An industry framework to estimate the changes in hurricane wind risk due to climate change (EGU2023-13295)

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I Year Loss Table (YLT)

Given a current insured portfolio, let $\boldsymbol{Y}$ be the probabilistic distribution of the potential losses over one year, event by event.

The Year Loss Table (YLT) represents a set of Monte Carlo simulations of $\boldsymbol{Y}$, hereafter an example for 10,000 simulations:

Simulation Number w_i	$Y(w_i)$	Number of simulated events k_i
1	$(E_{1,1}, E_{1,2})$	2
2		0
i	$(E_{i,1}, E_{i,2},\dots, E_{i,k_i})$	k_i
10 000	$(E_{10\,000,1})$	1

Where E_{i,k_i} is the modelled insured loss of hurricane events in the US, based on a stochastic event set. k_i represents the annual frequency.

For each E_{i,k_i}, natural catastrophe models also provide information such as intensity or duration. In particular, the Saffir Simpson category of each event is denoted by C_{i,k_i} and takes its values in $\{0,1,2,3,4,5\}$, 0 being a Tropical Depression or Tropical Storm.

The loss of each E_{i,k_i} is derived by intersecting the intensity information, vulnerability curves (mapping intensity with destruction level of insured assets) and the exposure information of the insured goods.

The number of simulations (10,000 here) should be high enough to capture extreme events and obtain convergence. In practice it is closer to 10^6.

The YLT is a standard output in the cat modelling industry for all types of insured risks (commercial, marine, residential…) and all kinds of perils.

II Risk measures' derivation

From the YLT we derive two risk measures:

(i) Occurrence Exceedence Probability (OEP)

$$OEP(w_i) = \max_{0 \le l \le k_i} E_{i,l}$$

(ii) Aggregate Exceedance probability (AEP)

$$AEP(w_i) = \operatorname*{sum}_{0 \le l \le k_i} E_{i,l}$$

The OEP distribution can be useful to define limits (99.5% quantile of this distribution) and deductibles (95% quantile of this distribution) of per event reinsurance contracts. The AEP distribution is used in a similar way for reinsurance contracts that work on an annual aggregated basis. The AAL (Annual Average Loss) can be derived by averaging the AEP with the total number of simulations.

III Adjusting the YLT

(i) Hypotheses

We adjust the YLT by increasing the proportion of events with Saffir Simpson categories 4 or 5, while keeping the overall annual frequency unchanged. We consider increasing factors (denoted as Factor_Sup) ranging from 5% to 35%.
As a reference, based on several studies, Knutson et al. 2020 shows a +13% median projected change in the proportion of storms reaching category 4 or 5.

(ii) Probability rescaling

For each Saffir Simpson category $C_0, \dots, C_5$, the empirical probabilities $P_0, \dots, P_5$ to get an event of a given category are derived based on the YLT. We then derive $(P_0^*, \dots, P_5^*)$:

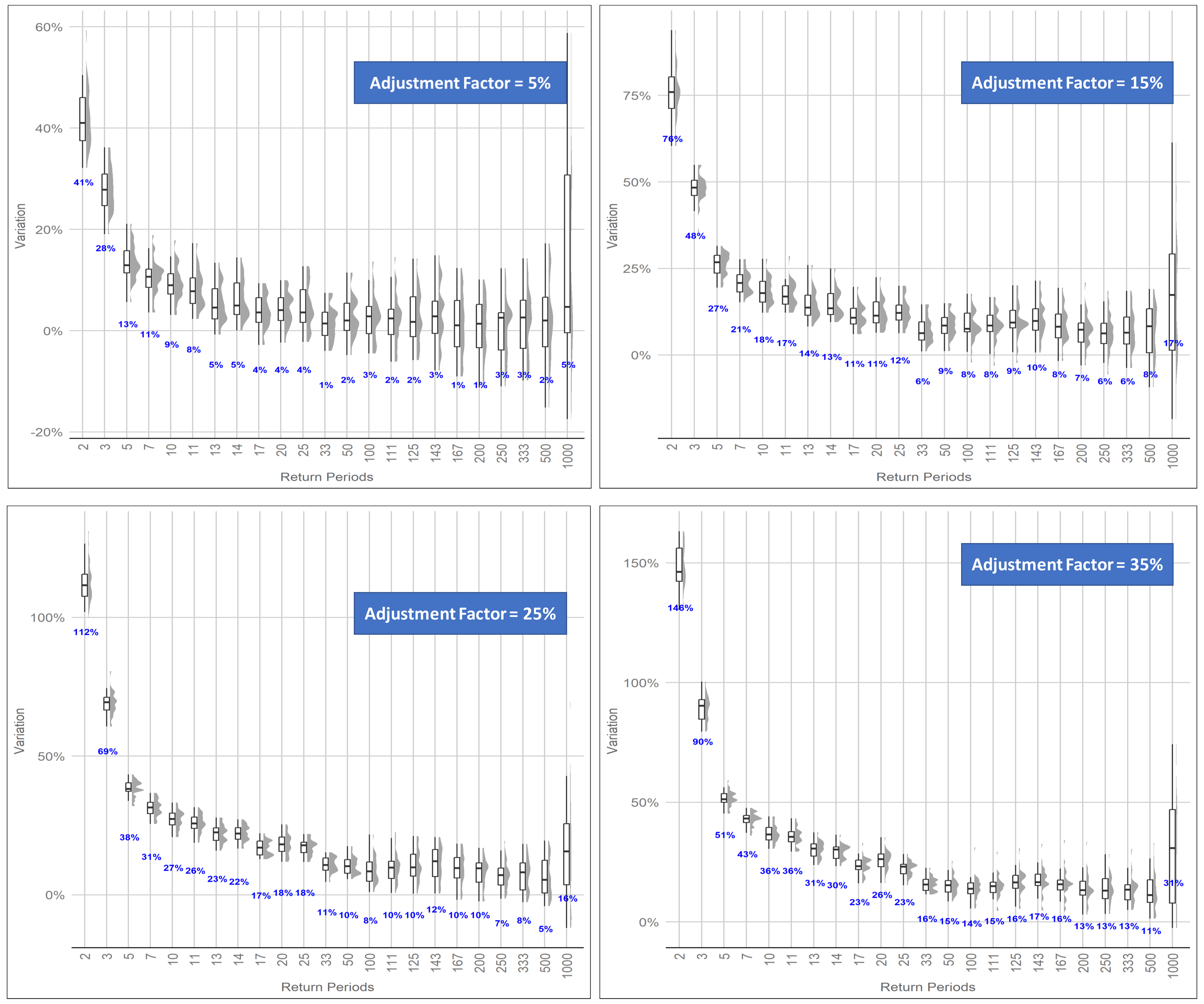
P_l^* = (1+ Factor_Sup) x P_l for l in { 4,5 }
$P_l^* = \frac{1-(P_4^*+P_5^*)}{P_0+P_1+P_2+P_3}$ x P_l for l in { 0,1,2,3 }

(iii) Resampling

First, for a given simulation, we sample a number of events $\mathrm{k_i}$ based on their empirical distributions in the YLT.
Second, we assign a category $\mathrm{C_{i,k_i}}$ to these $\mathrm{k_i}$ events based on a multinomial distribution, where the classes are the Saffir Simpson categories and the class probabilities are $(P_0^*, \dots, P_5^*)$.
Third, we assign a loss to these events by randomly sampling events with the same category in the YLT. A new YLT, denoted by YLT* is derived. YLT and YLT* have the same number of simulations.

IV Results and findings

Below we compare the impacts of the increased proportion of category 4/5 events on the baseline OEP of a fictive but representative US insured portfolio.



Increasing the proportion of the most extreme events produces strong increases in the smallest return periods (<20 years) of the OEP.
This is explained by integrating large events in simulations that had yet to factor in such a high level of storm intensity.
However, the higher return periods (>20 years) show much less sensitivity and are uniformly impacted. The latter result was expected as the most extreme events' intensity remains unchanged.

V Conclusion

For insurers, the YLT can serve to integrate climate change impacts in their hurricane risk estimation.

The adjustment consists in increasing the proportion of the most extreme hurricane events. The lowest return periods (<20 years) of the OEP show the largest risk increases.