BUILDING TIME-DEPENDENT EQ RECURRENCE MODELS FOR PROBABILISTIC LOSS COMPUTATIONS

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“What are the uses cases for Operational Earthquake Forecasting in the Risk Transfer industry?”, Ned asked
How are risk models “consumed”? what are the time constants?
Effects of short to medium-term clustering on risk metrics?
Where it would come from for EQs? and how?
Is the baseline well established (for “mainshock long-term models”)?
What are the complications related to short-term clustering for a risk model (once the forecast is known)?
Time-dependent
Short-term horizon (but often no aftershocks)
Loss per events
Financial model needs the order in which events happen and time between events when they affect same sites, not just event frequencies

RISK MEASURES:
Annual average loss
Loss for 1 in 250 yr events
Average loss for events larger than the 1 in 250 yr...

* Over next 1 to 6 years

losses in $ from
- the most damaging event (OEP)
- all the events occurring in a year (AEP)
TIME-SCALES ASSOCIATED TO THE CONSUMPTION OF RISK MODELS

**Change Management**
Users of risk models assess new model releases;
They validate the results using their in-house loss histories (claims data);

**Regulatory requirements**
Users need to justify their choices in premium and reserves based on risk metrics extracted from model results to the regulatory agencies (e.g., SOLVENCY II in Europe);

**Underwriting policy**
Development:
Based on the premium and the correlation of exposure for a given peril or several perils, the company issues underwriting guidelines, as to where to write business, where they are already at capacity, and where they would need to reduce their involvement to look for more diversification of their portfolio.
Application “in the field”

**Capital markets**
Development of parametric catastrophe bond (e.g., exceedance of some ground motion level at some pre-specified station)

**Catastrophe Bond**
Buying and selling a share in a cat bond can happen very fast
TIME-SCALES ASSOCIATED TO THE CONSUMPTION OF RISK MODELS

**CAT RESPONSE I**

After a large event, find closest event in the model or produce footprint so that clients can run the event on their portfolio and get an estimate on the geographical extent of the damage (e.g., to plan the deployment of building inspectors) and the estimated losses (check reserves).

- Updates needed very often (hrs to days)
- Large demand on short-term forecast

**CAT RESPONSE II**

Information on aftershock productivity or signs of increase or decrease in productivity, or signs of being back to normal

- Days to months
- For underwriting policy
- For cat bond market

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x: clustered model
o: non-clustered model

The maximum loss in a year (OEP) for the clustered model might be lower than for the non-clustered model.

The total (aggregate) annual loss (AEP) on the other end will occasionally (i.e., at large return periods) be much larger than for the non-clustered model.

Same average: 6 events in 3 years, but 2 views on clustering.
(RE-)INSURANCE

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Limit
Attachment point/Deductible

Annual contract, 1st event
(RE-)INSURANCE

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Advance knowledge on the probability of having 2 or more loss-causing events would change the strategy for risk management, reserves, and risk transfer, maybe going to buy 2nd event reinsurance contracts, or aggregate limits instead of per occurrence.
we are in a soft market, more multi-year contracts

For solvency issues, need to choose limit and contract length according to a view of risk

(Re-)Insurance

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aggregate over contract length, e.g., 2 years, until aggregate limit reached
(RE-)INSURANCE

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attachment point/deductible

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Limit
Attachment point/Deductible

Year 1 Year 2 Year 3

Losses

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(RE-)INSURANCE

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Information on multi-year clustering (proba of 2 or more loss causing events in next 2 years or next 5 years) would be very valuable for multi-year aggregate limit contracts

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Depending on the declustering method used originally, adding aftershocks would either:
- increase both average event rates and temporal and spatial clustering (and change the b-values)
- leave the (long-term) event rate the same but increase the clustering.

Note: in the most advanced short-term models, rates of the background and clustered model components are estimated simultaneously, warranting more in-depth analysis of the change in risk perspective.
What are the chances of getting more than 2 loss-causing events in a given region over a period of xx years using a long-term “mainshock” model?

What are the chances of getting a “New Madrid” or a “Canterbury” situation elsewhere just from a long-term model?

We create hundreds of thousands of realizations of 6 year periods, and we go through those periods with more than 2 events to identify which successions of events in the region would be perceived as sequences.

Fitzenz et al AGU 2014

Drayton et al NZSEE 2015
Antithetic faulting triggered by slip on a listric master fault (DuRoss et al 2015).

Dense fault networks at plate boundary

Cook Strait, NZ
Wallace et al 2011

Salt Lake City Segment
West Valley fault zone

Figure 13. Compilation of regional Holocene palaeoearthquakes. Errors in submarine earthquake ages are expressed at 95% confidence. For onshore data, the age bars are probability distributions.
DEPENDENCIES BETWEEN FAULTS

Dense fault networks at plate boundary

Antithetic faulting triggered by slip on a listric master fault (DuRoss et al 2015).

From physics-based numerical model by Robinson 2011

Time between successive characteristic EQs

Cook Strait, NZ
Wallace et al 2011

Salt Lake City Segment
West Valley fault zone

DuRoss et al 2015
FEEDBACK LOOPS TO BE CONSIDERED TO MODEL DEVELOPING SEQUENCES OF EVENTS

Event → Exposure → Vulnerability → Damage → Loss

Damage/reconstruction affects value
Damage alters vulnerability
Reconstruction

Earthquake Sequences

Muir-Wood and Fitzenz, AGU 2013
x: clustered model
o: non-clustered model

This plot assumes the losses for each event are the same regardless of when they occur relative to each other, but if they affect the same buildings, it won’t be true.

but for cat bond purposes, only the epicenter/time or ground motion at site matter, not losses.

Same average: 6 events in 3 years, but 2 views on clustering.
THANK YOU FOR YOUR ATTENTION!