Learnings from our CatFocus® European windstorm catastrophe model

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Take home messages

- **Hazard calibration is a tricky thing with the challenge "to calibrate but not over-calibrate"**
- **Here we demonstrate how a single model bias in wind gust strongly impacts the performance of a model ensemble for extreme events**
- **Vulnerability calibration/validation is even trickier due to difficulties in claims handling**
- **Empirical vulnerabilities based on claims for the same event from three portfolios show substantial differences**

The CatFocus® European windstorm (EU WS) model

- **Historical event set:** 145 storms for 1957-present (Friederike) Storm footprints based on maximum 3-sec surface gust from COSMO NWP model (7km resolution, incl. data assimilation).
- **Stochastic event set:** 11'000 storms based on 22 historical and near-future RCM simulations from ENSEMBLE project[1] (RCMs: 25km resolution statistically downscaled to 7km). Stochastic storms were calibrated with historical event set[2].
- **Vulnerabilities** based on wind engineering-based functions calibrated against claims from large historical windstorm events like 87J, Daria, Lothar, Martin, Anatol and more. Vulnerabilities are specific to lines line of business, coverage, country and region and building quality (such as construction type, year built and construction material)

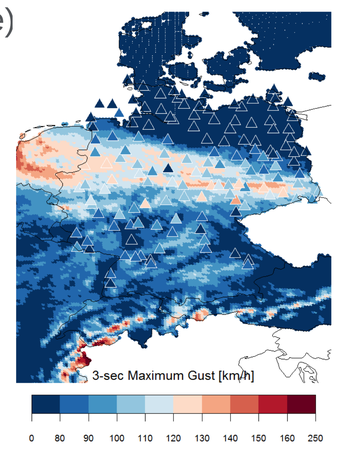

Figure 1: CatFocus® historical footprint of windstorm Friederike 18.01.2018 (shaded) compared to DWD gust observations (triangles)

Some lessons on hazard calibration…

- The regional climate model (RCM) based storm footprints within the CatFocus® stochastic event set require calibration to become comparable to the historical event set. The challenge is to calibrate but not over-calibrate!
- Here, the wind gust calibration is done by ensuring that the cumulative distribution function (CDF) of 70 reference storms of each RCM is matching the wind gust CDF of 70 historical reference storms on a European-wide level (see **Figure 2**).
- Even after that Europe-wide calibration the RCMs' contributing to the stochastic event set models can vary on a more regional level (see **Figure 3**)
- In the example of Norway, the deviations in regional wind gust CDFs did lead to a considerable spread in loss occurrence exceedance probabilities (OEPs) since the differences in wind gust got amplified through the vulnerability curves (**Figure 4**).
- When only using the EU-wide calibration some local biases in just 2 of the 22 RCMs of the stochastic event set were dominating the loss OEP curve leading to a distinct overestimation of loss in Norway (blue curve in **Figure 6**). For the EU-wide loss curve this bias is of lower order importance (red curve in **Figure 6**).
- The "Norway problem" was solved by an additional CDF calibration (**Figure 2**) for the region of Norway itself (removing the degrees of freedom shown in **Figure 3**)
- After the additional calibration the resulting Norway loss OEPs become much more comparable to the historical event set (**Figures 5 and 7**)

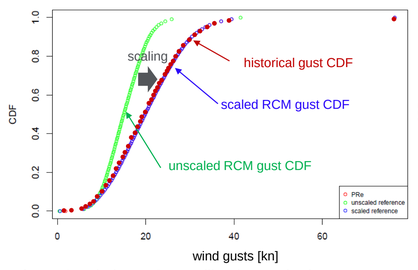

Figure 2: Wind gust CDF calibration method:
For each RCM within the stochastic event set the wind gust CDF of 70 reference storms is calibrated to fit the CDF of 70 reference historical storms.

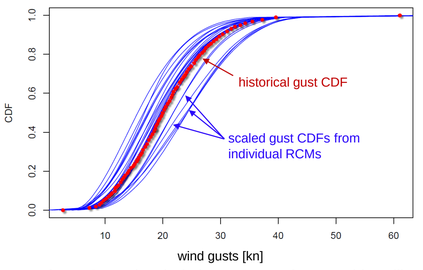

Figure 3: Regional wind gust CDFs after EU-wide calibration: After EU-wide calibration the individual RCMs of the stochastic event set have still have some remaining degrees of freedom on a regional level (shown here for Norway CDFs).

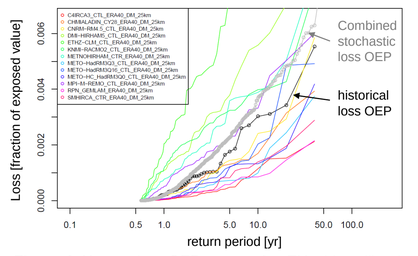

Figure 4: Norway loss OEP curves after EU-wide calibration: Individual RCMs reference storms show a wide range of loss OEPs compared to historical reference storms.

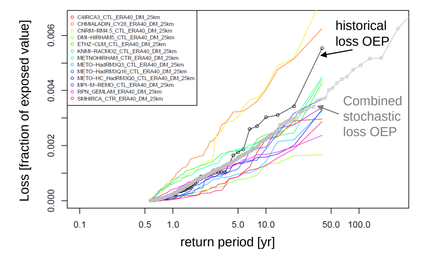

Figure 5: Norway loss OEP curves after additional calibration: Compared to Figure 4, individual RCMs loss OEPs show smaller range and better agreement with historical OEP.

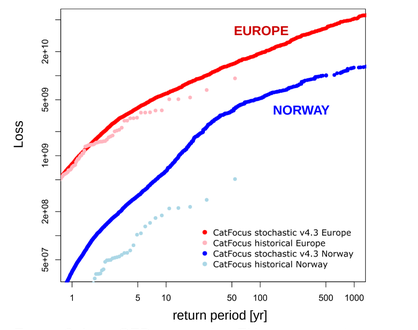

Figure 6: Loss OEP curves after EU-wide calibration: Stochastic and historical OEPs fit overall for Europe but strongly disagree for Norway.

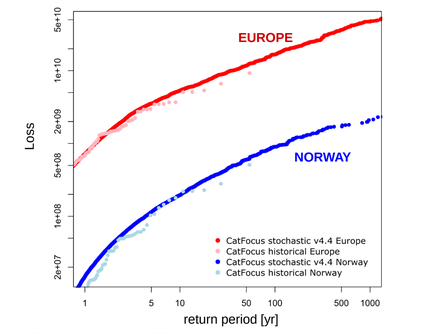

Figure 7: Loss OEP curves after additional calibration: Stochastic and historical OEPs fit well for Europe and Norway.

… and some on vulnerability validation

- Catastrophe model vulnerability validation and calibration with loss data requires information of exposure, hazard intensity and actual loss for the same event.
- Here, we validate the CatFocus® residential wind vulnerabilities for Southwestern France with exposure and loss claims data (**Figure 8**) from three portfolios for winter storm Klaus in 2009.
- Since the catastrophe model's vulnerabilities are always linked/calibrated to the model's hazard module, we use the Klaus 2009 footprint of the CatFocus® historical event set (**Figure 9**) for estimation of the wind gust.
- The three portfolios' claims based empirical vulnerabilities (based on a Loess fit to the collection of claims) for Klaus vary considerably (**Figures 10 and 11**), particularly for low wind speeds.
- These differences can be for right (e.g. difference in exposure characteristics) or wrong reasons (i.e. granularity of claims, impact of deductibles, handling of zero/small losses, event definition). In the example here, available exposure characteristics were not sufficient to explain the differences.
- Bespoke views of vulnerability need to be informed by their relative contribution to the existing data used to calibrate the main vulnerabilities → just blindly adjusting an existing catastrophe models' vulnerability with claims will likely result in overfitting.

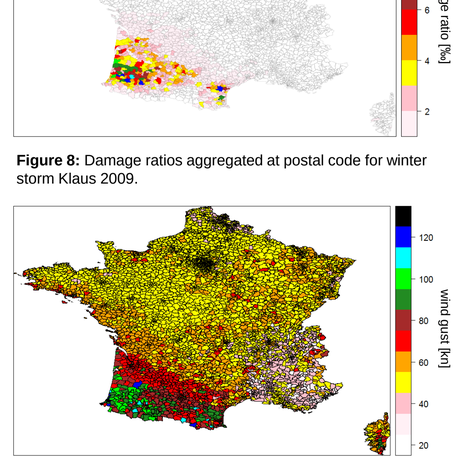

Figure 8: Damage ratios aggregated at postal code for winter storm Klaus 2009.

Figure 9: Wind gust [kn] footprint for winter storm Klaus 2009 based on the CatFocus® historical event set.

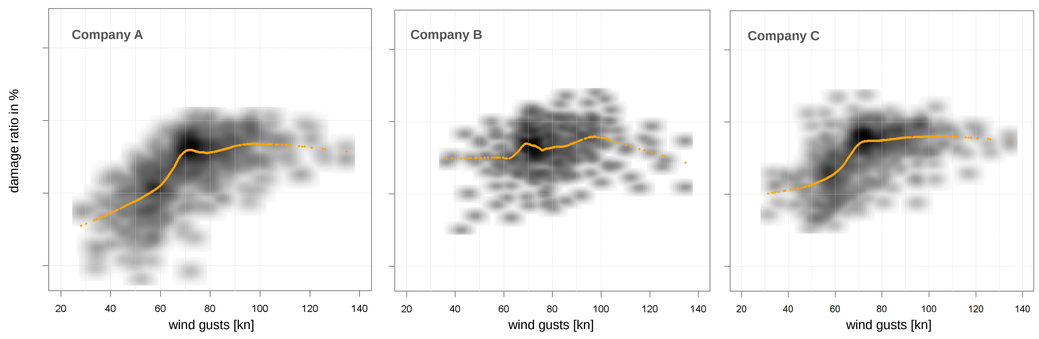

Figure 10: Damage ratios based on claims of loss vs. wind gust distribution (matched at postal code level) including the statistical Loess fit (yellow line) for winter storm Klaus 2009 based on claims and exposure data of three portfolios and wind gust estimates from the CatFocus® historical Klaus event.

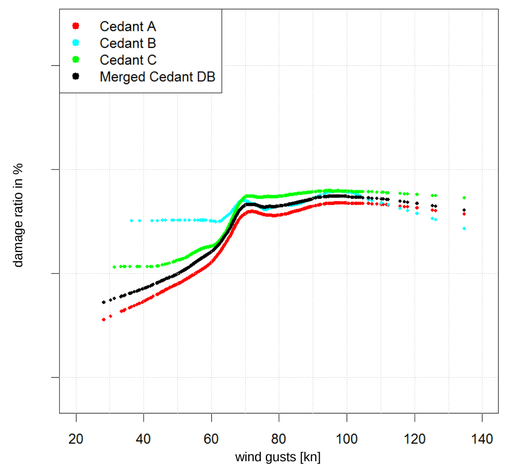

Figure 11: Damage ratios based on claims of loss (Loess fit) shown in Figure 10 for the three different companies and their combined curve (black line) for winter storm Klaus 2009.

References
[1] Christensen et. al., Formulation of very-high-resolution regional climate model ensembles for Europe, in: ENSEMBLES: Climate Change and its Impacts: Summary of research and results from the ENSEMBLES project., edited by: van der Linden, P. and Mitchell, J. F. B., MetOffice Hadley Centre, Exeter, UK, 47–58, 2009.
[2] Haylock MR, European extra-tropical storm damage risk from a multi-model ensemble of dynamically-downscaled global climate models. NHESS, 11: 2847-2857, 2011