The Use of Seasonal Forecasting Information in Catastrophe Loss Modelling

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Catastrophe Loss Modelling

'Catastrophe Loss Modelling' (event-specific stochastic modelling of highly-correlated multi-location loss) was developed in the late 1980s, initially for problems associated with earthquake insurance and reinsurance. These techniques were successfully expanded to cover hurricane loss modelling in the early 1990s, and extra-tropical cyclone windstorms in the mid 1990s. Today holistic (ie correlated) risk analysis models have been developed for analysing the financial consequences of other climate hazards including flood, freeze and drought.

Catastrophe loss modelling involves the generation of a population of stochastic events, each comprising a complete and realistic representation of the 'hazard field' (ie spatial extent and strength of earthquake vibration, wind-gusting, flood-depths etc) of a physical catastrophe. This stochastic population has to comprise adequate regional coverage, rich parameter diversity and a sufficient number of extreme events (most readily achieved by employing stratified sampling to create larger numbers of events of reduced probability in the extreme tails of distributions). The hazard field of each synthetic event has to respect the inherent complexity of earthquake fault-rupture or hurricane circulation as well as the modifying potential of the terrain, on the propagation and amplification of seismic vibration or localised modifications of windspeeds. Based on empirically calibrated vulnerability relationships between hazard effects and damage (typically expressed as % of value), and knowledge of the types and values of buildings present at each location within a portfolio, a $ (or %) loss is generated for each stochastic event.

From the losses for each member of the stochastic population two fundamental perspectives on risk become available: the expected (or average annualised) loss is the sum of each event loss multiplied by its respective probability, and the Exceedence Probability (or EP) relationship displays the probability of suffering a loss in excess of any value within a selected time-interval. The EP curve provides the fundamental perspective on which all risk transfer structures (such as reinsurance) can be evaluated both for their expected loss and their impact on the residual risk.

Catastrophe loss modelling requires interdisciplinary teams of scientists, engineers and statisticians. As many of the users of this kind of information are not engineers, models are delivered in the form of desk-top business-management software applications. While traditional insurance and reinsurance contracts are renewed annually (typically at the beginning of the year), and hence provide little opportunity to revisit pricing decisions, tradable catastrophe bonds (whose principal is at risk on the occurrence of a loss of a certain magnitude) provide new markets for real-time risk information. RMS is the largest company specialising in catastrophe loss modelling with around 450 staff engaged in all those activities required to develop and support the use of software models.

Beyond baseline activity rates

The overall activity rates developed within Catastrophe Loss models of windstorm are based on the longest availability of complete and accurate records. For European windstorm, for example, a complete population of the tracks of storms in and around Britain has been developed back to the origins of synoptic meteorology in the 1860s. For Atlantic hurricanes the record is generally considered complete back to the 1880s. Activities measured over these centennial time-scales provide the fundamental baseline of risk in the model. From this baseline it is possible to explore how risk varies over shorter time-periods: including months, years, and distinct states of the climate system.

In parallel with the development and calibration of the stochastic event set, a historical reconstruction exercise is undertaken to recreate the windfields of all significant historical windstorms or hurricanes over the past century. These windfields are then simulated across the 1999 distribution of building locations and values to generate individual 'as if' losses for 'an industry portfolio' (either representing the whole of the built environment and infrastructure or that part of it that is insured). Loss is a convenient parameter by which to collapse the whole consequences of events including the number, individual severities, sizes specific tracks etc. The historical reconstructions provide the potential to explore the seasonal or climatological controls of loss. It is possible for example to review how average annualised loss varies by month along the coast of the Eastern US (the hurricane loss season is all but over in Texas by the time it arrives in the North-East coastal states). It is also possible to determine how this loss, expressed by year, month and region varies according to the prevailing state of ENSO.

Forecasting provides opportunities to refine the baseline probabilistic output of the simulation model. There are two time-scales of relevance. The first, short-term forecasting concerns improving the determination of the track location, size and severity of a windstorm after it has already been initiated. In contrast to other applications, such as the evacuation of coastal communities, for the purposes of catastrophe loss modelling, timing is of lesser concern. However as a hurricane may be sustained for more than a week, it is important that a forecast is available for the period up until the storm is likely to have its greatest impact (typically at 'landfall' in Central America or US). The whole design of the stochastic simulation process within the RMS Atlantic hurricane model makes it possible to simulate in real-time hundreds or thousands of potential outcomes of a hurricane and determine the risk, both per location (most simply represented as a pure 'cents per $1000' of insured coverage) as well as a loss Exceedence Probability distribution. As part of the loss simulation process the most useful format for taking forecasting information would be as the whole suite of GCM ensemble runs, with information from each simulation on both storm location and severity throughout the forecasting period.

The second forecasting time-scale concerns seasonal forecasting of windstorm or hurricane activity. The definition of 'seasonal' can encompass any time-scale from a year down to a few remaining weeks of the hurricane season itself. In modelling work at RMS the Atlantic hurricane population has been broken down into five categories according to where hurricanes form and the prevailing track directions. Within each of these categories there are subtle variations in behaviour that may determine whether a storms ends up as a Hurricane Andrew in Florida or simply fizzles out in the mid-Atlantic, all of which can be incorporated into the stochastic simulation process if they can be forecasted. As the whole methodology of catastrophe modelling is probabilistic, forecasts themselves need to contain as much information as can be generated in terms of numbers of events, regions, track types, sizes, severities etc. For all forecasted information interlinkages between parameters are of particular interest and confidence limits must be provided (ideally by being able to view all individual simulation runs and calibration tests).

Over the next few years the boundary between short and medium term forecasting and catastrophe loss modelling is likely to be one of considerable growth. RMS is an example of the new class of scientifically literate customer for forecast information that will require raw model output rather than generalised interpretations mediated by a forecaster.