Physics-Guided Open-Data CAT Bond Trigger Design

for European Earthquake and Flood Risk (EuroCatFM)

Insurance Data Science Conference · Hannover · 10 June 2026

Grace Rigamonti Osorno · University of Macerata

Section A earthquake + Section B flood

Open data | **Hybrid / parametric trigger prototypes** | **Basis-risk diagnostics** | **Technical fair-coupon prototypes**

From public hazard/loss data to risk-transfer prototypes

1 Open data → **2** Tail calibration EVT/POT → **3** Dependence upper tail → **4** Trigger layer OR/AND or ramp → **5** ECB curve discounting → technical fair-coupon prototype

Earthquake module

OpenQuake event-loss books → portfolio total structural loss → loss–magnitude tail dependence → hybrid OR/AND trigger → ECB curve discounting → technical fair-coupon prototype.

Flood module

HANZE event loss + GISCO/NUTS + EFAS event-region → EVT and tail dependence → scaled-ramp trigger → ECB curve discounting → technical fair-coupon prototype

Boundary	Used	Not claimed
Data	Public loss/hazard	No proprietary claims microdata
Pricing	Risk-based technical fair coupon	No market-clearing ILS spread
Geography	Diagnostic country/event-region layer	No sovereign issuance claim

Country layer: geography diagnostics

OpenQuake / ESRM20/ESHM20 footprint logic: countries define diagnostic pools; portfolio-total event losses remain the pricing unit.

44 country/geography units

223,158 country + structural rows

Group 1 - Euro-Mediterranean pool | 23 units · 200,264 country-structural rows

Countries/geographies: Albania; Andorra; Austria; Bosnia and Herzegovina; Bulgaria; Croatia; Cyprus; France; Gibraltar; Greece; Italy; Kosovo; Latvia; Malta; Monaco; Montenegro; North Macedonia; Portugal; Serbia; Slovenia; Spain; Switzerland; Türkiye.

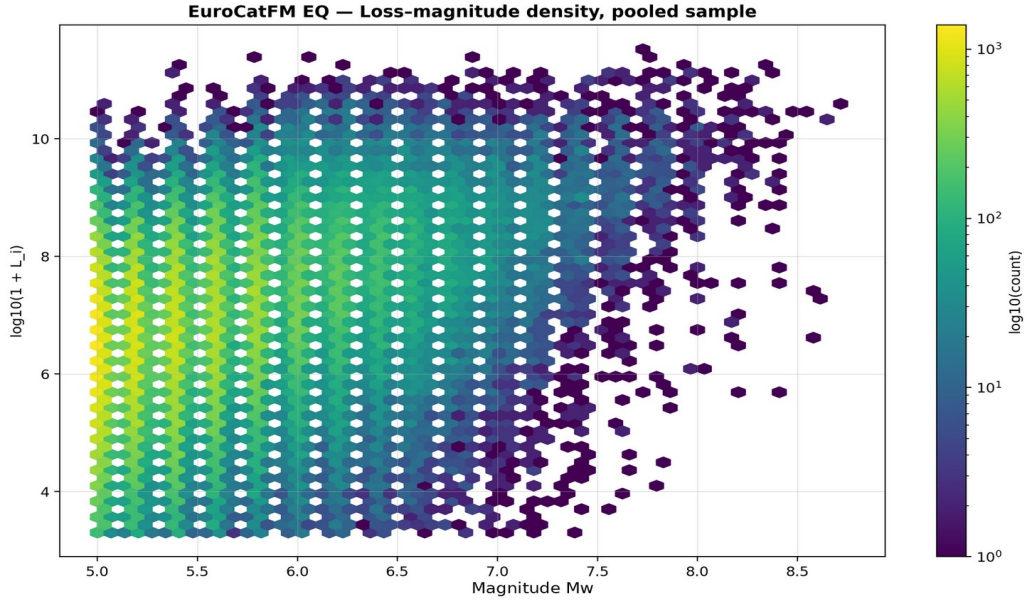
Group 2 - Central / Northern Europe pool | 20 units · 20,715 rows

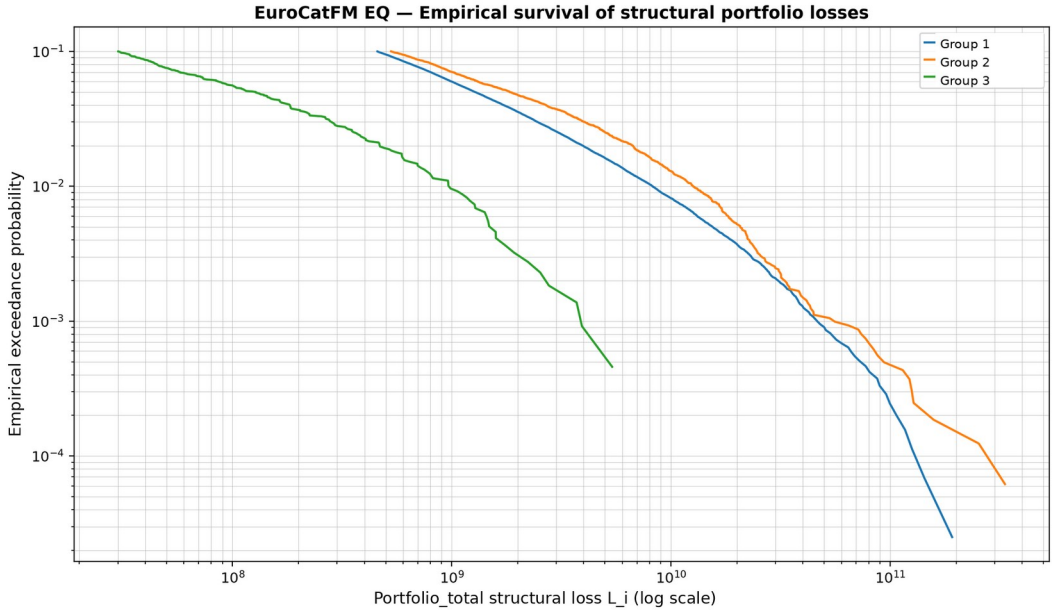
Countries/geographies: Belgium; Czechia; Denmark; Estonia; Finland; Germany; Hungary; Ireland; Isle of Man; Liechtenstein; Lithuania; Luxembourg; Moldova; Netherlands; Norway; Poland; Romania; Slovakia; Sweden; United Kingdom.

Group 3 - Iceland sleeve | 1 unit · 2,179 rows | Iceland

Portfolio structural loss–magnitude pairs are the pricing unit

Country rows explain risk composition; portfolio total rows price the risk-pool prototype.



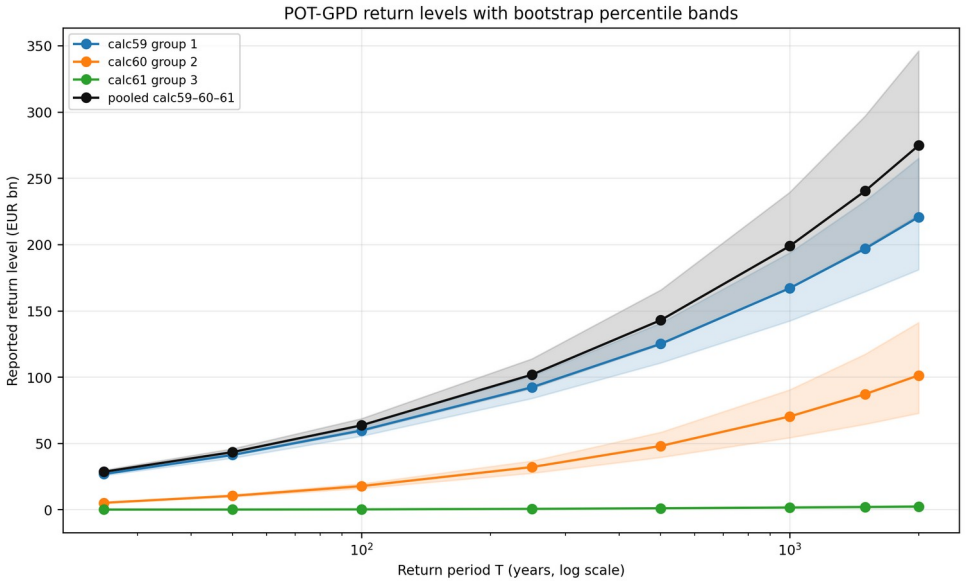


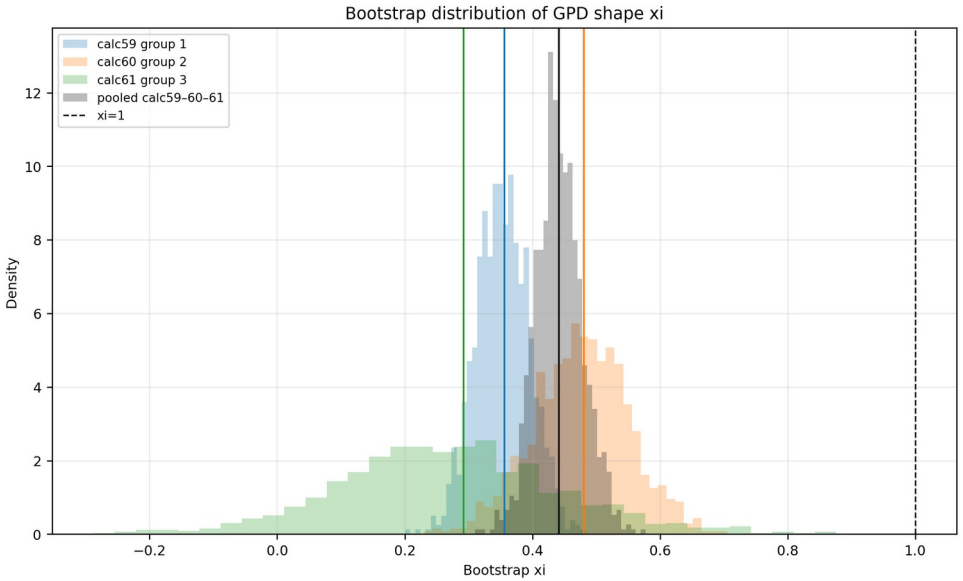
Risk pool	N	P 99.9% loss	Max loss	Mw max	Kendall τ
Group 1	159,636	€46.429bn	€227.900bn	8.75	0.245
Group 2	16,151	€51.774bn	€334.175bn	8.40	0.244
Group 3	2,179	€3.547bn	€5.396bn	7.75	0.201
Pooled	177,966	€45.956bn	€334.175bn	8.75	0.235

Earthquake modelling uses 177,966 portfolio total + structural event-loss–magnitude pairs.

EVT converts modelled losses into tail-severity layers

Threshold selection uses stability, goodness-of-fit and finite-CVaR checks.



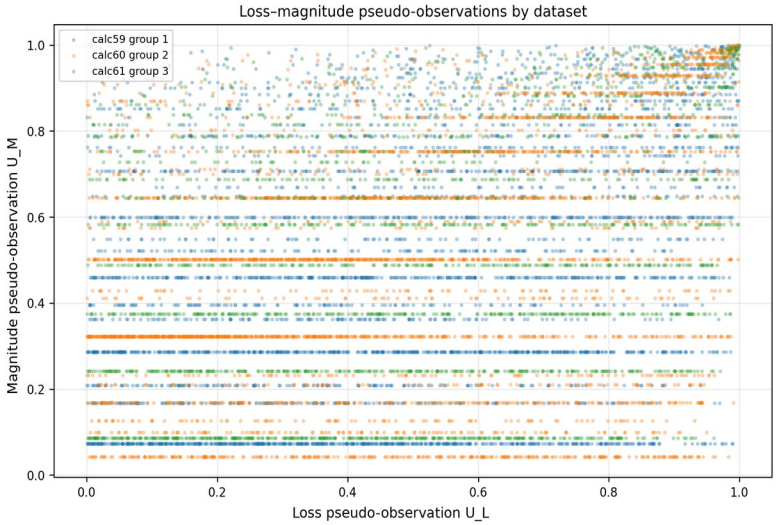


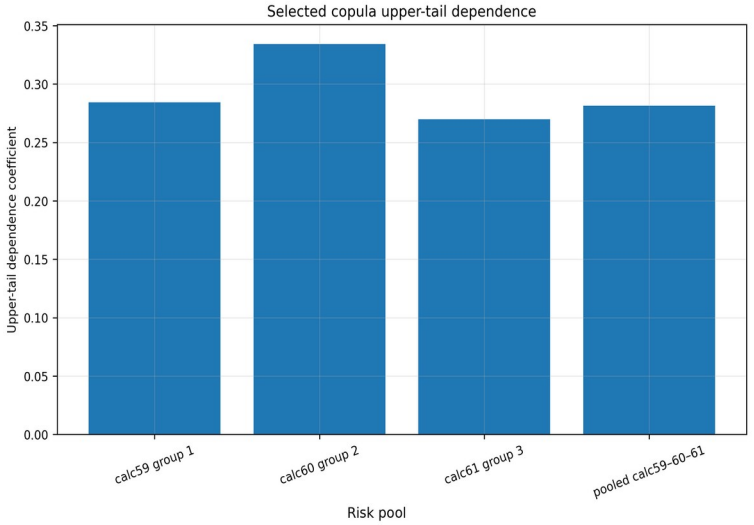
Pool	u	ξ	β	VaR 99.5%	CVaR 99.5%
Group 1	€15.520bn	0.356	€14.347bn	€15.535bn	€37.827bn
Group 2	€5.030bn	0.481	€6.374bn	€20.519bn	€47.119bn
Group 3	€0.353bn	0.292	€0.550bn	€1.493bn	€2.742bn
Pooled	€11.351bn	0.442	€10.768bn	€16.135bn	€39.212bn

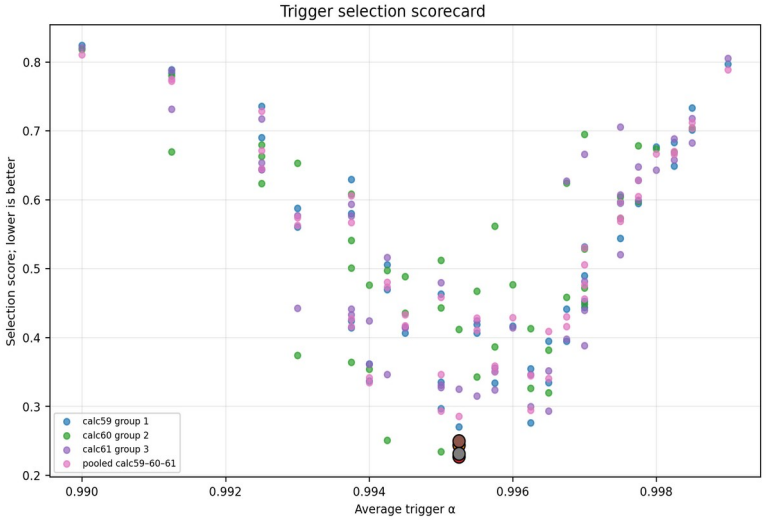
All selected earthquake tail indices are positive and below one: heavy tails are material, but point-estimate CVaR is finite.

Tail dependence is the bridge from hazard physics to trigger design

Rank-scale copula diagnostics protect the model from loss-scale distortions.





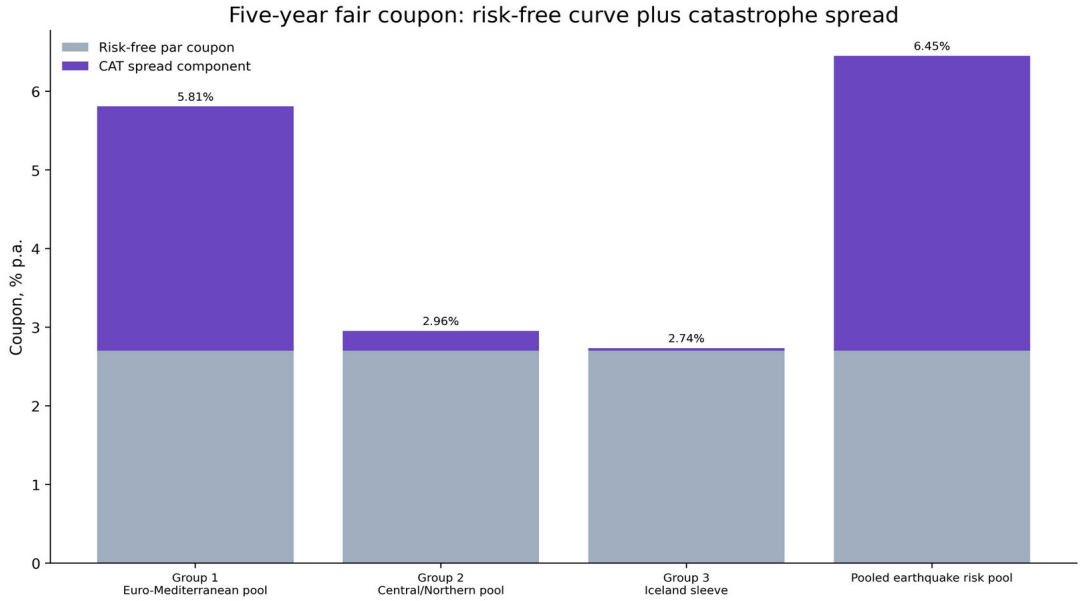


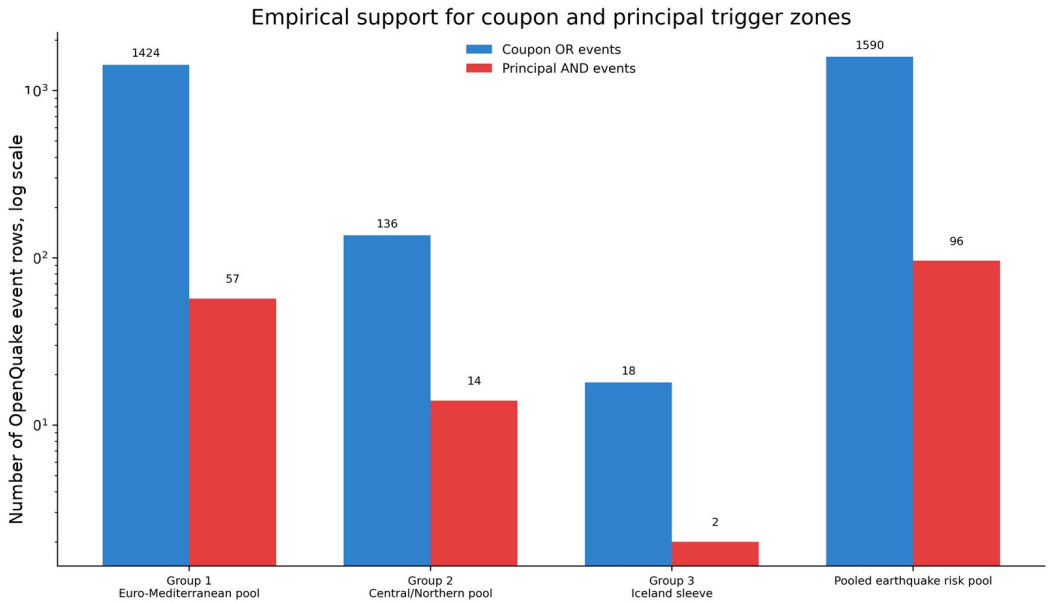
Pool	Selected Copula	λU	Tr_L	Tr_M	Annual OR	Annual AND
Group 1	Gumbel	0.284	€10.855bn	7.75	12.541%	1.393%
Group 2	Gumbel	0.334	€15.428bn	7.80	1.305%	0.148%
Group 3	Gumbel	0.270	€2.421bn	7.15	0.174%	0.019%
Pooled	Gumbel	0.281	€11.353bn	7.75	14.089%	1.658%

The trigger split is deliberate: OR is the more responsive coupon layer; AND is the stricter principal-risk layer.

Technical fair coupon is explained by frequency, severity and trigger activity

Output is a risk-pool prototype; it is not a traded spread or sovereign issuance.





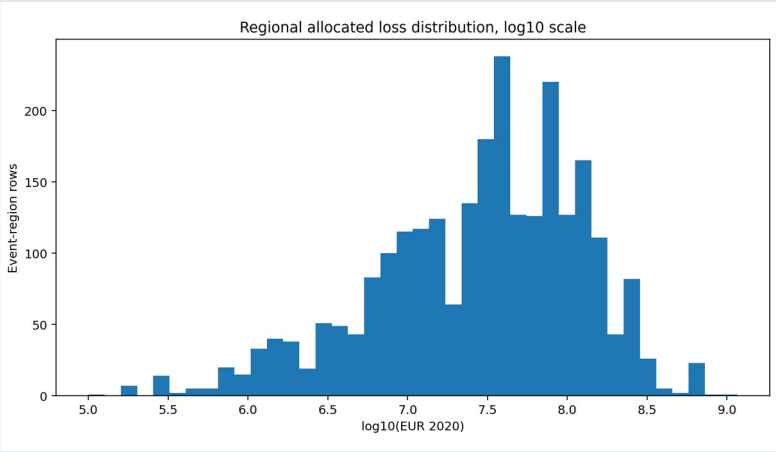
Risk pool	Fair coupon 1Y	Fair coupon 5Y	Technical CAT spread 5Y
Group 1	4.3999%	5.8084%	310.42 bps
Group 2	2.6375%	2.9550%	25.09 bps
Group 3	2.4791%	2.7365%	3.23 bps
Pooled	4.7877%	6.4517%	374.75 bps

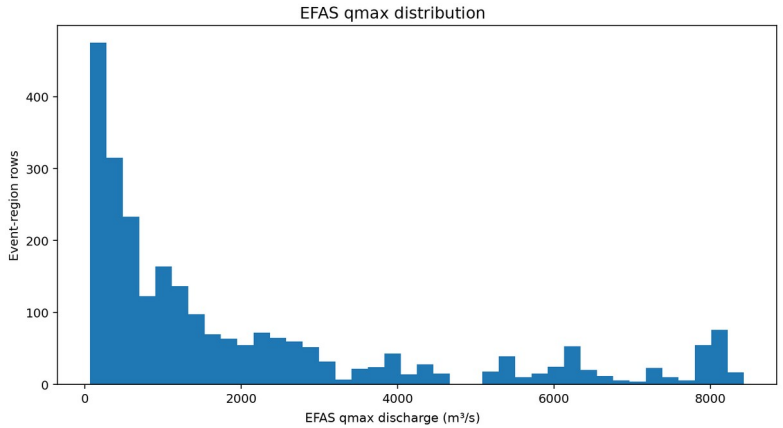
The pooled and Group 1 designs carry the material catastrophe spread; the Iceland sleeve remains close to the risk-free layer.

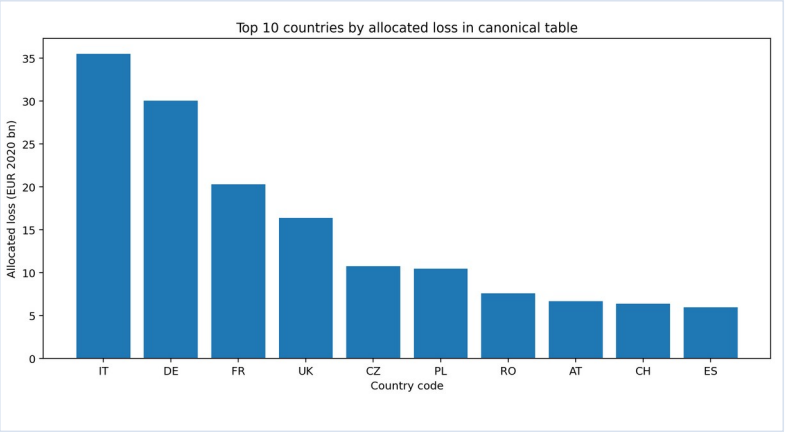
Grace Rigamonti Osorno

Flood data: event-region before tail and trigger modelling

HANZE loss history + GISCO/NUTS geography + EFAS qmax discharge



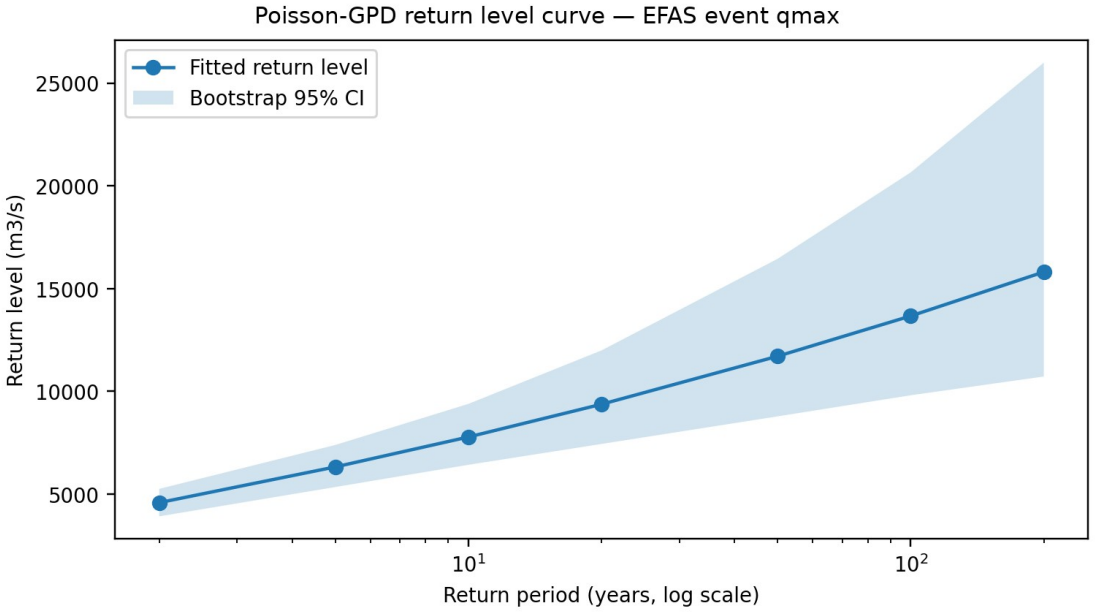


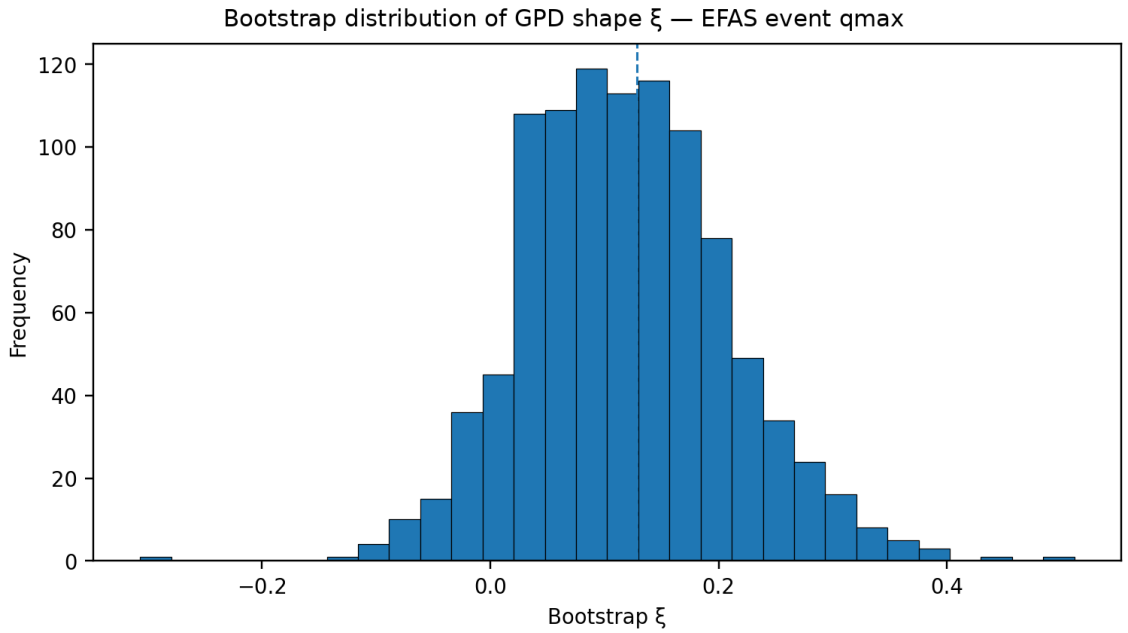


Metric	Value	Use in modelling
Event-region rows / events	2,557 / 604	event-region and event-level views
Countries / period	37 / 1992–2020	European open-data
Allocated loss total	€168.526bn	Loss layer
EFAS qmax median / max	1,078.642 / 8,429.966 m³/s	Hazard trigger layer

EVT on EFAS qmax identifies the hazard tail used for trigger prototyping

Return level curve + bootstrap ξ.





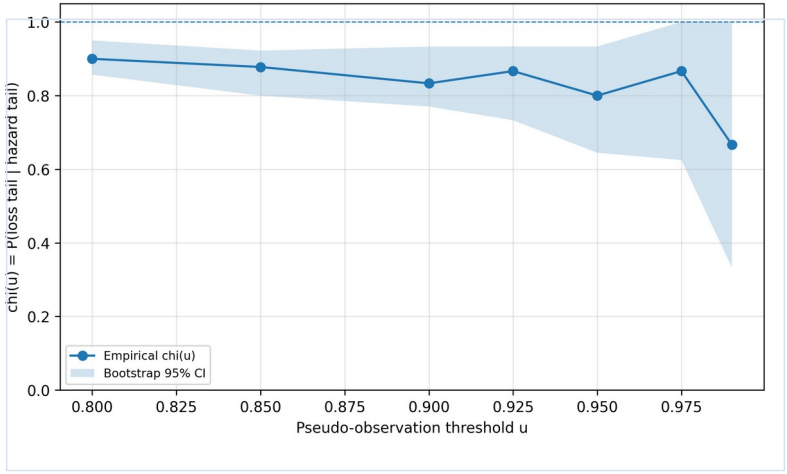
Series	n	u	Nu	ξ	β	VaR 99.5% / CVaR 99.5%
EFAS event qmax	604	1,271.08 m³/s	121	0.1286	1,359.38 m³/s	7,691.80 / 10,199.66 m³/s
Event loss	604	€634.22m	61	0.8221	€399.16m	€5.894bn / €32.436bn

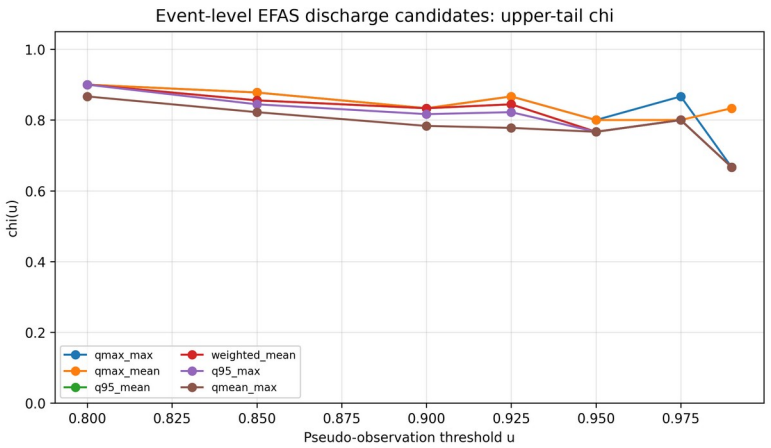
The EFAS qmax tail is stable enough for a hazard-trigger prototype and the loss tail is heavier.

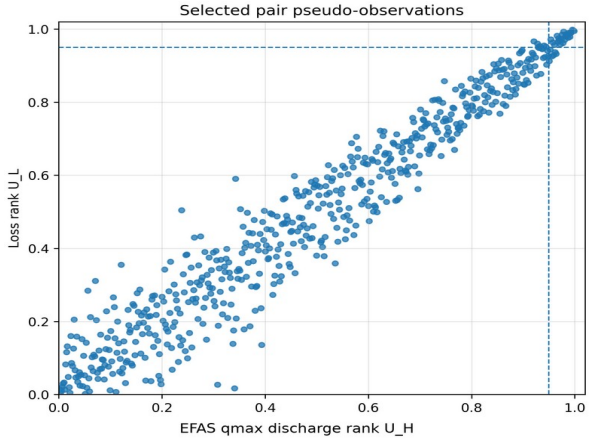
Grace Rigamonti Osorno

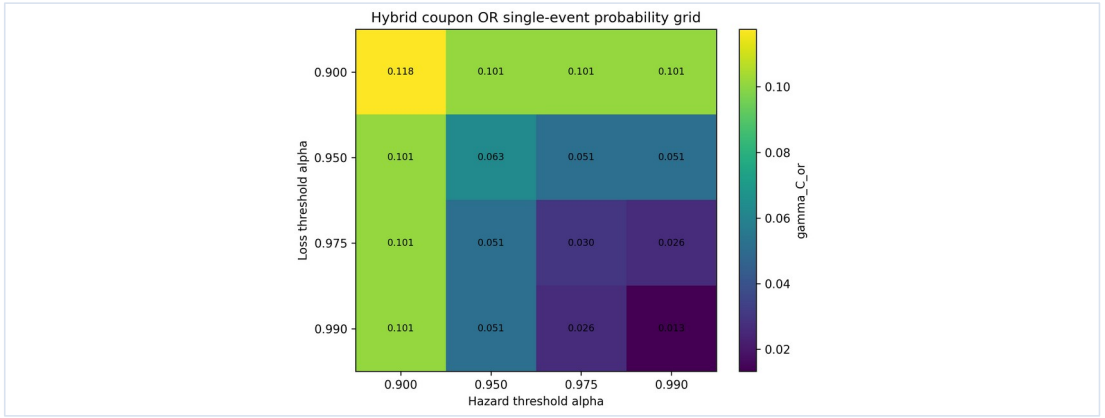
Flood trigger design starts from tail dependence, not average correlation

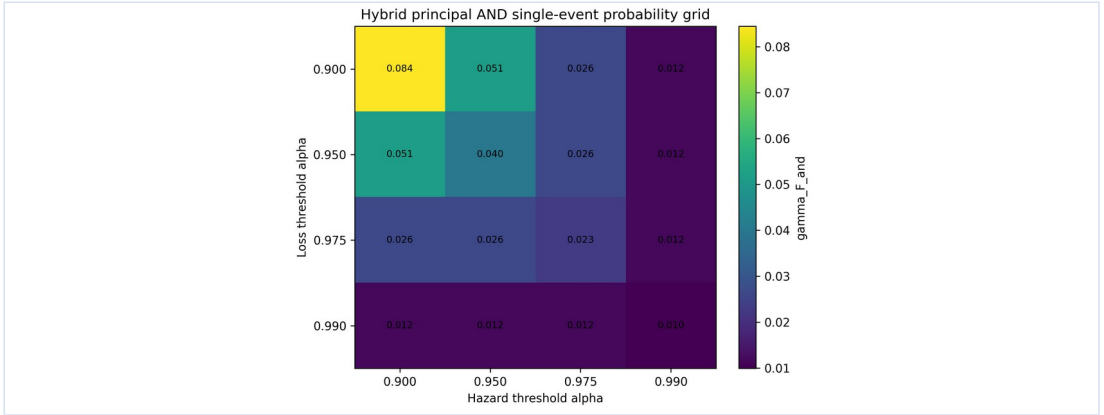
The selected EFAS event-level qmax is chosen quantitatively before any pricing step.











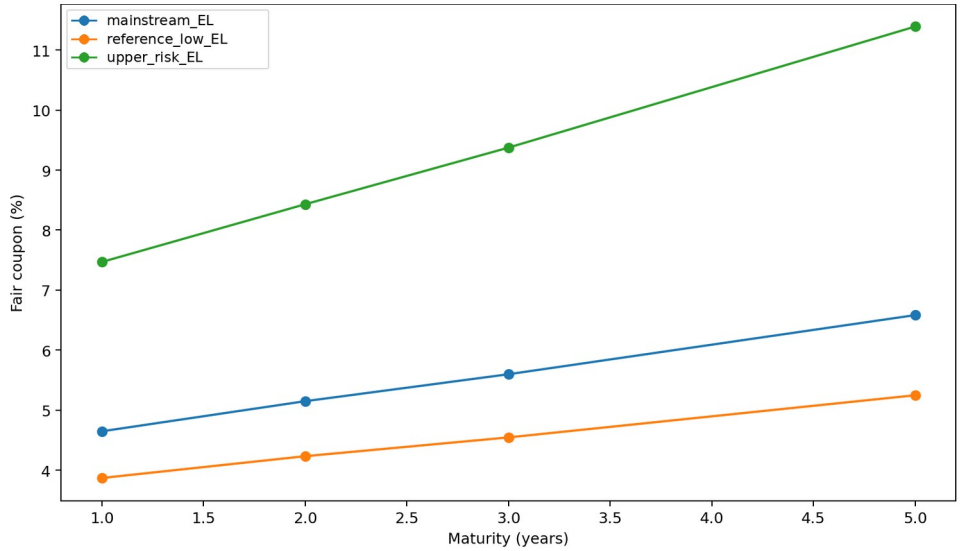
Selected EFAS qmax max: Kendall τ=0.8497, Spearman ρ=0.9693, χ(0.95)=0.8000; OR/AND grids are diagnostic comparability layers with peril Earthquake.

Market-plausibility: the stress design (OR/AND triggers) is not the final flood pricing result

The final layer replaces excessive expected-loss stress outputs with EFAS qmax scaled-ramp designs.

Layer	Annual EL	Decision
Initial stress diagnostic	6.66%–12.60%	Not selected
Final reference	0.9088%	Selected
Final mainstream	1.9588%	Selected
Final upper-risk	3.9287%	Selected

Fair-coupon by maturity

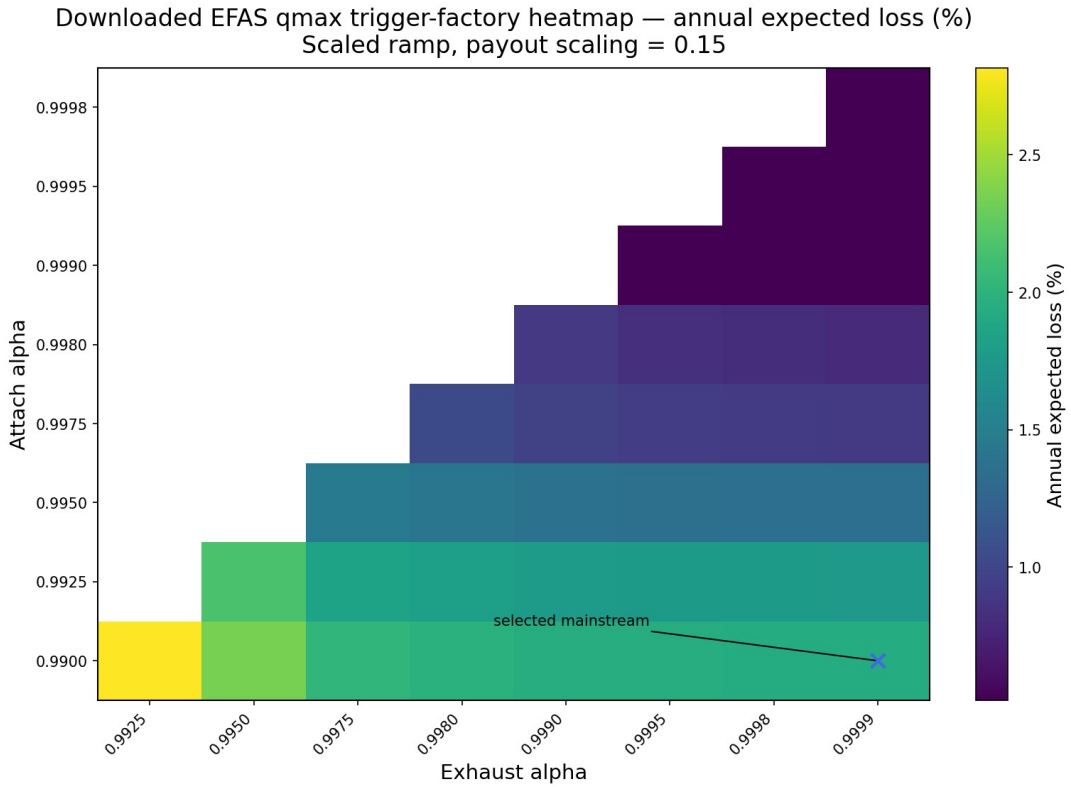


Design	Annual EL	5Y fair coupon	5Y Technical CAT spread	5Y principal EL
Reference low-EL	0.9088%	3.6592%	95.55 bps	4.5458%
Mainstream EL	1.9588%	4.8214%	211.77 bps	9.7834%
Upper-risk EL	3.9287%	7.2137%	451.01 bps	19.7224%

Final flood pricing uses EFAS qmax scaled-ramp; high-EL outputs are retained only as stress diagnostics.

Trigger-factory heatmap selects the mainstream layer

EFAS qmax scaled-ramp, payout scaling 0.15; the heatmap is an EL design.



Selected mainstream layer

Attach α = 0.9900 · Exhaust α = 0.9999

1.9588%
annual expected loss

4.8214%
5Y fair coupon

211.8 bps
5Y technical CAT spread

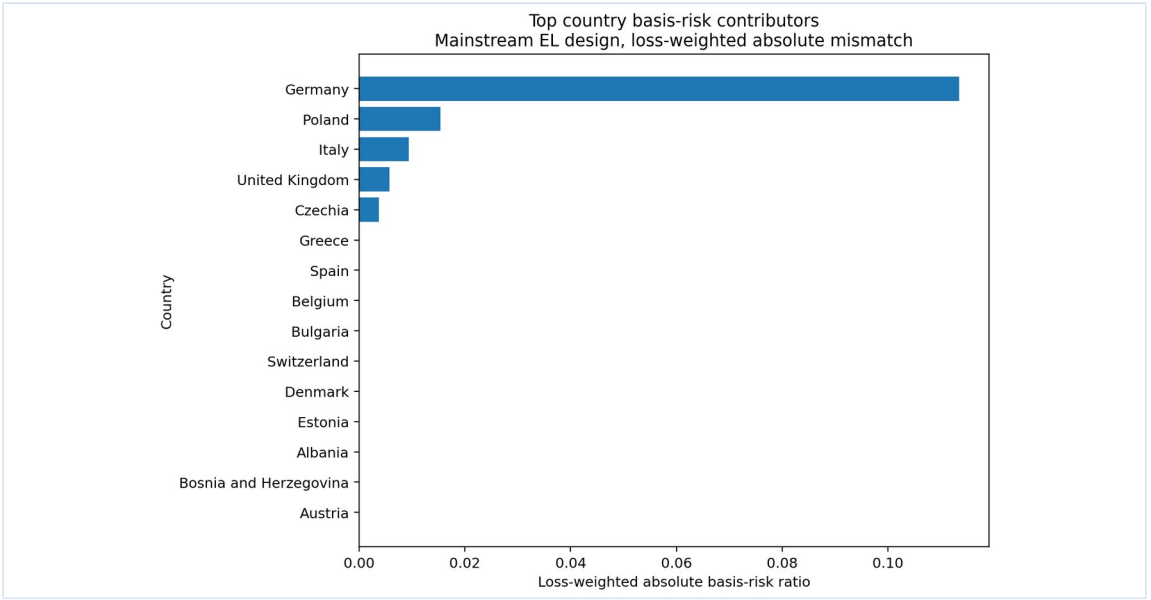
7
positive payout events

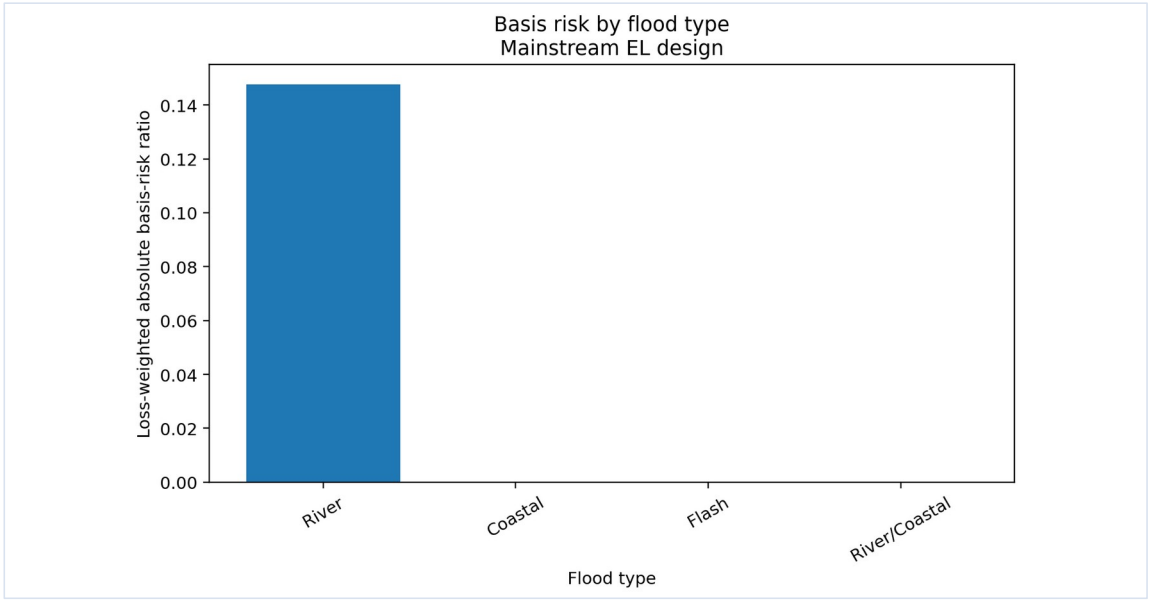
The selected cell is not the lowest-risk corner and not the stress region. It is the middle layer used for the flood fair-coupon prototype.

Design	Annual EL	1Y fair coupon	5Y fair coupon	5Y CAT spread	5Y principal EL
Reference low-EL	0.9088%	3.3949%	3.6592%	95.55 bps	4.5458%
Mainstream EL	1.9588%	4.5055%	4.8214%	211.8 bps	9.7834%
Upper-risk EL	3.9287%	6.4667%	7.2137%	451.0 bps	19.7224%

Basis-risk diagnostics make the EFAS qmax trigger discussion concrete

Mismatch is reported by design, country and flood type.





Design	Positive events	RMSE	MAE	Loss-weighted abs BR	Precision	Recall
Reference low-EL	4	0.0601	0.0051	0.1584	1.0000	0.5714
Mainstream EL	7	0.0558	0.0048	0.1476	0.8571	0.8571
Upper-risk EL	7	0.0483	0.0041	0.1271	0.8571	0.8571

Mainstream EL balances event support and classification quality; Germany is the main loss-weighted basis-risk contributor in this prototype.

Two perils, one governance logic: separate pricing unit from diagnostic geography

Layer	Earthquake	Flood	Decision use
Data unit	Portfolio total structural event loss + Mw	HANZE event / event-region loss + EFAS qmax	prevents double counting
Tail layer	Loss EVT/POT with finite-CVaR gate	Loss and qmax EVT/POT	sets severity and trigger layers
Dependence	Gumbel loss–magnitude upper tail	χ upper-tail hazard–loss diagnostic	supports hybrid/parametric triggers
Pricing output	Risk-pool technical fair coupon	EFAS scaled-ramp technical coupon	prototype pricing only
Basis risk	Country/source diagnostics	Country/flood-type mismatch diagnostics	sponsor governance

5Y pricing anchor	Technical fair coupon	Technical CAT spread	Interpretation
Earthquake pooled	6.4517%	374.75 bps	risk-pool aggregate
Flood Mainstream EL	4.8214%	211.77 bps	scaled-ramp
Flood Upper-risk EL	7.2137%	451.01 bps	higher expected principal loss

Conclusions and flood extension: Global Human Settlement Layer (GHSL) / Joint Research Centre (JRC) exposure

Flood extension

Integrate Global Human Settlement Layer (GHSL) exposure proxies from the Joint Research Centre (JRC), plus vulnerability layers, into flood event-region diagnostics: exposure-weighted loss allocation, vulnerability-sensitive basis-risk maps, and country sleeve screening.

Source	Role
OpenQuake / EFEHR / ESRM20/ESHM20	earthquake event-loss, hazard-risk context
HANZE + GISCO/NUTS + EFAS	flood loss/geography/hazard context
ECB yield curves	zero-coupon discounting and coupon decomposition

EuroCatFM is an open-data prototyping environment for physically coherent trigger design, technical fair-coupon analysis and basis-risk governance.

Grace Rigamonti Osorno

THANK YOU

Grace Rigamonti Osorno
University of Macerata

Insurance Data Science Conference · Hannover · 10 June 2026

EuroCatFM

Physics-Guided Open-Data CAT Bond Trigger Design
for European Earthquake and Flood Risk

Contact: g1.rigamontiosorno@unimc.it