Discussion paper

Discussion on "Public Hurricane Loss Evaluation Models: Predicting losses of residential structures in the state of Florida" by S. Hamid et al.

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1. Introduction

The paper outlines the science and engineering approach used in developing the Florida Public Hurricane Loss Model (FPHLM). Loss models are important because a purely actuarial approach to projecting the future risk of large losses is limited by the amount of data on past damage amounts. A public model is important because it provides an independent check on private model results, which are used to set residential and commercial insurance premiums. We are happy to have this opportunity to congratulate the authors on the development of this public loss model and on their exposition of its various components. The authors have provided an important service to the public and risk management community and the work will undoubtedly stimulate additional research on various aspects of quantifying the expected losses from hurricanes at landfall.

2. Model components

The model consists of three components: (1) Tropical storm frequency and intensity (meteorology); (2) Vulnerability of building construction type (vulnerability); and (3) Actuarial loss distributions (actuarial). To our knowledge this is the standard approach used by most risk modelers. In the meteorology component, a 50K-year catalog of synthetic hurricanes is generated that mirrors historical hurricane activity in and around Florida. Synthetic hurricanes are generated using frequency and intensity distributions derived from past hurricanes and a numerical model that provides near-ground level wind conditions locally from equations that describe atmospheric forces inside a hurricane. In the vulnerability component, a distribution of proportional loss is estimated for each combination of building construction type using various wind speeds and wind directions. In the actuarial component, synthetic hurricanes together with the vulnerability distributions are used to generate loss distributions from a portfolio of insured properties. Expected annual losses are estimated for policies at a spatial resolution of interest (at least down to the zip code level) in an insurance portfolio.

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3. Strengths and limitations

The strengths of the FPHLM approach are:

- Independence: Each component can be verified independently of the other components
- Flexibility: The model can be applied to any portfolio of properties
- Modularity: A new component can replace an older component without changing other components
- Theoretical basis: Some of the meteorology component is based on physical theory

The first three strengths make it relatively seamless to apply the approach to an arbitrary portfolio given the hurricanes, the vulnerability distributions, and the insurance data. Since building construction is similar in different regions, one only has to replace the set of synthetic hurricanes for different properties. Also, if the engineer or meteorologist decides to update a particular component, the other components can be left alone. Another strength is the use of the maximum potential intensity [4] to derive the highest hurricane intensity for a given geographic region. The use of limits based on physical arguments prevents the inclusion of unrealistic events in the hurricane catalog.

The limitations of the approach are independence of model components, insensitivity to climate variations, and cascading affects. While independence can be a strength because it allows flexibility it can also be a limitation because the total variance is the sum of the variance of each component. This necessitates larger loss distributions for a given portfolio than might otherwise be the case using a more integrated approach.

The approach as described in the paper is insensitive to climate variability and change since it uses all the historical data to generate a single loss amount aggregated by year, for instance. While this may have been a design decision imposed on the modelers, it is not realistic as the strongest hurricanes are getting stronger [3] and interannual climate variations are known to influence the probability of hurricanes along the US coast, including those affecting Florida [1]. In fact, Jagger et al. [6] show a climate signal in normalized historical loss data. The authors mention selective sampling based on the phase of the El Niño/La Niña cycle, but they say nothing about the North Atlantic Oscillation or solar activity [2]. Moreover dividing sampling years by the magnitude of specific climate variables may lead to unreasonably small sample sizes for more than one or two variables.

As a demonstration of changes to hurricanes in the vicinity of Florida that might be due, at least in part, to climate change, Fig. 1 shows the time series of intensification for all intensifying hurricanes passing within 1000 km of the geographic center of Florida (83° W, 23° N). The radius defines the same threat area used by the modelers to capture the statistical characteristics of historical tropical cyclones that have affected Florida. The red lines show the trend for the 10th, 50th, and 90th percentiles of the distribution. The data used as part of the model construction clearly show today's hurricanes approaching Florida are intensifying more rapidly than those in the past. Why this is occurring remains to be investigated.

4. Model enhancements

The FPHLM can be enhanced in a couple of ways. First, using a parametric wind intensity distribution [5] would reduce the variance of this component of the model. Second, it would be helpful for users of the model to have clarification on the sensitivity issue. Figure 13 of the paper shows an expected percentage reduction for loss variance (EPR) of more than 150% for a category five hurricane (maximum wind speeds in excess of 69 ms^{-1}). From a naive perspective and in view of the equation used to calculate EPR, we note any value over 100% is not really possible. Using the definition of EPR and dividing through by $\mathrm{Var}(Y)$ we have:

$$\mathrm{EPR} = \mathrm{Var}(\mathbb{E}(Y|X))$$
$$\mathrm{Var}(Y) = \mathbb{E}(\mathrm{Var}(Y|X)) + \mathrm{Var}(\mathbb{E}(Y|X))$$
$$1 = \mathbb{E}(\mathrm{Var}(Y|X))/\mathrm{Var}(Y) + \mathrm{EPR}/100$$
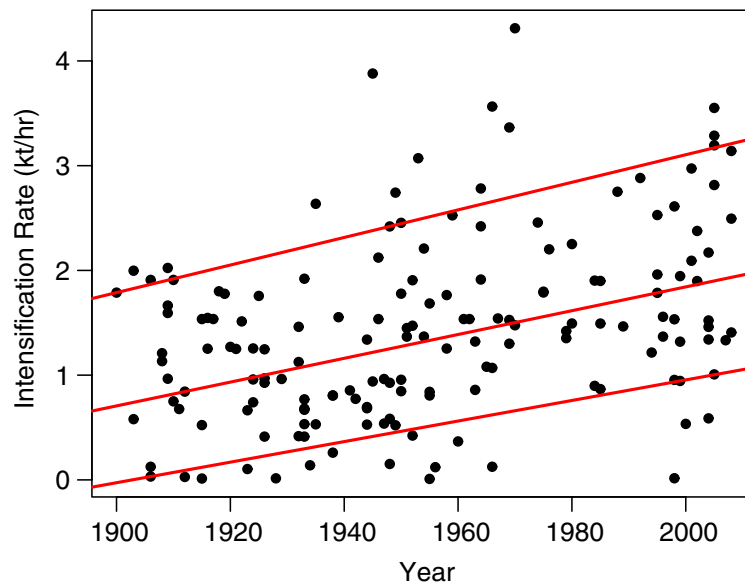$$\mathrm{EPR} \leq 100.$$

Fig. 1. Maximum intensification values (kt hr^{-1}) for all intensifying hurricanes passing within 1000 km (great-circle distance) of 83° W longitude and 23° N latitude. A knot (kt) or nautical mile per hour is commonly used in operational meteorology in the United States and one kt equals 0.5144 ms^{-1}. The trend lines correspond to the 10th, 50th, and 90th percentiles (bottom to top) of the distribution. Although year explains only 14% of the variation, the upward trend in average intensification amounts to one knot per hour per year and is statistically significant from zero (p-value < 0.001).

Third, the authors have not made a clear distinction between sensitivity and uncertainty analyses. Note that in a linear model one can derive the uncertainty from the sensitivity by squaring the standardized regression coefficients and dividing by the variance of the response variable, as the expected value of the response given a predictor is just the slope coefficient for independent predictors.

5. Final words

The FPHLM represents a standard approach to estimating hurricane-generated insured losses. It will be a valuable asset to the Florida Commission on Hurricane Loss Projection Methodology (FCHLPM) in their efforts to provide a scientific review of the various private loss models, and we applaud the developers. The approach can be improved with a statistical framework to some of the components and, in a related way, by considering the hurricane risk conditional on a variable and changing climate. Finally, it would be helpful to have greater clarification on the issue of model sensitivity.

References

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