from the scientific and engineering fields including hydrology, seismology and meteorology
- Allow the incorporation of insurance financial structures (limits, deductibles)
- They generate a “synthetic” or “stochastic” history of events, extrapolating beyond the historical record
- They estimate the risk to an individual location, a policy, or an entire portfolio, bringing in spatial (and temporal) correlation
- They are not perfect!

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## ... and why do we need them?

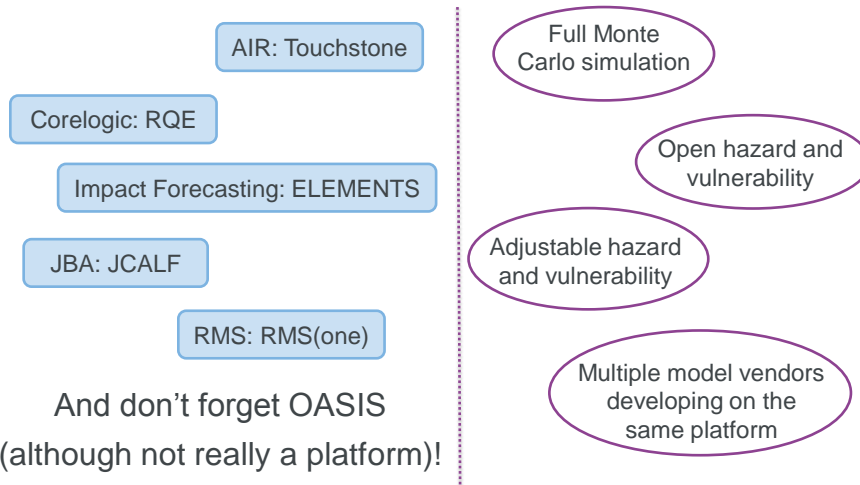
- Insufficient claims experience
  - Less than 10 years fairly common
- Trends invalidating claims experience
  - Climate change
  - Demographic change: change in population, change in wealth, change in location of exposures
  - Inflation
  - Building standard and infrastructure changes (e.g. flood defences)
- They are especially useful for understanding the geographical distribution and the long term levels of risk

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## There are an increasing amount of Cat model platforms...



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## ... and an increasing number of models and vendors.



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## BUT, there are barriers to new platform and model adoption.

- Another IT Project? 😞
  - New servers
  - Cloud hosting? – security checks and data volume throughput
  - System integration (underwriting, pricing, roll-up, reporting)
- Training
- New workflow
  - Getting exposure data into and results out of the model efficiently
- Recalibrating view of risk (including technical price)
  - Increased model validation
- Real world resource constraints

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## How high is the uncertainty in Cat models?

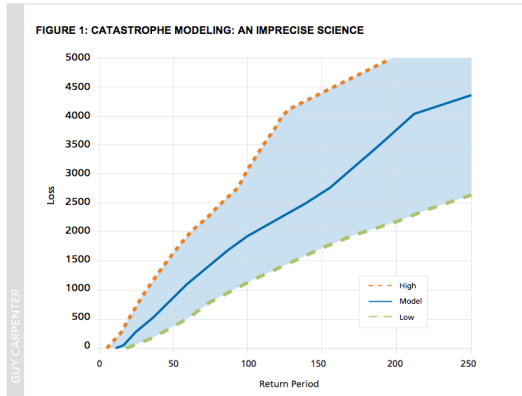
- For an **industry US hurricane** portfolio, how much uncertainty do you think there is in the 100 year return period loss? This is a peril region with 100 year plus record of scientific data, an open data policy, and well recorded industry losses.
- Would the 2 standard error interval be well represented by:
  - A) - 20% to + 20%
  - B) - 30% to + 50%
  - C) - 40% to + 90%

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## Uncertainty in Cat models is high



Geographic Scale	Lower Value of Range	Upper Value of Range
National	60% of PML estimate	190% of PML estimate
State	40% of PML estimate	270% of PML estimate
Localized	25% of PML estimate	430% of PML estimate

- The following remind us of the uncertainty in Cat models:
  - Significant model changes from one version to the next
  - Significant differences between one vendor and another
  - A model poorly representing an actual event
- Not a new topic (e.g. David Miller 1999), but often much overlooked

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## Uncertainty terminology can be confusing

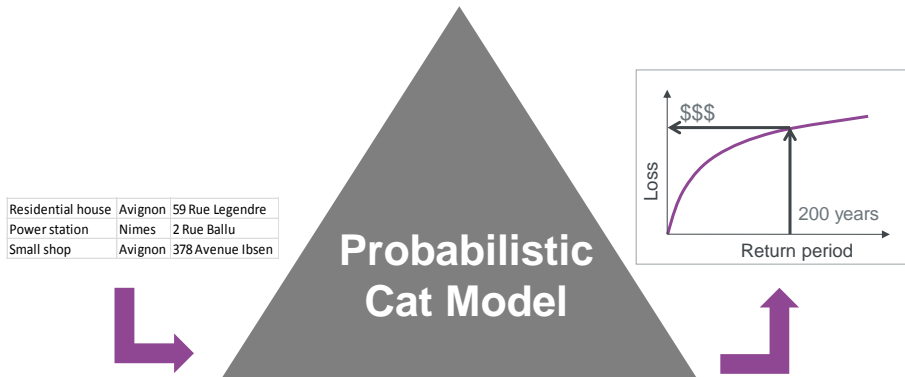
- Scientists
  - **Aleatoric** = *Process*: The irreducible, inherent, randomness in the underlying process
  - **Epistemic** = *Parameter + model*: The uncertainty in modelling that stems from the known incomplete knowledge of the process
  - **Ontological**: The “unknown unknowns”
- Actuaries
  - **Process** = Aleatoric
  - **Parameter**: Even if we understand the process completely the model parameters will not be known with 100% accuracy (*epistemic*)
  - **Model**: Uncertainty from using the incorrect model (*epistemic*)
- Cat vendors
  - **Primary**: The uncertainty associated with the event generation process (includes *aleatoric* and *epistemic*)
  - **Secondary**: The uncertainty associated with the estimation of loss, given that the event has happened (includes *aleatoric* and *epistemic*)

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## Cat model structure

- Cat model = tool to estimate losses to an insured portfolio caused by a natural or man-made peril

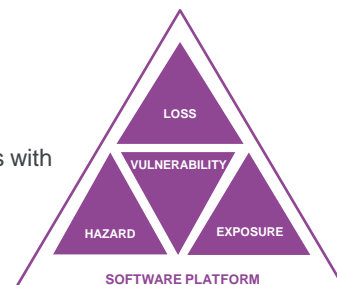


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## Cat model components

- **Hazard** = physically modelled peril
  - Events with defined severity (footprints) and frequency
- **Exposure** = input portfolio handling
  - Classification and localization of the risks
- **Vulnerability** = assessment of the impact
  - Functions to relate exposure characteristics with relative damage given the hazard intensity
- **Loss** = incorporation of policy conditions
  - Application of limits, deductibles and RI



→ **Linked together within a software platform**

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## Most uncertainty is not explicitly represented in most Cat models

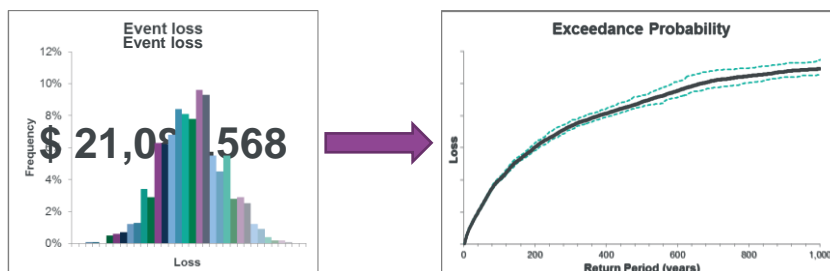
Component	Uncertainty source	Explicitly represented in Cat Model	Comment
HAZARD	The natural process itself	Yes	The purpose of the model (and the reason for insurance)!
	Footprints modelling	Not normally	Uncertainty arises from input data (DTM, gauge data), choice of model (distribution type, GMPE, hydraulic model) and selected parameters or their estimation
	Event set time dependence	Sometimes	Some peril regions have alternative event sets (e.g. near term, warm SST, time dependent earthquake, windstorm clustering)
	Local geophysical conditions (e.g. surface roughness, soil type)	Partly	Some uncertainty represented through the secondary uncertainty
EXPOSURE	Poor quality data and / or geocoding precision	Sometimes	In some models secondary uncertainty increases with unknown data or poor geocoding (location uncertainty)
	Variation in the hazard and location of property within the model grid cell	Partly	In some models explicitly represented, in some models represented through the secondary uncertainty
VULNERABILITY	Damage curve definition	Yes	Secondary uncertainty
	Location / coverage uncertainty correlation	Sometimes	Models often assume 100% coverage correlation and 0% location correlation – but this varies
PLATFORM	Implementation / discretization	No	Should be reduced by proper testing during model development
	Sampling	No	Can be reduced, but only with increased run-times
USER	Insufficient understanding of the model	No	Portfolio data preparation, parameters mapping, model settings, results interpretation

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## Cat model results

- Standard model outputs only provide a limited view on uncertainty (mean + standard deviation)
- Propagation of uncertainty to model results drives the need to get used to new view on model results and how to handle them
- Solvency II pushes model users to understand model uncertainties and incorporate them in the decision making process



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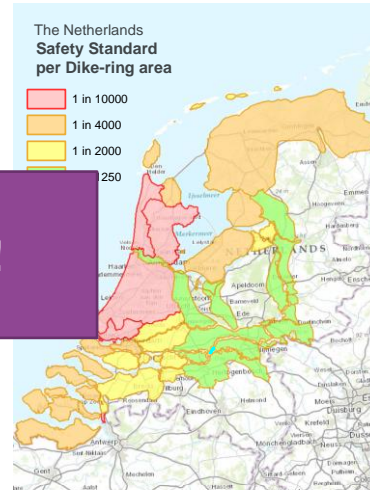
## Uncertainty in the spotlight

Example: Dutch storm surge flood model hazard modelling

- Probability of flooding (per ring): crucial component and a source of uncertainty
  - Dike-ring #1: 1 in 500 years
- Values obtained from expert sources
- Model is developed on assumption

**NO!**

**Is this good enough solution, is the above uncertainty quantified?**



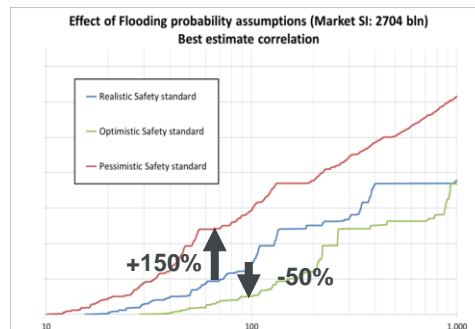
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## Uncertainty in the spotlight

Example: Dutch storm surge flood model hazard modelling

- Local experts provide two additional views on probability of flooding:
  - Option 2: Optimistic
    - Dike-ring #1: 1 in 1,000 years
  - Option 3: Pessimistic
    - Dike-ring #1: 1 in 200 years



**Final solution = implementation of all three options to see the impact on results – how big it may be?**

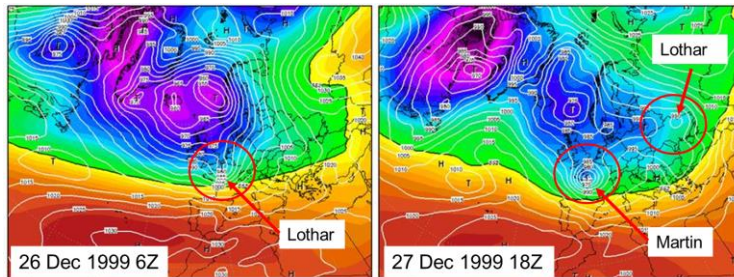
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## Uncertainty in the spotlight

### Example: European windstorm clustering

- Temporal clustering of storms is a complex natural process which cannot be effectively captured with a purely statistical approach
- GCM simulation is a physical reconstruction of a global weather
- Stochastic events extracted from GCM exhibit realistic clustering pattern



### What is the impact of the physically modelled clustering on results?

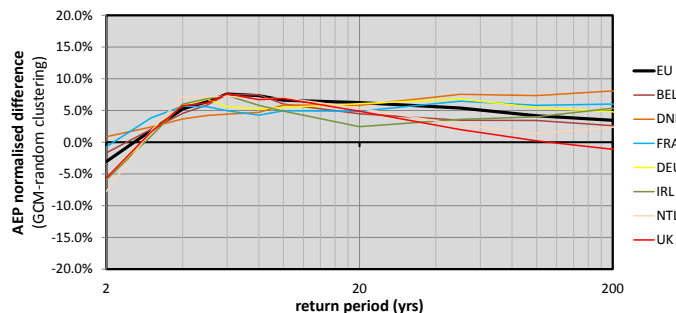
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## Uncertainty in the spotlight

### Example: European windstorm clustering

- Net difference between the GCM based AEP and a randomly clustered (Poisson) AEP
- Positive values indicate that the GCM based AEP is above the Poisson based one (**over-dispersion**)



### Neglecting natural storms clustering can lead to underestimation of AEP

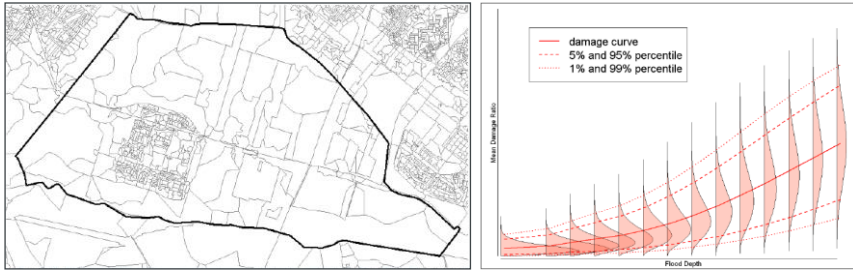
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## Uncertainty in the spotlight

### Example: Secondary uncertainty

- Secondary uncertainty is a widely used term in relation with cat models as it presents the most common implemented uncertainty
- Monte Carlo sampling usually covers
  - Location uncertainty – hazard profiles or location sampling
  - Damage uncertainty – damage ratio defined by mean and stdev



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## Uncertainty in the spotlight

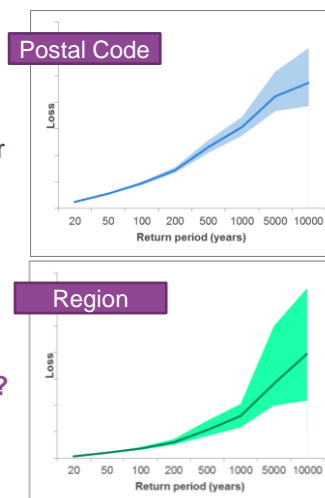
### Example: Secondary uncertainty and geocoding precision

- You run the Czech flood model on Postal code (2667 rows) and Region level (14 rows)
- Only secondary uncertainty, same number of samples used for both analyses
- Results differ and you need to decide which one to trust

Which is which?

What are the reasons for such difference?

- Number of records in the input portfolios
- Geocoding & analysis resolution



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## So why are Cat models used?

- Assessment of impact of perils with lacking record of insurance claims history
- Rating agency and regulatory pressure: focusing on high quantiles (Solvency II - 1 in 200 years) of potential loss distribution
- Comparative analytics: some of the errors / uncertainties will cancel out

**What else can you do?**

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## Do Cat models have any further benefits?

- Help drive improved data capture which is useful for exposure management
- Outputs of Cat models (AALs on grid) can be used as enhanced tools for underwriting
  - Better insight into potential risk than usual flood maps
  - Direct technical premium estimate

**Usage of Cat models can help drive better exposure data capture, leading to improved knowledge of a portfolio**

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## How do we handle Cat model uncertainty?

- Transparency and openness of models, thorough testing
  - Better understanding of the models and their compatibility with your portfolio data
  - Customization of the model components using your claims data and bespoke portfolio characteristics
- Model blending (Calder et al, 2012) – but use with care!
- Reporting that highlights uncertainty to enable an educated interpretation and use of model results: show a range!
- Don't follow the crowd

**The value of uncertainty quantification is in knowing the uncertainty and using this knowledge to support your decisions whatever the goal is.**

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## Uncertainty handling in practice

**Make model developers work harder and ask!**



- Which uncertainties have you identified?
- Which ones have you quantified?
- Why haven't you quantified all identified uncertainties?
- Which ones have you implemented?
- Why haven't you implemented all quantified uncertainties?
- What is the effect of all quantified uncertainties?
- What is the technical solution of implementing different uncertainties?
- Can I quantify these myself for my portfolio?
- Does the platform allow it?

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## Uncertainty Oath of a model developer

- As physicians have the Hippocratic Oath, this is our proposal for model developers' **"Uncertainty Oath"**

*I swear that I will do my best to identify possible uncertainties, quantify the most important ones and show the results of this quantification (in other words the effect of my decisions) to the model users.*

*Where possible I will implement different options into the model so that the user can experience the full scale of results as the nature intended.*

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## Thank you for your attention!

### Questions?

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## Appendix: Impact Forecasting



- **Impact Forecasting (Catastrophe model developers)**
  - Independent, transparent, open, modular and bespoke models
  - Natural and man-made perils
  - Filling the gaps and main perils
  - Global team (~90 people) in London, Prague, Chicago, Singapore and Bangalore
  
- **ELEMENTS (Catastrophe modelling platform)**
  - Runs Impact Forecasting and 3rd party models,
  - Visualisation and reporting of uncertainty & mapping
  - 25 programmers in last 4 years
  - Distributed to and run by re/insurers and Aon Benfield colleagues
  - Integrated with other Aon Benfield tools

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## Appendix: Cat Risk Intelligence



- **Cat Risk Intelligence Ltd**
  - UK based independent consultancy
  - Specialising in helping firms **better understand and manage their Cat risk**
  - Director has 17 years industry experience, including as pricing actuary and “Global Head of Cat” for top 5 insurer
  
- **Specialising in**
  - Strategic development and improvement of Cat teams and processes
  - Solvency II Cat related requirements
  - Portfolio optimisation
  - Cat pricing
  - Developing a view of risk and model validation
  - Training

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## Appendix: Selected references

- **Calder et al (2012)** Catastrophe Model Blending: Techniques and Governance, *GIRO - UK Actuarial Profession*
- **Major J. (2011)** Managing Catastrophe Model Uncertainty: Issues and Challenges. *Guy Carpenter Report*
- **Miller D. (1999)** Uncertainty in Hurricane Risk Modeling and Implications for Securitization, *Casualty Actuarial Society Discussion Paper Program*