Model evaluation del rischio terremoto e secondary perils

21 Settembre 2023

Riassicurazione nei rischi catastrofali

I Mercati riassicurativi internazionali, supportati da una serie di sviluppi e innovazioni degli ultimi anni, possono contribuire alla gestione del rischio migliorando la capacità dei primari mercati assicurativi per offrire copertura e supportare la loro capacità di gestione dei rischi di catastrofe (anche fornendo competenze sulla quantificazione del rischio)

La natura di questi mercati fornisce una fonte esterna di finanziamento per la ripresa e ricostruzione che dovrebbe contribuire anche a ridurre il mercato economico e assicurativo interruzioni che spesso seguono grandi eventi catastrofici.

il contributo della riassicurazione al rischio catastrofale è soprattutto relativo a 4 aree:

- (i) aumento della capacità del mercato primario;
- (ii) gestione rischi catastrofali;
- (iii) ridurre le perturbazioni economiche all'indomani della catastrofe eventi;
- (iv) ridurre le perturbazioni del mercato assicurativo primario dovute a eventi catastrofali.

Riassicurazione nei rischi catastrofali

La riassicurazione fornisce copertura assicurativa agli assicuratori primari (o cedenti) sulla base di un accordo contrattuale volto a risarcire le perdite al verificarsi di un evento determinante

Le cedenti possono richiedere una copertura riassicurativa per una serie di motivi, tra cui:

(i) ridurre la volatilità dei risultati tecnici che potrebbe essere elevata nelle linee di business soggette al rischio catastrofe;

(ii) aumentare la capacità di sottoscrizione, sia per un dato contraente/rischio o per un portafoglio di polizze/rischi;

(iii) supportare l'ingresso in una nuova linea di business

(iv) stabilire un livello di rischio diversificazione adeguato

I riassicuratori possono anche acquisire una copertura assicurativa ("retrocessione") per le loro esposizioni, tipicamente coprono catastrofi o rischi estremi (vale a dire eventi a bassa frequenza/elevata gravità).
Un riassicuratore (retrocedente) acquista la retrocessione dai retrocessionari, che possono essere altri riassicuratori o investitori sul mercato dei capitali o anche assicuratori diretti.
La retrocessione può fornire copertura a livello di portafoglio o di pilastro, e fornisce molti degli stessi vantaggi che la riassicurazione offre agli assicuratori primari, come ad esempio consentendo di sottoscrivere più attività e garantendo la diversificazione del rischio.

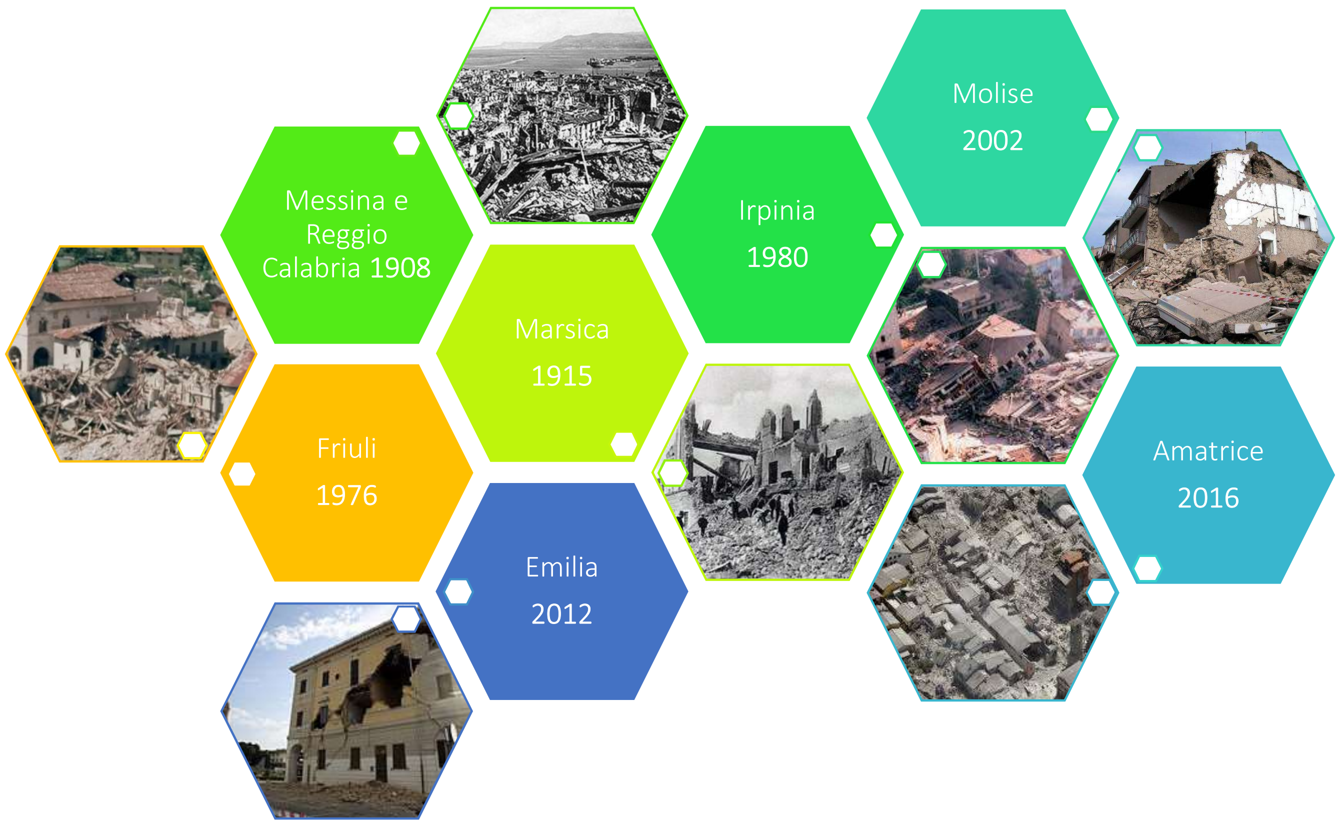
Diverse forme di riassicurazione tradizionale

	Proportional		Non-proportional		
	Quota Share	**Surplus Share**	**Excess of loss per risk**	**Catastrophe Excess-of-Loss (Per Occurrence & Aggregate)**	**Aggregate Stop Loss**
Description	Cedant transfers a fixed percentage of every risk in a defined category from the first dollar of premium.	Cedant determines level to retain for each risk (a line) and every risk that provides coverage greater than the retained line is ceded on a proportional basis. Proportion ceded varies with size of risk.	Excess of loss reinsurance in which the reinsurance limit and the cedant's loss retention apply per risk rather than per event or in the aggregate.	Covers a cedant for the amount of loss over a specified retention with respect to an accumulation of losses resulting from a catastrophic event (per occurrence) or multiple events (aggregate).	A share of the cedant's total (cat and non-cat) losses during the period (usually a year) above an agreed retention (typically set as a percentage of aggregate net premium or a specified loss ratio) are ceded through a stop loss cover.
Uses and advantages	Provides good protection against frequency/severity potential and protection of net retention on a first-dollar basis. Allows recovery on smaller losses and increases capacity to underwrite larger limits with existing capital.		Provides good protection against frequency or severity depending on the retention level. Allows a greater net premium retention and reduces reinsurance premium and cost of administration.		
	Supports cedants entry into new lines of business	Allows cedant to cede higher proportion of less profitable risks than quota share or non-proportional reinsurance while helping to eliminate peaks in a portfolio.	Absorbs large single risk losses and therefore increases capacity to write larger limits while maintaining manageable risk level and stabilising financial results.	Can reduce volatility in annual catastrophe-related losses or protect against solvency risk of severe events. Aggregate provides coverage for more frequent catastrophe events and also avoids interpretation issues related to the definition of an event. Per event/occurence coverage protects against severe losses.	Protects overall underwriting results (specifically large claims fluctuations), generally after other types of reinsurance have been applied. Avoids interpretation issues related to the definition of an event.
Reinstatements	N/A	N/A	Possibly	Yes (except aggregate)	No
Popularity	Common for new companies.	Normally more common than quota share.	Very prevalent	Very prevalent	Not as prevalent as other non-proportional reinsurance.
Lines	Property and Casualty	Property (mainly)	Property and Casualty	Property (mainly)	Property, Agriculture
Premium calculation	Calculated as a proportion of underlying insurance premium which reflects amount of risk transferred.		Two main methods:(i) exposure rating based on the sums insured and types of exposures; (ii) experience rating based on the estimated or projected loss experience		
Administrative cost	Less costly than surplus due to low administration	Costlier than quota share due to more administration	Less costly to administer than surplus		
Commission	Ceding commission paid to cover proportionate share of business acquisition costs. Profit commission may also be paid if reinsurance turns out to be profitable.		Rarely includes a ceding commission		

Source: Ania

RISCHI CATASTROFALI DA NATURAL EVENTS

In Italia più di 400 terremoti distruttivi negli ultimi 2000 anni



Eventi terremoto storici

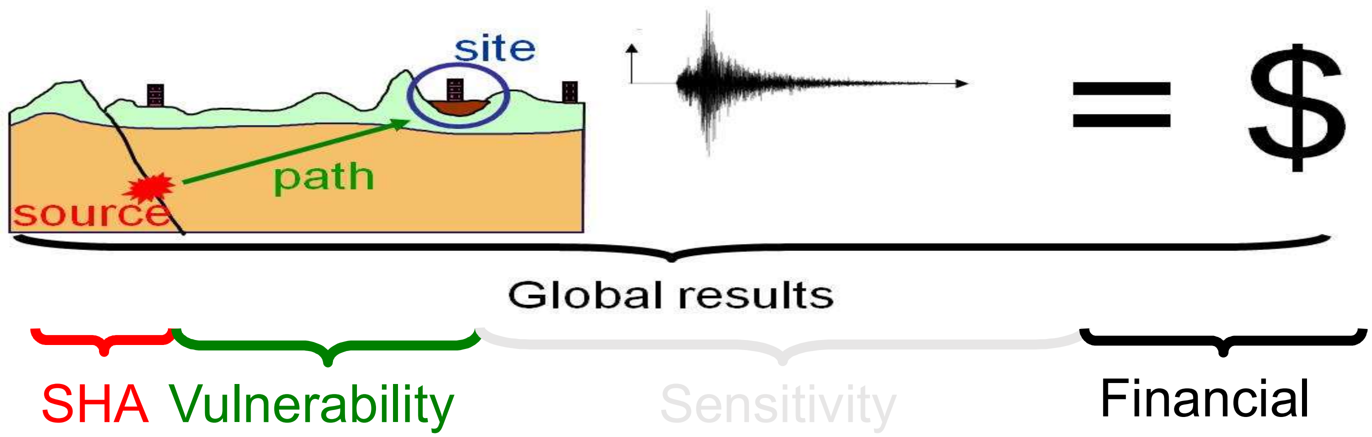
Anno	Evento	Mw	Danni Economici € M	Danni Assicurati € M	% Danni Assicurati	Vittime
2012	Emilia 20/05	6.0	8.255	884	10,7%	7
1997	Umbria	6.0	2.547	130	5,1%	12
2016	Amatrice	6.2	2.000	<100	5.0%	292
1980	Irpinia	6.9	25.289	86	0,3%	3
2012	Emilia 29/05	5.8	4.487	84	1,9%	19
2009	Abruzzi	6.3	2.727	108	1,4%	308
2002	Molise	5.9	1.011	6	0,6%	30
1976	Friuli	6.5	13.601	4	0,03%	922

Risarcimenti da Eventi Catastrofali

Ancora oggi lo Stato viene considerato come alternativa privilegiata per ottenere un risarcimento per i danni da evento catastrofale

Il modello Terremoto

Un modello probabilistico attraverso la combinazione delle probabilità di avvenimento degli eventi, della stima del movimento del terreno e del danno prodotto, definisce come risultato un PML (Probable Maximum Loss) dove ad ogni valore di danno è associata una probabilità (periodo di ritorno) di eccedere quel determinato valore



Il modello Terremoto

Ogni modello per la valutazione del rischio terremoto è costituito dai seguenti quattro moduli:

SIMULAZIONE STOCASTICA DEGLI EVENTI

- Contiene un database di eventi terremoto stocastici (definiti sulla base dell'esperienza storica) che possono colpire il territorio italiano. Ogni evento è descritto da parametri fisici, localizzazione geografica e frequenza di avvenimento.

MODULO HAZARD

- Viene determinata l'intensità dell'evento attraverso la simulazione del movimento del terreno.

VULNERABILITA'

- Viene calcolato il grado medio di danno ed il coefficiente di variabilità associato al danno provocato su coperture Fabbricato, Contenuto e Danni Indiretti.

VALUTAZIONE ECONOMICA

- Viene calcolato il danno assicurato dopo l'applicazione delle condizioni di polizza e della struttura riassicurativa a copertura.

Il modello Terremoto

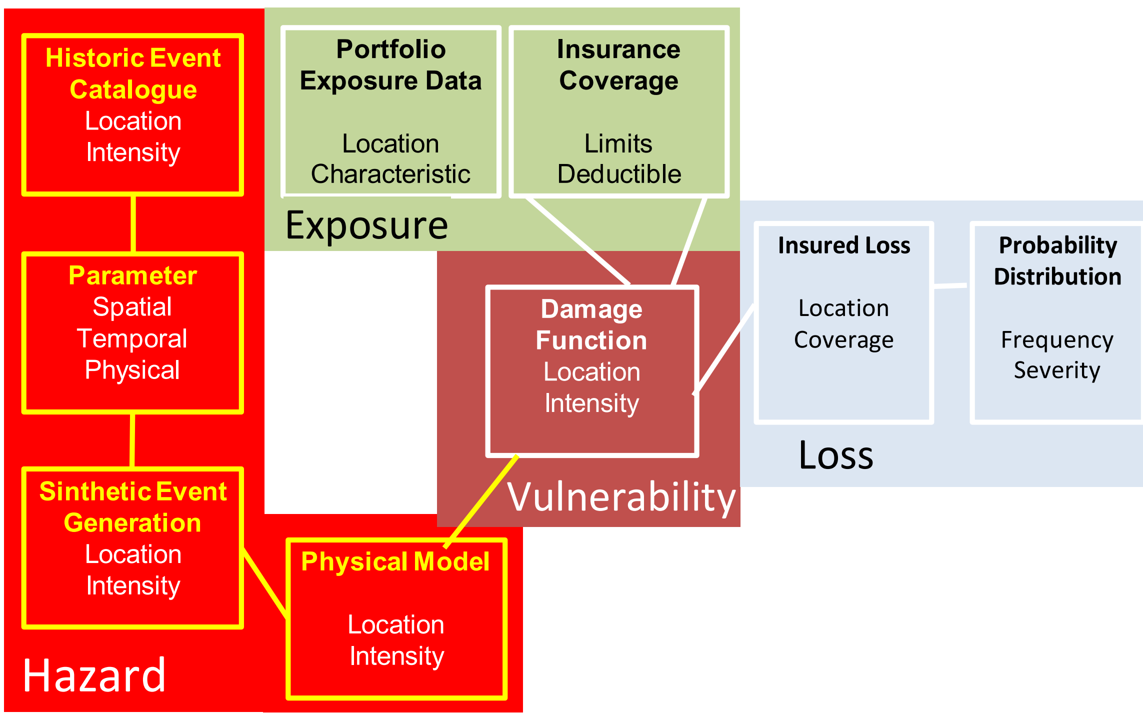
I tre principali modelli sono:

- RMS
- RQE
- AIR

RMS è il modello più comunemente usato in Italia per la valutazione del rischio terremoto e per definire la strategia di riassicurazione. Ha un database di circa 15.000 eventi ed è l'unico dei tre modelli a simulare eventi con epicentro in zone di frontiera. RMS è un modello stocastico sviluppato dalla società RMS, società di consulenza specializzata nello sviluppo di soluzioni per la gestione dei rischi. I risultati dell'analisi del rischio sismico sono generati utilizzando modelli sviluppati da Risk Management Solutions, Inc. Le tecnologie e i dati utilizzati per fornire queste informazioni si basano su dati scientifici, matematici e modelli empirici e sull'esperienza acquisita da parte di ingegneri sismici, geologi e geotecnici

AIR è il modello principalmente usato nella stima degli uragani americani. Air è un modello stocastico sviluppato dalla società AIR Worldwide utilizzato da riassicuratori, assicuratori e da coloro che hanno l'esigenza di gestire il rischio come aziende, organizzazioni governative e parastatali, investitori, hedge fund e altri istituti finanziari

Struttura del modello



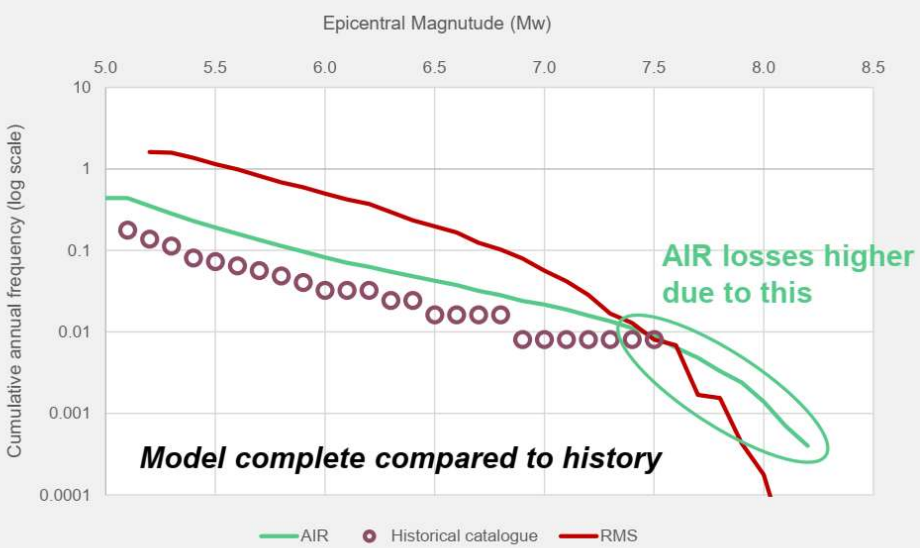
Review e test dei modelli

I modelli probabilistici di valutazione del rischio terremoto sono soggetti a periodiche review per testarne l'efficacia e la validità dei risultati, soprattutto comparandoli con l'effettiva storia sinistri

Nel 2022, ad esempio, per RMS è stato proposto un aggiustamento in Italia delle curve di attenuazione, per ricalibrarle più efficacemente in quanto il modello usa delle curve molto datate. Le registrazioni degli scuotimenti degli eventi degli ultimi anni hanno evidenziato un'attenuazione più veloce di quanto inizialmente ipotizzato

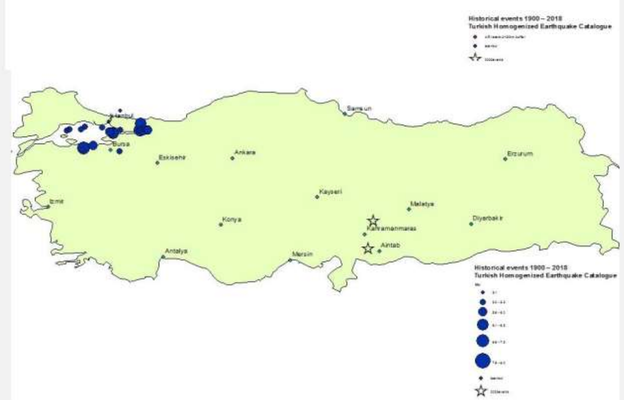
O ancora, in base agli ultimi terremoti avvenuti nel 2023 in Turchia, si stanno comparando i risultati diversi di AIR ed RMS e gli impatti in termini di severità/frequenza di ogni modello anche in rispetto ad esempio al catalogo degli eventi storici (esempio nelle prossime slide)

Validating the model frequency of intense earthquake around Istanbul



AIR assumes higher event frequency > 7.5 magnitude driving the AIR>RMS relativity typically seen in model output

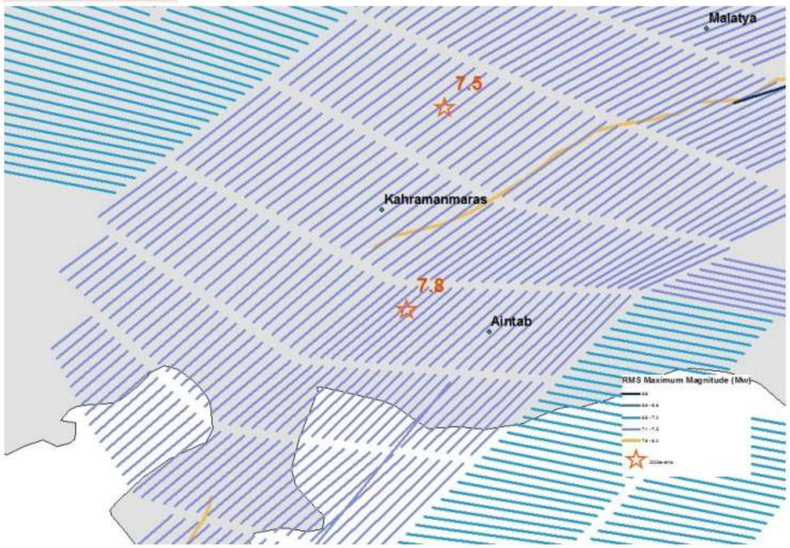
AIR stochastic events within 150km buffer of Istanbul

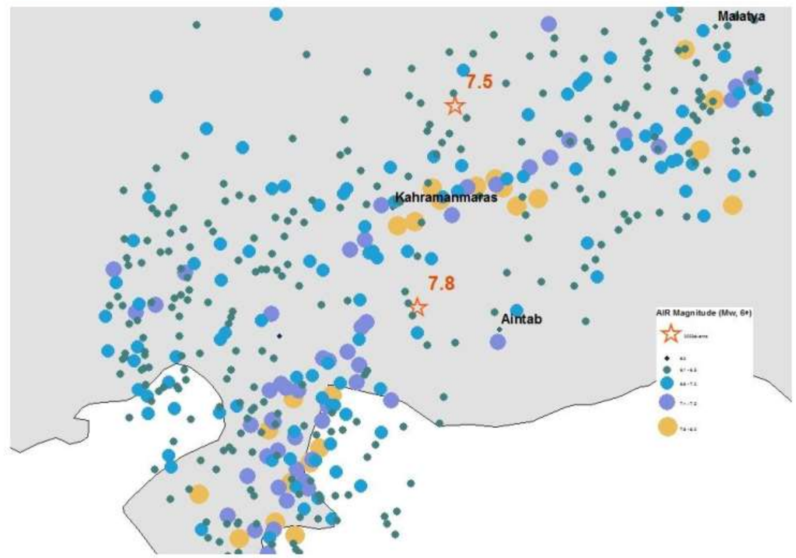


Historical earthquake catalogue (Turkish Homogenized Earthquake Catalogue (TURHEC), 1900-2018

Source: Howden

Validating the model frequency of intense earthquake on the east Anatolian fault





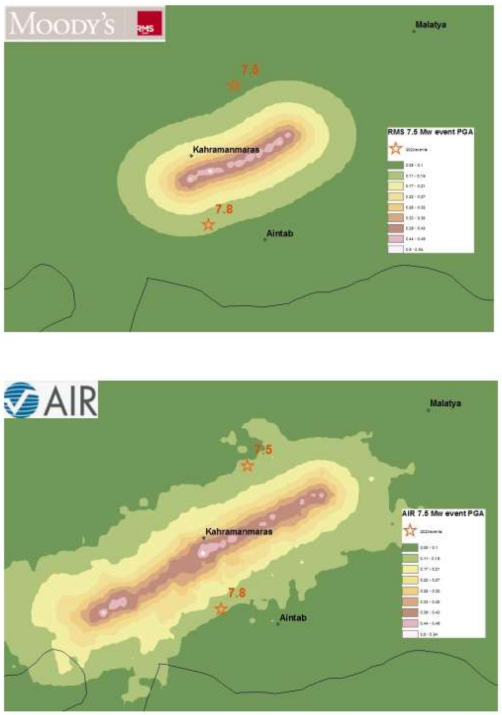
RMS (left) and AIR (right) both miss the possibility of a significant earthquake away from the East Anatolian Fault on the Surgu / Cardak fault zones

Left: RMS maximum magnitude assumed per source zone

Right: AIR stochastic events > Magnitude 6 within 150km buffer of Feb events

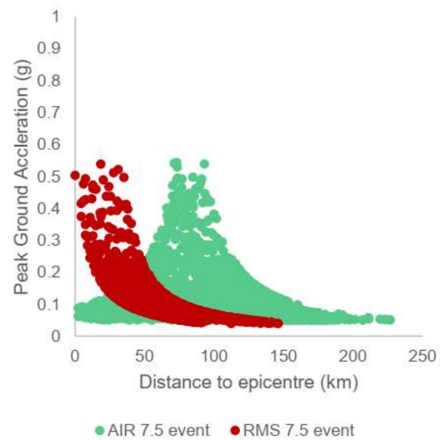
Source: Howden

Ground motion Prediction Equation Differences

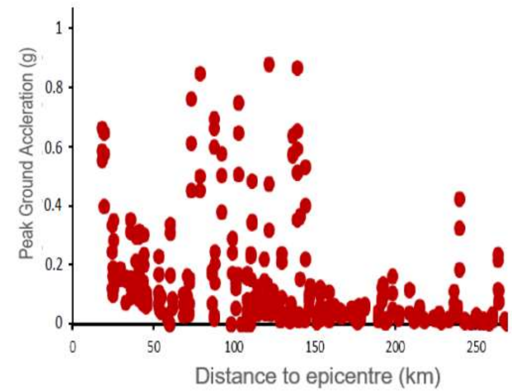


Peak Ground Acceleration for RMS (top) and AIR (bottom) from sample magnitude 7.5 events for the East Anatolian fault

Peak Ground Acceleration by distance to the epicentre RMS (top) and AIR (bottom) from sample magnitude 7.5 events for the East Anatolian fault



Peak recorded ground acceleration VS epicentral Distance for the 1stMainshock of MW7.8: Source: AFAD



AIR better models the realistic spread and extent of earthquake damages seen from a magnitude 7.5 event – larger footprints contribute to the the AIR>RMS relativity typically seen in model output

Source: Howden

Dati di Input

- Numero di Polizza;
- Localizzazione Geografica (Cap, Comune, Provincia, Indirizzo, Cresta). La localizzazione geografica delle esposizioni può essere eseguita sia in modo dettagliato a livello di indirizzo civico che aggregato per codice postale o zona cresta;
- Somme Assicurate (Fabbricato, Contenuto, Danni Indiretti);
- Limiti di Indennizzo e Franchigie.

Dati di Input aggiuntivi

- Tipologia di *Occupancy* (destinazione sociale della struttura coperta; e.g Residenziale, Industriale, Commerciale, ecc)

- Materiale di Costruzione (Cemento Armato, Muratura, Acciaio, ecc);

- Anno di costruzione;

- Numero di piani.

Se queste informazioni non sono disponibili i vari modelli applicano ipotesi di default.

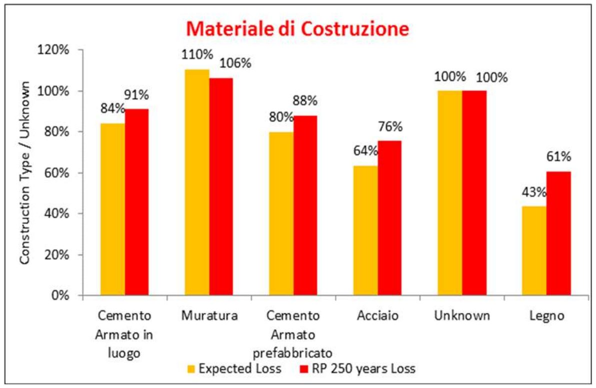
Dati di Input

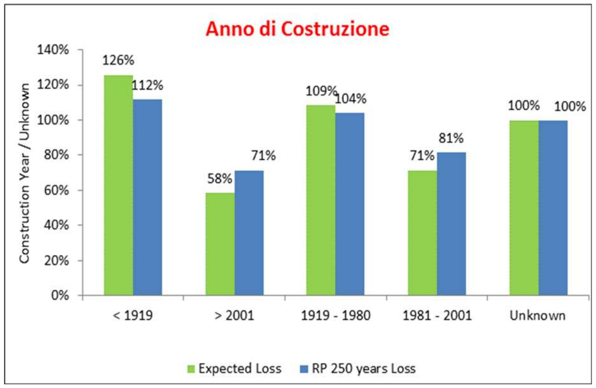
In termini di vulnerabilità, le risultanze dei danni attesi sono fortemente influenzati dalla tipologia di struttura costruttiva (Cemento Armato, Muratura, Legno) e da altri fattori che caratterizzano la costruzione come:

- anno di costruzione;
- numero di piani;
- stato di manutenzione;
- tipologia d'utilizzo del fabbricato.

Ad esempio, per il modello *RMS®*, il valore *Gross Loss* OEP a 250 anni di Periodo di Ritorno dei Fabbricati Residenziali in Acciaio è inferiore quasi del 50% rispetto a fabbricati per i quali la tipologia di costruzione è *Sconosciuta, dell11%* per fabbricati in muratura e del 26% per le classi in Cemento Armato e Prefabbricato.

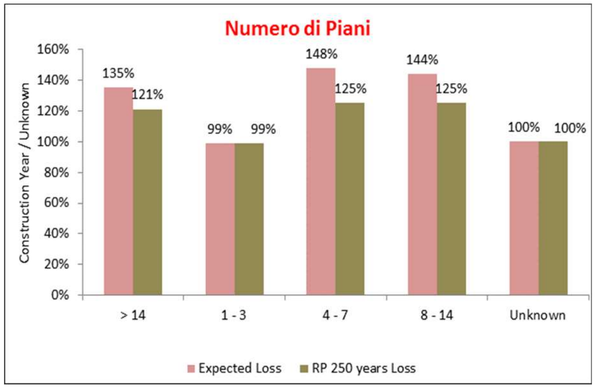
La Vulnerabilità dei modelli (RMS)





- L’imputazione del materiale di costruzione permette di ridurre mediamente del 20% il PML
- L’imputazione dell’anno di costruzione permette di ridurre mediamente del 30% il PML
- La considerazione di tali fattori nella definizione del tasso tecnico permette una sottoscrizione migliore del rischio

Esempio basato su un portafoglio di rischi residenziali



Esempi di Input

LOCNUM	POSTALCODE	CRESTA	CNTRYSCHEME	CNTRYCODE	BLDGSCHEME	BLDGCLASS	NUMBLDGS	OCCSCHEME	OCCTYPE	EQCV1VAL	EQCV2VAL	EQCV3VAL	EQCV1VCUR	EQCV2VCUR	EQCV3VCUR	EQSITELIM	EQSITELCUR	EQSITEDED	EQSITEDCUR
1	87018	87	ISO3A	ITA	RMS	0	1	ATC	2	170.000	-	-	EUR	EUR	EUR	85.000	EUR	10.000	EUR
2	87018	87	ISO3A	ITA	RMS	0	1	ATC	2	170.000	-	-	EUR	EUR	EUR	85.000	EUR	10.000	EUR
3	25050	25	ISO3A	ITA	RMS	0	1	ATC	2	371.300	23.700	-	EUR	EUR	EUR	197.500	EUR	10.000	EUR
4	41026	41	ISO3A	ITA	RMS	0	1	ATC	2	263.200	16.800	-	EUR	EUR	EUR	140.000	EUR	10.000	EUR
5	32032	32	ISO3A	ITA	RMS	0	1	ATC	2	282.000	18.000	-	EUR	EUR	EUR	150.000	EUR	10.000	EUR
6	36030	36	ISO3A	ITA	RMS	0	1	ATC	2	170.000	-	-	EUR	EUR	EUR	85.000	EUR	10.000	EUR
7	35010	35	ISO3A	ITA	RMS	0	1	ATC	2	240.000	-	-	EUR	EUR	EUR	120.000	EUR	10.000	EUR
8	35010	91	ISO3A	ITA	RMS	0	1	ATC	2	830.278	52.996	-	EUR	EUR	EUR	441.637	EUR	10.000	EUR
9	32032	32	ISO3A	ITA	RMS	0	1	ATC	37	670.000	-	-	EUR	EUR	EUR	335.000	EUR	10.000	EUR
10	32028	32	ISO3A	ITA	RMS	0	1	ATC	37	700.000	-	-	EUR	EUR	EUR	350.000	EUR	10.000	EUR
11	01100	01	ISO3A	ITA	RMS	0	1	ATC	2	190.000	-	-	EUR	EUR	EUR	95.000	EUR	10.000	EUR
12	35010	45	ISO3A	ITA	RMS	0	1	ATC	2	161.000	-	-	EUR	EUR	EUR	80.500	EUR	10.000	EUR
13	22073	22	ISO3A	ITA	RMS	0	1	ATC	2	300.000	-	-	EUR	EUR	EUR	150.000	EUR	10.000	EUR

Principali voci:

CRESTA: attribuzione della zona geografica (solitamente indicata con le prime 2 cifre del Codice di Avviamento Postale);

OCCTYPE: tipo di edificio (p.e.: il codice 2 indica un edificio Residenziale, codice 37 Commerciale; codice 38 Industriale, …);

EQCV1VAL: Somma Assicurata riferita al Fabbricato;

EQCV2VAL: Somma Assicurata riferita al Contenuto;

EQCV3VAL: Somma Assicurata riferita alla Interruzione di Esercizio;

EQSITELIM: Limite di Indennizzo

Dati di Ouput

I modelli principali (RMS ed AIR) producono come output, oltre al PML, anche la tabella degli Eventi (Event Loss Table). Gli ELT contengono per ogni evento stocastico simulato le seguenti informazioni

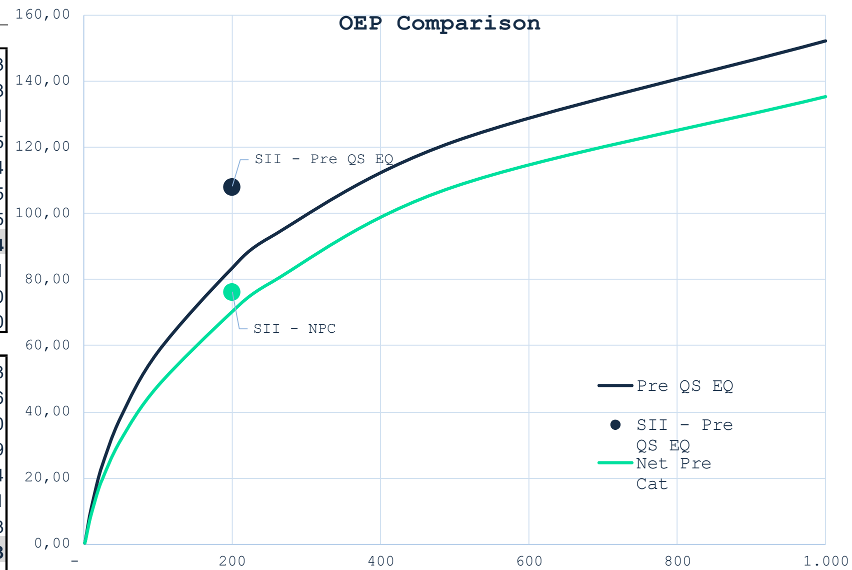
- Codice Identificativo dell'Evento
- Probabilità di avvenimento
- Danno Atteso
- Standard Deviation
- Esposizione all'evento (somma assicurata)

Le tabelle degli eventi costituiscono gli input dei vari tool dfa che attraverso l'uso di distribuzioni di probabilità simulano i sinistri catastrofali da allocare ai vari layer e quindi definire il pricing di un trattato catastrofale non proporzionale

Esempio di Output

View	Gross	Pre QS EQ	Net Pre Cat	QS Resid. EQ
TSI	13.460,14	13.270,52	9.422,62	
Risks	18.849	18.849	18.849	
RMS v21 - OEP				
2	0,27	0,26	0,17	0,03
5	3,98	3,93	3,18	0,58
10	10,40	10,27	8,44	1,71
20	20,01	19,77	16,23	3,75
25	23,89	23,60	19,35	4,64
50	38,71	38,27	31,31	8,25
100	58,67	58,02	47,69	13,15
200	**84,29**	**83,41**	**70,13**	**18,14**
250	93,57	92,63	78,67	19,31
500	122,65	121,74	108,06	20,90
1.000	153,52	152,13	135,22	21,00
RMS v21 - AEP				
2	0,32	0,31	0,20	0,03
5	4,57	4,50	3,61	0,66
10	11,75	11,59	9,49	1,90
20	22,29	22,01	18,02	4,09
25	26,46	26,14	21,39	5,04
50	42,19	41,70	34,10	8,81
100	62,93	62,21	51,14	13,83
200	**89,06**	**88,13**	**73,99**	**18,83**
250	98,47	97,46	82,61	19,94
500	127,89	126,77	112,11	21,00
1.000	159,39	157,92	139,98	21,46
RMS v21 - STATS				
AAL	4,52	4,47	3,67	0,80
StdDv	13,61	13,48	11,62	2,42

SolvencyII		SII - Pre QS E	SII - NPC
200		**108,28**	**76,36**



Source: Howden

Esempio di Output – Event Loss table

Mean Loss Net Loss Post Cat	Std Dev Correlated	Std Dev Independent	Exposure Value	Annual Rate	Event Id	Source ID	Peril	Region
75.350.681,44	7.639.814,82	354.978,25	79.392.787,71	0,0001470816640%	1064632	1371	Earthquake	E7
75.303.177,62	11.279.960,22	528.426,06	81.889.958,55	0,0001279902680%	1095862	5449	Earthquake	E7
74.064.036,65	9.974.984,46	464.553,32	79.882.831,55	0,0001429091410%	1064639	1372	Earthquake	E7
64.311.801,05	11.275.309,85	549.490,26	71.892.469,91	0,0001388967800%	1064646	1373	Earthquake	E7
63.568.401,76	7.561.324,93	576.565,75	68.884.043,28	0,0001945583560%	1055559	279	Earthquake	E7
63.073.640,04	12.815.649,29	594.311,81	72.385.659,65	0,0001130132200%	1092810	5083	Earthquake	E7
62.104.644,07	6.777.229,20	519.422,80	66.620.577,00	0,0001944779570%	1055551	278	Earthquake	E7
60.847.901,86	6.291.819,40	537.893,50	64.551.164,09	0,0001187843280%	1095854	5448	Earthquake	E7
59.504.766,96	6.590.691,48	513.393,05	63.919.607,78	0,0001976833350%	1055543	277	Earthquake	E7
57.722.741,69	9.344.038,68	441.526,20	63.872.906,00	0,0001590068790%	1064674	1377	Earthquake	E7
57.707.808,52	11.027.292,99	525.064,55	65.753.517,58	0,0001513342340%	1064625	1370	Earthquake	E7
56.356.139,18	5.700.967,99	451.015,31	60.033.349,86	0,0001474802280%	1055511	273	Earthquake	E7
56.186.825,93	11.433.171,11	537.263,46	64.744.139,14	0,0001493290710%	1064667	1376	Earthquake	E7
55.407.847,95	6.780.274,19	557.618,55	60.147.659,98	0,0001152377880%	1092818	5084	Earthquake	E7
53.042.663,20	5.917.739,32	532.993,81	57.046.876,82	0,0008156425790%	1095863	5449	Earthquake	E7
51.432.859,69	5.901.367,34	473.004,10	55.485.006,15	0,0001540286350%	1055519	274	Earthquake	E7
50.069.808,20	11.116.140,25	549.716,75	58.853.542,76	0,0001399204510%	1064660	1375	Earthquake	E7
48.889.756,75	9.757.870,71	499.853,27	56.450.418,29	0,0009500793570%	1064633	1371	Earthquake	E7
47.374.305,85	10.428.320,61	516.058,02	55.832.985,75	0,0001690872300%	1064681	1378	Earthquake	E7
47.204.470,15	10.942.656,12	561.877,98	56.343.359,54	0,0009231268450%	1064640	1372	Earthquake	E7
47.013.800,97	6.764.180,29	566.074,00	52.180.146,02	0,0001177961510%	1092826	5085	Earthquake	E7
46.774.563,00	7.359.780,22	635.709,60	52.516.480,35	0,0001271969720%	1095830	5445	Earthquake	E7
45.467.932,13	6.188.589,35	504.218,31	50.111.800,52	0,0001623732600%	1055527	275	Earthquake	E7
44.787.106,28	5.926.099,76	528.220,36	49.202.666,86	0,0000558131430%	1095806	5442	Earthquake	E7
42.492.278,64	6.470.971,27	572.535,56	47.947.285,50	0,0007331662350%	1092811	5083	Earthquake	E7
41.668.900,70	5.944.245,21	478.366,76	46.407.488,09	0,0001587186260%	1055631	288	Earthquake	E7

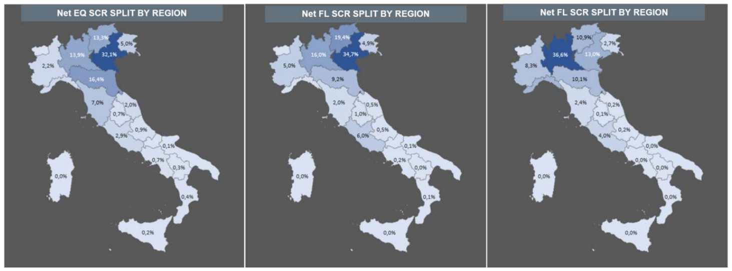
Uso Strategico Outputs Catastrofali

E’ lunga la serie di attività finalizzate all’uso strategico degli output derivanti dalla modellizzazione dei rischi catastrofali e in particolar modo del Rischio Terremoto.

Si possono estrarre gli outputs (Expected Loss, Std Deviation, CoV) derivanti da una modellizzazione del rischio terremoto relativamente ai “Vendor” ed agli “Alternative Vendor” Models, al minimo livello di dettaglio e considerando tutte le possibili combinazioni tra i vari Primary Modifiers (Area Geografica/Tipologia di Rischio/Materiale di costruzione/Anno di Costruzione).

Analizzando e lavorando sui data-outputs di dettaglio, si può fornire alle compagnie l’allocazione per ogni singolo rischio del portafoglio sia del costo della Riassicurazione “Netta” dello stesso che del costo “reale” della riassicurazione, secondo le seguenti formule:

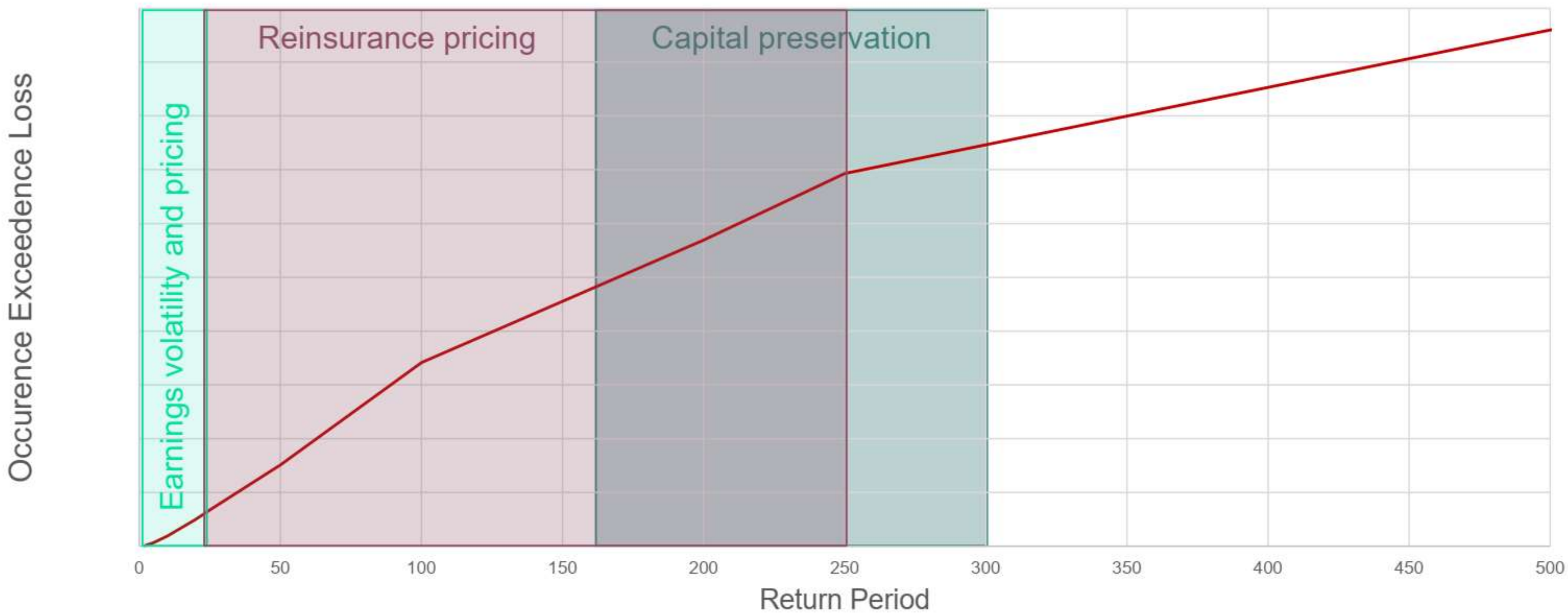
Net Expected Loss + **Cost of Net Capital** (Company RoE x Net VaR 200Years) + **Cost of Reinsurance** (Reins. Premium + Exspected Reinstatement Premium – Expected Recoveries) = **Net Cat Cost**



Oltre a report finalizzati alla rappresentazione dell’allocazione dei costi, si può dare supporto tramite l’utilizzo degli outputs di dettaglio per finalità di pricing della garanzia catastrofale:

- fornendo files dashboard in grado di dare indicazione sul premio equo di un singolo rischio considerando tutte le possibili combinazioni tra i vari Primary Modifiers (Area Geografica/Tipologia di Rischio/Materiale di costruzione/Anno di Costruzione,) e le varie condizioni di polizza (franchige, limiti)
- supportando le attività di selezione e sottoscrizione dei rischi catastrofali attraverso la costruzione di specifici Cat Score Index funzionali alla valutazione dell’impatto di ogni nuovo rischio sottoscritto sulla necessità di capitale della compagnia

Use of cat models for capital, reinsurance and underwriting decisions



Catastrophe models help address these questions that empirical data alone cannot

Advisory: Reinsurance Optimization

Risk/Reward Analysis

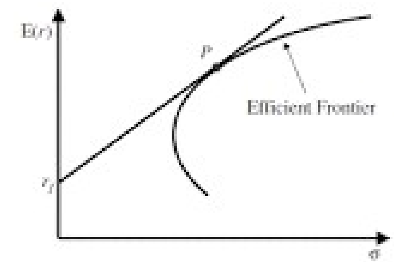
Struttura Efficiente

- Reins EVA
- Capital Relief
- Ceded RoE
- Ceded Margin

Frontiera Efficiente

- Reins EVA vs Capital Relief
- Ceded RoE vs Volatility Relief
- Ceded Margin vs Reins EVA

Efficient Frontier



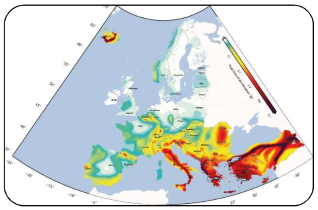
Reinsurance Solvency 2 Compliance Analysis

Riassicurazione vs Solvency2

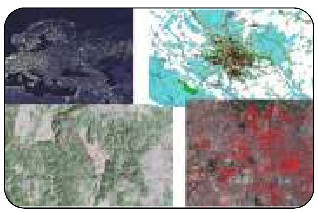
- SCR Sensitivity analysis
- Premium, Reserve and Cat SCR Optimization
- Counterparty default SCR Mitigation

Italy EQ Modelling: Alternative Vendor model - RED EQ Model

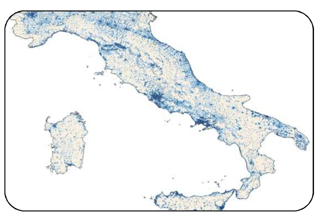
RED (Risk Engineering & Development), é una societá legata all-Universitá di Pavia che fornisce servizi forniti finalizzati alla valutazione ed alla modellizzazione di eventi catastrofali con particolare attenzione a terremoti ed alluvioni, RED ha collaborato con la societa specializzata messicana ERN - Evaluación de Riesgos Naturales y Antropogénicos per lo sviluppo del modello paneuropeo sul rischio sismico



- Nuovo HAZARD MODEL pienamente coerente con i risultati del progetto SHARE del 2014,
- Basato su un catalogo unico dei terremoti storici armonizzati per l'Europa e su un nuovo modello di sorgente sismica europea omogeneizzata
- Catalogo stocastico molto ampio con milioni di eventi simulati, garantendo in questo modo la stabilità delle stime di danno



- Nuovo database armonizzato di 300 CURVE DI VULNERABILITÀ basato sulle più recent studi empirici, analitici e ibridi sulla vulnerabilità degli edifici in tutta Europa, inclusi diversi progetti di ricerca finanziati dall'UE
- INDUSTRY EXPOSURE DATABASE ad alta risoluzione basato sulle informazioni più aggiornate sulle caratteristiche degli edifici in tutta Europa e sviluppato con l'ausilio di un nuovo set di dati GIS Open-Source,



- Presente sulle piattaforme R-Plus, Nasdqq, Oasis
- Combinazione di portafogli di diversa granularità
- AAL, PML,
- Piattaforma molto flessibile e output trasparente con funzionalità di reporting

Recent Developments in the EQ Insurance Market

Understanding	Tools
Lessons Learned	Market Trends

Building vulnerability lessons learned

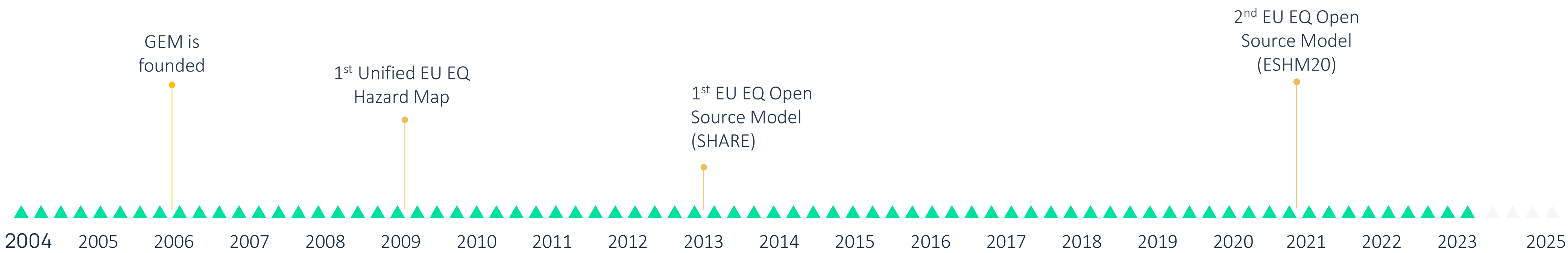
Often no shear walls, even in tall buildings

Very thin supporting columns

'Soft story' failure even in modern construction

Example construction with shear walls and strong beams

Past 20 Years – A Timeline

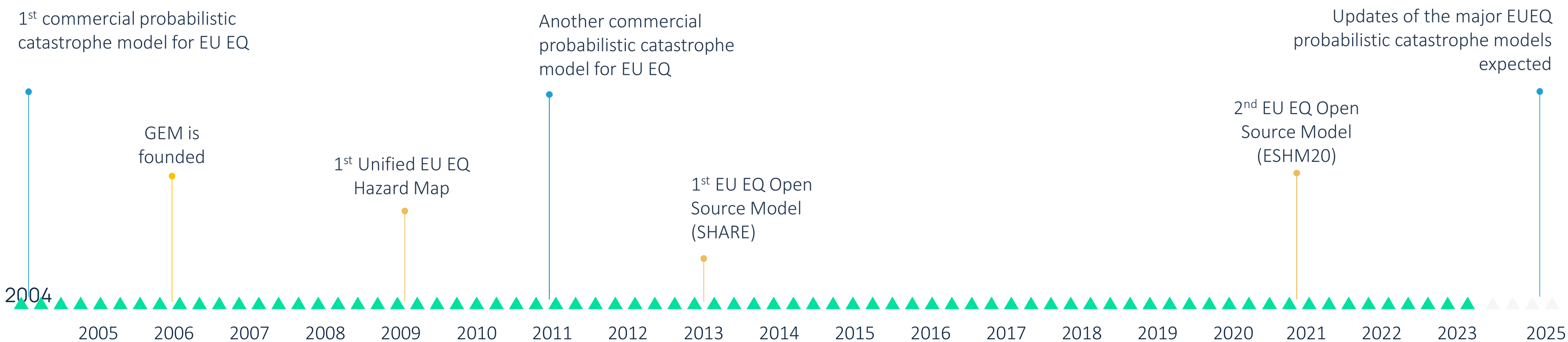


Understanding the risk

- 2006. The GEM Foundation (Global Earthquake Model) is founded
- 2009. The 1st EU wide seismic hazard map is published (Grunthal et al.)
- 2013. The 1st open source seismic hazard model is released (SHARE)
- 2021. The open source seismic hazard model is updated (ESHM20) and a seismic risk model is released (ESHR20)

→ Easily accessible and high quality research data now available to anyone

Past 20 Years – A Timeline



Understanding the risk

- 2006. The GEM Foundation (Global Earthquake Model) is founded
- 2009. The 1st EU wide seismic hazard map is published (Grunthal et al.)
- 2013. The 1st open source seismic hazard model is released (SHARE)
- 2021. The open source seismic hazard model is updated (ESHM20) and a seismic risk model is released (ESHR20)

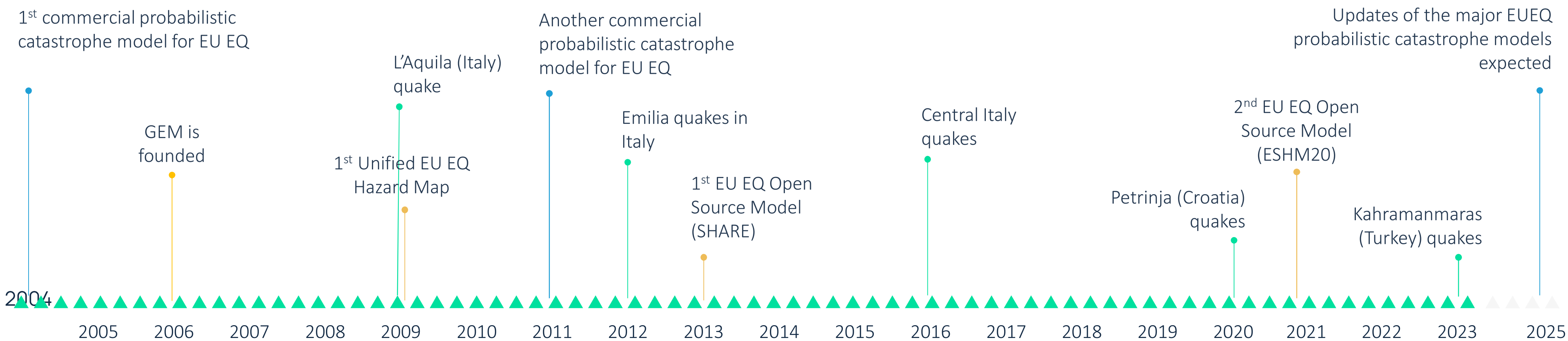
→ Easily accessible and high quality research data now available to anyone

Tools for the (Re)insurance ind.

- 2004. The first commercial probabilistic cat model is released
- 2011. A second commercial probabilistic cat model is made available to the industry
- 2025/26. Both major cat model used in the (re)insurance industry are expected to be updated in the near future

→ Multiple tools available to the (re)insurance industry for a technical evaluation of the risk

Past 20 Years – A Timeline



Understanding the risk

- 2006. The GEM Foundation (Global Earthquake Model) is founded
- 2009. The 1st EU wide seismic hazard map is published (Grunthal et al.)
- 2013. The 1st open source seismic hazard model is released (SHARE)
- 2021. The open source seismic hazard model is updated (ESHM20) and a seismic risk model is released (ESHR20)

→ Easily accessible and high quality research data now available to anyone

Tools for the (Re)insurance ind.

- 2004. The first commercial probabilistic cat model is released
- 2011. A second commercial probabilistic cat model is made available to the industry
- 2025/26. Both major cat model used in the (re)insurance industry are expected to be updated in the near future

→ Multiple tools available to the (re)insurance industry for a technical evaluation of the risk

Lessons learned (from past events)

- 2012. Emilia (Northern Italy) quakes – unexpected seismic deficiencies
- 2016. Central Italy quakes – performance of historical constructions
- 2020. Petrinja (Croatia) quake – powerful event in lower frequency area
- 2023. Kahramanmaras (Turkey) quakes – structural performance for high level of shaking

→ Uncertainty remains large // aftershock sequence, seismic code compliance, historical building vulnerability, etc.

Market Trends
(a selection)

1. Increase of technical underwriting for the earthquake coverage
2. Development of parametric products
3. Cat bonds
4. National pools

The availability of consolidated and reliable probabilistic earthquake models allows for a more accurate and consistent selection of the risk at underwriting.

Through the usage of advanced tools, quake portfolios can be more balanced overall:

Better risk selection and verification

- Proper evaluation of main structural characteristics (year of construction, material, height)
- Consideration of additional parameters

Better accumulation control

- Avoid unpredicted spikes in case of an event
- Reduce unwanted deviations from market average
- Control reinsurance expenses

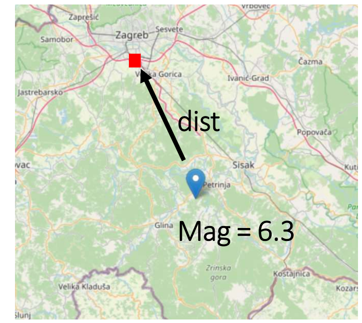
Market Trends
(a selection)

1. Increase of technical underwriting for the earthquake coverage
2. Development of parametric products
3. Cat bonds
4. National pools

Parametric insurance is an innovative approach to provide insurance that pays out on the basis of a predetermined index exceeding a pre-determined level (e.g. wind speed, magnitude, etc.). It suits particularly well to earthquake insurance.

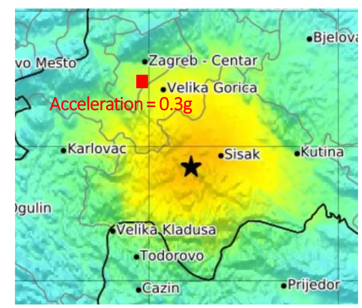
1st generation – Magnitude and distance

The policy pay out occurs only then the magnitude exceeds a certain threshold and the epicentral distance from the structure is below a max value.



2nd generation – local shaking intensity

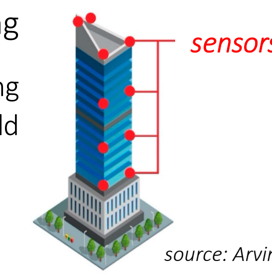
The policy pay out occurs only when the **estimated** local shaking intensity (eg. Acceleration) exceeds a certain threshold



source: adapted from INGV

3rd generation – structural health monitoring

The policy pay out occurs only when the **recorded** building acceleration exceeds a certain threshold



source: Arvindan et al. (2021)

Market Trends
(a selection)

1. Increase of technical underwriting for the earthquake coverage
2. **Development of parametric products**
3. Cat bonds
4. National pools

Parametric insurance is particularly suited for

- Financing of emergency management
- Business interruption coverage
- Municipality sector

mostly thanks to its transparent and rapid pay-out process:

Traditional (indemnity-based) insurance

Event occurs → Insured checks the damage → A claim is submitted → An adjuster checks the claim → A claim is paid based on adjuster report

Parametric insurance

Event occurs → 3rd party verifies the trigger → A claim is paid

Overall shorter process and less people and admin involved

However, parametric insurance is not suited to completely substitute traditional insurance because of the potential basis risk that is introduced (difference between claim payement and actual damage)

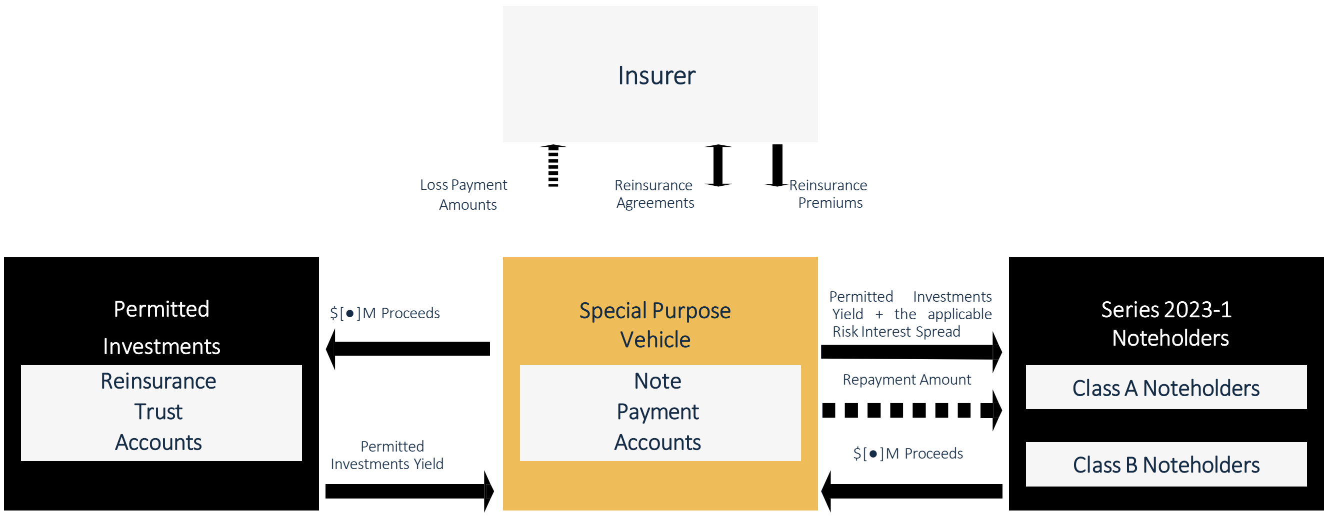
Market Trends
(a selection)

1. Increase of technical underwriting for the earthquake coverage
2. Development of parametric products
3. Cat bonds
4. National pools

Cat Bonds are a further financing tool utilized by (re)insurers to transfer risk to the capital markets. Sponsors who wish to transfer risk via a Cat Bonds setup a special purpose vehicle (SPV) with the legal authority to act as an insurer.

If a pre-defined trigger event occurs during the term of the bond, all or part of that principal is transferred to the sponsor, leading to a full or partial loss for investors. In the event no such event occurs, principal is returned to investors following expiration of the note

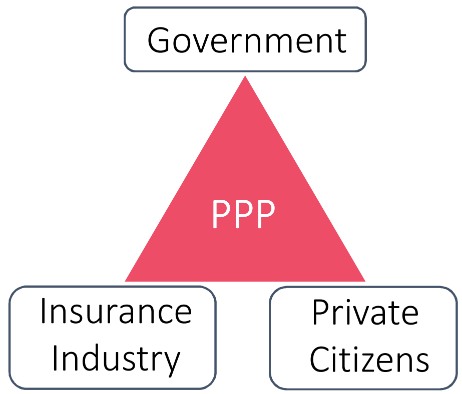
- Allows further diversification by transferring risk to markets
- Fit for large portfolios / public exposures
- Requires a rigorous and established risk evaluation process (EQ models for EU region are accepted and already used in previous Cat Bonds)



Market Trends
(a selection)

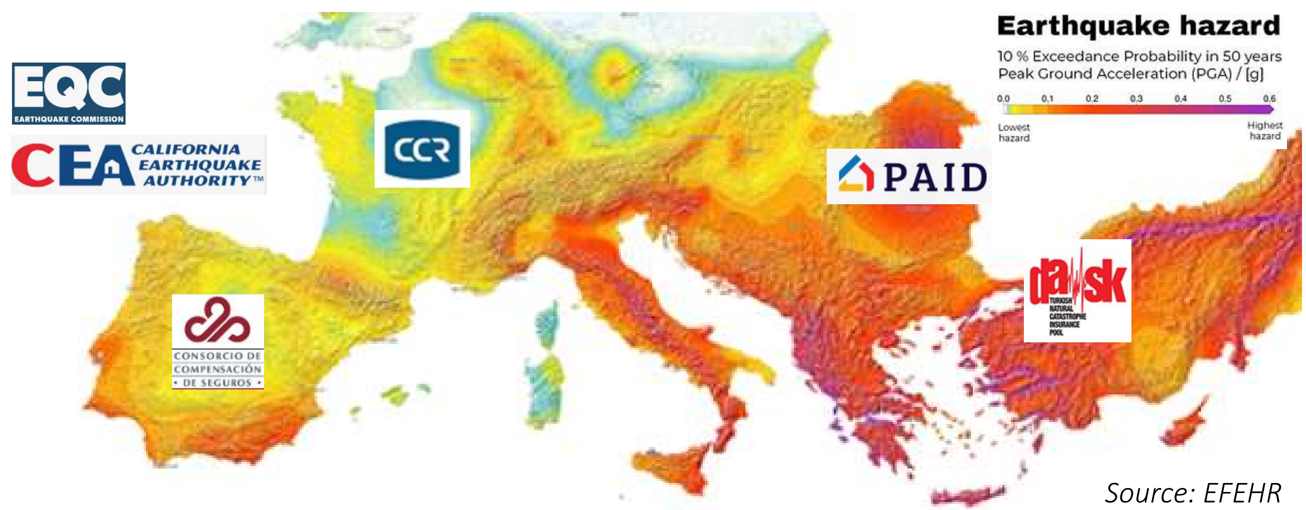
1. Increase of technical underwriting for the earthquake coverage
2. Development of parametric products
3. Cat bonds
4. National pools

Earthquake risk remains highly volatile and diversification remains essential. National pools can help in coordinate the management, reduction and transfer of the risk.



Many pools are based on a «public-private» partnership, with each player contributing to the scheme:

- Citizens, eg. Policy holders
- Government, eg. Management and partial risk taker
- Insurance Industry, eg. Distribution, claims, reinsurance, etc.



Source: EFEHR

Nuove Visioni di Rischio – Secondary Perils

Focus: Secondary Perils

Definizione di una visione alternativa del rischio Hail Italy su portafogli Property, MoD ed Agro derivante da scoring geospaziali su base scientifica derivante da collaborazioni con società proprietarie di Big Data in ambito Climate and Cat Events Management

Modello Hail Italy: Overview

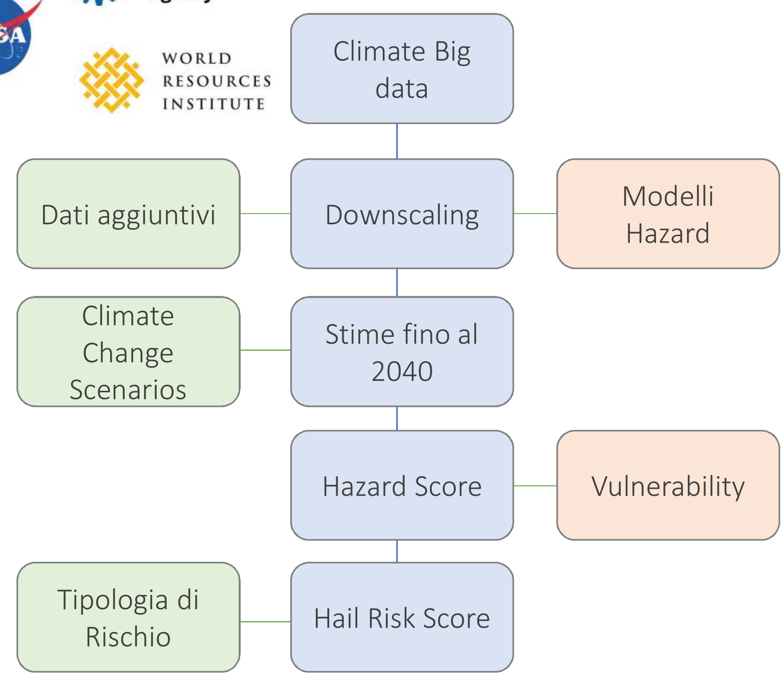
1. Downscaling dei big data climatici a bassa risoluzione attraverso un algoritmo geospaziale e dati ausiliari (quota, uso del suolo, ecc.)
2. Output derivanti da modelli Hazard Probabilistico
3. Scenari di cambiamento climatico da fonti internazionali (es. CMIP5-6, CORDEX) gli orizzonti temporali più lunghi
4. Le mappe di rischio risultanti sono riclassificate in punteggi (da 1 a 10) utilizzando criteri di vulnerabilità
5. Le mappe subclassificate per le varie tipologie di rischio costituisco la base per la generazione di scenari Hail probabilistici

JRC EUROPEAN COMMISSION

European Environment Agency

NASA

WORLD RESOURCES INSTITUTE



2023 – The costliest year for Nat Cat events

2023 has been characterized by a peculiar series of atmospheric events:

- a very warm and dry winter has been followed by exteme rainfall in May which led to a large flood event in Emilia Romagna – the largest flood event since the Po basin floods in 2000
- A series of severe storms in July have generated extemely large hails and extremely strong winds throughout the month – with a severity never recorded in the recent past

Insurance losses have been very significant making 2023 the costliest year for the market since the 2012 Emilia Romagna earthquake series.

It is estimated a total loss of about 2.8Bil Eur of insured losses for the May and July events combined. This amount largely exceeds the loss associated to atmospheric events that has been observed in the 2018-2022 period, which exhibited an average yearly loss in the 600-800mil Eur loss range per year.

The insurance and reinsurance markets are still elaborating the implications of the 2023 series of events, particularly in relation to the severity of the July storms. Initial interactions with reinsurers on the topic, however, already indicate a change of attitute by the markets in relation to the assessment and pricing of atmospheric perils in Italy.

Emilia Romagna Flood event 2023

A massive flood event hit the Emilia-Romagna region mid of May 2023. There have been 15 deaths and 36,000 people evacuated so far. The event featured an amount of rain falling in 36 hours generally observed in six months, and affected many cities and towns, including Bologna, Cesena, Forlì, Ravenna and Rimini; this was just two weeks after a previous flood event of lower impact that involved the city of Faenza.

Significant damages were registered both on agricultural production (Emilia Romagna has some of the most productive agricultural areas of the entire territory) and on industrial areas, infrastructure and energy facilities.

Moreover, the cancellation of the F1 Grand Prix in Imola was also noted. More than 300 landslides resulting from the flood event were also recorded.

Historically, Norther Italy has been familiar with such events. Indeed, it is recalled the event that hit Polesine in the 1950s and the event in Florence in the 1960s.

Emilia Romagna Flood event 2023

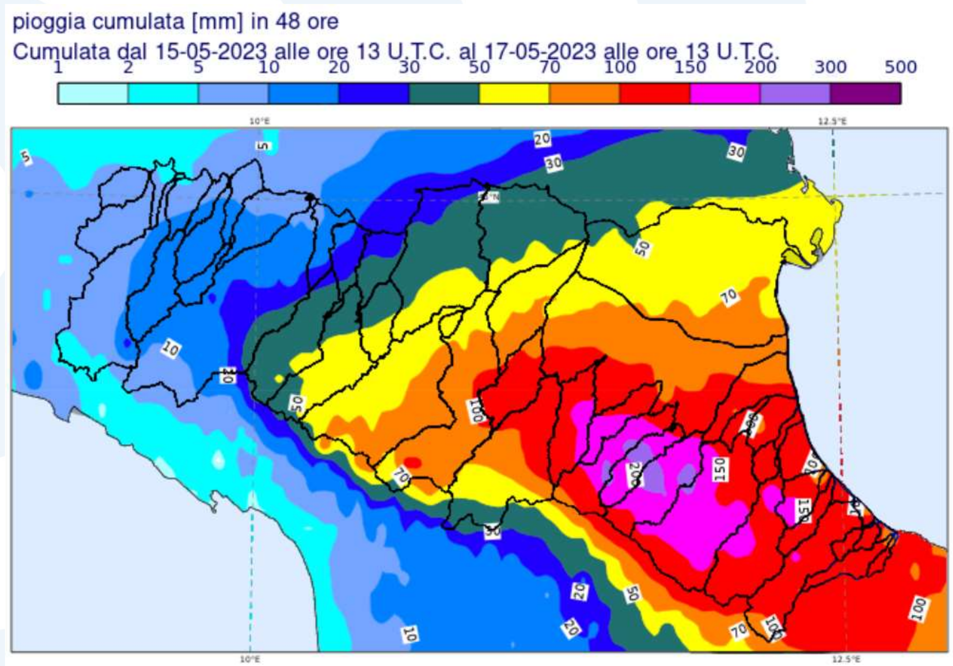
The event that led to the severe weather and heavy rainfall in Emilia-Romagna was named Minerva by the Meteorological Operations Center (CNMCA).

In the previous months, the region was heavily affected by drought conditions that led to dry soils and, consequently, reduced permeability. The region was then hit by heavy rains in early May that caused flash flooding and saturated soil.

Between Monday, May 15 and Wednesday, May 17, in some areas an average of 200 mm of rain fell in 36 hours, meanwhile in Forlì, Cesena and Ravenna, 500 mm of rainfall has been registered. This is equivalent to almost half of the average total annual rainfall for this region.

The heavy rains caused high levels of river flows; 24 rivers and affluents have exceeded their dikes.

During the highest alert period, cumulative rainfall peaks were recorded, with levels between 200 mm and 300 mm, with peaks of 500 mm corresponding to 50% of the annual total.



Source: https://allertameteo.regione.emilia-romagna.it/cumulativa-48#map-toolbar time-player--dato-osservato--cumulata-48h

Emilia Romagna Flood event 2023

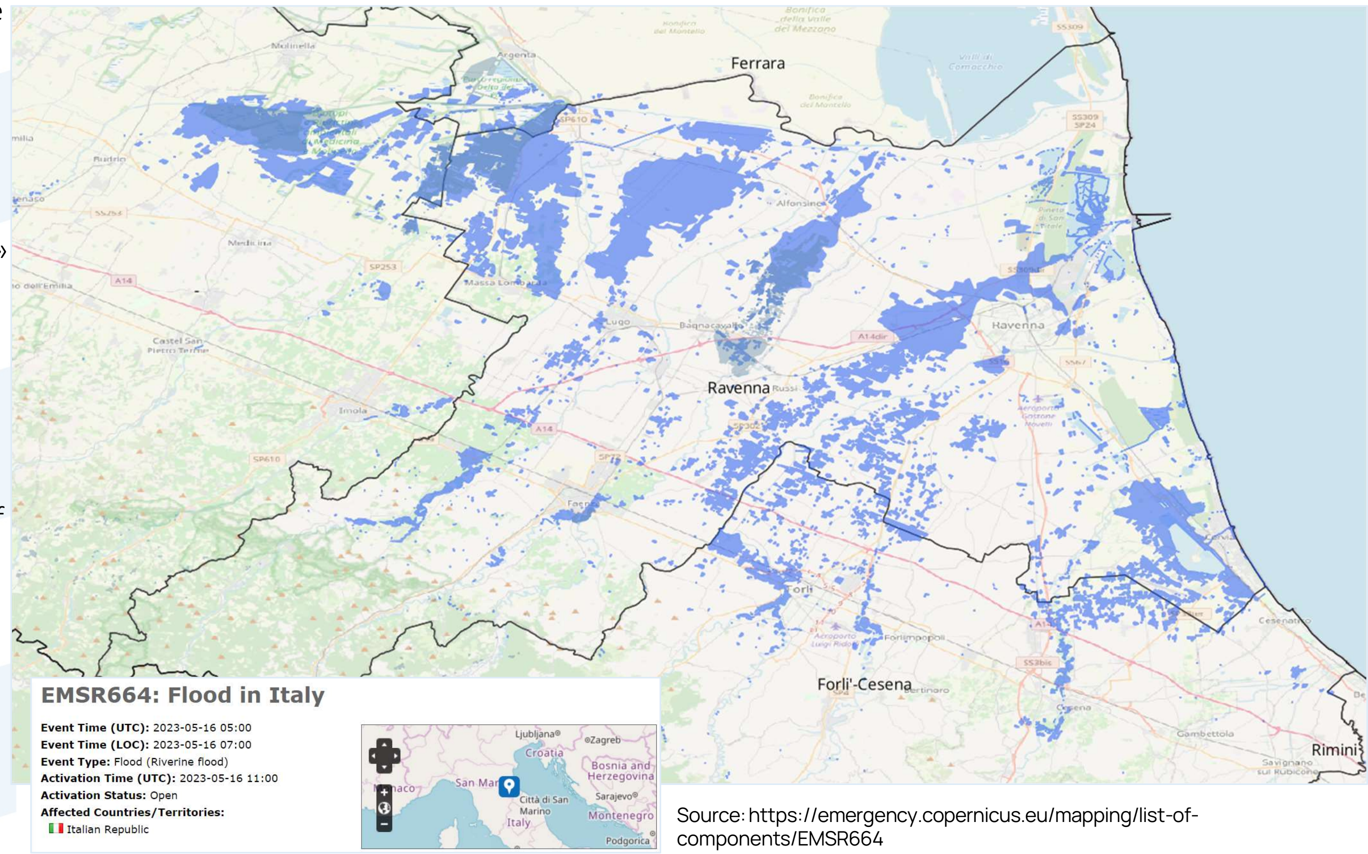
Satellite Maps

Following the event, satellite maps of the flooded area have been provided by Copernicus, the satellite service from the EU.

Copernicus maps and publicly available (shown on the right).

Satellite maps allow to perform an immediate «post event» analysis and to have an overview of impacted areas. However, the uncertainty correlated to the usage of such maps should also be considered (related to technology used, avaliability of satellites at the moment of the event, weather conditions and clouds, etc.).

Moreover Copernicus maps only provide the delineation of the flood extent, with no additional information regarding other flood parameters (eg. Water depth, flood duration, debries, etc.)



Source: https://emergency.copernicus.eu/mapping/list-of-components/EMSR664

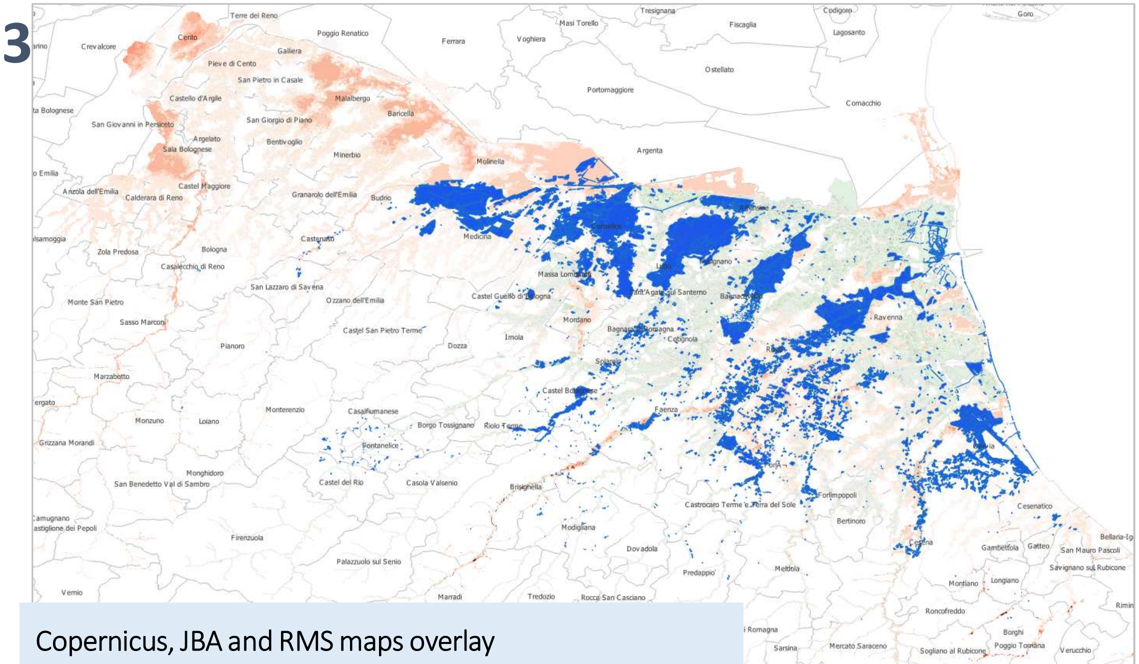
Emilia Romagna Flood event 2023

Vendor Maps

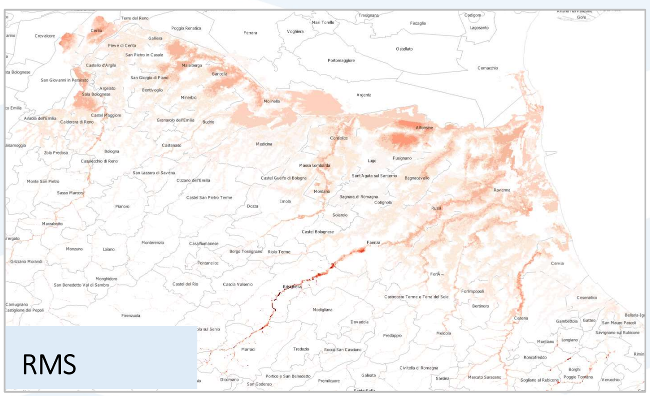
Model vendors have also provided their own post-event flood map estimate.

It should be highlighted that vendor maps are not based on satellite and/or on site information, but rather on pre-run numerical simulations, adapted to the characteristics of the Emilia event. Vendor maps, however, provide flood depth.

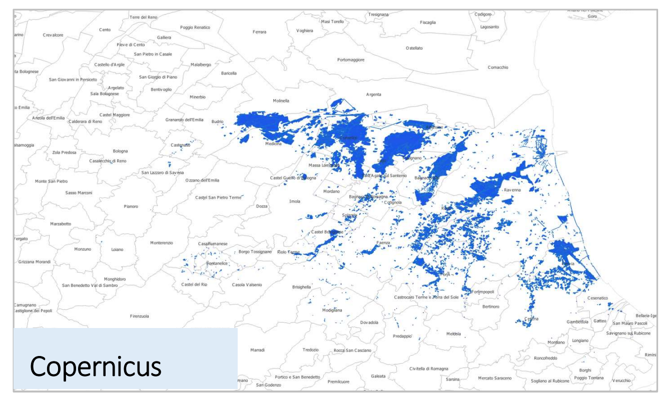
The image to the right overlays **Model Vendor Maps and Copernicus,** highlighting **significant differences in terms of estimated flood extent by the three providers.**



Copernicus, JBA and RMS maps overlay


RMS


JBA

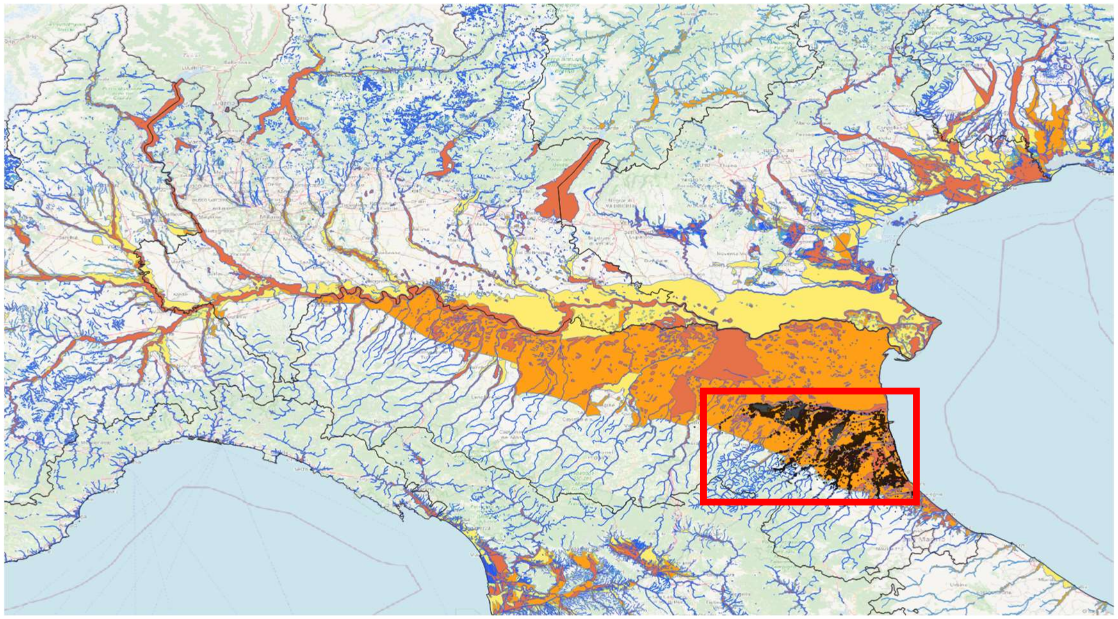

Copernicus

Emilia Romagna Flood event 2023

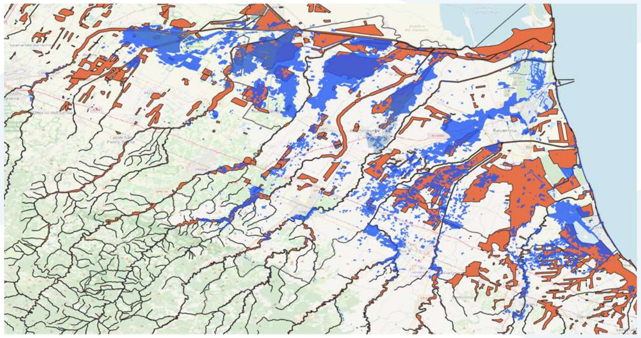
Flood hazard of the affected area

The maps to the right and bottom overlay the Copernicus post-eventflood map and the ISPRA national flood hazard map. ISPRA hazard maps define three level of flood frequency, low (yellow), medium (orange), high (dark orange).

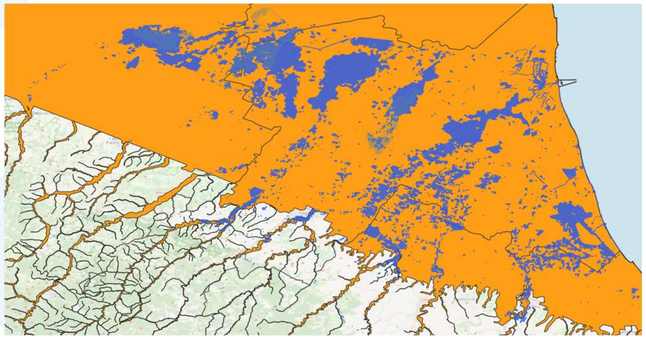
The comparison **shows that a large portion of the impacted areas appear to be outside the High Frequency zone (20 years return period)**, even though they fall weel within the Medium Frequency zone (50 years return period)



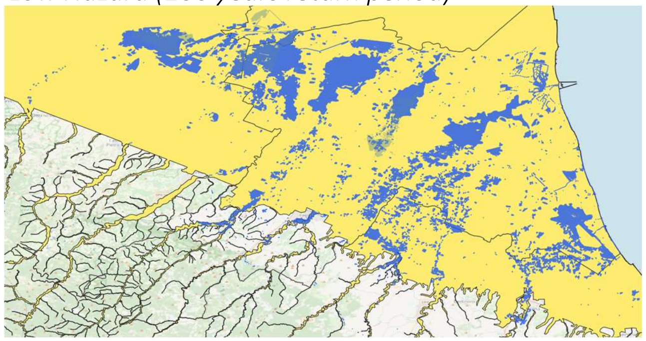
High Hazard (20 years return period)



Medium Hazard (50 years return period)



Low Hazard (100 years return period)



Emilia Flood event 2023

Historical flood comparison

By considering the period between 2010 and July 2022 only, Italy experiences 1.318 severe events with serious consequences for land and citizens, 516 floods from heavy rainfalls, 367 damages caused by windstorms, 123 river floods and 55 landslides due to heavy rainfalls.

Preliminary data comparison approximates the Emilia Romagna event to the two largest floods occurred in November 1994 and October 2000, which have resulted in the largest insurance loss so far.

Event	Area	Deaths	Evacuated	Economic loss (Eur M)	Insurance Loss (Eur M)
May 2023	**Emilia Romagna**	**15**	**36.000**	~~**5.000**~~ **(*)** **8.860**	**(?)**
October 2011	Liguria, Toscana	6	1.183	1.170	260
October 2010	Veneto	3	3.350	426	50
October 2000	Piemonte, Val d'Aosta, Liguria, Lombardia	34	40.000	4.140	460
November 1994	Piemonte	70	2.226	6.460	450

(*) The most recent official estimates have raised the total economic loss from initial press figures of 5Bil Eur to 8.86Bil Eur (Government estimate on 16/06/23). The total economic loss estimates are split as follows:

- 4.3Bil Eur for emergency management, infrastructures and territory recovery
- 2.1Bil Eur for residential and private owners
- 1.2Bil Eur for commercial and industrial business
- 1.1Bil Eur for agro business

Italy Flood Modelling: JBA Flood Model

- JBA é una societá UK che produce tool di simulazione stocastica degli Eventi Alluvione.
- Rappresenta il leader globale nel Flood Modelling
- Il Modello JBA Global Flood Model include anche l'Italia

- Il Global Flood Model di JBA è il primo nel suo genere.
- Capacità unica di modellare gli eventi legati ai bacini fluviali ed alle atre tipologie di superficie (pluviali) con una risoluzione di 30 m

- Il Global Flood Model colma le lacune lasciate dai modelli catastrofali attualmente disponibili, offre un'alternativa ai modelli esistenti

- Il Global Flood Model utilizza la Global Flood Map e il Global Flood Event Set di JBA, leader di mercato, che incorporano oltre 15 milioni di eventi idrologici . Il modello permette inoltre di determinare i risultati sulla base di diverse tipologie di clausole orarie.

- Il modello è alimentato dalla tecnologia FLY, il rivoluzionario motore di analisi di JBA, che fornisce nuovi livelli di personalizzazione

RMS HD - Italy Flood and Severe Convective Storm

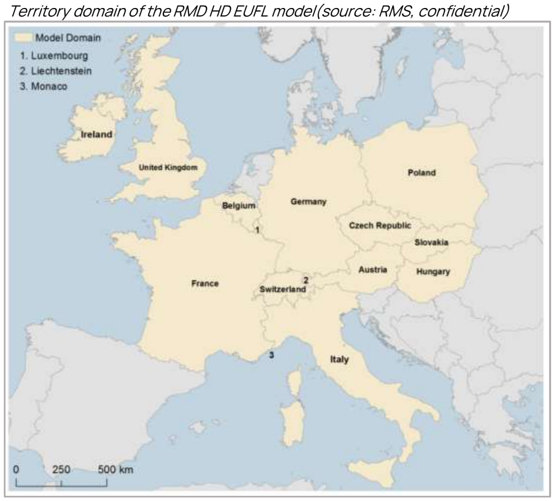
In the recent past RMS has developed and released a comprehensive modelling solution for atmospheric perils in Europe, namely the RMS HD European Flood model (released in 2016 (Italy in 2018) and then updated in 2020) and the RMS HD European Severe Convective Storm model (released in 2022).

Both models cover Italy and provide a complete view on riverine and flash flood (part of the FL model) and on hail, straight line wind and tornado (part of the SCS model), which are all relevant source of damage for the Italian territory. The models run on the recent RMS platform called HD, which allows for a rigorous implementation of uncertainty, temporal characteristics of the perils and contract hour clauses.

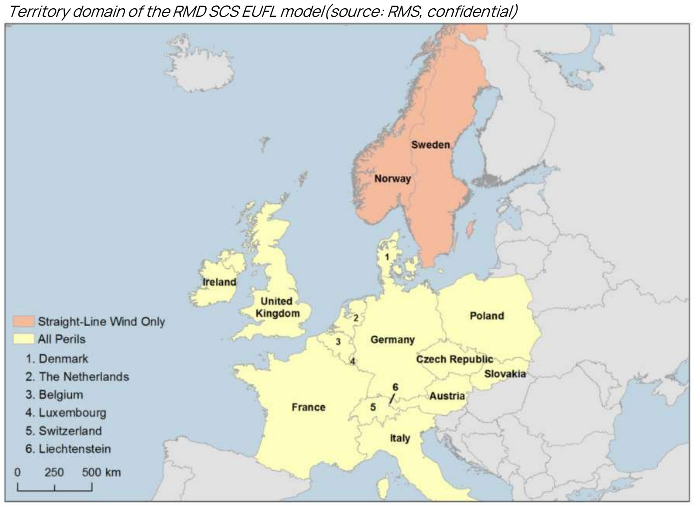
RMS HD model usage in support of reinsurance transactions in Italy has been limited in the past, also because models have been released only very recently. The two models, however, provide an out-of-the-box 360 degree modelling solution to the atmospheric perils in Italy, developed by well renown vendor.

The RMS HD atmospheric peril model set could be used to provide an analytical perspective to the May and July loss and estimate a loss return perils in the wider insurance market context.

Territory domain of the RMD HD EUFL model(source: RMS, confidential)



Territory domain of the RMD SCS EUFL model(source: RMS, confidential)



Highlights of the new RMS HD SCS model (source: RMS, confidential)

Three Models in One
- Comprehensive list of sub-perils, including hail, straight-line wind, and tornado
- Seasonality of events
- Cross-sub-peril and cross-country correlation

Engineering-Based Vulnerability
- 3000+ country-specific vulnerability curves
- 33 secondary modifiers
- Enhanced secondary uncertainty enables realistic claims distribution

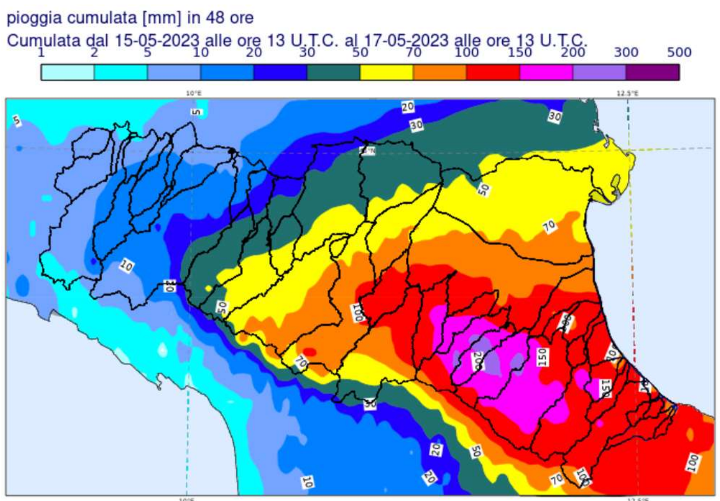
All Lines of Business and Coverages Are Modeled
- Residential, commercial, industrial, agricultural, and automobile lines
- Building, contents, and business interruption coverages

New HD Financial Model
- All financial perspectives
- Bespoke hours clauses and other time-dependent terms
- Model extensively validated against both component and loss datasets

Emilia Romagna Flood in May – Market Loss

A massive flood event hit the Emilia-Romagna region mid of May 2023. There have been 15 deaths and 36,000 people evacuated. In the previous months, the region was heavily affected by drought conditions that led to dry soils and, consequently, reduced permeability.

Between Monday, May 15 and Wednesday, May 17, in some areas an average of 200 mm of rain fell in 36 hours, meanwhile in Forlì, Cesena and Ravenna, 500 mm of rainfall has been registered. This is equivalent to almost half of the average total annual rainfall for this region. The heavy rains caused high levels of river flows; 24 rivers and affluents have exceeded their dikes.



During the highest alert period, cumulative rainfall peaks were recorded, with levels between 200 mm and 300 mm, with peaks of 500 mm corresponding to 50% of the annual total. (source: Arpa Emilia Romagna)

It has been performed a post event assessment to estimate the total damage of the insured market using three alternative flood maps (RMS, JBA, Copernicus).

- The Market loss (Property + MOD) is estimated to be 655Mln Eur in average (respectively EUR 867Mln for RMS, EUR 615Mln for JBA and EUR 482Mln for Copernicus)
- For all the three different maps, the largest damaged area is Ravenna.

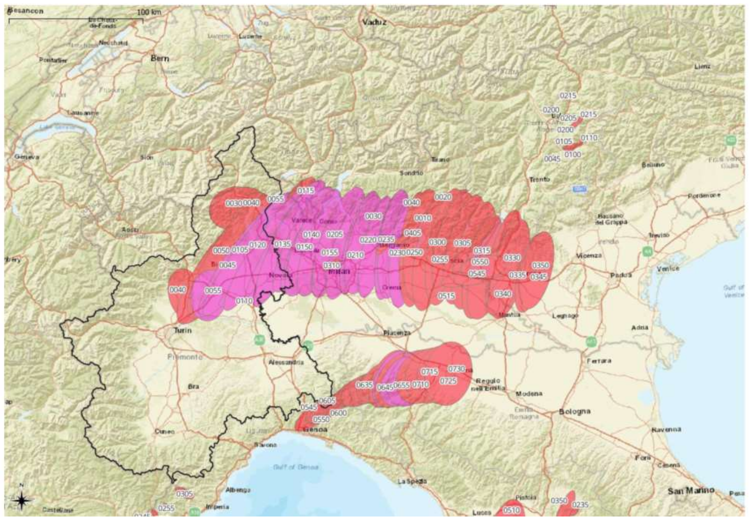
Type of Risk	RMS Incurred Loss Estimate	JBA Incurred Loss Estimate	COPERNICUS Incurred Loss Estimate	AVERAGE Incurred Loss Estimate
COM and IND	614.81	461.00	378.46	484.76
Residential	87.43	59.11	56.81	67.78
Others	91.76	57.81	16.86	55.48
Total Property	**793.99**	**577.93**	**452.12**	**608.01**
Total MOD	**73.57**	**36.99**	**30.33**	**46.97**
Total	**867.56**	**614.92**	**482.45**	**654.98**

TSI in Mln of Euro

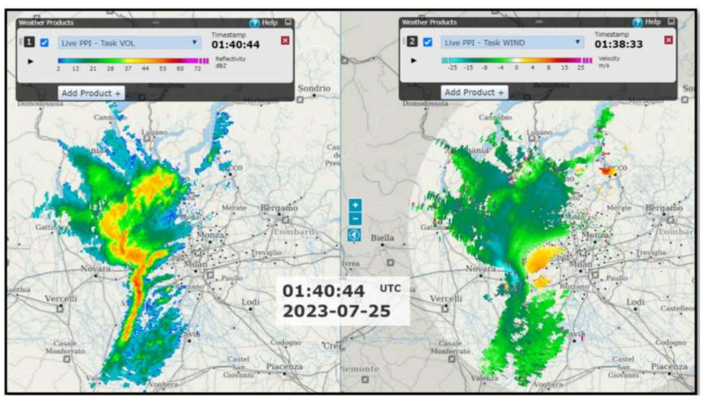
Source: Howden

North Italy Severe Convective Storms in July – Market Loss

Hail intensity distribution over North Italy during the 25th of July



Wind speed distribution in Milan early in the morning of the 25th of July



Graph Source: Arpa Piemonte and Arpa Lombardia

The entire month of July has been characterized in multiple occations by hot air masses originating from North Africa moving across the Mediterranean sea and gaining significant humidity, which then encountered colder air masses in the North of Italy originated from a large depressionary system over North Europe.

The interaction of these two masses with significantly different humidity and temperature characteristics has favoured the development of powerful and extensive storms across North Italy. The complex systems of storms could be categorized into three distinct moments:

- July 3 to 6
- July 12 to 14
- July 18 to 25

In all cases the storms were associated with strong hail with very large stone size, powerful winds (exceeding 30 m/s) and very dense thunderstorm patterns.

The most damaging storm has cenrtainly been the one centered around the 25th of July. Based on an initial market reconnaissance, it is estimated an insured loss of about 1.5Bil Eur for the 25th of July event.

For the entire month of July, it is estimated an insured aggregated loss of about 2.2Bil Eur.

Loss estimates are to be considered as preliminary as based on a mix of reserved and loss adjusted claims and full develpment of the claims is still to be completed.

Source: Howden

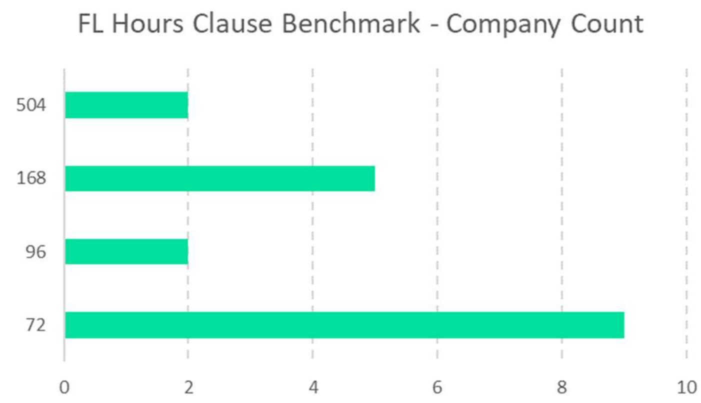
Hours Clause Benchmark - Italy

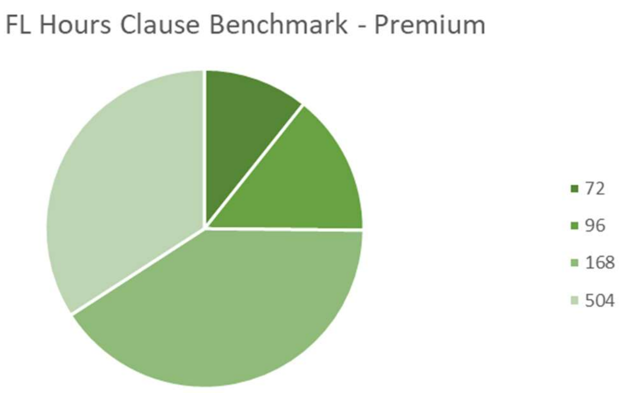
There is not a single standard for hours clause in the Italian market and different companies have different durantions and/or additional constraints in the event definition (eg. geographical)

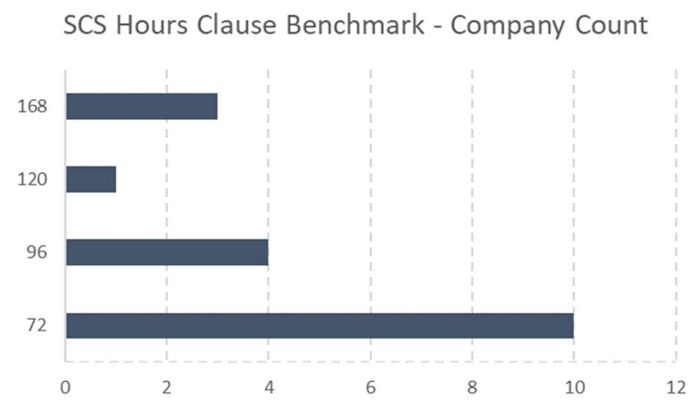
Howden has performed a benchmark study on hours clauses for the flood and severe convective storm peril based on market intelligence, the results of which is reported in the charts to the right. The data reported includes both national and multinational companies with operating entities in Italy.

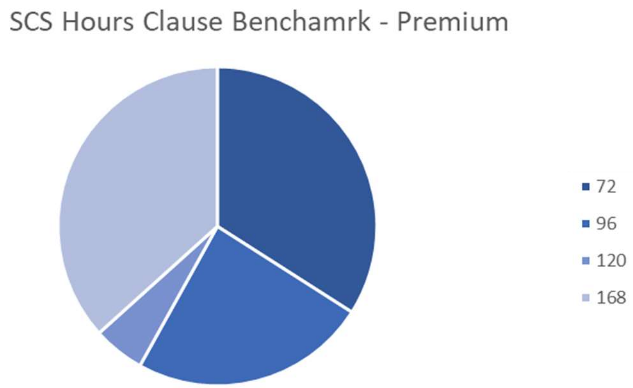
The most common hours clauses are 72h/96h or 168h with some exceptions (see bar charts with company count by hours clause duration).

The distribution of hours clauses by total premium volume is however different (see pie charts to the right), which indicates different hours clause standards by company size.









Source: Howden

Model Results – Hours Clause Sensitivity

RMS HD SCS

Italy Hail - RMS HD SCS v 1.0 - High Vuln

Hours Clause	IT Hail - 168h	IT Hail - 72h	Variation
TSI	7,450,027	7,450,027	0.0%
RMS HD v1.0 - OEP			
2	248.89	224.13	-9.9%
5	494.38	462.51	-6.4%
10	741.51	700.56	-5.5%
20	1,051.36	1,014.55	-3.5%
25	1,165.17	1,120.03	-3.9%
50	1,588.44	1,533.14	-3.5%
100	2,203.83	2,151.40	-2.4%
200	**2,986.04**	**2,919.33**	**-2.2%**
250	3,247.21	3,205.63	-1.3%
500	4,330.85	4,283.33	-1.1%
1,000	5,533.16	5,473.79	-1.1%
RMS HD v1.0 - AEP			
2	732.07	732.07	0.0%
5	1,162.46	1,162.46	0.0%
10	1,506.63	1,506.63	0.0%
20	1,900.57	1,900.57	0.0%
25	2,052.13	2,052.13	0.0%
50	2,526.75	2,526.75	0.0%
100	3,144.85	3,144.85	0.0%
200	**3,975.73**	**3,975.73**	**0.0%**
250	4,285.38	4,285.38	0.0%
500	5,184.03	5,184.03	0.0%
1,000	6,400.38	6,400.38	0.0%
RMS HD v1.0 - STATS			
AAL	878.66	878.66	0.0%
StdDv	614.76	614.76	0.0%

** value in Mln Euro*

RMS HD FL

Italy Flood - RMS HD FLOOD v 2.1

Hours Clause	IT Flood - 168h	IT Flood - 72h	Variation
TSI	2,847,790	2,847,790	0.0%
RMS HD v2.1 - OEP			
2	12.98	12.64	-2.6%
5	110.67	105.20	-4.9%
10	262.40	247.85	-5.5%
20	529.04	494.79	-6.5%
25	655.84	606.26	-7.6%
50	1,170.33	1,041.18	-11.0%
100	1,923.78	1,684.10	-12.5%
200	**3,012.39**	**2,608.24**	**-13.4%**
250	3,361.17	2,972.68	-11.6%
500	4,818.28	4,039.25	-16.2%
1,000	6,137.74	5,338.37	-13.0%
RMS HD v2.1 - AEP			
2	16.58	16.58	0.0%
5	147.33	147.33	0.0%
10	346.10	346.10	0.0%
20	683.33	683.33	0.0%
25	828.08	828.08	0.0%
50	1,439.15	1,439.15	0.0%
100	2,336.31	2,336.31	0.0%
200	**3,578.23**	**3,578.23**	**0.0%**
250	4,026.33	4,026.33	0.0%
500	5,694.76	5,694.76	0.0%
1,000	7,356.23	7,356.23	0.0%
RMS HD v2.1 - STATS			
AAL	158.51	158.51	0.0%
StdDv	565.25	565.25	0.0%

** value in Mln Euro*

A specific sensitivity analysis has been performed for both the the SCS and FL peril, using the 168h and 72h hours cluases as alternatives.

As shown in the tables to the right, SCS results show only a fairly limited sensitivity to hours clause at long return periods (eg. 200y).

A larger sensitivity is shown by the FL model results, which decrease by more than 13% at 200y Rp if the hours clause is reduced from 168h to 72h.

The different sensitivity of the results of the two perils is in line with expectations, considering the flood events are generated and develop over a longer period of time compared to severe convective storms.

Source: Howden