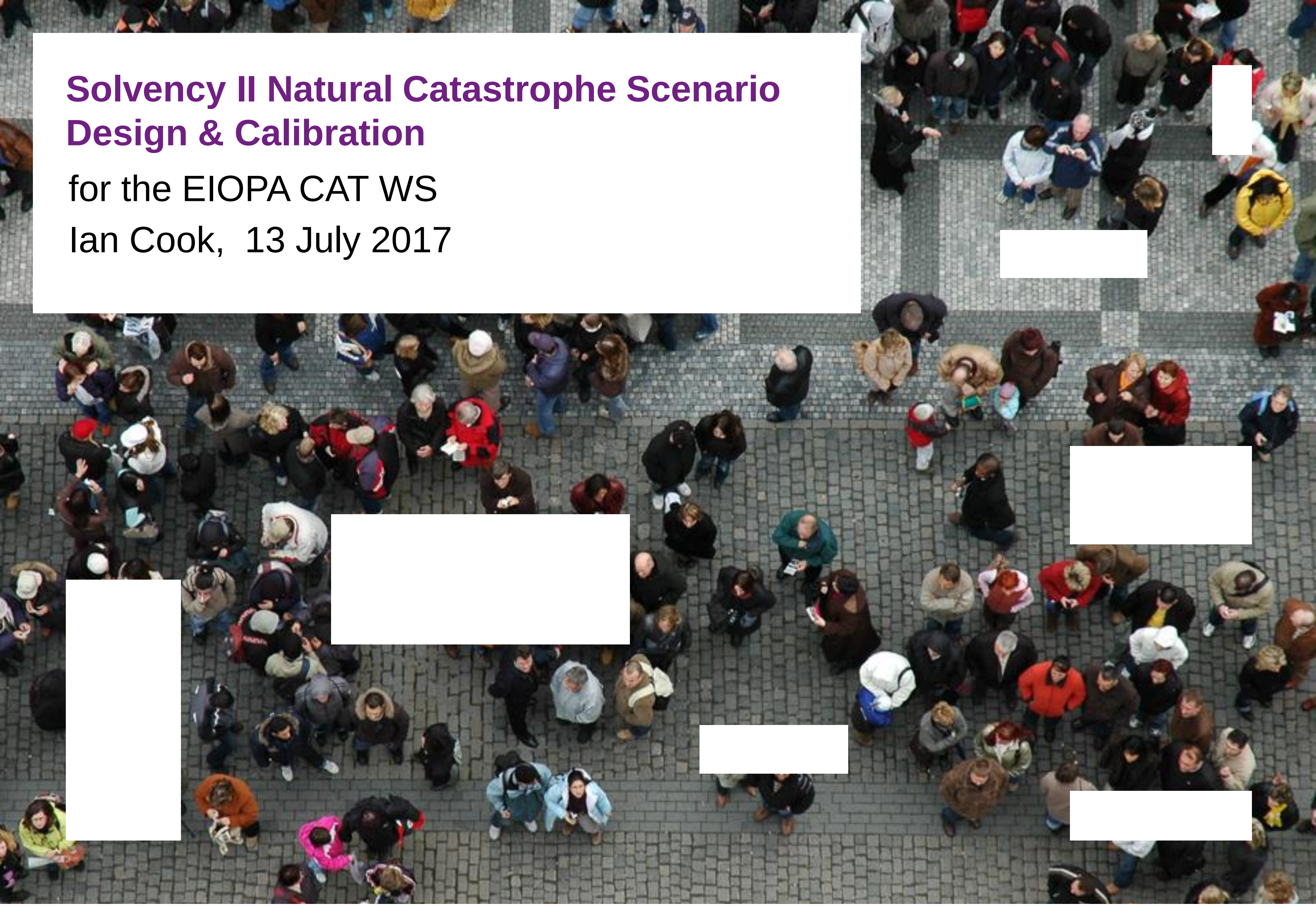
Solvency II Natural Catastrophe Scenario Design & Calibration

for the EIOPA CAT WS

Ian Cook, 13 July 2017



Contents & Disclaimer …

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- Disclaimer

  This is my attempt to briefly summarize relevant information about the standardized cat scenarios and their calibration. It is based on a number of publicly available documents and my best recollection of discussions in the original CEIOPS Cat Task Force and its successor groups. Any mistakes are mine. Any opinions expressed are not necessarily those of my employer.

Design

Scope

3.1045 The non life Catastrophe Standardised scenarios considered in this document are:

- Natural Catastrophes: extreme or exceptional events arising from the following perils:
  - Windstorm
  - Flood
  - Earthquake
  - Hail

- Source
  - CEIOPS calibration paper
- Notes
  - Windstorm includes storm surge
  - Flood includes fluvial & pluvial

Scenario Structure

3.1048 A number of options were considered for the calibration of natural catastrophe and pros and cons of each were assessed in turn. After careful thought and consideration it was decided that:

- that the Catastrophe standardised scenarios should be driven by undertakings' exposure,
- that aggregate country level exposure data is inadequate to properly reflect the variability in natural catastrophe risk – especially for large countries with strong gradients of risk, hence
- the Catastrophe standardised scenarios should be based on exposure at a sub-country level and use something akin to CRESTA zones which are an existing industry standard (or something similar if CRESTA are not available).

- Source
  - CEIOPS calibration paper

Scenario Formula

3.1049 On that basis the following proposal was agreed for the estimation of a catastrophe charge for natural catastrophes:

$$WTIV_{ZONE} = F_{ZONE} * TIV_{ZONE}$$

$$CAT_{Peril} = Q_{CTRY} \sqrt{\sum_{rxc} AGG_{r,c} * WTIV_r * WTIV_c}$$

Where

CAT_{Peril}	The estimation of cat capital charge for a specific country
Q_{CTRY} =	1 in 200 year factor for each country and peril
F_{ZONE} =	relativity factors for each zone by country
$AGG_{r,c}$ =	Rows and columns of the aggregation matrix AGG by country.
$WTIV_{ZONE}$=	Geographically weighted total insured value by zone
TIV_{ZONE}=	Total insured value for the Fire and other damage line of business exposures by each CRESTA zone.

- Source
  - CEIOPS calibration paper
- Notes
  - The resulting CAT_{Peril} is a 1-in-200 year ***occurrence*** loss.
  - The EIOPA changed the notation for the Delegated Acts with **F** becoming **W** and **AGG** becoming **Corr**

Non-Property Exposures

3.1102 The calibrations provided for Natural catastrophe only consider the impact of such events on the 'Fire and other damage' line of business. In reality such events when they occur can often impact several lines of business at once.

3.1103 Two areas were this was considered material and thus should be taken into account in the estimation of catastrophe risk for natural hazards are:

- MAT: the TIV for static marine exposures should be included for all perils
- Motor own damage: for Flood and Hail the TIV for the "motor, other" line of business should be included

- Source
  - CEIOPS calibration paper
- Notes
  - MAT exposures are treated in the formula exactly as 'Fire and other damage' exposures
  - Motor exposures are scaled by a factor of 1.5 for Flood and 5.0 for Windstorm to reflect their relatively higher vulnerability compared to 'Fire and other damage' exposures

Annualization / Multiple Events

3.1098 The above calibration only considers the possibility of one event occurring during the year (i.e. it is based on an occurrence not annual aggregate loss view). In reality extreme scenarios such as Windstorms and Floods can happen more than once in a year. As a result the net cat risk charge needs to take into account two different drivers of risk – the risk associated with a single very large occurrence and also the risk posed by multiple more moderately sized occurrences. The former tests the resilience of vertical reinsurance protections and the latter the resilience of reinsurances to multiple large occurrences (sideways protection). As a result, a calibration based on one event could result in an underestimation compared to a calibration based on more than one event occurring in a year.

3.1099 For the perils of windstorm and flood the calculation of Catastrophe Risk charge therefore takes into account the possibility of multiple insured events in any given year. This is addressed in the template by calculating a Catastrophe Risk charge under both of the following circumstances:

- one large event, at 1 in 200 level occurrence basis, plus a second, smaller event
- two moderate events
- the larger of the results for the two sets of circumstance being used.

- Source
  - CEIOPS calibration paper
- Notes
  - The two event assumption was later extended to include Hail, leaving only Earthquake as a single event

Interpretation

Parameters

▪ Country Factors	Q
▪ Zonal Relativities	F or W
▪ Aggregation Matrices	AGG or Corr

Interpretation - Country / “Q” Factors

Country Factors

The country factors represent the per-occurrence 99.5% loss for that peril in the country under consideration, as a ratio of the total sums insured in the country. This can be represented as the one in two hundred years per occurrence PML (Probable Maximum Loss) percentage. For each peril best estimates of each country’s 1/200 year per occurrence PML were provided. Expert judgment was used to identify outliers and obtain consensus on the outcome. It was assumed that a peril is not significant for a given country, if its estimated country factor was less than 1/15 of the largest peril-specific factor for that country.

3.1052 It is important that when looking at the factors readers interpret these correctly. The factors are not only a measure of the intensity of the hazard in a region, but also a measure of the vulnerability of the building stock and concentrations of exposure at risk. For countries with high earthquake risk and a history of damaging earthquakes, they typically have strong building-codes that would moderate the impact compared to countries with weaker buildings.

- Source
  - EIOPA underlying assumptions document
  - CEIOPS calibration paper

Interpretation - Country / “Q” Factors

- “Q” Factors
  - Windstorm — Article 121, Paragraph 5(a) and Annex V
  - Earthquake — Article 122, Paragraph 2(a) and Annex VI
  - Flood — Article 123, Paragraph 5(a) and Annex VII
  - Hail — Article 124, Paragraph 5(a) and Annex VIII

- These are the most important parameters for the natural peril scenarios
  - For an undertaking writing an exactly ‘industry average’ portfolio, the country factor is effectively the only parameter that matters.
  - The aggregate level of industry capital for a natural peril in a country is also given solely by the country factor

- Consistency between countries is important
  - Previous incarnations of the Task Force / Sub Group always tried to consider whether proposed country factors made sense in relation to neighbouring countries.

Interpretation - Zonal Relativities / “F” or “W” Factors

- The zonal relativities represent the difference in natural peril risk expressed as the ratio between -
  - an undertaking writing an ‘zonal average’ portfolio in a single geographic zone, and
  - an undertaking writing an ‘countrywide average’ portfolio

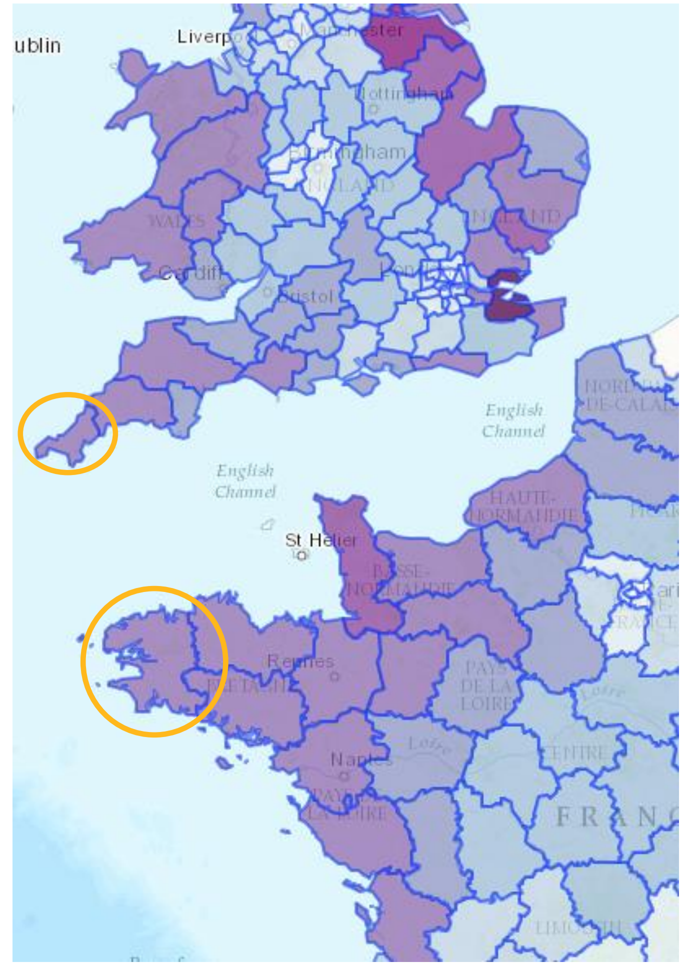
- Like the country factors, the zonal relativities do not just represent differences in hazard, but also reflect difference in
  - vulnerability
  - exposure concentration with the zone

- The zonal relativities should not affect the total level of required capital for natural perils business written in a country.
- They do affect the allocation of that required capital across undertakings within a country.

Interpretation - Zonal Relativities / “F” or “W” Factors

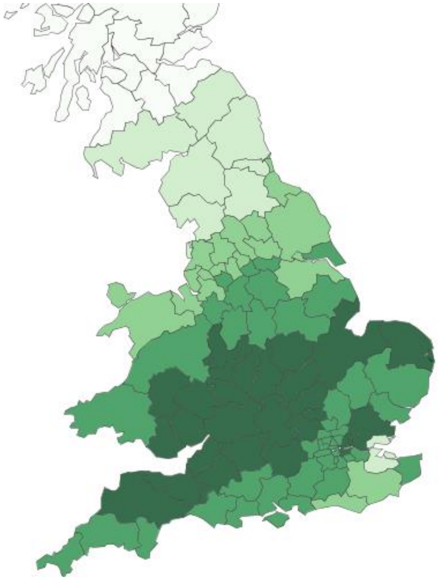
- Because the denominators of the ratios are different for different countries, the zonal relativities are not directly comparable between countries.
- e.g. windstorm
  - FR, zone 29, has weight 3.4
  - UK, zone TR, has weight 2.4

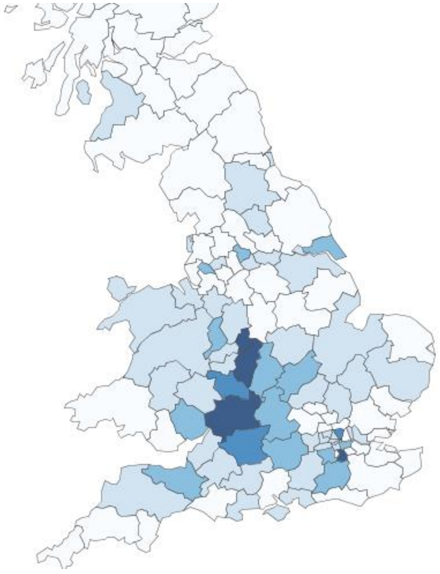
  does not imply FR 29 is 40% more risky than UK TR.
- Instead consider zonal weight * country factor. e.g.
  - FR, zone 29 => 3.4 x 0.12% = 0.408%
  - UK, zone TR => 2.4 x 0.17% = 0.408%



Interpretation - Aggregation Matrices

- The aggregation matrices are used to allow for diversification of risk between zones.
- The maps on the right show the aggregation matrix factors for UK zone GL.
- The 1st map is for Windstorm and reflects the general W-E of windstorms across the UK
- The 2nd map is for Flood and largely reflects the route of the River Severn.





- Like the country factors and zonal relativities, the values do not only reflect correlations of hazard.
- In addition, the values will also reflect the mathematical formulation of the risk metric and matrix aggregation method being used by SII. (See Appendix)

Calibration

Calibration Steps

- Country Factors

- Zonal Relativities
- Aggregation Matrices

- Normalization

Calibration - Country Factor

- Original 2009/2010 Calibrations

  3.1051 Each participant of the CTF provided their own industry view of what a 1 in 200 year loss could be as a percentage of Total insured value for a particular country. Where views diverged the CTF discussed further before making a final decision.....

- Between 0 and 5 submissions were received for each country/peril combination.
- These showed a wide range (e.g. 2x for windstorm, 5x for flood and earthquake) reflecting the uncertainty of modelling extreme return periods.

- Note that it was possible for some group members to have a view on the country factors even if they did not have their own detailed probabilistic model. Reasons for this include
  - them having a less detailed aggregate model, or
  - licencing model from a 3rd party vendor, but making in-house adjustments based on own data sources

Calibration - Country Factor

- The values were considered in recommending the country factor to use -
  - those submitted anonymously by CTF members,
  - those for neighbouring countries, and
  - the existing factor value (if modification was being considered)

- The process used to select the recommended value was expert judgement (using a mini-Delphi type method.)
  - Advantages
    - consistency between countries taken into account
    - can be used when no models available
  - Disadvantages
    - Harder to document exact process of reaching a specific number

- What other methods could be used ?

Calibration - Country Factor – Alternative Methods

- Simple average of submitted factors ?
  - Advantages
    - transparent, mechanical process that is easily documented
  - Disadvantages
    - hard to ensure consistency with neighbouring countries
    - can produce strange conclusions where model coverage is different (*)
    - treats all models as equal irrespective of quality
    - cannot be applied where no factors are submitted
    - any update of an included model could be argued to require a recalibration

* consider the example on the right
- both models A & B show country Y as more risky than country X
- model C only covers country X and rates it more risky than both models A and B do.
- However, taking an average of all available models results in a higher factor for country X than Y despite the models that cover them both considering Y should be higher than X.

		Country X	Country Y
Model	A	0.10%	0.12%
	B	0.15%	0.16%
	C	0.22%	(n/a)
Average		0.16%	0.14%

Calibration - Country Factor – Alternative Methods

- Weighted average of submitted factors using expert judgement to decide weights based on scoring models against a number of specific criteria ?
  - Advantages
    - contribution of a model to the overall result depends on quality
    - well used process in industry
    - model scores easily documented
  - Disadvantages
    - the level of information and documentation needed is unlikely to be available
    - extremely time consuming
    - hard to ensure consistency with neighbouring countries
    - can still produce strange conclusions where model coverage is different
    - cannot be applied where no factors are submitted

Calibration - Country Factor

- Method Choices
  - Original CTF (mini-Delphi) Method
  - Simple Average
  - Weighted Average

  - Others ?

- It would be desirable for the same approach should be used for all country/perils ?

Calibration – Zonal Relativities & Aggregation Matrices

- The zonal relativities and aggregation matrices are of secondary importance to the country factor.

3.1092 Catastrophe models developed by members of the task force were used in part of this estimation process. However, in most cases adjustments were made to reflect the collective expert judgement and experience so that the Catastrophe standardised scenarios being proposed reflected the consensus view of the CTF not any of the particular cat models. The correlation matrices have all been approved by the collective expert judgement of the CTF to make sense, and could be reviewed in future if required, for example if a new type of storm or earthquake occurred that altered the previous-held scientific viewpoint of the pattern of natural perils across Europe.

Calibration – Zonal Relativities & Aggregation Matrices

- Models need to be more detailed to provide a view on these parameters and hence there are / will be fewer views than on country factors.

- The original CTF, for each country/peril used, in most cases, a single catastrophe model as the basis for the calibration of the zonal relativities and aggregation matrices.
- However, adjustments were made in some cases to reflect known quirks in the models used.

- Using more than one model increases complexity as the issues with selecting a single country factor are magnified by several orders of magnitude.

- In some cases, (see 3.1907), the CTF calibrated the matrices using a TVaR approach instead of VaR to avoid coefficients > 1 in the matrices.

Calibration – Zonal Relativities & Aggregation Matrices

- Using more than one model increases complexity as the issues with selecting a single country factor are magnified by two orders of magnitude.
- However, the modification to the CZ FL scenario in 2012/3 set a precedent for using multiple models for the calibration of a scenario where the models were quite different. (See separate attachment.)
- It may be appropriate here to use a varying approach here between different country/perils as
  - there will be a smaller set of models to chose from,
  - the impact is limited to a single country/peril and should not introduce any inconsistencies in calibration level.

Calibration - Rounding & “Normalisation”

- The numbers in the final scenario are rounded -
  - zonal relativities to 1 decimal place
  - aggregation matrix elements to the nearest 0.25

- It is also important that when exposures with an industry average zonal distribution are input to the formula that the resulting loss equals the total exposure times the country factor.

Calibration - Rounding & “Normalisation”

- The steps for rounding and normalisation are as follows -
  - round the aggregation matrix elements to the nearest of the following values [0,0.25,0.5,0.75,1]
  - Input the ***industry zonal distribution*** into the formula
  - set the normalization weights to 1
- Then repeat the following steps as many times as necessary -
  a. multiply the raw zonal relativities by the normalization weights and round to the nearest 1 decimal place
  b. calculate the result of the scenario as a % of exposure using the normalized relativities
  c. divide the result of (b) by the country factor
  d. if the result of (c) is not sufficiently close to 1, then multiply the normalization weights by (c) and repeat from step (a)

Appendix

- The use of a value-at-risk metric with matrices for aggregation is a fairly crude approximation that fails in the presence of non-Gaussian distributions.

- Consider two zones A and B each subject to cat losses **independently** with Poisson frequency and with Pareto severity distributions (with shape parameters 1.75 and 1.5)

Return Period	1-in-200 occurrence loss Zone A	Zone B	Zone A+B
10	1.5	1.0	2.0
20	2.2	1.6	3.0
50	3.7	2.9	5.2
100	5.6	4.6	7.9
200	8.3	7.4	12.0
500	14.0	13.6	21.2
1000	20.8	21.5	32.7

- Implied aggregation matrix coefficient =
  (12.0*12.0 – 8.3*8.3 – 7.4*7.4) / (2 * 8.3 * 7.4)
  = 0.17

- The values in the aggregation matrixes therefore can be considered to some extent to be correcting the approximation.