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Exploring alternative wind vulnerability and loss modeling methods - application to Europe extra-tropical cyclones

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Catastrophe models are used to assess the economic and insured loss to the built environment due to natural hazards such as earthquakes, windstorms, floods, storm surges, tsunamis, etc. A conventional catastrophe model estimating direct economic loss could be divided into three basic components; hazard, vulnerability and exposure. For a single event, the hazard component represents the best estimate realization of the hazard footprint over a region at the modeling resolution, i.e. variable grid, postalcode, cresta, etc. The vulnerability component represents the response of the buildings or any modeled structure to the hazard, quantified in terms of a loss ratio. The exposure component represents the value of the buildings in a portfolio covering a region or those underwritten by an insurer or a re-insurer. The exposure together with the vulnerability functions produces the expected economic loss of the hazard footprint for a given hazard event. In the case of estimating indirect economic losses and insured losses financial models are utilized with various financial structures applied on the economic loss estimates.

The commonly used method of characterizing wind vulnerability of buildings is to develop functions of mean loss ratio or mean damage ratio (MDR) vs wind speed where the wind speed is often defined as the peak gust measured at a height of 10m above the ground elevation. The uncertainty associated with MDR due to the likelihood of the building experiencing a range of damage states and hence loss ratios at a given wind speed is quantified by a continuous statistical distribution with a mean (which is the MDR) and a standard deviation, SD. For a given event footprint a conventional catastrophe model calculates an MDR and associated SD for each location of a building portfolio. This together with the location exposure or insured value results in the location loss. The location losses are then aggregated together with their SDs to obtain the total expected loss over the event footprint and the associated uncertainty. Now, the actual loss in the building portfolio may not occur at every location, i.e. there are locations with and without loss. It is anticipated that the total incurred loss over the footprint falls within the range of modeled footprint loss and closer to the expected modeled loss value.

An alternative methodology to the above was explored where it was attempted to model realizations of actual losses expected at each location. Firstly the building vulnerability was represented by its underlying fragility functions where each fragility function characterizes the likely damage mode and hence the loss ratio the building could experience during a windstorm and the associated probability of occurrence conditional on the wind speed. The damage modes considered are mutually exclusive and engineering considerations determine the extent of correlation between each damage mode (or sub-damage state). The fragility functions therefore describe the damage matrix for a building subjected to the wind hazard and this matrix produces the probability of damage as well as no damage. Hence at a building location subjected to a certain wind speed within the hazard footprint, one could sample from the damage matrix the actual damage ratio, which could range from zero (where no damage could occur) to the maximum likely damage ratio. By sampling all locations N times, one could subsequently obtain N realizations of the loss footprint hence obtain the expected total event loss and the loss distribution quantifying the uncertainty. In evaluating the insured loss or gross loss, the calculated ground-up loss at a location is used in the expected mode to estimate the gross loss based on the deductibles, limits and other relevant financial structures. This is in contrast to the conventional catastrophe model where the gross loss is calculated as a distributed loss using MDR and SD. The location correlation modeling was explored in the alternative methodology using correlated sampling techniques and compared with the methodology in the conventional distributed loss model. A methodology for modeling location losses where all primary building classifications are

not unknown was also explored within the alternative methodology using building inventory information.

This paper discusses the alternative methodology and presents modeled loss results from both the conventional distributed loss model and the alternative model for a study data set based on European building data and extra-tropical cyclones. The applicability of the alternative model for modeling extra-tropical cyclone losses in Europe was demonstrated using an actual client portfolio and losses from a Europe historical windstorm.