Willis Towers Watson challenges for University of Bath SAMBa ITT 2019

Centre for Doctoral Training (CDT) in Statistical Applied Mathematics (SAMBa) Integrated Think Tank (ITT), week commencing 28th Jan 2019

Challenges
1) **Attributing Frequencies to Windstorm Event Scenarios**
2) **Towards Establishing a Volcanic Hazard Index (VHI)**
3) **Machine Learning Approaches to Parametric Insurance Applications**

NB: the highly structured and deliverable-oriented Simplitium /Modex /Oasis challenge on catastrophe model statistical sampling to be dealt with separately with University of Bath.
- o https://oasislmf.org/
- o https://www.simplitium.com/modex

Two books that that may be of general interest are:

Calculating Catastrophe, 2011, Gordon Woo,
Reviews:
https://www.researchgate.net/publication/257393558_Calculating_Catastrophe_by_Gordon_Woo
http://nalag.cs.kuleuven.be/papers/ade/n057/review.pdf

Contents include:

- Natural Hazards
- Societal Hazards
- A Sense of Scale
- A Measure of Uncertainty
- Catastrophe Complexity
- Terrorism
- Forecasting
- Disaster Warning
- Disaster Scenarios
- Catastrophe Cover
- Catastrophe Risk Securitization
- Risk Horizons

The Mathematics of Natural Catastrophes, 1999, Gordon Woo, Imperial College Press
https//www.barnesandnoble.com/w/mathematics-of-natural-catastrophes-gordon-woo/1100237303

1) Attributing Frequencies to Windstorm Event Scenarios

Introduction
See Appendix 1: A Short Introduction to Catastrophe Modelling.

Challenge: How to establish a methodology for assigning a probability of occurrence for hypothetical catastrophes?

Catastrophe models are typically built by deriving a stochastic catalogue of events. These events have a probability of occurrence or return period assigned to them by simply ranking the events by loss and considering the length of the catalogue. Another common tool in the re-insurance industry for assessing potential loss is hypothetical scenarios. For example, altering the track of a historical storm so it hits an area of high exposure (e.g. a city) or increasing the intensity of storm. However, there is no methodology for establishing the probability of these hypothetical events. Such a probability would be an extremely useful metric for the re-insurance industry to assess risk, without the need of building a catastrophe model.

There is a freely available historical tropical cyclone track set – IBTrACS. This is a record of the position and intensity of storms back as far as 1851. Given this historical dataset, is it possible to find the probability of a hypothetical tropical cyclone track? If this were to be possible, can we extend the view past hazard and come up with a way of including exposure data?

Obstacles for this challenge include:
- The probability of the exact track and intensity of any hypothetical storm occurring is extremely small and not particularly helpful. There would probably need to be some way of working out important characteristics then working out the probability of that occurring.
- It is extremely difficult for me to not start thinking in terms of building a catastrophe model as a method of solving the problem, but the whole idea would be to have a more elegant and efficient mathematical solution.

Data
- Tropical cyclone track set – International Best Track Archive for Climate Stewardship (IBTrACS) https://www.ncdc.noaa.gov/ibtracs/
- Example hypothetical tracks and portfolios could be created beforehand, if useful.

References
- "A geostatistical extreme-value framework for fast simulation of natural hazard events", May 2016, Benjamin D. Youngman, David B. Stephenson, Proceedings of the Royal Society, A
- http://rspa.royalsocietypublishing.org/content/472/2189/20150855
- Counterfactual Disaster Risk Analysis: Reimagining history, October 2017, Lloyd's of London https://www.lloyds.com/news-and-risk-insight/press-releases/2017/10/what-if
- A Lloyd's report urges insurers to ask "what if?" Counterfactual risk analysis might improve underwriting, October 2017, The Economist
- Willis Research Network wins Lloyd's Science of Risk Prize, November 2016, https://www.willistowerswatson.com/en/press/2016/11/Willis-Research-Network-wins-Lloyds-science-of-risk-prize

2) Towards Establishing a Volcanic Hazard Index (VHI)

Introduction
Volcanic eruptions are complex phenomena, with multiple ensuing hazards, including pyroclastic flows, lava flows, lahars, ash clouds, and other explosive eruptive deposits. Due to the variable hazards and impacts that can occur alone, or more often together, analysing volcanic risk and insuring communities, businesses and governments has been challenging.

Understanding the potential evolution of a volcanic crisis is crucial for designing effective mitigation strategies. This is especially the case for volcanoes close to densely populated regions, where inappropriate decisions may trigger widespread loss of life, economic disruption, and public distress.

Volcanic unrest is a geophysical process that could last for years with swarms of activity, and not always end up in eruption, making the management of volcanic emergencies very complicated. From a population safety perspective, evacuating thousands and restricting access seems to be the right course of action. But as weeks go by, with entire families living in shelters, people's frustration grows, making the crisis management more challenging. For this, decision makers are under a lot of pressure to successfully provide practical and reassuring solutions. The fate of the population´s economy and population's future weighs heavily on those responsible for managing the volcanic emergency.

An outstanding goal for improving the management of volcanic crises, therefore, is to develop objective, real-time approaches to help decision makers and vulnerable communities manage the unfolding of this extreme event risks.

Volcanic Explosivity Index (VEI)
The Volcanic Explosivity Index (VEI) was developed by Newhall and Self in 1982 as the core to an index which acts as a substitute for assessment of impact and loss from volcanic eruptions. VEI is used to measure the size of explosive eruptions, with indices running from 0 to 8, and it is a relative measure commonly based on the volume of material erupted, to what height, and for how long. When volume data are lacking, the height of the eruption column is used to designate VEI. A relationship between VEI and fatalities has been established.

However, VEI has some significant limitations because it is only a measure of the size of explosive eruptions. It does not include lava and lahar hazards, which can be significant causes of impact and loss. In addition, VEI mixes magnitude and intensity of eruptions by including column height as a way of estimating VEI in the absence of volume data. Column height scales with eruption intensity rather than magnitude and these two parameters are not simply correlated. Further, eruptions with the same VEI can lead to very different levels of damage and loss even at the same volcano (e.g. pyroclastic flows down an unpopulated flank vs a populated flank).

These shortcomings highlight the need for developing a more comprehensive Volcanic Hazard Index (VHI) as a better proxy for impact and loss, which might combine variables including VEI, type of volcanic product (pyroclastic flow, lahar, tephra fall, lava flow, etc.) and physical and topographic characteristics of the volcano. Could such a hybrid index underpin a post-eruption parametric product proxying impact and loss?

Modelling Loss Approach - Hazard Footprint
A footprint-based approach to capture the spatial extent of different volcanic hazards post-event could also be attempted, which is akin to the use of windstorm or earthquake shaking footprints in conventional parametric models, which are then superimposed on 'locked' exposure and vulnerability modules to generate impact and, ultimately, financial loss.
Hazards fall into two groups;:

1. Flow hazards
   - pyroclastic and lava flows and lahars
2. Fall hazards
   - proximal fallout of large tephra in potential great thicknesses, more distal finer-grained and thinner ash deposits

Both can be modelled in advance to build a set of scenarios for a given volcano or volcanic type and, ultimately, a stochastic catalogue of hazard footprints, and both can be measured or mapped quickly after an event through either remote sensing (for flow footprints) or through modelling (for tephra footprint and thickness).

For tephra fall, area covered and thickness / loading are the key parameters, with relationships between these and damage to buildings, impact on crops and effect on airports and aircraft (a major area of potential loss) reasonably well established. For flow hazards, it is reasonable to assume complete damage and loss for anything within a flow footprint, so mapping the footprint onto exposure value will enable evaluation of the loss.

A 'modelled loss' approach to a post-eruption parametric product appears to have potential, although we recognise the need to take a generic approach to the development of a product concept and supporting stochastic modelling framework, to ensure that it is deployable across a range of volcano and socio-economic settings as opposed to needing to be bespoke for every volcano, which would likely not be viable.

A Parametric Approach to Volcanic Risk
A parametric solution to transfer volcanic risk and pre-position finance to fund post-eruption activities, such as immediate response and recovery, will require the following:
   o Identify and define parametric indices that best have the potential to capture the relationship between the hazard and the impact (ultimately the financial impact). That is, the relationship between volcanic activity and, for example, immediate response / recovery cost (noting that there is flexibility in parametric insurance to put a 'cost' on impacts in different ways, from pure asset damage (used for tropical cyclone and earthquake policies by the Caribbean Catastrophe Risk Insurance Facility (CCRIF), scaled to government portion) through broadly defined emergency response costs (used by Pacific Catastrophe Risk Insurance Company (PCRIC)) to a per-person cost of meeting short- to medium-term need (used by Africa Risk Capacity (ARC)).
   o Historic values of the indices, and a model of possible future scenarios for underwriting (pricing) purposes. Documented history provides only a partial guide to the future, with incompleteness and possible biases that will need correcting using statistical methods.
   o A robust definition of the conditions under which the insurance contract operates. This will typically include a definition of:
      o the location within which the event needs to occur for the index to be valid (i.e. named volcanoes, or defined region of volcanoes, or entire country);
      o the physical characteristics that form the index. For example, the VEI or hazard footprint(s) of a given eruption;
      o financial structure of the insurance product, which identifies the relationship between the index and financial pay-outs, including attachment and exhaustion levels and scaling factor; and
      o a policy period during which the event must occur.
   o The agreement of a calculation agent, which is an independent provider of data to populate the index (i.e. the data upon which the occurrence and value of a claim will be calculated).
   o An exact definition of how the pay-out is calculated and how it will be paid.

Significant innovation is required because volcanic eruptions can generate several different kinds of hazard which lead to very different kinds of impact and losses. Thus, impact and loss is not simply related to eruption size. Major hazards include pyroclastic flows, lahars and lava flows, as well as tephra fall and acid rain, which can affect places a long way from the volcano. While tephra fall and acid rain hazard and associated losses are strongly affected by the wind, eruption intensity (through column height) and magnitude, pyroclastic flows, lahars and lava flows are controlled by factors like vent location and volcano topography in addition to eruption intensity and magnitude. Lahar hazard is not simply related to eruption size, and may be triggered by meteorological events or other factors (e.g. overflow of a crater lake) and can continue for years or even decades after an eruption. No single index yet exists to comprehensively take account of the multi-hazards nature of volcanic eruptions and which might therefore act as the starting point for forming a proxy for impact and loss.

Challenge: How could a Volcanic Hazard Index (VHI) be established that could support a parametric index product to capture the impacts of eruptions?

The development of a VHI would combine:
- VEI
- Type of volcanic product (i.e. pyrocrlastic flow, lahar, tephra fall, lava flow, etc.)
- Physical characteristics of the volcano
- Topographic characteristics of the volcano
- Modification by volcano Population Exposure Index (PEI) in order to form a proxy for cost / loss
- VHI scaling by public infrastructure in proximity to volcano?
- Historical record assembled for specific volcanos with robust monitoring?
  - Documented history provides only a partial guide to the future, with incompleteness and possible biases that will need correcting using statistical methods
    - could be fully stochastic or based on scenarios?

How could detailed learning from well-studied volcanoes be applied to situations of data scarcity? This question applies particularly for hazard footprint modelling, as described above.

Data
TBA
- VEI/PEI data
- Evacuation Database
- Volcanoes of Concern
- Real-time Earth Observation data

References
- Monitoring the world's forgotten volcanoes from space
  http://www.bristol.ac.uk/research/impact/monitoring-volcanoes/
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- Fearnley C, McGuire W, Davies G, Twigg J (2012) Standardisation of the USGS volcano alert level system (VALs): analysis and ramifications. Bull Volcanol 74 (9):2023–2036.
- Winson A, Costa F, Newhall C, Woo G (2014) An analysis of the issuance of volcanic alert levels during volcanic crises. Journal of Applied Volcanology 3:14.

3) Machine Learning Approaches to Parametric Insurance Applications

Introduction
See Appendix 2: A Short Introduction to Parametric (Index-Based) Insurance.

Case study 1:

Population growth, rapid urbanisation and growing economic activity are significantly growing demand for water, whilst ecosystem losses and climate change impacts are further stressing supplies. Water scarcity is becoming a significant threat to lives and livelihoods.

New forms of insurance and related disaster risk financing tools, such as parametrics, may enable international relief agencies, development organisations, governments and civil society to take proactive action. Predictive alerts and near-real time data analysis could provide these actors with the information to alerts for activities which prevent initial water stress from potentially cascading into large scale catastrophes.

Case study 2:
How to create a 'warm autumn' weather index that correlates well with the observed sales of clothing/fashion retailers? Many of the larger high street merchandising chains blame warm autumns for loss of sales of the winter collection. The challenge has always been to define a warm autumn in a way that correlated with list sales.
- https://www.realbusinessrescue.co.uk/news/warmer-weather-in-autumn-will-badly-affect-retail-sales-warns-brc
- Primark sales hit by warm autumn weather https://www.bbc.co.uk/news/business-43196147
- https://www.telegraph.co.uk/business/2017/11/07/warm-october-leaves-retailers-feeling-weather/
- https://www.independent.co.uk/news/uk/home-news/uk-weather-latest-forecast-rain-hot-weather-met-office-autumn-a8551021.html

Challenge - Case study 1: How can machine learning techniques be applied to inform and develop understanding of the relationship between water stress and societal/political stability which may lead to opportunities for parametric insurance products to mitigate risk?

For this project, the links between water and security need to be better understood analytically, from the investigation of empirical data. Rapid advances in global modelling, big data, and satellite imagery, combined with local knowledge and increasing transparency, should make early warning and analysis of likely water-related societal impacts possible.

Outcomes:
- How can machine learning analytics be applied to combining varied water stress indicators (such as severe drought, shrinking reservoirs, declining crop yields) with country vulnerability indicators (such as per capita GDP, child mortality rate, state fragility index ranking) to forecast likelihood of drought or conflict?
- Can algorithms be reasonably trained on existing conflict database information?
- What is the most reliable configuration of data-sets that presage water scarcity and how reliable is this in probabilistic terms?
- Could predictive analytics based on machine learning algorithms be used to develop a near-real-time early warning system? Possibly identifying the probability of drought and/or conflict.

- o Could such a warning system identify water and security hotspots world-wide, ideally with at least quarterly updating?

Methodologies:
- o What alternative data sources might be available to support such work?
- o How to deal with issues of data bias?
- o How to deal with 'semi-parametric' issues of combining machine learning with more traditional statistical approaches?
- o Do online estimation methods have anything valuable to contribute to this field, perhaps regarding slow-onset events such as drought?

Data

Water stress indicators
- Normalized Difference Vegetation Index (NDVI) & Enhanced Vegetation Index (EVI)
- Water Requirement Satisfaction Index (WRSI)
- The World Resources Institute (WRI) 'Resource Watch' data platform https://resourcewatch.org/data/explore, for example:
  - Average aridity, calculated as the ratio of mean annual precipitation to mean annual potential evapotranspiration (source: CGIAR-CSI)
  - Standardised Precipitation-Evapotranspiration Index (source: CSIC)
  - Groundwater Vulnerability to Floods and Droughts (source: WHYMAP)
  - Global Croplands and Watering Source (source: ICRISAT)
  - Location and temporal distribution of global surface water from 1984 to 2015 (source: EC JRC)
  - Fragile States Index (source: FFP)
  - International Water Event Database (source: OSU)
  - Internal Displacement from Conflict and Natural Disasters (source: IDMC)

Conflict databases
- Armed Conflict Location & Event Data Project (ACLED) data-set
  - o Disaggregated conflict collection with information on the dates, actors, types of violence, locations, and fatalities of all reported political violence and protest events across Africa, South Asia, South East Asia and the Middle East. Political violence and protest includes events that occur within civil wars and periods of instability, public protest and regime breakdown
  - o Updated weekly
  - o Africa records from 1997 to present day
- Uppsala Conflict Data Program (UCDP)

References
- o Chavez and Biffis (2017) Satellite Data and Machine Learning for Weather Risk Management and Food Security. *Risk Analysis*
- o Park et al. (2016) Drought assessment and monitoring through blending of multi-sensor indicies using machine learning approaches for different climate regions. *Agricultural and Forest Meteorology.*
- o Perry (2013) Machine Learning and Conflict Prediction: A Use Case. *Stability: International Journal of Security and Development.*
- o World Economic Forum report 'Harnessing Artificial Intelligence for the Earth', 2018 http://www3.weforum.org/docs/Harnessing_Artificial_Intelligence_for_the_Earth_report_2018.pdf
- o Water, Peace and Security Initiative (WPSI) https://www.un-ihe.org/news/water-peace-and-security-partnership

- o Parametric or Semi-Parametric Models in Survival Analysis?
  https://www.theanalysisfactor.com/parametric-or-semi-parametric-models-in-survival-analysis/
- o Wheatley-Price P, Hutton B, Clemons M. The Mayan Doomsday's effect on survival outcomes in clinical trials. CMAJ. 2012 Dec 11; 184(18): 2021–2022. doi: 10.1503/cmaj.121616
- o Global Partnership for Education, 'Sustaining the Gains – feasibility of risk financing for education' https://www.globalpartnership.org/download/file/fid/58815
- o Wetlands International, 'Outil de Prédiction des Inondations dans la Delta Intérieur du Niger' (OPIDIN), https://www.opidin.org/en/

4) Earthquake: Predicting Aftershock Sequences

Introduction
See Appendix 1: A Short Introduction to Catastrophe Modelling.

Increasing numbers of studies focus on predicting aftershock sequences but this component is not included in any catastrophe modelling application. In other words, the prediction of the main shocks are already considered by catastrophe models yet aftershocks are not included – this is an open area of debate in the industry. A methodology for inclusion used by Willis Re to develop new models or adjust existing ones to take into account the whole earthquake sequence.

Challenge: How could aftershock sequences be (best) incorporated into earthquake catastrophe modelling processes?
- o Develop a methodology to include aftershocks in a stochastic event set.
    - o E.g. for a given mainshock, define what the spatial distribution and the magnitude distribution of the aftershocks are.
    - o There is some literature on different statistical models used for this purpose
        - ▪ References available
- o Define the magnitude and the location of all M3+ aftershocks produced by ~5 idealised earthquake scenarios

Data
TBA

- o Catastrophe model stochastic event sets
- o Historical seismic data catalogues for mainshocks and aftershocks

References
https://www.rms.com/blog/2014/09/08/understanding-aftershock-risk-the-10th-u-s-national-conference-on-earthquake-engineering/

https://www.air-worldwide.com/Blog/Opportunities-and-Challenges-in-Modeling-Earthquake-Aftershocks/

Appendix 1: A Short Introduction to Catastrophe Modelling

Catastrophe' (cat) models have become the analytical backbone of natural hazards analytics of extreme events for the re/insurance industry over the past 30 years, prompted by events such as Hurricane Andrew (1992) . A quantitative revolution in risk management was triggered across the insurance industry, based on modelling the three components of risk: hazard, exposure (portfolios of asset values) and the vulnerability of the latter to the former.

Catastrophe modelling framework

The 'Gearbox': Catastrophe Modelling - The common currency of physical risk communication
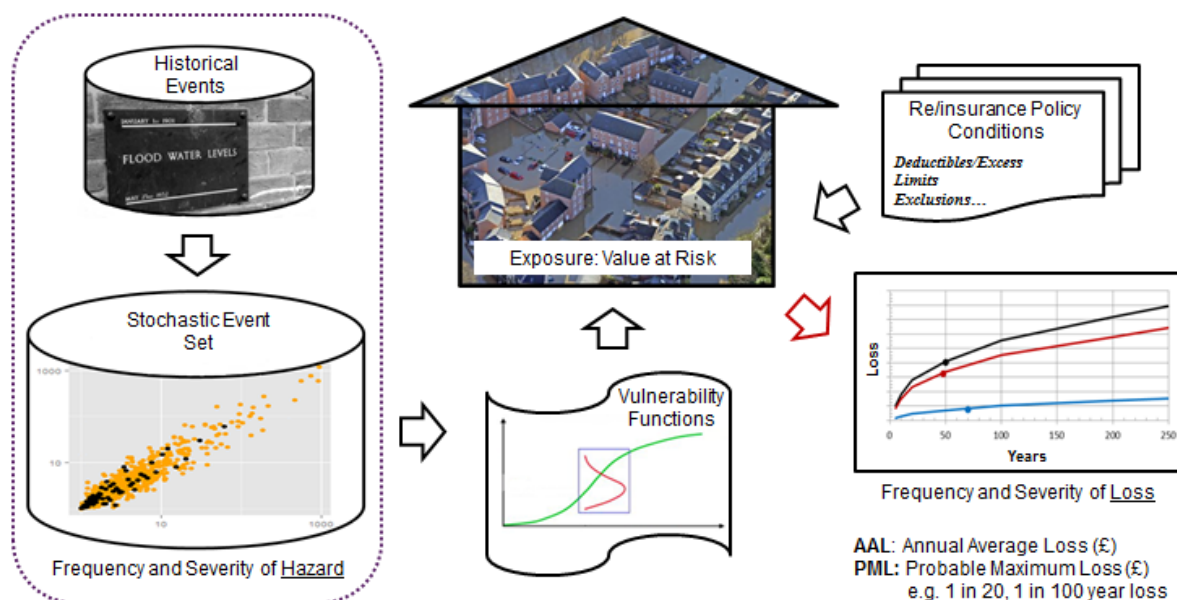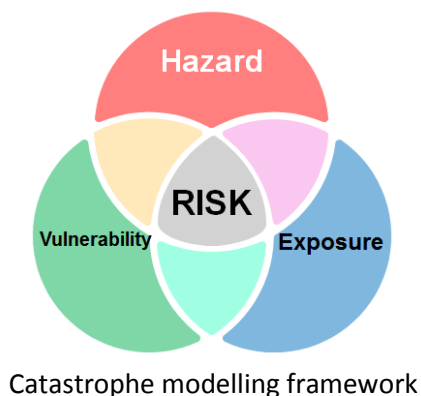
Unique and challenging dimensions of these catastrophe models include:
1. Spatial extent: national (and increasingly international) portfolios of insured assets (usually domestic, commercial/industrial and agricultural buildings, contents and business interruption policies) had to be considered. Hazard coverage much also match such demanding model domains, beyond individual river catchment or city-based studies, for example.
2. Location of value at risk: insurance company data capture has improved in terms of both completeness and resolution, such as from postcode level to individual latitude, longitude geo-location.
3. Limited historical record of hazard: unlike motor or health claims, which generate large volumes of data for statistical analysis, data-sets of windstorm, earthquake or flood activity are relatively short in timescale (e.g. 50 to 100 years), particularly when compared to rare but devastating events. Statistical (e.g. Monte Carlo simulations) and physical modelling (e.g.

numerical weather prediction, NWP) have been employed to effectively generate catalogues of many thousands of years of 'synthetic' events.

4. Event-by-event analysis: unlike many aggregate risk assessment approaches (such as seismic hazard mapping of return period flood outlines), catastrophe models must consider each individual intensity footprint of a windstorm, flood envelope or earthquake and match this to both the specific geographical distribution of an insured portfolio and the event-based policy wordings for deductibles and limits.

Communication of model results is expressed as 'return periods of loss', the inverse which is the more technically familiar 'exceedance probability'. For example, a 1 in 200 year loss, which has become a benchmark solvency metric across European insurance regulation, has a 0.5% (1/200) probability of occurring in any given year.
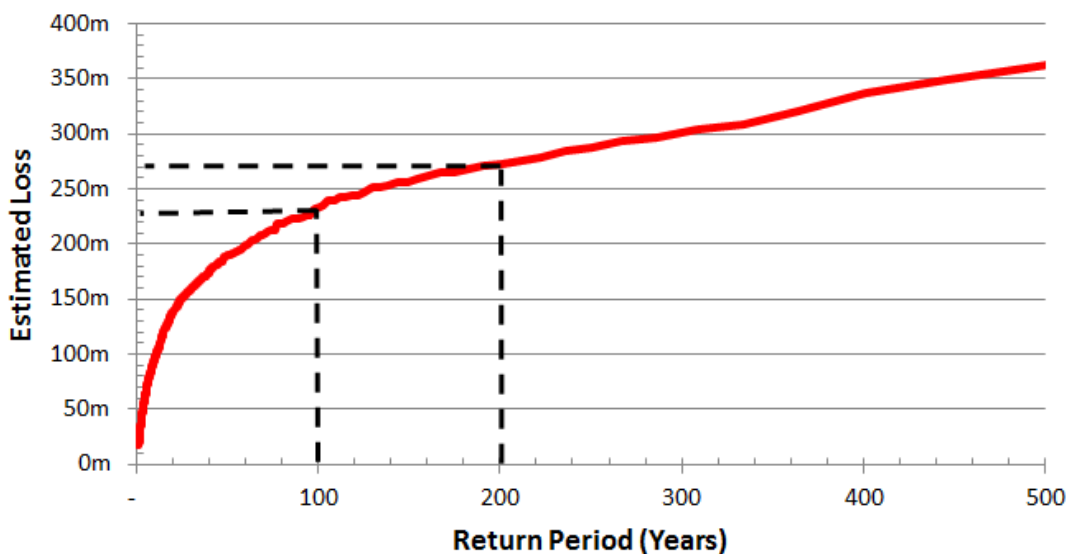
Catastrophe model loss metric: exceedance probability curve

General References

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Blackett review: Review of UK computational modelling capabilities, February 2018.
https://www.gov.uk/government/publications/computational-modelling-blackett-review

Global Assessment Report on Disaster Risk Reduction 2015, United Nations Office for Disaster Risk Reduction https://www.preventionweb.net/english/hyogo/gar/2015/en/home/index.html
https://www.unisdr.org/we/inform/publications/53086

Catastrophe Modelling

Catastrophe Modeling: A New Approach to Managing Risk, 2005, Editors: Grossi, Patricia, Kunreuther, Howard (Eds.)
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http://knowledge.wharton.upenn.edu/article/catastrophe-modeling-a-new-approach-to-managing-risk/

RMS: A guide to Catastrophe Modelling, 2008. http://forms2.rms.com/rs/729-DJX-565/images/rms_guide_catastrophe_modeling_2008.pdf

Catastrophe Modelling Guidance for Non-Catastrophe Modellers, June 2013
http://www.lmalloyds.com/CMDownload.aspx?ContentKey=5f8ba7c4-40f9-4e94-b212-f039f24fe761&ContentItemKey=894a1f1e-fff7-4940-9f61-441b309e1a73

Understanding Uncertainty in Catastrophe Modelling For Non-Catastrophe Modellers
http://www.lmalloyds.com/AsiCommon/Controls/BSA/Downloader.aspx?iDocumentStorageKey=cc44f6be-b83f-4cf9-903c-e802c1f312a8&iFileTypeCode=PDF&iFileName=Understanding%20uncertainty%20in%20cat%20modelling%20for%20non-cat%20modellers

Non-modelled risks: A guide to more complete catastrophe risk assessment for (re)insurers, April 2014.
https://www.abi.org.uk/globalassets/sitecore/files/documents/publications/public/2014/prudential-regulation/nonmodelled-risks-a-guide-to-more-complete-catastrophe-risk-assessment-for-reinsurers.pdf

Actuarial approaches to catastrophe loss modelling

A Study of the Loss Distribution of Natural Disasters in Norway, 2016, Department of Mathematics, University of Oslo
https://www.duo.uio.no/bitstream/handle/10852/52885/oppginnlev-b59b778d-33b0-4496-ad3b-5d2354eb131bYueXuThesis.pdf?sequence=11

Simplitium
The Catastrophe Risk Modelling Market: From Laggards to Leaders, September 2018
https://www.simplitium.com/news/new-whitepaper-explores-risk-modelling-and-market-barriers

Appendix 2: A Short Introduction to Parametric (Index-Based) Insurance

Traditional 'indemnity' insurance works by a premium being paid in return for a promise to cover the actual loss incurred of an incident or named peril. Payment is made only after an actual loss assessment and investigation, with the goal to put the insured back in the position they were prior to the event.

A parametric (or index-based) solution is a type of insurance that covers the probability of a predefined event happening instead of indemnifying actual loss incurred. It is an agreement to make a payment upon the occurrence of a triggering event, and as such is detached of an underlying physical asset or piece of infrastructure.

Parametric products, which are a relatively new market innovation, allow clients to insure risks that are difficult or even impossible, to insure in the mass market. A complex insurance claim on a traditional indemnity policy can take a long time to adjust and be paid out. However, the clarity around parametric policies means claims are resolved much faster and without dispute; thus the liquidity risk of a traditional insurance contract is mitigated.

	Traditional insurance	Parametric solutions
Payment trigger	Payment triggered by actual loss of or damage to a physical asset. *For example, a fire causing physical damage to your property resulting in a physical damage and business interruption loss.*	Payment triggered by event occurrence exceeding parametric threshold. *For example, an earthquake of minimum magnitude of 7.0 within a defined area.*
Recovery	Reimbursement of actual loss sustained. *For example, the assessment and claims investigation of actual loss sustained due to a fire.*	Pre-agreed payment structure based on event parameter or index value. *For example, increasing pay-out amounts with increasing earthquake magnitude.*
Basis risk	Policy conditions, deductibles and exclusions. *Traditional policies often include significant deductibles and exclusions, which are an efficient instrument in conventional covers to align the interests of the insured and the insurer.* *This can however leave the insured party with a significant amount of retained risk.*	Correlation of chosen index, the pay-out, and the loss sustained. ***What is basis risk?*** *Basis risk is the risk that the trigger index does not perfectly correlate with the underlying risk exposure resulting in the client suffering a loss but the parametric insurance not being triggered.* *Whilst basis risk can never be fully eliminated when it comes to index based insurance, it can minimized by more sophisticated structures such as double trigger events or staggered pay-out structures.*

Parametric insurance products are particularly relevant to weather-related applications in industrialised and low income economies, for both acute (e.g. tropical cyclones, earthquake) and chronic (e.g. heat wave, drought) risks. Index data for physical measurements, such as rainfall, collected at local weather stations or by satellite, rather than based on a consequence of weather,

such as a farmer's crop yield. This subtle distinction resolves a number of fundamental problems that makes traditional insurance unworkable in rural parts of developing countries.

Insurance is important for international development because uninsured losses lock vulnerable populations in a vicious cycle of destitution. Agricultural insurance and disaster insurance are either unavailable or prohibitively expensive in many developing countries. Combined with broader risk management solution, parametric index insurance can be an appropriate solution to overcome these obstacles.

There is talk of using a parametric product to decentralize insurance by employing blockchain technology. Such a decentralized insurance product removes the need for an insurer to underwrite and process claims. Furthermore, utilizing blockchain and smart contracts for parametric insurance can provide a level of transparency and trust to the insured.

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https://corporatesolutions.swissre.com/insights/knowledge/what_is_parametric_insurance.html
https://corporatesolutions.swissre.com/insights/knowledge/10_myths_about_parametric_insurance.html
https://www.captive.com/news/2018/07/09/parametric-insurance-new-spin-old-product
https://www.wfp.org/report/weather-index-insurance
http://wiiedu.iri.columbia.edu/materials/updated_educationalMat/html/whatisindexinsurance/weather/weatherindexinsurance_en.html

Appendix 3: University of Bath participants in introductory Willis Towers Watson meeting, 23rd October, 2019

- Professor Andreas Kyprianou
    - SAMBa co-director
    - https://researchportal.bath.ac.uk/en/persons/andreas-kyprianou
- Dr Susie Douglas
    - SAMBa centre manager
- Dr Alex Cox
    - SAMBa academic lead
    - https://researchportal.bath.ac.uk/en/persons/alex-cox
- Dr Simon Shaw
    - https://researchportal.bath.ac.uk/en/persons/simon-shaw
- Dr Matt Nunes
    - https://www.scopus.com/authid/detail.uri?authorId=13606213400
- Elizabeth Gray
    - 3rd year SAMBa student
- Tom Davies
    - 1st year SAMBa student
- Zsofia Talyigas
    - 1st year SAMBa student

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