Better understanding of a key peril

European windstorms are complicated, difficult to model perils, but as James Webb explains, models are increasing in sophistication and quantification of uncertainties is improving.

LOSS MODELLING FOR WINDSTORMS is a relatively young discipline that has evolved from purely statistical (Pareto) models fitted to loss history, to deterministic "what-if," or "probable maximum loss" scenarios, and now to today's fully probabilistic models of ever increasing sophistication.

EQECAT's assessment of European windstorm loss potential indicates a 100-year return period risk of over €28bn. Such extra-tropical cyclones/windstorms are highly complex events, unlike tropical cyclones such as North Atlantic hurricanes which tend to display more symmetrical behaviour.

Modelling methodologies employed until recently include historical event pressure fields or event parameters, measured wind speed data and numerical weather prediction (NWP), a mathematical model approach to simulating wind fields.

In Europe, today's climate hazard models can employ a number of sophisticated and computationally intensive techniques. These now include atmosphere ocean general circulation models (AOGCM) and hybrid hazard models. AOGCMs are a class of computer-driven mathematical and physical models used globally for substantially longer climatological investigation runs. NWP modelling has also been used to predict windstorms, with a varying degree of success.

Fundamental to this scientific advancement, and a principal challenge for probabilistic loss modelling, is the desire to reduce model uncertainty. Model uncertainty relates to how well key model components represent the real world. Does the model reflect the hazard in terms of severity and frequency? Does it accurately represent building damage vulnerabilities and associated variability? And does the financial loss module effectively capture policy conditions and related economic factors? These issues combine to have a direct bearing on model results upon which re/insurers rely to manage risk.

Reducing uncertainty

Clearly, modelling uncertainties can't be eliminated and modelling is by its very nature uncertain. In general, however, uncertainties can, and ought, to be quantified. In some cases, they can be reduced through choice, refinement of the methodology or selection of source data.

From a user's perspective, catastrophe loss models introduce two types of uncertainty: those pertaining to modelling assumptions made by developers, and those inherent in the modelling process and source data.

Uncertainties relating to the modelling process and source data are more difficult to treat, as they are intrinsically connected to every part of the process and tend to increase substantially along the modelling chain. They apply equally to the hazard, vulnerability, claims and exposure data used for model calibration.

An important test is the quantification of uncertainties contained in each step of the modelling process.

When treated correctly, the uncertainties associated with each module are analysed individually before being concatinated to a total uncertainty provided with the final loss estimate. The reduction of these uncertainties ranges from the relatively easy – such as achieving high resolution geocoding of exposure – to the highly complex, such assessing non-adherence to building codes.

A critical area of model uncertainty for European windstorms relates to the wind hazard itself. There are two major methodologies of footprint generation. The first is based on interpolation of actual gust measurements post-treated for effects of local conditions. The other is based on modelled gusts derived from various gust parameterisation programs implemented in NWP models. Both approaches have their advantages and disadvantages.

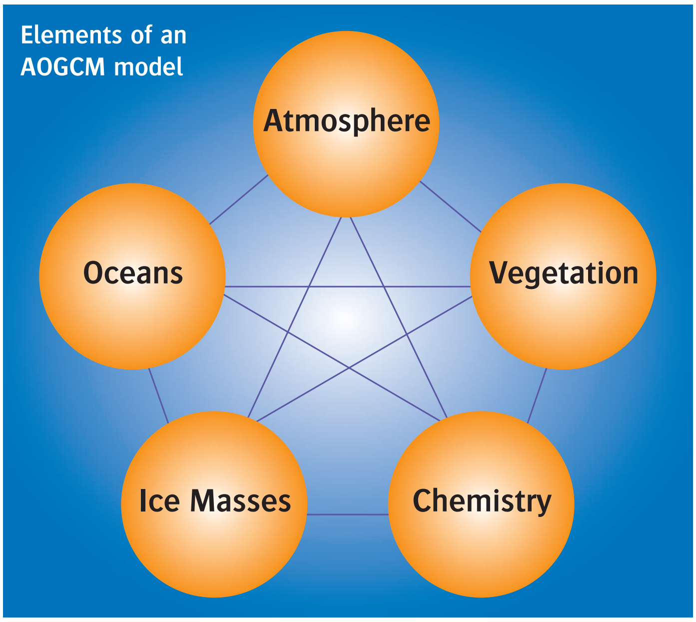
While NWP has been used quite successfully in the weather prediction arena, European winsdstorm hazard can only be approximated by NWP model simulations. This is especially so in regions with very dense meteorological station networks, such as Western Europe. While the NWP approach gives a vertical dimension to the hazard and may help us to understand better storm development, it isn't of direct use for the modelling of losses on the ground.

This can be contrasted to the methodology based on the use of recorded gust measurements. Due to their 1-2% maximum error rate, these measurements are widely considered as the "ground truth", which NWP model simulations can currently only approximate.

AOGCM-based modelling

Certain elements of atmospheric modelling, as performed by academic institutions, will play an increasingly important role in the future of loss modelling. The challenge lies in the selection of the aspects which are most suitable for use in this particular application.

NWP models have been used for some time for the generation of historical and stochastic event sets. In contrast, the use of coupled AOGCMs for the generation of hybrid hazard is relatively recent, and is opening up opportunities in the area of loss modelling. These include investigation into the possible effects of future climate change on risk.



AOGCM and NWP models are essentially the same. Both are based on the laws of thermodynamics and fluid motions, and tend to have the same modules designed to simulate major components of the earth system, such as atmosphere, ocean, vegetation, ice masses and chemistry. The key difference is how these models are run and applied. Both are global models – although only regional formats of NWP models tend to be used for loss modelling purposes – with heavy demand on computing resources, which currently places limits on their use.

NWP models are typically used for short time series of only a few days. Thus, they can be run at a higher resolution than AOGCMs, which are set up for long climatological runs of dozens or even hundreds of years.

Because of their short simulation periods, NWP models essentially use their atmospheric modules only. There is no need for them to use interactively other parts of the system, as sea surface temperatures or the vegetation cover don't change substantially in the few days over which these models run.

In contrast, AOGCMs make full use of all components of the earth system and their interaction during simulation periods. The key difference is that they generate their own synthetic "weather" and its annual or decadal cycles. It is this feature that can be used to reduce hazard uncertainty, including how to validate/refine:

- The spatial distribution of modelled storms.
- The possible physical thresholds of storm parameters, such as maximum storm area, which are used in the probabilistic perturbation process.
- Modelled event frequencies. The peril phenomena are well understood due the relatively high frequency of moderate to low severity events and recorded data over the last 50 years, but the smaller number of high severity windstorms over this period prompts investigation into the probabilities of these lower frequency disastrous events.
- The temporal clustering of modelled events, as occurred in reality in 1990 and 1999.

Meanwhile, model vulnerability functions typically rely heavily on insurance claims and exposure data. This data is extremely important, but still provides an incomplete picture.

Useful claims and exposure data cover limited time periods and relate to limited wind speed ranges. The data can also suffer from inaccuracies and incompleteness. It is useful, therefore, to combine findings from claims and exposure data with an engineering-based approach. Our approach has been to attempt to understand and incorporate the effects of a wider range of wind speeds for relevant building types and combine these with engineering-based research into relative vulnerabilities of building codes across modelled countries. This provides a more robust foundation for model vulnerability functions.

While this approach is beneficial, there are related exposure data issues in Europe that need consideration. Exposure data tends to be more aggregated than, for example, in North America. As a result, a model disaggregation methodology based on recent census and other statistical data is an effective solution. Also, European building stock includes a relatively high proportion of older (pre-WWII) construction, and vulnerability functions need to reflect the use of more construction types.

More uncertainty

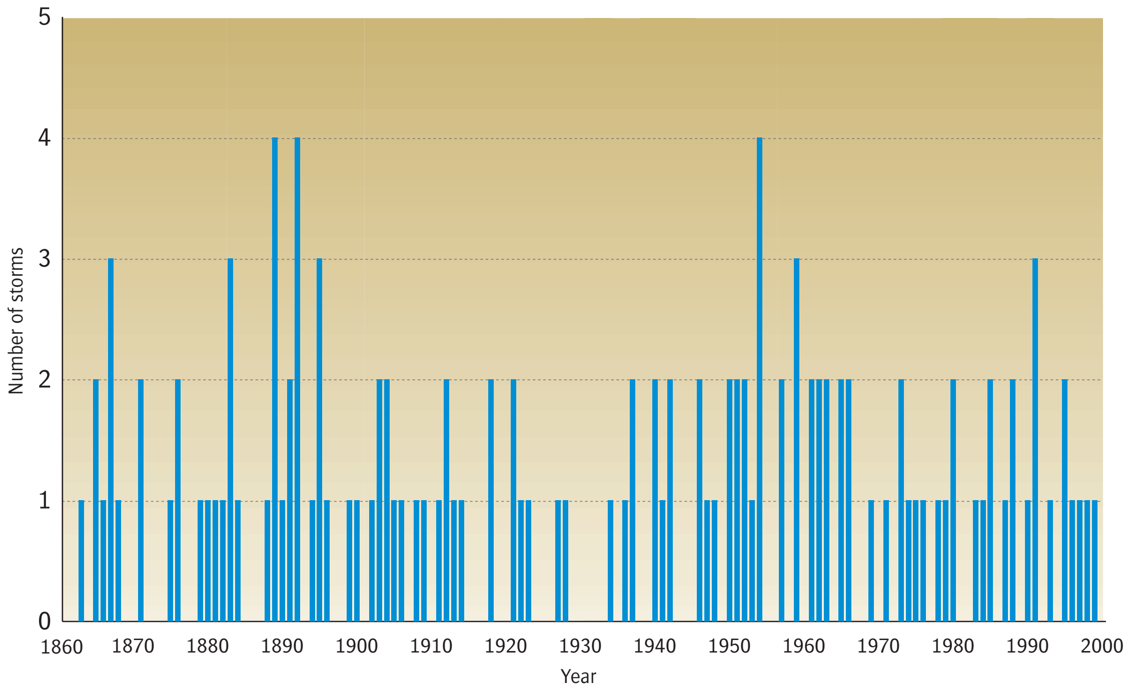
Other important model uncertainty challenges remain. These include ensuring accurate spatial correlation of windstorm hazard across European countries. If the model hazard domain is pan-European, we can effectively lessen this uncertainty.

Capturing risks that may not usually be modelled and which correlate with European windstorm is another step in decreasing uncertainty. Areas that are important to consider are:

- insured risks that are typically covered alongside win damage in policies, such as storm surge risk in the United Kingdom
- other exposure types that have presented a surprising degree of re/insurance loss, such as forestry risk in Scandinavia.

Modelling European windstorm risk is a complex endeavour. As with other models, the need to reduce model uncertainty is a key driver of model development and has led to the use of sophisticated, state-of-the-art techniques. Ultimately, this isn't science for science's sake – the aim is always to provide the insurance industry with the most reliable representation of risk to support business decisions.

James Webb is EQECAT's European product manager. This article was created with input from EQECAT's Model Development Group (www.eqecat.com).



An approach to hazard uncertainty

At EQECAT, our recent solution to the task of decreasing hazard uncertainty has been the adoption of a hybrid hazard model, one that combines the best and most suitable aspects of both measured and modelled windstorm characteristics. To do this, we used analytical input from meteorological experts at the Freie Universität Berlin using the ECHAM/OM1 atmosphere ocean general circulation models (AOGCM) developed by the Max-Planck Institute in Germany.

An example of the value of the AOGCM analysis used by EQECAT is the comparison above of the observed frequency of years marked by clustering of severe storms over Europe to those found in a 140-year long AOGCM run.

Numbers of severe storms per year over continental Europe as simulated with ECHAM5/OM1 coupled AOGCM model. Run with climatic forcing the model generates synthetic storm systems like Daria (25 January 1990) or Anatol (3 December 1999) respectively.

Consequently, the storm clustering has to be interpreted in statistical sense (eight years in 140 with three or more severe storms) only. This frequency is in broad agreement with the observed frequency of years marked by clustering of severe storms (two years in 40 with three or more severe storms.)

Is European windstorm risk changing?

While it is generally agreed that 12 years in the last two decades have been among the warmest in the measurement period of 1850 to the present, there is no substantial evidence that windstorm risk has changed significantly in these two decades. Current studies of climate scenarios indicate a slight decrease in total numbers of extra-tropical cyclones, yet a slight increase in the number of high severity events over specific regions, including the North-East Atlantic and the westernmost part of Europe.