Nat Cat Models:
the experience of Reale Group

December 5, 2019

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Reasons for Undertaking Nat Cat Modelisation

Non-Life CAT Risks Introduction

CAT NON-LIFE MODULE	
Modules	**Perils**
NATURAL	Windstorm
	Earthquake
	Flood
	Hail
	Subsidence
NON-PROPORTIONAL PROPERTY REINSURANCE*	
MAN-MADE	Motor vehicle liability
	Marine
	Aviation
	Fire
	Liability
	Credit and Suretyship
OTHER	Transport of goods
	Non-prop Reinsurance MAT*
	Miscellaneous Financial Loss
	Non-prop Reinsurance MTL and TPL*
	Non-prop Reinsurance CRC*

Natural Catastrophe risk is the risk of loss or adverse change in the value of insurance liabilities, resulting from significant uncertainty of pricing and provisioning assumptions related to extreme or exceptional natural events, over a time horizon of one year.

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Reasons for Undertaking Nat Cat Modelization

2018 EIOPA's Second Set of Advice

Explicit guidance from EIOPA Nat Cat modelling in February 2018

"The risks weights and risk factors […] have been calibrated by taking account of national market average contractual limits and national markets average deductibles. The intention was to apply the risk factors directly to the undertaking's sum insured without contractual limits and without deductibles, so that the SCR per peril is calibrated at the appropriate level for each country.

EIOPA's Second Set of Advice to the European Commission on specific items in the Solvency II Delegated Regulation, EIOPA, 28 February 2018

- Reale Group, in accordance with other Italian insurance companies, used to use **limits of indemnity in place of insured sum** for the calculation of scenarios of NAT CAT module.
- In accordance with the second advice provided by EIOPA, the Group has adapted the calculation of the CAT NAT SCR from the end of 2018 in line with the italian market.
- EIOPA' s Second Set of Advice made Nat Cat perils' SCRs **inadequate** to represent Reale Mutua and Italiana's risk profiles
- As a consequence of this, Reale Group decided to enrich the in-force PIM structure via the **modelization of Nat Cat perils, starting from Earthquake**

The Earthquake Cat External Model

Nat Cat modelling

The use of actuarial methodologies based on an extrapolation of extreme event losses from **historical claims** information available has **limitations**, especially in the case of events with **low frequency of occurrence and high severity**. This brought to a wide usage within the insurance industry of the so-called **Probabilistic Catastrophe Models**.

A probabilistic model for Natural Catastrophe risk requires a **deep scientific and engineering knowledge** of the characteristics of the underlying physical mechanisms that control the occurrence and behaviour of natural hazards and its impacts on the exposed assets. In addition, **substantial amount of data** for model construction and validation are required. The probabilistic model requires:

- The **simulation of thousands of representative, or stochastic, catastrophic events** in time and space
- Compiling detailed **databases of building inventories**
- **Estimating physical damage** to various types of **structures** and their **contents**
- Translating **physical damage to monetary loss**
- Summing over **entire portfolios** of risks

- Reale Group opted for the usage of an **External Probabilistic Catastrophe Model and for the outsourcing to an External Provider** to produce the results for the Earthquake Non-Life CAT Risk (before integrating them within the Partial Internal Model)

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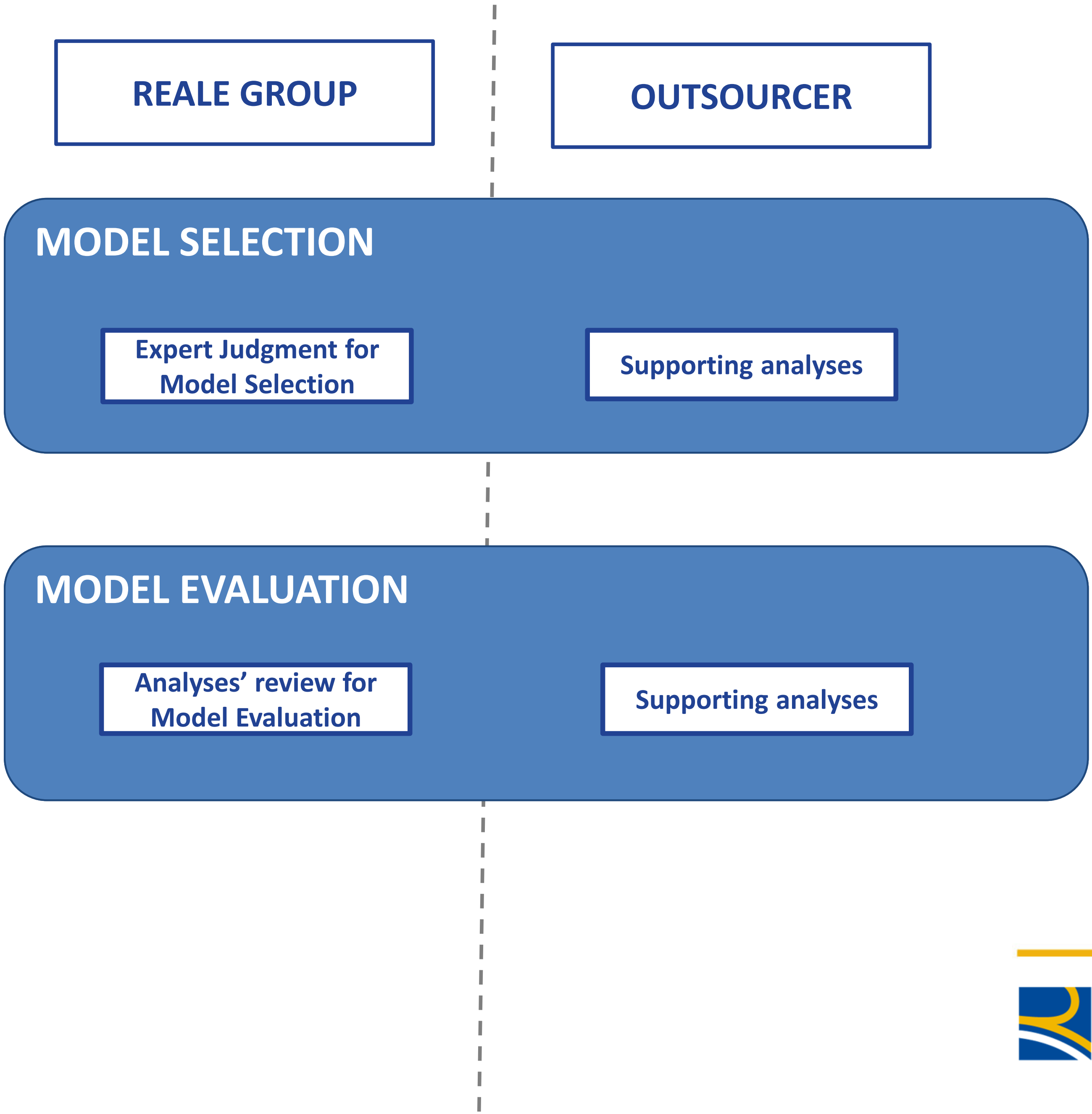
The External Model Process



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The External Model Process

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CAT DATA PREPARATION

- Data Extraction
- Data Quality
- Data Delivery

EXTERNAL MODEL RUN

- Model Calibration
- External Model Run
- Appropriateness check of Ext. Model Results

PIM RUN

- ELT simulation in PIM (Earthquake risk PDF)
- PIM Run

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Model Selection

The model selection is applied to the following **catastrophe models**:

1. **AIR Touchstone v6.2**
2. **RMS RiskLink v18**
3. **Corelogic RQE v17.1**

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Model Selection

The following tests have been executed during the model selection phase:

Test Code	Test Relevance
Model Documentation	Medium
Model Platform	High
Model Methodology	High
Model Vendor Continuity	Medium
Model Relevance in the Market	High
Model Results Plausibility	High
Model Simulation of Company Historical Losses	High
Company Experience with the Model	High

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Model Evaluation

After having selected the model, Reale Group undertake an in-depth analysis on the chosen model. This phase, performed by the Risk Model Unit, is called **Model Evaluation** and consists of a series of tests aimed at assessing the advantages of the model, as well as detecting its possible weaknesses and limitations and suggesting adjustments.

The same areas with respect to the Model Selection phase are investigated, but in a much deeper way

The Model Evaluation proves the **adequateness of the selected model** for Reale Group purposes but also identifies some limitations that can be solved via model adjustments, that are possible thanks to the flexibility of the platform.

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Input data

The following table summarizes the **exposure data** to be provided, **classified by** their **importance** for the earthquake catastrophe modelling:

PRIMARY PARAMETERS	**SUMS INSURED**	The total Sums Insured for Earthquake risk at policy and site level
	INSURANCE TERMS	Limits and deductibles (franchise deductible / loss deductible) at policy and site level. For multi-site policies, information on the conditions common to all covered locations (LMR) should be provided
	GEOLOCALIZATION	Street address, city, postal code, province, state, country
	REINSURANCE TERMS	Information on available (facultative and treaty) reinsurance to mitigate the insurance company losses
	OCCUPANCY	Intended use of the building (e.g. residential, commercial, industrial, agriculture, municipal)
SECONDARY PARAMETERS	**CONSTRUCTION CLASS**	Specifies the type of construction (e.g. masonry, concrete/reinforced concrete, steel, adobe, wood…)
	CONSTRUCTION YEAR	Year of construction of the building
	NUMBER OF FLOORS	Number of floors of the building

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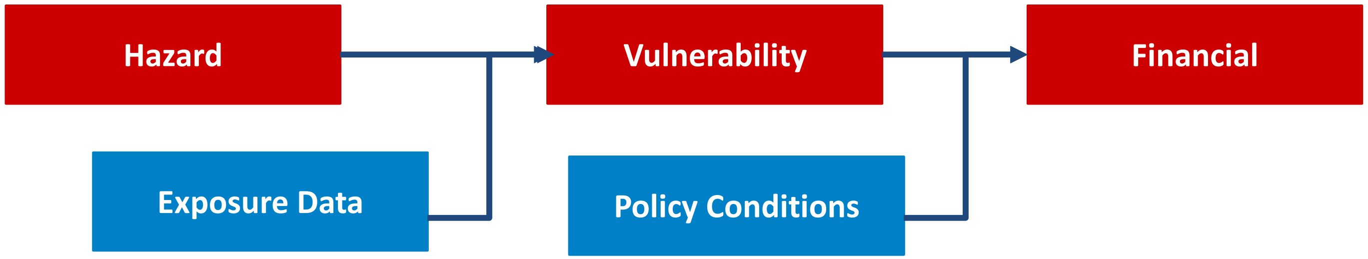
Model Methodology

The methodology of Nat Cat models can be subdivided into **three modules**: Stochastic event set, Hazard, Vulnerability and Financial



Hazard module – Stochastic Event Set

- Stochastic events are generated by a **database of sources**, which can generate earthquakes that would affect the region.
- In particular, the stochastic event set is based on country specific seismic information and knowledge about seismogenic areas and faults.
- For Italy the information is mostly based on the database of individual seismogenic sources (DISS) compiled by the INGV

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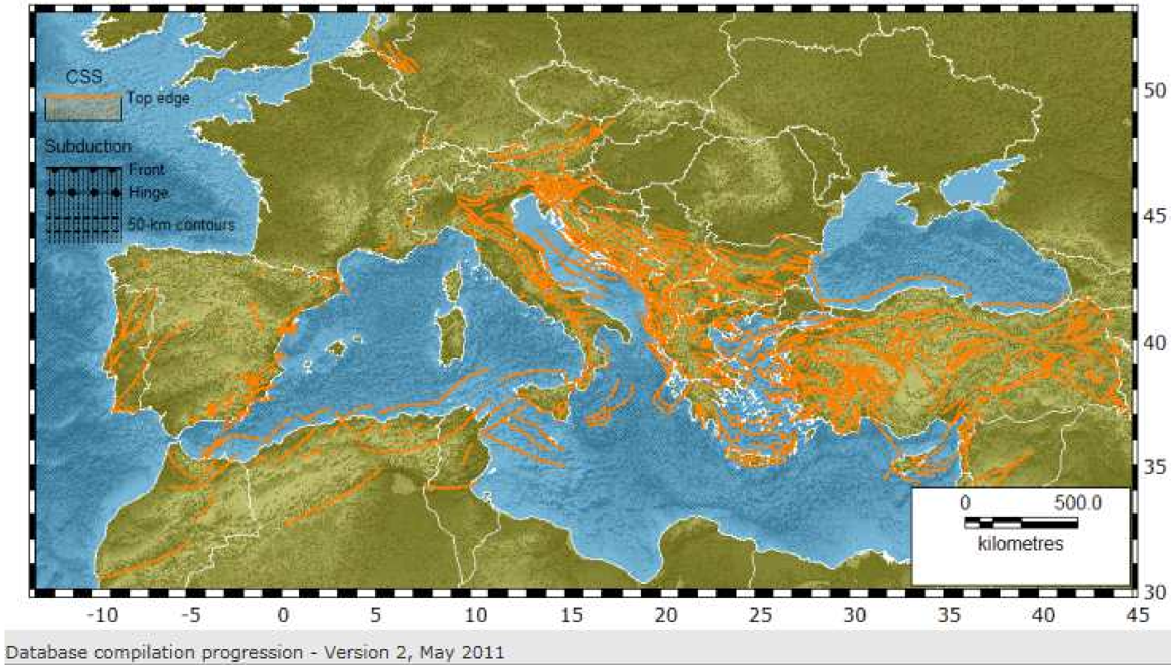
Model Methodology – Hazard Module



The image shows the European Database of Seismogenic Faults (EDSF) that was compiled in the framework of the EU Project **SHARE** and including also Italy.

Comparable information is at the basis of the development of the event set for the selected model.

- **Hazard module – Attenuation Relationships**
  - This part of the Hazard module includes two major elements: **attenuation** (i.e. **ground motion prediction equations**) and **geotechnical hazard data**. The main ground shaking parameter is the **spectral acceleration (SA)** and the GMPEs are based on a blend of published attenuations functions.
  - A database of **superficial geology** is used to determine how the ground shaking will be amplified at a given site. Additionally, databases of landslide and liquefaction susceptibility are also factored into loss calculations.

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Model Methodology – Vulnerability Module

- **Vulnerability module** :

  - The model correlates the **damageability** of a site to various **building characteristics:**
    - **occupancy**
    - **construction class**
    - **year of construction**
    - **number of stories**
    - **seismic zone**
    - **building inventory database**

  - The vulnerability module aims at establishing a **relationship between the local intensities and the building damage ratios, via the vulnerability curves**

  - Other than for **buildings**, the model also includes vulnerability curves for damage affecting **content** and **business interruption**.

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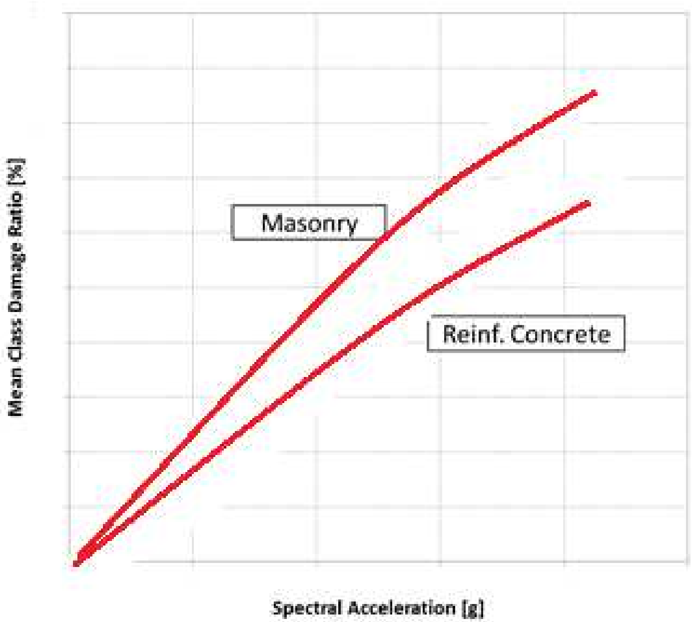
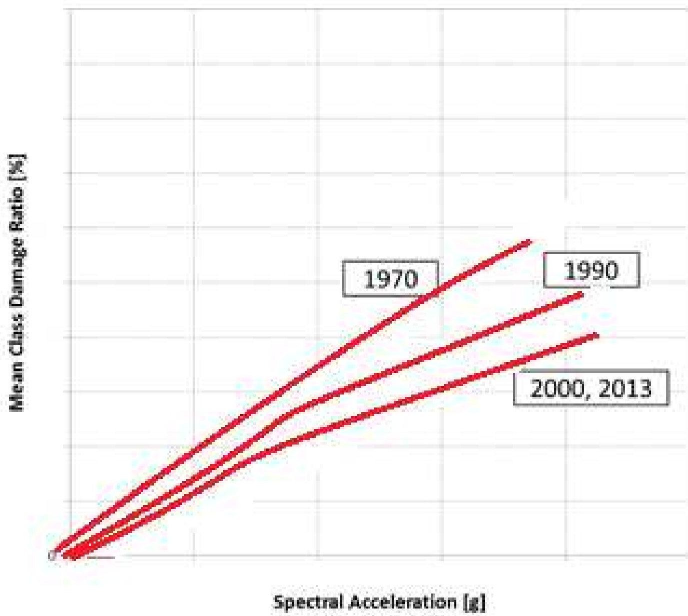
Model Methodology

ILLUSTRATIVE





Construction class
Masonry constructions are more vulnerable than reinforced concrete ones.

Year Built
The vulnerability increases for older structures.

- **Financial module**:
  - The module allows for the calculation of a **wide variety of financial perspective** (e.g. gross loss, ceded loss).
  - Moreover, losses can aggregated from site level to higher levels (e.g. policy, portfolio)

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EVENT LOSS TABLE

It is a representation of the **event-by-event claims cost simulated** by the external model, which can be treated by the PIM for simulation of aggregate cost of natural event losses and related Solvency Capital Requirement.

The **Event Loss Table** is usually composed by a list of **parameters** characterizing **each event** *j*:

Parameter	Description
Event ID	Unique **identifier** of the event
Rate (λ_j)	Annual event **frequency**
Mean (μ_j)	**Average loss** if the event occurs
Sdi ($\sigma_{j,I}$)	**Uncorrelated component** of the **standard deviation** of the loss if the event occurs
Sdc ($\sigma_{j,C}$)	**Correlated component** of the **standard deviation** of the loss if the event occurs
Exposure (e_j)	**Maximum loss**, equal to the total amount in the portfolio which is exposed to the event

The **standard deviation** of the loss of each event is represented by the **sum of an uncorrelated component** (*Sdi*) and a **correlated component** (*Sdc*). This simplifies the preliminary aggregation procedure which has to be performed in case each event (row) in the ELT is built up from **components** (e.g. lines of business or portfolios) whose **individual losses are partially dependent on one another**.

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ILLUSTRATIVE

The following table presents the format of the **Event Loss Table of the two companies**, whose partitions have been **aggregated.**

		RMA				ITA (including UNIQA)			
EventID	Rate	Mean	StdDevI	StdDevC	Exposure	Mean	StdDevI	StdDevC	Exposure
1000001	0,1E-06	1.910.060	1.717.718	972.737	80.722.095	414.231	234.464	238.944	46.174.207
1000002	0,1E-06	87.480	112.654	69.458	20.245.776	8.552	15.557	7.979	9.832.151
1000003	0,2E-06	5.951.674	1.618.554	2.949.029	570.053.931	1.526.568	776.822	793.764	120.936.959
1000004	0,3E-06	455.269	316.369	269.648	36.784.241	111.298	81.355	71.823	6.750.067
1000005	0,4E-06	885.917	440.718	538.696	84.838.632	212.782	129.328	143.883	21.159.971
1000006	0,1E-06	113.417	165.214	64.919	6.944.026	29.571	36.176	19.463	2.611.144
1000007	0,2E-06	138.876	183.001	78.243	6.974.844	38.181	41.508	25.246	3.062.340
1000008	0,3E-06	2.767.112	781.357	1.751.649	511.606.649	691.219	395.960	490.503	126.392.235
1000009	0,6E-06	27.627	63.151	16.865	67.797.262	6.431	12.537	4.606	20.236.253
…	…	…	…	…	…	…	…	…	…

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The ***total loss* for Earthquake risk *Y*** is equal to the following:

$$Y := \sum_{j=1}^{n} \sum_{k=0}^{N(\lambda_j)} X_{j,k}$$

where

- n is the **number of events** in the Event Loss Table (ELT)
- j is the **j-th event** in the ELT
- $N(\lambda_j)$ is a **Poisson random variable** with **parameter** λ_j
- $X_{j,0} = 0$
- If $N(\lambda_j) > 0$, then $X_{j,k}$, for $k = 1, \dots, N(\lambda_j)$ are **independent random variables** distributed as:

$$X_{j,k} \sim B(\alpha_j, \beta_j) \cdot e_j$$

  - B is a **Beta distribution with parameters** (α_j, β_j):

$$\alpha_j = \left(\frac{\mu_j}{\sigma_{j,I} + \sigma_{j,C}}\right)^2 \left(1 - \frac{\mu_j}{e_j}\right) - \frac{\mu_j}{e_j}, \qquad \beta_j = \alpha_j \left(\frac{\mu_j}{e_j} - 1\right)$$

  - If $(\sigma_{j,I} + \sigma_{j,C}) = 0$ or $e_j = 0$, then $X_{j,k}$ becomes a **degenerate variable** equal to μ_j
- For a given event *j*, the random variables $X_{j,k}$ are **independent of each other** and **independent of** $N(\lambda_j)$

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