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Developing a unified and consistent database for historical natural events, and subsequent losses, within a catastrophe modeling framework

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Summary

The insurance industry faces highly complex P&C challenges, among which natural catastrophe risk, also labeled as "CAT" risk. Global insurance groups must develop a sound understanding of the frequency, intensity, and impacts of natural hazard events, to protect their economic capital and ensure their solvency.

To address this challenge, the AXA Group Risk Management proceeds to an **annual collection of all AXA CAT exposure data to assess the risk on a per-entity, per-peril, and per-geography basis** to finally aggregate it at Group level. Alongside this process, the collection and analysis of "**scenarios**", either historical events, or potential future disasters, improves the robustness and understanding of risk assessment.

However, there is currently **no unified and consistent database recording the characteristics of natural events and their actualized economic and industry impacts**. This work aims at developing a database for that would 1) gather an exhaustive inventory of historical natural events and, 2) throughout the integration within the existing CAT modeling ecosystem, automatize model validation, back-testing, and risk analysis with respect to market and as-if losses.

Motivations

There are few databases with global coverage, among which one may cite **EM-DAT** (UC Louvain), **NatCatSERVICE** (Munich Re), **Sigma** (Swiss Re), or **GLIDE** (Asian Disaster Reduction Centre). Evidence have been given that EM-DAT, which is the main database publicly available, has numerous missing data. Though useful it is, natural events might be underreported, and impact information underestimated (Jones, et al., 2022). The GLIDE database aims at providing a global unique identifier for natural events, but it has not been widely adopted and events are not listed.

By constructing a unified database, we are targeting the following identified shortcomings:

- **Limited scope:** we aim at encompassing a wide variety of perils faced by the economy globally.
- **Inconsistent data:** inconsistent methods for collecting and reporting data makes it challenging to analyze trends over time. A unique identifier is attributed to each single event and used across our systems.
- Impact **benchmarking:** impact validation and management of uncertainties can be significantly improved by a systematic comparison between the modelled impacts from various sources.
- **Time lag** and infrequent **update :** we aim at collecting and updating the data automatically.

Catastrophe modeling framework

Catastrophe risk is here defined as the **cost due to potential damage resulting from the exposure of a vulnerable element to a source of danger** (Figure 1). This source of danger, or hazard, can be of natural or anthropogenic origin.

Through policies, insurance companies consistently collect CAT exposure data (geographical, physical, and financial information) on a per-entity (e.g., AXA France, AXA Mexico…) and per-location basis (houses, factories, vehicles…). This information about exposure data and its associated vulnerability is then modeled against millions of stochastic events (e.g., windstorms, earthquakes, floods). This process, also called catastrophe modeling produces ensembles of event losses that represent the risk on a per-entity per-peril per-geography basis (Mitchell-Wallace, et al., 2017; Michel, 2017; Deroche, et al., 2023).

Catastrophe modeling can be done by either commercial software, or through internal development; which offers multiple solutions, each with their own assumptions, for the same set of exposure data. At the AXA Group Risk Management, current development of catastrophe models is done with the web application Notus.

Figure 1: Risk results from the intersection of the presence of vulnerable populations or assets, exposed to the occurrence of a dangerous event (hazard)

Approach

The first step of this project lies in building a database which list events, whether they are historical (past events that have occurred) or fictional (scenarios by governmental agencies for instance). Completeness of the catalog is key, which calls for a robust database structure and an automated filling process.

Each row would display information about:
- Name, Description, Hazard, Occurrence of secondary hazards (ex: tsunami for earthquakes)
- Sources
- Date or Time period
- Geographical scope (Continent, Country, or Region)
- Market Loss
- AXA loss, and claims, per entity, and the overall AXA loss (can be nullable)
- Known losses from other catastrophe models

ID	Name	Description	Year	Hazard	Source	StartDate	EndDate	Region	Notus Loss	AXA Asif loss	Loss from Model A
1	2010 M8 Maule Earthquake	2010 Maule earthquake - Chile	2010	Earthquake	USGS	2010-02-27	2010-02-27	South America	38m€	19m€	5m€
2	2016 Blue Cut Wildfire	Blue Cut Wildfire - California, United States of America	2016	WildFire	AXA LiveCAT	2016-08-16	2016-08-23	North America	2m€	6m€	NA
3	2004 Indian Ocean Tsunami	Earthquake and Tsunami - Indian Ocean (Southern Asia)	2004	Tsunami	Lloyds	2004-12-26	2004-12-26	Asia	130m€	NA	100m€
4	2020 Sabine Windstorm	From Sunday 9 February to Tuesday 11 February 2020, extratropical cyclone "Sabine" (also named "Ciara" and "Elsa") caused significant damage across Austria, Belgium, Denmark, France, Germany, Ireland, Luxembourg, the Netherlands, Norway, Sweden, Switzerland, and the United Kingdom.	2020	Windstorm	PERILS	2020-02-09	2020-02-11	Europe	10m€	12m€	15m€

Figure 2: Example of a hypothetical database, that would document natural events (historical or fictional) and collect views of risk using various approach (losses from models, claims, market share…)

Overview of the system

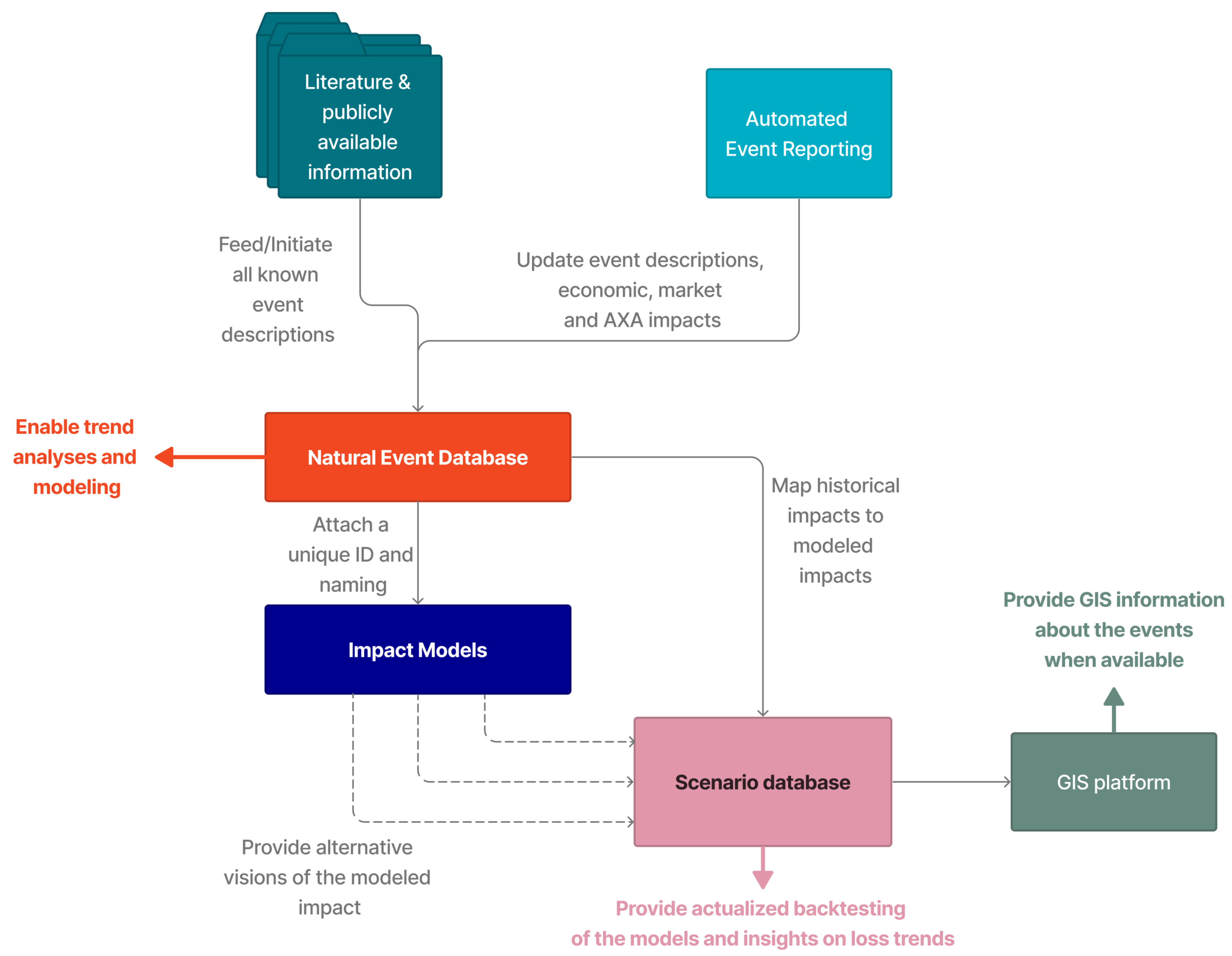

Figure 3: The modeling ecosystem around natural events at AXA. Natural events occurrences are updated regularly in the Events database with their description and actual impacts when available. When the event is of importance to AXA, different versions of it are modelled to feed a Scenario database. These scenarios incorporate the uncertainties in hazard, vulnerability for a given event intersected with AXA's exposure. The scenarios can be automatically updated as the science progresses and the exposure changes. The results can be served through a GIS platform to perform geographical analyses against the exposure and provide visual representations of the risk.

Perspectives

The development of a unified and consistent Natural Events database is the cornerstone of a robust risk assessment framework for a global insurance company such as AXA.
Coupled with R&D expertise on Natural Events modeling and integrated within a suite of automated IT solutions, it drives the understanding of the risk and the back testing of modeling assumptions. With such a database, industry experts are better equipped to answer two types of questions:

What is ?

Examples:
- **What are similar events to event X?**
- **What are the trends in current losses?**
- **What is the return period of event X?**

What if ?

Examples:
- **What if event X had occurred 100km farther North ?**
- **What if fluvial defenses are improved?**
- **What if the exposure is increased in coastal areas?**

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