Improving weather models for the insurance industry

Introduction

Predicting the risk of extreme weather events, such as floods, storms, or ground frost is critical in property insurance. The dominant approach in the primary insurance industry is to classify the risk of events into coarse categories — a 1-in-100 year or 1-in-250 year storm or flood, for example — without time dependence. This ignores the effect of global trends which could influence the future activity of extreme events on a range of time scales.

The broad goal for the study group is to evaluate the feasibility of developing more detailed estimates of extreme weather risk. These could allow an insurance company to:

- Invest in claims, underwriting and pricing initiatives to diversify risk
- Guide reinsurance strategy
- Inform customers on how best to prepare during a high-risk period
- Ensure that claims departments have all necessary resources in place
- Plan early interventions to minimise damage in the event of a storm, flood, or freeze.

Specific goals

1) To propose strategies for estimating the risk of extreme weather in the UK seasons to decades ahead
2) To explore the seasonal dependence of weather risks, using historical data.
3) To evaluate the effect that global phenomena such as climate oscillations, global warming, and even solar activity may have on risk estimates.
4) To suggest metrics for the assessment of the benefits of new weather risk estimates using insurance claims data.

Methodological considerations

There are various ways of estimating risks of weather events that can cause severe damages and losses. Historical data can be analysed to determine frequency of occurrence and probability distributions — but data may be sparse and may have trends. *Weather generators* (statistical models fitted to past time series) can be used to simulate weather and create a wide range of scenarios.

There are several methodological challenges to consider: (i) how best to deal with correlations between weather variables such as precipitation, temperature, and frost, (ii) how to model the spatial dependence of the variables, (iii) how to model the probability distribution at each time point and the risk of extreme events.
Dynamical models like those used for numerical weather forecast systems and climate change projections provide outlooks for days to decades ahead, and data from such systems may be used to modify risk estimates. The climate system contains slow variability on a wide range of timescales, and knowledge of the observed current climate state can condition risk estimates.

Participants should consider a range of approaches to estimate relevant risks. It will be important to suggest methods to cross-validate the model with the data available and evaluate the predictive value of different modelling choices.

More broadly, participants can consult experts from Aviva to further define the scope of the problem. For example, what is the geographic area of interest; how far in advance are estimates useful, and what types of extreme events may be of interest? An important part of the exercise will be to explore what data are needed to train a model, what is available, and consider how to acquire more data relevant to the problem – observations, simulations, and forecasts.

Finally, it is important to consider how to validate the weather risk estimates against insurance claims data, combining the predictions with important side information available to the insurer, such as detailed maps of flood risk.

Data and modelling resources

There are many relevant sources of data, model, and risk information, and an initial task will be to explore these. A few starting points are provided here.

Observational data: The Met Office provides open access to several observational datasets. In particular, the HadUK Gridded Dataset contains data from weather stations across the UK going back to 1862 interpolated on grids of various sizes over the country. This dataset contains information on air temperature (monthly means, minima, and maxima), precipitation, wind speed, and days of ground frost, among others.

A broader source of climate datasets including observational data, seasonal forecasts, and climate change projections is provided by the Copernicus Programme.

The IRI Climate Data Library is an alternative source for climate datasets, projections, and analysis tools.

Long-range forecasts:
https://climate.copernicus.eu/seasonal-forecasts
https://www.metoffice.gov.uk/research/climate/seasonal-to-decadal/long-range/index

Stochastic weather generators:
https://www.ipcc-data.org/guidelines/pages/weather_generators.html
https://rmets.onlinelibrary.wiley.com/doi/10.1002/joc.3896

Return periods:
http://climatica.org.uk/climate-science-information/return-periods-extreme-events
https://rmets.onlinelibrary.wiley.com/doi/pdf/10.1002/joc.1155

Climate oscillations: Climate oscillations are recurrent patterns with wide-ranging, effects on e.g. temperature, precipitation, and storm tracks. They are irregular, although some oscillations have a characteristic time scale. In particular, the North Atlantic oscillation has an important effect on UK weather.

North Atlantic Oscillation
https://en.wikipedia.org/wiki/North_Atlantic_oscillation
https://www.cpc.ncep.noaa.gov/data/teledoc/nao.shtml
https://www.metoffice.gov.uk/research/climate/seasonal-to-decadal/gpc-outlooks/ens-mean/nao-description

Atlantic Multidecadal Oscillation
https://en.wikipedia.org/wiki/Atlantic_multidecadal_oscillation
https://climatedataguide.ucar.edu/climate-data/atlantic-multi-decadal-oscillation-amo

Madden-Julian Oscillation. 'The 40-day wave' mainly impacts the tropics, but also has mid-latitude effects.
https://www.metoffice.gov.uk/weather/learn-about/weather/atmosphere/madden-julian-oscillation
https://www.climate.gov/news-features/blogs/enso/what-mjo-and-why-do-we-care

Climate change and extremes:
https://www.ipcc-data.org/sim/ar5_tables/ar5_extremes.html

Solar activity: A relationship between solar activity and the climate has been previously reported. For an example, see
https://www.nature.com/articles/ngeo1282