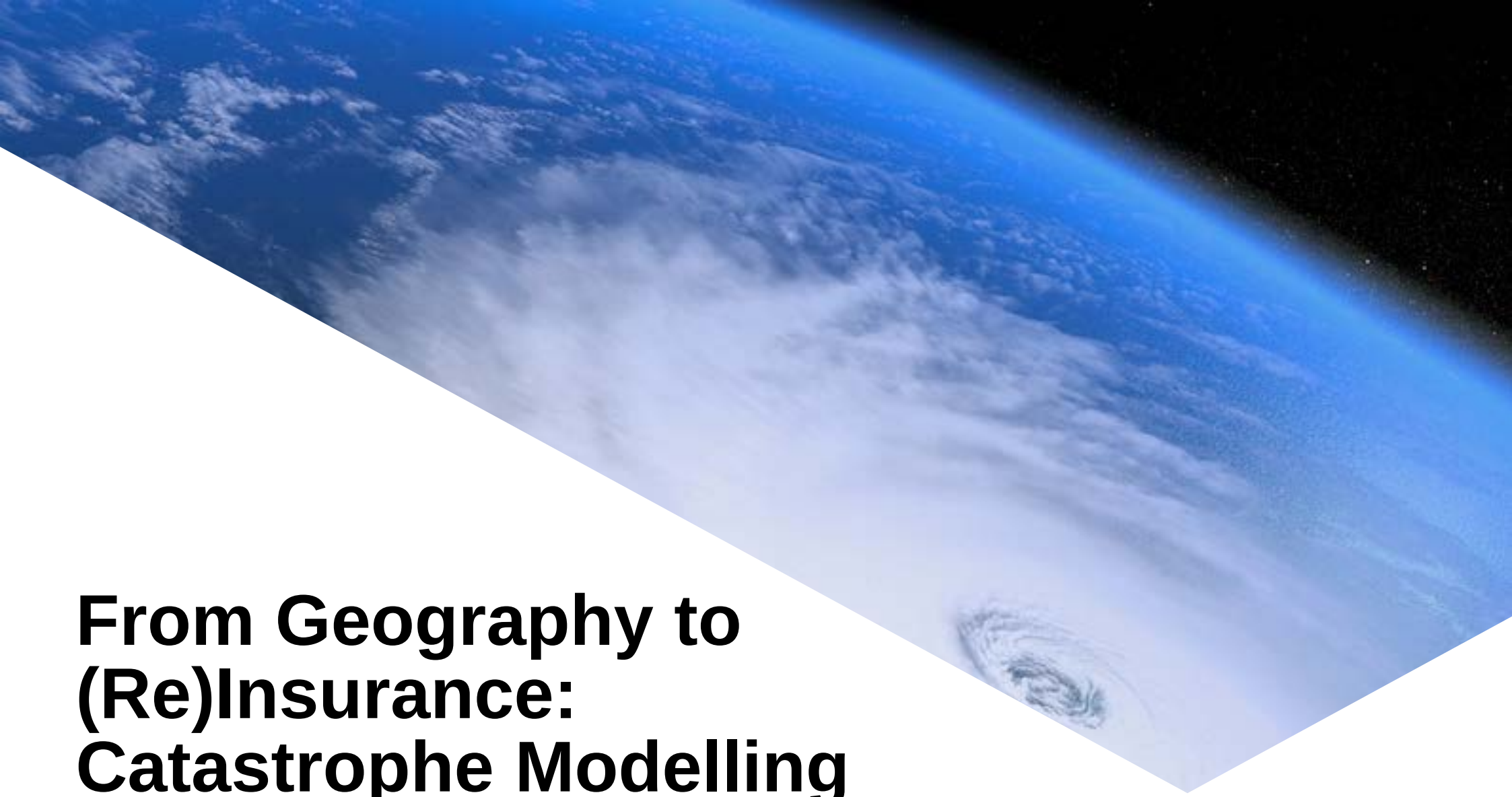

From Geography to (Re)Insurance: Catastrophe Modelling

Presentation for Masaryk University

28th April 2020

Karel Vojak

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Content

Open the link below and watch the short video

Source: https://www.youtube.com/watch?v=2n8kJBcGaTM

Insurance and Reinsurance

Was this gentleman insured?

Insurance

Source: https://www.youtube.com/watch?v=2n8kJBcGaTM

Was the insurance company reinsured – prepared to pay his and all other claims?

Reinsurance

Insurance and Reinsurance

Typical risk transfer: from owner (you) to reinsurance companies

The primary buyer of insurance, insured
- You
- Me
- Tereza
- Viktor
- Marketa
- …

Intermediary between insured owner and insurance company, helping owners with their insurance
- Aon Risk Solutions
- Marsh
- Renomia
- …

Insurer
- Generali
- Kooperativa
- Allianz
- UNIQA
- …

Intermediary between insurance and reinsurance company, helping insurers with their reinsurance
- Aon Reinsurance Solutions
- Guy Carpenter
- Willis Re
- …

Reinsurers
- Swiss Re
- Munich Re
- Scor
- TransRe
- …

Reinsurance = insurer's insurance

Zajištění = pojištění pojišťoven

Why Insurance Company Buys Reinsurance?

To be ready to pay large losses to all clients - owners

Question: Hmm…but I thought insurers have enough money from the premium (pojistné) they get from their clients (owners)?

Answer: Typically an insurance company pays single claims (car accident, family house on fire,…) easily, but sometimes the loss can be so big that the collected premium may not be enough for covering everything.

Q: So what kind of events do insurance companies worry about?

A: Large rare losses. Catastrophes.

Q: What catastrophes?

A: Mainly natural and man-made catastrophes causing large damage and financial losses covered by insurance policies. Natural catastrophes are typically driving the need for reinsurance. After a catastrophe, insurance companies need to pay a lot of money within very short time. If they don't have money to cover the claims, they bankrupt.

Q: Has it really happened that an insurance company bankrupt because of a natural catastrophe?

A: Yes. Unfortunately. Sad example of the insurance industry unpreparedness for large losses was hurricane Andrew in 1992. Several insurance companies went out of business leaving their clients without money. Other insurers went into sever solvency issues as well.

Q: It was a fraud or why insurance companies didn't have enough money?

A: No fraud. They thought this cannot happen. Several decades before Andrew, there was no major hurricane making a landfall and causing such dramatic damage. Almost everybody believed that the worst what can happen is a loss of about 5 billion USD I think. That's what the past insurance data told them. Andrew insured loss was more than 15 billion USD…

Q: So was there any lesson insurance industry learned from that catastrophe?

A: Yes. Andrew was a wake up call for more robust estimations of what can potentially happen and what insurance industry needs to be prepared for. Andrew changed the (re)insurance industry and it was the beginning of real catastrophe modelling.

Q: OK, so insurers buy reinsurance from reinsurers to prevent insolvency after an extreme rare loss. But I still feel that big traditional insurers must have collected a lot of money, so they should need no reinsurance…

A: On long term, you are right. But it is more complex within timescales of few years. There are other lines of business, cost of capital one need to hold, regulation, and many other things. However, the main point is still that reinsurance allows insurers to be ready for a big catastrophe loss.

Q: Reinsurers provide insurance for insurers. So reinsurers must be way bigger companies than insurers?

A: That's not necessary. Typically an insurance company is reinsured by several reinsurers, each participating with some percentage on the deal. The main point of insurance and reinsurance business is diversification. Reinsurers write typically business over the globe, so it is impossible for most natural catastrophe to hit whole earth – whole business of a reinsurer. On the other, many insurance companies are more local and majority of their business can be hit by a hurricane, flood,… Basically the risk transfer throughout the industry from an homeowner to reinsurers includes diversification in each step.

Q: Uff… many thanks

What Are the Main Perils to the Insurance Industry?

Worldwide:

- Hurricanes
- Floods
- Earthquakes (and tsunami)
- EU Windstorms
- Hailstorms
- Tornadoes
- Wildfires
- Terrorism (man-made)

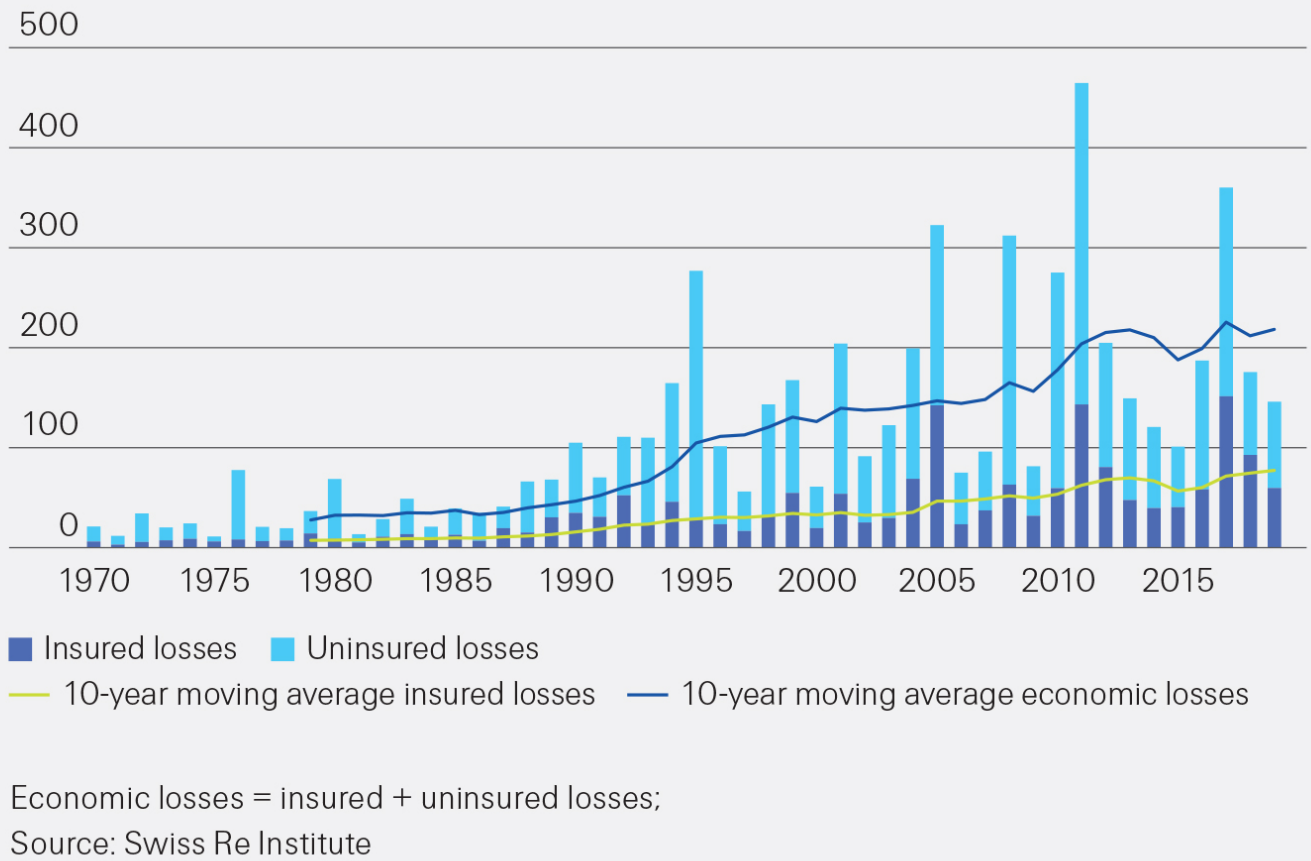
Europewide:

- The continent-wide costliest peril is windstorm, but in some regions it is flood (Central Europe) or earthquake (Italy, Greece,…)

Brief History of Catastrophe Economic Losses

Economic annual losses

Insured vs uninsured losses, 1970–2019 (USD billion, 2019 prices)



Economic losses = insured + uninsured losses;
Source: Swiss Re Institute

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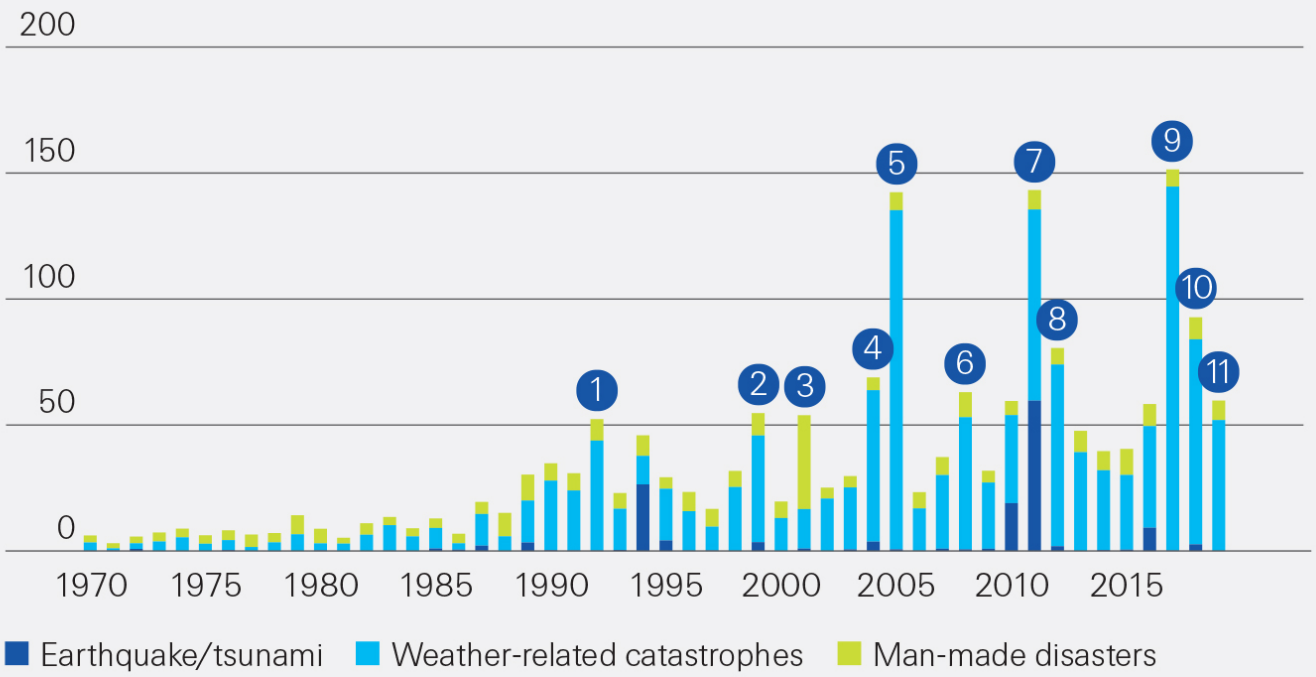
Brief History of Insured Catastrophe Losses

Insured annual losses with notes on selected major disasters driving the total loss that year

Insured catastrophe losses, 1970–2019, in USD billion at 2019 prices

1. Hurricane Andrew
2. Winter Storm Lothar
3. WTC
4. Hurricanes Ivan, Charley, Frances
5. Hurricanes Katrina, Rita, Wilma
6. Hurricanes Ike, Gustav
7. Japan, NZ earthquakes, Thailand flood
8. Hurricane Sandy
9. Hurricanes Harvey, Irma, Maria
10. Camp Fire, Typhoon Jebi
11. Typhoons Hagibis, Faxai



Source: Swiss Re Institute

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What Helps (Re)Insurers to Understand and Manage Catastrophes They May Be Facing In (Near) Future?

Catastrophe Modelling

2

Intro to Catastrophe Modelling

Catastrophe Modelling – What Is It and Why Is It Used?

Catastrophe modelling is the process of using computer-assisted calculations to estimate losses from a catastrophic events.

Catastrophe model is a tool - a software providing information of what financial loss (e.g. EUR) from certain peril (storm, earthquake, flood,…) an insurance company can expect with what probability.

Catastrophe modelling has two main aims in the (re)insurance industry:

- To help understand, **evaluate, and quantify the natural catastrophe exposure and risk faced by a (re)insurance company**

  "*Do I have enough cover?*" *"Jsem dostatečně zajištěn?"* "*What is my 1-in-200 years loss?"* "*What is return period of my largest loss in past?"*
- To **assist** in determining appropriate risk **mitigation strategies**

  "Is my reinsurance structure efficient?" "*Do I get the right price?"*

Why (re)insurance industry use catastrophe models?

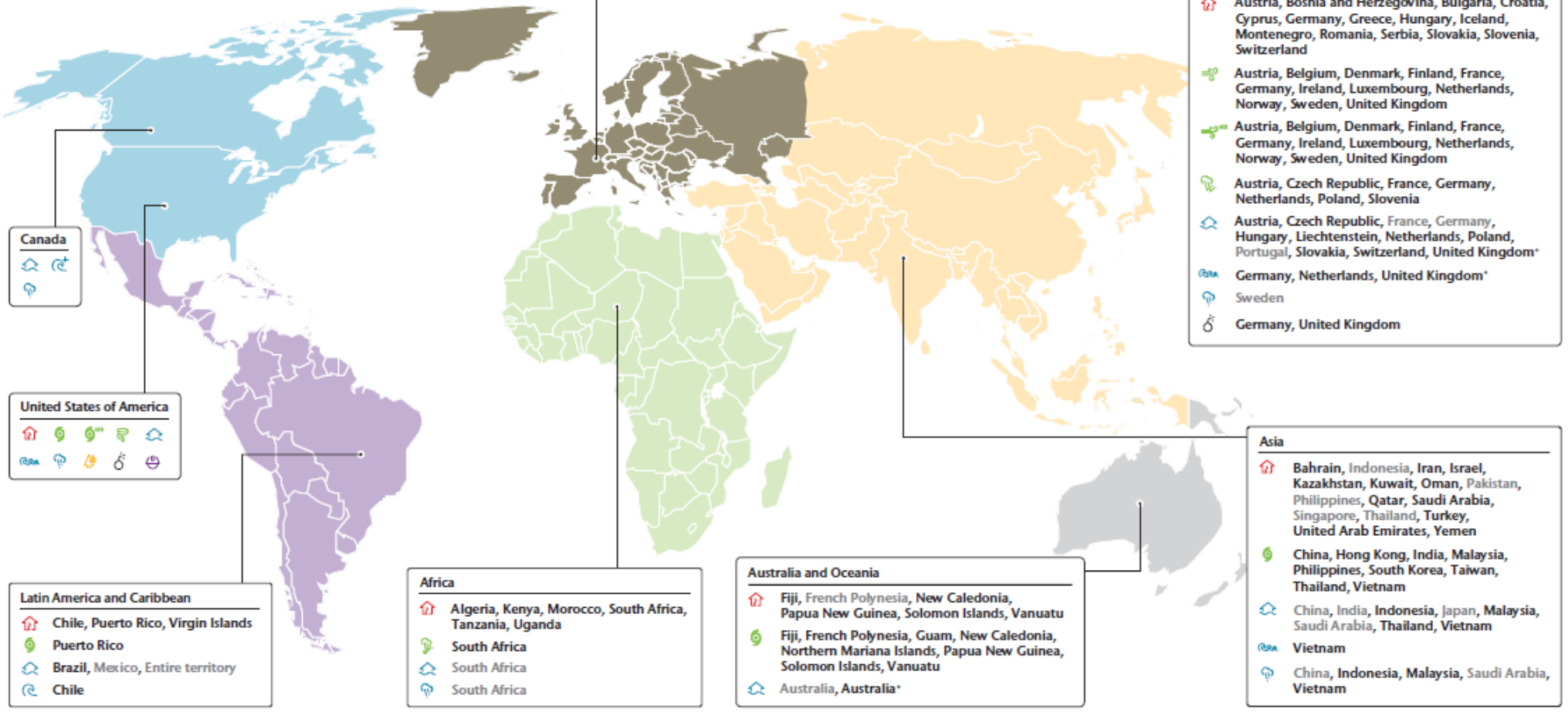
- Statistical methods based on historical data do not provide reliable results when estimating impacts of rare extreme catastrophes. The industry needs better estimations. Examples where pure statistics was not enough:
  - Hurricane Andrew 1992 – (re)insurers believed this was impossible because nothing like that could have been seen in historical insurance loss data over many years prior 1992.
  - Haiti – 6 people died due to earthquakes there between years 1900 and 2009. In January 2010 more than 250000 people died in the earthquake. Did a statistician have a chance to predict such catastrophe?
- **Understanding the physics of natural catastrophes, modelling natural catastrophes from geo-science perspective, and linking this with impact of the catastrophes (engineering and financial perspective) allows for more reliable estimations**
  - First catastrophe (cat) models were developed in late 80's, but there was not much interest in the (re)insurance industry. Cat model results were basically ignored. A cat model estimated that a loss from a hurricane in US can exceed tens of billion USD. (Re)insurers didn't care that time. After hurricane Andrew, it was clear that pure statistics is not enough and that climatology+statistics+claims can provide much better estimations.

→ Because it provides better answers than other methods for estimating impacts of natural catastrophes

What Perils Are Modelled?

Today catastrophe models are available for most perils and regions

Example: Models developed by **Impact Forecasting**



Map Icons

earthquake · tropical cyclone · severe convective storm · windstorm · hail · fluvial flood · storm surge · tsunami · pluvial flood / cloudburst · brushfire · terrorism · workers' compensation

AER Automated Event Response scenario model only

Country + third party models

Main Catastrophe Models Providers

Four main commercial catastrophe model vendors – firms developing and selling catastrophe models

- RMS (Risk Management Solutions)
- World's largest catastrophe modelling company
- Founded in 1988
- Headquartered in San Francisco with several offices around the world
- Clients include 85% of the top 40 global reinsurance companies

- AIR (Applied Insurance Research)
- Part of the Verisk Analytics family of companies, a leading data analytics provider
- Headquartered in Boston with several offices around the world
- Founded in 1987

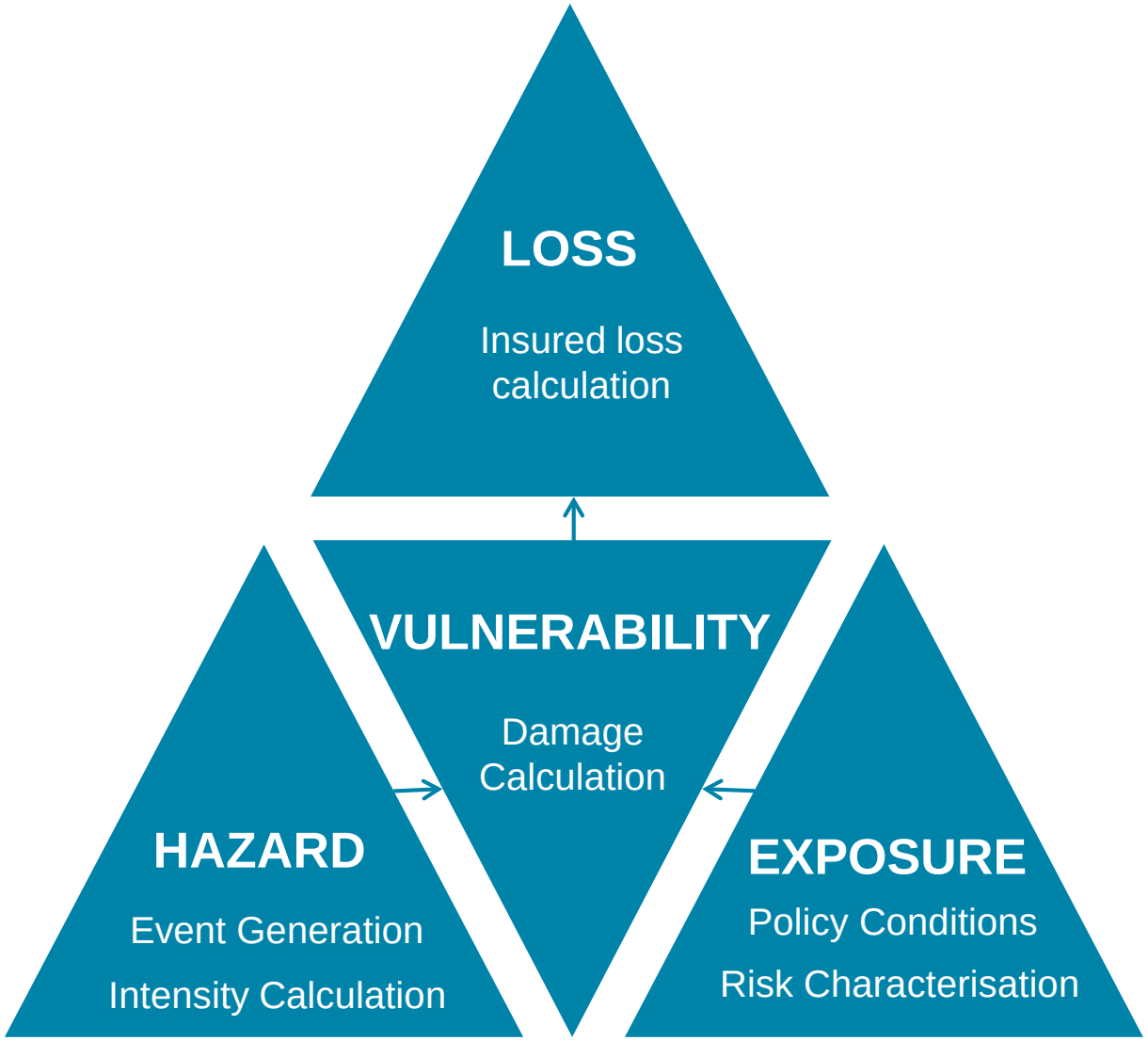
- Previously EQECAT (acquired by CoreLogic in 2013)
- CoreLogic is large data provider as well as analytics services
- EQECAT founded in 1994
- Headquartered in Los Angeles with offices around the world

- Impact Forecasting – Aon catastrophe modelling team
- Founded in 1996
- Models for peak risk zones around the globe, as well as for the emerging markets.
- Headquartered in London with offices around the world including Prague
- Head of Impact Forecasting holds a PhD in Physical Geography from Charles University in Prague

There are also other cat models developed by reinsurers, brokers, smaller modelling firms

How Cat Models Work

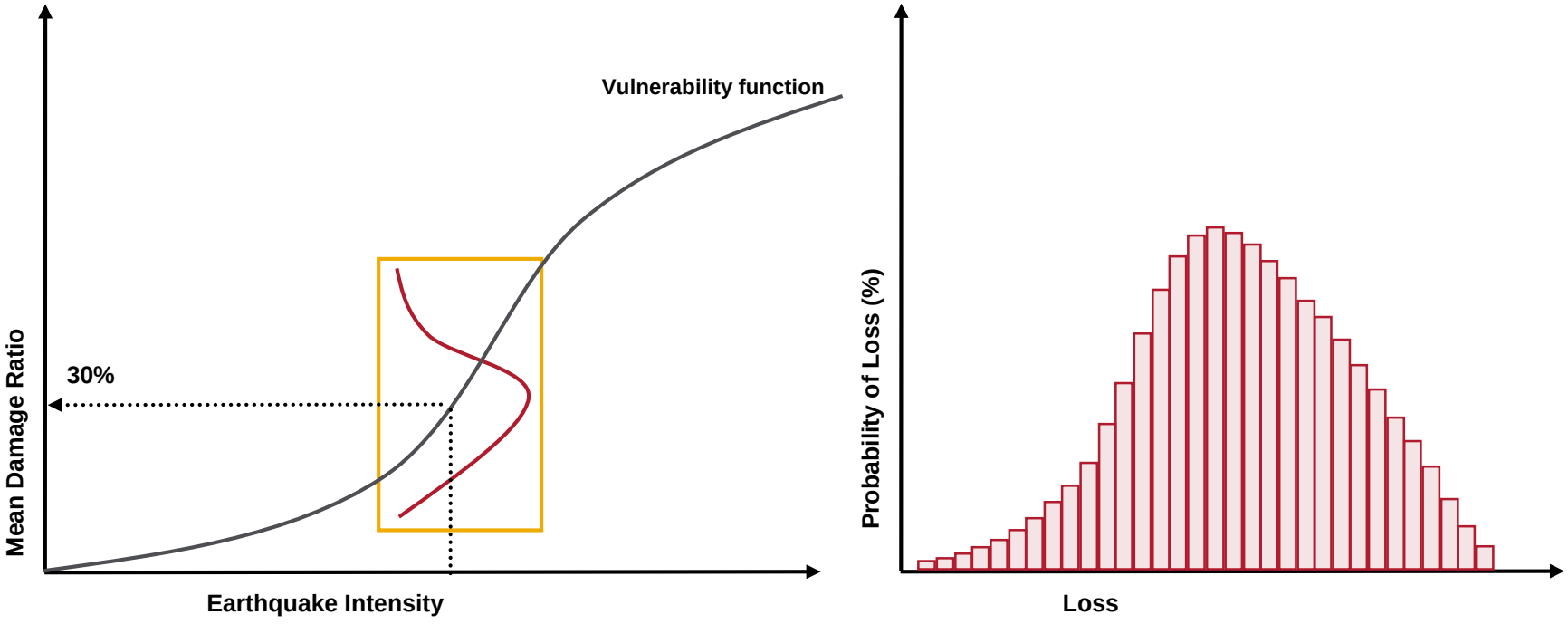
Cat model consists typically of 4 main parts



- EXPOSURE – Insured portfolio; portfolio is a set of buildings (example of portfolio: 1 million residential buildings of various value and with addresses and 10 thousands industrial buildings of various value with addresses in CZ)
  - This an input to catastrophe model
- HAZARD – Simulated thousands of hypothetical – but physically realistic – windstorms (or earthquakes, floods… below windstorm used as an example)
  - Each storm's intensity expressed as wind speed field (footprint, map)
  - Each storm of certain frequency
  - Several methods of generating hypothetical storms exist, including use of reanalyses, global circulation models, mesoscale weather forecast models, records from weather stations, GIS,…
- VULNERABILITY – each storm's intensity translated into damage on the exposure (on each building within a portfolio)
  - The vulnerability part uses functional relationship between wind speed and a damage on a structure
  - Probabilistic approach – uncertainty in the relationship between wind speed and damage considered
- LOSS – Policy conditions covering the insured property applied on the calculated damage and finally:
  - Set of potential losses from each hypothetical storm on a portfolio calculated to "Event Loss Table (ELT)"
  - Final outcomes: Occurrence Exceedance Probability (OEP), Annual Average Loss (AAL)

Probabilistic Approach

- Critical aspect of catastrophe modelling - uncertainties taken into account
- Certain local intensity of a natural catastrophe (wind speed, peak ground acceleration, flood depth, hail size,…) can cause various damage – sometimes nothing happens to a building (0% damage), sometimes a window is broken, sometimes a roof is blown away, sometimes whole building collapses (100% damage)
- Example below – an earthquake of certain intensity causes on average 30% damage on a building (Mean Damage Ratio = 30%) – the left graph. However, this is an average for the given intensity and it could be that the loss can range from 0% to 100% damage and there is typically a distribution around the mean loss allowing for loss calculations with uncertainties considered – the right graph.



Cat Model Inputs

Input – Information about the portfolio – **WHAT** is in the portfolio and **WHERE** it is located

List of insured property (buildings, contents, cars,…)

- Example of a (fictitous) portfolio as input data (exposure) from an insurance company

Policy (pojistka)	Location ID	Country	Postal Code	Address	Occupancy	Construction	Building Value	Deductible (spoluúčast)	Limit
000256	1	CZ	13000	Horní 17	Commercial	Reinforced Concrete	3000000	1900	-
000256	2	CZ	77146	Dolní 6	Residential	Masonry	200000	100	-
000257	3	SK	83104	Střední 127	Industrial	Unknown	2500000	2%	1000000
…	…	…	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…	…	…
0A7763	623991	CZ	26203	Podzemní 64	Residential	Unknown	300000	150	-

Cat Model Outputs

Event Loss Table (ELT)

- Core outcome from cat model and the basis for further analyses and results
- List of all modelled hypothetical events (e.g. thousands of storms) with corresponding losses on a portfolio and including frequency of each storm.
- Example:

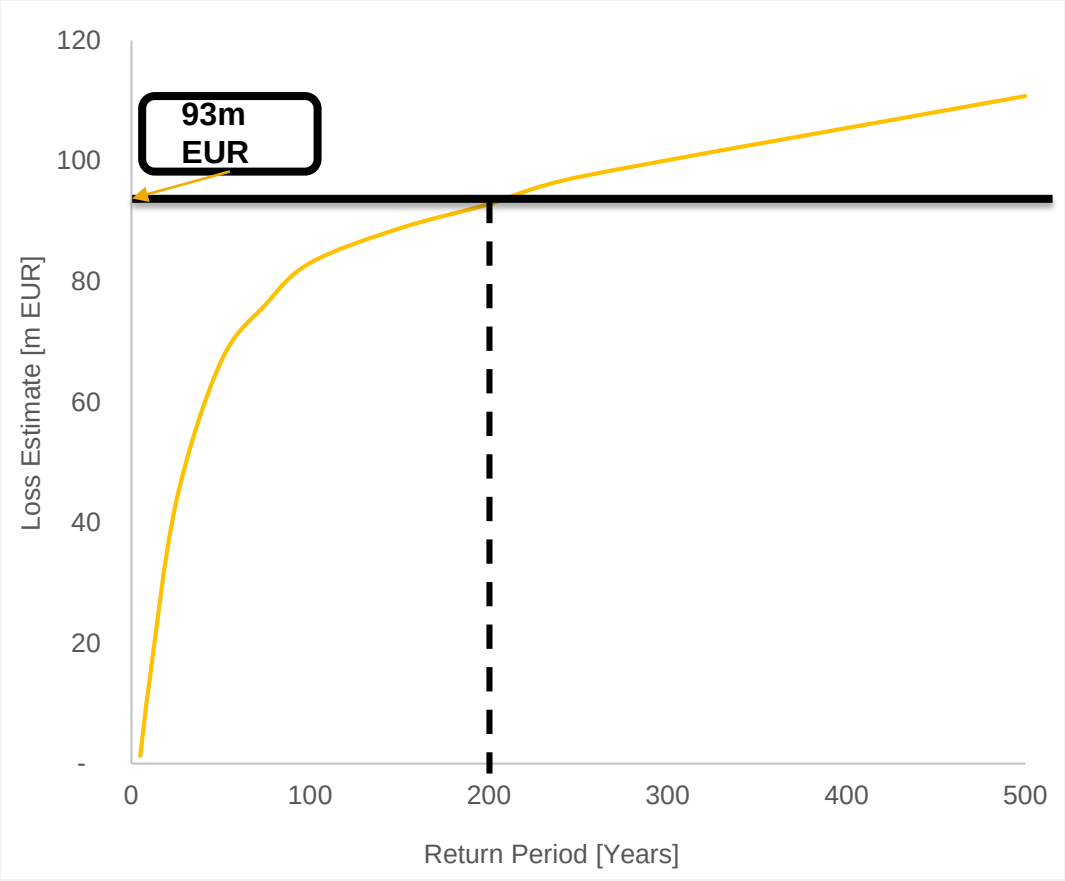
Event ID	Frequency	Mean Loss	Std Dev
1	0.0002298	358,401	252,189
2	0.0001925	1,565,878	840,450
3	0.0002601	1,511,418	814,073
4	0.0001567	45,862,410	9,305,069
5	0.0004021	300,263	218,313
…	…	…	…
…	…	…	…
…	…	…	…
…	…	…	…
18143	0.0001142	167,166	119,497

Annual Average Loss (AAL)

- Calculated from ELT
- Hypothetical long term average of annual loss for a company from the analyzed peril. Example: 10.5 million EUR

Occurrence exceedance probability curve (OEP)

- Calculated from ELT
- Certain loss is exceeded with certain probability (usually expressed as return period). This tell insurers what they need to be prepared for.
- Example below: an insurance company can expect loss of 93 million EUR or more once in 200 years, according to the “yellow” cat model



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Few Notes on EU Windstorm Catastrophe Modelling

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European Windstorm

- The costliest natural peril in Europe
  - Some major historical windstorms: 87J, 1990 storms (Daria, Herta, Vivian, Wiebke), Anatol and Lothar and Martin 1999, Erwin 2005, Kyrill 2007, Klaus 2009, Xynthia 2010, Christian 2013
- European Windstorm = Extratropical cyclone = Winter windstorm
  - Deep low pressure systems typically originating in west Atlantic and travelling towards Europe
  - Sometimes an extratropical cyclone gets very deep and extreme pressure gradients lead to extreme wind speeds
  - Rarely an extreme extratropical cyclone strikes the continent and has disastrous impact in many European countries – large regions can be affected

Orkanen over Danmark klokken 17:49 den 3. december 1999. Data: NOAA / billedbehandling DMI.

Key Challenges – Examples in CZ

Windstorm is a Europe-wide perils affecting mainly western Europe.

However, do you remember major windstorms in the Czech Republic?

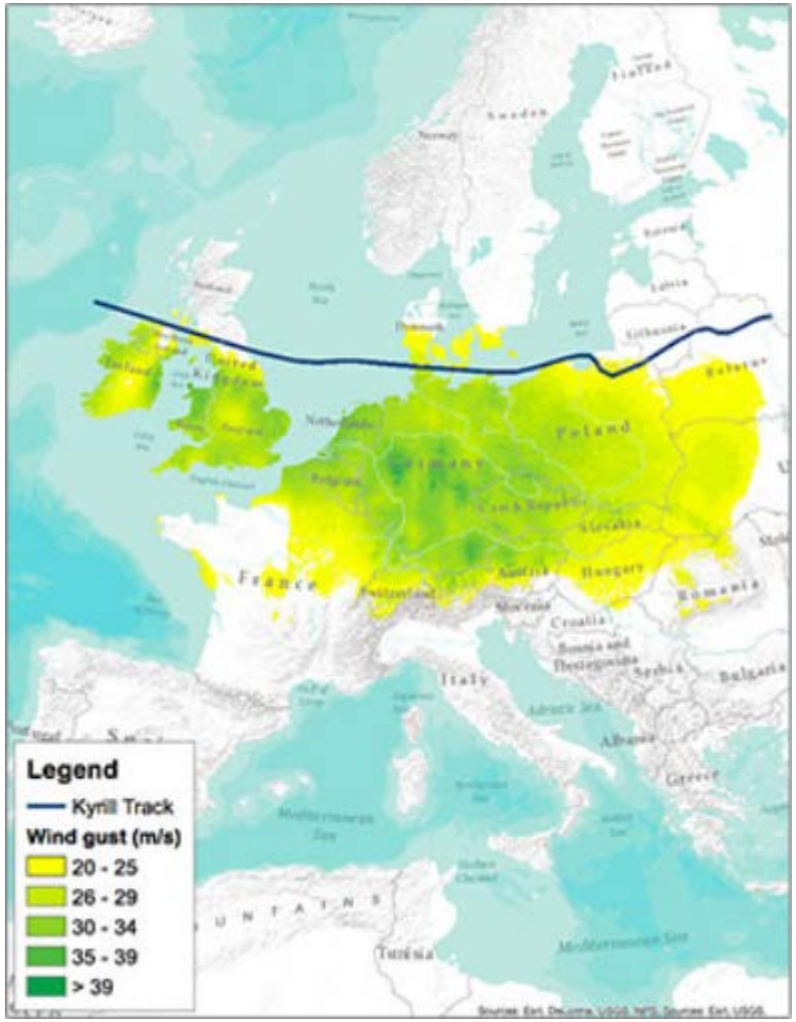
- Kyrill 2007
- Emma 2008
- Herwart 2017
- Sabine 2020

Questions

- How often a storm with “Kyrill” devasting effect hits CZ? What is Kyrill’s return period?
- Can it be worse? What is the worst case windstorm insurance companies need to be prepared for? How much is the windstorm loss of return period 200 years?
- What is the return period of storms with impact similar to Herwart?

How to find answers?

- Limited historical data in CZ covering few decades (insurance losses or reliable wind speed records) do not allow for robust estimations of the biggest extremes
- Cat models help – they include thousands of hypothetical storms to capture windstorm climatology and include extremes never recorded in history
  - Windstorm cat models are based on various sophisticated methods and data such as global circulation models (GCM), reanalyses (e.g. ERA-Interim), specific perturbation and interpolation techniques, etc.
  - Even the models are based on relatively up-to-date science and data, there are limitations (e.g. resolution of reanalyses and RCM); models are not perfect
  - Cat modelling is still “young” discipline. Science drives improvements and critical assessment of current tools. Looking at the topic from various angles is needed. Example: Climate modelling using supercomputers and (vs.) historical climatology



Kyrill footprint – map of maximum wind gusts during the storm. Source: AIR, https://www.air-worldwide.com/blog/posts/2017/1/kyrill-the-winter-storm-that-walloped-most-of-europe/

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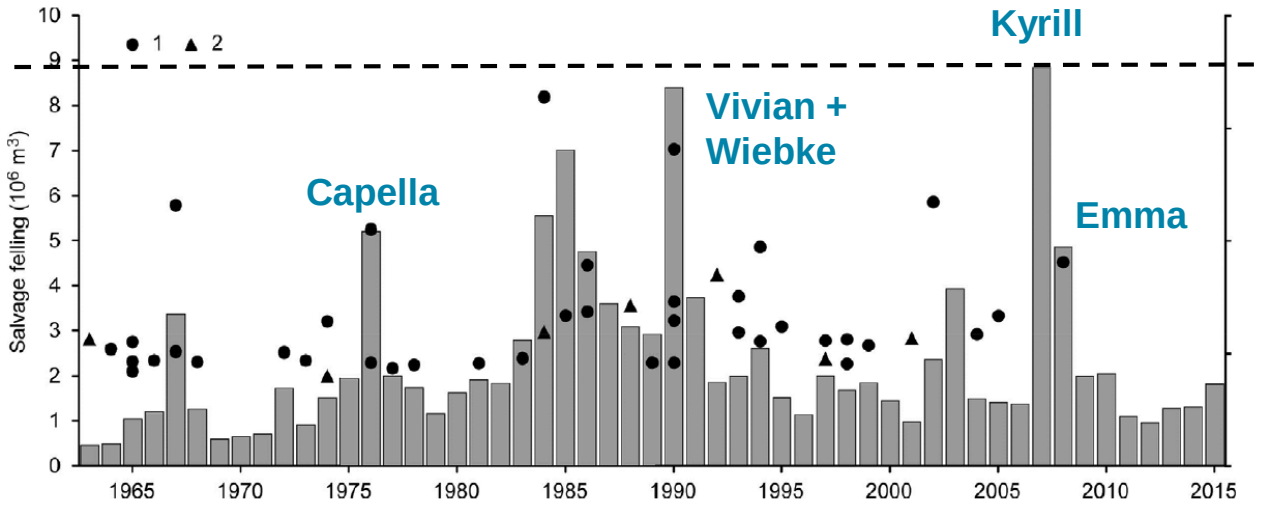
So what is the return period of Kyrill-size loss in CZ?

- Cat model A (primarily based on statistical perturbations of footprints derived from reanalysis) : **X** years
- Cat model B (primarily based GCM simulations, downscaled to finer resolution) : **Y** years

- More recent paper suggests that model A appears too optimistic/pessimistic and model B appears too optimistic/pessimistic
  - Adjustments to model A/B is therefore recommended to better reflect the latest science
  - According to the adjusted model A/B, Kyrill-size windstorm loss in CZ is of return period **Z** years
  - **Z** is the final answer… until better model/approach/findings/data improves this estimate (your turn!)

Example of recent findings with direct impact on catastrophe modelling:



Source: Brazdil R. et al. (2018): Windstorms and forest disturbances in the Czech Lands: 1801-2015. Agricultural and Forest Meteorology. vol. 250-251. p 47-63.

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Comments & Takeaways

Final Comments and Takeaways

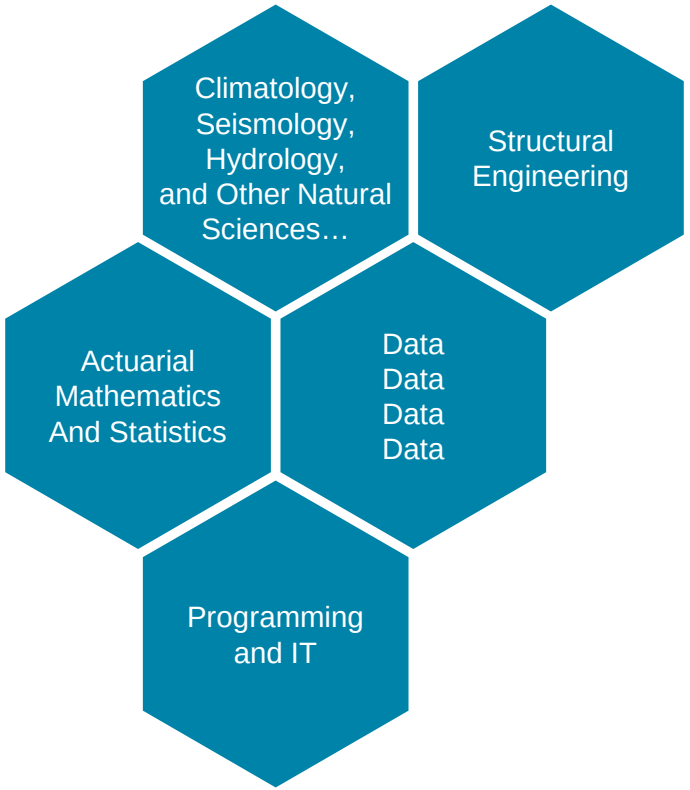
- Cat models are tools to estimate impacts of catastrophes
- Cat models are embedded in the (re)insurance industry
- Cat models are based on knowledge and findings from various disciplines including natural sciences, actuarial mathematics, engineering,…
  - The multi-disciplinary nature together with major role of natural sciences … anyone feels the link with geography?
- Don't forget that "model" is synonym to something imperfect – critical thinking is always an advantage

- From geography to (re)insurance

Question: *Karle, you studied physical geography and now you are pojišťovák. How that happen?*

KV: *Via catastrophe modelling. Catastrophe modelling is the link between (re)insurance and geography.*

Catastrophe modelling is multi-disciplinary



… and requires excellence in each discipline

5

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About Aon

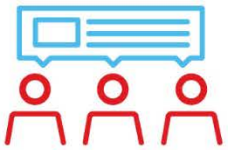
Aon is a leading global professional services firm providing ***advice and solutions in Risk, Retirement and Health*** at a time when those topics have never been more important to the global economy. Aon develops insights – ***driven by data and delivered by experts*** – that reduce the volatility our clients face and help them maximize their performance

120 countries in which Aon operates

50K Aon colleagues around the world

Risk

Aon provides a wide range of commercial risk and reinsurance solutions to help clients better identify, quantify and manage their risk exposure



$120B of risk premium placed annually

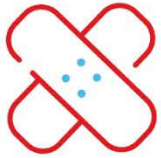
Retirement

Aon provides actuarial, investment and bundled retirement solutions to help clients design and implement secure, equitable and sustainable retirement programs

$3.3T in assets under advisement[1]

Health

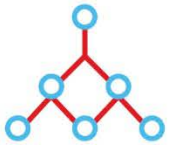
Aon provides consulting, global benefits and exchange solutions to help clients mitigate rising health care costs and improve employee health and well-being



$180B of health care premiums directed annually

ENABLED BY

Data & Analytics



Aon combines proprietary data, technology and advisory services to develop insights that help clients reduce volatility and improve performance

[1]As of 6/30/2017, includes non-discretionary assets advised by AHIC and its global affiliates which includes retainer clients and clients in which AHIC and its global affiliates have performed project services for over the past 12 months. Project clients may not currently engage AHIC at the time of the calculation of assets under advisement as the project may have concluded earlier during preceding 12-month period.

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Commercial Risk Solutions

We provide risk advisory, risk transfer and structured solutions to help organizations and individuals manage their risk exposure

Reinsurance Solutions

We provide risk transfer, claims advocacy and capital management solutions to help re/insurers reduce volatility and build more resilient communities

Retirement Solutions

We provide actuarial, investment and bundled retirement solutions to help clients design and implement secure, equitable and sustainable retirement programs

Health Solutions

We provide consulting, global benefits and exchange solutions to help clients mitigate rising health care costs and improve employee health and well-being

Data & Analytic Services

We combine proprietary data, technology and advisory services to develop insights that help clients reduce volatility and improve performance

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Aon Reinsurance Solutions

Client Needs

Achieving growth

Re/insurers need advice on how to boost underwriting profitability and manage investments in a challenging market

Improving resilience

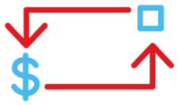
Businesses, governments and communities are looking for new solutions to transfer risk and increase resilience to emerging risks

Adapting to disruption

Re/insurers need new strategies to integrate technological innovation across risk, capital and data and analytics

Aon Solutions

Risk Transfer



We provide a full range of risk transfer solutions for re/insurers across treaty, facultative and alternative markets

Claims Advocacy

We use proprietary data and analytics and extensive carrier relationships to help re/insurers resolve claims efficiently

Capital Management

We help businesses and governments access new sources of capital and optimize risk transfer to increase resilience

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Data & Analytics

We have

over 100 proprietary analytical tools to help clients better predict and model their **risk exposures**

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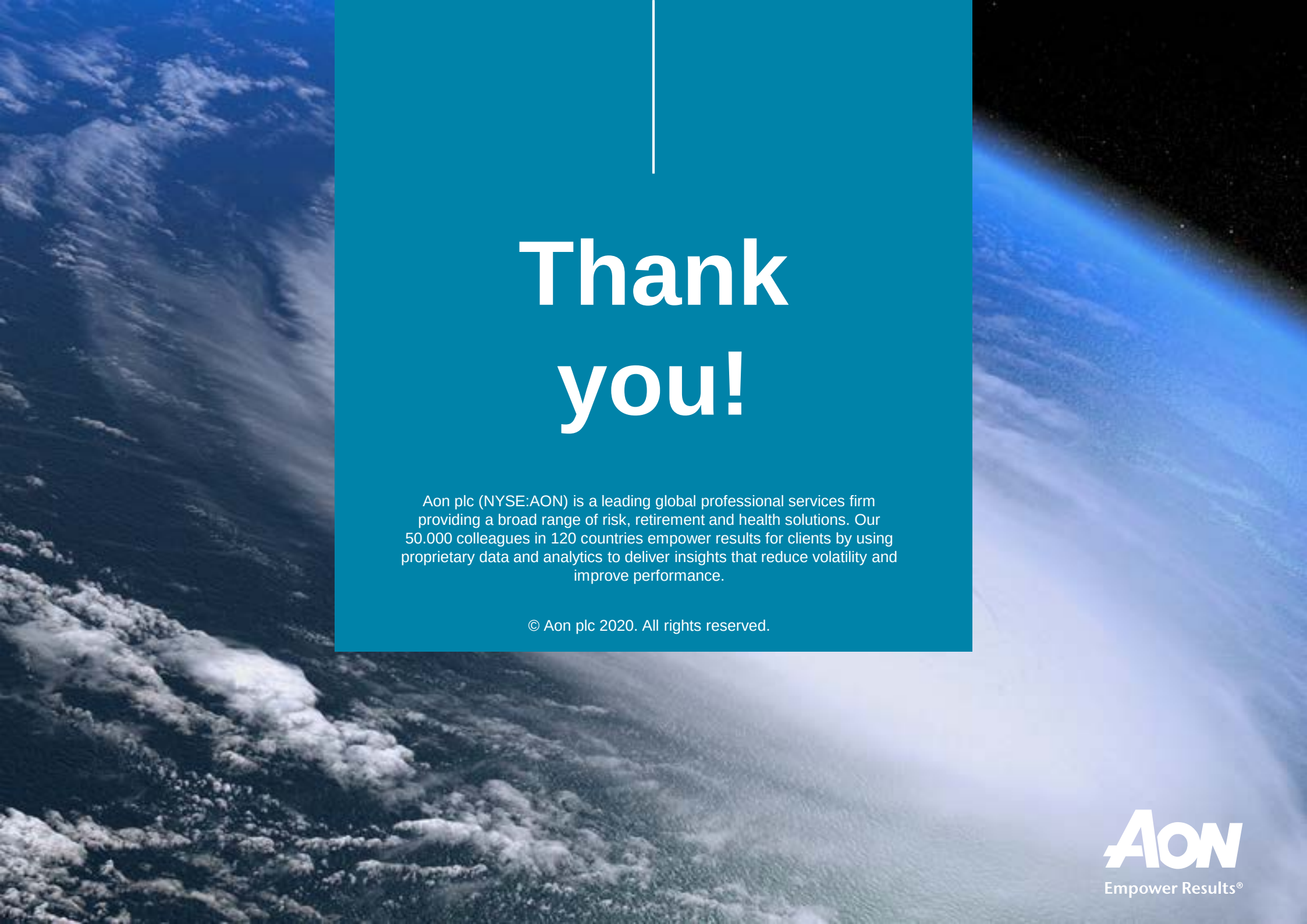

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